FANUC AC SPINDLE MOTOR αi series
FANUC AC SPINDLE MOTOR βi series
FANUC BUILT-IN SPINDLE MOTOR Bi series

PARAMETER MANUAL

B-65280EN/08

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In this manual we have tried as much as possible to describe all the various matters.
However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.
Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".

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The parameters described in this manual must be set correctly according to the relevant descriptions. If the parameters are not set correctly, vibrations and unpredictable motions can occur. When setting and updating the parameters, place top priority on safety in operation by taking actions, such as heightening the speed step by step and performing an operation so that an emergency stop can be initiated immediately, until the settings are confirmed to be appropriate.

- When an abnormality such as an alarm or a hardware failure occurs, the operations described in the specifications are not guaranteed unless otherwise specifically noted. When action corresponding to the abnormality is specifically described, take the action. When no action is described, please contact FANUC.
- Generally, safety functions represent functions that protect the operators from machine danger. The signals and functions described in the specifications cannot be used separately for the safety functions unless otherwise described as being usable for the safety functions. Their specifications are not assumed to be used as the safety functions in this case, an unexpected danger may be caused. For information about the safety functions, please contact FANUC.

- A wrong device connection or setting can lead to unpredictable operation. When starting to operate the machine for the first time after assembling the machine, replacing components, or modifying parameter settings, exercise the greater care.

DEFINITION OF WARNING, CAUTION, AND NOTE

This manual includes safety precautions for protecting the user and preventing damage to the machine. Precautions are classified into Warning and Caution according to their bearing on safety. Also, supplementary information is described as a Note. Read the Warning, Caution, and Note thoroughly before attempting to use the machine.

⚠ **WARNING**

Applied when there is a danger of the user being injured or when there is a damage of both the user being injured and the equipment being damaged if the approved procedure is not observed.

⚠ **CAUTION**

Applied when there is a danger of the equipment being damaged, if the approved procedure is not observed.

NOTE

The Note is used to indicate supplementary information other than Warning and Caution.

Even those matters described under "CAUTION" may lead to serious consequences depending on the situation. Thus, be sure to observe the approved procedure.

* Read this manual carefully, and store it in a safe place.

PREFACE

This manual describes the parameters and functions of the FANUC servo amplifier α*i*/β*i* series spindle. This manual is divided into five parts and appendix. This manual includes Part I, which provides a description related to the α*i* series spindle and B*i*I series spindle, Part II, which provides a description related to the β*i* series spindle, Part III, which provides a description related to the αC*i* series spindle, Part IV, which provides a description related to the B*i*S series spindle, and Part V, which provides a description related to the β*i*Ic series spindle.
Unless otherwise noted, the parameter numbers for FANUC Series 16*i* are used in the text. When using any other model, reference the corresponding parameter numbers.
The table below indicates the abbreviated model names used with the parameter numbers.

Product name	Abbreviated model name in text	Abbreviated model name in table
FANUC Series 30*i*	Series 30*i*	30*i*
FANUC Series 31*i*	Series 31*i*	
FANUC Series 32*i*	Series 32*i*	
FANUC Series 0*i*-MODEL D	Series 0*i*-D	
FANUC Series 16*i*	Series 16*i*	16*i*
FANUC Series 18*i*	Series 18*i*	
FANUC Series 21*i*	Series 21*i*	
FANUC Series 0*i*-MODEL C	Series 0*i*-C	
FANUC Series 15*i*	Series 15*i*	15*i*

For detailed information indicating which model each function described in this manual can be used with, refer to the manual of each CNC. For the package specifications, in particular, refer to the CNC manual.

The manuals related to the α*i*/β*i* series spindle are listed below.

(1) FANUC AC SPINDLE MOTOR α*i* series DESCRIPTIONS (B-65272EN)
(2) FANUC AC SPINDLE MOTOR αC*i* series DESCRIPTIONS (B-65372EN)
(3) FANUC AC SPINDLE MOTOR β*i* series DESCRIPTIONS (B-65312EN)
(4) FANUC SERVO AMPLIFIER α*i* series DESCRIPTIONS (B-65282EN)
(5) FANUC SERVO AMPLIFIER β*i* series DESCRIPTIONS (B-65322EN)
(6) FANUC AC SERVO MOTOR α*i*s series,
FANUC AC SERVO MOTOR α*i* series,
FANUC AC SPINDLE MOTOR α*i* series,
FANUC SERVO AMPLIFIER α*i* series MAINTENANCE MANUAL (B-65285EN)
(7) FANUC AC SERVO MOTOR β*i*s series,
FANUC AC SPINDLE MOTOR β*i* series,
FANUC SERVO AMPLIFIER β*i* series MAINTENANCE MANUAL (B-65325EN)
(8) FANUC AC SPINDLE MOTOR α*i* series
FANUC AC SPINDLE MOTOR β*i* series
FANUC BUILT-IN SPINDLE MOTOR B*i* series PARAMETER MANUAL (B-65280EN)
(9) FANUC BUILT-IN SPINDLE MOTOR B*i*I series DESCRIPTIONS (B-65292EN)
(10) FANUC SYNCHRONOUS BUILT-IN SPINDLE MOTOR B*i*S series
DESCRIPTIONS (B-65342EN)

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I. FANUC AC SPINDLE MOTOR αi series FANUC BUILT-IN SPINDLE MOTOR BiI series

1 START-UP

1.1 START-UP PROCEDURE

A. Check the spindle-related specifications.
- CNC model
- Spindle motor
- Power supply (PS)
- Spindle amplifier
- Detector system

B. Check all connections. (See DESCRIPTIONS.)

C. Prepare and check the PMC ladder program.

D. Check the CNC parameter setting for using the αi series (Serial) spindle. (See Subsection 1.2.1.)

E. Perform automatic αi series (Serial) spindle parameter initialization. (See Subsection 1.2.2.)
- Set a motor model code and the parameter enabling use of the automatic parameter initialization function, then turn the CNC off and then on again.

F. Change parameter data (when no model code is used).
- For a motor for which there is no model code, perform automatic initialization by specifying 300 (or 400 when the speed range switching function is used), then change the parameter data according to the parameter list for the motor.

G. Set the parameters related to the detectors. (See Section 1.3.)

H. When using a machine in a system that has already been started, load all CNC parameters for the machine.

I. Check the waveforms of the feedback signals from detectors. (Refer to the MAINTENANCE MANUAL (B-65285EN).)

1.2 SPINDLE SERIAL INTERFACE (OPTIONAL FUNCTION)

1.2.1 Parameters Related to Spindle Serial Output

This subsection provides a list of the parameters related to spindle serial output only. For details of each parameter, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.2, “SPINDLE SERIAL OUTPUT/SPINDLE ANALOG OUTPUT.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.2, “SPINDLE SERIAL OUTPUT.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.2, “SPINDLE SERIAL OUTPUT/SPINDLE ANALOG OUTPUT.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.2, “SPINDLE SERIAL OUTPUT/SPINDLE ANALOG OUTPUT.”
(e) For Series 30*i*/31*i*/32*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.2, “SPINDLE SERIAL OUTPUT.”
(f) For Series 0*i* -D
“FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.3, “SPINDLE SERIAL OUTPUT.”

Parameter No.			Description
15*i*	**16*i***	**30*i***	
—	3701#1	—	Whether to use the serial interface (Set 0.)
—	—	3716#0	Selection of a spindle (analog/serial) (Set 1.)
5606#0	—	—	Selection of an interface (serial/analog) (Set 1.)
—	3701#4	—	Number of connectable serial spindles (Whether to use the second serial spindle)
—	—	3702#1	Multi-spindle control function (Whether to use the multi-spindle control function)
5841	—	—	Motor number of each spindle
—	—	3717	Amplifier number of each spindle
5845	—	3718	Spindle indication subscript (main spindle)
5846	—	3719	Spindle indication subscript (sub-spindle)
5850	—	—	Spindle number selected at power-on/reset time

NOTE
To use the spindle serial interface, the CNC software option is required.

1.2.2 Automatic Spindle Parameter Initialization

> **NOTE**
> When automatic spindle parameter initialization is performed, the parameter settings that have already been adjusted (such as sensor settings and orientation stop positions) are also initialized. To prevent the adjusted parameter settings from being initialized, do not perform automatic initialization.

(1) Parameter list

Parameter No.			Description
15*i*	**16*i***	**30*i***	
5607#0	4019#7	4019#7	Function for automatically initializing spindle parameters
3133	4133	4133	Spindle motor model code

(2) Procedure for automatic spindle parameter initialization

Perform automatic spindle parameter initialization by following the procedure below.

<1> Set the model code for the desired motor for automatic parameter initialization.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3133	4133	4133	Model code

> **NOTE**
> 1 The control method usable with the αi series spindle is spindle HRV control only. The conventional control method is not supported.
> 2 When using a spindle motor that has no model code, set model code "300" ("400" for a spindle motor with speed range switching control) for automatic parameter setting, then manually input data according to the parameter table for each motor model.

<2> Set the relevant parameter to enable automatic spindle parameter initialization.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
—	4019#7	4019#7	1
5607#0	—	—	0

> **NOTE**
> This bit is reset to its original value after automatic parameter initialization.

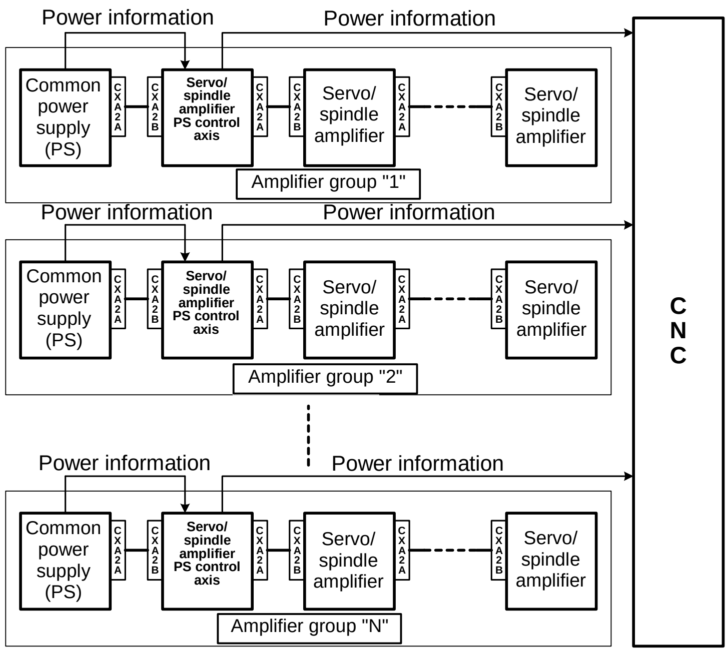
<3> Turn the CNC off, then on again. Then, the spindle parameters specified with a model code are automatically initialized.

1.2.3 Automatic Setting of the Parameter for Specifying the PS Control Axis

* To use the 30*i*-B series SP, the following operation is required.

For the power supply (PS) for the 30*i*-B series, control is now performed by software. On the CNC, this allows you to know power information. Since the PS cannot communicate with the CNC directly, power information is transferred to the CNC through an SV or SP called a PS control axis.

(The PS control axis refers to an SV or SP connected in the closest vicinity of the PS in the amplifier connection using CXA2x connectors.)



To enable the CNC software to recognize the PS control axis, an amplifier group number must be set in one of the following parameters:

Parameter No. 2557 when the PS control axis is an SV
Parameter No. 4657 when the PS control axis is an SP

The parameters can be set automatically by following the procedure below.

* If the amplifier configuration is changed, an invalid PS control axis specification alarm occurs immediately after CNC start-up. Perform automatic setting again.

<1> Set the relevant parameter to enable automatic PS control axis setting.

Parameter No. 30*i*-B	Description
11549#0	1

> **NOTE**
> This bit is reset to its original value after automatic setting.

<2> Turn the CNC off, then on again. Then, the PS control axis parameter is automatically set.

1.2.4 Diagnosis (Diagnosis Screen)

This subsection provides a list of the diagnosis (diagnosis screen) indications related to spindle serial output only. For details, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.2, “SPINDLE SERIAL OUTPUT/SPINDLE ANALOG OUTPUT.”

(b) For Series 30*i*/31*i*/32*i*

"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.2, "SPINDLE SERIAL OUTPUT."

(c) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.2, "SPINDLE SERIAL OUTPUT/SPINDLE ANALOG OUTPUT."

(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.2, "SPINDLE SERIAL OUTPUT/SPINDLE ANALOG OUTPUT."

(e) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.2, "SPINDLE SERIAL OUTPUT."

(f) For Series 0*i* -D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.3, "SPINDLE SERIAL OUTPUT."

(1) For Series 16*i*

Address	Description
400	Information including spindle control
408	Information about spindle serial output interface communication errors
409	Information about spindle serial output interface activation

(2) For Series 30*i*

Address	Description
400	Information including spindle control
408	Information about spindle serial output interface communication errors

(3) For Series 15*i*

Address	Description
1500	Information about spindle serial output interface communication errors

1.2.5 Alarm

This subsection provides a list of the alarms related to spindle serial output only. For details of each alarm, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.2, "SPINDLE SERIAL OUTPUT/SPINDLE ANALOG OUTPUT."

(b) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.2, "SPINDLE SERIAL OUTPUT."

(c) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.2, "SPINDLE SERIAL OUTPUT/SPINDLE ANALOG OUTPUT."

(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.2, "SPINDLE SERIAL OUTPUT/SPINDLE ANALOG OUTPUT."

(e) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.2, "SPINDLE SERIAL OUTPUT."

(f) For Series 0*i* -D

"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.3, "SPINDLE SERIAL OUTPUT."

(1) For Series 16*i*

Alarm No.	Description
749	A serial communication error occurred while the system was being activated after power-on.
750	The (serial) spindle amplifier was not activated normally at power-on time.

(2) For Series 15*i* and Series 30*i*

Alarm No.		Description
15*i*	30*i*	
PS0223	—	Before a spindle to be controlled is set correctly, a command for using the spindle was executed.
SP0201	—	The same motor number other than 0 is set more than once in parameter No. 5841.
SP0202	—	A spindle number greater than the number of spindles is set in parameter No. 5850.
SP0220	SP1220	The cable connected to the serial spindle amplifier is disconnected, or no serial spindle amplifier is connected.
SP0221	—	The correspondence between spindle numbers and motor numbers is incorrect.
SP0225	SP1225	A CRC error (communication error) occurred in communication between the CNC and serial spindle amplifier.
SP0226	SP1226	A framing error occurred in communication between the CNC and serial spindle amplifier.
SP0227	SP1227	A receive error occurred in communication between the CNC and serial spindle amplifier.
SP0228	SP1228	A communication error occurred in communication between the CNC and serial spindle amplifier.
SP0229	—	A communication error occurred in communication between serial spindle amplifiers (between motor numbers 1 and 2 or between motor numbers 3 and 4).
—	SP1229	A communication error occurred in communication between serial spindle amplifiers (between an odd-numbered amplifier and even-numbered amplifier).
SP0230	—	The value set in parameter No. 5841 is not within the allowable range.
SP0970	—	Spindle control initialization was not terminated.
SP0976	—	No amplifier number could be set for a serial spindle amplifier.
SP0978	—	A time-out was detected in communication with a serial spindle amplifier.
SP0979	—	The communication sequence was incorrect in communication with a serial spindle amplifier.
SP0980	SP1980 to SP1984	The SIC-LSI on the serial spindle amplifier side is faulty.
SP0981	—	An error occurred when data was written to the SIC-LSI on the serial spindle amplifier side.
SP0982	—	An error occurred when data was read from the SIC-LSI on the serial spindle amplifier side.
SP0983	—	An alarm on the spindle amplifier side could not be cleared.
SP0984	—	An error occurred during spindle amplifier reinitialization.
SP0985	—	Automatic parameter setting failed.
SP0987	SP1985 to SP1987	The SIC-LSI on the CNC side is faulty.
SP0996	—	The assignment of spindles and spindle motors is incorrect.
—	SP1245 to SP1247	A communication data error was detected on the CNC side.
—	SP1976 to SP1979	An error occurred with the spindle control software.
—	SP1988 to SP1989	An error occurred with the spindle control software.
—	SP1996	Spindle motor assignment is incorrect. Check the parameters indicated hereafter. (No.3716, No.3717)

1.3 PARAMETERS RELATED TO DETECTORS

NOTE

1 Note that the specifications of parameters related to detectors for the αi series spindle amplifiers differ from those of parameters for the α series spindle amplifiers.

2 The terms “motor sensor” and “spindle sensor” used in the text mean the speed/position detectors connected to the connectors described below.

(i) Motor sensor :
Detector connected to connector JYA2 or JYA3
(αiM sensor, αiMZ sensor, αiBZ sensor of a built-in motor, αiCZ sensor (analog, serial) of a built-in motor)

(ii) Spindle sensor :
Detector connected to connector JYA3 or JYA4
(αi position coder, α position coder S, separate αiBZ sensor, separate αiCZ sensor (analog, serial), and so forth)

1.3.1 List of Parameters for Detectors

Parameter No.			Description
15i	16i	30i	
—	3706#1,0	—	Gear ratio of spindle to position coder (×1, ×2, ×4, ×8)
5842	—	3720	Number of pulses of the position coder
3000#0	4000#0	4000#0	Direction of spindle and spindle motor rotation
3001#4	4001#4	4001#4	Spindle sensor mounting direction
3002#3,2,1,0	4002#3,2,1,0	4002#3,2,1,0	Spindle sensor type setting
3003#7,6,5,4	4003#7,6,5,4	4003#7,6,5,4	Setting of the number of spindle sensor gear teeth
3004#3,2	4004#3,2	4004#3,2	External one-rotation signal (proximity switch) setting
3006#1	4006#1	4006#1	Gear ratio increment system
3007#5	4007#5	4007#5	Whether to detect disconnection of feedback signals
3007#6	4007#6	4007#6	Whether to detect alarms related to position feedback signals (on non-Cs contouring control mode)
3010#2,1,0	4010#2,1,0	4010#2,1,0	Motor sensor type setting
3011#2,1,0	4011#2,1,0	4011#2,1,0	Setting of the number of motor sensor gear teeth
3016#5	4016#5	4016#5	Whether to detect alarms related to position feedback (in Cs contouring control mode)
3016#6	4016#6	4016#6	Whether to detect alarms related to threading feedback
3016#7	4016#7	4016#7	Setting of the function of detecting the one-rotation signal again each time position control mode is set.
3394#2	4394#2	4394#2	Setting of the detection lower limit of the one-rotation signal
3394#5	4394#5	4394#5	Whether to detect the alarm related to spindle sensor polarity erroneous setting
3056 to 3059	4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data (This data is selected by spindle control input signals CTH1A and CTH2A.)
3098	4098	4098	Maximum speed for position feedback signal detection
3171 3173	4171 4173	4171 4173	Denominator of arbitrary gear ratio between motor sensor and spindle (This data is selected by spindle control input signal CTH1A.)
3172 3174	4172 4174	4172 4174	Numerator of arbitrary gear ratio between motor sensor and spindle (This data is selected by spindle control input signal CTH1A.)
3334	4334	4334	Arbitrary number of motor sensor teeth
3355	4355	4355	Motor sensor signal amplitude ratio compensation

Parameter No.			Description
15*i*	16*i*	30*i*	
3356	4356	4356	Motor sensor signal phase difference compensation
3357	4357	4357	Spindle sensor signal amplitude ratio compensation
3358	4358	4358	Spindle sensor signal phase difference compensation
3361	4361	4361	Arbitrary number of spindle sensor teeth
3500 3502	4500 4502	4500 4502	Denominator of arbitrary gear ratio between spindle sensor and spindle (This data is selected by spindle control input signal CTH1A.)
3501 3503	4501 4503	4501 4503	Numerator of arbitrary gear ratio between spindle sensor and spindle (This data is selected by spindle control input signal CTH1A.)

1.3.2 Details of Parameters for Detectors

This subsection details the serial spindle parameters (in the four thousands for 16*i*, and in the four thousands for 30*i*, and in the three thousands for 15*i*) among the detector-related parameters. For details of other parameters, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, “SPINDLE SPEED CONTROL.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(e) For Series 30*i*/31*i*/32*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.4, “SPINDLE SPEED CONTROL.”
(f) For Series 0*i* -D
“FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.6, “SPINDLE SPEED CONTROL.”

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3000	4000	4000								ROTA1

ROTA1 Indicates the relationship between the rotation directions of spindle and spindle motor.
0 : Rotates the spindle and spindle motor in the same direction.
1 : Rotates the spindle and spindle motor in the reverse direction.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3001	4001	4001				SSDIRC				

SSDIRC Indicates the mounting direction of spindle sensor.
0 : Rotates the spindle and spindle sensor in the same direction.
1 : Rotates the spindle and spindle sensor in the reverse direction.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3002	4002	4002					SSTYP3	SSTYP2	SSTYP1	SSTYP0

SSTYP3 to SSTYP0 Spindle sensor type

This parameter sets the type of a separate detector to be attached to the spindle (detector to be connected to connector JYA3 or JYA4).

SSTYP3	SSTYP2	SSTYP1	SSTYP0	Spindle sensor type
0	0	0	0	None (No position control function is used.)
0	0	0	1	Uses the motor sensor for position feedback
0	0	1	0	αi position coder
0	0	1	1	Separate αiBZ sensor, αiCZ sensor (analog)
0	1	0	0	α position coder S
0	1	1	0	Separate αiCZ sensor (serial)
1	1	1	0	Separate αiBZ sensor, αiCZ sensor (analog) [Setting for detecting the one-rotation signal at less than 10 min^{-1} (*3)]

NOTE

1. When using a rectangular wave phase A/B, 1024-p/rev position coder, set the same settings as for the αi position coder (0,0,1,0).
2. It is not possible to use the αiCZ sensor (serial) as both motor sensor and spindle sensor.
3. When this setting is made in combination with the setting for detecting the one-rotation signal regardless of the spindle speed (bit 2 of parameter No. 4394 =1), the one-rotation signal can be detected at less than 10 min^{-1}.
   However, the position at which to detect the one-rotation signal varies with a change in the temperature of the sensor. Usually, set 0,0,1,1. Refer to "FANUC SERVO AMPLIFIER αi series Descriptions" (B-65282EN) for information about the extent to which the position at which to detect the one-rotation signal varies.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3003	4003	4003	PCPL2	PCPL1	PCPL0	PCTYPE				

PCPL2, PCPL1, PCPL0, PCTYPE Gear teeth number setting of the spindle sensor

This parameter sets the number of teeth of a separate detector to be attached to the spindle (detector to be connected to connector JYA3 or JYA4).

PCPL2	PCPL1	PCPL0	PCTYPE	Gear teeth number of the spindle sensor
0	0	0	0	256λ/rev
0	0	0	1	128λ/rev
0	1	0	0	512λ/rev
0	1	0	1	64λ/rev
1	0	0	0	768λ/rev
1	0	0	1	1024λ/rev
1	1	0	0	384λ/rev

NOTE

1. Set "0, 0, 0, 0" when using an α*i* position coder (bits 3, 2, 1, 0 of No. 4002 = 0, 0, 1, 0) or an α position coder S (bits 3, 2, 1, 0 of No. 4002 = 0, 1, 0, 0).
2. When the motor sensor is used for position feedback (bits 3, 2, 1, 0 of No. 4002 = 0, 0, 0, 1), this parameter need not be set.
3. When the number of α*i* BZ sensor teeth is 96 λ/rev, 192 λ/rev, 640 λ/rev, 768 λ/rev, or 1024 λ/rev, set 0,0,0 in this parameter, and set the number of teeth in the parameter specifying an arbitrary number of spindle sensor teeth (parameter No. 4361).

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3004	4004	4004					RFTYPE	EXTRF		

EXTRF, RFTYPE External one-rotation signal setting

This parameter sets the type of an external one-rotation signal (proximity) switch to be attached to the spindle (to be connected to connector JYA3).

RFTYPE	EXTRF	External one-rotation signal (proximity switch)
0	0	None
0	1	Detects the leading edge.
1	1	Detects the trailing edge.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3006	4006	4006							GRUNIT	

GRUNIT Sets a gear ratio setting resolution:

0 : 1/100 unit

1 : 1/1000 unit

Select a gear ratio data setting resolution from the following:

(a) Resolution based on motor rotation increased by a factor of 100 relative to one spindle rotation

(b) Resolution based on motor rotation increased by a factor of 1000 relative to one spindle rotation

Depending on the setting of this parameter, the increment system of the parameters indicated in the table below changes.

Parameter No.			Description
15*i*	16*i*	30*i*	
3056 to 3059	4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data

NOTE

Usually, use the 1/100 unit (setting "0").

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3007	4007	4007		PCALCH	PCLS					

PCLS Determines feedback signal disconnection detection.

0 : Performs disconnection detection.

1 : Does not perform disconnection detection.

When this bit is set to "0", spindle alarms 27 (Position coder signal disconnection), 73 (Motor sensor disconnection), and 84 (Spindle sensor disconnection) are checked.

NOTE

1. Usually, set “0”.
2. When adjusting the waveform of a motor/spindle sensor feedback signal, set “1” temporarily to disable disconnection detection. **After completion of adjustment, be sure to return the setting to “0” to enable disconnection detection.**
3. If dual check safety function is enabled, this parameter is invalid and disconnection detection is performed.
4. Set it to "0" when using the αiCZ sensor (serial). Setting it to "1" results in a spindle state error (error 43).

PCALCH Determines whether to use alarms related to position feedback signals (on non-Cs contouring control mode).

0 : Detects alarms.
1 : Does not detect alarms.

When this bit is set to “0”, spindle alarms 41, 42, 47, 81, 82, 83, 85, 86, and 87 are checked.

NOTE

Set it to "0" when using the αiCZ sensor (serial). Setting it to "1" results in a spindle state error (error 43).

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3010	4010	4010						MSTYP2	MSTYP1	MSTYP0

MSTYP2, MSTYP1, MSTYP0 Motor sensor type

This parameter sets the type of a detector built into the motor (detector to be connected to JYA2 or JYA3).

MSTYP2	MSTYP1	MSTYP0	Motor sensor type
0	0	0	αiM sensor
0	0	1	αiMZ sensor, αiBZ sensor, αiCZ sensor (analog)
0	1	1	αiCZ sensor (serial)
1	1	1	αiMZ sensor, αiBZ sensor, αiCZ sensor (analog) [Setting for detecting the one-rotation signal at less than 10 min^{-1} (*3)]

NOTE

1 It is not possible to use the αiCZ sensor (serial) as both motor sensor and spindle sensor.

2 If the αiCZ sensor (serial) is used as the motor sensor, it is not possible to use the following:
- αi position coder
- External one-rotation signal (proximity switch)

3 When this setting is made in combination with the setting for detecting the one-rotation signal regardless of the spindle speed (bit 2 of parameter No. 4394 =1), the one-rotation signal can be detected at less than 10 min^{-1}.
However, the position at which to detect the one-rotation signal varies with a change in the temperature of the sensor. Usually, set 0,0,1. Refer to “FANUC SERVO AMPLIFIER αi series Descriptions” (B-65282EN) for information about the extent to which the position at which to detect the one-rotation signal varies.

15i	16i	30i	#7	#6	#5	#4	#3	#2	#1	#0
3011	4011	4011						VDT3	VDT2	VDT1

VDT1 to VDT3 Gear teeth number setting of the motor sensor

This parameter sets the number of teeth of a detector built into the motor (detector to be connected to JYA2 or JYA3).

VDT3	VDT2	VDT1	Gear teeth number of the motor sensor
0	0	0	64λ/rev
0	0	1	128λ/rev
0	1	0	256λ/rev
0	1	1	512λ/rev
1	0	0	192λ/rev
1	0	1	384λ/rev

NOTE

1 When using a sensor with αiCZ sensor (analog, serial) 768 λ/rev or 1024 λ/rev, set 0,0,0 in this parameter, and set 768 or 1024 in the parameter specifying an arbitrary number of motor sensor teeth (parameter No. 4334).

2 When the number of αi BZ sensor teeth is 96 λ/rev, 640 λ/rev, 768 λ/rev, or 1024 λ/rev, set 0,0,0 in this parameter, and set the number of teeth in the parameter specifying an arbitrary number of motor sensor teeth (parameter No. 4334).

Motor models and corresponding αiM and αiMZ sensors

Motor model	Number of gear teeth of the detection ring on the αiM or αiMZ sensor
αiI0.5	64λ/rev
αiI1 to αiI3	128λ/rev
αiI6 to αiI50 αiIP12 to αiIP60	256λ/rev

WARNING
If the gear tooth number setting of the motor sensor is not correct, the spindle motor may rotate at a high speed above the specified speed. Check the gear tooth number of the motor sensor and set it correctly.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3016	4016	4016	RFCHK3	RFCHK2	RFCHK1					

RFCHK1 Determines whether to detect alarms related to position feedback (in Cs contouring control mode).
0 : Does not detect alarms.
1 : Detects alarms.
When this bit is set to "1", Spindle alarms 81, 82, 85, and 86 are checked.

NOTE
Set it to "0" when using the αiCZ sensor (serial). Setting it to "1" results in a spindle state error (error 43).

RFCHK2 Determines whether to detect the alarm related to threading position detection signal feedback (spindle alarm 46).
0 : Does not detect alarms.
1 : Detects alarms.

NOTE
Set it to "0" when using the αiCZ sensor (serial). Setting it to "1" results in a spindle state error (error 43).

RFCHK3 Setting of the function of detecting the one-rotation signal again each time position control mode is set.
0 : The one-rotation signal is not detected each time the operating mode changes.
Once the one-rotation signal has been detected, it is not detected again until the power goes off.
1 : The one-rotation signal is detected each time the operating mode changes.

NOTE
If the αiCZ sensor (serial) is used, this parameter is invalid.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3394	4394	4394			A21DEN			ZPHDTC		

ZPHDTC Sets the detection lower limit of the one-rotation signal.
0 : The one-rotation signal is detected when the spindle speed is 10 min^{-1} or more.
1 : The one-rotation signal is detected regardless of the spindle speed.

NOTE

1. This parameter is valid with 9D50 series E (05) edition or later, 9D70 series A (01) edition or later, 9D80 series A (01) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
2. This parameter is enabled when the spindle sensor is an αi position coder or α position coder S.
3. When the spindle sensor is the αiMZ, αiBZ, or αiCZ sensor (analog), and if the sensor type (bits 2, 1, 0 of parameter No. 4010 = 1, 1, 1 for the motor sensor or bits 3, 2, 1, 0 of parameter No. 4002 = 1, 1, 1, 0 for the spindle sensor) is set in combination with this parameter, the one-rotation signal is detected regardless of the spindle speed.
4. When the spindle sensor is the αiCZ sensor (serial), the one-rotation signal is detected regardless of the setting of this parameter and the spindle speed.

A21DEN Whether to detect the spindle sensor polarity erroneous setting alarm (spindle alarm 21).

0 : The spindle sensor polarity erroneous setting alarm is detected.

1 : The spindle sensor polarity erroneous setting alarm is not detected.

When the spindle sensor polarity erroneous setting alarm is incorrectly detected due to the following reasons, set this bit to disable the alarm detection.

- When the spindle is mechanically separated from the motor.
- When the belt between the spindle and the motor slips.

NOTE

This parameter is valid with 9D50 series E (05) edition or later, 9D70 series A (01) edition or later, 9D80 series A (01) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.

15i	16i	30i		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)

Valid data range : 0 to 32767

Standard setting : 100

These data are used to set the gear ratio between spindle and spindle motor.

Example :

When the spindle rotates once, set "250" as the data when the motor rotates 2.5 times.

A parameter is selected with the CTH1A and CTH2A input signals.

Set the gear or clutch status to correspond to the clutch/gear signal (CTH1A, CTH2A).

> **NOTE**
> When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*	
3098	4098	4098	**Maximum speed for position feedback signal detection**

Unit of data : 1min^{-1} (Unit of 10 min^{-1} when bit 2 (SPDUNT) of parameter No. 4006 = 1)
Valid data range : 0 to 32767
Standard setting : 0

This parameter sets a maximum spindle speed that enables the detection of a motor/spindle sensor feedback signal.
When "0" is set in this parameter, up to the maximum motor speed can be detected.

> **NOTE**
> 1 Usually, set "0".
> 2 If the αiCZ sensor (serial) is used, this parameter is invalid.

15*i*	16*i*	30*i*	
3171	4171	4171	**Denominator of arbitrary gear ratio between motor sensor and spindle (HIGH) CTH1A=0**
3172	4172	4172	**Numerator of arbitrary gear ratio between motor sensor and spindle (HIGH) CTH1A=0**
3173	4173	4173	**Denominator of arbitrary gear ratio between motor sensor and spindle (LOW) CTH1A=1**
3174	4174	4174	**Numerator of arbitrary gear ratio between motor sensor and spindle (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 0

These parameters set conversion coefficients (numerator, denominator) for using the detection arbitrary gear ratio function (DMR function) by multiplying a motor sensor (αiM or αiMZ sensor) feedback signal by a gear ratio to produce a spindle position feedback signal.
When the spindle rotates Q times while the motor shaft rotates P times (there is no common divisor other than 1 for P and Q), settings are:

No. 4171 (No. 4173 when CTH1A = 1) = P
No. 4172 (No. 4174 when CTH1A = 1) = Q

When one of these parameters is set to "0", it is assumed to be "1".

> **NOTE**
> 1 When using the external one-rotation signal (proximity switch), use the detection arbitrary gear ratio function (DMR function) by setting an arbitrary gear ratio between the motor sensor and spindle in this parameter.
> 2 If the αi CZ sensor (serial) is used, this parameter is invalid.

15*i*	16*i*	30*i*	
3334	4334	4334	**Arbitrary number of motor sensor teeth**

Unit of data : 1λ/rev (Number of motor sensor teeth)
Valid data range : 0, 32 to 4096
Standard setting : 0

When the number of motor sensor teeth is other than 64, 128, 192, 256, 384, and 512, set this parameter.
When “0” is set in this parameter, the setting of bits 2, 1, 0 (VDT3, VDT2, VDT1) of parameter No. 4011 is valid.

> ⚠ **WARNING**
> If the gear tooth number setting of the motor sensor is not correct, the spindle motor may rotate at a high speed above the specified speed. Check the gear tooth number of the motor sensor and set it correctly.

15*i*	16*i*	30*i*	
3355	4355	4355	**Motor sensor signal amplitude ratio compensation**
3357	4357	4357	**Spindle sensor signal amplitude ratio compensation**

Unit of data : 1%
Valid data range : -8 to 8
Standard setting : 0

These parameters set an amplitude ratio compensation value for the sensor feedback signal (phase A/B of the sinusoidal wave).
For details, refer to Section 4.3, “AMPLITUDE RATIO/PHASE DIFFERENCE COMPENSATION FUNCTION” in Part I.

> **NOTE**
> If the αi CZ sensor (serial) is used, this parameter is invalid.

15*i*	16*i*	30*i*	
3356	4356	4356	**Motor sensor signal phase difference compensation**
3358	4358	4358	**Spindle sensor signal phase difference compensation**

Unit of data : 1%
Valid data range : -4 to 4
Standard setting : 0

These parameters set a phase difference compensation value for the sensor signal (phase A/B of the sinusoidal wave).
For details, refer to Section 4.3, “AMPLITUDE RATIO/PHASE DIFFERENCE COMPENSATION FUNCTION” in Part I.

> **NOTE**
> If the αi CZ sensor (serial) is used, this parameter is invalid.

15*i*	16*i*	30*i*	
3361	4361	4361	**Arbitrary number of spindle sensor teeth**

Unit of data : 1λ/rev (Number of spindle sensor teeth)
Valid data range : 0, 64 to 4096
Standard setting : 0

When the number of spindle sensor teeth is other than 64, 128, 256, 384, 512, and 1024 set this parameter.

When “0” is set in this parameter, the setting of bits 7, 6, 5, 4 (PCPL2, PCPL1, PCPL0, PCTYPE) of parameter No. 4003 is valid.

15*i*	16*i*	30*i*	
3500	4500	4500	**Denominator of arbitrary gear ratio between spindle sensor and spindle (HIGH) CTH1A=0**
3501	4501	4501	**Numerator of arbitrary gear ratio between spindle sensor and spindle (HIGH) CTH1A=0**
3502	4502	4502	**Denominator of arbitrary gear ratio between spindle sensor and spindle (LOW) CTH1A=1**
3503	4503	4503	**Numerator of arbitrary gear ratio between spindle sensor and spindle (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 0

These parameters set conversion coefficients (numerator, denominator) for using the detection arbitrary gear ratio function (DMR function) by multiplying a spindle sensor (αi position coder, α position coder S, separate αiBZ sensor, or separate αiCZ sensor (analog)) feedback signal by a gear ratio to produce a spindle position feedback signal.
When the spindle rotates Q times while the motor shaft rotates P times (there is no common divisor other than 1 for P and Q), settings are:

No. 4500 (No. 4502 when CTH1A = 1) = P
No. 4501 (No. 4503 when CTH1A = 1) = Q

When one of these parameters is set to “0”, it is assumed to be “1”.

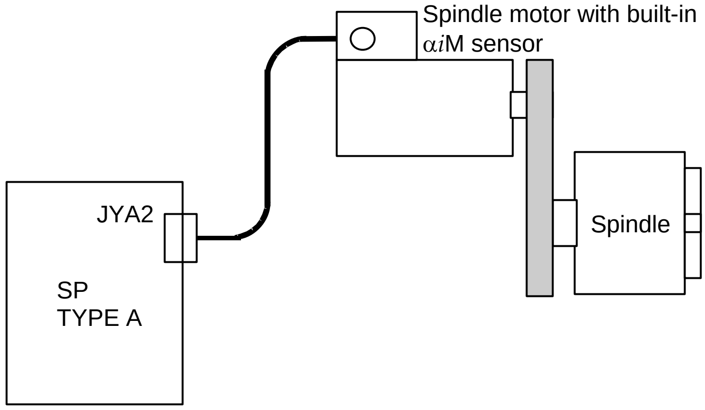
NOTE
1 This parameter is valid with 9D50 series F (06) edition or later, 9D70 series A (01) edition or later, 9D80 series A (01) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
2 When this parameter is used in a configuration having no external one-rotation signal (proximity switch), set the following parameters.
No.4007#6=1 : Alarms related to positional feedback signals (in non-Cs mode) are not detected.
No.4016#5=0 : Alarms related to positional feedback signals (in Cs mode) are not detected.
3 If the αi CZ sensor (serial) is used, this parameter is invalid.

1.3.3 Typical Detector Configurations

This subsection describes typical detector configurations and the parameter setting procedures for the detector configurations.
With the αi series spindle, the detector circuitry hardware is set according to the parameter setting. For this reason, an alarm such as a disconnection alarm may be output while parameters related to detectors are being set.
To initialize the hardware, after setting the parameters related to detectors, turn the power to the amplifier off once.

(1) When position control is not exercised

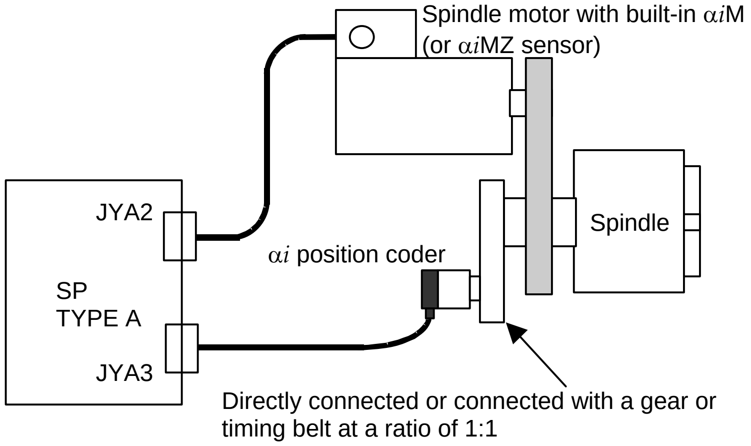
[Sample system configuration]



Parameter No.	Settings	Description
4002 #3,2,1,0	0,0,0,0	Does not exercise position control.
4010 #2,1,0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.

(2) When the αi position coder is used

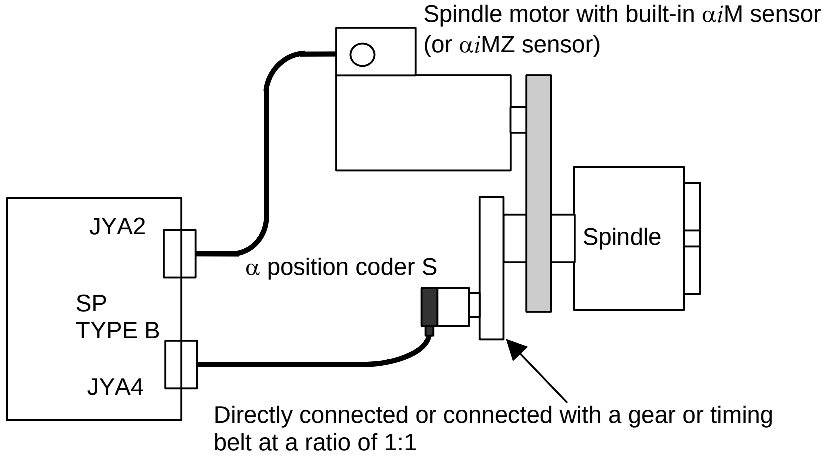
[Sample system configuration]



Parameter No.	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,2,1,0	0,0,1,0	Uses the αi position coder as the spindle sensor.
4003 #7,6,5,4	0,0,0,0	Sets the number of spindle sensor gear teeth.
4010 #2,1,0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056 to 4059	Depends on the configuration.	Gear ratio between the spindle and motor

(3) When the α position coder S is used

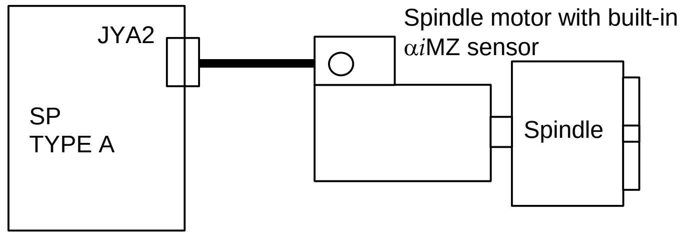
[Sample system configuration]



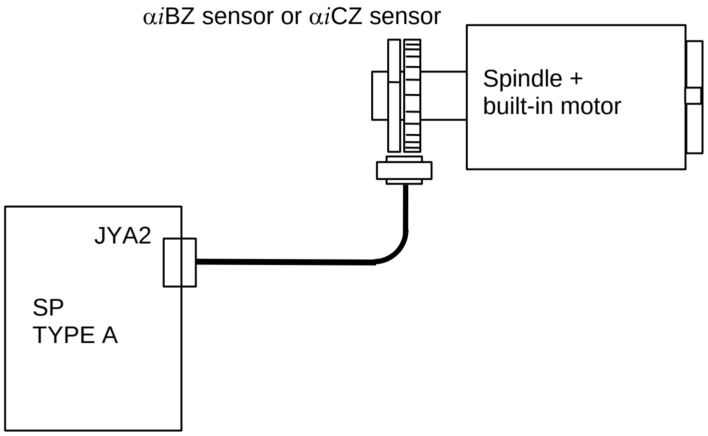
Parameter No.	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,2,1,0	0,1,0,0	Uses the α position coder S as the spindle sensor.
4003 #7,6,5,4	0,0,0,0	Sets the number of spindle sensor gear teeth.
4010 #2,1,0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056 to 4059	Depends on the configuration.	Gear ratio between the spindle and motor

(4) When the αiMZ, αiBZ, or αiCZ sensor (analog) is used

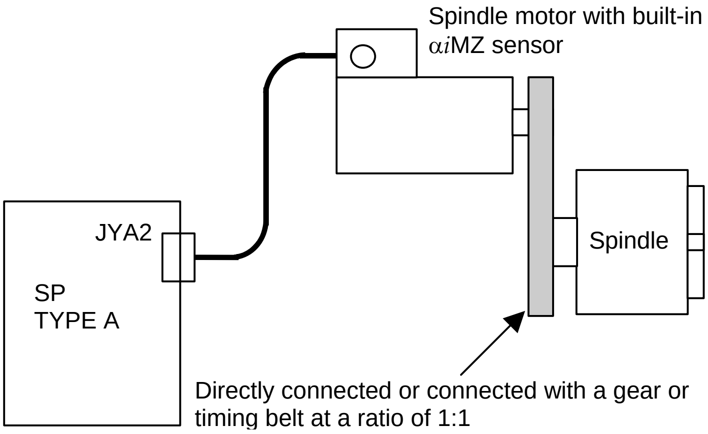
[Sample system configuration 1]



[Sample system configuration 2]



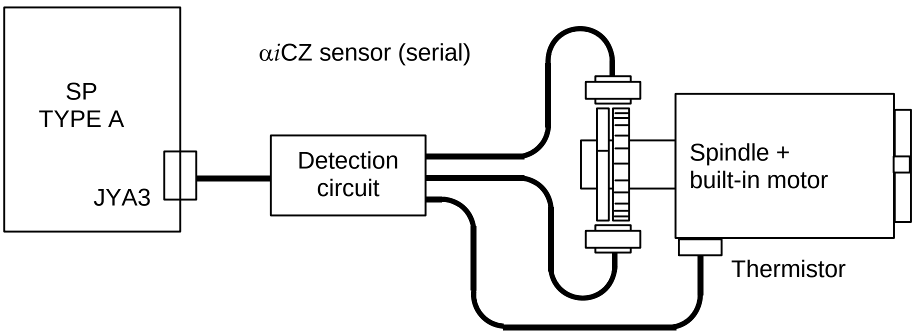
[Sample system configuration 3]



Parameter No.	Settings	Description
4000 #0	0	Rotation directions of the spindle and motor
4002 #3,2,1,0	0,0,0,1	Uses the motor sensor for position feedback.
4010 #2,1,0	0,0,1	Uses the αiMZ , αiBZ, or αiCZ sensor (analog) as the motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056 to 4059	100 or 1000	Gear ratio between the spindle and motor 1 : 1

(5) When the αiCZ sensor (serial) is used

[Sample system configuration]



Parameter No.	Settings	Description
4000 #0	0	Rotation directions of the spindle and motor
4002 #3,2,1,0	0,0,0,1	Uses the motor sensor for position feedback.
4007 #5	0	Feedback signal disconnection detection is enabled.
4007 #6	0	Alarms related to position feedback signals are enabled.
4010 #2,1,0	0,1,1	Uses the αiCZ sensor (serial) as the motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.(For 512λ/rev)
4016 #5	1	Alarms related to position feedback signals are enabled.
4016 #6	1	Alarms related to threading position feedback signals are enabled.
4056~4059	100 or 1000	Gear ratio between the spindle and motor 1 : 1
4334	Depends on the detector.	Sets the number of motor sensor gear teeth.(For 768λ/rev、1024λ/rev)

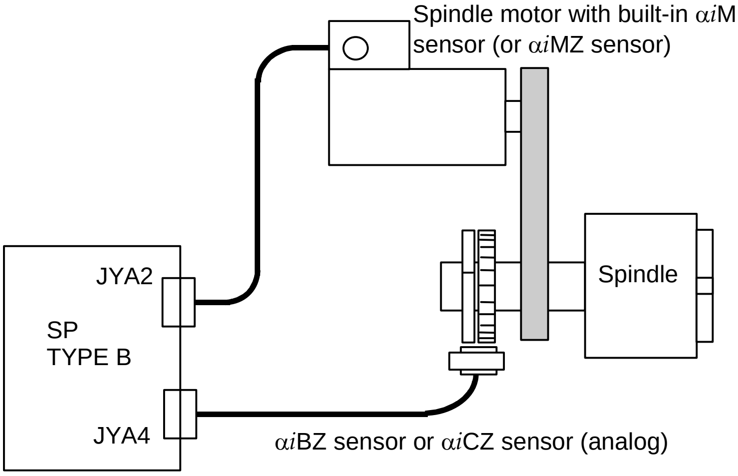
NOTE

When using the αiCZ sensor (serial), use spindle software of the following series and editions:

- 9D80 series E (05) edition or later, 9D90 series A (01) edition or later, or 9DA0 series A (01) edition or later when the number of teeth is 512 λ or 1024 λ
- 9D80 series F (06) edition or later, 9D90 series A (01) edition or later, or 9DA0 series A (01) edition or later when the number of teeth is 768 λ

(6) When the separate type αiBZ sensor or separate type αiCZ sensor (analog) is used

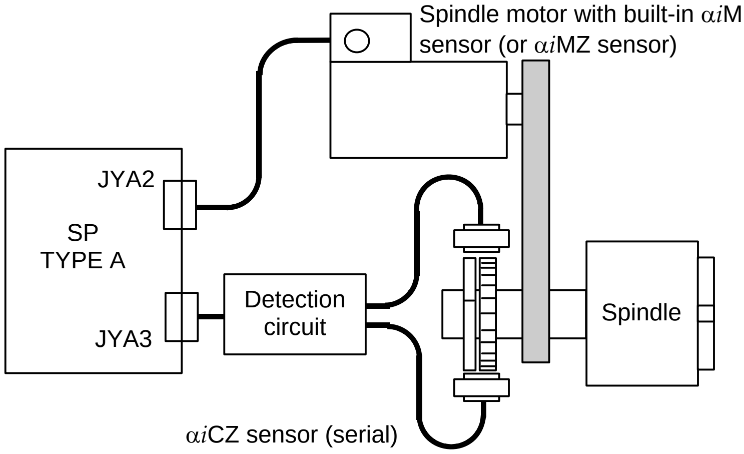
[Sample system configuration]



Parameter No.	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,2,1,0	0,0,1,1	Uses the αiBZ sensor or αiCZ sensor (analog) as the spindle sensor.
4003 #7,6,5,4	Depends on the detector.	Sets the number of spindle sensor gear teeth.
4010 #2,1,0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056 to 4059	Depends on the configuration.	Gear ratio between the spindle and motor

(7) When the separate type αiCZ sensor (serial) is used

[Sample system configuration]



Parameter No.	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,2,1,0	0,1,1,0	Uses the αiCZ sensor (sensor) as the spindle sensor.
4003 #7,6,5,4	Depends on the detector.	Sets the number of spindle sensor gear teeth.
4007 #5	0	Feedback signal disconnection detection is enabled.
4007 #6	0	Alarms related to position feedback signals are enabled.
4010 #2,1,0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4016 #5	1	Alarms related to position feedback signals are enabled.
4016 #6	1	Alarms related to threading position feedback signals are enabled.
4056~4059	Depends on the configuration.	Gear ratio between the spindle and motor

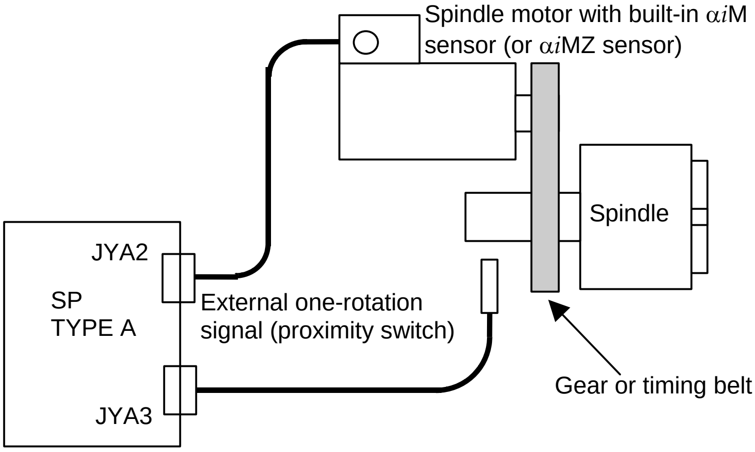
NOTE

When using the αiCZ sensor (serial), use spindle software of the following series and editions:

- 9D80 series E (05) edition or later, 9D90 series A (01) edition or later, or 9DA0 series A (01) edition or later when the number of teeth is 512 λ or 1024 λ
- 9D80 series F (06) edition or later, 9D90 series A (01) edition or later, or 9DA0 series A (01) edition or later when the number of teeth is 768 λ

(8) When the external one-rotation signal (proximity switch) is used

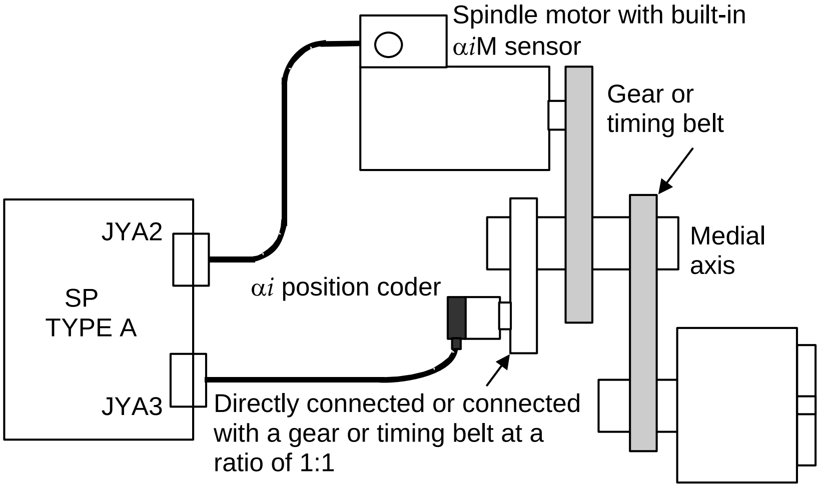
[Sample system configuration]



Parameter No.	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4002 #3,2,1,0	0,0,0,1	Uses the motor sensor for position feedback.
4004 #2	1	Uses the external one-rotation signal.
4004 #3	Depends on the detector.	Sets the external one-rotation signal type.
4010 #2,1,0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056 to 4059	Depends on the configuration.	Gear ratio between the spindle and motor
4171 to 4174	Depends on the configuration.	Arbitrary gear ratio between the motor sensor and spindle

(9) When the axis on which the spindle sensor is mounted is not the spindle

[Sample system configuration]



Parameter No.	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,2,1,0	Depends on the configuration.	Type of spindle sensor
4003 #7,6,5,4	Depends on the detector.	Sets the number of spindle sensor gear teeth.
4010 #2,1,0	0, 0, 0	Uses the αiM sensor as the motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.

Parameter No.	Settings	Description
4007 #6	1	Alarms related to positional feedback signals (in non-Cs mode) are not detected.
4016 #5	0	Alarms related to positional feedback signals (in Cs mode) are not detected.
4056 to 4059	Depends on the configuration.	Gear ratio between the spindle and motor
4500 to 4503	Depends on the configuration.	Arbitrary gear ratio between the spindle sensor and spindle

NOTE

Those functions such as the orientation function that require a one-rotation signal cannot be used.

2 EXPLANATION OF OPERATION MODES

2.1 VELOCITY CONTROL MODE

2.1.1 Start-up Procedure

A. Check that the serial spindle starts up normally and is ready for operation.

↓

B. Prepare and check the PMC ladder.

↓

C. Set the detector-related parameters according to the system configuration.

↓

D. Set the parameters related to spindle speed specification.

↓

E. Check that the spindle rotates at the desired speed.

↓

F. Make a velocity loop gain adjustment as required.
- No.4040, 4041 : Velocity loop proportional gain
- No.4048, 4049 : Velocity loop integral gain

2.1.2 Overview

The velocity control mode is a function for exercising velocity control to rotate the spindle motor according to a velocity command from the CNC.

> **NOTE**
> On a CNC screen (such as the spindle monitor screen and the adjustment screen), the velocity control mode is indicated as “NORMAL OPERATION MODE”.

2.1.3 System Configuration

The velocity control mode is applicable to all detector configurations. For system configurations, see Subsection 1.3.3, “TYPICAL DETECTOR CONFIGURATIONS”.

2.1.4 List of I/O Signals (CNC↔PMC)

This Subsection provides a list of the I/O signals related to the velocity control mode only. For details of each signal, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”

(b) For Series 30*i*/31*i*/32*i*

"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, "SPINDLE SPEED CONTROL."

(c) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."

(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."

(e) For Series 30*i*/31*i*/32 -B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.4, "SPINDLE SPEED CONTROL."

(f) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.6, "SPINDLE SPEED CONTROL."

For details of the I/O signals common to the CNCs, see Chapter 3, "I/O SIGNALS (CNC↔PMC)", in Part I.

(1) Input signals(PMC→CNC)

(a) Series 16*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(b) Series 30*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G005							FIN	
1st-	G024	RI7A	RI6A	RI5A	RI4A	RI3A	RI2A	RI1A	RI0A
2nd-	G232	RI7B	RI6B	RI5B	RI4B	RI3B	RI2B	RI1B	RI0B
1st-	G025	RISGNA			RI12A	RI11A	RI10A	RI9A	RI8A
2nd-	G233	RISGNB			RI12B	RI11B	RI10B	RI9B	RI8B
1st-	G026		GS4A	GS2A	GS1A				
2nd-	G272		GS4B	GS2B	GS1B				

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA		SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA
2nd-	G235	G074	G074	MRDYB		SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB
1st-	G226	G071	G071				SOCNA			*ESPA	
2nd-	G234	G075	G075				SOCNB			*ESPB	
1st-	G229	G072	G072				OVRA				
2nd-	G237	G076	G076				OVRB				

(2) Output signals (CNC→PMC)

(a) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O

NOTE
1 These signals are valid with the M series only.

(b) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O

NOTE
1 These signals are valid with the M series only.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F008							SF	
Common to all axes	F020	S7	S6	S5	S4	S3	S2	S1	S0
Common to all axes	F021	S15	S14	S13	S12	S11	S10	S09	S08
Common to all axes	F022	S23	S22	S21	S20	S19	S18	S17	S16
Common to all axes	F023	S31	S30	S29	S28	S27	S26	S25	S24
Common to all axes	F045			SRSRDY					
1st-	F010	RO7A	RO6A	RO5A	RO4A	RO3A	RO2A	RO1A	RO0A
2nd-	F320	RO7B	RO6B	RO5B	RO4B	RO3B	RO2B	RO1B	RO0B
1st-	F11	RO15A	RO14A	RO13A	RO12A	RO11A	RO11A	RO10A	RO9A
2nd-	F321	RO15B	RO14B	RO13B	RO12B	RO11B	RO11B	RO10B	RO9B
1st-	F014	MR7A	MR6A	MR5A	MR4A	MR3A	MR2A	MR1A	MR0A
2nd-	F324	MR7B	MR6B	MR5B	MR4B	MR3B	MR2B	MR1B	MR0B
1st-	F015	MR15A	MR14A	MR13A	MR12A	MR11A	MR10A	MR9A	MR8A
2nd-	F325	MR15B	MR14B	MR13B	MR12B	MR11B	MR10B	MR9B	MR8B
1st-	F234	SSPD7A	SSPD6A	SSPD5A	SSPD4A	SSPD3A	SSPD2A	SSPD1A	SSPD0A
2nd-	F250	SSPD7B	SSPD6B	SSPD5B	SSPD4B	SSPD3B	SSPD2B	SSPD1B	SSPD0B
1st-	F235	SSPD15A	SSPD14A	SSPD13A	SSPD12A	SSPD11A	SSPD10A	SSPD9A	SSPD8A
2nd-	F251	SSPD15B	SSPD14B	SSPD13B	SSPD12B	SSPD11B	SSPD10B	SSPD9B	SSPD8B
1st-	F341								SRRDYA
2nd-	F342								SRRDYB

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045		TLMA	LDT2A	LDT1A	SARA	SDTA	SSTA	
2nd-	F245	F049	F049		TLMB	LDT2B	LDT1B	SARB	SDTB	SSTB	

2.1.5 Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
—	3705#0	3705#0	Sets SF signal output and the S code for an S command.
—	3705#2	3705#2	Gear switch method (M series only)
—	3705#4	3705#4	Sets SF signal output and the S code for an S command (T series only).
—	3705#5	3705#5	Sets SF signal output when constant surface speed control is exercised and an S code is specified (M series only).
—	3705#6	3705#6	Sets SF signal output (M series only).
—	3706#4	3706#4	Spindle gear selection method (M series only)
—	3706#7,6	3706#7,6	Spindle speed command polarity (valid when input signal SSIN = 0)
—	3709#0	3709#0	Number of sampling operations at spindle speed calculation time (T series only for 16i)
—	3735	3735	Minimum clamp speed of the spindle motor (M series only)
—	3736	3736	Maximum clamp speed of the spindle motor (M series only)
—	3740	3740	Time until the spindle speed arrival signal is checked
—	3741	3741	Maximum spindle speed for gear 1
—	3742	3742	Maximum spindle speed for gear 2
—	3743	3743	Maximum spindle speed for gear 3
—	3744	3744	Maximum spindle speed for gear 4 (T series only)
—	3751	3751	Spindle motor speed at the switch point between gear 1 and gear 2 (M series only)
—	3752	3752	Spindle motor speed at the switch point between gear 2 and gear 3 (M series only)
—	3772	3772	Maximum allowable spindle speed
2031	3031	3031	Allowable number of S code characters
2003#1	—	—	Sets an S code polarity.
2204#0	—	—	Sets the display of an actual spindle speed.
2402#6	—	—	Sets the S code specified in a block containing G92.
5602#3	—	—	Whether to provide an indication for an alarm detected with the spindle amplifier. (Set “0” usually.)
5611	—	—	Number of sampling operations when an average spindle speed is to be found.
5612	—	—	Unit of spindle speed output with the DO signal
5807#0	—	—	Enables/disables the spindle alarms (SPxxxx) of all spindles. (Set “0” usually.)
5842	—	3720	Number of position coder pulses
5847	—	3721	Number of gear teeth on the position coder side on velocity control (for feed per revolution, threading, etc.)
5848	—	3722	Number of gear teeth on the spindle side on velocity control (for feed per revolution, threading, etc.)
5850	—	—	Spindle number to be selected at power-on/reset time
5820#4	—	—	Sets the method of spindle speed calculation.
3006#5	4006#5	4006#5	Sets an analog override range.
3009#4	4009#4	4009#4	Whether to output the load detection signals (LDT1, LDT2) during acceleration/deceleration
3009#6	4009#6	4009#6	Analog override type
3012#7	4012#7	4012#7	Sets the spindle HRV function. (Set “1”.)
5607#0	4019#7	4019#7	Automatic spindle parameter setting function

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3352#1	4352#1	4352#1	Sets the peak hold function for load meter output.
3020	4020	4020	Maximum motor speed
3022	4022	4022	Speed arrival detection level
3023	4023	4023	Speed detection level
3024	4024	4024	Speed zero detection level
3025	4025	4025	Torque limitation value
3026	4026	4026	Load detection level 1
3027	4027	4027	Load detection level 2
3028	4028	4028	Output limitation pattern
3029	4029	4029	Output limitation value
3030	4030	4030	Soft start/stop setting time
3040 3041	4040 4041	4040 4041	Velocity loop proportional gain on the velocity control mode (A parameter is selected by the PMC input signal CTH1A.)
3048 3049	4048 4049	4048 4049	Velocity loop integral gain on the velocity control mode (A parameter is selected by the PMC input signal CTH1A.)
3056 to 3059	4056 to 4059	4056 to 4059	Spindle and motor gear ratio data (A parameter is selected by the PMC input signals CTH1A and CTH2A.)
3081	4081	4081	Delay time until the motor power is turned off
3082	4082	4082	Acceleration/deceleration time
3083	4083	4083	Motor voltage on the velocity control mode
3136	4136	4136	Motor voltage on the velocity control mode (for low-speed characteristics)
3171 3173	4171 4173	4171 4173	Denominator of an arbitrary gear ratio between the motor sensor and spindle (A parameter is selected by the input signal CTH1A.)
3172 3174	4172 4174	4172 4174	Numerator of an arbitrary gear ratio between the motor sensor and spindle (A parameter is selected by the input signal CTH1A.)
3399#2	4399#2	4399#2	Specifies whether to enable the soft start/stop function when emergency stop operation is performed.
3508	4508	4508	Rate of change in acceleration at soft start/stop

NOTE

1 For the detector-related parameters, see Section 1.3, “PARAMETERS RELATED TO DETECTORS”, in Part I.

2 For velocity loop proportional/integral gain adjustment, see Section 4.1, “VELOCITY LOOP GAIN ADJUSTMENT”, in Part I.

2.1.6 Details of Related Parameters

This Subsection details the serial spindle parameters (in the four thousands for 16*i* , and in the four thousands for 30*i*, and in the three thousands for 15*i*) among the parameters related to the velocity control mode. For details of other parameters, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”

(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, “SPINDLE SPEED CONTROL.”

(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”

(d) For Series 0*i*

"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."

(e) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.4, "SPINDLE SPEED CONTROL."

(f) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.6, "SPINDLE SPEED CONTROL."

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3006	4006	4006			ALGOVR					

ALGOVR Sets a spindle analog override range.
0 : 0 to 100% (standard setting value)
1 : 0 to 120%

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3009	4009	4009		OVRTYP		LDTOUT				

LDTOUT Whether to output the load detection signals (LDT1 and LDT2) during acceleration/deceleration
0 : Not output during acceleration/deceleration. (standard setting value)
1 : Output (at all times) during acceleration/deceleration if the parameter-set level is exceeded.

OVRTYP Analog override type
0 : Override of linear function type (standard setting value)
1 : Override of quadratic function type

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3012	4012	4012	SPHRV							

SPHRV Sets the spindle HRV control function.
0 : Disables spindle HRV control.
1 : Enables spindle HRV control. (standard setting value)
Set to "1".

NOTE
The control method usable with the α*i* series spindle is spindle HRV control only. The conventional control method is not supported.

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4019	4019	PRLOAD							

PRLOAD Automatic parameter setting function
0 : Does not perform automatic parameter setting. (standard setting value)
1 : Performs automatic parameter setting.
After setting a desired motor model code in parameter No. 4133 and setting this bit to 1, turn off the power to the CNC, then turn on the power to the CNC again. The parameters (No. 4000 to No. 4175) for the α*i* series spindle corresponding to the model code are automatically initialized. Upon completion of automatic setting, this bit is automatically set to 0.

> **NOTE**
> With FS15*i*, the parameter address of this function is different, namely, bit 0 of No. 5607 is used. Moreover, note that the meanings of settings are reversed as follows.
> 0 : Performs automatic parameter setting.
> 1 : Does not perform automatic parameter setting.
> In this case, set a model code in parameter No. 3133.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3352	4352	4352							PKHALW	

PKHALW Sets the peak hold function for load meter output.
0 : Does not use the peak hold function. (standard setting value)
1 : Uses the peak hold function.

15*i*	16*i*	30*i*	
3020	4020	4020	**Maximum motor speed**

Unit of data : 1min^{-1} (Unit of 10 min^{-1} when bit 2 (SPDUNT) of parameter No. 4006 = 1)
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.
This parameter sets a maximum spindle motor speed.

> ⚠ **WARNING**
> The spindle motor may rotate at the maximum spindle motor speed specified by this parameter. Therefore, this parameter must not be set to a value greater than the maximum rotation speed indicated by the specification of the spindle motor.

15*i*	16*i*	30*i*	
3022	4022	4022	**Speed arrival detection level**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 150
This parameter sets a speed arrival signal (SARA) detection range.
When the motor speed reaches within ±(setting data/10)% of a specified speed, the speed arrival signal (SARA) is set to 1.

15*i*	16*i*	30*i*	
3023	4023	4023	**Speed detection level**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 30
This parameter sets a speed detection signal (SDTA) detection range.
When the motor speed is (setting data/10)% of a maximum speed or less, the speed detection signal (SDTA) is set to 1.

15*i*	16*i*	30*i*	
3024	4024	4024	**Speed zero detection level**

Unit of data : 0.01%

Valid data range : 0 to 10000
Standard setting value : 75

This parameter sets a speed zero detection signal (SSTA) detection range.
When the motor speed is (setting data/100)% of a maximum speed or less, the speed zero detection signal (SSTA) is set to 1.

15*i*	16*i*	30*i*	
3025	4025	4025	**Torque limitation value**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 50

This parameter sets a torque limitation value to be applied when the torque limitation command HIGH (TLMHA) or the torque limitation command LOW (TLMLA) is specified.
The data indicates limitation values when the maximum torque is 100%.

Torque limitation command LOW(TLMLA)	Torque limitation command HIGH(TLMHA)	Description
0	0	No torque limitation is imposed.
0	1	The torque is limited to the value set in this parameter.
1	0	The torque is limited to a half of the value set in this parameter.
1	1	

15*i*	16*i*	30*i*	
3026	4026	4026	**Load detection level 1**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 83

This parameter sets a load detection signal 1 (LDT1A) detection range.
When the output of the spindle motor is (setting data)% of the maximum output or more, load detection signal 1 (LDT1A) is set to 1.

15*i*	16*i*	30*i*	
3027	4027	4027	**Load detection level 2**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 95

This parameter sets a load detection signal 2 (LDT2A) detection range.
When the output of the spindle motor is (setting data)% of the maximum output or more, load detection signal 2 (LDT2A) is set to 1.

15*i*	16*i*	30*i*	
3028	4028	4028	**Output limitation pattern**

Unit of data :
Valid data range : 0 to 9
Standard setting value : 0

Select an appropriate pattern from the following:

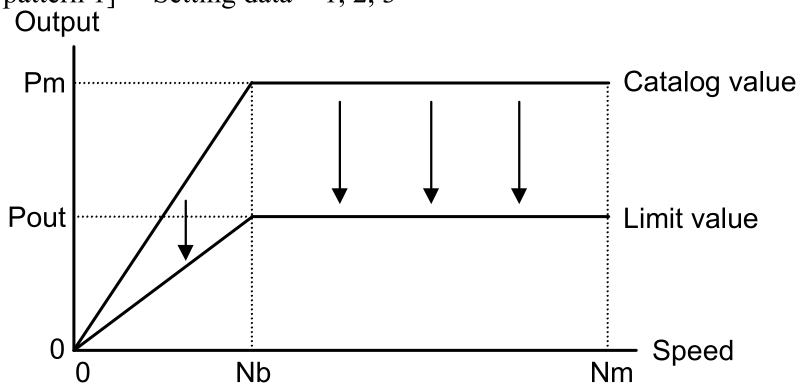
A : Output is limited only at acceleration time and deceleration time for gradual acceleration/deceleration, and the rated output is used for steady-state rotation. (Setting data: 1, 4, or 7)
(Function similar to soft start/stop)

B : Maximum output is used at acceleration time and deceleration time, and output is limited in steady-state rotation. (Setting data: 2, 5, or 8)

C : Using the same motor and amplifier, a machine with a different output specification is produced. (Setting data: 3, 6, or 9)

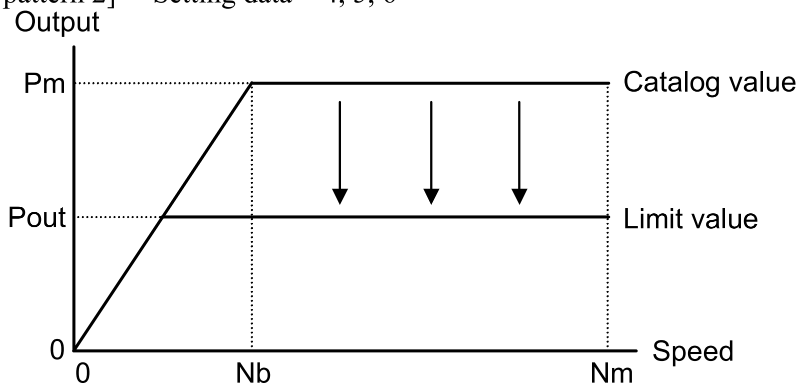
Description	Setting data		
	Pattern 1	**Pattern 2**	**Pattern 3**
No output limitation is imposed.	0	0	0
A. Output is limited only at acceleration time and deceleration time.	1	4	7
B. Output is not limited at acceleration time and deceleration time, but output is limited in steady-state rotation.	2	5	8
C. Output is limited in all operations.	3	6	9

[Output limitation pattern 1]--- Setting data = 1, 2, 3 ---



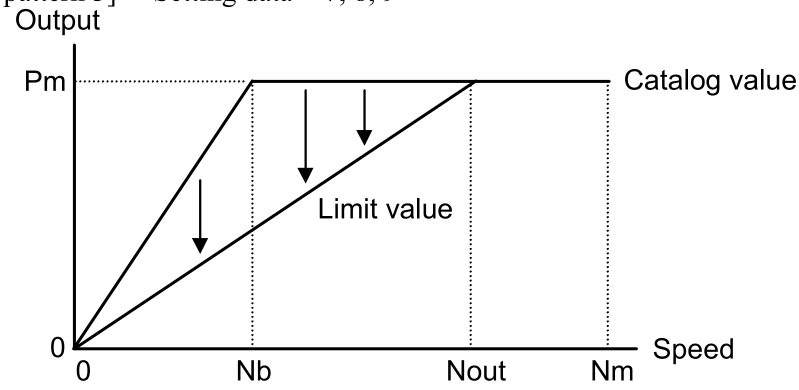
$$\text{Pout} = \frac{\text{Setting in parameter No. 4029}}{100} \times \text{Pm}$$

[Output limitation pattern 2]--- Setting data = 4, 5, 6 ---



$$\text{Pout} = \frac{\text{Setting in parameter No. 4029}}{100} \times \text{Pm}$$

[Output limitation pattern 3]--- Setting data = 7, 8, 9 ---



$$\text{Nout} = \frac{100}{\text{Setting in parameter No. 4029}} \times \text{Nb}$$

15*i*	16*i*	30*i*	
3029	4029	4029	**Output limitation value**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 100

This parameter sets a desired limitation value, with the maximum output (overload tolerance) being 100%.
This setting becomes valid when output is limited by setting parameter No. 4028.

15*i*	16*i*	30*i*	
3030	4030	4030	**Soft start/stop setting time**

Unit of data : 1min^{-1}/sec (Unit of 10min^{-1}/sec when bit 2 (SPDUNT) of parameter No. 4006 = 1)
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets an acceleration value (speed change rate) when the soft start/stop function is enabled (when the soft start/stop signal SOCNA = 1).

> **NOTE**
> When 0 is set, the soft start/stop function is disabled.

15*i*	16*i*	30*i*		
3040	4040	4040	**Velocity loop proportional gain on velocity control mode (HIGH)**	**CTH1A=0**
3041	4041	4041	**Velocity loop proportional gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This data is used to set the velocity loop proportional gain on velocity control mode.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3048	4048	4048	**Velocity loop integral gain on velocity control mode (HIGH)**	**CTH1A=0**
3049	4049	4049	**Velocity loop integral gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This data is used to set the velocity loop integral gain on velocity control mode.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These data are used to set the gear ratio between spindle and spindle motor.
Example :
When the spindle rotates once, set “250” as the data when the motor rotates 2.5 times.
A parameter is selected with the CTH1A and CTH2A input signals.
Set the gear or clutch status to correspond to the clutch/gear signal (CTH1A, CTH2A).

NOTE
When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*	
3081	4081	4081	**Delay time until the motor power is turned off**

Unit of data : 10ms
Valid data range : 0 to 1000
Standard setting value : 20 (200ms)

This parameter sets a period of time from the stop of the motor (detection of the speed zero detection signal SSTA set to 1) until the power to the motor is turned off if the SFR/SRV signal is off.

NOTE
When a small value is set in this parameter, the motor can coast after the power to the motor is turned off.

15*i*	16*i*	30*i*	
3082	4082	4082	**Setting of acceleration/deceleration time**

Unit of data : 1sec
Valid data range : 0 to 255
Standard setting value : 10

This parameter sets a period of time in which alarm detection is disabled by assuming that the spindle motor is being accelerated or decelerated even if the velocity error exceeds the velocity error excess alarm (spindle alarm 02) level after start of acceleration/deceleration on the velocity control mode.
In the velocity control mode, a step-by-step speed command is specified. So, the spindle motor cannot follow up the command immediately after start of acceleration/deceleration, and the velocity error exceeds the velocity error excess alarm level. This parameter is used to prevent the velocity error excess alarm (spindle alarm 02) from being detected incorrectly immediately after start of acceleration/deceleration.

NOTE
With a machine tool such as a lathe that has a large load inertia, the acceleration/deceleration time becomes longer. In such a case, set the value corresponding to the acceleration/deceleration time of the machine in this parameter.

15*i*	16*i*	30*i*	
3083	4083	4083	**Motor voltage setting on velocity control mode**
3136	4136	4136	**Motor voltage setting on velocity control mode (for low-speed characteristics)**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : Depends on the motor model.

This parameter sets the motor voltage under the no-load condition in velocity control mode.
The motor voltage to be set depends the motor model, the most usual setting is 30.
If an abrupt application of a heavy load in the no-load condition lowers the motor speed, adjust this parameter to around 50 to 70 to improve the torque response characteristic.
Note that, however, setting a large value causes heating and large activation sound during no-load motor operation.

15*i*	16*i*	30*i*	
3171	4171	4171	**Denominator of an arbitrary gear ratio between the motor sensor and spindle (HIGH) CTH1A=0**
3172	4172	4172	**Numerator of an arbitrary gear ratio between the motor sensor and spindle (HIGH) CTH1A=0**
3173	4173	4173	**Denominator of an arbitrary gear ratio between the motor sensor and spindle (LOW) CTH1A=1**
3174	4174	4174	**Numerator of an arbitrary gear ratio between the motor sensor and spindle (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

These parameters set conversion coefficients (numerator, denominator) for using the detection arbitrary gear ratio function (DMR function) by multiplying a motor sensor (αiM sensor) feedback signal by a gear ratio to produce a spindle position feedback signal.
When the spindle rotates Q times while the motor shaft rotates P times (there is no common divisor other than 1 for P and Q), the settings are:

No. 4171 (No. 4173 when CTH1A = 1) = P
No. 4172 (No. 4173 when CTH1A = 1) = Q

When 0 is set in any of these parameters, the setting of 1 is assumed.

NOTE

1 When performing feed per revolution with the detection arbitrary gear ratio function (DMR function), set an arbitrary gear ratio between the motor sensor and spindle in this parameter.
2 Threading using the detection arbitrary gear ratio function (DMR function) is not supported.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3399	4399	4399						SOSALW		

SOSALW When the motor rotation operation is quitted *),
0: the acc./dec. by soft start/stop is not executed. (Standard setting)
1: the acc./dec. by soft start/stop is executed.

When this bit is 1 and the acceleration setting for soft start/stop is valid (parameter No. 4030 ≠ 0 and SOCNA = 1), deceleration is performed at the acceleration for soft start/stop (parameter No. 4030) if the motor rotation operation is quitted by an emergency stop or the like.

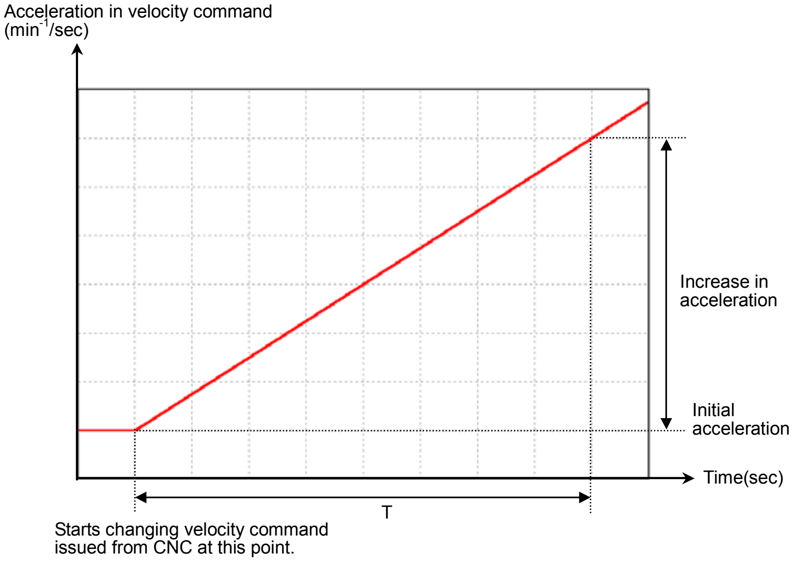
*) "Quitting the motor rotation operation" refers to any of the following operations:
- Input of emergency stop signal
- Input of external reset signal
- Input of reset and rewind signal
- In put of reset signal from MDI
- Release of axis selection signal

NOTE

1 This parameter is valid with 9D50 series O (15) edition or later, 9D70 series F (06) edition or later, 9D80 series A (01) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
2 Quitting a reference position return operation for Cs contouring control or rigid tapping is supported in 9D5A series J (10) edition or later, 9D53 series W (23) edition or later, 9D70 series X (24) edition or later, 9D80 series U (21) edition or later, 9D90 series F (06) edition or later, and 9DA0 series I (09) edition or later.

15*i*	16*i*	30*i*	
3508	4508	4508	**Rate of change in acceleration at soft start/stop**

Unit of data : $10\text{min}^{-1}/\text{sec}^2$
Valid data range : 0 to 32767
Standard setting : 0
This parameter sets the jerk (the rate of change in acceleration) when the soft start/stop function is enabled (soft start/stop signal SOCNA = 1).



Increase in acceleration = 10 × setting in parameter No. 4508 × T
Initial acceleration = Setting in parameter No. 4030

> **NOTE**
> 1 This parameter is valid with 9D50 series G (07) edition or later, 9D70 series A (01) edition or later, 9D80 series A (01) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
> 2 If 0 is set, a liner type velocity command is observed when the soft start/stop function is enabled.

2.1.7 Troubleshooting

If the spindle motor does not operate normally, take an action by referencing the items listed below according to the state of trouble.
For an action to be taken when an alarm is issued, refer to the maintenance manual.

	State of trouble
(i)	When the motor does not rotate
(ii)	When the motor does not rotate at a specified speed
(iii)	When the motor vibrates and makes an abnormal sound when rotating
(iv)	When an overshoot or hunting occurs
(v)	When the cutting capability is degraded
(vi)	When the acceleration/deceleration time is long

(i) When the motor does not rotate

(1) Check the connections. (Refer to Descriptions.)
  (a) Motor power line phase order
  (b) Feedback signal cable connection
  (c) DC link connection between the common power supply (PS) and spindle amplifier

(2) Check the parameter settings.
  (a) Parameter data for each motor model
  (b) Detector-related parameter data (Refer to Subsection 1.3.2, “Details of Parameters for Detectors”, in Part I)

(c) Setting of a maximum motor speed

15*i*	16*i*	30*i*	Description
3020	4020	4020	Maximum motor speed

(d) Parameters related to spindle speed specification
For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B
CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."
For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A
CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, "SPINDLE SPEED CONTROL."
For Series 15*i*
"FANUC Series 15*i*-MODEL B
CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."
For Series 0*i*
"FANUC Series 0*i*-MODEL C
CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."
For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B
CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.4, "SPINDLE SPEED CONTROL."
For Series 0*i*-D
"FANUC Series 0*i*-MODEL D
CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.6, "SPINDLE SPEED CONTROL."

(3) Check the input signals.
(a) Input signals for spindle control (PMC→CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA		SFRA	SRVA				
2nd-	G235	G074	G074	MRDYB		SFRB	SRVB				

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G226	G071	G071							*ESPA	
2nd-	G234	G075	G075							*ESPB	

(4) Check the feedback signal.
(a) Feedback signal level (Refer to Maintenance Manual.)
(b) Shielding and grounding (Refer to Descriptions.)

(ii) When the motor does not rotate at a specified speed

(1) Check the connections. (Refer to Descriptions.)
(a) Motor power line connection
(b) Feedback signal cable connection point

(2) Check the parameter settings.
(a) Parameter data for each motor model

(b) Detector-related parameter data (Refer to Subsection 1.3.2, "Details of Parameters for Detectors", in Part I)
(c) Setting of a maximum motor speed

15*i*	16*i*	30*i*	Description
3020	4020	4020	Maximum motor speed

(d) Parameters related to spindle speed specification
For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B
CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."
For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A
CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, "SPINDLE SPEED CONTROL."
For Series 15*i*
"FANUC Series 15*i*-MODEL B
CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."
For Series 0*i*
"FANUC Series 0*i*-MODEL C
CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."
For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B
CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.4, "SPINDLE SPEED CONTROL."
For Series 0*i*-D
"FANUC Series 0*i*-MODEL D
CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.6, "SPINDLE SPEED CONTROL."

(3) Check the feedback signal.
(a) Feedback signal level (Refer to Maintenance Manual.)
(b) Shielding and grounding (Refer to Descriptions.)

(iii) When the motor vibrates and makes an abnormal sound when rotating

(1) Check the feedback signal.
(a) Feedback signal level (Refer to Maintenance Manual.)
(b) Shielding and grounding (Refer to Descriptions.)

(2) Check the parameter settings.
The velocity loop gain may be too large. Adjust the following parameters:

15*i*	16*i*	30*i*	Description	Setting data
3040	4040	4040	Velocity loop proportional gain (HIGH)	Decrease the setting values.
3041	4041	4041	Velocity loop proportional gain (LOW)	
3048	4048	4048	Velocity loop integral gain (HIGH)	
3049	4049	4049	Velocity loop integral gain (LOW)	

(3) Make a comparison with the case of motor coasting.

If vibration and sound produced when the motor coasts are extremely smaller than those produced when the motor is driven, the control circuit is faulty. If sound produced remains unchanged, the motor or the machine may be faulty. If the feedback signal cable from the motor is disconnected during motor rotation, an alarm is issued, and the motor coasts. Before performing the coasting of the motor, consult with the machine tool builder for confirmation. Depending on the sequence, the brake may be applied.

(iv) When an overshoot or hunting occurs

(1) Check the parameter settings.
   (a) The velocity loop gain may be too large. Adjust the following parameters:

15*i*	16*i*	30*i*	Description	Setting data
3040	4040	4040	Velocity loop proportional gain (HIGH)	Decrease the setting values.
3041	4041	4041	Velocity loop proportional gain (LOW)	
3048	4048	4048	Velocity loop integral gain (HIGH)	
3049	4049	4049	Velocity loop integral gain (LOW)	

(v) When the cutting capability is degraded

(1) Check the parameter settings.
   (a) Parameter data for each motor model
   (b) Output limitation pattern and output limitation value

15*i*	16*i*	30*i*	Description
3028	4028	4028	Output limitation pattern
3029	4029	4029	Output limitation value

(2) Check the input signals.
   (a) Torque limitation commands (TLMH, TLML)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070							TLMHA	TLMLA
2nd-	G235	G074	G074							TLMHB	TLMLB

(3) Check the machine.
   (a) Belt tension, and so forth

(vi) When the acceleration/deceleration time is long

(1) Check the parameter settings.
   (a) Parameter data for each motor model
   (b) Output limitation pattern and output limitation value

15*i*	16*i*	30*i*	Description
3028	4028	4028	Output limitation pattern
3029	4029	4029	Output limitation value

   (c) Regenerative power limitation (Check if the same value as in the parameter table for each motor model is set.)

15*i*	16*i*	30*i*	Description
3080	4080	4080	Regenerative power limitation

15*i*	16*i*	30*i*	Description
3166	4166	4166	Regenerative power limitation (for low-speed characteristics)

(2) Check the input signals.
 (a) Torque limitation commands (TLMH, TLML)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070							TLMHA	TLMLA
2nd-	G235	G074	G074							TLMHB	TLMLB

2.2 POSITION CODER METHOD SPINDLE ORIENTATION (OPTIMUM ORIENTATION)(OPTIONAL FUNCTION)

2.2.1 Start-up Procedure

A. Check that operation in the velocity control mode is enabled.

B. Prepare and check the ladder program for spindle orientation.

C. Set the parameters related to spindle orientation or detector.

D. Check the position detect signal (position coder signal).

E. Check whether orientation is performed.

NG

OK

F. Set and check the direction used for orientation.
- Set the direction of rotation used for orientation.

G. Adjust the orientation stop position.
- Detection level for the orientation completion signal
- Orientation stop position shift
- Orientation stop position

H. Adjust the parameters according to the adjustment procedure.
- Velocity loop proportional and integral gains for orientation
- Position gain for orientation
- Spindle acceleration command and limit ratio for acceleration command
- Bell-shaped acceleration/deceleration time constant

I. Check ATC operation.

2.2.2 Overview

Unlike a function for stopping the spindle at a predetermined position mechanically, for example, by using a stopper, the spindle orientation function stops the spindle at a predetermined position by directly reading the position feedback signal from a position detector attached to the spindle of the machine.

Furthermore, by applying the optimum orientation function, the spindle acceleration command is automatically optimized. This is expected to reduce the positioning time required by conventional method orientation. It is, therefore, recommended to apply the optimum orientation function.

NOTE

1 To use this function, the CNC software option is required.

2 For an explanation of the changes that must be made to parameters to migrate from conventional method orientation to optimum orientation, see Subsection 2.2.3, "Migration from Conventional Method Orientation to Optimum Orientation", in Part I.

3 Optimum orientation function can be used with 9D50 series S (19) edition, 9D70 series I (09) edition, 9D80 series C (03) edition, 9D90 series A (01) edition, and 9DA0 series A (01) edition or later.

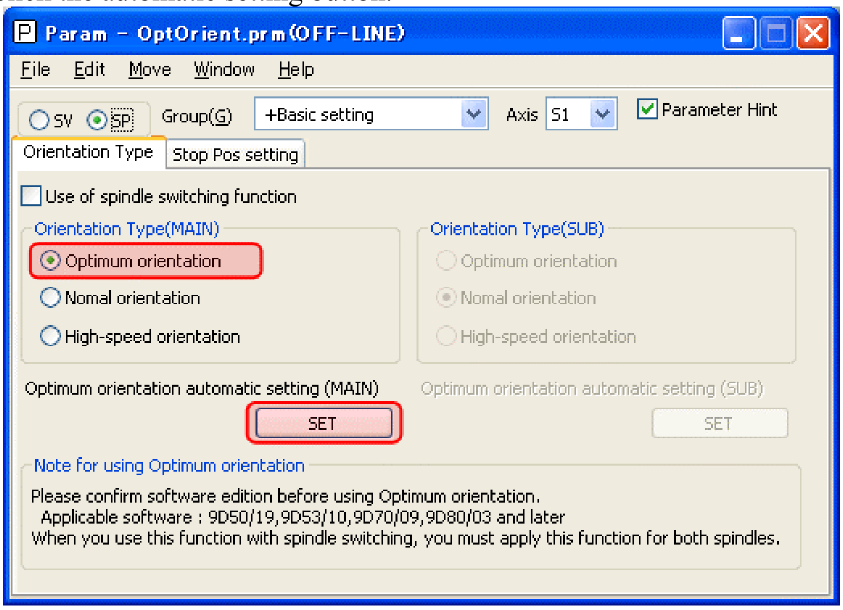
4 For an explanation of conventional method orientation, see Section 5.4, "CONVENTIONAL METHOD ORIENTATION", in Part I.

5 If using the output switching function together, do not change the motor winding during spindle orientation (input signal: ORCMA = 1).

6 If using the spindle switching function together, use this function on both MAIN and SUB sides.

2.2.3 Transition from Conventional Method Orientation to Optimum Orientation

Open the parameter window of the SERVO GUIDE, and select **"SP"-"Orientation"-"Basic setting"-"Orientation Type"**. For Orientation Type, select "Optimum orientation" and click the automatic setting button.



NOTE

1 Usually, this operation alone successfully performs the migration. If adjustment is necessary, see Subsection 2.2.13, "Tuning Procedure".
2 When the external one-rotation signal (proximity switch) is used, select **"SP"-"Orientation"-"Optimum orientation"** and set the one-rotation signal detection speed (50 to 100 min^{-1}) according to the sensor specifications.
3 If setting parameters from the "SYSTEM>parameter screen" of the CNC, see Subsection 2.2.13, "Tuning Procedure".
4 Optimum orientation parameter setting using the parameter window can be used with the SERVO GUIDE Ver5.00 or later.

2.2.4 Feature

(1) Elimination of a mechanical section used for stopping at a predetermined position
Only a position detector needs to be connected to the spindle. A mechanical section (such as a stopper and pin) used to mechanically stop the spindle at a predetermined position for spindle orientation is unnecessary.

(2) Reduction in orientation time
A spindle motor attached to the spindle is used. So, orientation is enabled directly at high speed, independently of gear shifting, thus resulting in a remarkable reduction in orientation time.
Furthermore, by applying the optimum orientation function, the spindle acceleration command is automatically optimized, which can reduce the positioning time required by conventional method orientation.

(3) Simplified power magnetic sequence
The required sequence consists of only a command for stopping at a predetermined position, completion signal, and clutch/gear signal. No other signals are required. Sequences for an orientation speed command and torque limitation command are unnecessary.

(4) Reliability
This function is based on a purely electric method. So, an external shock does not damage the mechanical section, thus improving reliability.

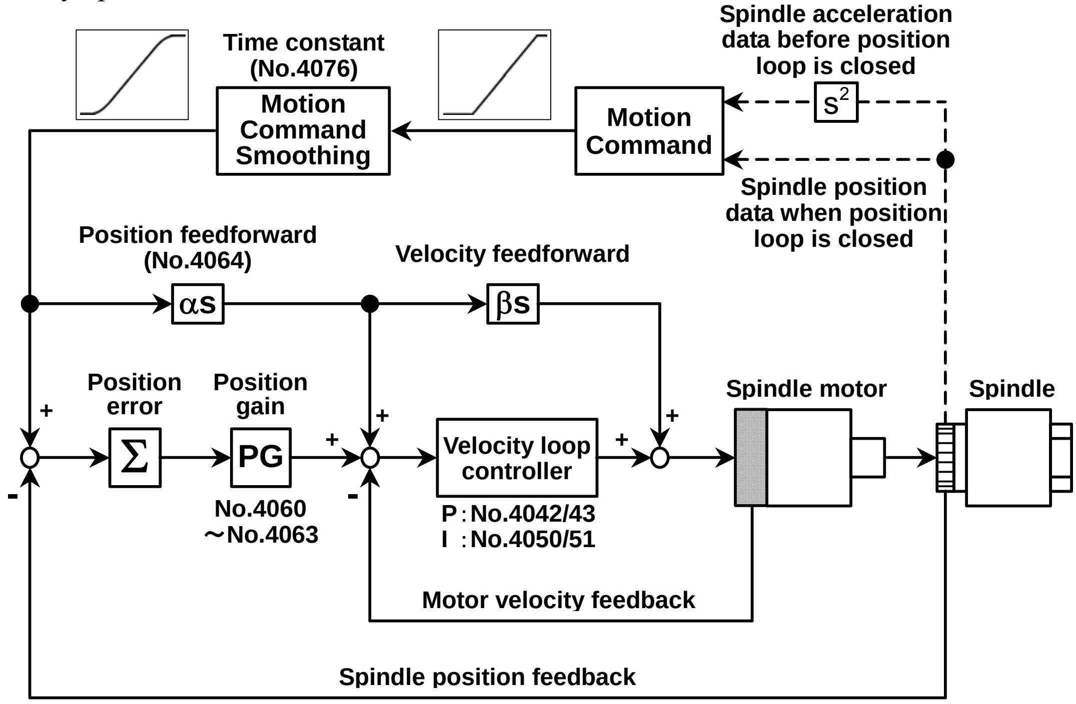
(5) High precision and high rigidity
The precision and rigidity of the spindle stopping at a predetermined position are sufficiently high for tool change operation (ATC).

(6) Workpiece positioning
On a lathe, a workpiece can be positioned to align the workpiece attachment/detachment direction.

(7) Reduction in the number of processes in boring
When a boring process ends, the workpiece can be positioned in the same direction as the direction of spindle rotation. So, the workpiece is not damaged by the tool tip.
Moreover, the tool tip can be attached or detached in a constant direction relative to the workpiece, so that a program can be created easily.

2.2.5 Block Diagram

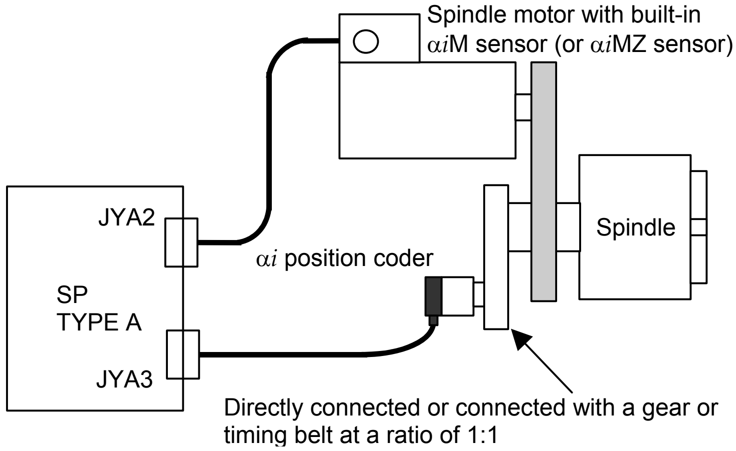
A block diagram of optimum orientation is shown below.
The spindle amplifier detects the spindle acceleration after spindle orientation is specified by the time position loop is closed. The spindle acceleration command (= the slope of motion command) is automatically optimized based on this detected value.



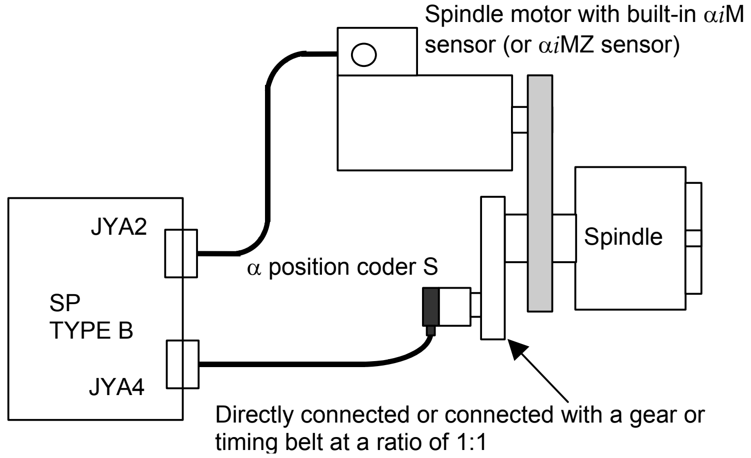
2.2.6 System Configuration

The system configurations that enable the use of the position coder method orientation (optimum orientation) function are shown below.

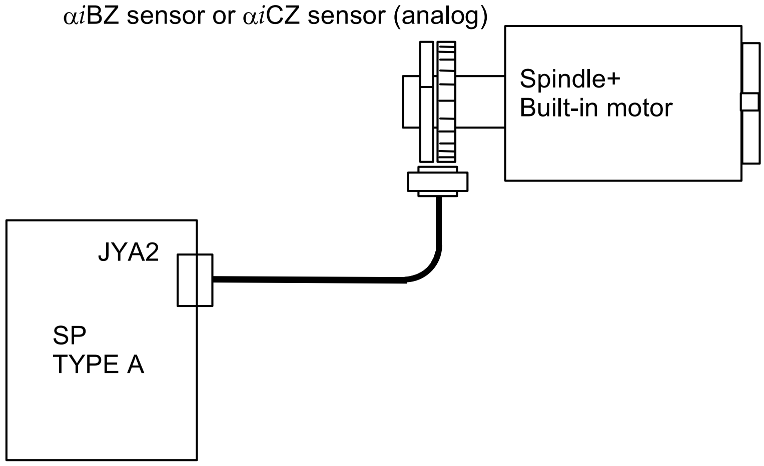
(1) When the αi position coder is used



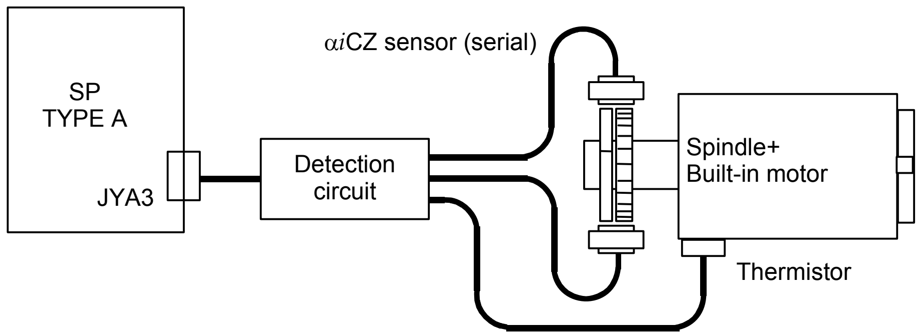
(2) When the α position coder S is used



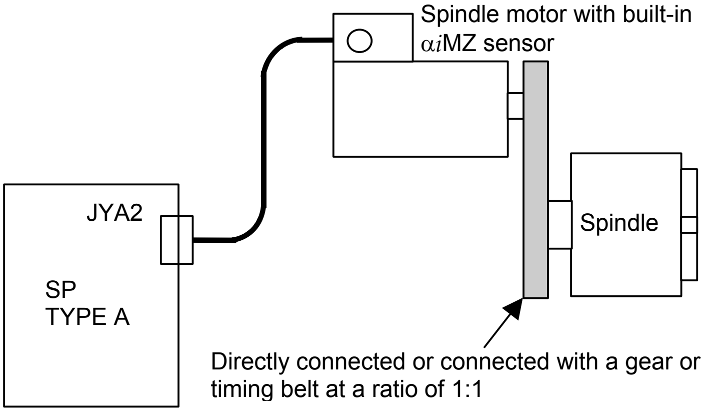
(3) When the built-in motor (αiBZ sensor, αiCZ sensor (analog)) is used



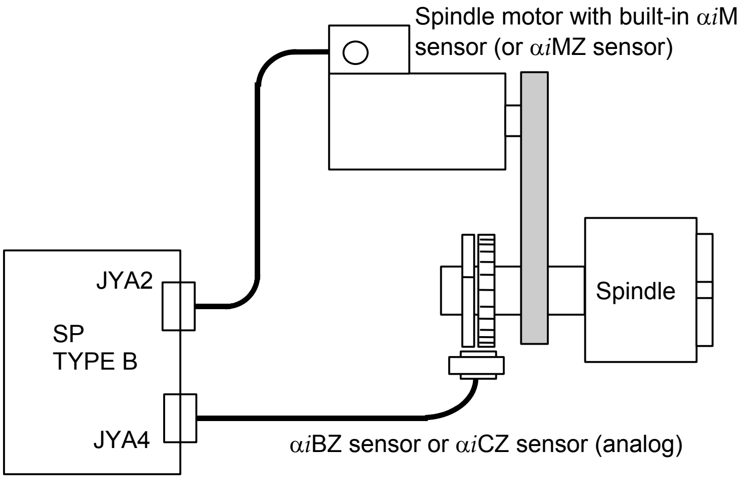
(4) When the built-in motor (αiCZ sensor (serial)) is used



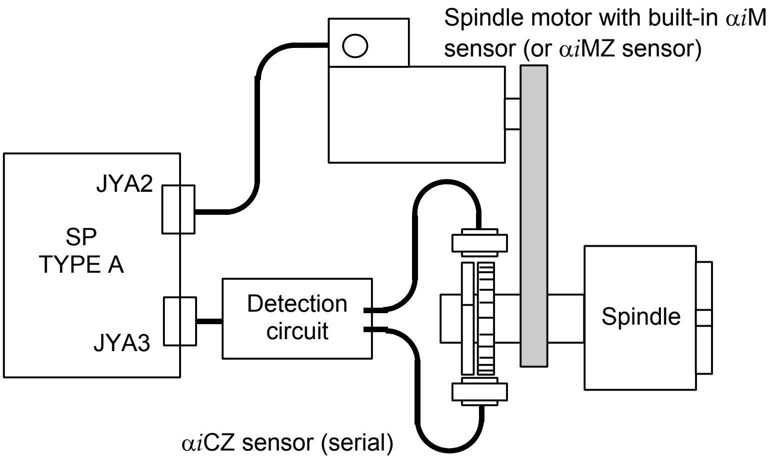
(5) When the spindle motor with built-in αiMZ sensor is used



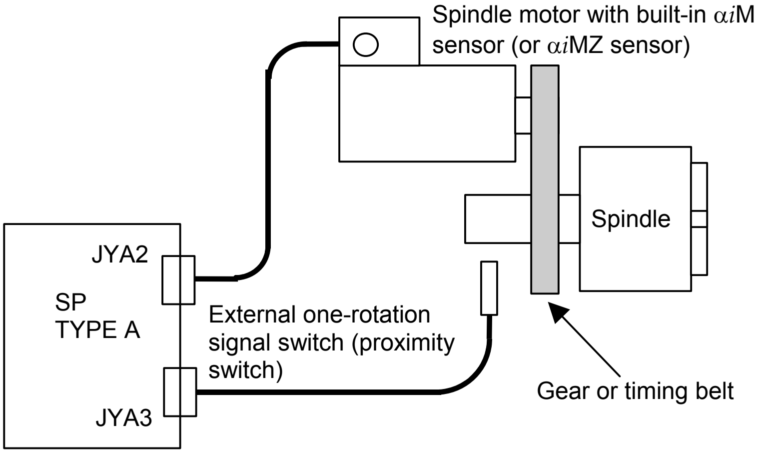
(6) When the separate type αiBZ sensor or the separate type αiCZ sensor (analog) is used



(7) When the separate type αiCZ sensor (serial) is used



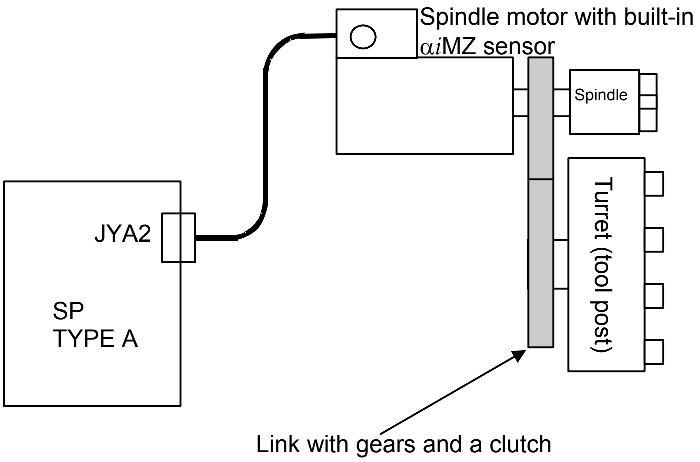
(8) When the external one-rotation signal (proximity switch) is used



NOTE

1. To detect the one-rotation signal securely, fix the direction (bits 3 and 2 of parameter No. 4003) in which the spindle rotates during spindle orientation to one direction.
2. Specify the type (bits 3 and 2 of parameter No. 4004) of an external one-rotation signal (proximity switch).
3. To detect the one-rotation signal securely, set the spindle orientation speed (parameter No. 4038) to a value between 50 and 100 min^{-1} according to the specification of the external one-rotation signal (proximity switch).
4. A sequence for detecting the one-rotation signal is started after the orientation speed has been reached.
5. Specify the denominator/numerator parameters (Nos. 4171 to 4174) of an arbitrary gear ratio between the motor sensor and spindle.

(9) System in which the turret and the motor with a built-in αiMZ sensor are linked with gears and a clutch (for turret indexing)



2.2.7 Stop Position Specification Method

Stop position specification method	Description
Parameter-based specification	Set the number of pulses (±4095 pulses) from the one-rotation signal to a stop position (360° = 4096 pulses).
External setting for stop position specification	Specify the number of pulses (0 to 4095 pulses) from the one-rotation signal to a stop position with a PMC signal (360° = 4096 pulses). The sum of the number of pulses set in the parameter and the number of pulses specified with a PMC signal represents a final stop position.

2.2.8 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st SP	G227	G070	G070		ORCMA			CTH1A	CTH2A		
2nd SP	G235	G074	G074		ORCMB			CTH1B	CTH2B		
1st SP	G229	G072	G072						NRROA	ROTAA	INDXA
2nd SP	G237	G076	G076						NRROB	ROTAB	INDXB
1st SP	G230	G078	G078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
2nd SP	G238	G080	G080	SHB07	SHB06	SHB05	SHB04	SHB03	SHB02	SHB01	SHB00
1st SP	G231	G079	G079					SHA11	SHA10	SHA09	SHA08
2nd SP	G239	G081	G081					SHB11	SHB10	SHB09	SHB08

(2) Details of input signals (PMC→CNC)

(a) Orientation command (ORCMA)

(i) This signal is used to stop the spindle at a predetermined position in order to change the tool or attach or detach a workpiece.

(ii) If this signal is set to 1, the spindle, when rotating, is immediately decelerated to stop at a predetermined position.

(iii) If an orientation command is issued for safety, set the forward/reverse spindle rotation command (SFRA/SRVA) and the speed command to 0. With these settings, the spindle does not start rotation even if ORCMA is set to 0 during tool change operation.

(iv) Set this signal to 0 with the tool change completion signal or the workpiece attachment/detachment completion signal.

(v) At power-on time, be sure to set the orientation command signal to 0.

(vi) If an alarm is issued or an emergency stop operation is performed during orientation, ensure that the orientation command signal is reset (to 0). At power-on time, return the ATC arm to a safe position so that the arm and associated equipment are not damaged when the spindle and tool rotate.

CAUTION

Do not change status of following signals during spindle orientation command is active (i.e. ORCMA=1)

CTH1A, CTH2A: Clutch / gear signals
RSLA: Output switching request signal

(b) Clutch/gear signals (CTH1A, CTH2A)

(i) These signals are used to select spindle control parameters (position gain, gear ratio, and velocity loop gain) when there are two or more gear change stages between the spindle and spindle motor.

(ii) Make settings as indicated in the table below according to the state of the clutch or gear. The names such as HIGH GEAR are given for convenience, and the correspondence to the actual gears is free.

CTH1A	CTH2A	
0	0	HIGH GEAR
0	1	MEDIUM HIGH GEAR
1	0	MEDIUM LOW GEAR
1	1	LOW GEAR

CAUTION

Do not change status of following signals during spindle orientation command is active (i.e. ORCMA=1)

CTH1A, CTH2A: Clutch / gear signals

(c) Spindle orientation stop position change command (INDXA)

(i) This signal is used to change to another orientation position after a spindle orientation operation is performed by stop position external setting type orientation.
This signal is valid when the spindle orientation command (ORCMA) = 1.

(ii) When this signal makes a transition from 1 to 0, the spindle is oriented to the position (arbitrary position in one rotation: absolute position command) specified by new stop position data (SHA11 to 00) within one rotation.

(iii) The direction of orientation rotation is specified by the shortcut command (NRROA) and the rotation direction command (ROTAA).

(iv) This function is valid when the CNC parameter for the stop position external setting type orientation function is set.

(d) Spindle orientation stop position change shortcut command (NRROA)

(i) This signal is used for shortcut (within ±180 degrees) positioning at the next stop position when a rotation direction is specified to change the orientation position after a spindle orientation operation.

(ii) When this signal is set to 1, shortcut positioning is performed, regardless of the spindle orientation stop position change rotation direction command (ROTAA).

(e) Spindle orientation stop position change rotation direction command (ROTAA)

(i) This signal is used to specify a rotation direction when the orientation position is successively changed to another orientation position after a spindle orientation operation.
When this signal is set to 0, the spindle rotates CCW and stops.
When this signal is set to 1, the spindle rotates CW and stops.

(ii) This signal is valid when the spindle orientation stop position change shortcut command (NRROA) is set to 0.

(f) Spindle orientation external stop position command (SHA11 to SHA00)

(i) With the stop position external setting type spindle orientation function, a stop position is set. A stop position is determined by the expression indicated below. This command specifies an absolute position during one rotation.

$$\text{Stop position (degrees)} = \frac{360}{4096} \times \sum_{i=0}^{11} (2^i \times Pi)$$

Pi = 0 when SHAi = 0. Pi = 1 when SHAi = 1.

(ii) When the stop position external setting type spindle orientation function is used, the position coder method spindle orientation stop position setting parameter (No. 4031) is invalid.

(3) Address list of output signals (CNC→PMC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st SP	**F229**	**F045**	**F045**	**ORARA**							
2nd SP	**F245**	**F049**	**F049**	**ORARB**							

(4) Details of output signals (CNC→PMC)

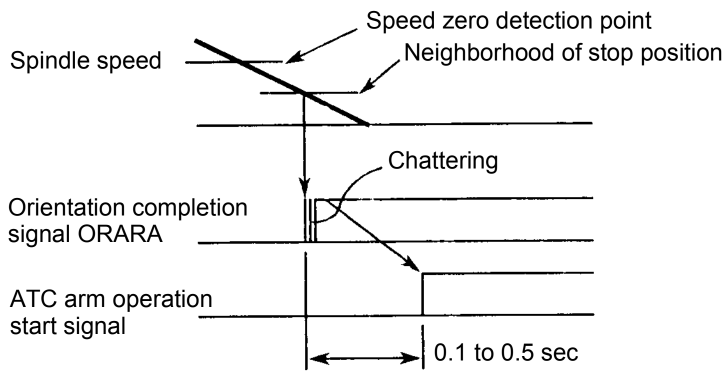
(a) Spindle orientation completion signal (ORARA)

(i) This signal is set to 1 when the spindle stops in the neighborhood of a predetermined position (±1°, for example) after an orientation command is input.
ORARA is set to 1 when the following three conditions are satisfied:
- ORCMA=“1”
- SSTA(speed zero detection signal)=“1”
- The spindle is in the neighborhood of a predetermined position.

The condition for the neighborhood of a predetermined position is set using parameter No. 4075 (orientation completion signal detection level). Only when all of the three conditions are satisfied, the orientation completion signal is output. Such a state that the orientation completion signal is not output when a certain time has elapsed after the input of an orientation command is abnormal. In this case, issue an orientation alarm by detecting this state with a power magnetic sequence.

(ii) When this signal is set to 1, start a tool change operation and workpiece attachment/detachment operation.

(iii) The orientation completion signal is output when the spindle is in the neighborhood of a predetermined position. This means that this signal does not represent a complete stop signal. With some machines, the operation time for the arm to grasp the tool of the spindle may be short. In this case, insert a time (0.1 to 0.5 second) before operating the arm for ATC so that the arm grasps the tool when the spindle has stopped completely.

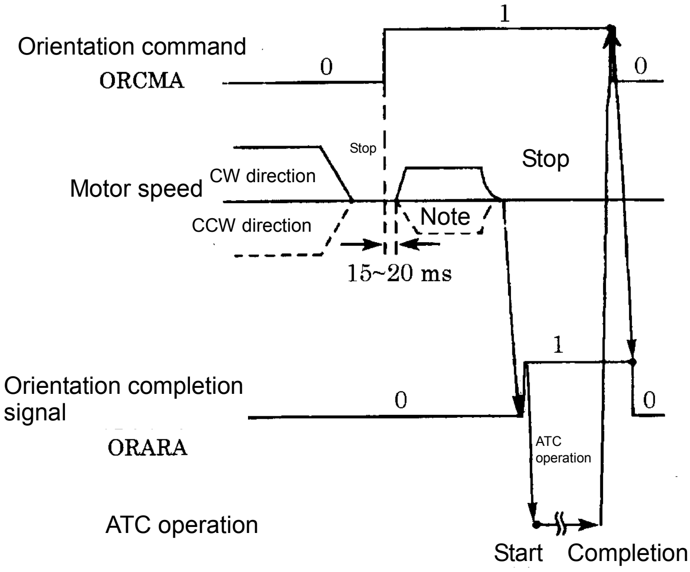


(iv) This signal is set to 0, for example, when the spindle is moved out of the neighborhood of a predetermined stop position as in a case where an external force is applied. In this case, use a sequence that stops tool change operation. However, do not cancel the orientation command, but execute a tool change operation after the orientation completion signal is set to 1 again.

(v) If the ATC of the machine has a structure that can cause a serious accident such as destruction due to a circuit failure, create a signal for indicating an automatic tool change enable area by using a proximity switch to make a double safety check with a power magnetic sequence before changing the tool.

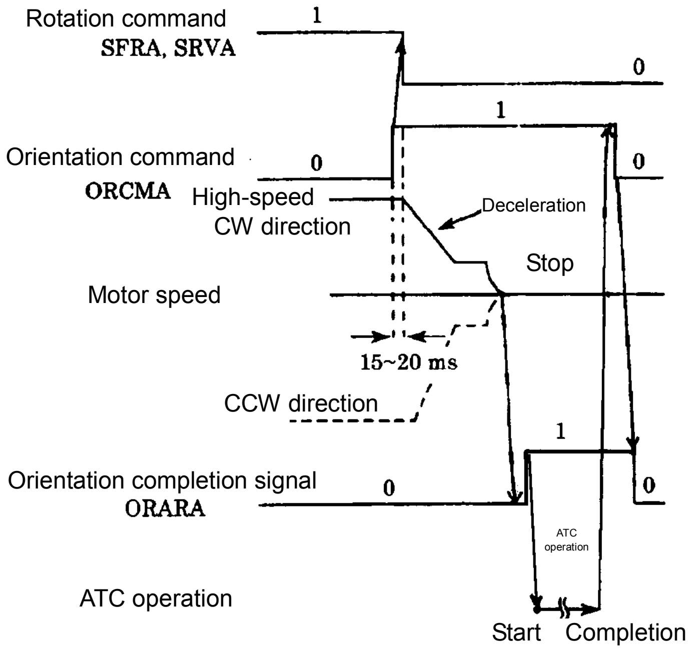
2.2.9 Examples of Sequences

Orientation command at stop time

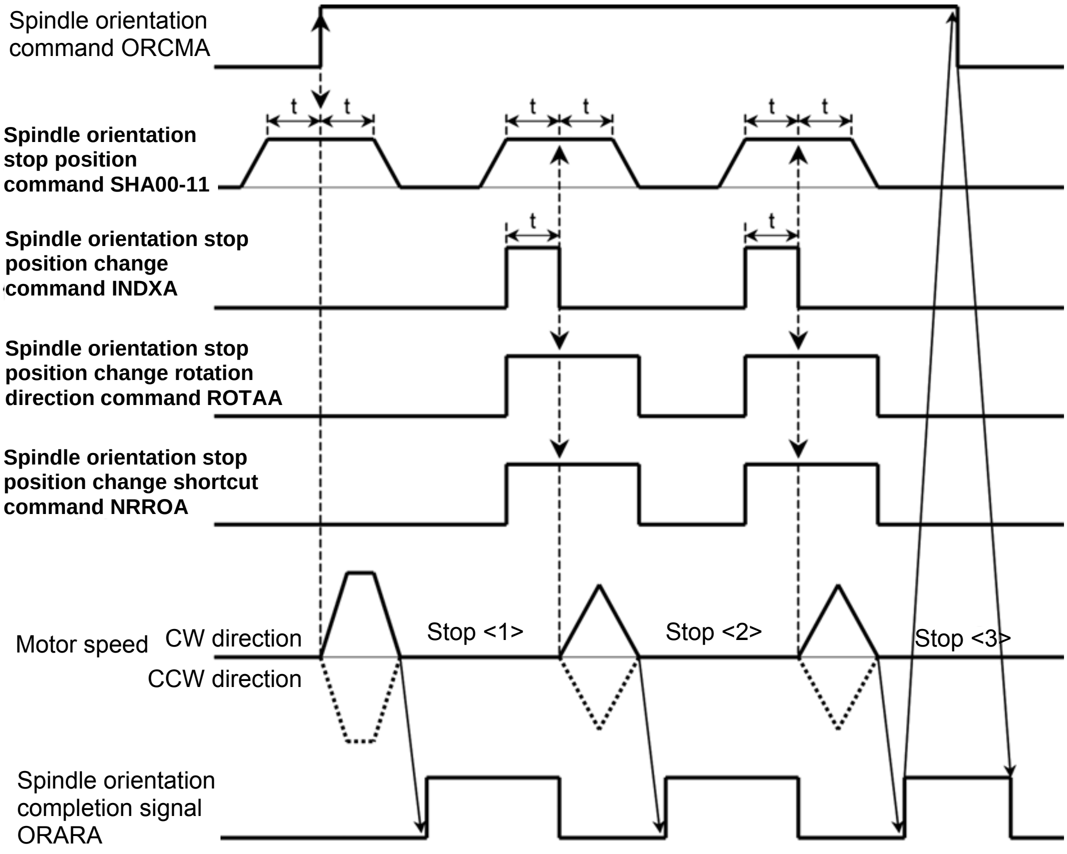


> **NOTE**
> The rotation direction of the spindle motor can be selected by parameter settings. By default, the spindle rotates in the direction specified before the orientation command signal is issued and then it stops at a predetermined position.

Orientation command during high-speed rotation



Stop position external setting type spindle orientation



Note) Set t = 50 msec or more.

Stop <1>

- Predetermined stop position based on the normal orientation command
- The rotation direction of the spindle motor is determined by parameter setting.
- After the power is turned on, the spindle rotates at the orientation speed and seizes the one-rotation signal before stopping at a predetermined position for the first time. After the first stop, the spindle stops at a predetermined position within one rotation.
- When the stop position external setting type spindle orientation function is used, the spindle stops at a predetermined position after shifting by the stop position data read on the rising edge of the spindle orientation command signal if the data of the spindle orientation stop position command SHA00-SHA11 is set after the first stop.

Stop <2>, <3>

- Predetermined stop positions based on the stop position external setting type spindle orientation function
- The rotation direction of the spindle motor depends on the spindle orientation stop position change rotation direction command (ROTAA) and the spindle orientation stop position change shortcut command (NRROA).

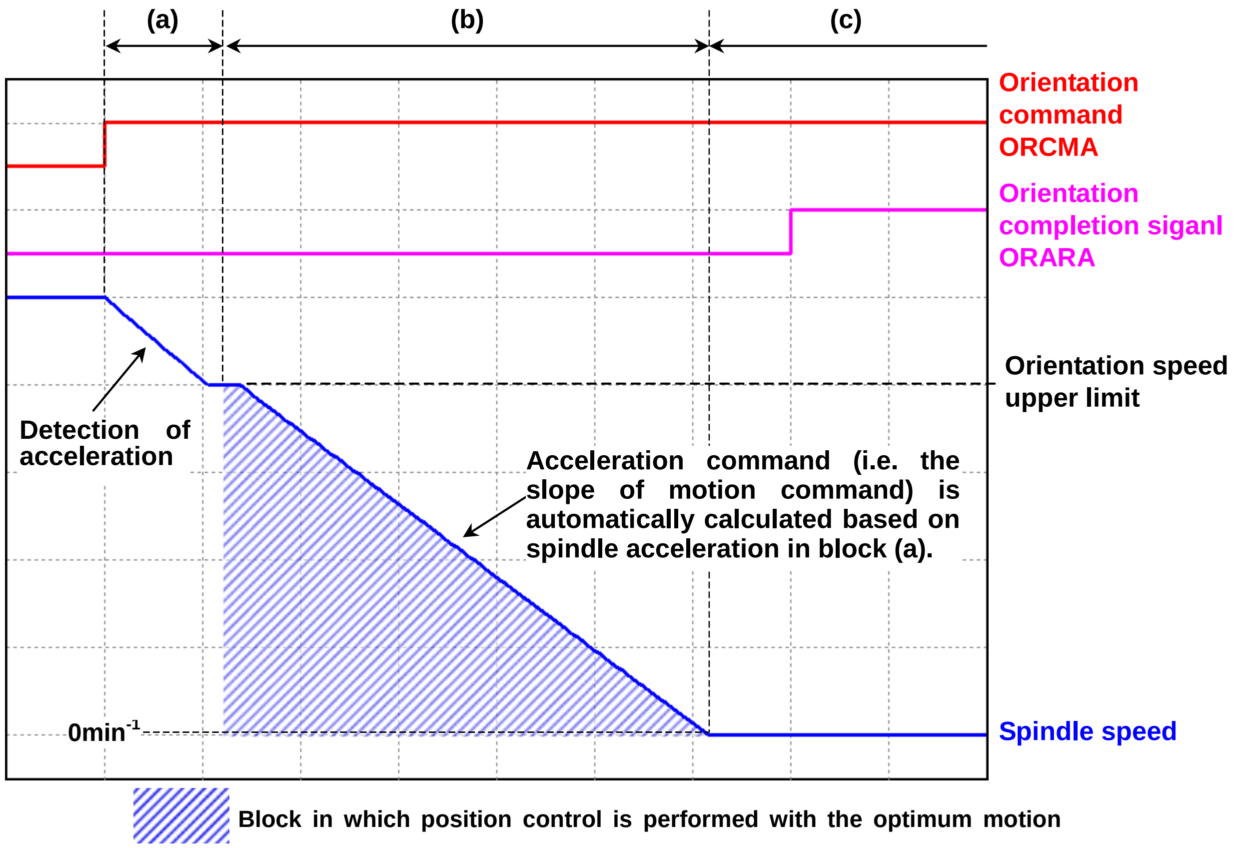
NOTE

The spindle orientation stop position change command INDXA is valid only when the spindle orientation command ORCMA is set to 1.

2.2.10 Explanation of Operation

This subsection describes the operation of optimum orientation.

(1) Starting spindle orientation when the spindle is rotating at or faster than the orientation speed upper limit

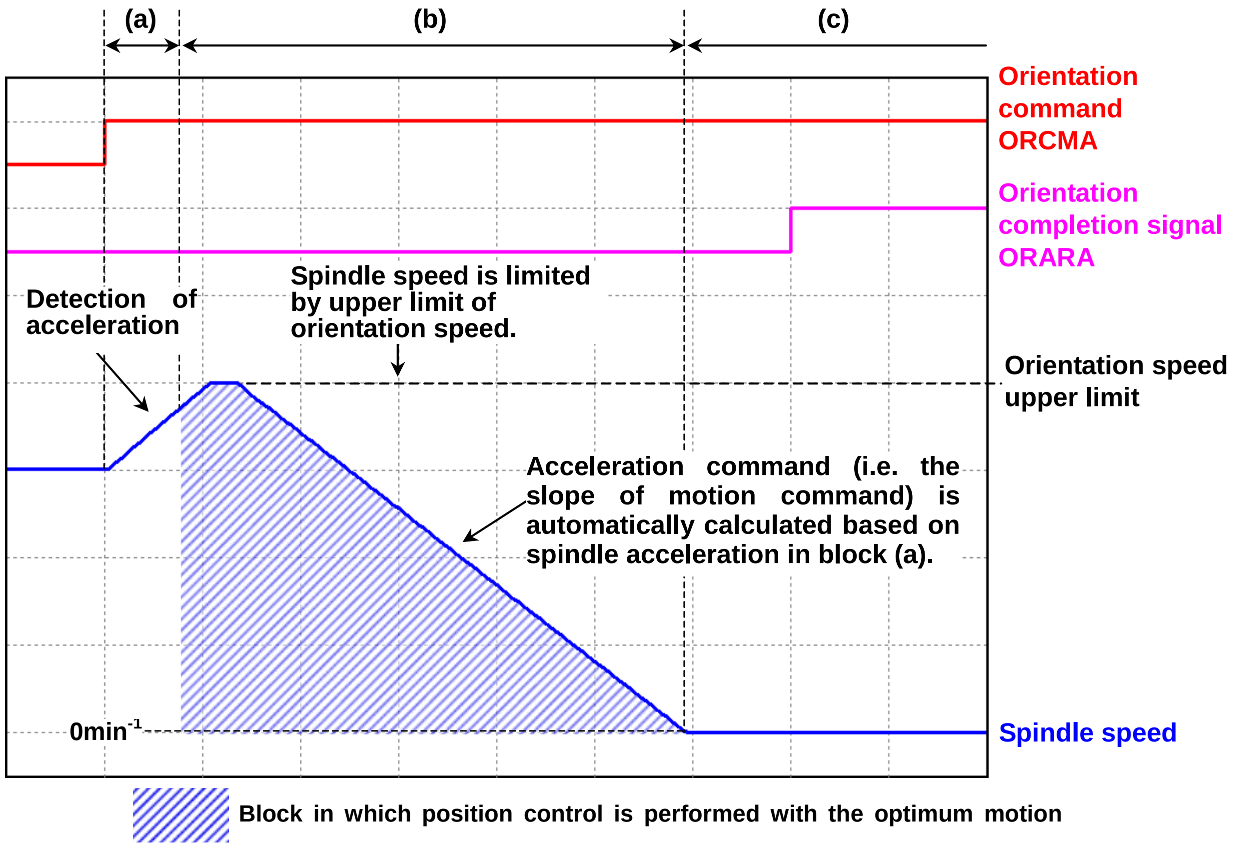


(a) Spindle amplifier decelerates spindle to the speed specified in parameter No. 4038 (upper limit of orientation speed) and detects spindle acceleration. The one-rotation signal is also detected in case of the first-time orientation after power-on.

(b) Optimum motion command based on spindle acceleration detected in block (a) is calculated and spindle position control is performed.

(c) Spindle orientation completion signal (ORARA) is output when motion command distribution is finished and position error become less than or equal to the number of pulses specified in parameter No. 4075 (orientation completion signal detection level).

(2) Starting spindle orientation when the spindle is rotating at or slower than the orientation speed upper limit

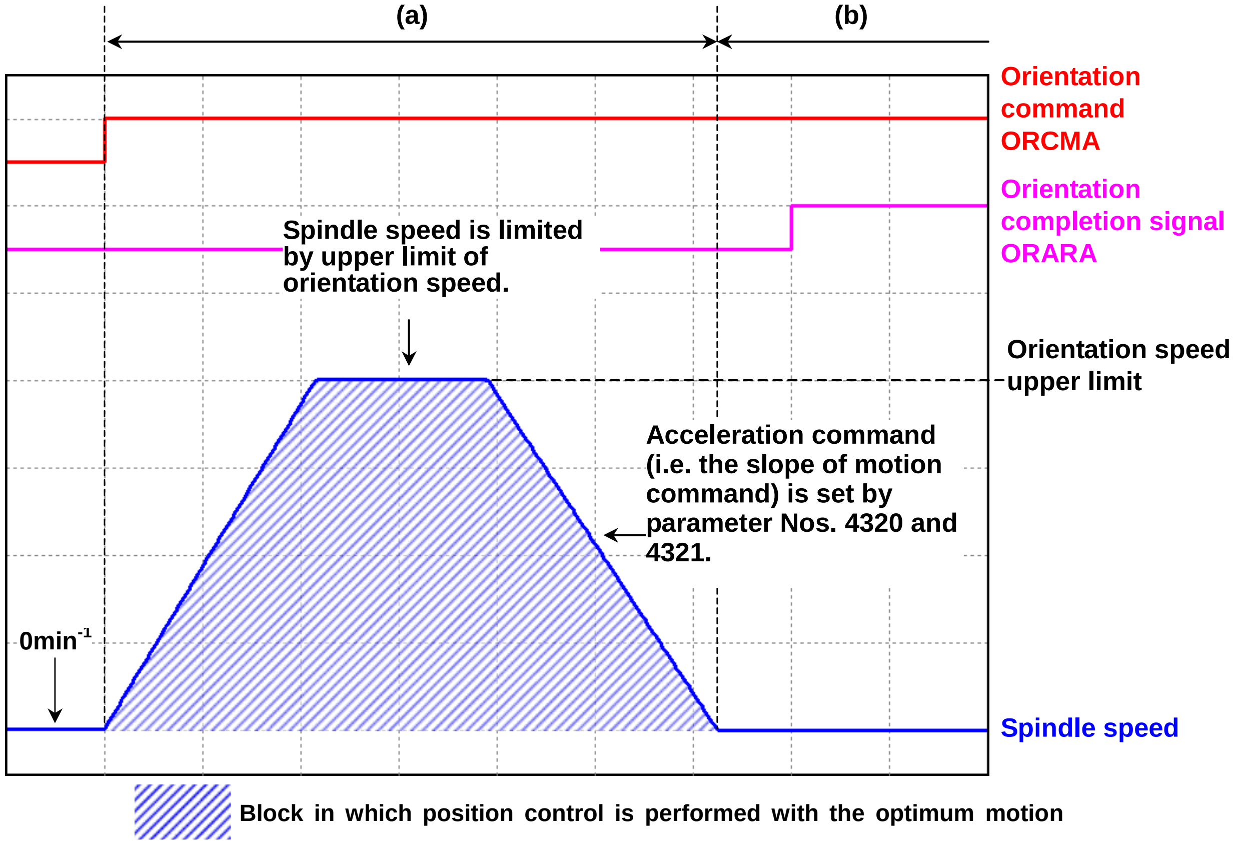


(a) Spindle amplifier accelerates spindle until the time specified in parameter No.4076 [high byte] (delay time for acceleration detection) passed and detects spindle acceleration. The one-rotation signal is also detected in case of the first-time orientation after power-on.

(b) Optimum motion command based on spindle acceleration detected in block (a) is calculated and spindle position control is performed.

(c) Spindle orientation completion signal (ORARA) is output when motion command distribution is finished and position error become less than or equal to the number of pulses specified in parameter No. 4075 (orientation completion signal detection level).

(3) Starting spindle orientation when the spindle is in the zero-speed state (Zero-speed detection signal SSTA = 1)



(a) Spindle amplifier calculates optimum motion command based on spindle acceleration command specified in parameters Nos. 4320 and 4321 and performs spindle position control. In case of the first-time after power-on, the same operation as that described in (2) is performed.

(b) Spindle orientation completion signal (ORARA) is output when motion command distribution is finished and position error become less than or equal to the number of pulses specified in parameter No. 4075 (orientation completion signal detection level).

2.2.11 Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
3015#0	4015#0	4015#0	Specifies whether to use the spindle orientation function. (Set this bit to 1.) (The CNC software option is required.)
5609#2	3702#3,#2	3729#0	Specifies whether to use the spindle orientation function with the stop position external setting type. (For 16i, #2: First spindle, #3: Second spindle)
3003#0	4003#0	4003#0	Choice of orientation method (To be set to 0 for the position coder method)
3003#3,#2	4003#3,#2	4003#3,#2	Direction of rotation in spindle orientation
3017#7	4017#7	4017#7	Shortcut function when orientation is specified in stop state
3018#6 #3	4018#6 #3	4018#6 #3	Type of position coder method orientation (Bits 6 and 3 to be set to 0 and1)
3018#5 #4	4018#5 #4	4018#5 #4	Optimum orientation: Setting of velocity feedforward (These bits are selected by the input signal CTH1A)
3031	4031	4031	Stop position for position coder method orientation (This parameter is disabled when spindle orientation with an externally set stop position or an externally set incremental command is used.)

Parameter No.			Description
15*i*	16*i*	30*i*	
3038	4038	4038	Optimum orientation: Orientation speed upper limit
3042 3043	4042 4043	4042 4043	Velocity loop proportional gain for orientation (A parameter is selected by the CTH1A input signal.)
3050 3051	4050 4051	4050 4051	Velocity loop integral gain for orientation (A parameter is selected by the CTH1A input signal.)
3056 to 3059	4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio (A parameter is selected by the CTH1A and CTH2A input signals.)
3060 to 3063	4060 to 4063	4060 to 4063	Position gain for orientation (A parameter is selected by the CTH1A and CTH2A input signals.)
3064	4064	4064	Rate of change in the position gain upon completion of spindle orientation
3075	4075	4075	Detection level for the spindle orientation completion signal
3076	4076	4076	Speed limit ratio for spindle orientation
3077	4077	4077	Spindle orientation stop position shift
3084	4084	4084	Motor voltage for spindle orientation
3320 3321	4320 4321	4320 4321	Optimum orientation: Spindle acceleration command (These parameters are selected by the input signal CTH1A)
3324	4324	4324	Optimum orientation: One-rotation signal detection speed
3326 3327	4326 4327	4326 4327	Optimum orientation: Limit ratio for acceleration command / Optimum orientation: Time constant for overshoot compensation (These parameters are selected by the input signal CTH1A)
3328	4328	4328	Command multiplier for orientation
3370	4370	4370	Filter time constant for spindle acceleration detection
—	—	4590 4591	Orientation speed limit ratio 1/orientation speed limit ratio 2
—	—	4607	Motor voltage after completion of optimum orientation

NOTE

1 For the parameters related to detectors, see the Section 1.3, “PARAMETERS RELATED TO DETECTORS” in the Part I.

2 For velocity loop proportional/integral gain adjustment, see Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT", in Part I.

3 When using the external one-rotation signal (proximity switch), fix the orientation-time rotation direction (bits 3 and 2 of No. 4003) at one direction.

4 When using the external one-rotation signal (proximity switch), set the type of the external one-rotation signal (bits 3 and 2 of No. 4004).

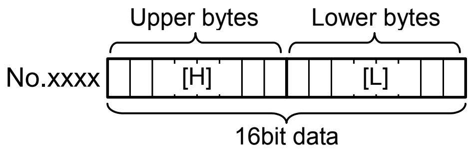
5 When using the external one-rotation signal (proximity switch), set an orientation speed from 50 to 100 min^{-1} (No. 4038) according to the specification of the used external one-rotation signal.

6 When using the external one-rotation signal (proximity switch), set the numerator/denominator of an arbitrary gear ratio between the motor sensor and spindle (No. 4171 to No. 4174).

2.2.12 Details of Related Parameters

NOTE

The "[H]" and "[L]" suffixes of parameter No. express the upper bytes and lower bytes of parameter No. xxxx. (See illustration below.)



Example:
When No. 4076[L] : Bell shaped acc./dec time constant = 100
No. 4076[H] : Delay time for acceleration detection = 25
the setting value of parameter No. 4076 is as follows:
No.4076 = 25 × 256+100 = 6500

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3015	4015	4015								ORIENT

ORIENT: Whether to use the spindle orientation function (The CNC software option is required.)
0: Does not use the spindle orientation function.
1: Use the spindle orientation function.
Set 1.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3003	4003	4003					DIRCT2	DIRCT1		PCMGSL

DIRCT2, DIRCT1 Setting of rotation direction at spindle orientation

DIRCT2	DIRCT1	Rotation direction at spindle orientation
0	0	By rotation direction immediately before (It is CCW at the power on.)
0	1	By rotation direction immediately before (It is CW at the power on.)
1	0	CCW (counterclockwise) direction looking from shaft of motor
1	1	CW (clockwise) direction looking from shaft of motor

NOTE

When using the external one-rotation signal (proximity switch), fix the orientation-time rotation direction at CCW or CW for stable detection of the one-rotation signal.
(Bits 3, 2 of No. 4003) = 1, 0 or 1, 1)

PCMGSL Selects the type of orientation.
Set this bit to 0.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3017	4017	4017	NRROEN							

NRROEN Specifies whether to use the shortcut function when orientation is specified in the stop state.
0 : Does not use the function.

1 : Uses the function.

When this bit is set to 1, short cut operation is performed when the following conditions are satisfied:

- Bit 7 of parameter No. 4016 (RFCHK3) is set to 0.
- Zero speed detection output signal SST is set to 1.
- Shortcut command input signal NRROA is set to 1.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3018	4018	4018		ORTYP1	OOTCML	OOTCMH	ORTYP0			

ORTYP1、ORTYP0 Type of position coder method orientation

ORTYP1	ORTYP0	Orientation type
0	0	Conventional method orientation
0	1	Optimum orientation
1	0	High-speed spindle orientation

Set "0,1" (optimum orientation).

OOTCMH: Optimum orientation : Setting of velocity feedforward (CTH1A=0)
OOTCML: Optimum orientation : Setting of velocity feedforward(CTH1A=1)

0: Velocity feedforward is unavailable
1: Velocity feedforward is available

Set 1.

15*i*	16*i*	30*i*	
3031	4031	4031	**Stop position of position coder method orientation**

Unit of data : 1pulse (360deg /4096)
Valid data range : 0 to 4095
Standard setting value : 0

This data is used to set the stop position of position coder method orientation. This parameter is invalid for stop position external setting-type and incremental command external setting-type spindle orientation. Instead, the stop position commands (input signals: SHA11 to SHA00) are valid.

15*i*	16*i*	30*i*	
3038	4038	4038	**Optimum orientation : Spindle orientation speed**

Unit of data : 1min^{-1} (10min^{-1} when bit 2 of parameter No.4006(SPDUNT) is set to 1)
Valid data range : 0 to 32767
Standard setting value : 0

This parameter is used to set the upper limit of spindle velocity command after position loop is closed.

If the setting is "0", "base speed of spindle motor/gear ratio between spindle and motor" is automatically assumed, using the settings of parameters Nos. 4056 to 4059 (gear ratio data between spindle and motor).

NOTE

When an improper value is set in any of parameters Nos. 4056 to 4059, the upper limit of the orientation speed is not calculated correctly and unexpected operation can occur.
Be sure to set proper gear ratios in parameters Nos. 4056 to 4059.

15*i*	16*i*	30*i*		
3042	4042	4042	**Velocity loop proportional gain on orientation (HIGH)**	**CTH1A=0**
3043	4043	4043	**Velocity loop proportional gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

This data is used to set the velocity loop proportional gain on orientation.

15*i*	16*i*	30*i*		
3050	4050	4050	**Velocity loop integral gain on orientation (HIGH)**	**CTH1A=0**
3051	4051	4051	**Velocity loop integral gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

This data is used to specify a velocity loop integral gain for spindle orientation.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0、CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0、CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1、CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1、CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting value : 100

These parameters set the gear ratio of the spindle motor relative to the spindle.
When the motor rotates 2.5 times, for every rotation of the spindle, for example, set 250 in the parameter.
A parameter is selected by the CTH1A and CTH2A input signals.
The gear or clutch status must correspond to the status of the CTH1A and CTH2A input signals.

NOTE

When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*		
3060	4060	4060	**Position gain on orientation (HIGH)**	**CTH1A=0, CTH2A=0**
3061	4061	4061	**Position gain on orientation (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3062	4062	4062	**Position gain on orientation (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3063	4063	4063	**Position gain on orientation (LOW)**	**CTH1A=1, CTH2A=1**

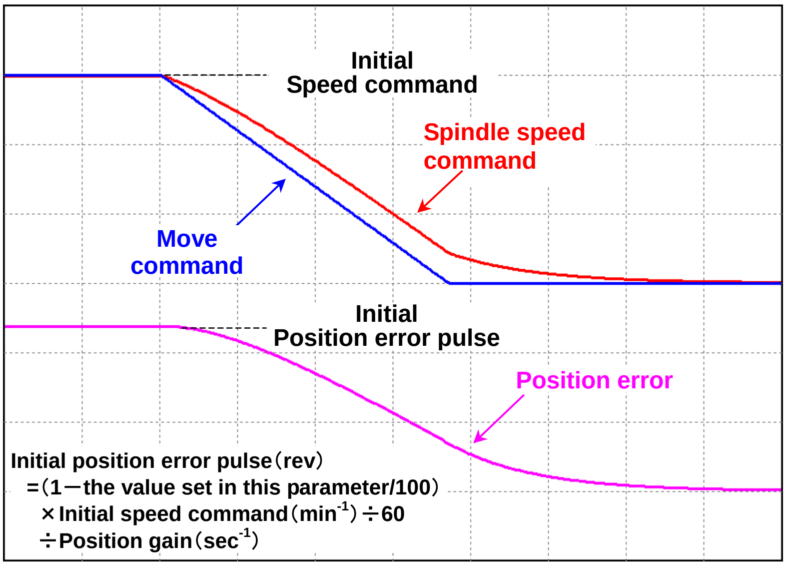
Unit of data : $0.01sec^{-1}$
Valid data range : 0 to 32767
Standard setting : 1000

These parameters set the position gain for orientation.

15*i*	16*i*	30*i*	
3064	4064	4064	**Optimum orientation: Position feedforward coefficient**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 100

This parameter is used to set position feedforward coefficient.
Normally, set 100.



15*i*	16*i*	30*i*	
3075	4075	4075	**Orientation completion signal detection level (limits of in-position)**

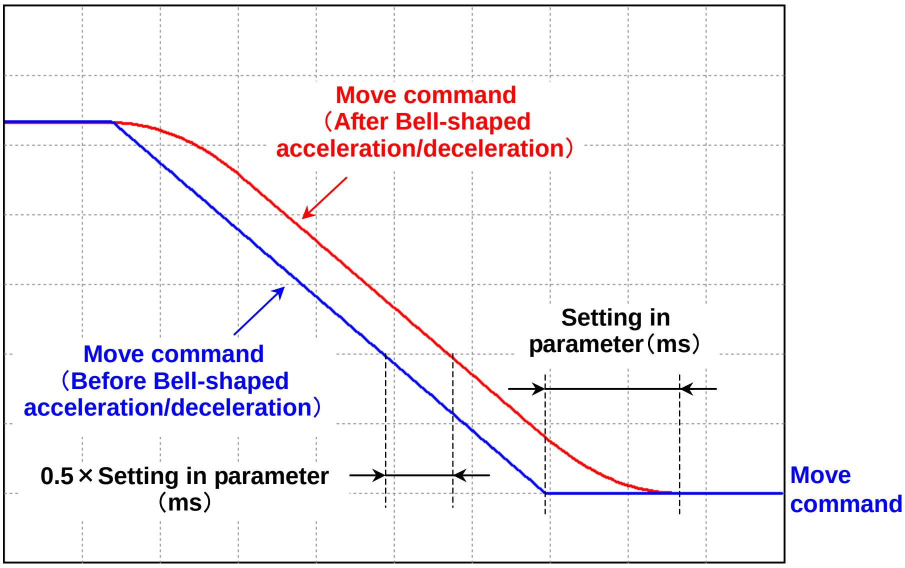
Unit of data : ±1 pulse unit (360 degrees/4096)
Valid data range : 0 to 100
Standard setting : 10

This data is used to set the detecting level of orientation completion signal (ORARA). ORARA is assumed to be 1 if the position error is within the setting.

15*i*	16*i*	30*i*	
3076[L]	4076[L]	4076[L]	**Optimum orientation : Bell-shaped acceleration/deceleration time constant**

Unit of data : 1msec
Valid data range : 0 to 255
Standard setting value : 0

This data is used to set bell-shaped acceleration/deceleration time constant.
If the setting is "0", "31" (= 31 msec) is assumed to be set in the parameter.
Normally, set 0.



15*i*	16*i*	30*i*	
3076[H]	4076[H]	4076[H]	**Optimum orientation: Delay time for acceleration detection**

Unit of data : 10msec
Valid data range : 0 to 125
Standard setting value : 0

This data is used to set the lower limit of the time between the instant when the orientation command ORCMA is input and the instant when position loop is closed. The acceleration command is automatically set based on the acceleration data detected by the time position loop is closed.
If the setting is "0", "2" (= 20 msec) is assumed to be set in the parameter.
Normally, set 0.

15*i*	16*i*	30*i*	
3077	4077	4077	**Orientation stop position shift value**

Unit of data : ±1 pulse unit (360 degrees/4096)
Valid data range : -4095 to 4095
Standard setting : 0

In the position coder method orientation, set this data to shift stop position. If a positive value is specified, the position where the spindle stops is shifted counterclockwise (CCW).

15*i*	16*i*	30*i*	
3084	4084	4084	**Motor voltage setting on orientation**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : The value may vary, however, depending on the motor model.
This parameter sets the motor voltage for orientation.
Normally, set 100.

15i	16i	30i		
3320	4320	4320	**Optimum orientation : Spindle acceleration command (HIGH)**	**CTH1A=0**
3321	4321	4321	**Optimum orientation : Spindle acceleration command (LOW)**	**CTH1A=1**

Unit of data : 10min^{-1}/sec
Valid data range : -10000 to 10000
Standard setting value : 0

When setting value is zero or positive

When orientation is commanded in the rotating state, the spindle acceleration command is automatically set based on the spindle acceleration detected from the time the orientation command (ORCMA) is input until the position loop is closed.
These parameters are used to set spindle acceleration command in case of

- Orientation when spindle is zero-speed state (Zero-speed detection signal SST = 1)
- Incremental command external setting-type orientation

If the setting is "0", "133" (= 1330 min^{-1}/sec) is assumed to be set in the parameter.

When setting value is negative

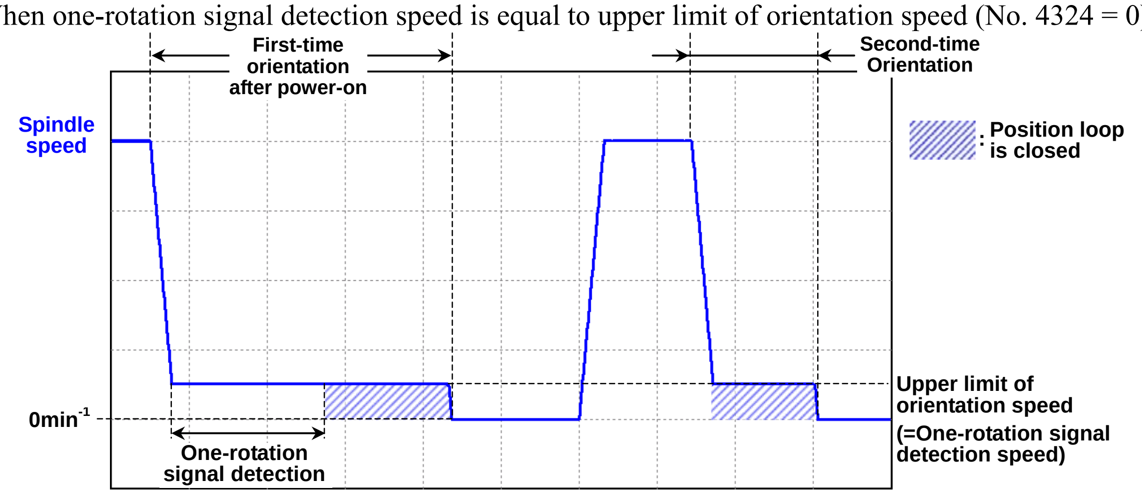
These parameters are used to set spindle acceleration command regardless of the spindle speed when orientation is commanded. (The absolute value of the setting value is treated as acceleration command.)

15i	16i	30i	
3324	4324	4324	**Optimum orientation : One-rotation signal detection speed**

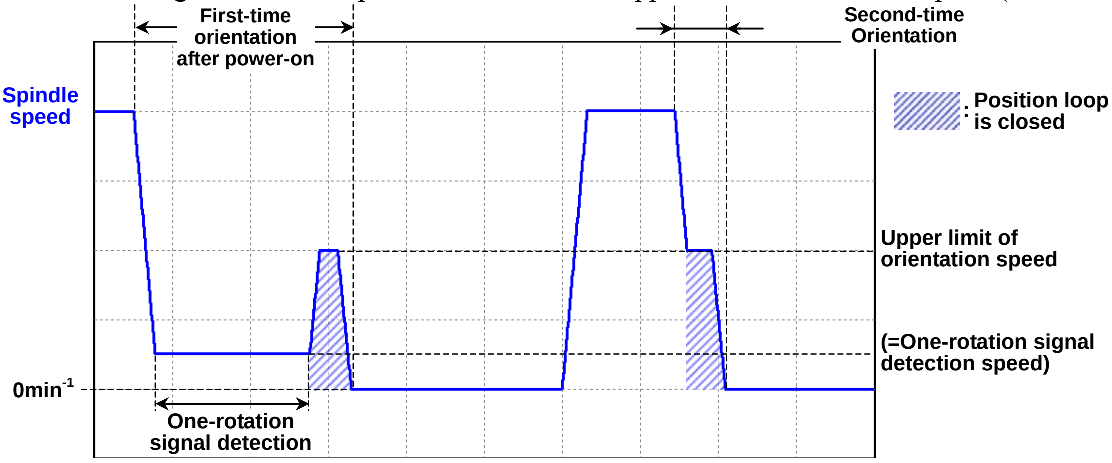
Unit of data : 1min^{-1} (10 min^{-1} when bit 2 (SPDUNT) of parameter No. 4006 =1)
Valid data range : 0 to 32767
Standard setting value : 0

In case of the first-time orientation command (ORCMA) after power-on, the spindle accelerates or decelerates toward the speed set by this parameter and detects one-rotation signal.
If the setting is "0", setting value of parameter No. 4038 (upper limit of orientation speed) is assumed to be set in the parameter.
If the external one-rotation signal (proximity switch) is used, setting this parameter and the upper limit of orientation speed separately can reduce orientation time of second-time or later after power-on.

When one-rotation signal detection speed is equal to upper limit of orientation speed (No. 4324 = 0)



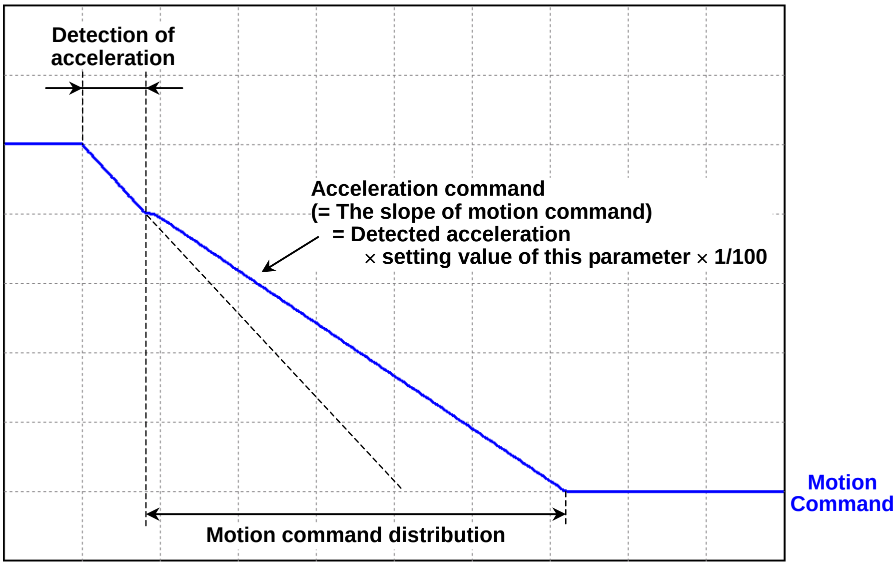
When one-rotation signal detection speed is different from upper limit of orientation speed (No. 4324 ≠ 0)



15*i*	16*i*	30*i*	
3326[L]	4326[L]	4326[L]	Optimum orientation : Limit ratio of acceleration command(HIGH)CTH1A=0
3327[L]	4327[L]	4327[L]	Optimum orientation : Limit ratio of acceleration command(LOW) CTH1A=1

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 0

This parameter is used to set limit ratio for acceleration command.
If the setting is “0”, “95”(=95%) is assumed to be set in the parameter.
Usually, specify “0”.



15*i*	16*i*	30*i*	
3326[H]	4326[H]	4326[H]	Optimum orientation : Time constant for overshoot compensation (HIGH) CTH1A=0
3327[H]	4327[H]	4327[H]	Optimum orientation : Time constant for overshoot compensation (LOW) CTH1A=1

Unit of data : 1msec
Valid data range : 0 to 125
Standard setting value : 0

This parameter is used to set time constant for overshoot compensation.
If the setting is “0”, “5”(=5msec) is assumed to be set in the parameter.

Usually, specify “0”.

15*i*	16*i*	30*i*	
3328	4328	4328	**Command multiplier for spindle orientation by a position coder**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

Set a command multiplier for the orientation function with an externally set incremental command.
If this parameter is set to "0", the multiplier is automatically assumed to be "1" (= ×1).
If this parameter is set to a value other than "0", the incremental command is

"Incremental command data (SHA11 to SHA00) × setting of this parameter"

To use spindle rotation speed control, set this parameter to "4096", because the resolution commanded for orientation is 4096 pulses per spindle rotation.

NOTE

1 For an explanation of the incremental command type spindle orientation function, see Section 5.3, "INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION (SPINDLE ROTATION SPEED CONTROL)", in Part I.
2 In case of optimum orientation, the maximum number of revolution (incremental command) that can be specified is
30000 revolution (= 30000 × 4096 pulses).

15*i*	16*i*	30*i*	
3370	4370	4370	**Filter time constant for spindle acceleration detection**

Unit of data : 1msec
Valid data range : 0 to 100
Standard setting value : 0

This parameter is used to set filter time constant for spindle acceleration detection.
The following are the recommended settings for the individual types of spindle sensor.

Type of spindle sensor	Setting value
Except for α*i* position coder (No.4002#3,2,1,0 ≠ 0, 0, 1, 0)	5 to 15
α*i* position coder (No.4002#3,2,1,0 = 0, 0, 1, 0)	10 to 20

If the setting is "0",

"5" (= 5 msec): except for α*i* position coder
"10" (= 10 msec): α*i* position coder

is assumed to be set in this parameter.

15*i*	16*i*	30*i*	
-	-	4590[L]	**Optimum orientation: Orientation speed limit ratio 1 (HIGH) CTH1A=0**
-	-	4590[H]	**Optimum orientation: Orientation speed limit ratio 2 (HIGH) CTH1A=0**
-	-	4591[L]	**Optimum orientation: Orientation speed limit ratio 1 (LOW) CTH1A=1**
-	-	4591[H]	**Optimum orientation: Orientation speed limit ratio 2 (LOW) CTH1A=1**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 0

These parameters are used to set orientation speeds, in conjunction with parameter No. 4038 for setting the orientation speed upper limit. Normally, set "0" in these parameters because they need not be adjusted.

[Reference]
When an orientation operation is started at a speed near the orientation speed upper limit (parameter No. 4038), the orientation time may be reduced by limiting the orientation speed with these parameters.

Orientation speed limit ratio 1, ORSCF1, is used to define orientation speed lower limit, ORSPDL, as shown below:

$$\mathrm{ORSPDL} = \frac{100 - \mathrm{ORSCF1}}{100} \times \mathrm{ORSPDU}$$

Then, the following can be used to calculate orientation speed, ORSPD, as shown below:

- Spindle speed for the orientation command : ORSINI
- Orientation speed upper limit (set in parameter No. 4038): ORSPDU
- Orientation speed lower limit : ORSPDL
- Orientation speed limit ratio 2 : ORSCF2

$$\mathrm{ORSPD} = \frac{\mathrm{ORSCF2}}{100} \times \mathrm{ORSINI} + \frac{100 - \mathrm{ORSCF2}}{100} \times \mathrm{ORSPDL}$$

(Clamping is performed so that ORSPDL ≤ ORSPD ≤ ORSPDU.)

15*i*	16*i*	30*i*	
-	-	4607	**Motor voltage after completion of optimum orientation**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 0

This parameter is used to set a motor voltage after completion of optimum orientation. The rigidity at the orientation stop can be increased by adjusting this parameter setting. Normally, set "0" in this parameter because it need not be adjusted.

- When this parameter is "0":
  Motor voltage after completion of orientation = parameter No. 4083 (motor voltage on the velocity control mode [for high-speed winding])
- When this parameter is other than "0":
  Motor voltage after completion of orientation = parameter No. 4607

2.2.13 Tuning Procedure

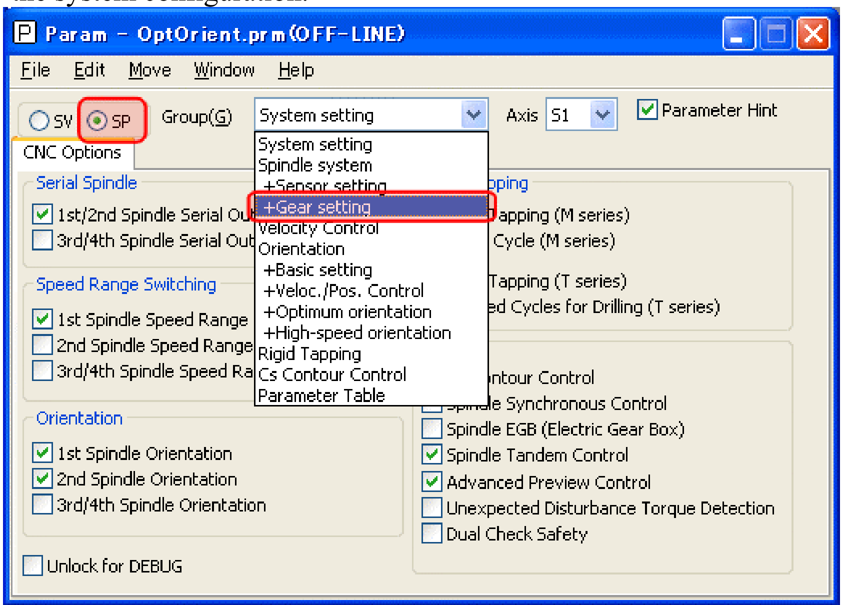
(1) Parameter initialization

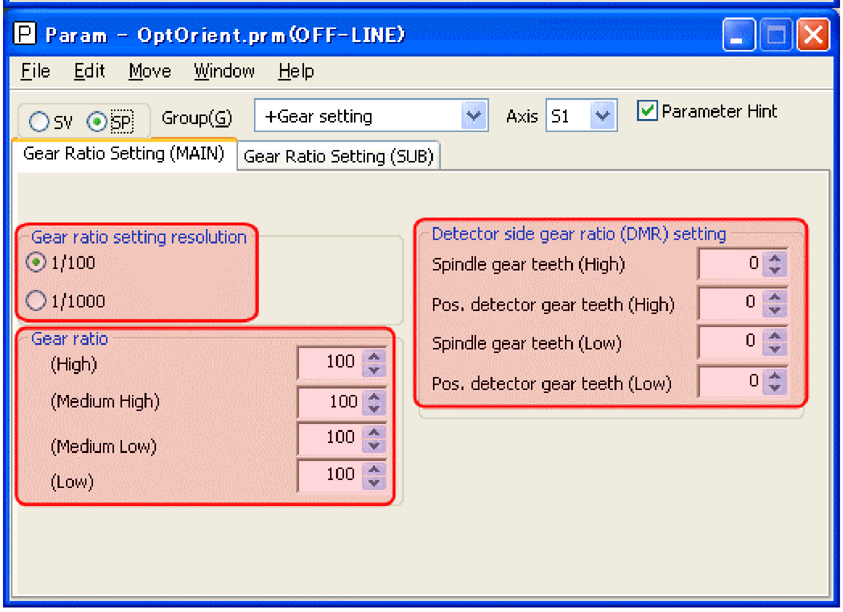
(A) If making settings from the parameter window of the SERVO GUIDE

(i) Open the parameter window of the SERVO GUIDE, and select **"SP"-"Spindle system"-"Gear setting"**, and set

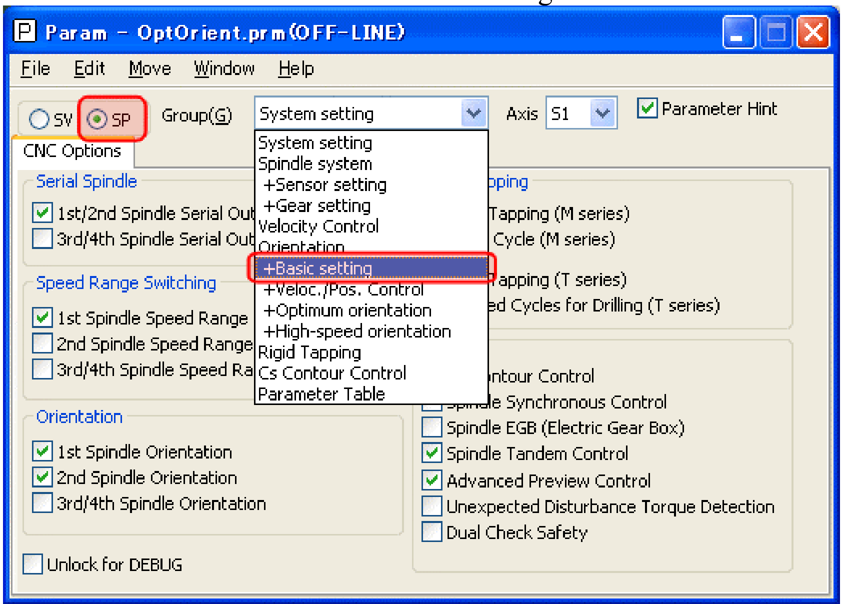
- Gear ratio setting resolution
- Gear ratio
- Detector side gear (DMR) setting

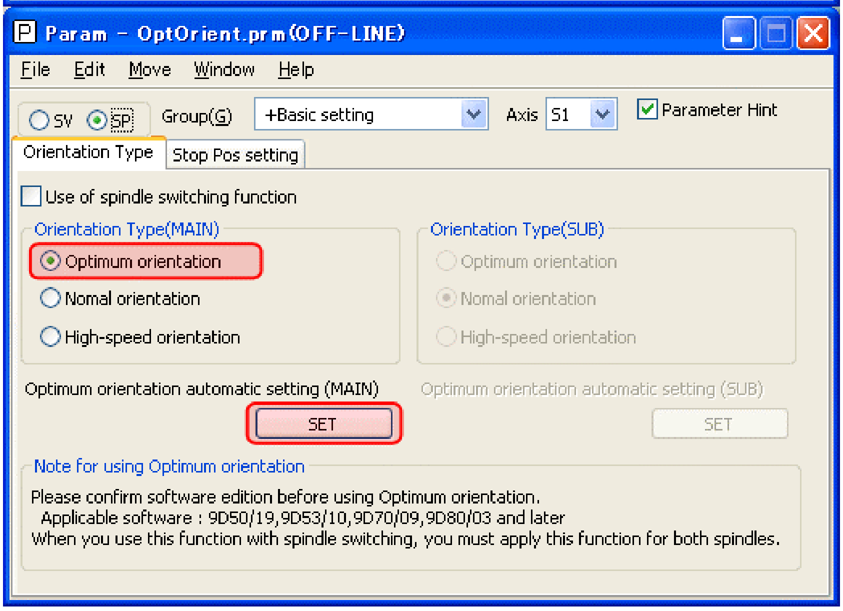
according to the system configuration.





(ii) Select **"SP"-"Orientation"-"Basic setting"-"Orientation Type"**. For Orientation Type, select "Optimum orientation" and then click the automatic setting button.

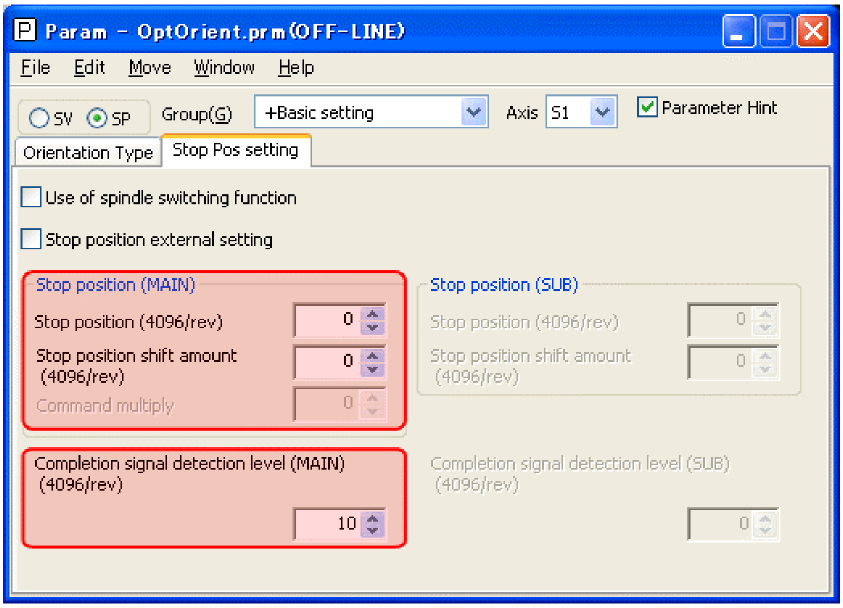




(iii) Select **"SP"-"Orientation"-"Basic setting"-"Stop Pos setting"**, and set

- Stop position
- Stop position shift amount
- Command multiply
- Completion signal detection level

according to the use.

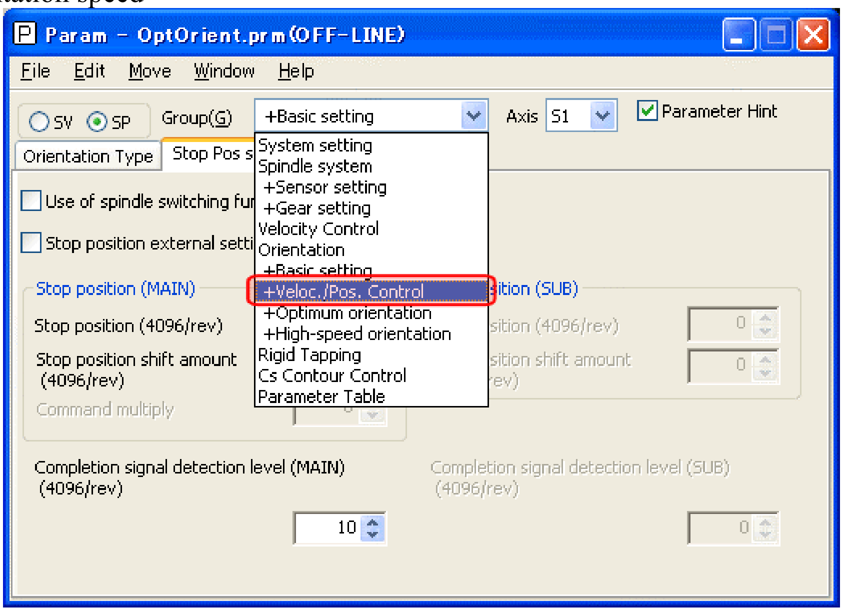


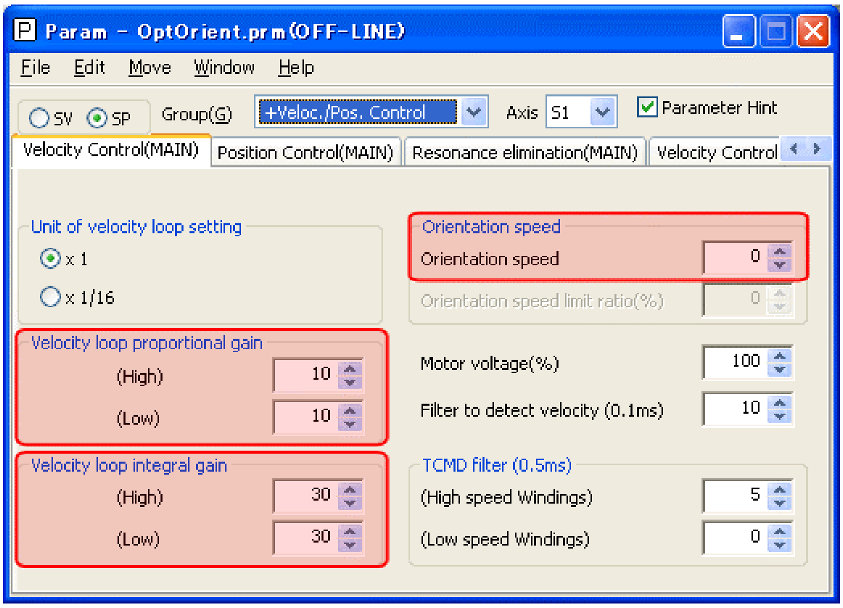
(iv) Select **"SP"-"Orientation"-"Veloc./Pos. Control"-"Velocity Control"**, and set

- Velocity loop proportional gain: 10
- Velocity loop integral gain: 30

If wishing to limit the spindle speed during position control, set the upper limit for

- Orientation speed



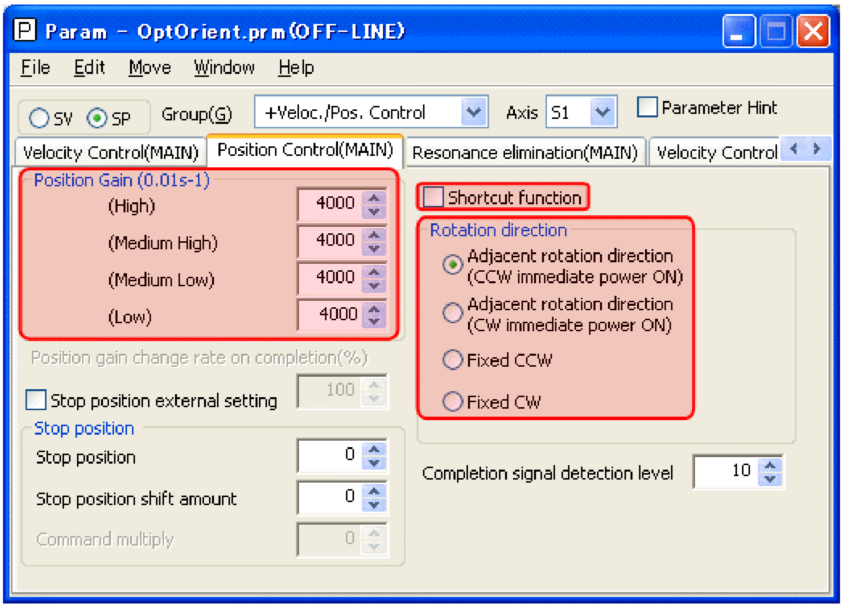


(v) Select **"SP"-"Orientation"-"Veloc./Pos. Control"-"Position Control"**, and set
- Position Gain: 3000 to 4000

Set
- Shortcut function
- Rotation direction

according to the use.

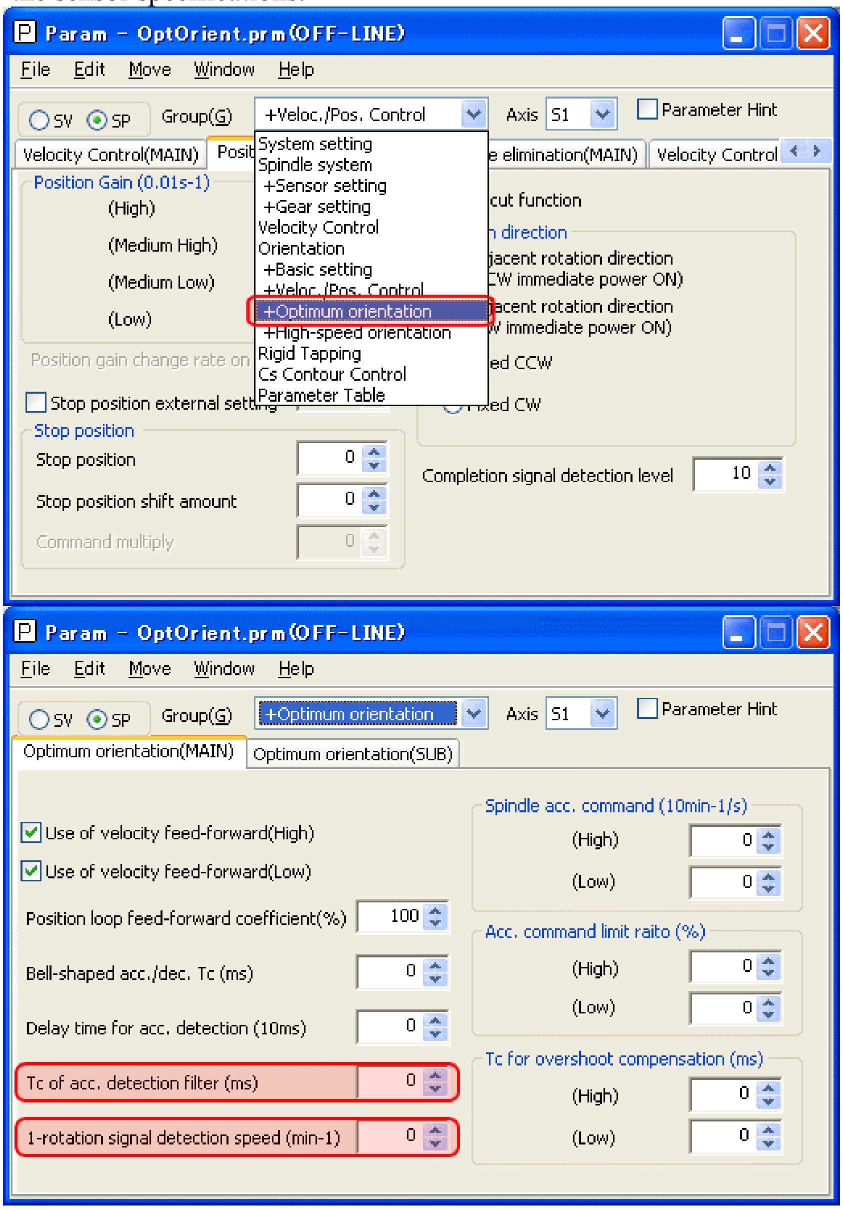
If using the external one-rotation signal (proximity switch), set Rotation direction to either Fixed CCW or Fixed CW



(vi) Select **"SP"-"Orientation"-"Optimum orientation"**, and set
- Tc of acc. detection filter: 0

If using the external one-rotation signal (proximity switch), set
- 1-rotation signal detection speed: 50 to 100

according to the sensor specifications.



(B) If making settings from the SYSTEM> parameter screen of the CNC

Initialize the parameters as listed below.
Orientation may work well with following settings. Tune parameters if necessary.

No.	Description	Initial setting
4003#0	Selecting a spindle orientation type	0
4003#3,#2	Spindle rotation direction at orientation	Select a rotation direction.
4006#1	Unit of gear ratio setting	Specify an appropriate value depending on the system configuration.
4017#7	Short-cut function when spindle orientation from stopped state is specified	Specify an appropriate value according to the use of the machine.

No.	Description	Initial setting
4018#6,3	Type of position coder method orientation	0, 1
4018#4,5	Setting of velocity feedforward	1, 1
4031	Spindle orientation stop position	Specify a stop position.
4038	Spindle orientation speed upper limit	0
4042 to 4043	Velocity proportional gain on orientation	10
4050 to 4051	Velocity integral gain on orientation	10
4056 to 4059	Gear ratio	Specify an appropriate value depending on the system configuration.
4060 to 4063	Position gain on orientation	3000
4064	Percentage limit to an acceleration during deceleration	100
4075	Orientation completion signal detection level	Specify an appropriate value according to the use of the machine.
4077	Orientation stop position shift value	Specify a stop position.
4084	Motor voltage on orientation	100
4171,4173	Denominator of the motor sensor-to-spindle arbitrary gear ratio	Specify an appropriate value depending on the system configuration.
4172,4174	Numerator of the motor sensor-to-spindle arbitrary gear ratio	Specify an appropriate value depending on the system configuration.
4320 to 4323	Acceleration during motor deceleration	Tune according to actual measurements.
4324	One-rotation signal detection speed	0 *[3] 3
4326,4327	Limit ratio for spindle acceleration command / Time constant for overshoot compensation	0
4328	Command multiplier for orientation	Specify an appropriate value according to the use of the machine.
4370	Filter time constant for spindle acceleration detection	0
4590,4591	Orientation speed limit ratio 1/ Orientation speed limit ratio 2	0
4607	Motor voltage after completion of optimum orientation	0

NOTE

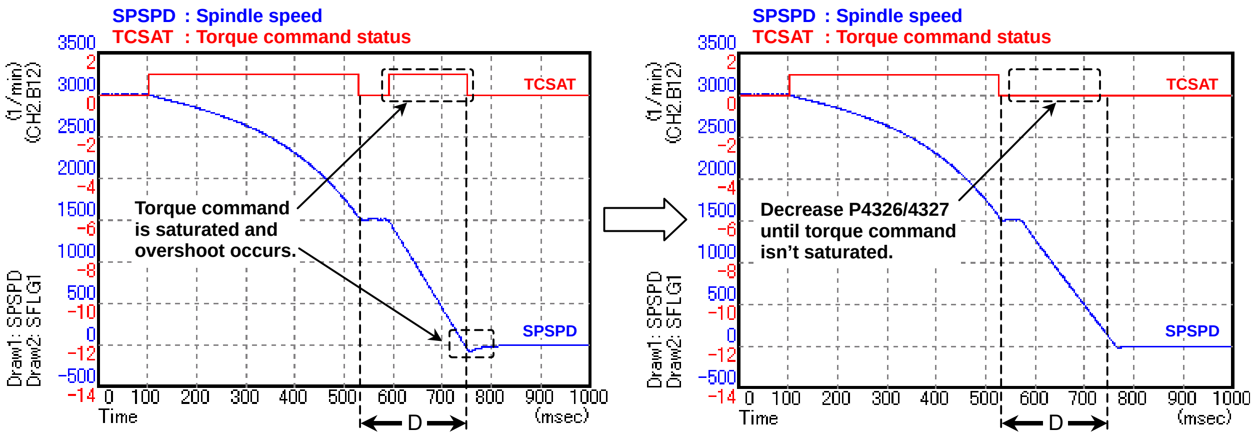
1. Fix the rotation direction at one direction when the external one-rotation signal (proximity switch) is used.
2. Set upper limit if it is necessary to specify the maximum speed of spindle during position control.
3. Set 50 to 100 min^{-1} according to the specification of the sensor when the external one-rotation signal (proximity switch) is used.

(2) Tuning example 1: If specifying orientation when the spindle is rotating

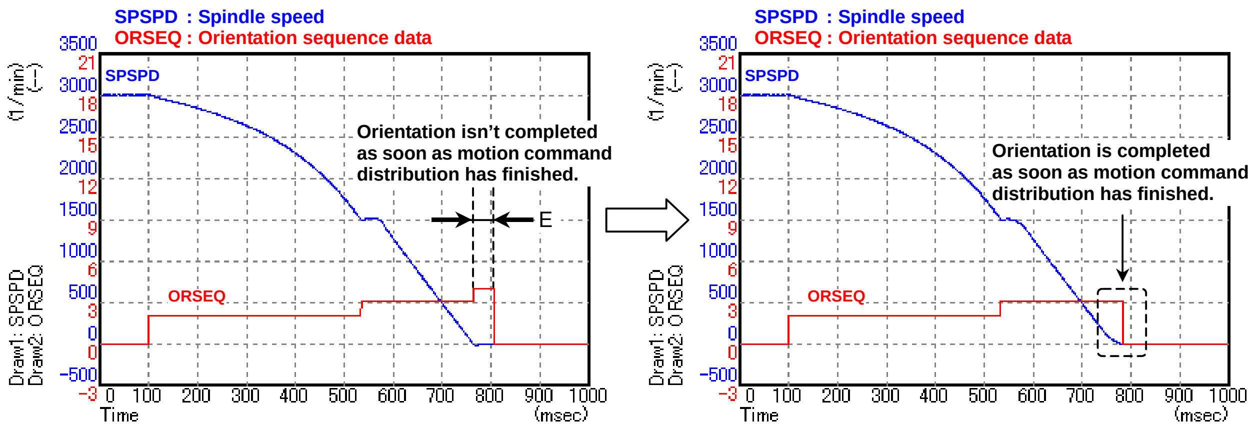
(a) Tuning the velocity loop proportional gain (Nos. 4042/4043) and integral gain (Nos. 4050/4051)
Detach the load inertia (tool and workpiece) from the spindle. Then tune the velocity proportional/integral gain by referring to Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT", in Part I.

(b) Tuning the position gain (Nos. 4060 to 4063)
Basically, the position gain needs no changes from the initial values mentioned in the preceding section.

(c) Tuning the limit ratio for acceleration command (Nos. 4326/4327)
Perform orientation from maximum spindle speed. If the torque command is saturated (TCSAT = 1) while motion command distribution is executing (Section D: ORSEQ = 3), decrease the limit ratio for the acceleration command (Nos. 4326/4327) in steps of 5% from the initial value of 95%.



(d) Tuning the bell-shaped acc./dec. time constant (No. 4076)
If the time from the end of motion command distribution to orientation completion (Section E: ORSEQ = 4) is long, increase the bell-shaped acc./dec. time constant (No. 4076) in steps of 4 ms from the initial value of 32 ms.



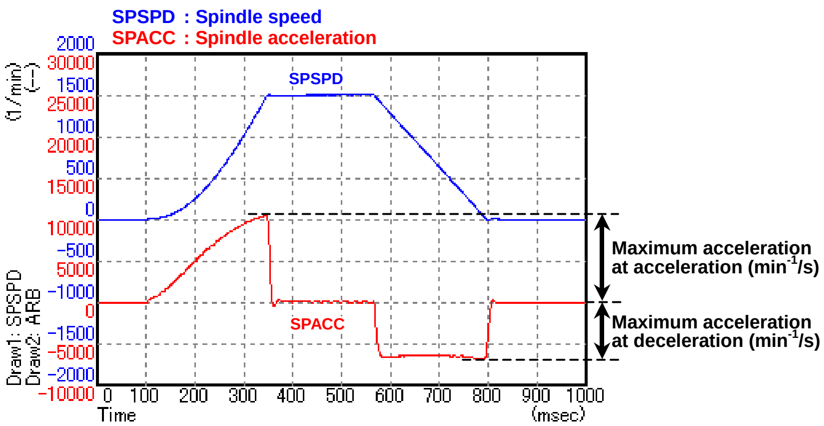
(e) Checking orientation with the load inertia attached
Attach the load inertia to the spindle and check orientation from the maximum spindle speed.

(3) Tuning example 2: If specifying orientation when the spindle is zero-speed state

(a) Tuning the velocity loop proportional gain (Nos. 4042/4043) and integral gain (Nos. 4050/4051)
Attach the load inertia (tool and workpiece) to the spindle. Then tune the velocity proportional/integral gain by referring to Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT", in Part I.

(b) Tuning the position gain (Nos. 4060 to 4063)
Basically, the position gain needs no changes from the initial values mentioned in the preceding section.

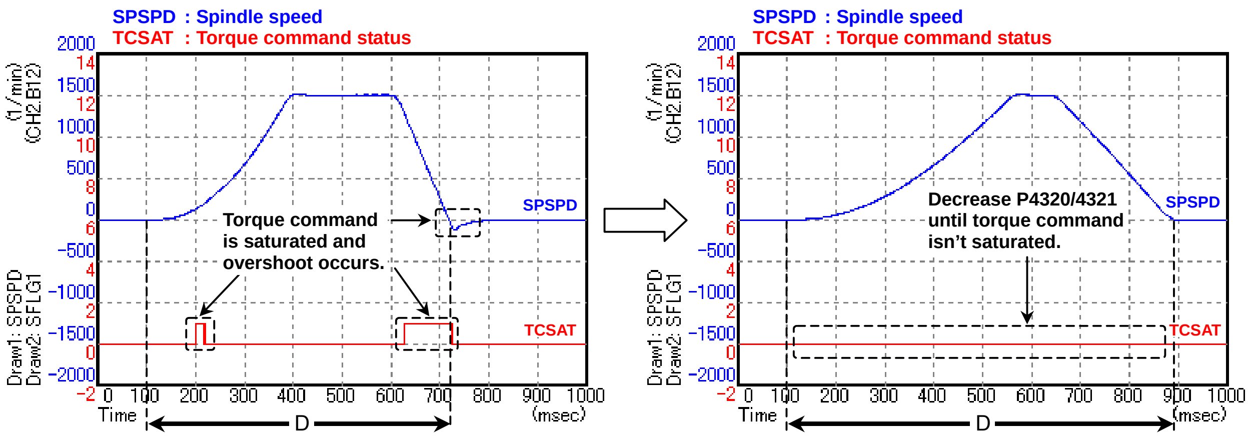
(c) Specifying the [provisional value] of the spindle acceleration command (Nos. 4320/4321)
Perform acc./dec. form 0 min^{-1} to maximum speed in velocity control mode, and measure spindle acceleration.



Specify the spindle acceleration command (Nos. 4320/4321) as follows:

Setting value = 0.1 × min (|max. acceleration at acc.|, |max. acceleration at dec.|)

(d) Tuning the spindle acceleration command (Nos. 4320/4321)
Perform orientation from the state in which motor excitation is off. If the torque command is saturated (TCSAT = 1) while motion command distribution is executing (Section D: ORSEQ = 3), decrease the spindle acceleration command (Nos. 4320/4321) until torque command is not saturated.



(e) Tuning the bell-shaped acc./dec. time constant (No. 4076)
Tune the bell-shaped acc./dec. time constant (No. 4076) in the same way as that described in (2).

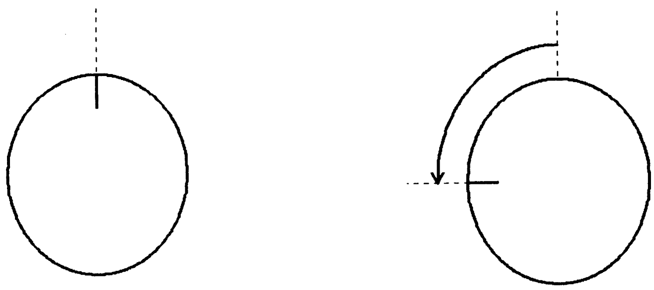
2.2.14 Adjusting the Orientation Stop Position Shift Parameter

Adjust the orientation stop position shift parameter by following the procedure below.

(a) Specify parameters as follows:
Bit 1 of No. 3117 = 1 (to enable the display function of diagnosis screen No. 445)
Bit 7 of No. 4016 = 0
No. 4031 = 0 (When external signals are used for setting, set the input signals SHA11 to SHA00 to 0.)
No. 4077 = 0
(b) Enter an orientation command (ORCMA) to stop orientation.
(c) After orientation is stopped, check that diagnosis screen No. 445 displays "0".
Cancel the orientation command and set the emergency stop state to deactivate the motor.
(d) Rotate the spindle manually to the position where you want the spindle to stop then read the displayed value of diagnosis screen No. 445.
(e) Set the displayed value of (d) as the parameter data for an orientation stop position shift amount (No. 4077).

[Example]

Value displayed in No. 445 when orientation is stopped = "0" ⇨ Value displayed in No. 445 when the spindle is rotated manually in the emergency stop state = "1024"



Value to be specified in the parameter No. 4077 = 1024

> **NOTE**
> 1 The display function of diagnosis screen No. 445 is a maintenance function. After completion of adjustment, return the setting of bit 1 of parameter No. 3117 to "0".
> 2 The FS15*i* does not have the spindle position data display function.

2.2.15 Supplementary Descriptions

(1) Correspondence of parameter Nos. when the spindle switching control function is used

15*i*		16*i*		30*i*		Description
MAIN	SUB	MAIN	SUB	MAIN	SUB	
3015#0	←	4015#0	←	4015#0	←	Whether the spindle orientation function is available
3003#3 #2	3179#3 #2	4003#3 #2	4179#3 #2	4003#3 #2	4179#3 #2	Rotation direction for orientation
3003#0	3179#0	4003#0	4179#0	4003#0	4179#0	Orientation method selection
3017#7	3193#7	4017#7	4193#7	4017#7	4193#7	Short-cut function when spindle orientation from stopped state is

15*i*		16*i*		30*i*		Description
MAIN	SUB	MAIN	SUB	MAIN	SUB	
						specified
3018#6 #3	3194#6 #3	4018#6 #3	4194#6 #3	4018#6 #3	4194#6 #3	Type of position coder method orientation
3018#4	3194#4	4018#4	4194#4	4018#4	4194#4	Setting of velocity feedforward (HIGH)
3018#5	3194#5	4018#5	4194#5	4018#5	4194#5	Setting of velocity feedforward (LOW)
3031	3204	4031	4204	4031	4204	Spindle orientation stop position
3038	3205	4038	4205	4038	4205	Upper limit of orientation speed
3042	3208	4042	4208	4042	4208	Velocity loop proportional gain for orientation (HIGH)
3043	3209	4043	4209	4043	4209	Velocity loop proportional gain for orientation (LOW)
3050	3213	4050	4213	4050	4213	Velocity integral gain for orientation (HIGH)
3051	↑	4051	↑	4051	↑	Velocity integral gain for orientation (LOW)
3056	3216	4056	4216	4056	4216	Gear ratio data between spindle and motor (HIGH)
3057	↑	4057	↑	4057	↑	Gear ratio data between spindle and motor (MEDIUM HIGH)
3058	↓	4058	↓	4058	↓	Gear ratio data between spindle and motor (MEDIUM LOW)
3059	3217	4059	4217	4059	4217	Gear ratio data between spindle and motor (LOW)
3060	3218	4060	4218	4060	4218	Position gain for orientation (HIGH)
3061	↑	4061	↑	4061	↑	Position gain for orientation (MEDIUM HIGH)
3062	↓	4062	↓	4062	↓	Position gain for orientation (MEDIUM LOW)
3063	3219	4063	4219	4063	4219	Position gain for orientation (LOW)
3064	3220	4064	4220	4064	4220	Position feedforward coefficient
3075	3226	4075	4226	4075	4226	Orientation completion signal detection level
3076	3227	4076	4227	4076	4227	Bell-shaped acc./dec. time constant / Delay time for acceleration detection
3077	3228	4077	4228	4077	4228	Orientation stop position shift value
3084	3237	4084	4237	4084	4237	Motor voltage for orientation
3320	3322	4320	4322	4320	4322	Spindle acceleration command (HIGH)
3321	3323	4321	4323	4321	4323	Spindle acceleration command (LOW)
3324	3325	4324	4325	4324	4325	One-rotation signal detection speed
3326	3330	4326	4330	4326	4330	Limit ratio for acceleration command (HIGH) / Time constant for overshoot compensation (HIGH)
3327	3331	4327	4331	4327	4331	Limit ratio for acceleration command (LOW) / Time constant for overshoot compensation (LOW)
3328	3329	4328	4329	4328	4329	Command multiplier for orientation
3370	3383	4370	4383	4370	4383	Filter time constant for spindle acceleration detection
—	—	—	—	4590	4720	Orientation speed limit ratio 1 (HIGH)/ Orientation speed limit ratio 2 (HIGH)
—	—	—	—	4591	4721	Orientation speed limit ratio 1 (LOW)/ Orientation speed limit ratio 2 (LOW)
—	—	—	—	4607	4737	Motor voltage after completion of optimum orientation

NOTE

Use the optimum orientation function for both MAIN spindle and SUB spindle when the spindle switching control function is used concurrently.

(2) Spindle data related to optimum orientation

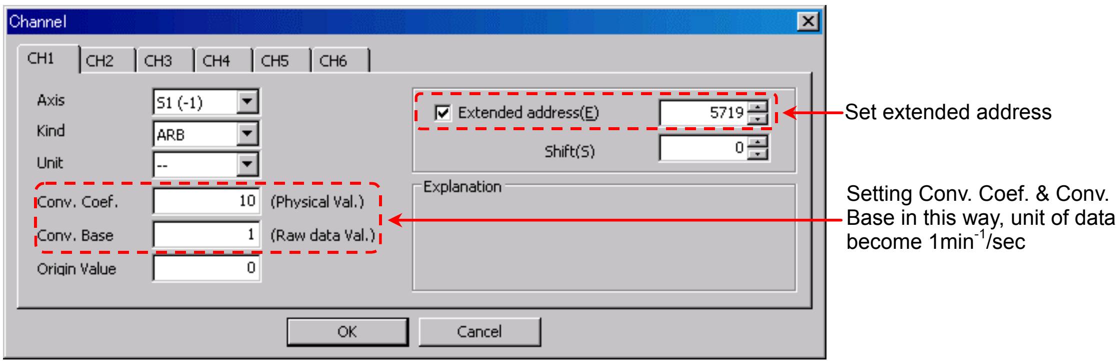
The following are setting examples that an be used if data related to optimum orientation is to be measured using the SERVO GUIDE.

Refer to FANUC SERVO GUIDE OPERATOR'S MANUAL (B-65404EN) or online help for detailed explanations about how to use the SERVO GUIDE.

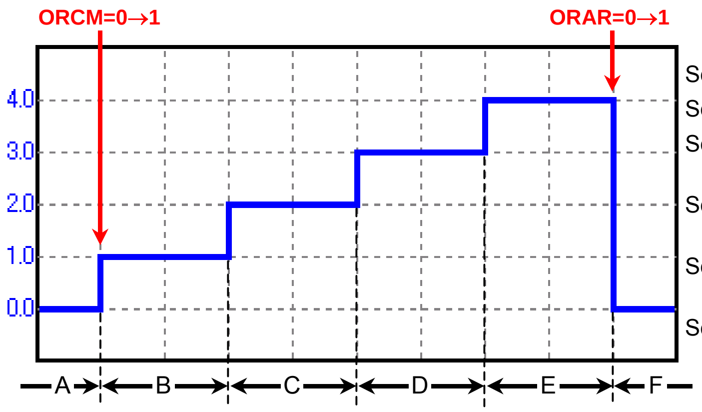
Data	Kind	Unit	Conv. Coef.	Conv. Base	Shift	Notet
Spindle speed	SPSPD	1/min	1	1	-12	
Spindle acceleration*1	SPACC	—	10	1	0	Unit:1min^{-1}/sec
Orientation sequence data*2	ORSEQ	—	1	1	0	
Position error at orientation	ORERR	pulse	0.25	1	-10	4096 pulses/rev
Torque command	TCMD	%	100	16384	0	
Torque command status*3 (bit12 of spindle flag 1)	SFLG1#12 (TCSAT)	—	1	1	0	0:TCMD isn't saturated 1:TCMD is saturated

NOTE

1 If the SERVO GUIDE is of Version 4.10 or later.
For an earlier version, make the following settings on the channel setting screen of the graph window.



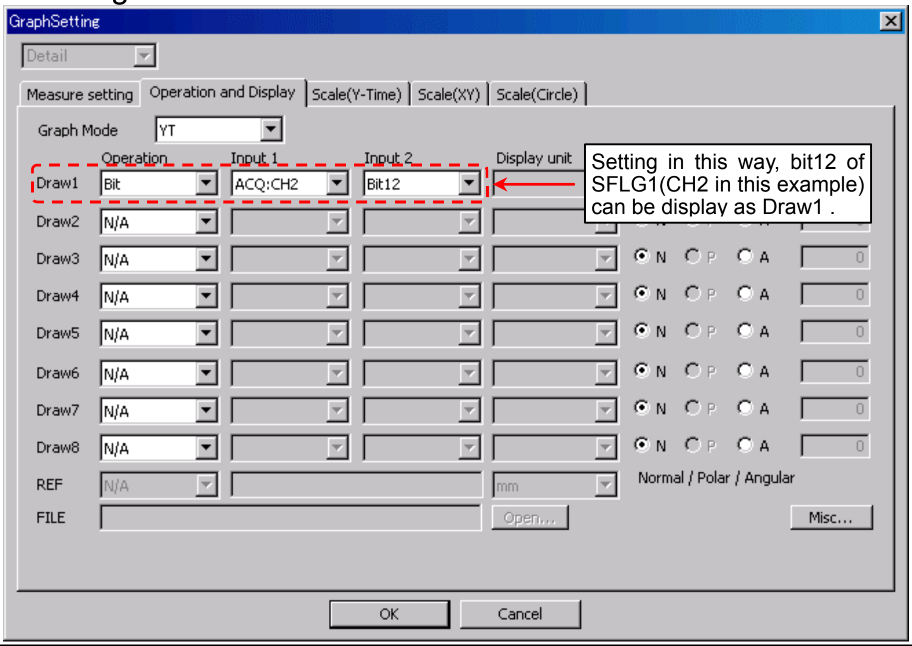
2 Orientation sequence (ORSEQ) is data showing the states of orientation.
Shown below is an example of output wave-form, together with the meaning of each state.



Section A: Before orientation is commanded
Section B: One-rotation signal detection
Section C: Acceleration or deceleration for spindle acceleration detection
Section D: Position loop is closed (motion command distribution is executing)
Section E: Position loop is closed (motion command distribution has finished)
Section F: Orientation completion

NOTE

3 To display the torque command status decision flag, set spindle flag 1 on the channel setting screen of the graph window, and make the following settings on the GraphSetting screen.



2.3 RIGID TAPPING (OPTIONAL FUNCTION)

2.3.1 Start-up Procedure

A. Check that operation in the velocity control mode is enabled.

↓

B. Prepare and check the rigid tapping ladder program.

↓

C. Set up the detector-related parameters according to the system configuration.
- Specify to use the spndile sensor and spindle motor.
- Specify the rotation direction of the spindle and motor and that of the spindle and position coder.
- Set up the gear ratio between the spindle and motor.
- Specify an arbitrary gear ratio (for rigid tapping that uses a signal from the built-in sensor when the gear ratio between the spindle and motor is not 1:1).

↓

D. Adjust the parameters according to the adjustment procedure.
- Maximum rotation speed and acceleration/deceleration time constant for rigid tapping
- Position gain for rigid tapping
- Velocity loop proportional and integral gains for rigid tapping
- Motor voltage for rigid tapping
- Motor activation delay

↓

E. Check the precision by actually performing cutting.
If there is a problem with the precision of the machine, adjust the acceleration/deceleration time constant and velocity loop gains again.

2.3.2 Overview

Rigid tapping is a function for performing high-precision tapping by exercising position control so that the spindle rotation is synchronized with tapping axis feed at all times.
This Subsection describes the specifications of the rigid tapping function related to the serial spindle.

NOTE
To use this function, the CNC software option is required.

2.3.3 FSSB High-speed Rigid Tapping

In rigid tapping, when high-speed communication is used through the FSSB connection between the spindle amplifier and servo amplifier, it is possible to reduce the synchronous error and to shorten the cycle time while maintaining precision.

However, FSSB high-speed rigid tapping cannot be used for the following:
- Rigid tapping through spindle control by an analog spindle or servo motor
- Rigid tapping with two or more spindles and one servo axis through spindle command synchronization

- Rigid tapping with two or more servo axes simultaneously used for one spindle

2.3.3.1 Series and Edition of Applicable FSSB High-speed Rigid Tapping Software

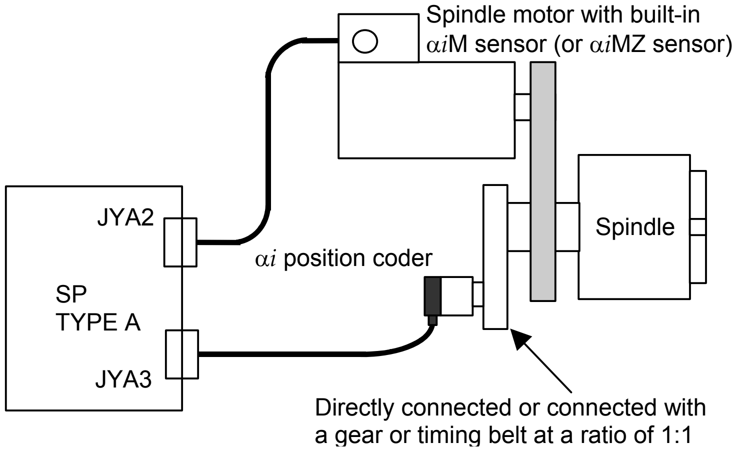
Spindle Software

Series	Edition	CNC
9DA0	G (07)	FS30*i* -B / FS31*i*-B / FS32*i*-B /

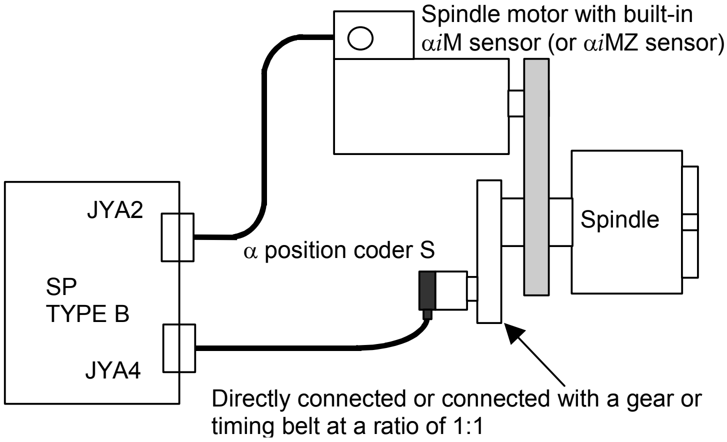
2.3.4 System Configuration

The system configurations that enable the use of rigid tapping are shown below.

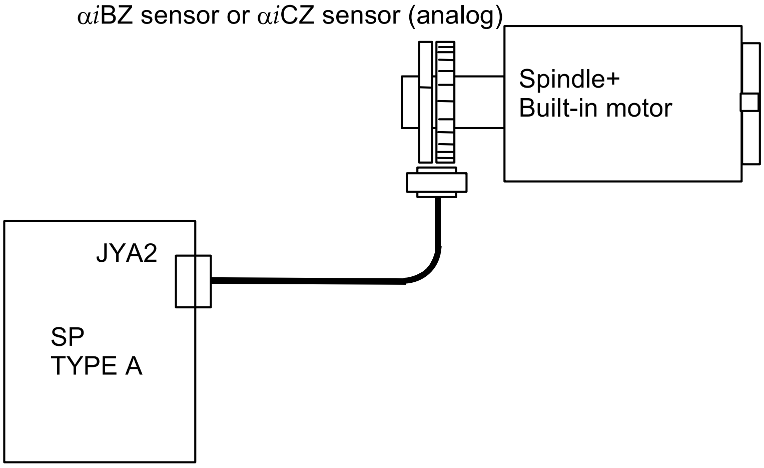
(1) When the α*i* position coder is used



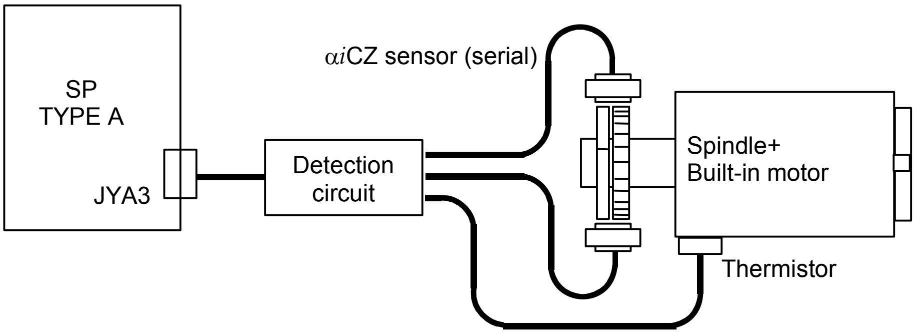
(2) When the α position coder S is used



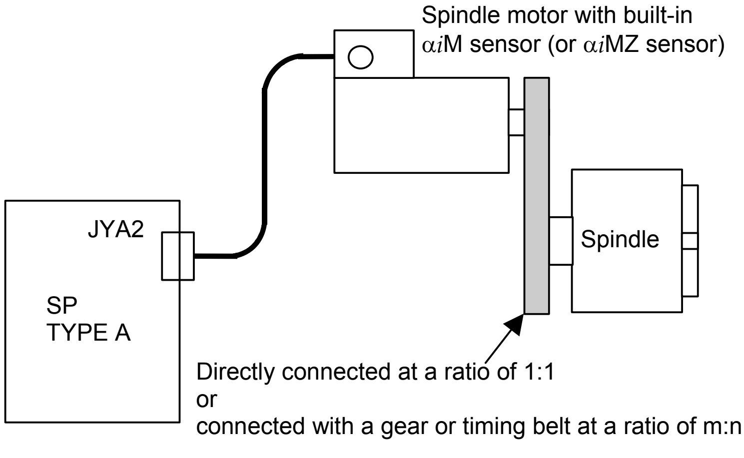
(3) When the built-in motor (αiBZ sensor or αiCZ sensor (analog)) is used



(4) When the built-in motor (αiCZ sensor (serial)) is used



(5) When the spindle motor with built-in αiM sensor (or αiMZ sensor) is used



NOTE

1 When performing rigid tapping by using a signal from the sensor built into the motor as a position feedback signal, use one of the following functions if the gear ratio between the motor and spindle is other than 1:1
   (a) Detection arbitrary gear ratio function (DMR function)
   (b) Command arbitrary gear ratio function (CMR function)

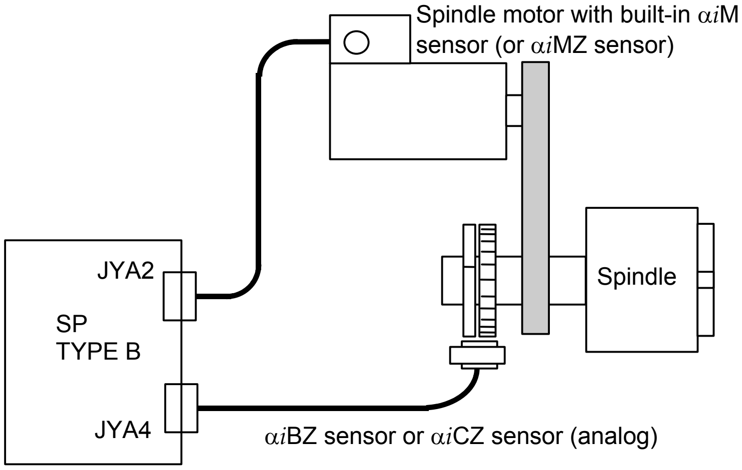
2 When using the detection arbitrary gear ratio function (DMR function), set the following:
   - Parameters (No. 4171 to No. 4174) for the numerator/denominator of an arbitrary gear ratio between the motor sensor and spindle

3 When using the detection arbitrary gear ratio function (DMR function) with a motor containing a built-in αiMZ sensor, set bit 6 of No. 4007 to 1 so that the alarms related to the position feedback signal (when non-Cs contouring control is exercised) are not detected.

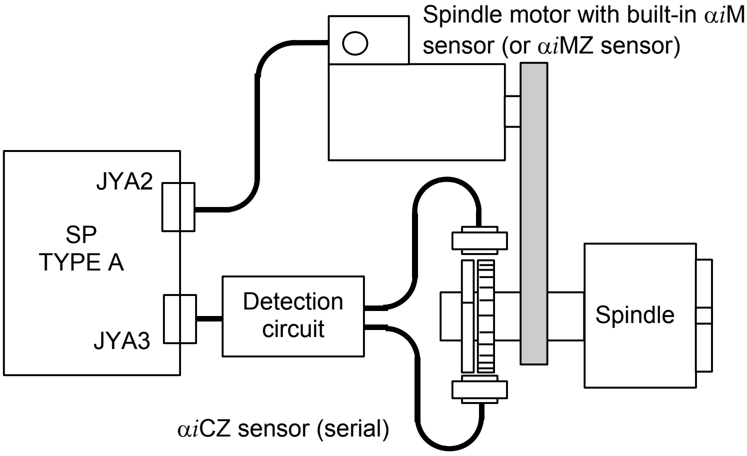
4 When using the command arbitrary gear ratio function (CMR function) with FS16*i*, set the following:
   - Enable the setting of an arbitrary gear ratio between the spindle and position coder (bit 1 of No. 5200 = 1).
   - Enable the setting of the command arbitrary gear ratio function (CMR) on rigid tapping (bit 7 of No. 4006 = 1).
   - Set the parameters for specifying the number of gear teeth on the spindle side (No. 5221 to No. 5224).
   - Set the parameters for specifying the number of gear teeth on the position coder side (No. 5231 to No. 5234).

5 Reference position return can be performed when a motor with a built-in αiMZ sensor is used and the spindle is directly connected to the motor or the spindle is connected to the motor at a ratio of 1:1.

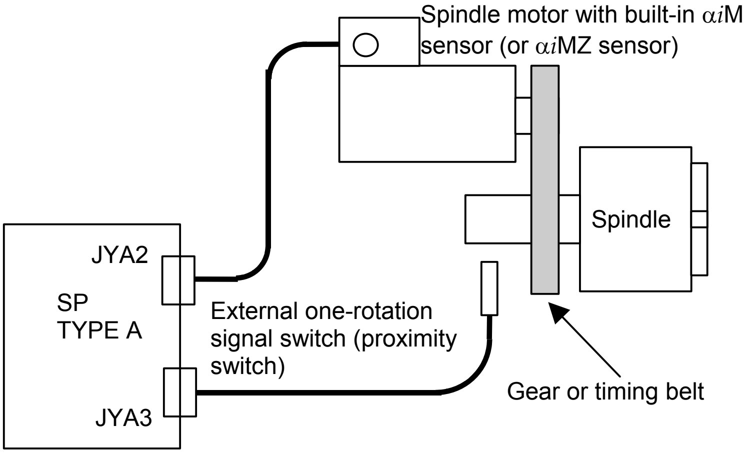
(6) When the separate type αiBZ sensor or separate type αiCZ sensor (analog) is used



(7) When the separate type αiCZ sensor (serial) is used



(8) When the external one-rotation signal (proximity switch) is used



NOTE

1. When using the external one-rotation signal (proximity switch), use the detection arbitrary gear ratio function (DMR function).
2. When using the detection arbitrary gear ratio function (DMR function), set the following:
   - Parameters (No. 4171 to No. 4174) for the numerator/denominator of an arbitrary gear ratio between the motor sensor and spindle
3. Set the type of the external one-rotation signal (proximity switch) (bits 3 and 2 of No. 4004).
4. For stable detection of the one-rotation signal, set a reference position return speed (No. 4074) from 50 to 100 min^{-1} according to the specification of the used external one-rotation signal (proximity switch).
5. When orientation based on the external one-rotation signal is used together, match the reference position return speed and direction with the orientation speed and direction.

2.3.5 List of I/O Signals (CNC↔PMC)

This Subsection provides a list of the I/O signals related to rigid tapping only. For details of each signal, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.11, “RIGID TAPPING.”

(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.11, “RIGID TAPPING.”

(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.8, “RIGID TAPPING.”

(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.10, “RIGID TAPPING.”

(e) For Series 30*i*/31*i*/32*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.12, “RIGID TAPPING.”

(f) For Series 0*i*-D
“FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.13, “RIGID TAPPING.”

For details of the I/O signals common to the CNCs, see Chapter 3, “I/O SIGNALS (CNC↔PMC)”, in Part I.

(1) Input signals (PMC→CNC)

(a) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
G027							SWS2 (*1)	SWS1 (*1)
G028						GR2	GR1	
G029								GR21 (*2)
G061								RGTAP

NOTE

1 The rigid tapping of the second spindle is available by the multi-spindle control function.
When SWS1 is set to 1 (regardless of whether SWS2 is set to 0 or 1), rigid tapping is performed using the 1st spindle. When SWS1 is set to 0, and SWS2 is set to 1, rigid tapping is performed using the 2nd spindle.

2 This signal is used when the rigid tapping of the second spindle. According to the GR21 signal, the individual gear parameters for gear 1 or 2, also used for the 1st spindle, are selected.

(b) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
G027							SWS2 (*1)	SWS1 (*1)
G028						GR2	GR1	
G029							GR22 (*2)	GR21 (*2)
G061								RGTAP

NOTE
1 The rigid tapping of the second spindle is available by the multi-spindle control function.
When SWS1 is set to 1 (regardless of whether SWS2 is set to 0 or 1), rigid tapping is performed using the 1st spindle. When SWS1 is set to 0, and SWS2 is set to 1, rigid tapping is performed using the 2nd spindle.
2 This signal is used when the rigid tapping of the second spindle.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
1st-	G026								SPSTPA
2nd-	G272								SPSTPB

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070			SFRA	SRVA	CTH1A	CTH2A		
2nd-	G235	G074	G074			SFRB	SRVB	CTH1B	CTH2B		

(2) Output signals (CNC→PMC)

(a) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F065							RGSPM (*1)	RGSPP (*1)
F076					RTAP			

NOTE
1 These signals are effective when M series.

(b) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F065							RGSPM (*1)	RGSPP (*1)
F076					RTAP			

NOTE
1 These signals are effective when M series.

(c) Series 15*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F040				RTAP				
F155						RSPC	RSPM	RSPP

2.3.6 Sequence

For a rigid tapping sequence, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.11, “RIGID TAPPING.”

(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.11, “RIGID TAPPING.”

(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.8, “RIGID TAPPING.”

(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.10, “RIGID TAPPING.”

(e) For Series 30*i*/31*i*/32*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.12, “RIGID TAPPING.”

(f) For Series 0*i*-D
“FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.13, “RIGID TAPPING.”

2.3.7 Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
-	5210	5210	M code of rigid tapping command
5606#6	5202#0 (M series only)	5202#0	Whether to perform orientation (reference position return) when starting rigid tapping
-	3706#1,0 3707#1,0	-	Gear ratio between spindle and position coder, 1:1, 1:2, 1:4, 1:8
5842	-	3720	Number of pulse of the position coder
-	5200#1	-	Selection of arbitrary gear ratio between spindle and position coder
5852 5855 5858 5861	5221 5222 5223 5224	5221 5222 5223 5224	Teeth number of spindle side at arbitrary gear ratio (command) setting (16*i*/30*i*: No. 5224 is used for the T series only.)
5851 5854 5857 5860	5231 5232 5233 5234	5231 5232 5233 5234	Teeth number of position coder side at arbitrary gear ratio (command) setting (16*i*/30*i*: No. 5234 is used for the T series only.)
3065 to 3068	5280 5281 to 5284	5280 5281 to 5284	Position gain of tapping axis at rigid tapping (16*i*/30*i*: No. 5284 is used for the T series only.)
5605#1	-	-	Acc/Dec type (Set to 1.)
5711	5241 5242 5243 5244	5241 5242 5243 5244	Spindle maximum speed at rigid tapping (16*i*/30*i*: No. 5244 is used for the T series only.)

Parameter No.			Description
15*i*	**16*i***	**30*i***	
5605#2 5757 5886 5889 5892	- - - - -	- - - - -	Spindle speed for determining an acceleration value for cutting feed on rigid tapping
5605#2 5751 5886 5889 5892	5261 5262 5263 5264	5261 5262 5263 5264	Acc/Dec time constant (16*i*/30*i*: No. 5264 is used for the T series only.)
5605#2 5752 5885 5888 5891 5894	- - - - -	- - - - -	FL speed for spindle and drilling axis acceleration/deceleration on rigid tapping
-	5200#4	5200#4	Override selection at extracting
5883	5211	5211	Override value at extracting
-	5201#2 5271 to 5274	5201#2 5271 to 5274	Time constant at extracting (No. 5274 is used for the T series only.)
-	-	5203#2	Feed-forward function at rigid tapping
1827	5300	5300	In-position width of tapping axis
5875	5301	5301	In-position width of spindle
1837	5310 5341	5310	Allowable level of position error of tapping axis at moving
5876	5311	5311	Allowable level of position error of spindle at moving
1829	5312	5312	Allowable level of position error of tapping axis at stop
5877	5313	5313	Allowable level of position error of spindle at stop
5853 5856 5859 5862	5321 to 5324	5321 to 5324	Backlash of spindle (16*i*: No. 5322 and No. 5324 are used for the T series only. 30*i*: No. 5324 is used for the T series only.)
-	5203#5	5203#5	Selection of the bell-shaped acceleration/deceleration function for rigid tapping (the CNC software option (bell-shaped acceleration/deceleration for rigid tapping) is required.)
- - - -	5365 5366 5367	5365 5366 5367 5368	Bell-shaped acceleration/deceleration time constant for rigid tapping (For the 16*i*, the relevant parameters are valid with the M series only. For the 30*i*, parameter No. 5368 is valid with the T series only.)
3000#4	4000#4	4000#4	Reference position return direction on servo mode
3002#5	4002#5	4002#5	Whether to enable the rotation direction signal (SFR/SRV) on servo mode
3006#7	4006#7	4006#7	Setting of the command arbitrary gear ratio function (CMR) on rigid tapping
3016#4	4016#4	4016#4	Setting related to the motor voltage control characteristics on Cs contouring control or servo mode
3017#7	4017#7	4017#7	Shortcut function when orientation is specified in stop state
-	-	4037	Velocity loop feed-forward coefficient
3044 3045	4044 4045	4044 4045	Velocity loop proportional gain on servo mode/spindle synchronous control (It is selected by input signal CTH1A/B.)
3052 3053	4052 4053	4052 4053	Velocity loop integral gain on servo mode/spindle synchronous control (It is selected by input signal CTH1A/B.)
3056 to 3059	4056 to 4059	4056 to 4059	Gear ratio between spindle and motor (It is selected by input signal CTH1A or CTH2A)

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3065 to 3068	4065 to 4068	4065 to 4068	Spindle position gain on servo mode/spindle synchronous control (It is selected by input signal CTH1A or CTH2A)
3073	4073	4073	Grid shift amount on servo mode
3074	4074	4074	Reference position return speed on Cs contouring control/servo mode
3091	4091	4091	Position gain change ratio at reference position return time on servo mode
3085	4085	4085	Motor voltage (for high-speed characteristics) on servo mode/spindle synchronous control
3137	4137	4137	Motor voltage (for low-speed characteristics) on servo mode/spindle synchronous control
3099	4099	4099	Delay time for stable motor excitation
3171 3173	4171 4173	4171 4173	Denominator of an arbitrary gear ratio between the motor sensor and spindle (A parameter is selected by the input signal CTH1A.)
3172 3174	4172 4174	4172 4174	Numerator of an arbitrary gear ratio between the motor sensor and spindle (A parameter is selected by the input signal CTH1A.)
-	-	4344	Advanced preview feed-forward coefficient
3406	4406	4406	Acceleration/deceleration time constant for Cs contouring control/servo mode
	-	4540#1	Setting related to motor voltage control characteristics on servo mode
-	-	4549#1	Setting for FSSB high-speed rigid tapping

NOTE

1 For the parameters related to detectors, see Section 1.3, "PARAMETERS RELATED TO DETECTORS" in the Part I.

2 For velocity loop proportional/integral gain adjustment, see Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT", in Part I.

2.3.8 Details of Related Parameters

This Subsection details the serial spindle parameters (in the four thousands for 16*i*, and in the four thousands for 30*i*, and in the three thousands for 15*i*) among the parameters related to rigid tapping. For details of other parameters, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.11, "RIGID TAPPING."

(b) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.11, "RIGID TAPPING."

(c) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.8, "RIGID TAPPING."

(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.10, "RIGID TAPPING."

(e) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.12, "RIGID TAPPING."

(f) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.13, "RIGID TAPPING."

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3000	4000	4000				RETSV				

RETSV Reference position return direction on servo mode (rigid tapping/spindle positioning)
0 : The spindle performs a reference position return operation in the CCW(counterclockwise) direction.
1 : The spindle performs a reference position return operation in the CW(clockwise) direction.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3002	4002	4002			SVMDRT					

SVMDRT Whether to enable the rotation direction signal (SFR/SRV) function on servo mode (rigid tapping/spindle positioning)
0 : Enables the rotation direction function.
If a move command from the CNC is positive (+),
(a) The spindle rotates in the CCW direction when the input signal SFR (bit 5 of G70) = 1.
(b) The spindle rotates in the CW direction when the input signal SRV (bit 4 of G70) = 1.
1 : Disables the rotation direction function.
If a move command from the CNC is positive (+), the spindle rotates in the CCW direction when the input signal SFR = 1 or SRV = 1.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3006	4006	4006	RGTCMR							

RGTCMR Sets the command arbitrary gear ratio function (CMR) on rigid tapping.
0 : Disables the command arbitrary gear ratio function.
1 : Enables the specified arbitrary gear ratio function.
Set this parameter to 1 when rigid tapping is performed using a signal from the sensor built-into the motor as a position feedback signal and the gear ratio between the motor and spindle is other than 1:1.
When using the command arbitrary gear ratio function (CMR function), set the following as well:

- Enabling an arbitrary gear ratio between the spindle and position coder (bit 1 of No. 5200 = 1)
- Parameters for the number of gear teeth on the spindle side (No. 5221 to No. 5224)
- Parameters for the number of gear teeth on the position coder side (No. 5231 to No. 5234)

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3016	4016	4016				IDLPTN				

IDLPTN Setting related to the motor voltage control characteristics on Cs contouring control or servo mode (rigid tapping)
Set this bit to 1 when setting a value less than 100 as the motor voltage on Cs contouring control (No. 4086) or as the motor voltage on servo mode (No. 4085).

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3017	4017	4017	NRROEN							

NRROEN Specifies whether to use the shortcut function when orientation is specified in the stop state.

0 : Does not use the function.
1 : Uses the function.
When the setting is 1, shortcut operation is performed when the following conditions are satisfied:
i) Bit 7 (RFCHK3) of parameter No. 4016 is set to 0.
ii) Zero speed detection output signal SST is set to 1.
iii) Shortcut command input signal NRROA is set to 1.

-	-	30*i*	
-	-	4037	**Velocity loop feed-forward coefficient**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets a velocity loop feed-forward coefficient for using feed-forward control. Set the result of calculation of the following expression:

$$\text{Setting} = 214466 \times \frac{[\text{spindle inertia + rotor inertia}](\text{kg}\cdot\text{m}^2)}{\text{Maximum motor torque (N}\cdot\text{m)}}$$

15*i*	16*i*	30*i*	
3044	4044	4044	**Velocity loop proportional gain on servo mode/spindle synchronous control (HIGH) CTH1A=0**
3045	4045	4045	**Velocity loop proportional gain on servo mode/spindle synchronous control (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

These parameters set a velocity loop proportional gain on servo mode (rigid tapping/spindle positioning) or spindle synchronous control.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*	
3052	4052	4052	**Velocity loop integral gain on servo mode/spindle synchronous control (HIGH) CTH1A=0**
3053	4053	4053	**Velocity loop integral gain on servo mode/spindle synchronous control (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

These parameters set a velocity loop integral gain on servo mode (rigid tapping/spindle positioning) or spindle synchronous control.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)

Valid data range : 0 to 32767
Standard setting : 100

These data are used to set the gear ratio between spindle and spindle motor.
Example :
When the spindle rotates once, set "250" as the data when the motor rotates 2.5 times.
A parameter is selected with the CTH1A and CTH2A input signals.
Set the gear or clutch status to correspond to the clutch/gear signal (CTH1A, CTH2A) in input signals.

> **NOTE**
> When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*	
3065	4065	4065	**Spindle position gain on servo mode/spindle synchronous control (HIGH) CTH1A=0, CTH2A=0**
3066	4066	4066	**Spindle position gain on servo mode/spindle synchronous control (MEDIUM HIGH) CTH1A=0, CTH2A=1**
3067	4067	4067	**Spindle position gain on servo mode/spindle synchronous control (MEDIUM LOW) CTH1A=1, CTH2A=0**
3068	4068	4068	**Spindle position gain on servo mode/spindle synchronous control (LOW) CTH1A=1, CTH2A=1**

Unit of data : 0.01sec^{-1}
Valid data range : 0 to 32767
Standard setting value : 1000

These parameters set a position gain on servo mode (rigid tapping/spindle positioning) or spindle synchronous control.
A parameter is selected according to the input signals CTH1A and CTH2A.

15*i*	16*i*	30*i*	
3073	4073	4073	**Grid shift amount on servo mode**

Unit of data : 1 pulse unit (360 degrees/4096)
Valid data range : 0 to 4095
Standard setting value : 0

This parameter is used to shift the reference position on servo mode (rigid tapping/spindle positioning).
The reference position of the spindle is shifted in the CCW direction by the specified number of pulses.

15*i*	16*i*	30*i*	
3074	4074	4074	**Reference position return speed on Cs contouring control/servo mode**

Unit of data : 1min^{-1}
Valid data range : 0 to 32767
Standard setting value : 0

- When 0 is set
  The orientation speed is the reference position return speed in servo mode (rigid tapping/spindle positioning).
- When a value other than 0 is set

The value set in this parameter is used as a reference position return speed on servo mode (rigid tapping/spindle positioning).

> **NOTE**
> When using an external one-rotation signal (proximity switch), for stable detection of the one-rotation signal, set a reference position return speed (parameter No. 4074) from 50 to 100 min^{-1} according to the specification of the external one-rotation signal (proximity switch) you want to use.

15*i*	16*i*	30*i*	
3085	4085	4085	**Motor voltage (for high-speed characteristics) on servo mode/ spindle synchronous control**
3137	4137	4137	**Motor voltage (for low-speed characteristics) on servo mode/ spindle synchronous control**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : Depends on the motor model.

These parameters set a motor voltage on servo mode (rigid tapping, spindle positioning, and so forth) and spindle synchronous control.
When performing rigid tapping, set "100" usually.
When the maximum speed for rigid tapping (in terms of motor axis) is higher than the base speed of the spindle motor (No. 4100 for high-speed characteristics and No. 4138 for low-speed characteristics), set a value less than "100" as the motor voltage for rigid tapping (No. 4085 for high-speed characteristics and No. 4137 for low-speed characteristics), according to the following expression:

$$\text{Motor voltage (\%)} = 100 \times \frac{\text{Spindle motor base speed}}{\text{Maximum speed for rigid tapping (in terms of motor axis)}}$$

In this case, set "1" for the setting related to the motor voltage control characteristics (bit 4 of parameter No. 4016) or the setting related to the motor voltage control characteristics on servo mode (bit 1 of parameter No. 4540).

15*i*	16*i*	30*i*	
3091	4091	4091	**Position gain change ratio at reference position return time on servo mode**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 100

This parameter sets a position gain change ratio at reference position return time on servo mode (rigid tapping, spindle positioning, and so forth).

> **NOTE**
> An overshoot can occur at reference position return time for a cause such as an excessively high reference position return speed and an excessively large spindle inertia. In this case, an overshoot can be avoided by setting a small value in this parameter.

15*i*	16*i*	30*i*	
3099	4099	4099	**Delay time for stable motor excitation**

Unit of data : 1ms
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets a period of time required until motor excitation becomes stable at the time of switching to rigid tapping or Cs contouring control.

> **NOTE**
> In switching from the velocity control mode to rigid tapping mode, the stop time excessive error alarm can be issued intermittently. This is because the excitation state of the spindle motor changes abruptly, and therefore a transient state occurs in the motor, thus moving the motor shaft slightly.
> In such a case, set this parameter. In general, set a value from about 300 to 400 (300 to 400 msec).

15*i*	16*i*	30*i*	
3171	4171	4171	**Denominator of an arbitrary gear ratio between the motor sensor and spindle (HIGH) CTH1A=0**
3172	4172	4172	**Numerator of an arbitrary gear ratio between the motor sensor and spindle (HIGH) CTH1A=0**
3173	4173	4173	**Denominator of an arbitrary gear ratio between the motor sensor and spindle (LOW) CTH1A=1**
3174	4174	4174	**Numerator of an arbitrary gear ratio between the motor sensor and spindle (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

These parameters set conversion coefficients (numerator, denominator) for using the detection arbitrary gear ratio function (DMR function) by multiplying a motor sensor (α*i*M sensor or α*i*MZ sensor) feedback signal by a gear ratio to produce a spindle position feedback signal.
When the spindle rotates Q times while the motor shaft rotates P times (there is no common divisor other than 1 for P and Q), the settings are:

No. 4171 (No. 4173 when CTH1A = 1) = P
No. 4172 (No. 4174 when CTH1A = 1) = Q

When 0 is set in any of these parameters, the setting of 1 is assumed.

> **NOTE**
> When using the external one-rotation signal (proximity switch), use the detection arbitrary gear ratio function (DMR function) by setting an arbitrary gear ratio between the motor sensor and spindle with this parameter.

15*i*	16*i*	30*i*	
-	-	4344	**Advanced preview feed-forward coefficient**

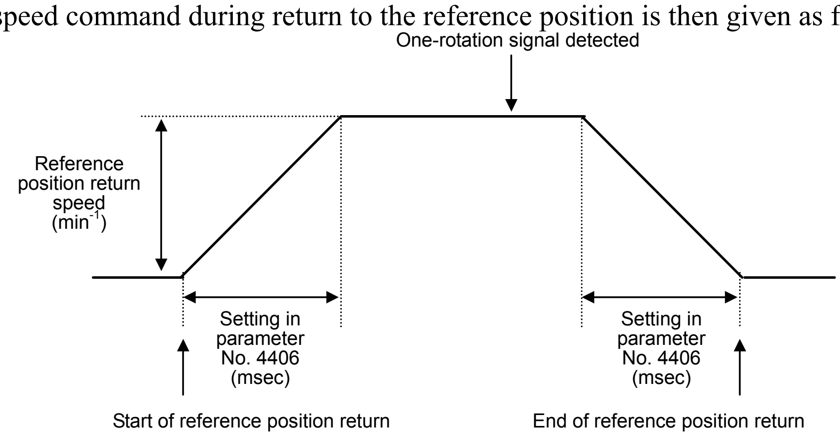
Unit of data : 0.01%
Valid data range : 0 to 10000
Standard setting value : 0

This parameter sets a feed-forward coefficient for using feed-forward control. Set the same value as for the servo axis simultaneously subjected to interpolation.

15i	16i	30i	
3406	4406	4406	**Acceleration/deceleration time constant for reference position return on Cs contouring control/servo mode**

Unit of data : 1msec
Valid data range : 0 to 32767
Standard setting : 0

This parameter sets a reference position return acceleration for Cs contouring control or servo mode (rigid tapping/spindle positioning). Use of this parameter can reduce the shock due to acceleration/deceleration during return to the reference position. The spindle speed command during return to the reference position is then given as follows:



NOTE

1 When 0 is set in this parameter, a velocity command is assumed as follows.
- Before detecting the one-rotation signal: Reference position return speed (step-type velocity command)
- After detecting the one-rotation signal:
  Distance to the reference position × Position gain

2 This parameter is enabled when soft start/stop signal SOCNA is 1.

15i	16i	30i	#7	#6	#5	#4	#3	#2	#1	#0
-	-	4540							EXPTRG	

EXPTRG Setting related to the motor voltage control characteristics on servo mode (rigid tapping)
Set this bit to 1 when setting a value less than 100 as the motor voltage on servo mode (parameter No. 4085).
This bit is valid only for the setting for the motor voltage on servo mode (parameter No. 4085).

15i	16i	30i	#7	#6	#5	#4	#3	#2	#1	#0
-	-	4549							FHRSP	

FHRSP Setting for FSSB high-speed rigid tapping
0 : FSSB high-speed rigid tapping is disabled.
1 : FSSB high-speed rigid tapping is enabled.

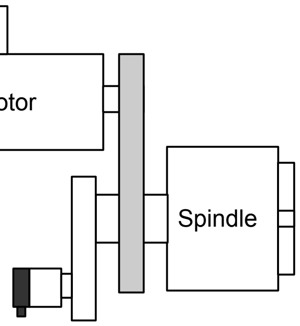
2.3.9 Parameter Setting Procedure

(1) Command arbitrary gear ratio (CMR)

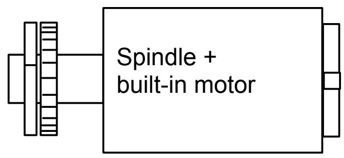
(a) For a configuration in which the sensor built into the motor is used for position detection and the gear ratio between the spindle and motor is not 1:1, as shown in sample system configuration 2 below, the command arbitrary gear ratio (CMR) is used.

[Sample system configuration 1]

When the position detector is connected to the spindle at a ratio of 1:1, the command arbitrary gear ratio (CMR) function is not used.



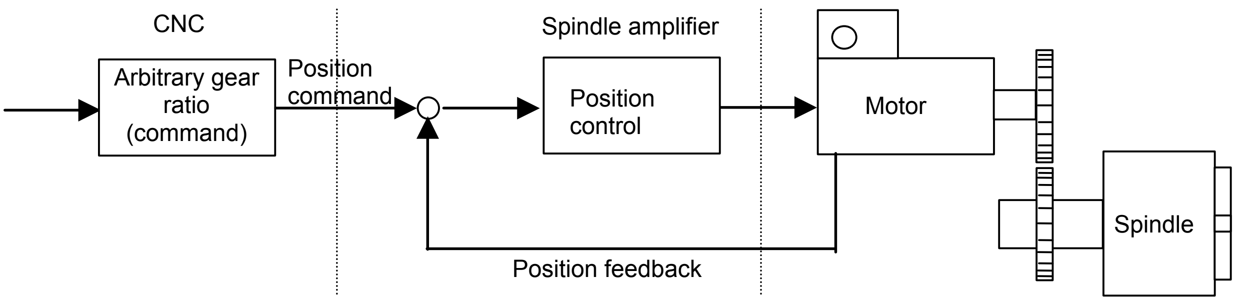
αi position coder
(connected to the spindle at a ratio of 1:1)



αiBZ sensor
(directly connected to the spindle)

[Sample system configuration 2]

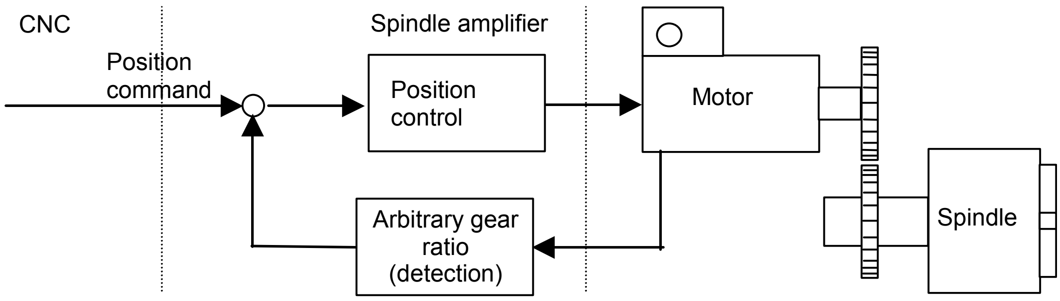
When the sensor built into the motor is used as the position detector in a configuration in which the gear ratio between the spindle and motor is not 1:1, the command arbitrary gear ratio (CMR) function is used.



> **NOTE**
> This system configuration also enables the detection arbitrary gear ratio function (DMR function) to be used.

[Sample system configuration 3]

When orientation by the external one-rotation signal is used in a configuration in which the gear ratio between the spindle and motor is not 1:1, the detection arbitrary gear ratio function (DMR function) is used, and the command arbitrary gear ratio function (CMR function) is not used.



(b) To use the command arbitrary gear ratio (CMR), set the following parameters:

15*i*	16*i*	30*i*	Setting data
3006#7	4006#7	4006#7	1

0 : The command arbitrary gear ratio (CMR) is not used.
1 : Rigid tapping is performed using the command arbitrary gear ratio (CMR) with the sensor built into the motor.

(c) Set the parameters to enable the command arbitrary gear ratio (arbitrary gear ratio between the spindle and position coder).

15*i*	16*i*	30*i*	Setting data
-	5200#1	-	1

(d) Set the parameter "the arbitrary gear ratio between the spindle and the position coder" according to each CNC.

[Series 16*i*]

(1) Set the gear teeth number of the spindle side.
Each parameter is selected according to the gear selection signal.
Standard machining [M series] : GR3O, GR2O, GR1O
Turning [T series] and machining [M series] with surface speed constant option : GR2, GR1
Second spindle of turning [T series] : GR21 (Multi-spindle control option is needed)

Standard machining [M series]

Gear signal			Parameter No.
GR1O	GR2O	GR3O	
1	0	0	5221
0	1	0	5222
0	0	1	5223

Turning [T series] and machining [M series] with surface speed constant

<table>
<tr><th colspan="3">Gear signal</th><th colspan="2" rowspan="2">Parameter No.</th></tr>
<tr><th colspan="2">1st. sp</th><th>2nd. sp</th></tr>
<tr><th>GR1</th><th>GR2</th><th>GR21</th><th>T series</th><th>M series</th></tr>
<tr><td>0</td><td>0</td><td>0</td><td colspan="2">5221</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td colspan="2">5222</td></tr>
<tr><td>0</td><td>1</td><td>—</td><td colspan="2">5223</td></tr>
<tr><td>1</td><td>1</td><td>—</td><td>5224</td><td>5223</td></tr>
</table>

(2) Set the gear teeth number of the position coder side.
Each parameter is selected according to the gear selection signal.
Standard machining [M series]: GR3O, GR2O, GR1O
Turning [T series] and machining[M series] with surface speed constant option : GR2, GR1
Second spindle of turning [T series] : GR21 (Multi- spindle control option is needed)

Standard machining [M series]

Gear signal			Parameter No.
GR1O	GR2O	GR3O	
1	0	0	5231
0	1	0	5232
0	0	1	5233

Turning [T series] and machining [M series] with surface speed constant

Gear signal			Parameter No.	
1st. sp		2nd. sp		
GR1	GR2	GR21	T series	M series
0	0	0	5231	
1	0	1	5232	
0	1	–	5233	
1	1	–	5234	5233

[Series 30*i*]

(1) Set the gear teeth number of the spindle side.
Each parameter is selected according to the gear selection signal.
Standard machining [M series] : GR3O, GR2O, GR1O
Turning [T series] and machining [M series] with surface speed constant option : GR2, GR1
Second spindle : GR21, GR21 (Multi-spindle control option is needed)

Standard machining [M series]

Gear signal			Parameter No.
GR1O	GR2O	GR3O	
1	0	0	5221
0	1	0	5222
0	0	1	5223

Turning [T series] and machining [M series] with surface speed constant

Gear signal		Parameter No.	
GRs1*	GRs2*	T series	M series
0	0	5221	
1	0	5222	
0	1	5223	
1	1	5224	5223

* First spindle: GR1, GR2 / Second spindle: GR21, GR22

(2) Set the gear teeth number of the position coder side.
Each parameter is selected according to the gear selection signal.
Standard machining [M series]: GR3O, GR2O, GR1O
Turning [T series] and machining[M series] with surface speed constant option: GR2, GR1
Second spindle : GR21, GR21
(Multi-spindle control option is needed)

Standard machining [M series]

Gear signal			Parameter No.
GR1O	GR2O	GR3O	
1	0	0	5231
0	1	0	5232
0	0	1	5233

Turning [T series] and machining [M series] with surface speed constant

Gear signal		Parameter No.	
GRs1*	GRs2*	T series	M series
0	0	5231	
1	0	5232	
0	1	5233	
1	1	5234	5233

* First spindle: GR1, GR2 / Second spindle: GR21, GR22

[Series 15*i*]

Gear signal		Parameter No.	
CTH1A	CTH2A	Gear teeth number of spindle side	Gear teeth number of position coder side
0	0	5852	5851
0	1	5855	5854
1	0	5858	5857
1	1	5861	5860

(2) Gear ratio between the spindle and the motor

The loop gain constant (position gain constant) parameter is not used in the αi series (serial) spindle system.
"Gear ratio between the spindle and the motor" parameter should be set instead of it.
Each parameter is selected according to the gear selection signal (CTH1A/B, CTH2A/B).

[1st. sp]

Gear signal		Parameter No.		
CTH1A	**CTH2A**	**15*i***	**16*i***	**30*i***
0	0	3056 (S1)	4056 (S1)	4056 (S1)
0	1	3057 (S1)	4057 (S1)	4057 (S1)
1	0	3058 (S1)	4058 (S1)	4058 (S1)
1	1	3059 (S1)	4059 (S1)	4059 (S1)

[2nd. sp]

Gear signal		Parameter No.		
CTH1B	**CTH2B**	**15*i***	**16*i***	**30*i***
0	0	3056 (S2)	4056 (S2)	4056 (S2)
0	1	3057 (S2)	4057 (S2)	4057 (S2)
1	0	3058 (S2)	4058 (S2)	4058 (S2)
1	1	3059 (S2)	4059 (S2)	4059 (S2)

(3) Position gain

In rigid tapping, the tapping axis and spindle are controlled to be synchronized. So, the position gains of the tapping axis and spindle must be set to the same value.

[Series 16*i*]

The position gain parameter of the tapping axis in the rigid tapping is selected as follows according to the gear selection signal.
Standard machining [M series]: GR3O, GR2O, GR1O
Turning [T series] and machining [M series] with surface speed constant option : GR2, GR1
Second spindle of turning [T series]: GR21 (Multi-spindle control option is needed)

Standard machining [M series]

Gear signal			Parameter No.
GR1O	**GR2O**	**GR3O**	
			5280 (*1)
1	0	0	5281
0	1	0	5282
0	0	1	5283

Turning [T series] and machining [M series] with surface speed constant

Gear signal			Parameter No.	
1st. sp		**2nd. sp**		
GR1	**GR2**	**GR21**	**T series**	**M series**
			5280 (*1)	
0	0	0	5281	
1	0	1	5282	
0	1		5283	
1	1		5284	5283

NOTE
1 When this parameter is "0", each gear parameter becomes valid.
When this parameter is not "0", each gear parameter becomes invalid, and this parameter is always used.

The position gain parameter of the spindle in the rigid tapping is selected as follows according to the gear selection signal (CTH1A/B, CTH2A/B). (This is common T series and M series)

[1st. sp]

Gear signal		Parameter No.
CTH1A	CTH2A	
0	0	4065 (S1)
0	1	4066 (S1)
1	0	4067 (S1)
1	1	4068 (S1)

[2nd. sp]

Gear signal		Parameter No.
CTH1B	CTH2B	
0	0	4065 (S2)
0	1	4066 (S2)
1	0	4067 (S2)
1	1	4068 (S2)

⚠ **CAUTION**

Take care to input the gear selection signal GR1, GR2, GR21, GR1O, GR2O, GR3O and CTH1A/B, CTH2A/B according to the real gear state in order to get the same position gain of the tapping axis and that of the spindle, because GR1, GR2, GR21, GR1O, GR2O, GR3O and CTH1A/B, CTH2A/B are inputted independently.

[Series 30*i*]

The position gain parameter of the tapping axis in the rigid tapping is selected as follows according to the gear selection signal.
Standard machining [M series]: GR3O, GR2O, GR1O
Turning [T series] and machining [M series] with surface speed constant option : GR2, GR1
Second spindle : GR22, GR21(Multi-spindle control option is needed)

Standard machining [M series]

Gear signal			Parameter No.
GR1O	GR2O	GR3O	
1	0	0	5231
0	1	0	5232
0	0	1	5233

Turning [T series] and machining [M series] with surface speed constant

Gear signal		Parameter No.	
GRs1*	GRs2*	T series	M series
		5280 [*1]	
0	0	5281	
1	0	5282	
0	1	5283	
1	1	5284	5283

* First spindle: GR1, GR2 / Second spindle: GR21, GR22

NOTE

1 When this parameter is "0", each gear parameter becomes valid.
When this parameter is not "0", each gear parameter becomes invalid, and this parameter is always used.

The position gain parameter of the spindle in the rigid tapping is selected as follows according to the gear selection signal (CTH1A/B, CTH2A/B). (This is common T series and M series)

[1st. sp]

Gear signal		Parameter No.
CTH1A	CTH2A	
0	0	4065 (S1)
0	1	4066 (S1)
1	0	4067 (S1)
1	1	4068 (S1)

[2nd. sp]

Gear signal		Parameter No.
CTH1B	CTH2B	
0	0	4065 (S2)
0	1	4066 (S2)
1	0	4067 (S2)
1	1	4068 (S2)

> ⚠ **CAUTION**
> Take care to input the gear selection signal GR1, GR2, GR21, GR22, GR1O, GR2O, GR3O and CTH1A/B, CTH2A/B according to the real gear state in order to get the same position gain of the tapping axis and that of the spindle, because GR1, GR2, GR21, GR22, GR1O, GR2O, GR3O and CTH1A/B, CTH2A/B are inputted independently.

[Series 15*i*]

In the rigid tapping, the same parameter address data is used for the position gain of the tapping axis and the spindle.
Each position gain is selected as follows according to the gear selection signal (CTH1A, CTH2A).

Gear signal		Parameter No.
CTH1A	CTH2A	
0	0	3065
0	1	3066
1	0	3067
1	1	3068

(4) Acceleration/deceleration time constant
[Series 16*i*]

(1) Each parameter can be set for each gear and is selected according to the gear selection signal.
By setting the following parameter, the different time constant between the cutting in and cutting out (extracting) becomes available.

5201 #2

0 : The same time constant between cutting in and out. (No. 5261 to 5264)

1 : The different time constant between cutting in and out.
Cutting in : No. 5261 to 5264
Cutting out: No. 5271 to 5274

Standard Machining [M series]: GR3O, GR2O, GR1O
Turning [T series] and Machining [M series] with surface speed constant : GR2, GR1
2nd. sp of Turning [T series] : GR21 (Multi- spindle control option is needed)

Standard machining [M series]

Gear signal			Time constant (Cutting in) Parameter No.	Time constant (Cutting out) Parameter No.	Spindle max. speed at rigid tapping Parameter No.
GR1O	GR2O	GR3O			
1	0	0	5261	5271	5241
0	1	0	5262	5272	5242
0	0	1	5263	5273	5243

Turning [T series] and machining [M series] with surface speed constant

Gear signal			Time constant (Cutting in) Parameter No.	Time constant (Cutting out) Parameter No.	Spindle max. speed at rigid tapping Parameter No.	
1st. sp		2nd. sp				
GR1	GR2	GR21			T series	M series
0	0	0	5261	5271	5241	5241
1	0	1	5262	5272	5242	5242
0	1	-	5263	5273	5243	5243
1	1	-	5264 (*1)	5274 (*1)	5244 (*1)	-

> **NOTE**
> 1 This is not available for Machining (M series).

(2) The override at extracting.

5200 #4 0 : The override at extracting is not valid.
1 : The override at extracting is valid.
(Set override value at No. 5211)

[Series 30*i*]

(1) Each parameter can be set for each gear and is selected according to the gear selection signal.
By setting the following parameter, the different time constant between the cutting in and cutting out (extracting) becomes available.

5201 #2 0 : The same time constant between cutting in and out. (No. 5261 to 5264)

1 : The different time constant between cutting in and out.
Cutting in : No. 5261 to 5264
Cutting out: No. 5271 to 5274

Standard Machining [M series]: GR3O, GR2O, GR1O
Turning [T series] and Machining [M series] with surface speed constant : GR2, GR1
2nd. sp : GR21, GR21 (Multi- spindle control option is needed)

Standard machining [M series]

Gear signal			Time constant (Cutting in) Parameter No.	Time constant (Cutting out) Parameter No.	Spindle max. speed at rigid tapping Parameter No.
GR1O	GR2O	GR3O			
1	0	0	5261	5271	5241
0	1	0	5262	5272	5242
0	0	1	5263	5273	5243

Turning [T series] and machining [M series] with surface speed constant

Gear signal		Time constant (Cutting in) Parameter No.	Time constant (Cutting out) Parameter No.	Spindle max. speed at rigid tapping Parameter No.	
GRs1*	GRs2*			T series	M series
0	0	5261	5271	5241	5241
1	0	5262	5272	5242	5242
0	1	5263	5273	5243	5243
1	1	5264 (*1)	5274 (*1)	5244 (*1)	-

* First spindle: GR1, GR2 / Second spindle: GR21, GR22

> **NOTE**
> 1 This is not available for Machining (M series).

(2) The override at extracting.

5200 #4 0 : The override at extracting is not valid.
1 : The override at extracting is valid.
(Set override value at No. 5211)

[Series 15*i*]

(1) Acc/Dec type

5605 #1

0 : Exponential type Acc/Dec
1 : Linear type Acc/Dec

NOTE
Usually, linear type acceleration/deceleration (bit 1 of No. 5605 = 1) is used.

(2) Set Acc/Dec the time constant of the rigid tapping mode.
<1> The time constant is a fixed value if bit 2 of parameter No. 5605 = 0.

Acc/Dec time constant	5751
Spindle speed	5757

<2> When bit 2 of parameter No.5605 is set to 1, one of the four acceleration/deceleration time constants is selected, depending on the spindle speed.

	Spindle speed	Acc/Dec time constant
Gear 1	5886	5884
Gear 2	5889	5887
Gear 3	5892	5890
Gear 4	-	5893

2.3.10 Adjustment Procedure

(1) Parameters used for adjustment

The table below lists and describes the parameters used for adjusting rigid tapping.

Parameter No. (FS16*i*,30*i*)	Description
5241 to 5244	Maximum spindle speed on rigid tapping (Depends on the GR signal. No.5244 is for the T series only.)
5261 to 5264	Acceleration/deceleration time constant on rigid tapping (Depends on the GR signal. No.5264 is for the T series only.)
5280 to 5284	Position gain of tapping axis on rigid tapping (No.5280 is for all gears. No.5281 to No.5284 depend on the GR signal. No.5284 is for T series only.)
4065 to 4068	Spindle position gain on rigid tapping (depends on CTH1A and CTH2A signals)
4044 to 4045	Velocity loop proportional gain on rigid tapping (depends on CTH1A signal)
4052 to 4053	Velocity loop integral gain on rigid tapping (depends on CTH1A signal)
4085	Motor voltage on rigid tapping (for high speed characteristics)
4137	Motor voltage on rigid tapping (for low speed characteristics)
4016#4	Motor voltage control characteristic settings on rigid tapping
4099	Delay time for motor excitation.
4540#1	Setting for motor voltage control characteristics on rigid tapping

(2) Initialization

Before adjustment, initialize the parameters related to rigid tapping with a spindle motor.

Parameter No. (FS16*i*,30*i*)	Initial setting
5241~5244	Set the maximum spindle speed on rigid tapping.

5261~5264	Set them with either of the methods <1> and <2> below. <1> Method to set parameters from the spindle acceleration time In velocity control mode, measure the acceleration time [ms] required to achieve the maximum spindle speed on rigid tapping (Nos. 5241 to 5244), and set the value equal to the acceleration time multiplied by 1.5 to 2. <2> Method to set the acceleration/deceleration constant from an expression $tr[\mathrm{ms}] = \frac{Jm[\mathrm{kgm}^2] + JL[\mathrm{kgm}^2]}{T\max(Nr)[\mathrm{Nm}]} \times \frac{2\pi}{60} \times Nr[\mathrm{min}^{-1}] \times Gear \times 1000 \times 1.2$ *tr* [ms] : Acceleration/deceleration time constant on rigid tapping (Nos. 5261 to 5264) *Nr* [min^{-1}] : Maximum spindle speed on rigid tapping (Nos. 5241 to 5244) *Gear* : Gear ratio data between spindle and motor (motor speed per one spindle rotation) *Tmax(Nr)* [Nm] : Maximum torque of the spindle motor at *Nr* *Jm* [kgm^2] : Rotor inertia of the spindle motor *JL* [kgm^2] : Spindle load inertia (converted for the motor shaft)
5280~5284	3000
4065~4068	3000
4044~4045	10
4052~4053	10
4085	100 When the maximum speed for rigid tapping (in terms of motor axis) is higher than the base speed of the spindle motor (No. 4100 for high-speed characteristics), set the value calculated from the following expression: Motor voltage (%)= $100 \times \frac{\text{Spindle motor base speed (No.4100)}}{\text{Maximum speed for rigid tapping (in terms of motor axis)}}$
4137	100 When the maximum speed for rigid tapping (in terms of motor axis) is higher than the base speed of the spindle motor (No. 4138 for low-speed characteristics), set the value calculated from the following expression: Motor voltage (%)= $100 \times \frac{\text{Spindle motor base speed (No.4138)}}{\text{Maximum speed for rigid tapping (in terms of motor axis)}}$
4016#4	0 Set this bit to 1 when setting parameter No. 4085 or 4137 to a value less than 100.
4099	300
4540#1	0 Set this bit to 1 when setting parameter No. 4085 or 4137 to a value less than 100.

(3) Spindle data used for adjustment

Adjust the parameters while observing the motor speed, torque command, velocity error, synchronous error, and other waveform by using a spindle check board and oscilloscope or SERVO GUIDE. The table below lists spindle check board settings for observing the waveform.

<table>
<tr><th colspan="2">Check board setting address</th><th rowspan="2">Settings</th><th rowspan="2">Observing data</th></tr>
<tr><th>Output to CH1</th><th>Output to CH2</th></tr>
<tr><td>d-05</td><td>d-09</td><td>25</td><td rowspan="4">Velocity error
±128 min^{-1} at ±5 V
±256min^{-1} at ±5 V if d-06 (d-10) is set to 13</td></tr>
<tr><td>d-06</td><td>d-10</td><td>12</td></tr>
<tr><td>d-07</td><td>d-11</td><td>0</td></tr>
<tr><td>d-08</td><td>d-12</td><td>1</td></tr>
<tr><td>d-05</td><td>d-09</td><td>90</td><td rowspan="4">Torque command
Maximum positive/negative torque command at ±5 V
Maximum positive/negative torque command at ±2.5 V if d-06 (d-10) is set to 8</td></tr>
<tr><td>d-06</td><td>d-10</td><td>7</td></tr>
<tr><td>d-07</td><td>d-11</td><td>0</td></tr>
<tr><td>d-08</td><td>d-12</td><td>1</td></tr>
<tr><td>d-05</td><td>d-09</td><td>68</td><td rowspan="4">Synchronous error (value converted for the spindle: 4096 pulses/rev)
±128 pulses at ±5 V
±256 pulses at ±5 V if d-06 (d-10) is set to 1
±512 pulses at ±5 V if d-06 (d-10) is set to 2</td></tr>
<tr><td>d-06</td><td>d-10</td><td>0</td></tr>
<tr><td>d-07</td><td>d-11</td><td>0</td></tr>
<tr><td>d-08</td><td>d-12</td><td>1</td></tr>
<tr><td>d-05</td><td>d-09</td><td>19</td><td rowspan="4">Motor speed
±8192 min^{-1} at ±5 V
±4096 min^{-1} at ±5 V if d-06 (d-10) is set to 17
±2048 min^{-1} at ±5 V if d-06 (d-10) is set to 16</td></tr>
<tr><td>d-06</td><td>d-10</td><td>18</td></tr>
<tr><td>d-07</td><td>d-11</td><td>0</td></tr>
<tr><td>d-08</td><td>d-12</td><td>1</td></tr>
</table>

NOTE

When observing the synchronous error of Series 16*i*, set the following parameters:

No. 3700, #7 = 1:
Uses the synchronous error output (maintenance function).
(Return the setting to 0 after the observation is completed.)

No. 5203, #7 = 1 :
Sets a synchronous error update cycle.
(Return the setting to 0 after the observation is completed.)

No. 5204, #0 = 0 :
Displays the synchronous error on the diagnosis screen.

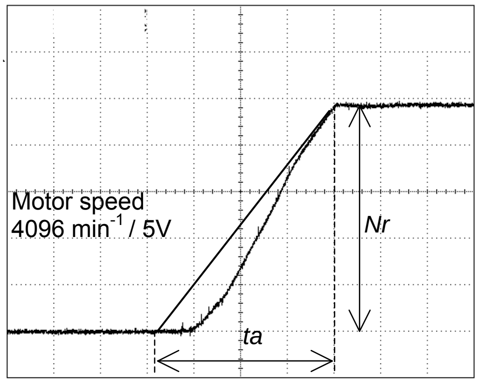
(4) Adjustment procedure

(4)-1 Specifying an acceleration/deceleration time constant (1): Specifying a provisional value

Before optimizing the acceleration/deceleration time constant, adjust the gain to improve the response. Following (a) or (b) below, specify a provisional acceleration/deceleration time constant according to the target maximum speed.

(a) Specifying a provisional time constant according to the velocity waveform in actual acceleration/deceleration

Observe the motor velocity waveform (velocity control mode) in acceleration up to the maximum rigid tapping speed. Specify such a provisional time constant that the inclination (acceleration) during rigid tapping acceleration becomes about a half of the inclination of a tangent to the motor velocity waveform near the location of maximum speed. See the sample waveform shown below.



Nr:	Maximum rigid tapping speed (No. 5241 to 5244) 4000 min^{-1} in this example
ta:	Time of acceleration by the maximum torque at *Nr* About 400 ms in this example
tr:	Rigid tapping acceleration/deceleration time constant (No. 5261 to 5264) 800 ms, which is two times *ta*, in this example

In this example, the maximum rigid tapping speed *Nr* is set to 4000 min^{-1}. To determine the acceleration/deceleration time constant, the motor velocity waveform in acceleration up to 4000 min^{-1} is observed. If the acceleration is performed with the maximum motor torque at 4000 min^{-1}, the acceleration time *ta* needed to attain 4000 min^{-1} is about 400 ms, as shown above. This is the minimum value of acceleration/deceleration time constant *tr*, which can be specified without consideration of cutting load. A time constant that can be specified in consideration of cutting load is usually about 1.2 to 1.5 times this value. As a provisional value for gain adjustment, approximately double (800 ms) is specified here.

(b) Specifying a value calculated from the relationship between the maximum torque and spindle inertia

Specify an acceleration/deceleration time constant calculated from the following expression:

$$tr[\mathrm{ms}] = \frac{Jm[\mathrm{kgm}^2] + JL[\mathrm{kgm}^2]}{T\max(Nr)[\mathrm{Nm}]} \times \frac{2\pi}{60} \times Nr[\mathrm{min}^{-1}] \times GR \times 1000 \times 2$$

tr[ms] : Acceleration/deceleration time constant on rigid tapping (No. 5261 to 5264)
Nr[min^{-1}] : Maximum spindle speed on rigid tapping (No. 5241 to 5244)
GR : Spindle-motor gear ratio (Motor rotation per spindle rotation)
Tmax(Nr) [Nm]: Maximum torque of spindle motor at *Nr*
Jm[kgm^2] : Rotor inertia of spindle motor
JL[kgm^2] : Spindle load inertia(converted for the motor shaft)

(4)-2 Specifying a position gain

Specify an initial value of about 2000(20 sec^{-1}) to 3000(30 sec^{-1}), then adjust the value as needed. Basically, specify identical values for the spindle and tapping axis.
After specifying the position gain, check whether the spindle is operating as designed. For that purpose, check that the position error (value displayed on the CNC screen) during stable rotation at the maximum speed is almost the same as the theoretical value. This theoretical value is calculated as shown below. If the theoretical value is substantially different, re-check the parameters related to position gain, gear ratio, and detector.

$$Perr(Nr)[pulse] = \frac{Nr[\mathrm{min}^{-1}]}{60} \times 4096[pulse/rev] \times \frac{1}{PG[\mathrm{sec}^{-1}]}$$

Perr(Nr) [pulse] : Position error in stable rotation at *Nr*
Nr [min^{-1}] : Maximum speed on rigid tapping
PG [sec^{-1}] : Position gain on rigid tapping

If the gear ratio is 1:1 at *Nr*=4000 min^{-1} and *PG*=3000 (30 sec^{-1}), the position error in stable rigid tapping at *Nr* is calculated as follows:

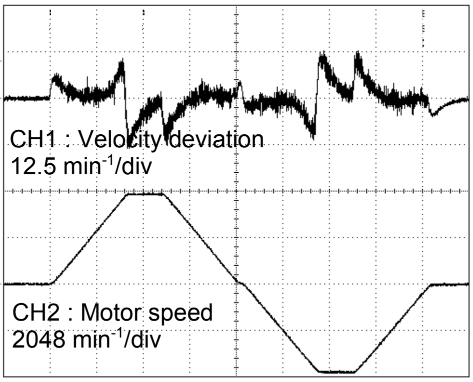
$$Perr(Nr) = \frac{4000}{60} \times 4096 \times \frac{1}{30} = 9102[pulse]$$

(4)-3 Specifying a velocity loop gain

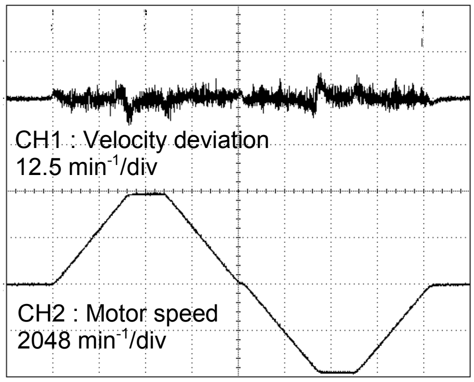
Refer to Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT" for details of the velocity loop proportional/integral gain. Adjust the velocity loop proportional/integral gain so that the velocity error decreases.

During the adjustment, observe the velocity error and motor speed. Sample waveforms before and after the adjustment are shown below:

(a) Waveform before adjustment (No. 4044 = 10, No. 4052 = 10)



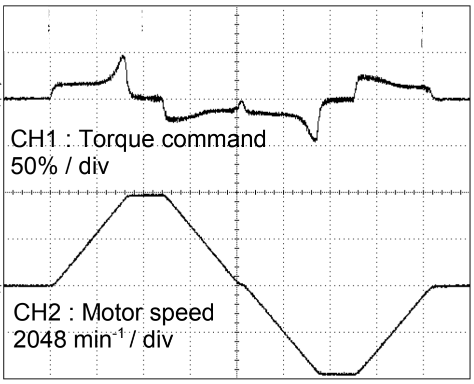
(b) Waveform after adjustment (No. 4044 = 20, No. 4052 = 60)



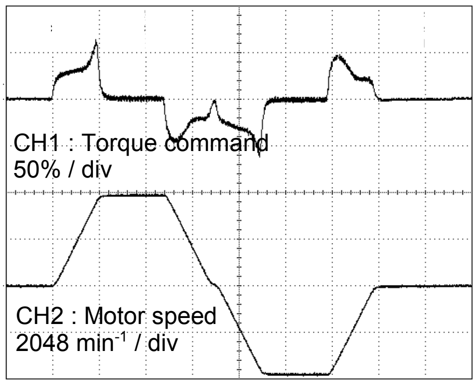
(4)-4 Specifying an acceleration/deceleration time constant (2) : Specifying an optimum value

Observing the torque command and motor speed, make a final adjustment of the time constant. Adjust the time constant in consideration of the actual cutting load, so that the peak torque at air cut becomes about 70% to 80% (3.5 to 4.0 V) of the maximum value. Sample waveforms before and after the adjustment are shown below:

(a) Waveform before adjustment (No. 5261 = 800)



(b) Waveform after adjustment (No. 5261 = 480)



(4)-5 Checking the synchronous error

The spindle adjustment ends when the adjustments described in above procedures are completed. After the spindle adjustment, check the synchronous error between the spindle and servo axis, which will be an index of rigid tapping precision.

The synchronous error is a difference between the spindle position error and the servo axis position error converted for the spindle.

$$SYNCER[\text{pulse}] = PERsp[\text{pulse}] - PERsv[\text{pulse}]$$

SYNCER [pulse]: Synchronous error (4096 pulses per spindle rotation)
PERsp [pulse]: Spindle position error
PERsv [pulse]: Servo axis position error converted for the spindle

(4)-6Making adjustments for FSSB high-speed rigid tapping

In conventional method rigid tapping, if the spindle torque at acceleration/deceleration is saturated, the synchronous error becomes worse extremely. The acceleration/deceleration time constant must therefore be adjusted to a value with an adequate margin with respect to the spindle torque of 100%.
In contrast, FSSB high-speed rigid tapping is a method by which the servo follows up the spindle, so it is possible to prevent the synchronous error from becoming worse even when the spindle torque is saturated to some degree. The cycle time can be shorter than ever before by adjusting the acceleration/deceleration time constant so that a torque command for tapping at the maximum possible load can be used as closely as possible to 100%.
If FSSB high-speed rigid tapping is used when the torque is saturated extremely, the synchronous error does not become much worse. However, an overshoot may occur at a hole bottom. Ensure that no overshoot occurs, and then adjust the acceleration/deceleration time constant. In addition, when the optimum rigid tapping acceleration/deceleration function (option) is also used, the spindle torque can always be used up to the limit according to the tapping speed, so the effect of FSSB high-speed rigid tapping is further enhanced.

2.3.11 Diagnosis (Diagnosis Screen)

This Subsection provides a list of the diagnosis (diagnosis screen) indications related to rigid tapping only. For details, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.11, “RIGID TAPPING.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.11, “RIGID TAPPING.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.8, “RIGID TAPPING.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.10, “RIGID TAPPING.”
(e) For Series 30*i*/31*i*/32*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.12, “RIGID TAPPING.”
(f) For Series 0*i*-D
“FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.13, “RIGID TAPPING.”

(1) Series 16*i*

Address	Description	Unit
0300	Position error pulse of the tapping axis (error)	Pulse
0450	Position error pulse of the spindle (error)	Pulse
0451	Interpolation pulse of the spindle	Pulse
0454	Integrated interpolation pulse of the spindle	Pulse
0455	Difference of move command converted for the spindle (instantaneous)	Pulse
0456	Difference of position error converted for the spindle (instantaneous)	Pulse
0457	(In terms of spindle) Width of synchronous error (maximum)	Pulse

Note

Note the following data:

0455: Difference of move command converted for the spindle (instantaneous)
0456: Difference of position error converted for the spindle (instantaneous)
0457: (In terms of spindle) Width of synchronous error (maximum)

The data is displayed only when bit 0 (DGN) of parameter No. 5204 is set to 0. Usually, set 0.

(2) Series 30*i*

Address	Description	Unit
0300	Position error pulse of the tapping axis (error)	Pulse
0450	Position error pulse of the spindle (error)	Pulse
0451	Interpolation pulse of the spindle	Pulse
0454	Integrated interpolation pulse of the spindle	Pulse
0455	Difference of move command converted for the spindle (instantaneous)	Pulse
0456	Difference of position error converted for the spindle (instantaneous)	Pulse
0457	(In terms of spindle) Width of synchronous error (maximum)	Pulse

(3) Series 15*i*

Address	Description	Unit
1600	Position error pulse of the spindle (instantaneous)	Pulse
1601	Position error pulse of the spindle (maximum)	Pulse
1602	Position error pulse of the tapping axis (instantaneous)	Pulse
1603	Position error pulse of the tapping axis (maximum)	Pulse
1604	(Value converted for the spindle) Width of synchronous error (instantaneous)	Pulse
1605	(Value converted for the spindle) Width of synchronous error (maximum)	Pulse

2.3.12 Alarm

This Subsection provides a list of the alarms related to rigid tapping only. For details, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.11, “RIGID TAPPING.”

(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.11, “RIGID TAPPING.”

(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.8, “RIGID TAPPING.”

(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.10, “RIGID TAPPING.”

(e) For Series 30*i*/31*i*/32*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.12, “RIGID TAPPING.”

(f) For Series 0*i*-D
“FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.13, “RIGID TAPPING.”

(1) Series 16i

(a) Program error (P/S Alarm)

Alarm number	Description
200	S command is over the range or not inputted.
201	F command is not inputted.
202	The interpolation pulse for the spindle is over the range
203	The commanded place of M29 or S command is not proper.
204	The axis move command is inserted between M29 and G84 (G74).
205	The rigid mode input signal is not ON during G84 (G74) although M29 is commanded. The rigid mode DI signal does not go ON. The rigid mode input signal goes OFF during the rigid tapping.
206	The plane change is commanded during the rigid tapping. (M series only)
207	In rigid tapping, the lead is too short or too long. (M series only)

(b) Servo alarm

Alarm number	Description
410	The position error of the tapping axis or the spindle at stop exceeds the alarm level.
411	The position error of the tapping axis or the spindle at moving exceeds the alarm level.
413	Tapping axis LSI overflow (error counter overflow)
740	Position error at rest on the spindle side is larger than the predetermined value (No. 5313).
741	The positional deviation during movement on the spindle side is larger than the setting of No. 5311, or the synchronous error is larger than the setting of No. 5214.
742	Spindle LSI overflow (error counter overflow)

(2) Series 30i

(a) Program error (P/S Alarm)

Alarm number	Description
PS0200	S command is over the range or not inputted.
PS0201	F command is not inputted.
PS0202	The interpolation pulse for the spindle is over the range
PS0203	The commanded place of M29 or S command is not proper.
PS0204	The axis move command is inserted between M29 and G84 (G74).
PS0205	The rigid mode input signal is not ON during G84 (G74) although M29 is commanded. The rigid mode DI signal does not go ON. The rigid mode input signal goes OFF during the rigid tapping.
PS0206	The plane change is commanded during the rigid tapping. (M series only)
PS0207	In rigid tapping, the lead is too short or too long. (M series only)

(b) Servo alarm

Alarm number	Description
SV0410	The position error of the tapping axis or the spindle at stop exceeds the alarm level.
SV0411	The position error of the tapping axis or the spindle at moving exceeds the alarm level.
SV0413	Tapping axis LSI overflow (error counter overflow)
SP0740	Position error at rest on the spindle side is larger than the predetermined value (No. 5313).
SP0741	The positional deviation during movement on the spindle side is larger than the setting of No. 5311, or the synchronous error is larger than the setting of No. 5214.
SP0742	Spindle LSI overflow (error counter overflow)

(2) Series 15i

(a) Program error (P/S Alarm)

Alarm number	Description
PS0223	An attempt was made to execute an instruction that uses the spindle although the spindle to be controlled has not been set correctly.

PS0531	When the feedrate instruction contains valid data below the decimal point, the alarm is set and the F code contains valid data below the decimal point.
PS0532	When the feedrate instruction contains valid data below the decimal point, the alarm is set and the E code contains valid data below the decimal point.
PS0533	The feedrate for the hole drilling axis calculated from the F and S codes is too slow in the feed per single rotation mode (G95).
PS0534	The feedrate for the hole drilling axis calculated from the F and S codes is too fast in the feed per rotation mode (G95).
PS0535	The feedrate for the hole drilling axis calculated from the E and S codes is too slow in the feed per rotation mode (G95).
PS0536	The feedrate for the hole drilling axis calculated from the E and S codes is too fast in the feed per rotation mode (G95).
PS0537	The speed obtained by applying override to the F instruction is too slow.
PS0538	The speed obtained by applying override to the F instruction is too fast.
PS0539	The speed obtained by applying override to the E instruction is too slow.
PS0540	The speed obtained by applying override to the E instruction is too fast.
PS0541	“0” has been instructed as the S code.
PS0542	“0” has been instructed as the feedrate (E code).
PS0543	The gear ratio between the spindle and position coder, or the set position coder number of pulses is illegal in the spindle position function and the rigid tapping function.
PS0544	The value specified with the S command exceeds the maximum spindle speed.

(b) Spindle alarm (SP alarm)

Alarm number	Description
SP0224	The spindle-position coder gear ratio was incorrect.
SP0231	The position error during spindle rotation was greater than the value set in parameter (No.5876).
SP0232	The position error during spindle stop was greater than the value set in parameter (No.5877).
SP0233	The error counter/speed instruction value of the position coder overflowed.
SP0234	Grid shift overflowed.
SP0235	The orientation (reference position return) speed is too fast.
SP0238	An attempt was made to change the spindle mode during the rigid tapping mode.

2.4 Cs CONTOURING CONTROL (OPTIONAL FUNCTION)

2.4.1 Start-up Procedure

A. Check that operation in the velocity control mode is enabled.

↓

B. Prepare and check the ladder program for the Cs contouring control function.

↓

C. Set the necessary parameters for Cs contouring control.

↓

D. Check and adjust the waveforms on the Cs contouring control detector.

↓

E. Check the operation of reference position return.
- Direction of return to the reference position in Cs contouring control mode
- Maximum speed in Cs contouring control mode
- Feedrate at which return to the reference position is performed in Cs contouring control mode
- Parameter for the rate of change in the position gain for return to the reference position in Cs contouring control mode

↓

F. Check the stop position when return to the reference position is performed.
- Grid shift in Cs contouring control mode

↓

G. Check the direction of spindle rotation in Cs contouring control mode.
- Parameter specifying the direction of rotation for a positive (+) motion command

↓

H. Adjust and check the Cs contouring control servo system.
(Check the operation in jog mode, rapid traverse mode, handle mode, and other modes.)
- Position gain in Cs contouring control mode
- Velocity loop proportional gain in Cs contouring control mode
- Velocity integral gain in Cs contouring control mode
- Motor voltage in Cs contouring control mode
- Disturbance torque compensating constant (acceleration feedback gain)
- Spindle speed feedback gain

↓

I. End of operation check in Cs contouring control mode

2.4.2 Overview

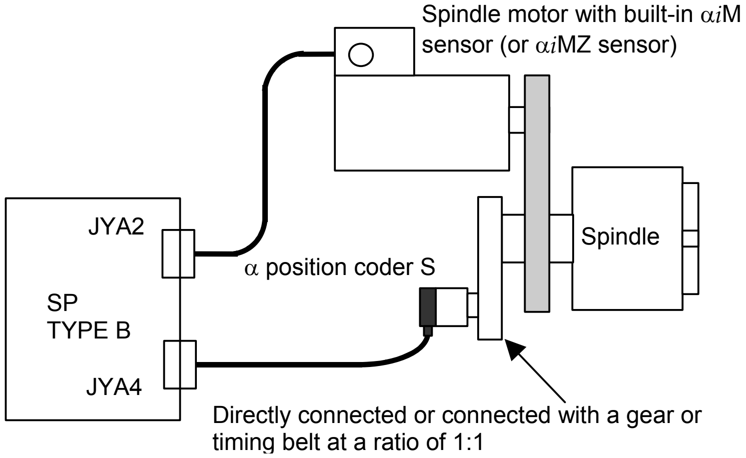
Cs contouring control is a function for exercising position control by handling the spindle as a CNC controlled axis with an αiMZ sensor, αiBZ sensor, αiCZ sensor (analog, serial), or α position coder S.
This function enables positioning and interpolation with another servo axis. This means that linear interpolation, circular interpolation, and so forth can be specified between the spindle and a servo axis.

NOTE
To use this function, the CNC software option is required.

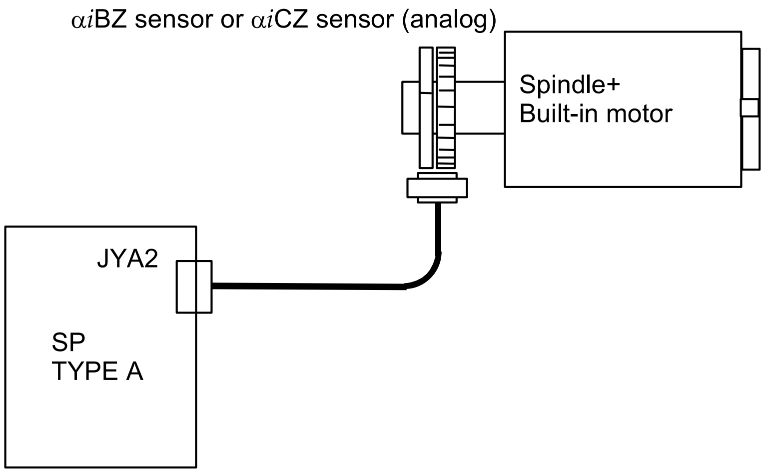
2.4.3 System Configuration

The system configurations that enable the use of the Cs contouring control function are shown below.

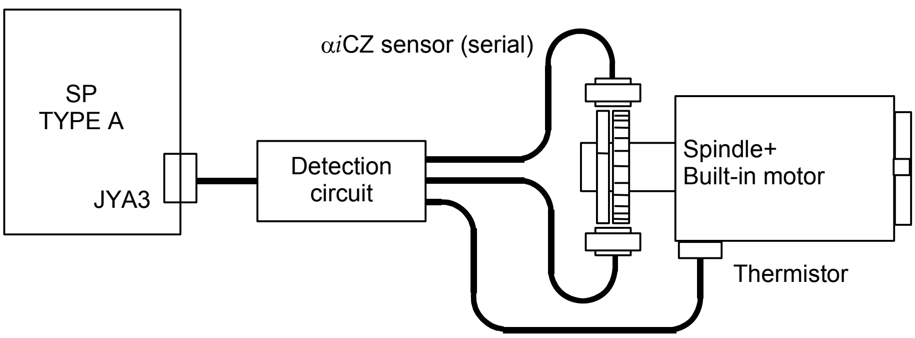
(1) When the α position coder S is used



(2) When the built-in motor (αiBZ sensor, αiCZ sensor (analog)) is used



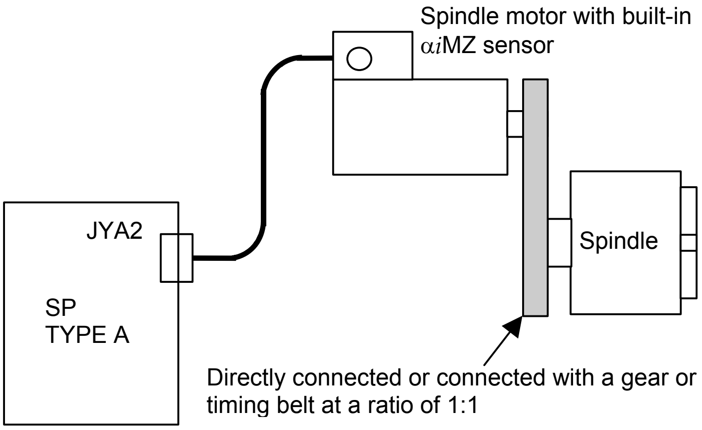
(3) When the built-in motor (αiCZ sensor (serial)) is used



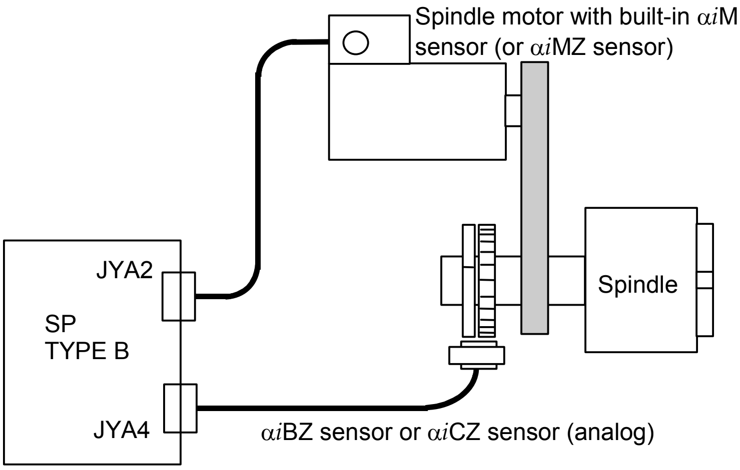
NOTE

In a configuration in which the αiCZ sensor (serial) is used as a motor sensor, to start Cs contouring control immediately after the power on, use spindle software 9D80 series H (08) edition or later, 9D90 series A (01) edition or later, or 9DA0 edition A (01) or later.

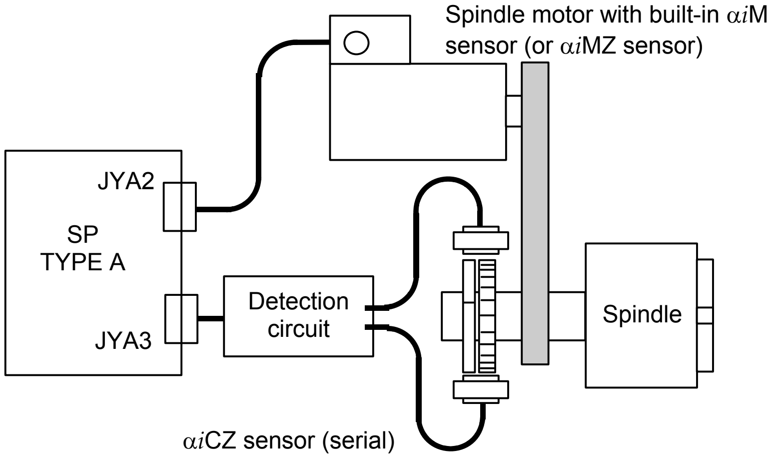
(4) When the spindle motor with built-in αiMZ sensor is used



(5) When the separate type αiBZ sensor or separate type αiCZ sensor (analog) is used



(6) When the separate type αiCZ sensor (serial) is used



NOTE

In a configuration in which the αiCZ sensor (serial) is used as a spindle sensor, to start Cs contouring control immediately after the power on, use spindle software 9D80 series H (08) edition or later, 9D90 series A (01) edition or later, or 9DA0 edition A (01) or later.

2.4.4 List of I/O Signals (CNC↔PMC)

This Subsection provides a list of the I/O signals related to Cs contouring control only. For details of each signal, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.9, “Cs CONTOUR CONTROL.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.9, “Cs CONTOUR CONTROL.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7, “Cs CONTOUR CONTROL.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.8, “Cs CONTOUR CONTROL.”
(e) For Series 30*i*/31*i*/32*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.10, “Cs CONTOUR CONTROL.”
(f) For Series 0*i*-D
“FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.11, “Cs CONTOUR CONTROL.”

For details of the I/O signals common to the CNCs, see Chapter 3, “I/O SIGNALS (CNC↔PMC)”, in Part I.

(1) Input signals (PMC→CNC)

(a) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
G027	CON							
G028						GR2	GR1	

(b) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
G027	CON							
G028						GR2	GR1	

(c) Series 15*i*

	#7	#6	#5	#4	#3	#2	#1	#0
G067	SCNTR1							
G071	SCNTR2							
:	:							

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070			SFRA	SRVA	CTH1A	CTH2A		
2nd-	G235	G074	G074			SFRB	SRVB	CTH1B	CTH2B		

1st-	G226	G071	G071			INTGA					
2nd-	G234	G075	G075			INTGB					

(2) Output signals (CNC→PMC)

(a) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F044							FSCSL	
F094	ZP8	ZP7	ZP6	ZP5	ZP4	ZP3	ZP2	ZP1

NOTE
1 These signals are valid with the M series only.

(b) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F044							FSCSL	
F094	ZP8	ZP7	ZP6	ZP5	ZP4	ZP3	ZP2	ZP1

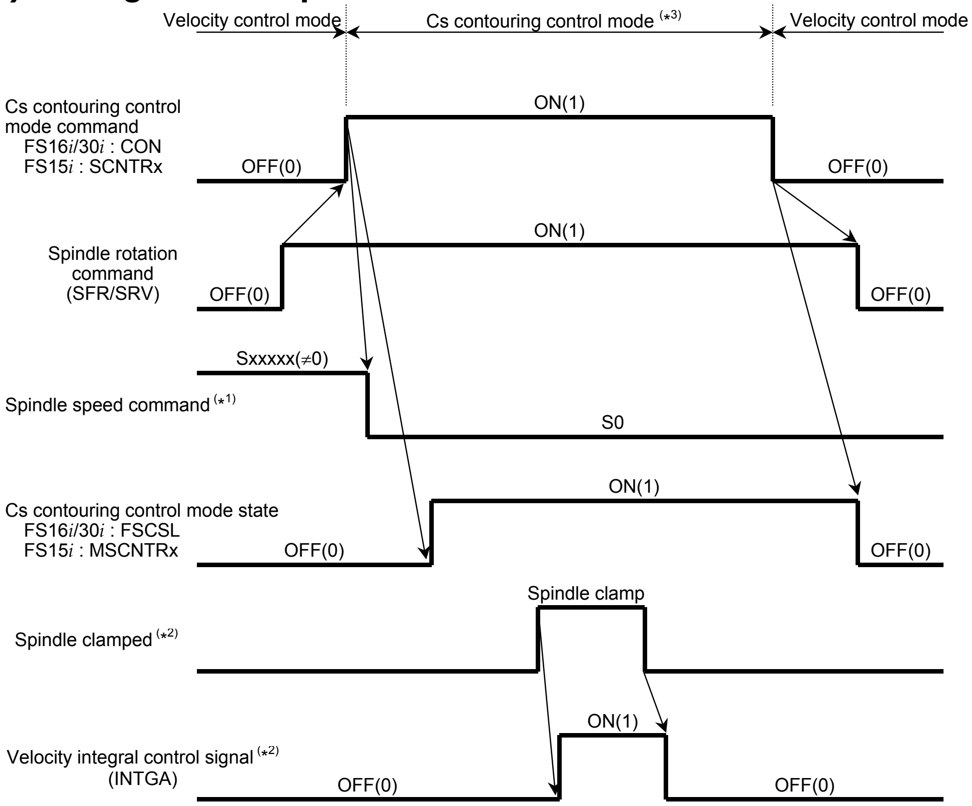
NOTE
1 These signals are valid with the M series only.

(c) Series 15*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F064								ZP1
F068								ZP2
:								:
F067	MSCNTR1							
F071	MSCNTR2							
:	:							

2.4.5 Examples of Sequences

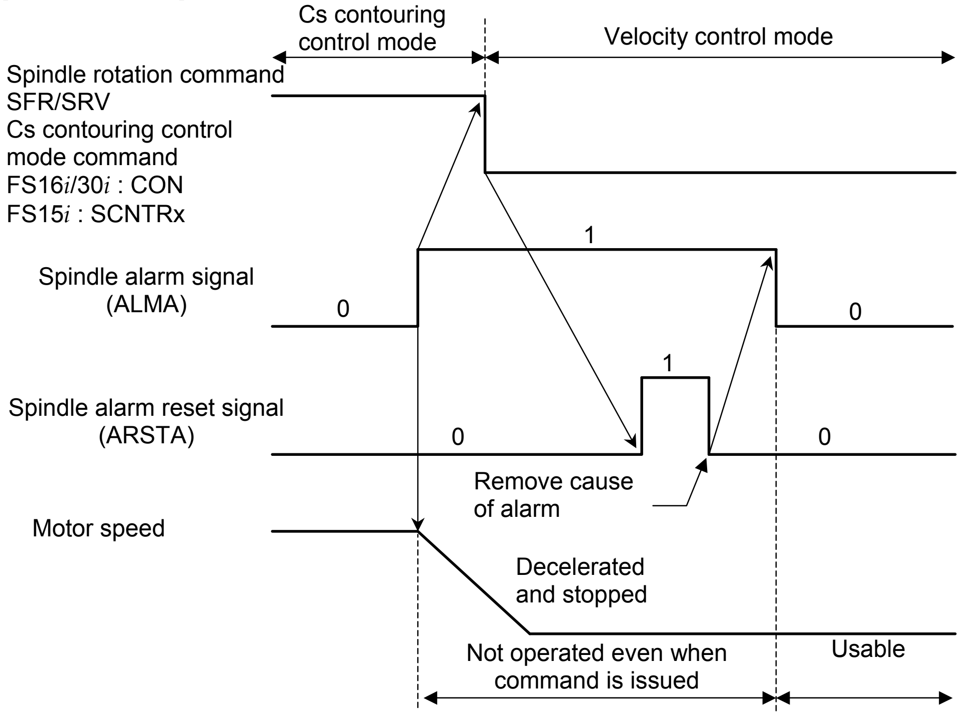
(Example 1) During normal operation



NOTE

1. In Cs contouring control mode, reset the spindle speed command (specify S0) for safety.
2. When the spindle is clamped to perform machining such as drilling after positioning based on Cs contouring control, the spindle may be clamped at a position slighted shifted from the specified position. In such a case, the velocity loop integral function attempts to move the spindle to the specified position, so that an excessively high current can flow through the motor.
   To prevent this, turn on (set to 1) the velocity integral control signal (INTGA) to disable the velocity loop integral function, or turn off the power to the motor with the servo-off signal.
3. In Cs contouring control, do not perform spindle gear switching. Be sure to perform spindle gear switching, if needed, on the velocity control mode.
4. For Cs contouring control, use either of the SFR and SRV signals.
5. In the Cs contouring control mode, do not change the SFR (SRV) signal.

(Example 2) When a spindle alarm is issued



NOTE

1. If a spindle alarm is issued, release the Cs contouring control mode. Resetting the alarm without releasing the mode and restarting operation may cause a miss positioning.
2. With the following series and editions, the alarm reset signal is valid only in the velocity control mode (in other modes, inputting the alarm reset signal does not release the alarm):
   - 9D50 series P (16) edition or later
   - 9D70 series G (07) edition or later
   - 9D80 series A (01) edition or later
   - 9D90 series A (01) edition or later
   - 9DA0 series A (01) edition or later

2.4.6 Velocity Loop Gains Override Function on Cs Contouring Control Mode

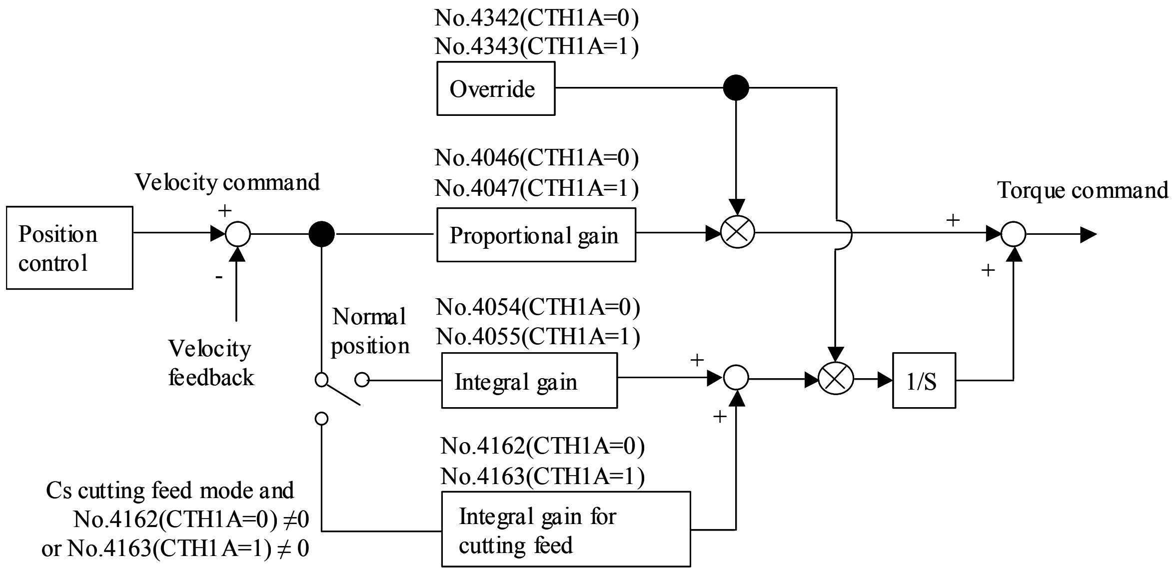
2.4.6.1 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D50	S (19)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i*
9D70	I (09)	FS30*i* / FS31*i* / FS32*i*
9D80	C (03)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS0*i* , FS30*i* / FS31*i* / FS32*i*

2.4.6.2 Block diagram

Shown below is a block diagram of the velocity loop for Cs contouring control mode.
The velocity loop gains override function is used to override the velocity loop gain on Cs contouring control mode according to load inertia changes.



> **NOTE**
> The override function is effective only for Cs contouring control mode (override fixed at 100% for the other modes).

2.4.7 Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
1005#0	1005#0	1005#0	Whether to use the reference position return function
1005#2	-	-	Sets automatic reference position return (G28). (Set “0”.)
1005#3	-	-	Set workpiece coordinate system preset at automatic reference position return time. (Set “1”.)
1600#2,1,0	1006#0	1006#0	Sets a linear axis/rotation axis. (Set “1”.)
1600#3	-	-	Sets a radius for a move command/rotation axis. (Set “0”.)
1804#7	-	-	Sets a Cs contouring control axis with a serial spindle. (Set “1”.)
2203#1	-	-	Sets machine position display on the CRT. (Set “1”.)
-	3700#1	3700#1	Specifies whether to enable the reference position return function for the first G00 command received after switching to Cs contouring control.
-	3712#2	3712#2	Sets the Cs axis coordinate establishment function.
1012 #3,2,1,0	1004 #1,0	1013 #3,2,1,0	Increment system (Usually, set and use IS-B.)
1020	1020	1020	Program axis name
-	1022	1022	Sets an axis of the basic coordinate system. (Set “0”.)
1023	1023	1023	Servo axis number (Set “-1”.)
1028	-	-	Spindle number of Cs contouring control axis
1260	-	1260	Movement per rotation of rotation axis (Set “360.0”.)
1420	1420	1420	Rapid traverse rate
1620	1620	1620	Linear acceleration/deceleration time constant for rapid feed
1820	1820	1820	Command multiplication (Usually, set “2” [= CMR 1].)
5879	1826	1826	In-position width

Parameter No.			Description
15*i*	**16*i***	**30*i***	
5880	1828	1828	Position error limit during movement
5881	1829	1829	Position error limit when stopped
5882	-	-	Position error limit when the servo system is off
5609#0	-	-	Sets a position gain for a servo axis subject to interpolation with the Cs contouring control axis. (“0”: Automatically set, “1”: Not automatically set. Usually, set “0”.)
-	3900 3910 3920 3930 3940	3900 3910 3920 3930 3940	Servo axis number subject to interpolation with the Cs contouring control axis
-	3901 to 3904 3911 to 3914 3921 to 3924 3931 to 3934 3941 to 3944	3901 to 3904 3911 to 3914 3921 to 3924 3931 to 3934 3941 to 3944	Position gain of a servo axis subject to interpolation with the Cs contouring control axis
5843	-	-	Number of pulses of position detector for Cs contouring control
3000#1	4000#1	4000#1	Spindle rotation direction for a positive motion command on Cs contouring control mode
3000#3	4000#3	4000#3	Direction of reference position return when the system enters Cs contouring control mode
3002#4	4002#4	4002#4	Whether to use the rotation direction signal (SFR/SRV) function on Cs contouring control
3005#0	4005#0	4005#0	Sets the detection unit for Cs contouring control.
3016#3	4016#3	4016#3	Sets the smoothing function in feed-forward control.
3016#4	4016#4	4016#4	Setting related to the motor voltage control characteristics on Cs contouring control or servo mode
3021	4021	4021	Maximum spindle speed on Cs contouring control mode
3036	4036	-	Feed-forward coefficient
3037	4037	4037	Velocity loop feed-forward coefficient
3046 3047	4046 4047	4046 4047	Velocity loop proportional gain on Cs contouring control mode (A parameter is selected by the CTH1A input signal sent from the PMC.)
3054 3055	4054 4055	4054 4055	Velocity loop integral gain on Cs contouring control mode (A parameter is selected by the CTH1A input signal sent from the PMC.)
3056 to 3059	4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio (A parameter is selected by the CTH1A and CTH2A input signals sent from the PMC.)
3069 to 3072	4069 to 4072	4069 to 4072	Position gain for axes subject to Cs contouring control (A parameter is selected by the CTH1A input signal sent from the PMC.)
3074	4074	4074	Feedrate for reference position return on Cs contouring control mode or servo mode
3086	4086	4086	Motor voltage on Cs contouring control mode
3092	4092	4092	Rate of change in the position gain when reference position return is performed on Cs contouring control mode
3094	4094	4094	Disturbance torque compensating constant (acceleration feedback gain)
3097	4097	4097	Spindle speed feedback gain
3099	4099	4099	Motor excitation delay
3131	4131	4131	Velocity detection filter time constant (on Cs contouring control)
3135	4135	4135	Grid shift on Cs contouring control mode

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3162 3163	4162 4163	4162 4163	Velocity loop integral gain for cutting feed on Cs contouring control (A parameter is selected by the PMC input signal CTH1A.)
3342 3343	4342 4343	4342 4343	Velocity loop gain override in Cs contouring control. (These parameters are selected by the input signal CTH1A of PMC.)
-	-	4344	Advanced preview feed-forward coefficient
-	4353#5	4353#5	Sets the Cs axis position data transfer function.
3406	4406	4406	Acceleration/deceleration time constant at return to the reference position in Cs contouring control/servo mode
—	—	4540#0	Setting related to motor voltage control characteristics on Cs contouring control
—	—	4598	Variable proportional gain function in the stop state for Cs control: magnification in the stop state
—	—	4599	Variable proportional gain function in the stop state for Cs control: judgment level for the stop state

NOTE
1 For the detector-related parameters, see Section 1.3, "PARAMETERS RELATED TO DETECTORS", in Part I.
2 For velocity loop proportional/integral gain adjustment, see Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT", in Part I.

2.4.8 Details of Related Parameters

This Subsection details the serial spindle parameters (in the four thousands for 16*i*, in the four thousands for 30*i*, and in the three thousands for 15*i*) among the parameters related to Cs contouring control. For details of other parameters, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.9, "Cs CONTOUR CONTROL."

(b) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.9, "Cs CONTOUR CONTROL."

(c) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7, "Cs CONTOUR CONTROL."

(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.8, "Cs CONTOUR CONTROL."

(e) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.10, "Cs CONTOUR CONTROL."

(f) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.11, "Cs CONTOUR CONTROL."

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3000	4000	4000					**RETRN**		**ROTA2**	

ROTA2 Indicates the spindle direction by the move command (+). (Only effective on Cs contouring control)

0 : When the value of a move command from the CNC is positive (+), the spindle rotates in the CCW direction.
1 : When the value of a move command from the CNC is positive (+), the spindle rotates in the CW direction.

Change the setting of this parameter when changing the rotation direction of the spindle on Cs contouring control.

RETRN Indicates the reference position return direction on Cs contouring control.
0 : Returns the spindle from the CCW direction to the reference position (counter clockwise direction).
1 : Returns the spindle from the CW direction to the reference position (clockwise direction).

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3002	4002	4002				CSDRCT				

CSDRCT Whether to use the rotation direction signal (SFR/SRV) on Cs contouring control
0 : Rotation direction function enabled
(1) When bit 1 (ROTA2) of No. 4000 = 0, and the value of a move command from the CNC is positive (+)
(a) The spindle rotates counterclockwise when input signal SFR(G70#5) is set to 1.
(b) The spindle rotates clockwise when input signal SRV(G70#4) is set to 1.
(2) When bit 1 (ROTA2) of No. 4000 = 1, and the value of a move command from the CNC is positive (+)
(a) The spindle rotates clockwise when input signal SFR(G70#5) is set to 1.
(b) The spindle rotates counterclockwise when input signal SRV(G70#4) is set to 1.
1 : Rotation direction function disabled
The rotation direction function of the SFR/SRV signal is disabled. Only the function for enabling spindle motor excitation is available.
(1) When bit 1 (ROTA2) of parameter No. 4000 is set to 0
When the value of a move command from the CNC is positive (+), and SFR/SRV = 1, the spindle rotates in the CCW direction.
(2) When bit 1 (ROTA2) of parameter No. 4000 is set to 1
When the value of a move command from the CNC is positive (+), and SFR/SRV = 1, the spindle rotates in the CW direction.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3005	4005	4005								CS360M

CS360M Sets the detection unit for Cs contouring control.
0 : 0.001°
1 : 0.0001°

Set 0 usually. When a α*i*CZ sensor (analog, serial) is used as the position detector and the setting unit IS-C is used, set 1.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3016	4016	4016				IDLPTN	FFSMTH			

FFSMTH Specifies whether to use the smoothing function under feed-forward control.
0 : Don’t use the smoothing function.
1 : Uses the smoothing function.

This bit specifies whether to use the smoothing function under feed-forward control on Cs contouring control mode.

IDLPTN Setting related to the motor voltage control characteristics on Cs contouring control or servo mode (rigid tapping)
Set this bit to 1 when setting a value less than 100 as the motor voltage on Cs contouring control (No. 4086) or as the motor voltage on servo mode (No. 4085).

15*i*	16*i*	30*i*	
3021	4021	4021	**Maximum speed on Cs contouring control mode**

Unit of data : 1min^{-1} (10min^{-1} when parameter No.4006#2 (SPDUNT) is set to 1)
Valid data range : 0 to 32767
Standard setting : 100
This parameter specifies the maximum speed of a spindle operating on Cs contouring control mode.
When 0 is specified as the parameter for the feedrate for reference position return on Cs contouring control mode (parameter No. 4074), reference position return is performed at the speed specified as the maximum speed in this parameter.

15*i*	16*i*	30*i*	
3036	4036	-	**Feed-forward coefficient**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : 0
Set the feed-forward coefficient when feed-forward control is executed on Cs contouring control.

15*i*	16*i*	30*i*	
3037	4037	4037	**Velocity loop feed-forward coefficient**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 0
Set a velocity loop feed-forward coefficient when feed-forward control is executed on Cs contouring control. Use the following expression to determine a value to be set:

$$\text{Setting} = 214466 \times \frac{[\text{spindle inertia + rotor inertia}](\text{kg}\cdot\text{m}^2)}{\text{Maximum motor torque (N}\cdot\text{m)}}$$

15*i*	16*i*	30*i*		
3046	4046	4046	**Velocity loop proportional gain on Cs contouring control (HIGH)**	**CTH1A=0**
3047	4047	4047	**Velocity loop proportional gain on Cs contouring control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 30
These parameters specify the proportional gains of the velocity loop on Cs contouring control mode.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3054	4054	4054	**Velocity loop integral gain on Cs contouring control (HIGH)**	**CTH1A=0**
3055	4055	4055	**Velocity loop integral gain on Cs contouring control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 50

These parameters specify the integral gains of the velocity loop for Cs contouring control mode.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These parameters set the gear ratio of the spindle motor to the spindle.
When the motor rotates 2.5 times for every rotation of the spindle, for example, set 250 in the parameter.
A parameter is selected by the CTH1A and CTH2A input signals.
The gear or clutch status must correspond to the status of the CTH1A and CTH2A input signals.

NOTE
When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle does not stop but keeps rotating at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*		
3069	4069	4069	**Position gain on Cs contouring control (HIGH)**	**CTH1A=0, CTH2A=0**
3070	4070	4070	**Position gain on Cs contouring control (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3071	4071	4071	**Position gain on Cs contouring control (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3072	4072	4072	**Position gain on Cs contouring control (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : $0.01sec^{-1}$
Valid data range : 0 to 32767
Standard setting : 3000

These parameters specify the position gains used on Cs contouring control mode.
A parameter is selected by the input signals CTH1A and CTH2A.

15*i*	16*i*	30*i*	
3074	4074	4074	**Speed for return to reference position on Cs contouring control mode/servo mode**

Unit of data : $1min^{-1}$
Valid data range : 0 to 32767

Standard setting : 0

- When 0 is set
  The value set in No. 4021 (maximum spindle speed) is used as a reference position return speed on Cs contouring control.
- When a value other than 0 is set
  The value set in this parameter is used as a reference position return speed on Cs contouring control.

> **NOTE**
> An overshoot can occur at reference position return time for a cause such as an excessively high reference position return speed by setting the parameter No. 4021 (maximum spindle speed on Cs contouring control mode). In this case, set this parameter.

15*i*	16*i*	30*i*	
3086	4086	4086	**Motor voltage setting on Cs contouring control**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : 100
Set the motor voltage to "100", when Cs contouring control is in operation.

> **NOTE**
> When the maximum speed for Cs contouring control (in terms of motor axis) is higher than the base speed of the spindle motor (No. 4100 for high-speed characteristics and No. 4138 for low-speed characteristics), set a value less than "100" in this parameter.
>
> $$\text{Motor voltage (\%)} = 100 \times \frac{\text{Spindle motor base speed}}{\text{Maximum speed in Cs contouring control (in terms of motor shaft)}}$$
>
> In this case, also set bit 4 of parameter No. 4016 to "1" as the setting related to motor voltage control characteristics on Cs contouring control.

15*i*	16*i*	30*i*	
3092	4092	4092	**The reduction rate of position loop gain in returning to the reference position on Cs contouring mode**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : 100
This parameter specifies a rate of change in the position gain used for reference position return on Cs contouring control mode.

> **NOTE**
> An overshoot can occur at reference position return time for a cause such as an excessively high reference position return speed and an excessively large spindle inertia. In this case, an overshoot can be avoided by setting a small value in this parameter.

15*i*	16*i*	30*i*	
3094	4094	4094	**The constant of the torque disturbance compensating (Acceleration feedback gain)**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 0

This parameter specifies the constant for compensating for a disturbance torque on Cs contouring control mode.

> **NOTE**
> By setting this parameter, stability in cutting can be improved.
> In this parameter, set a value from 500 to 2000.
> Do not set a value exceeding 4000.

15*i*	16*i*	30*i*	
3097	4097	4097	**Spindle speed feedback gain**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 0

This parameter is set to feed back spindle speed and compensate for torque disturbance on Cs contouring control in systems where spindles and spindle motors are linked by gears or belts.

> **NOTE**
> When a belt is used to connect the spindle with the motor, control stability may be improved by feeding back the spindle speed.
> In this parameter, set about the same value (10 to 50) as specified in parameter No. 4046 (velocity loop proportional gain), or a smaller value.

15*i*	16*i*	30*i*	
3099	4099	4099	**Delay time for motor excitation**

Unit of data : 1ms
Valid data range : 0 to 32767
Standard setting : 0

This parameter specifies the time required to achieve stable motor excitation on rigid tapping mode or Cs contouring control mode.

> **NOTE**
> At the time of switching from the velocity control mode to Cs contouring control mode, the stop time excessive error alarm can be issued intermittently.
> This is because the excitation state of the spindle motor changes abruptly, and therefore a transient state occurs in the motor, thus moving the motor shaft slightly.
> In such a case, set this parameter. In general, set a value from about 300 to 400 (300 to 400 msec).

15*i*	16*i*	30*i*	
3131	4131	4131	**Velocity detection filter time constant (on Cs contouring control)**

Unit of data : 0.1ms
Valid data range : 0 to 10000
Standard setting value : 0

This parameter sets a filter time constant for the velocity feedback signal on Cs contouring control. Usually, set 0.

15*i*	16*i*	30*i*	
3135	4135	4135	**Grid shift amount on Cs contouring control**

Unit of data : 1 pulse unit (=0.001°) (0.0001° when bit 0 (CS360M) of parameter No. 4005 is set to 1)
Valid data range : -360000 to +360000
(-3,600,000 to +3,600,000 when bit 0 (CS360M) of parameter No. 4005 is set to 1)
Standard setting value : 0

Use this parameter to shift the machine reference position on Cs contouring control.
The machine reference position of the spindle shifts by the set number of pulses in the CCW direction.

15*i*	16*i*	30*i*		
3162	4162	4162	**Velocity loop integral gain for cutting feed on Cs contouring control(HIGH)**	**CTH1A=0**
3163	4163	4163	**Velocity loop integral gain for cutting feed on Cs contouring control(LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

These parameters set a velocity loop integral gain for cutting feed (G01, G02, G03) on Cs contouring control.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

NOTE
When 0 is set in these parameters, the values set in No. 4054 and No. 4055 (velocity loop integral gain on Cs contouring control) are valid.

15*i*	16*i*	30*i*		
3342	4342	4342	**Velocity loop gain override in Cs contouring control (HIGH)**	**CTH1A=0**
3343	4343	4343	**Velocity loop gain override in Cs contouring control (LOW)**	**CTH1A=1**

Unit of data : 1%
Valid data range : 0 to 3000
Standard setting value : 0

These parameters specify override of velocity loop proportional gain and integral gain for Cs contouring control mode.
If the set value is "0", it is treated as "100".

NOTE
This parameter is valid with
9D50 series S (19) edition or later
9D70 series I (09) edition or later
9D80 series C (03) edition or later
9D90 series A (01) edition or later
9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
-	-	4344	**Advanced preview feed-forward coefficient**

Unit of data : 0.01%
Valid data range : 0 to 10000
Standard setting value : 0

This parameter sets a feed-forward coefficient for exercising feed-forward control when Cs contouring control is used.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
-	4353	4353			CSPTRE					

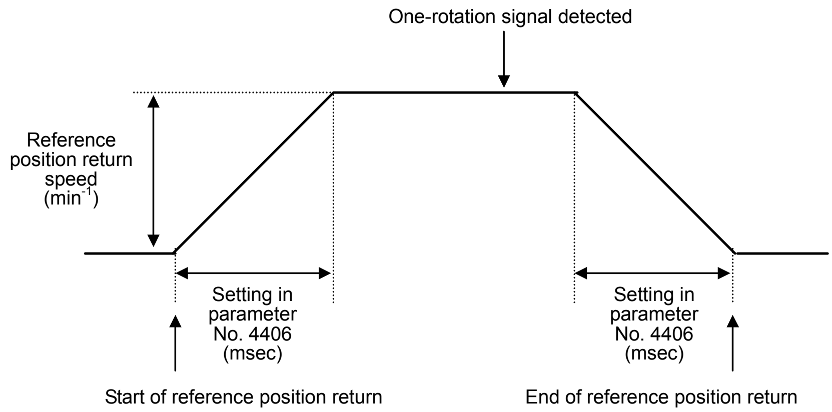
CSPTRE Sets the Cs axis position data transfer function.
0 : Disables the Cs axis position data transfer function.
1 : Enables the Cs axis position data transfer function.
Set this parameter to 1 when using the Cs axis coordinate establishment function.

NOTE
This parameter is valid with 9D50 series G (07) edition or later, 9D70 series A (01) edition or later, 9D80 series A (01) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3406	4406	4406	**Acceleration/deceleration time constant for Cs contouring control/servo mode**

Unit of data : 1msec
Valid data range : 0 to 32767
Standard setting : 0

This parameter set the reference position return acceleration for Cs contouring control or servo mode (rigid tapping/spindle positioning). Use of this parameter can reduce the shock due to acceleration/deceleration during return to the reference position. The spindle speed command during return to the reference position is then given as follows:



> **NOTE**
> 1 When 0 is set in this parameter, a velocity command is assumed as follows.
> - Before detecting the one-rotation signal: Reference position return speed (step-type velocity command)
> - After detecting the one-rotation signal: Distance to the reference position × Position gain
>
> 2 This parameter is enabled when soft start/stop signal SOCNA is 1.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
-	-	4540								**EXPTCS**

EXPTCS Setting related to motor voltage control characteristics on Cs contouring control
Set this bit to 1 when setting a value less than 100 as the motor voltage on Cs contouring control (parameter No. 4086).
Bit 4 of parameter No. 4016 is valid for all of Cs contouring control, rigid tapping (servo mode), and spindle synchronous control. Use this parameter to set each mode independently.
This parameter is valid only when bit 4 of parameter No. 4016 = 0.

15*i*	16*i*	30*i*	
-	-	4598	**Variable proportional gain function in the stop state for Cs control: magnification in the stop state**

Unit of data : 1%
Valid data range : 0~100 (0 means that the function is disabled.)
After a stop is checked in the Cs contouring control state, the variable proportional gain function in the stop state for Cs control suppresses vibration in the stop state by decreasing the velocity loop proportional gain to the level specified with the relevant parameter. In this parameter, set a magnification of the gain to be applied in the stop state.
The function is enabled when a value other than 0 is set in this parameter.

15*i*	16*i*	30*i*	
-	-	4599	**Variable proportional gain function in the stop state for Cs control: judgment level for the stop state**

Unit of data : Detection unit (0.001° (when bit 0 of parameter No. 4005 = 0), 0.0001° (when bit 0 of parameter No. 4005 = 1))
Valid data range : 0 to 32767
Standard setting : 0

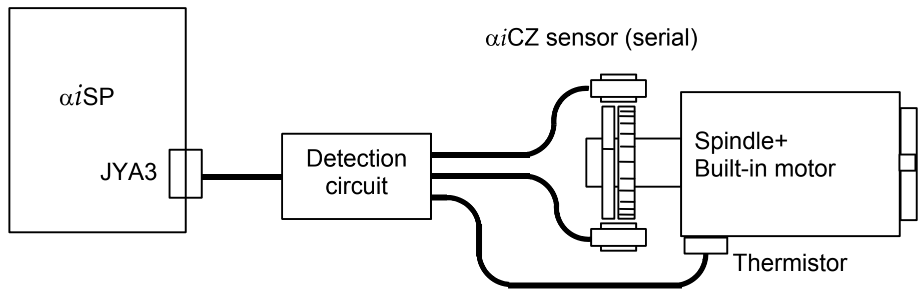
This parameter is used for stop state judgment in the Cs control state. After a move command for the Cs axis has become 0 and the time five times the reciprocal of the set position gain has elapsed, the spindle is regarded as being stopped when the position error becomes lower than or equal to the level set in this parameter.
Setting example) In parameter No. 4599, set a value larger than the absolute value of the position error of vibration in the stop state, and in parameter No. 4598, adjust a magnification in the stop state in a range of 25% to 90%.

2.4.9 Adjusting Cs Contouring Control

2.4.9.1 Overview

In recent years, a high-resolution spindle sensor such as the αiCZ sensor has been used for a built-in spindle motor, enabling high-precision Cs contouring control. To enable this type of control, this Subsection describes how to make adjustments to improve servo characteristics (responsiveness and stability) for Cs contouring control.

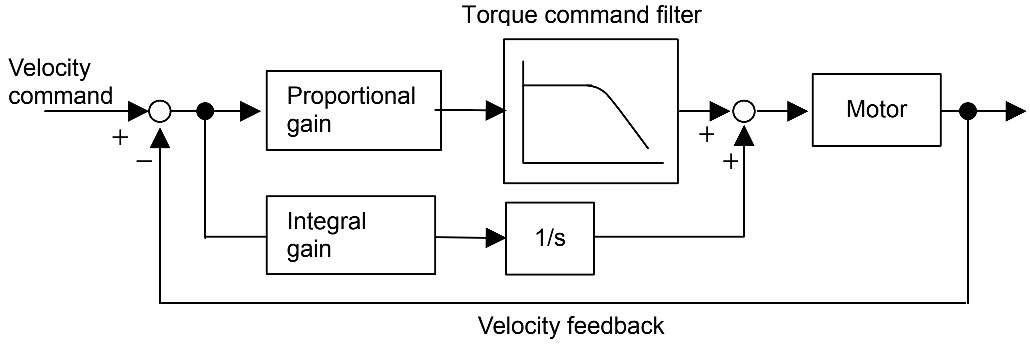
[Example of the use of the αiCZ sensor]



2.4.9.2 Adjustment Procedure

To improve servo characteristics for Cs contouring control, make adjustments by following the adjustment procedure below.

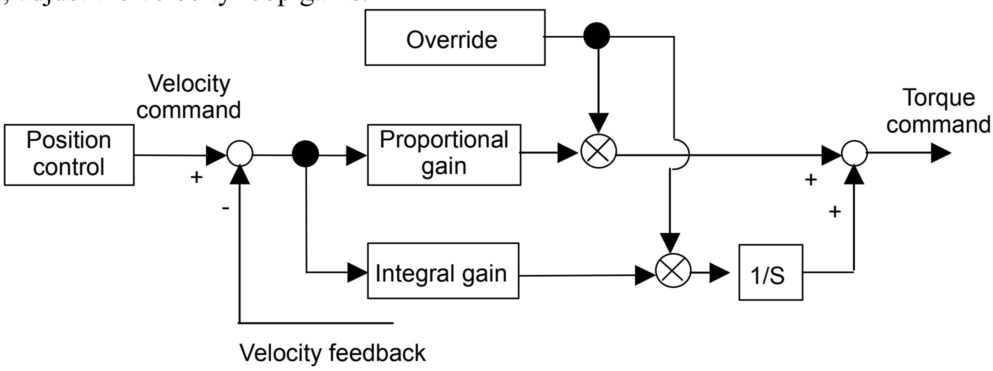
(1) Before adjusting the velocity loop gains, change the torque command filter setting.



15*i*	16*i*	30*i*	
3121	4121	4121	**Torque command filter time constant**
3157	4157	4157	**Torque command filter time constant (for low-speed characteristics)**

When automatic setting is performed, 5 is set in the parameter of the torque command filter time constant. The standard value of 5 is set assuming that a low-resolution sensor is used.
When using a high-resolution spindle sensor such as the αiCZ sensor, change this value, with 2 as a guideline, to improve the responsiveness of the velocity loop.
After changing this value, operate the axis and check to see if an abnormality such as an unusual sound occurs.

(2) Next, adjust the velocity loop gains.



15*i*	16*i*	30*i*	
3046	4046	4046	**Velocity loop proportional gain on Cs contouring control (CTH1A=0)**
3047	4047	4047	**Velocity loop proportional gain on Cs contouring control (CTH1A=1)**

15*i*	16*i*	30*i*	
3054	4054	4054	**Velocity loop integral gain on Cs contouring control (CTH1A=0)**
3055	4055	4055	**Velocity loop integral gain on Cs contouring control (CTH1A=1)**

15*i*	16*i*	30*i*	
3342	4342	4342	**Velocity loop gain override on Cs contouring control (CTH1A=0)**
3343	4343	4343	**Velocity loop gain override on Cs contouring control (CTH1A=1)**

Set the motor model-specific standard values for the velocity loop proportional and integral gains. (For an explanation of the motor model-specific standard parameters, see Subsection 2.4.9.3.)

The velocity loop gain override is a parameter that should basically be set according to the load inertial value.

$$Vovr\ [\%] = \left(\frac{JL\,[\mathrm{kgm^2}]}{Jm\,[\mathrm{kgm^2}]} + 1\right) \times 100$$

Vovr [%] : Velocity loop gain override
JL [kgm^2] : Spindle load inertia (converted for the motor shaft)
Jm [kgm^2] : Rotor inertia of spindle motor

Since this parameter serves as a magnification for both velocity loop proportional and integral gains, however, set this parameter value as large as possible in order to improve the responsiveness of the entire velocity loop. Be sure to adjust the final setting to approximately 80% of the oscillation limit.

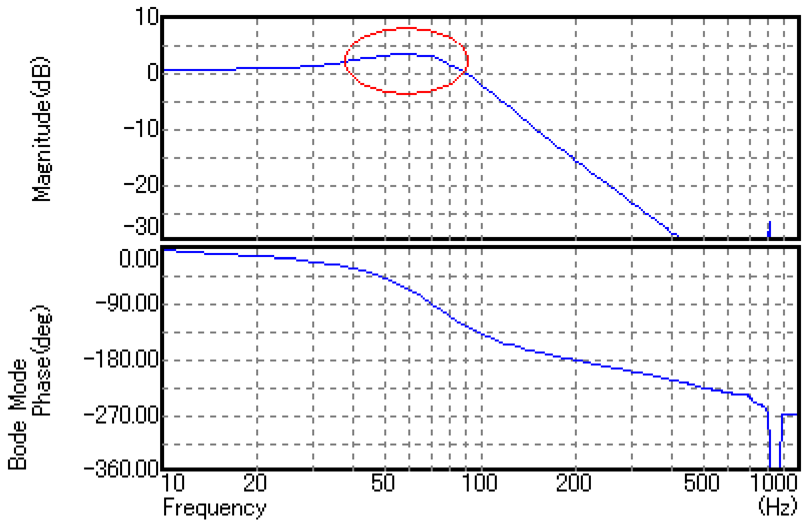
Parameter	Setting data
Velocity loop proportional gain	Motor model-specific standard value
Velocity loop Integral gain	Motor model-specific standard value
Velocity loop gain override	Adjusted value

When the values calculated from the above expression are set, and if any of the following oscillations occurs because, for example, the rigidity of the spindle is low, decrease the override to a value with a margin.

- The vibration sound of spindle occurs.
- Vibration of a torque command becomes large.
- Vibration of position error becomes large in the stop state.

When you can use the SERVO GUIDE, you should measure velocity loop frequency response, and make adjustments to increase the gains while observing the response. Basically, increase the velocity loop gain override to increase the response band. If there is a rise in the gain characteristic at a frequency near 40 to 70 Hz, however, make an adjustment to decrease the velocity loop integral gain slightly. The guideline for a rise is approximately 5 dB.

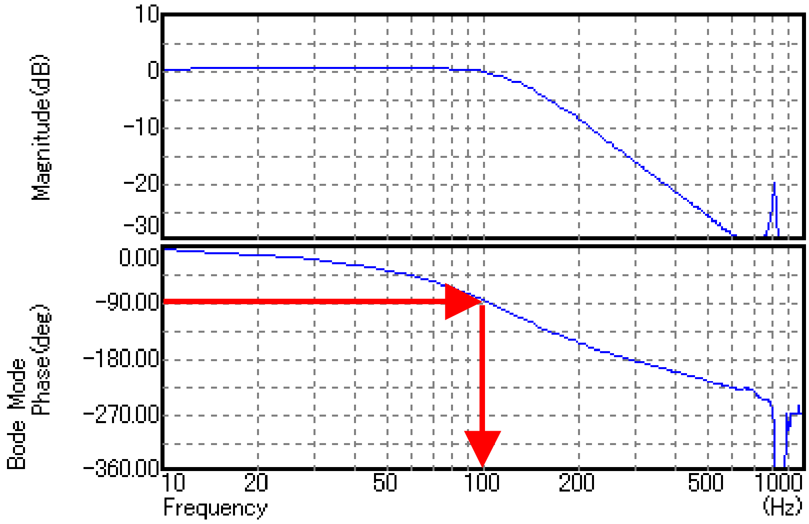
Example) Rise in the gain characteristic



(3) Finally, adjust the position loop gain.
Determine the position gain limit value while observing low-frequency vibration when the motor is stopped and when the motor rotates. Since the position gain is generally suited to the servo axis for simultaneous contouring control, it cannot be determined from the characteristic for the Cs axis only; consider the guideline for the setting of the Cs axis as approximately 80% of the limit value.

When you can use the SERVO GUIDE, you can measure velocity loop frequency response, check the cut-off frequency, and know the guideline for the position gain setting from that frequency.
In the Bode diagram, the cut-off frequency is a frequency with a phase of -90°.
When a built-in spindle motor is used and the cut-off frequency is F (Hz), the guideline for the position gain limit value is F (s^{-1}) or greater.

Example) Frequency response of a built-in spindle motor



Cut-off frequency of 100 Hz

In the above example, the cut-off frequency is 100 Hz, and it is therefore likely that a position gain of 100 s^{-1} or greater can be ensured.

2.4.9.3 Standard parameters of velocity loop gain for Cs contouring control for each motor model

NOTE

1 If the motor model is not included in the list , calculate gain according the following equation.

No. 4046 (or No. 4047) = 30159/ (T_{max}/J_m)

No. 4054 (or No. 4055) = 280735/ (T_{max}/J_m)

where

(For αi series spindle motors)

Tmax = Short time rated torque at constant torque range × 1.2 [Nm]

(For βi series spindle motors)

Tmax = Short time rated torque at constant torque range × 1.1 [Nm]

J_m = Motor rotor inertia [kgm^2]

2 Set the standard value in parameters (Nos. 4046/4047 and Nos. 4054/4055) for the selected winding (high-speed/low-speed).

(a) SPINDLE MOTOR αi I

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
αi I 0.5/10000	3	30
αi I 1/10000	10	98
αi I 1.5/10000	5	42
αi I 2/10000	8	75
αi I 3/10000	10	90
αi I 6/10000	9	88
αi I 8/8000	10	92
αi I 12/7000	18	171
αi I 15/7000	18	165
αi I 18/7000	19	175

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
αi I 22/7000	18	167
αi I 30/6000	24	223
αi I 40/6000	31	287
αi I 50/4500	24	223
αi I 1/15000	11	100
αi I 1.5/15000	8	71
αi I 2/15000	7	65
αi I 3/12000	10	90
αi I 6/12000 (Low-speed winding)	9	83
αi I 6/12000 (High-speed winding)	20	183
αi I 8/10000 (Low-speed winding)	10	92
αi I 8/10000 (High-speed winding)	26	245
αi I 12/10000 (Low-speed winding)	18	171
αi I 12/10000 (High-speed winding)	49	457
αi I 15/10000 (Low-speed winding)	19	179
αi I 15/10000 (High-speed winding)	51	476
αi I 18/10000 (Low-speed winding)	19	175
αi I 18/10000 (High-speed winding)	50	467
αi I 22/10000 (Low-speed winding)	19	181
αi I 22/10000 (High-speed winding)	52	482

(b) SPINDLE MOTOR αi IP series

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
αi IP 12/8000	12	114
αi IP 12/8000	18	171
αi IP 15/6000	13	122
αi IP 15/8000	20	184
αi IP 18/6000	10	95
αi IP 18/8000	18	167
αi IP 22/6000	11	104
αi IP 22/8000	17	155
αi IP 30/6000 (Low-speed winding)	17	156
αi IP 30/6000 (High-speed winding)	24	224
αi IP 40/6000 (Low-speed winding)	14	131
αi IP 40/6000 (High-speed winding)	20	186
αi IP 50/6000 (Low-speed winding)	18	166
αi IP 50/6000 (High-speed winding)	37	347
αi IP 60/4500 (Low-speed winding)	17	160
αi IP 60/4500 (High-speed winding)	32	300

(c) SPINDLE MOTOR αi I_T series

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
αi I_T 1.5/15000	4	35
αi I_T 2/15000	6	52
αi I_T 3/12000	12	107
αi I_T 6/12000 (Low-speed winding)	13	121
αi I_T 6/12000 (High-speed winding)	7	63
αi I_T 8/12000 (Low-speed winding)	11	100
αi I_T 8/12000 (High-speed winding)	5	47
αi I_T 8/15000 (Low-speed winding)	17	157
αi I_T 8/15000 (High-speed winding)	17	156
αi I_T 15/10000 (Low-speed winding)	24	224
αi I_T 15/10000 (High-speed winding)	14	131
αi I_T 15/12000 (Low-speed winding)	12	108
αi I_T 15/12000 (High-speed winding)	11	100
αi I_T 22/10000 (Low-speed winding)	37	347
αi I_T 22/10000 (High-speed winding)	17	160

(d) SPINDLE MOTOR αi I_L series

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
αi I_L 8/20000 (Low-speed winding)	10	92
αi I_L 8/20000 (High-speed winding)	24	224
αi I_L 15/15000 (Low-speed winding)	11	102
αi I_L 15/15000 (High-speed winding)	47	436
αi I_L 26/15000 (Low-speed winding)	18	163
αi I_L 26/15000 (High-speed winding)	42	393

(e) PINDLE MOTOR αi I series (400V)

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
αi I 0.5/10000HV	3	30
αi I 1/10000HV	10	91
αi I 1.5/10000HV	5	42
αi I 2/10000HV	8	71
αi I 3/10000HV	10	92
αi I 6/10000HV	9	85
αi I 8/8000HV	10	96
αi I 12/7000HV	18	171
αi I 15/7000HV	14	131
αi I 22/7000HV	19	179
αi I 30/6000HV	24	224
αi I 40/6000HV	32	302
αi I 60/4500HV	20	184
αi I 100/4000HV (Low-speed winding)	26	240
αi I 100/4000HV (High-speed winding)	52	480

(f) SPINDLE MOTOR α*i* I$_P$ series (400V)

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
α*i* I$_P$ 15/6000HV (Low-speed winding)	13	122
α*i* I$_P$ 15/6000HV (High-speed winding)	20	184
α*i* I$_P$ 22/6000HV (Low-speed winding)	11	104
α*i* I$_P$ 22/6000HV (High-speed winding)	17	157
α*i* I$_P$ 40/6000HV (Low-speed winding)	14	131
α*i* I$_P$ 40/6000HV (High-speed winding)	20	189
α*i* I$_P$ 50/6000HV (Low-speed winding)	18	166
α*i* I$_P$ 50/6000HV (High-speed winding)	37	347
α*i* I$_P$ 60/4500HV (Low-speed winding)	17	160
α*i* I$_P$ 60/4500HV (High-speed winding)	32	300

(g) SPINDLE MOTOR α*i* I$_T$ series(400V)

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
α*i* I$_T$ 1.5/15000HV	15	143
α*i* I$_T$ 2/15000HV	17	155
α*i* I$_T$ 3/12000HV	3	29
α*i* I$_T$ 6/12000HV (Low-speed winding)	9	88
α*i* I$_T$ 6/12000HV (High-speed winding)	25	234
α*i* I$_T$ 8/12000HV (Low-speed winding)	7	62
α*i* I$_T$ 8/12000HV (High-speed winding)	15	137
α*i* I$_T$ 8/15000HV (Low-speed winding)	10	92
α*i* I$_T$ 8/15000HV (High-speed winding)	26	245
α*i* I$_T$ 15/10000HV (Low-speed winding)	19	179
α*i* I$_T$ 15/10000HV (High-speed winding)	51	476
α*i* I$_T$ 15/12000HV (Low-speed winding)	11	102
α*i* I$_T$ 15/12000HV (High-speed winding)	39	364
α*i* I$_T$ 22/10000HV (Low-speed winding)	19	181
α*i* I$_T$ 22/10000HV (High-speed winding)	52	482

(h) SPINDLE MOTOR α*i* I$_L$ series(400V)

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
α*i* I$_L$ 8/20000HV (Low-speed winding)	10	92
α*i* I$_L$ 8/20000HV (High-speed winding)	24	224
α*i* I$_L$ 15/15000HV (Low-speed winding)	11	102
α*i* I$_L$ 15/15000HV (High-speed winding)	47	436
α*i* I$_L$ 26/15000HV (Low-speed winding)	18	163
α*i* I$_L$ 26/15000HV (High-speed winding)	42	393

(i) SPINDLE MOTOR B*i*I series (standard type)

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
B*i*I 50L/25000	1	13
B*i*I 80S/20000 (Low-speed winding)	11	100
B*i*I 80S/20000 (High-speed winding)	11	106
B*i*I 80M/15000	11	100
B*i*I 80L/8000	4	40
B*i*I 100S/12500	9	79
B*i*I 112SS/20000 (Low-speed winding)	4	38
B*i*I 112SS/20000 (High-speed winding)	19	178
B*i*I 112S/15000 (Low-speed winding)	5	47
B*i*I 112S/15000 (High-speed winding)	25	235
B*i*I 112M/15000	9	88
B*i*I 112L/15000 (Low-speed winding)	5	44
B*i*I 112L/15000 (High-speed winding)	13	122
B*i*I 112LL/15000 (Low-speed winding)	5	44
B*i*I 112LL/15000 (High-speed winding)	12	109
B*i*I 132M/14000 (Low-speed winding)	4	39
B*i*I 132M/14000 (High-speed winding)	14	133
B*i*I 132L/14000 (Low-speed winding)	5	43
B*i*I 132L/14000 (High-speed winding)	23	210
B*i*I 160S/13000 (Low-speed winding)	8	72
B*i*I 160S/13000 (High-speed winding)	14	135
B*i*I 160M/13000 (Low-speed winding)	7	69
B*i*I 160M/13000 (High-speed winding)	8	79
B*i*I 160L/13000 (Low-speed winding)	9	81
B*i*I 160L/13000 (High-speed winding)	19	180
B*i*I 160LL/13000 (Low-speed winding)	7	67
B*i*I 160LL/13000 (High-speed winding)	27	247
B*i*I 180M/6000 (Low-speed winding)	15	139
B*i*I 180M/6000 (High-speed winding)	27	248
B*i*I 180L/6000 (Low-speed winding)	16	145
B*i*I 180L/6000 (High-speed winding)	34	318
B*i*I 180LL/8000 (Low-speed winding)	13	120
B*i*I 180LL/8000 (High-speed winding)	42	391
B*i*I 200M/6000 (Low-speed winding)	12	111
B*i*I 200M/6000 (High-speed winding)	22	206
B*i*I 200L/6000 (Low-speed winding)	11	103
B*i*I 200L/6000 (High-speed winding)	20	187
B*i*I 250M/3000 (Low-speed winding)	19	180
B*i*I 250M/3000 (High-speed winding)	35	325

(j) SPINDLE MOTOR B*i*I series (high-speed type)

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
B*i*I 40S/70000	20	183
B*i*I 80S/40000	17	159
B*i*I 100S/20000 (Low-speed winding)	6	51
B*i*I 100S/20000 (High-speed winding)	9	86
B*i*I 112S/20000 (Low-speed winding)	6	56
B*i*I 112S/20000 (High-speed winding)	9	87
B*i*I 112M/20000 (Low-speed winding)	4	42
B*i*I 112M/20000 (High-speed winding)	24	225
B*i*I 112L/20000 (Low-speed winding)	5	50
B*i*I 112L/20000 (High-speed winding)	20	187
B*i*I 112L/25000 (Low-speed winding)	4	41
B*i*I 112L/25000 (High-speed winding)	12	111
B*i*I 132L/25000 (Low-speed winding)	5	49
B*i*I 132L/25000 (High-speed winding)	27	247
B*i*I 160M/20000 (Low-speed winding)	6	60
B*i*I 160M/20000 (High-speed winding)	34	312
B*i*I 160L/20000 (Low-speed winding)	9	82
B*i*I 160L/20000 (High-speed winding)	21	200
B*i*I 160LL/20000 (Low-speed winding)	11	106
B*i*I 160LL/20000 (High-speed winding)	68	635

(k) SPINDLE MOTOR β*i*I series

Motor model	Velocity loop proportional gain No.4046/ No.4047	Velocity loop Integral gain No.4054/ No.4055
β*i*I 3/10000	6	28
β*i*I 6/10000	8	40
β*i*I 8/10000	7	33
β*i*I 12/10000	8	37

2.4.10 Diagnosis (Diagnosis Screen)

Address			Description	Unit
15*i*	16*i*	30*i*		
—	0418	—	Position error value of the first spindle	Pulse
1540	—	0418	Position error value of the spindle	Pulse

2.4.11 Alarm

This Subsection provides a list of the alarms related to Cs contouring control only. For details of alarms, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.9, “Cs CONTOUR CONTROL.”

(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.9, “Cs CONTOUR CONTROL.”

(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7, “Cs CONTOUR CONTROL.”

(d) For Series 0*i*

"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.8, "Cs CONTOUR CONTROL."

(e) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.10, "Cs CONTOUR CONTROL."

(f) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.11, "Cs CONTOUR CONTROL."

(1) Series 16*i*

Alarm No.	Description
194	Cs contouring control is specified in serial spindle synchronous control mode.
197	A move command was issued from a program when the input signal CON (bit 7 of G027) is off.
751	An alarm was issued on the serial spindle amplifier side.
752	Switching to Cs contouring control mode is not terminated normally.

(2) Series 30*i*

Alarm No.	Description
PS0194	Cs contouring control is specified in serial spindle synchronous control mode.
PS0197	A move command was issued from a program when the input signal CON (bit 7 of G027) is off.
SP0752	Switching to Cs contouring control mode is not terminated normally.

(3) Series 15*i*

Alarm No.	Description
PS0571	A move command for Cs contouring control was issued for an axis not placed on Cs contouring control mode.
PS0572	A Cs contouring control axis command was issued for an axis in motion.

2.5 SPINDLE SYNCHRONOUS CONTROL (OPTIONAL FUNCTION)

2.5.1 Start-up Procedure

A. Check that operation in velocity control mode is ready.

↓

B. Prepare and check the ladder programs for the spindle synchronous control function.

↓

C. Set the parameters related to spindle synchronous control.

↓

D. Connect a position coder and check the feedback signal.

↓

E. Check the spindle synchronous speed.

↓

F. Check the direction of spindle rotation when spindle synchronous control is applied.
- Direction of spindle motor rotation when spindle synchronous control is applied.

↓

G. Check that errors such as overshoot or hunting do not occur before the spindle achieves the maximum speed for synchronization.
- Position gain for spindle synchronous control
- Acceleration/deceleration time constant used for spindle synchronous control control

↓

H. Check that the error pulse difference between the spindles is within ±5 pulses.
- Position gain for spindle synchronous control
- Spindle-to-motor gear ratio data
- Velocity loop proportional gain for spindle synchronous control
- Velocity loop integral gain for spindle synchronous control
- Incomplete integration coefficient
- Bell-shaped acceleration/deceleration time constant for spindle synchronous control
- Motor voltage for spindle synchronous control

↓

I. Check the operation of spindle phase synchronization control.
- Shift amount for spindle phase synchronization
- Compensation data for spindle phase synchronization

↓

J. End the checking of spindle synchronous control operation.

2.5.2 Overview

When, on a machine (such as a lathe) that has two facing spindles, workpiece seizure is to be switched from the first spindle to the second spindle during spindle rotation, or acceleration/deceleration is

performed while the first spindle and second spindle hold a workpiece, the two spindles must rotate at the same speed.
When the seizure of a uniquely shaped workpiece is to be switched from one spindle to the other, the two spindles must have the same spindle rotation phase (angular displacement).
The spindle synchronous control function exercises synchronous control between two spindles in these cases.

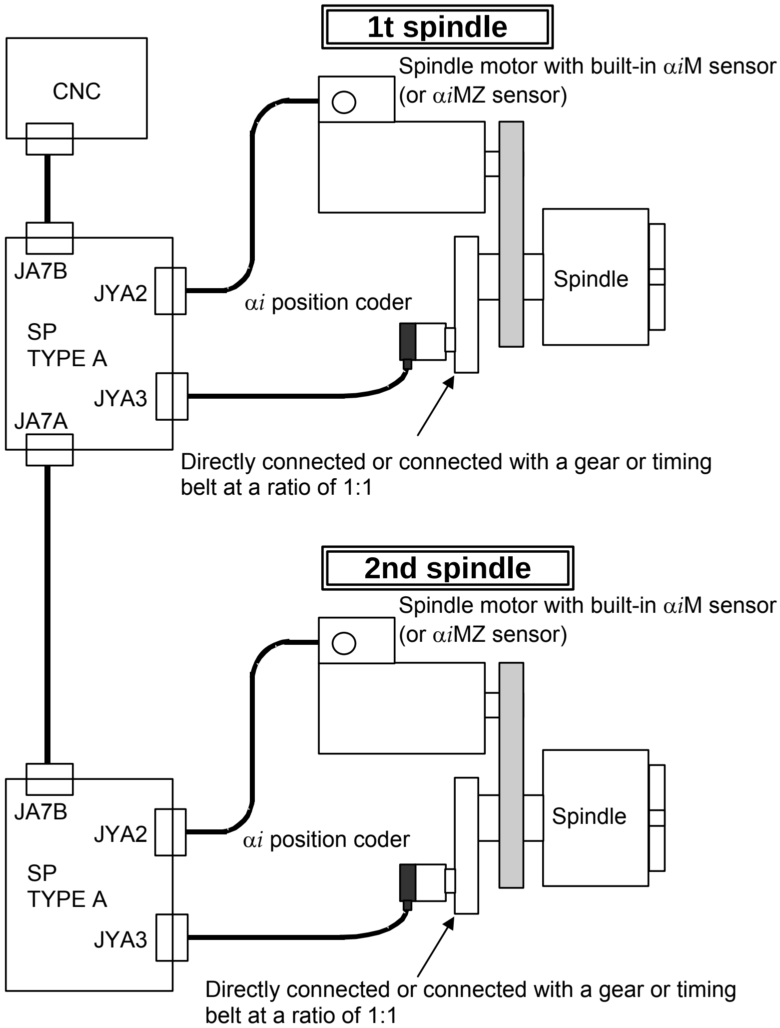
> ⚠ **CAUTION**
> 1 To use this function, the CNC software option is required.
> 2 This function cannot be used with FANUC Series 15*i*.

2.5.3 System Configuration

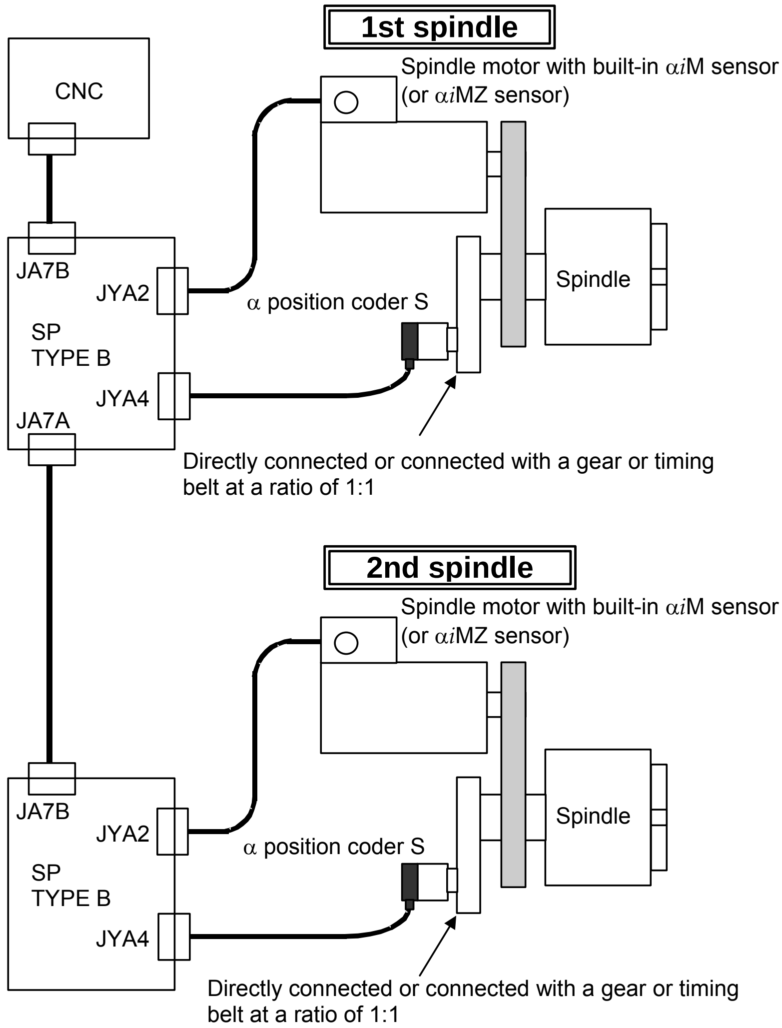
The system configurations that enable the use of the spindle synchronous control function are shown below.

> **NOTE**
> 1 Spindle synchronous control between spindles each having a different detector configuration is possible.
> 2 Spindle synchronous control between different path is possible. For details, see below:
> Section 9.12, “SPINDLE SYNCHRONOUS CONTROL”, in FANUC Series 16*i*/18*i*/21*i* –MODEL B CONNECTION MANUAL (FUNCTION) (B-63523EN-1)
> Section 11.13, “SPINDLE SYNCHRONOUS CONTROL”, in FANUC Series 30*i*/31*i*/32*i* –MODEL A CONNECTION MANUAL (FUNCTION) (B-63943EN-1)

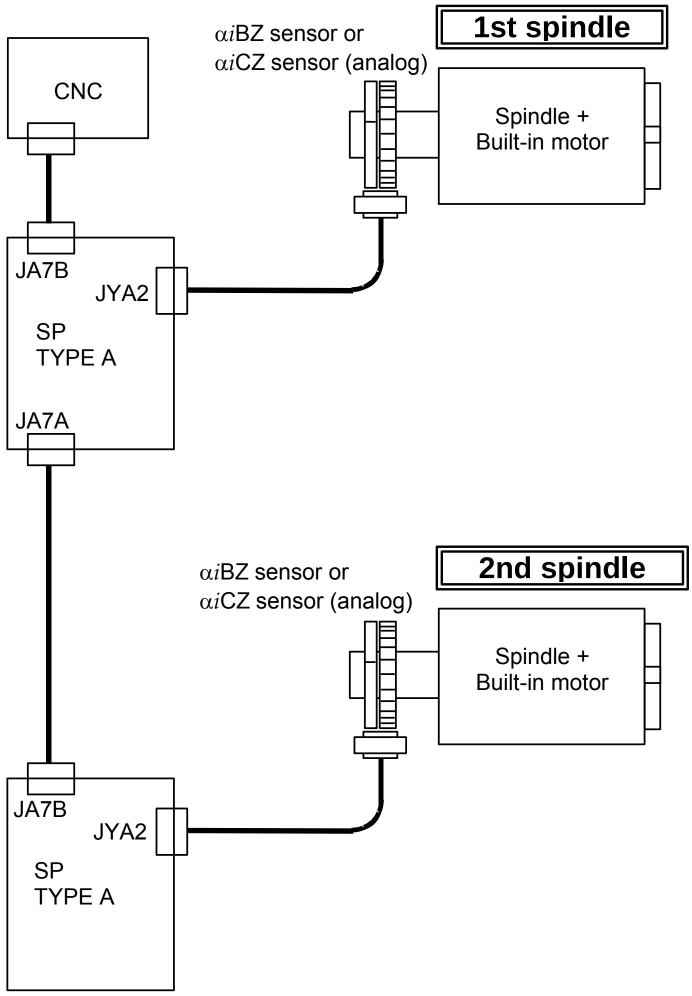
(1) When the αi position coder is used



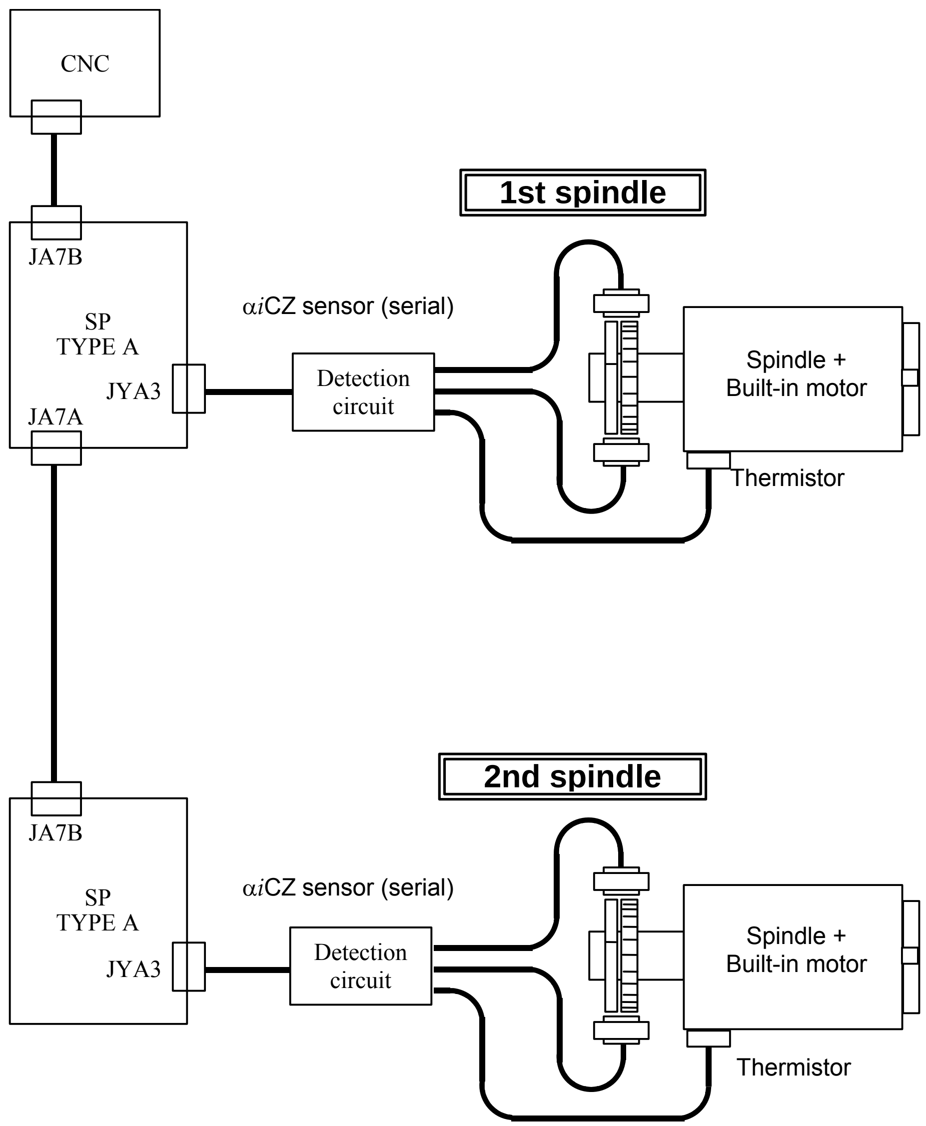
(2) When the α position coder S is used



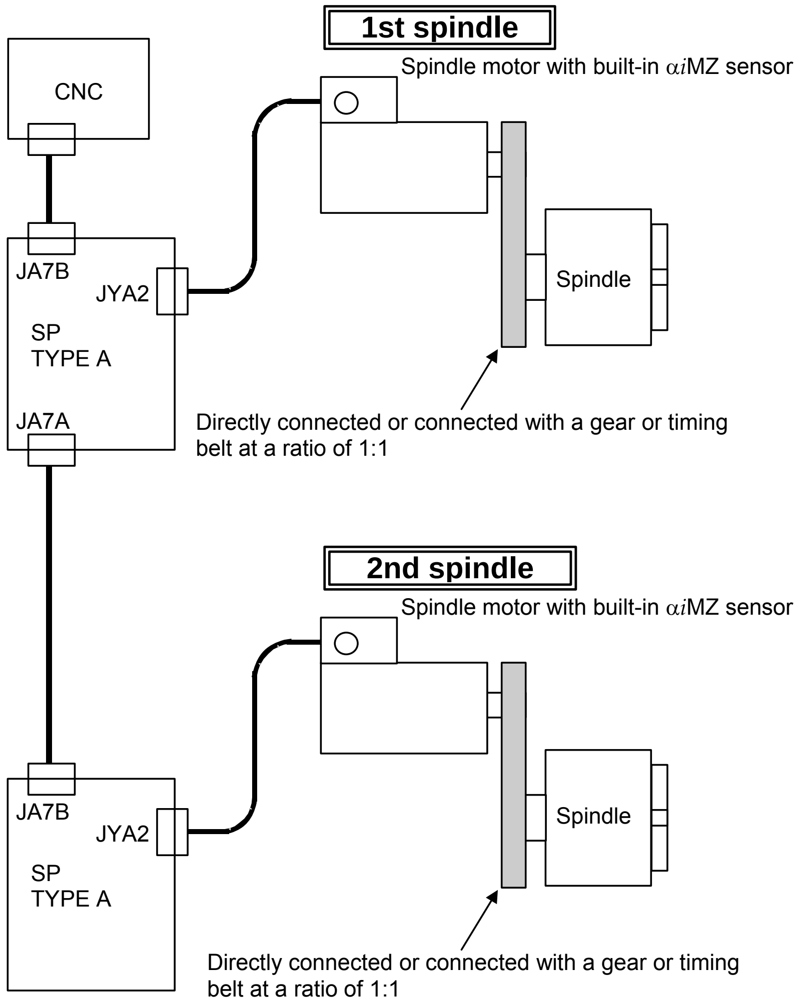
(3) When the built-in motor (αiBZ sensor, αiCZ sensor (analog)) is used



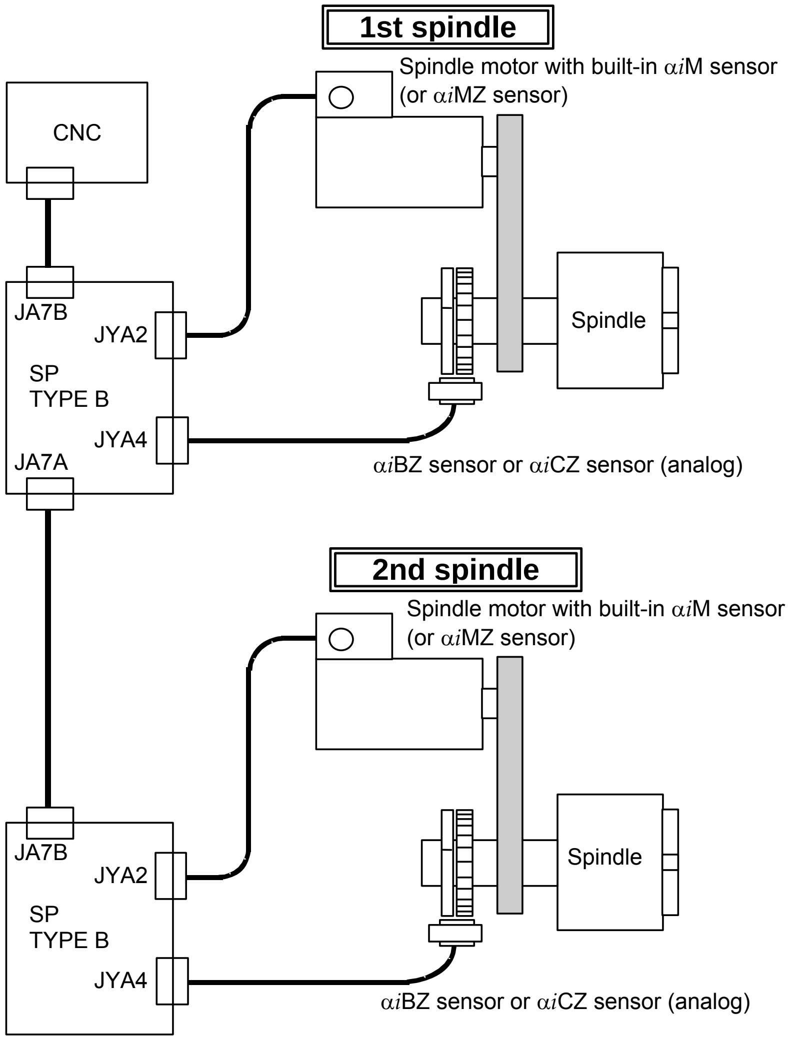
(4) When the built-in motor (αiCZ sensor (serial)) is used



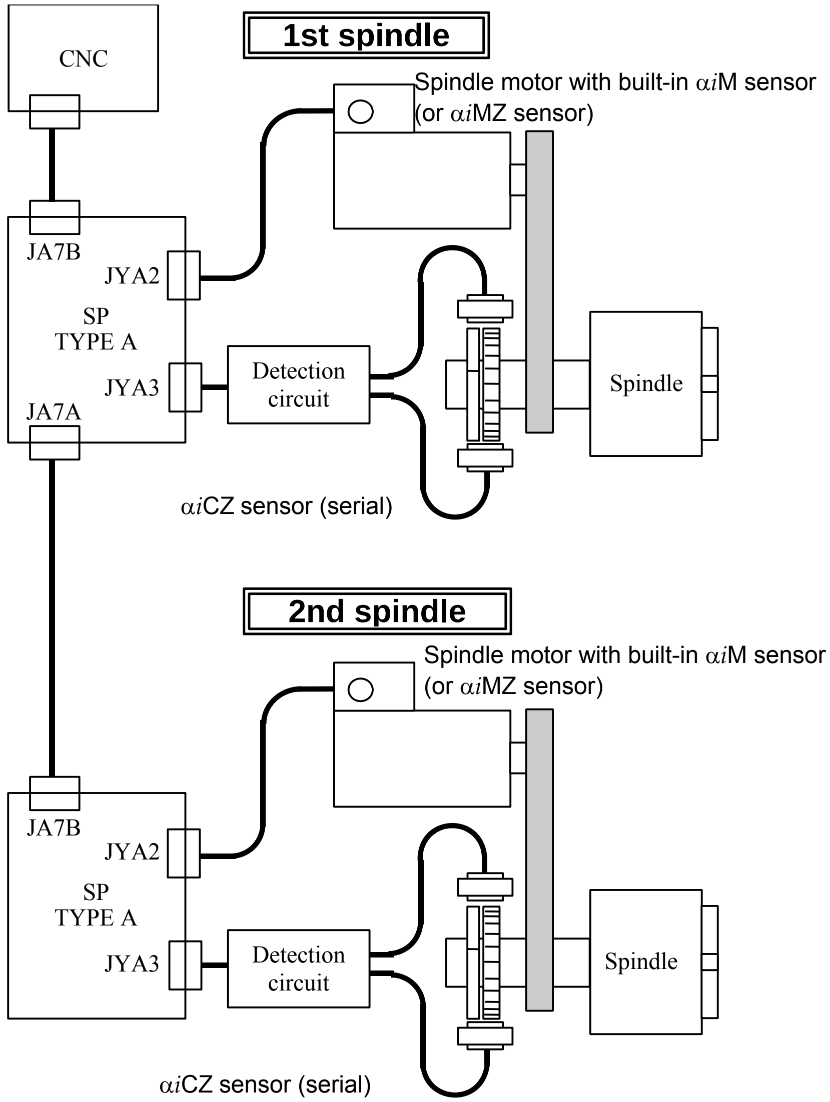
(5) When the spindle motor with built-in αiMZ sensor is used



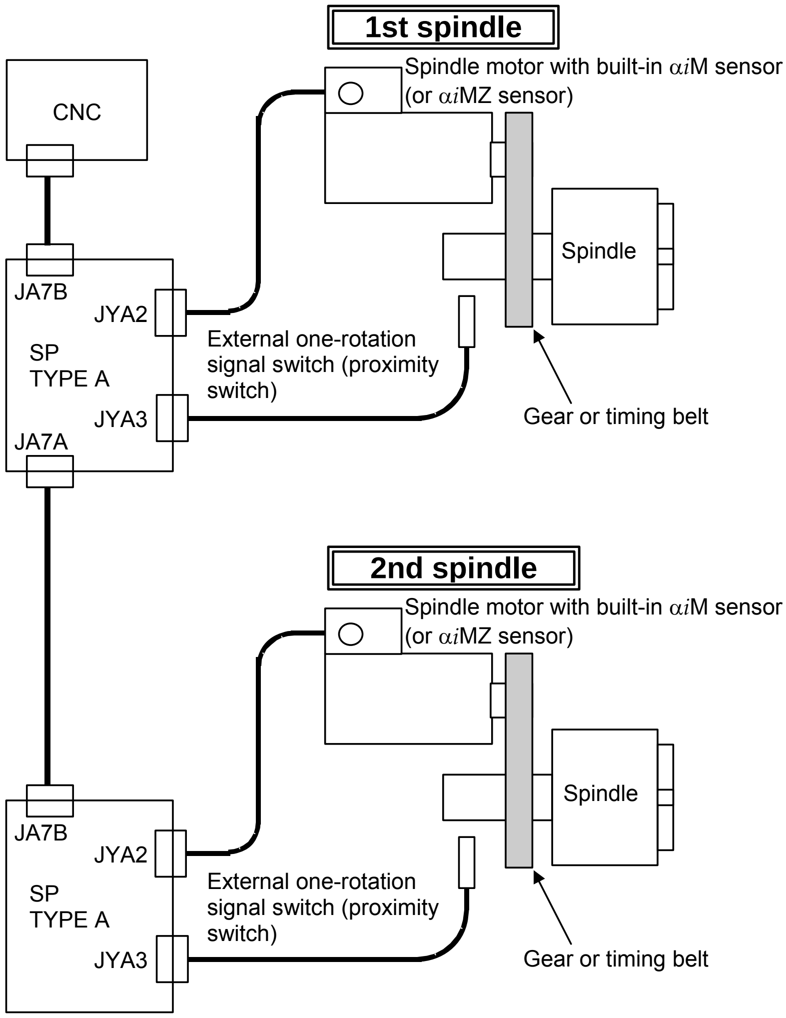
(6) When the separate type α*i*BZ sensor or separate type α*i*CZ sensor (analog) is used



(7) When the separate type αiCZ sensor (serial) is used



(8) When the external one-rotation signal (proximity switch) is used



NOTE

1 When using the external one-rotation signal (proximity switch), use the detection arbitrary gear ratio function (DMR function).
2 When using the detection arbitrary gear ratio function (DMR function), set the following:
 - Parameters (No. 4171 to No. 4174) for the numerator/denominator of an arbitrary gear ratio between the motor sensor and spindle
3 Set the type of the external one-rotation signal (proximity switch) (bits 3 and 2 of No. 4004).
4 For stable detection of the one-rotation signal, detect the one-rotation signal by performing spindle orientation before entering spindle synchronous control mode. For orientation based on the external one-rotation signal, see Section 2.2, “POSITION CODER METHOD ORIENTATION”, in Part I.

2.5.4 Explanation of Operation

(i) If spindle synchronous control is commanded when the two spindles are rotating at different speeds (including stop state), the two spindles are accelerated or decelerated to the commanded speed then enter synchronous control state.

(ii) If the synchronous speed command is changed after synchronous control state is entered, the spindles are accelerated or decelerated to the new commanded speed with the parameter-set acceleration while synchronous control state is held. If the synchronous speed command is 0 min^{-1}, the spindles stops in synchronism.

(iii) If spindle synchronous control at a synchronous speed of 0 min^{-1} is commanded when the spindles are in stop state, each spindle automatically makes two to three turns to detect the position coder one-rotation signal (as a preparation for spindle phase synchronous control), then enters synchronous control state.
Next, when the synchronous speed command is changed, the spindles are accelerated with the parameter-set acceleration while synchronous control state is held, until the speed command is changed.

(iv) When the seizure of a uniquely shaped workpiece needs to be switched between the two spindles, the rotation phase (angular displacement) of one spindle must match that of the other.
If a spindle phase synchronous control command is entered when the two spindles are rotating in synchronous control state, each spindle is controlled to have the parameter-set rotation phase (a momentary speed change occurs at this time), then enters synchronous control state again.
A rotation phase match can be secured by matching the reference positions of the two spindles by parameter setting beforehand.

(v) If the two spindles enter synchronous control state at a specified synchronous speed of 0 min^{-1}, and a phase synchronous control command is then entered, each spindle rotates and stops to achieve a parameter-set phase. This operation is performed as if spindle positioning (spindle orientation) is performed while the spindles are stopped. As a result, the reference position of one spindle matches that of the other (phase synchronization).
If the synchronous speed command is changed after the two spindles seize a uniquely shaped workpiece, the two spindles are accelerated to the new specified speed with the parameter-set acceleration while synchronous control state is held.

(vi) Even in the state where the two spindles are seizing a workpiece in synchronous control state, constant surface speed control can be exercised.
However, even if a speed change greater than the parameter-set acceleration is commanded, the speed changes within the parameter-set acceleration.

(vii) Do not change the rotation direction command (SFRA, SRVA) during synchronous control.

NOTE

For details, see below:
Section 9.12, “SPINDLE SYNCHRONOUS CONTROL”, in FANUC Series 16*i*/18*i*/21*i* -MODEL B CONNECTION MANUAL (FUNCTION) (B-63523EN-1).
Section 11.13, “SPINDLE SYNCHRONOUS CONTROL”, in FANUC Series 30*i*/31*i*/32*i* –MODEL A CONNECTION MANUAL (FUNCTION) (B-63943EN-1)
Section 9.11, “SPINDLE SYNCHRONOUS CONTROL”, in FANUC Series 0*i* -MODEL C CONNECTION MANUAL (FUNCTION) (B-64113EN-1).

2.5.5 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G038	G038					SPPHS	SPSYC		
Common to all axes	G032	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
Common to all axes	G033	G033			SSGN		R12I	R11I	R10I	R09I
1st-	G070	G070			SFRA	SRVA	CTH1A	CTH2A		
2nd-	G074	G074			SFRB	SRVB	CTH1B	CTH2B		
1st-	G071	G071			INTGA					
2nd-	G075	G075			INTGB					

(2) Details of input signals (PMC→CNC)

(a) Spindle synchronous control signal SPSYC

[Function] Specifies switching to spindle synchronous control mode.

[Operation] When this signal is set to 1, spindle synchronous control mode is set.
When this signal is set to 0, spindle synchronous control mode is cancelled.

(b) Spindle phase synchronous control signal SPPHS

[Function] Specifies spindle phase synchronous control mode (phase matching).

(i) This function is valid when the spindle synchronous control signal SPSYC is 1.

(ii) After the spindle synchronous speed control completion signal FSPSY is set to 1, specify this signal.

(iii) A spindle phase synchronous control operation is performed on the rising edge of this signal. So, the phase once matched is not shifted by setting this signal to 0.
However, a phase matching operation is performed when this signal is changed from 0 to 1 again.

[Operation] When this signal makes a transition from 0 to 1, spindle phase synchronous control is exercised.

(c) Velocity integral control signal INTGA

[Function] Enables or disables velocity integral control.

[Operation] When this signal is set to 1

⇒ The velocity loop integral function is disabled. This has the same effect as the setting of a velocity loop integral gain of 0.

When this signal is set to 0

⇒ The velocity loop integral function is enabled.

NOTE

1. When the two spindles seize the same workpiece, a spindle may be fixed at a position slightly displaced from the specified position because the two spindles are mechanically connected.
   In this case, an excessively high current can flow because the velocity loop integral function attempts to return the spindle to the specified position.
   To prevent this, turn on (set to 1) the velocity integral control signal INTGA to disable the velocity loop integral function if the two spindles are mechanically connected.
2. When the velocity integral control signal INTGA is turned on (set to 1), the velocity loop integral function is disabled. So, an increased synchronous error can occur. When the two spindles do not seize the same workpiece, turn off (set to 0) the velocity integral control signal INTGA to enable the velocity loop integral function.

(3) Address list of output signals (CNC→PMC)

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F044	F044				SYCAL	FSPPH	FSPSY		
1st-	F045	F045					SARA			
2nd-	F049	F049					SARB			

(4) Details of output signals (CNC→PMC)

(a) Spindle synchronous speed control completion signal FSPSY

[Function]

Posts that spindle synchronous control (speed synchronization) is completed.

[Output condition]

This signal is set to 1 when the following condition is satisfied:

(i) This signal is output when the two spindles have reached the speed corresponding to a specified spindle synchronous speed and the speed difference between the two spindles is equal to or less than the value set in parameter No. 4033 on spindle synchronous control mode.

This signal is set to 0 when any of the following conditions is satisfied:

(i) The two spindles have not reached the speed corresponding to a specified spindle synchronous speed on spindle synchronous control mode.
(ii) The speed difference between the two spindles is greater than the value set in parameter No. 4033 on spindle synchronous control mode.
(iii) Spindle synchronous control mode is not set.

NOTE

Even if this signal is set to 1 once, this signal is set to 0 when the speed difference becomes equal to or greater than the value set in parameter No. 4033 for a cause such as cutting load variation.

(b) Spindle phase synchronous control completion signal FSPPH

[Function]

Posts that spindle phase synchronous control (phase matching) is completed.

[Output condition]

This signal is set to 1 when the following condition is satisfied:

(i) This signal is output when phase matching is completed with the spindle phase synchronous control signal (the error pulse difference between the two spindles is equal to or less than the value set in parameter No. 4810) after the two spindles have reached the speed corresponding to a specified spindle synchronous speed on spindle synchronous control mode.

This signal is set to 0 when any of the following conditions is satisfied:

(i) Phase matching between the two spindles is not completed on spindle synchronous control mode. The error pulse difference between the two spindles is greater than the value set in parameter No. 4810 on spindle synchronous control mode.

(ii) Spindle phase synchronous control mode is not set.

NOTE

Even if this signal is set to 1 once, this signal is set to 0 when the speed difference becomes equal to or greater than the value set in parameter No. 4033 for a cause such as cutting load variation.

(c) Phase error monitoring signal SYCAL

[Function]

Posts that the error pulse difference between the two spindles is greater than the parameter-set value on spindle synchronous control mode.

[Output condition]

This signal is set to 1 when the following condition is satisfied:

(i) The error pulse difference between the two spindles after spindle synchronous control is completed is greater than the value set in parameter No. 4811 on spindle synchronous control mode.

This signal is set to 0 when any of the following conditions is satisfied:

(i) The error pulse difference between the two spindles is equal to or less than the value set in parameter No. 4811 on spindle synchronous control mode.

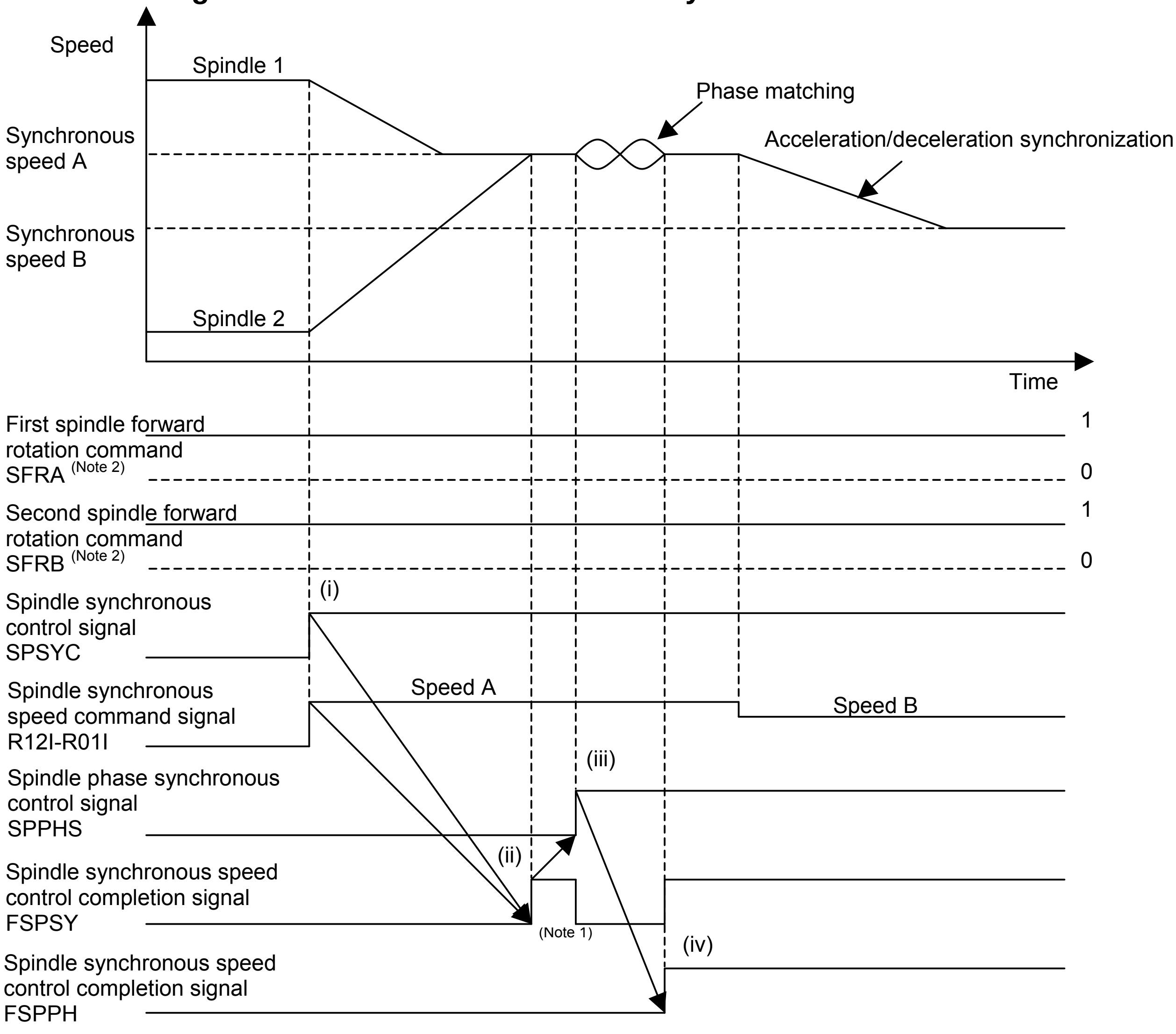
(ii) Spindle phase synchronous control mode is not set.

NOTE

Use this signal to take an action if an error such as an excessive synchronous error occurs for a cause on spindle synchronous control mode.

2.5.6 Examples of Sequences

(1) While spindle 1 is rotating, spindle 2 is accelerated for synchronization with spindle 1, and phase matching is performed. Then, the synchronous speed is also changed for acceleration/deceleration synchronization.



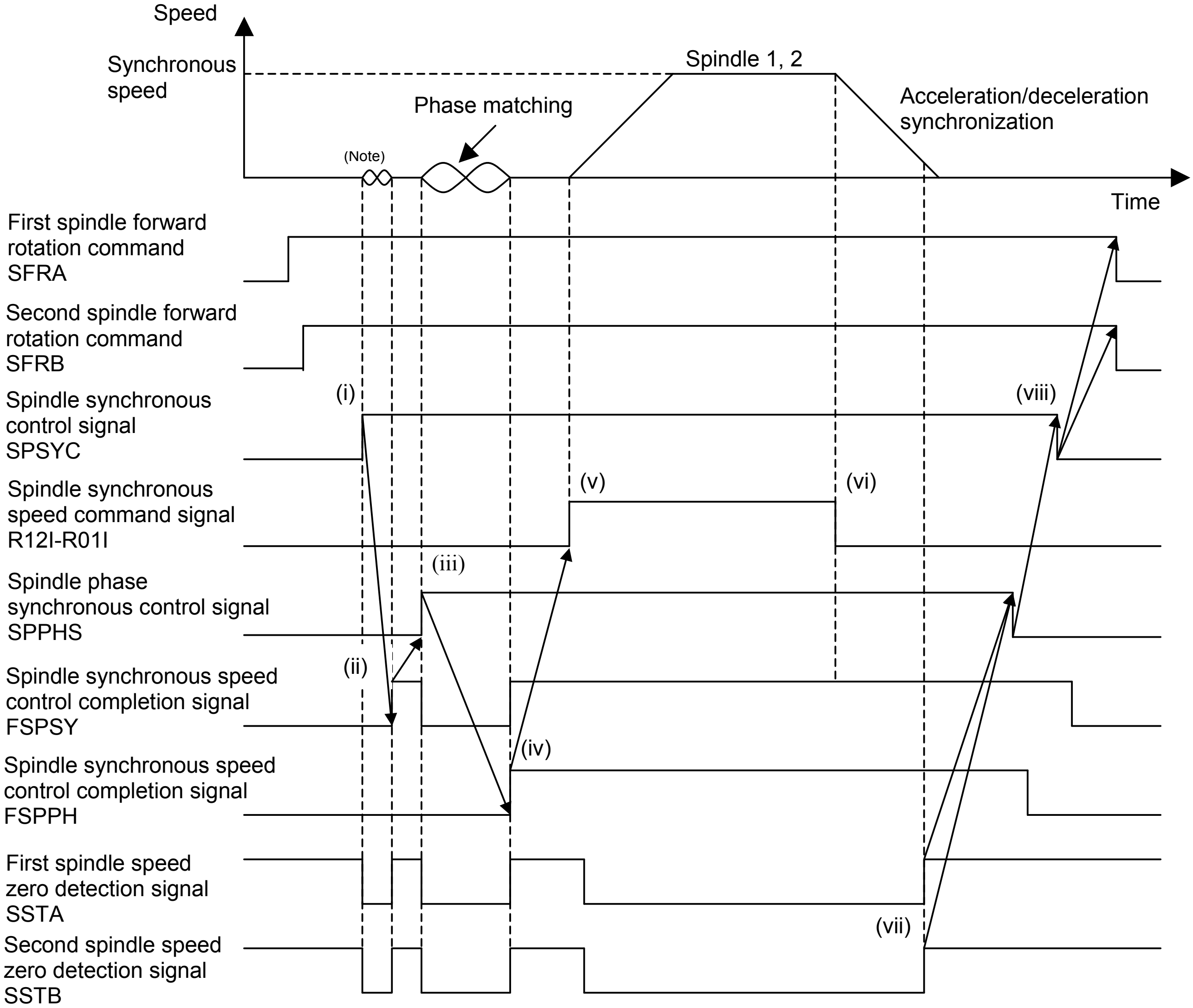
(i) The spindle synchronous speed command signal is input to set the spindle synchronous control signal SPSYC to 1.
(ii) The spindle synchronous speed control completion signal FSPSY set to 1 is awaited.
(iii) The spindle phase synchronous control signal SPPHS is set to 1.
(iv) The spindle phase synchronous control completion signal FSPPH set to 1 is awaited.

NOTE

1 When the spindle phase synchronous control signal is input, the spindle synchronous speed control completion signal is once set to 0, then is set to 1 again upon completion of phase synchronization.

2 Set the spindle forward rotation command SFR (or the spindle reverse rotation command SRV) to 1 at all times during spindle synchronous control.

(2) Spindle 1 and spindle 2 perform phase matching in stop state, then are accelerated in synchronism. Next, spindle 1 and spindle 2 are decelerated to a stop in synchronism.

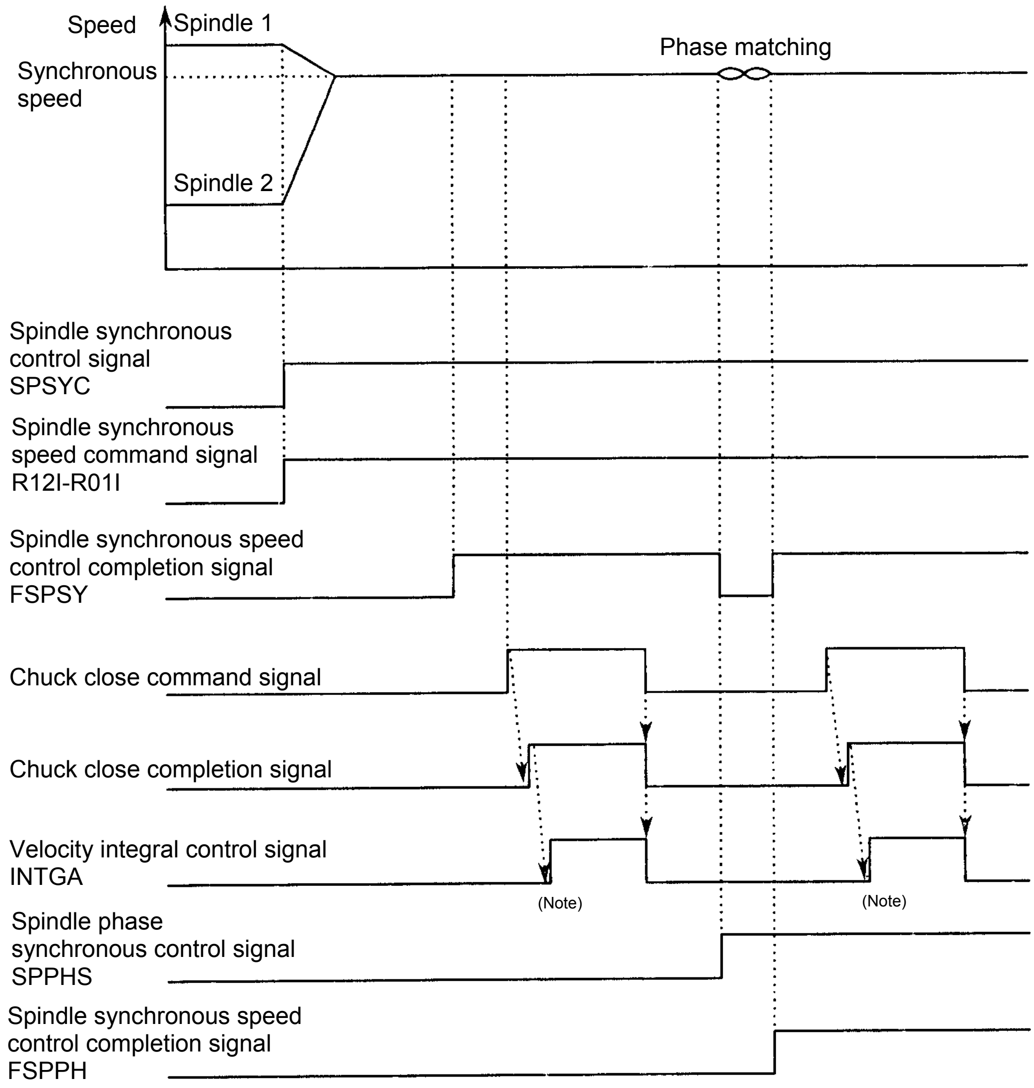


(i) The spindle synchronous speed command signal is set to 0, and the spindle synchronous control signal SPSYC is set to 1.
(ii) The spindle synchronous speed control completion signal FSPSY set to 1 is awaited.
(iii) The spindle phase synchronous control signal SPPHS is set to 1.
(iv) The spindle phase synchronous control completion signal FSPPH set to 1 is awaited.
(v) The spindle synchronous speed command signal is input.
(vi) The spindle synchronous speed command signal is set to 0.
(vii) The speed zero detection signal of both spindles set to 1 is awaited.
(viii) The spindle phase synchronous control signal SPPHS is set to 0 and the spindle synchronous control signal SPSYC is set to 0, then the forward rotation command SFR of both spindles is set to 0.

NOTE

If the mode is switched to the spindle synchronous control mode when a one-rotation signal is undetected, a one-rotation signal detection operation is automatically performed. So, the spindle automatically makes 2 to 3 turns even if such turns are not attempted. If both spindles are mechanically connected with each other and one-rotation signal detection operation is disabled, or spindle phase synchronous control is not exercised, automatic detection can be disabled by setting bit 3 of parameter No. 4006.

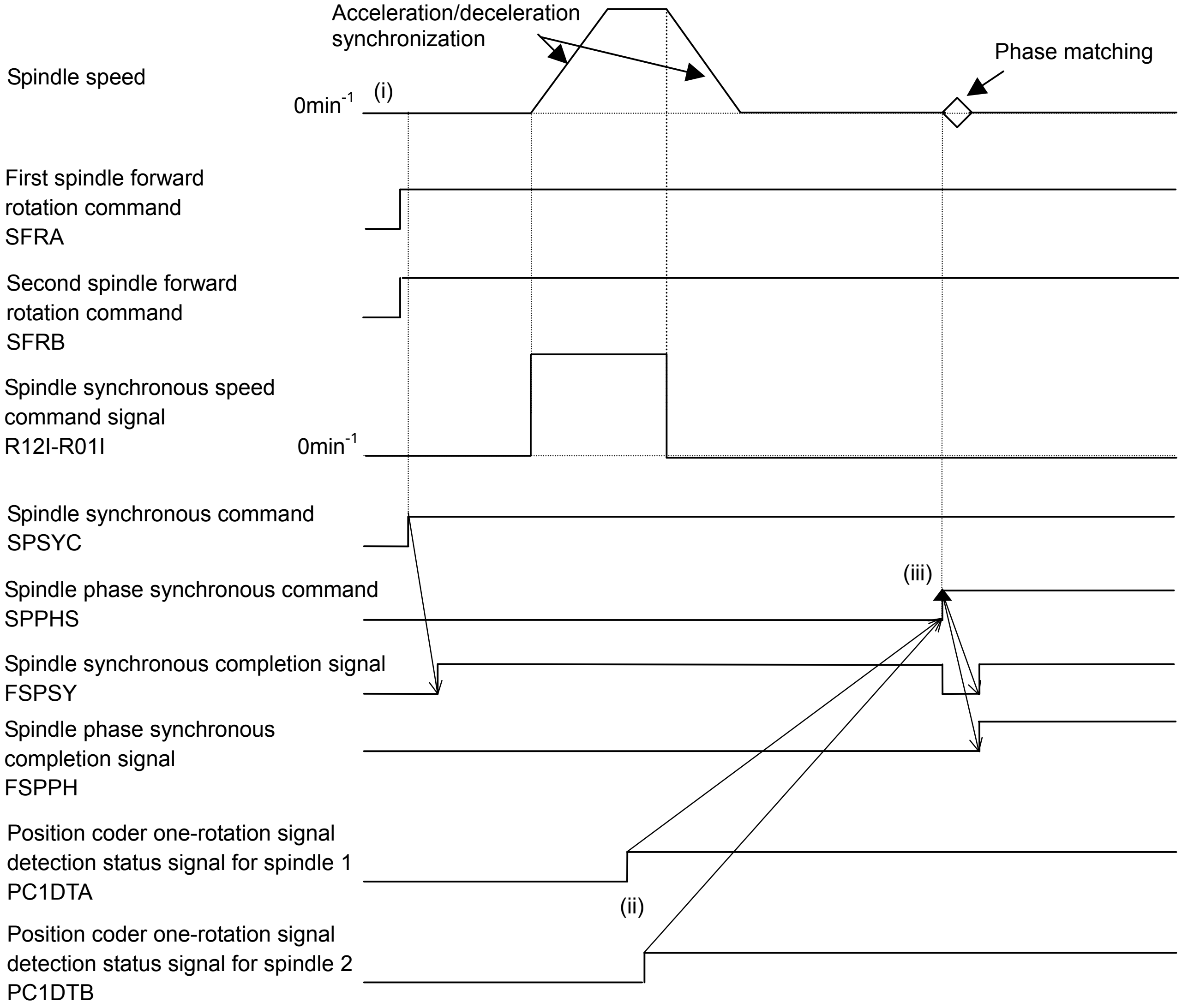
(3) When the velocity integral control signal is used



NOTE

Turn on (set to 1) the velocity integral control signal INTGA only when the two spindles are seizing the same workpiece. If the signal is turned on (set to 1) in other cases, the velocity loop integral function is disabled. So, an increased synchronous error can result.

(4) When phase synchronous control is performed without automatically detecting the one-rotation signal (Parameter No. 4006#3=1)



(i) When a spindle synchronous command is input, the one-rotation signal detection operation is not performed, and the spindle is stopped.
(ii) During rotation at a speed of several ten min^{-1} or higher, the one-rotation signal is detected automatically, and the position coder one-rotation signal detection status signal is set to 1.
(iii) Before inputting the phase synchronous command, check that the position coder one-rotation signal detection status signals of both spindles have been set to 1.

2.5.7 Related Parameters

Parameter No.		Description
16*i*	30*i*	
4800#0	-	Direction of rotation of the 1st spindle motor while synchronous control is applied
4800#1	-	Direction of rotation of the 2nd spindle motor while synchronous control is applied
-	4801#0	Direction of rotation of each spindle motor while synchronous control is applied
4810	4810	Error pulse difference between the two spindles for which to output the spindle phase synchronous control completion signal

Parameter No.		Description
16*i*	30*i*	
4811	4811	Error pulse difference between the two spindles for which to output the phase synchronous error monitor signal (SYCAL)
4002#6	4002#6	Whether to enable the rotation direction signal (SFR/SRV) function on spindle synchronous control
4001	4001	Lower limit setting of the acceleration for polygon machining with two spindles
4006#1	4006#1	Gear ratio increment system
4006#3	4006#3	Setting for disabling automatic one-rotation signal detection at spindle synchronous control mode switching time
—	4540#3	Setting related to motor voltage control characteristics on spindle synchronous control
4032	4032	Acceleration used for spindle synchronous control (The same value must be set for both the 1st and 2nd spindles.)
4033	4033	Spindle synchronous speed arrival level
4034	4034	Shift amount for spindle phase synchronous control
4035	4035	Compensation data for spindle phase synchronous control
4044 4045	4044 4045 (*)	Velocity loop proportional gain for spindle synchronous control (A parameter is selected by the CTH1A PMC input signal.) * When parameter No. 4550 ≠ 0 (No. 4551 ≠ 0), parameter No. 4550 (No. 4551) is valid.
4052 4053	4052 4053 (*)	Velocity loop integral gain for spindle synchronous control (A parameter is selected by the CTH1A PMC input signal.) * When parameter No. 4552 ≠ 0 (No. 4553 ≠ 0), parameter No. 4552 (No. 4553) is valid.
4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data (A parameter is selected by the CTH1A and CTH2A PMC input signals.)
4065 to 4068	4065 to 4068 (*)	Position gain for spindle synchronous control (The same value must be specified for both the 1st and 2nd spindles.) (A parameter is selected by the CTH1A and CTH2A PMC input signals.) * When parameters Nos. 4554 to 4557 ≠ 0, parameters Nos. 4554 to 4557 are valid.
4085	4085 (*)	Motor voltage for spindle synchronous control (for high-speed characteristics) * When parameter No. 4558 ≠ 0, parameter No. 4558 is valid.
4137	4137 (*)	Motor voltage for spindle synchronous control (for low-speed characteristics) * When parameter No. 4559 ≠ 0, parameter No. 4559 is valid.
4171 4173	4171 4173	Denominator of arbitrary gear ratio between motor sensor and spindle (This data is selected by spindle control input signals CTH1A.)
4172 4174	4172 4174	Numerator of arbitrary gear ratio between motor sensor and spindle (This data is selected by spindle control input signals CTH1A.)
4336	4336	Magnetic flux switching point used for calculating an acceleration/deceleration time constant used for spindle synchronous control (The same value must be specified for both the 1st and 2nd spindles.)
4340	4340	Bell-shaped acceleration/deceleration time constant for spindle synchronous control (The same value must be specified for both the first and second spindles.)
4346	4346	Incomplete integration coefficient
4515	4515	Excessive speed deviation alarm detection level on spindle synchronous control
4516	4516	Excessive positional deviation alarm detection level on spindle synchronous control
—	4550 4551	Velocity loop proportional gain for spindle synchronous control (A parameter is selected by the CTH1A PMC input signal.)
—	4552 4553	Velocity loop integral gain for spindle synchronous control (A parameter is selected by the CTH1A PMC input signal.)
—	4554～4557	Position gain for spindle synchronous control (The same value must be specified for both the 1st and 2nd spindles.) (A parameter is selected by the CTH1A and CTH2A PMC input signals.)
—	4558	Motor voltage for spindle synchronous control (for high-speed characteristics)
—	4559	Motor voltage for spindle synchronous control (for low-speed characteristics)

NOTE
1 For the detector-related parameters, see Section 1.3, "PARAMETERS RELATED TO DETECTORS", in Part I.
2 For velocity loop proportional/integral gain adjustment, see Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT", in Part I.

2.5.8 Spindle Parameters for Rigid Tapping and Spindle Synchronous Control

Of the spindle parameters for rigid tapping (servo mode) and spindle synchronous control, the velocity loop gains, position gains, and motor voltages can be set individually. The settings to be used exclusively for spindle synchronous control can be made in parameters Nos. 4550 to 4559; when the parameters ≠ 0, these parameters are valid for spindle synchronous control, and when the parameters = 0, the common parameters are valid as usual.

(1) Related Parameters

	Rigid tapping	Spindle synchronous control	Condition
Velocity loop proportional gain (HIGH) CTH1A=0	No.4044	No.4044	No.4550＝0
		No.4550	No.4550≠0
Velocity loop proportional gain (LOW) CTH1A=1	No.4045	No.4045	No.4551＝0
		No.4551	No.4551≠0
Velocity loop integral gain (HIGH) CTH1A=0	No.4052	No.4052	No.4552＝0
		No.4552	No.4552≠0
Velocity loop integral gain (LOW) CTH1A=0	No.4053	No.4053	No.4553＝0
		No.4553	No.4553≠0
Position gain (HIGH) CTH1A=0,CTH2A=0	No.4065	No.4065	No.4554＝0
		No.4554	No.4554≠0
Position gain (MEDIUM HIGH) CTH1A=0,CTH2A=1	No.4066	No.4066	No.4555＝0
		No.4555	No.4555≠0
Position gain (MEDIUM LOW) CTH1A=1,CTH2A=0	No.4067	No.4067	No.4556＝0
		No.4556	No.4556≠0
Position gain (LOW) CTH1A=1,CTH2A=1	No.4068	No.4068	No.4557＝0
		No.4557	No.4557≠0
Motor voltage (for high-speed characteristics)	No.4085	No.4085	No.4558＝0
		No.4558	No.4558≠0
Motor voltage (for low-speed characteristics)	No.4137	No.4137	No.4559＝0
		No.4559	No.4559≠0

2.5.9 Details of Related Parameters

This Subsection details the serial spindle parameters (in the four thousands for 16*i* and 30*i*) among the parameters related to spindle synchronous control. For details of other parameters, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.12, "SPINDLE SYNCHRONOUS CONTROL."

(b) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.13, "SPINDLE SYNCHRONOUS CONTROL."

(c) For Series 0*i*

"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.11, "SPINDLE SYNCHRONOUS CONTROL."

(d) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.14, "SPINDLE SYNCHRONOUS CONTROL."

(e) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.14, "SPINDLE SYNCHRONOUS CONTROL."

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4001	4001							POLYM	

POLYM The lower limit setting of the acceleration (parameter No. 4032) for polygon machining with two spindles is:

0 : Normal setting
For FS30*i* : 916
For FS16*i* : 229

1 : Extended setting
For FS30*i* : 1
For FS16*i* : 1

NOTE

1. This parameter is valid with 9D5A series D (04) edition or later, 9D53 series R (18) edition or later, 9D70 series R (18) edition or later, 9D80 series N (14) edition or later, 9D90 series B (02) edition or later, and 9DA0 series A (01) edition or later.
2. Use this bit only when spindle software of any of the above series and editions is applied to both spindle amplifiers for polygon machining with two spindles. Do not set this bit to 1 if the software is not applied.

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4002	4002		SYCDRT						

SYCDRT Whether to enable the rotation direction signal (SFR/SRV) function on spindle synchronous control

0 : Enables the rotation direction function.
If a move command from the CNC is positive (+),
(a) The spindle rotates in the CCW (counterclockwise) direction when the input signal SFR (bit 5 of G70) = 1.
(b) The spindle rotates in the CW (clockwise) direction when the input signal SRV (bit 4 of G70) = 1.

1 : Disables the rotation direction function.
If a move command from the CNC is positive (+), the spindle rotates in the CCW (counterclockwise) direction when the input signal SFR = 1 or SRV = 1.

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4006	4006					SYCREF		GRUNIT	

GRUNIT Sets a gear ratio setting resolution:

0 : 1/100 unit
1 : 1/1000 unit

Select a gear ratio data setting resolution from the following:

(a) Resolution based on motor speed increased by a factor of 100 relative to one spindle rotation
(b) Resolution based on motor speed increased by a factor of 1000 relative to one spindle rotation

Depending on the setting of this parameter, the increment system of the parameters indicated in the table below changes.

Parameter No.		Description
16*i*	**30*i***	
4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data

NOTE
1 Usually, use the 1/100 unit (setting “0”).
2 When the 1/100 unit is set as the gear ratio setting resolution (with the bit set to 0), a steady-state synchronous error may be indicated due to the fraction of the gear ratio.
In such a case, the synchronous error can be improved when the 1/1000 unit is set as the gear ratio setting resolution (with the bit set to 1).

SYCREF Setting for function performing automatic detection of the one-rotation signal on spindle synchronous control
0 : Automatic detection of the one-rotation signal carried out
1 : Automatic detection of the one-rotation signal not carried out. (When spindle phase synchronous control is not carried out)
When the mode is switched to spindle synchronous control mode after power-on, the two spindles automatically perform a one-rotation signal detection operation. So, the spindles automatically make two to three turns even if such turns are not intended.
This operation is required because the one-rotation signal must be detected to enable spindle phase synchronous control.
If the two spindles are mechanically connected to disable each spindle from performing a one-rotation signal detection operation, or if spindle phase synchronous control is not exercised, the operation above can be disabled by setting this bit to 1.
When this parameter is set to “1”, check that the one-rotation signal has been detected for both spindles (output signal PC1DTA = 1) before applying the spindle phase synchronous control signal (SPPHS).
If the one-rotation signal is not detected, specify a speed of several ten min^{-1} or higher in spindle synchronous control mode, and wait until the one-rotation signal is detected. (See sequence example (4).)

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
-	4540					EXPTSY			

EXPTSY (#3) Setting related to motor voltage control characteristics on spindle synchronous control
Set this bit to 1 when setting a value less than 100 as the motor voltage on spindle synchronous control (parameter No. 4085 (for high-speed winding) or No. 4137 (for low-speed winding)).
This parameter is valid only when bit 4 of parameter No. 4016 = 0.

16*i*	30*i*	
4032	4032	**Acceleration at spindle synchronous control**

Unit of data : 1min^{-1}/sec (when parameter No. 4006#2 (SPDUNT) = 1, 10 min^{-1}/sec)
Valid data range : 0 to 32767
Standard setting : 0

This parameter is used for spindle synchronous control or polygon machining with two spindles. For polygon machining with two spindles, when bit 1 (POLYM) of parameter No. 4001 = 1, the allowable data range is not limited.

<table>
<tr><th></th><th colspan="5">Data range</th></tr>
<tr><td>Spindle synchronous control</td><td colspan="5">0~32767</td></tr>
<tr><td rowspan="4">Polygon machining with two spindles</td><td colspan="4">POLYM =0</td><td>POLYM=1</td></tr>
<tr><td colspan="2">FS16i, FS0i-D</td><td colspan="2">FS30i</td><td rowspan="3">0~32767</td></tr>
<tr><td>SPDUNT=0</td><td>SPDUNT=1</td><td>SPDUNT=0</td><td>SPDUNT=1</td></tr>
<tr><td>0, 229~32767</td><td>0, 23~32767</td><td>0, 916~32767</td><td>0, 92~32767</td></tr>
</table>

NOTE

1 Set exactly the same data for 1st spindle and 2nd spindle. When different data is set, synchronization between the two spindles is not guaranteed.
2 When this parameter is set to 0, motor doesn't accelerate/decelerate, so, be sure to set proper value in this parameter.

16*i*	30*i*	
4033	4033	**Spindle synchronous speed arrival level**

Unit of data : 1min^{-1} (when parameter No. 4006#2 (SPDUNT) = 1, 10 min^{-1})
Valid data range : 0 to 32767
Standard setting : 10

For the synchronous speed command at spindle synchronous control, if the error of the respective spindle motor speeds are within the setting level, the spindle synchronous control complete signal (FSPSY) becomes "1".

16*i*	30*i*	
4034	4034	**Shift amount at spindle phase synchronous control**

Unit of data : 1 pulse unit (360 degrees/4096)
Valid data range : 0 to 4095
Standard setting : 0

Sets the shift amount from the reference position (one-rotation signal) at spindle phase synchronous control.

16*i*	30*i*	
4035	4035	**Spindle phase synchronous compensation data**

Unit of data : 1 pulse/2msec
Valid data range : 0 to 4095
Standard setting : 10

This parameter reduces speed fluctuations when aligning phase of spindles in spindle phase synchronous control.

When this parameter is "0", since the phase alignment amount is only issued once, the position error quickly becomes large, and there are large speed changes on phase alignment.
It is possible to perform smooth phase alignments through issuing separate commands for phase alignment amounts for the number of 2 msec pulses set in this parameter.

16*i*	30*i*	
4044	4044	**Velocity loop proportional gain on spindle synchronous control (HIGH)** **CTH1A=0**
4045	4045	**Velocity loop proportional gain on spindle synchronous control (LOW)** **CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This sets velocity loop proportional gain on spindle synchronous control.
It is selected HIGH when CTH1A=0 of input signal, and It is selected LOW when CTH1A=1 of input signal.

> **NOTE**
> When parameters Nos. 4550 and 4551 are set to values other than 0, the values set in parameters Nos. 4550 and 4551 are valid.

16*i*	30*i*		
4052	4052	**Velocity loop integral gain on spindle synchronous control (HIGH)**	**CTH1A=0**
4053	4053	**Velocity loop integral gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This sets velocity loop integral gain on spindle synchronous control. It is selected HIGH when CTH1A=0 of input signal, and It is selected LOW when CTH1A=1 of input signal.

> **NOTE**
> When parameters Nos. 4552 and 4553 are set to values other than 0, the values set in parameters Nos. 4552 and 4553 are valid.

16*i*	30*i*		
4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These parameters set the gear ratio of the spindle motor to the spindle.
When the motor rotates 2.5 times for each turn of the spindle, for example, set 250 in the parameter.
A parameter is selected by the CTH1A and CTH2A input signals.
The gear or clutch status must correspond to the status of the CTH1A and CTH2A input signals.

NOTE
When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle does not stop but keeps rotating at the time of orientation. So, be sure to set a proper gear ratio.

16*i*	30*i*		
4065	4065	**Position gain on synchronous control (HIGH)**	**CTH1A=0, CTH2A=0**
4066	4066	**Position gain on synchronous control (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
4067	4067	**Position gain on synchronous control (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
4068	4068	**Position gain on synchronous control (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : $0.01sec^{-1}$
Valid data range : 0 to 32767
Standard setting : 1000

This sets position gain in spindle synchronous control. It is selected by CTH1A or CTH2A of input signal.

NOTE
When parameters Nos. 4554, 4555, 4556, and 4557 are set to values other than 0, the values set in parameters Nos. 4554, 4555, 4556, and 4557 are valid.

16*i*	30*i*	
4085	4085	**Motor voltage setting on spindle synchronous control (for high-speed characteristics)**
4137	4137	**Motor voltage setting on spindle synchronous control (for low-speed characteristics)**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : Depend on motor model.

Set a motor voltage for spindle synchronous control.

NOTE
1 Usually, set the same value as for the setting of a motor voltage (No. 4083) on the velocity control mode.
2 When parameters Nos. 4558 and 4559 are set to values other than 0, the values set in parameters Nos. 4558 and 4559 are valid.

16*i*	30*i*		
4171	4171	**Denominator of arbitrary gear ratio between motor sensor and spindle (HIGH)**	**CTH1A=0**
4172	4172	**Numerator of arbitrary gear ratio between motor sensor and spindle (HIGH)**	**CTH1A=0**
4173	4173	**Denominator of arbitrary gear ratio between motor sensor and spindle (LOW)**	**CTH1A=1**
4174	4174	**Numerator of arbitrary gear ratio between motor sensor and spindle (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 0

These parameters set conversion coefficients (numerator, denominator) for using the detection arbitrary gear ratio function (DMR function) by multiplying a motor sensor (αiM or αiMZ sensor) feedback signal by a gear ratio to produce a spindle position feedback signal.
When the spindle rotates Q times while the motor shaft rotates P times (there is no common divisor other than 1 for P and Q), settings are:

No. 4171 (No. 4173 when CTH1A = 1) = P
No. 4172 (No. 4174 when CTH1A = 1) = Q

When 0 is set in any of these parameters, the setting of 1 is assumed.

> **NOTE**
> When using the external one-rotation signal (proximity switch), set the detection arbitrary gear ratio (DMR) between the motor sensor and spindle by using this parameter.

16*i*	30*i*	
4336	4336	**Acceleration switch point on spindle synchronous control**

Unit of data 1min^{-1} (when parameter No. 4006#2 (SPDUNT) = 1, 10 min^{-1})
Valid data range : 0 to 32767
Standard setting : 0

The acceleration for spindle synchronous control changes according to the speed set in this parameter as follows:

- Area where the spindle speed does not exceed the speed set in this parameter
  The acceleration for spindle synchronous control is constant (as set in parameter No. 4032).
- Area where the spindle speed exceeds the speed set in this parameter
  The acceleration for spindle synchronous control decreases in inverse proportion to the speed.

> **NOTE**
> 1 Set the same data for the first spindle and second spindle. If different data is set, synchronization between the two spindles is not guaranteed.
> 2 When this parameter is set to 0, linear acceleration/deceleration (constant acceleration) is performed.

16*i*	30*i*	
4340	4340	**Bell-shaped acceleration/deceleration time constant for spindle synchronous control**

Unit of data : 1msec
Valid data range : 0 to 512
Standard setting : 0

This parameter sets a bell-shaped acceleration/deceleration time constant for spindle synchronous control.
This parameter is applied to the move command after “Acceleration at spindle synchronous control” (parameter No. 4032) is applied.
When this parameter is set, the spindle synchronous speed control completion signal (FSPSY), output when the synchronous speed is first reached after the spindle synchronous control mode is entered, is delayed by the set time.

NOTE
Set the same data for the first spindle and second spindle. If different data is set, synchronization between the two spindles is not guaranteed.

16*i*	30*i*	
4346	4346	**Incomplete integration coefficient**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 0
Set this parameter to use incomplete integration for velocity loop integration control.

NOTE
Usually, this parameter need not be adjusted.

16*i*	30*i*	
4515	4515	**Excessive speed deviation alarm detection level on spindle synchronous control**

Unit of data : 1min^{-1} (10min^{-1} when bit 2 (SPDUNT) of parameter No. 4006 is set to 1)
Valid data range : 0 to 32767
Standard setting : 0

This parameter sets a level for detecting the excessive speed deviation alarm under spindle synchronous control.
If the positional deviation (position error) or the difference between the speed command for the spindle end calculated from the position gain and the actual spindle speed exceeds the value set in this parameter in the spindle synchronous control mode, the excessive speed deviation alarm under spindle synchronous control (spindle alarm C8) is detected.
When this parameter is set to 0, alarm detection is disabled.
If the speed integration control signal (INTG) is used, the speed deviation increases for a cause such as acceleration/deceleration and cutting load. The spindle speed deviation that causes torque command saturation is indicated below. Set an alarm level by using a calculated value as a guideline. (During spindle synchronous control, ensure that torque command saturation does not take place.)

Spindle speed deviation [min^{-1}] = $1024 \times A / P \times B / G$
where

No.4006#1	No.4009#0	A	B
0	0	1	100
0	1	16	100
1	0	1	1000
1	1	16	1000

P: Velocity loop proportional gain on spindle synchronous control (No.4044, 4045)
G: Gear ratio (No.4056 to 4059)

> **NOTE**
> This parameter is valid with
> 9D50 series N (14) edition or later
> 9D70 series D (04) edition or later
> 9D80 series A (01) edition or later
> 9D90 series A (01) edition or later
> 9DA0 series A (01) edition or later.

16*i*	30*i*	
4516	4516	**Excessive positional deviation alarm detection level on spindle synchronous control**

Unit of data : 100 pulses (weight of 4096 pulses/rev)
Valid data range : 0 to 32767
Standard setting : 0

This parameter sets a level for detecting the excessive positional deviation alarm under spindle synchronous control.
If the positional deviation (position error) exceeds the value set in this parameter in the spindle synchronous control mode, the excessive positional deviation alarm under spindle synchronous control (spindle alarm C9) is detected. When this parameter is set to 0, alarm detection is disabled.
As an alarm level, set a value greater than the positional deviation (position error) equivalent to the spindle speed specified in the spindle synchronous control mode. The positional deviation equivalent to the spindle speed can be calculated from the following expression:

Positional deviation [pulse]
= Spindle speed [min^{-1}] / 60 × 4096 × 100 / PG
where
PG: Position gain on synchronous control (Nos.4065 to 4068)

> **NOTE**
> This parameter is valid with
> 9D50 series N (14) edition or later
> 9D70 series D (04) edition or later
> 9D80 series A (01) edition or later
> 9D90 series A (01) edition or later
> 9DA0 series A (01) edition or later.

16*i*	30*i*	
-	4550	**Velocity loop proportional gain on spindle synchronous control (HIGH) CTH1A=0**
-	4551	**Velocity loop proportional gain on spindle synchronous control (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This sets velocity loop proportional gain on spindle synchronous control.
It is selected HIGH when CTH1A=0 of input signal, and It is selected LOW when CTH1A=1 of input signal.

NOTE
1 This parameter is valid with 9D70 series O (15) edition or later, 9D80 series K (11) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
2 When parameters Nos. 4550 and 4551 are set to 0, the values set in parameters Nos. 4044 and 4045 are valid.

16*i*	30*i*		
-	4552	**Velocity loop integral gain on spindle synchronous control (HIGH)**	**CTH1A=0**
-	4553	**Velocity loop integral gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This sets velocity loop integral gain on spindle synchronous control. It is selected HIGH when CTH1A=0 of input signal, and It is selected LOW when CTH1A=1 of input signal.

NOTE
1 This parameter is valid with 9D70 series O (15) edition or later, 9D80 series K (11) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
2 When parameters Nos. 4552 and 4553 are set to 0, the values set in parameters Nos. 4052 and 4053 are valid.

16*i*	30*i*		
-	4554	**Position gain on synchronous control (HIGH)**	**CTH1A=0, CTH2A=0**
-	4555	**Position gain on synchronous control (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
-	4556	**Position gain on synchronous control (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
-	4557	**Position gain on synchronous control (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : $0.01sec^{-1}$
Valid data range : 0 to 32767
Standard setting : 1000

This sets position gain in spindle synchronous control. It is selected by CTH1A or CTH2A of input signal.

NOTE
1 This parameter is valid with 9D70 series O (15) edition or later, 9D80 series K (11) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
2 When parameters Nos. 4554, 4555, 4556, and 4557 are set to 0, the values set in parameters Nos. 4056, 4057, 4058, and 4059 are valid.

16*i*	30*i*	
-	4558	**Motor voltage setting on spindle synchronous control (for high-speed characteristics of speed range switching)**
-	4559	**Motor voltage setting on spindle synchronous control (for low-speed characteristics of speed range switching)**

Unit of data : 1%
Valid data range : 0 to 100

Standard setting : Depend on motor model.
Set a motor voltage for spindle synchronous control.

NOTE
1 This parameter is valid with 9D70 series O (15) edition or later, 9D80 series K (11) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
2 Usually, set the same value as for the setting of a motor voltage (No. 4083) on the velocity control mode.
3 When parameters Nos. 4558 and 4559 are set to 0, the values set in parameters Nos. 4085 and 4137 are valid.

2.5.10 Number of Error Pulses in Spindle Synchronous Control

This Subsection describes the method of calculating the number of error pulses (position error) of each spindle on spindle synchronous control mode, and also describes the items to be checked when a calculated value differs from the actual number of error pulses.

(1) Calculating the number of error pulses on spindle synchronous control

When the spindle is rotating at a constant speed, the number of error pulses is calculated as follows:

$$\text{Number of error pulses(pulse)} = 4096(\text{pulse/rev}) \times \frac{\text{Spindle synchronization speed}(\text{min}^{-1})}{60(\text{sec})} \times \frac{1}{\text{Position gain}(\text{sec}^{-1})}$$

Example :
When spindle synchronous speed = 1000 min^{-1}, and position gain = 20 sec^{-1}

$$Number\ of\ error\ pulses = 4096 \times \frac{1000}{60} \times \frac{1}{20} = Approx.3413\,(\text{pulse})$$

(2) Checking the number of error pulses on spindle synchronous control

If the number of error pulses on spindle synchronous control checked by diagnosis (diagnosis screen) differs greatly from the calculated value, check the following:

(a) Spindle speed (This can be checked using the actual rotation speed indication of the CNC.)
(b) Motor speed indication on the spindle monitor screen or the spindle check board
(c) Actual gear ratio between the spindle and motor found from the spindle speed and motor speed checked by (a) and (b)
(d) Spindle-to-motor gear ratio parameters (Nos. 4056 to 4059)
(e) Position gain parameters (Nos. 4065 to 4068)
(f) How the gear selection signals (CTH1A, CTH2A) are used for selection (This item can be checked on the spindle motor screen or the PMC signal status screen.)

NOTE
When the 1/100 unit is set as the gear ratio setting resolution (with bit 1 of No. 4006 set to 0), the actual number of error pulses may differ from the calculated value by several pulses due to the fraction of the gear ratio.
In such a case, the difference between the actual number of error pulses and the calculated value can be decreased when the 1/1000 unit is set as the gear ratio setting resolution (with bit 1 of No. 4006 set to 1).

2.5.11 Specifying a Shift Amount for Spindle Phase Synchronous Control

The following describes an example of determining the shift amount for phase synchronization in synchronous control of the spindle phase.

(1) Apply synchronous control of the spindle phase by setting the following:
  (a) SFR (or SRV)=1 for the 1st and 2nd spindles : M03 (M04)
  (b) Spindle synchronous speed command = 0 min^{-1} : S0
  (c) For the 1st and 2nd spindles, set 0 in the parameter (No.4034) for the shift amount for spindle phase synchronous control.
(2) After establishing spindle phase synchronization, set SFR/SRV for the 2nd spindle to 0 (to deactivate the motor).
  The motor for the 2nd spindle is placed in power-off state at this time, so that the 2nd spindle can be rotated manually.
(3) Rotate the 2nd spindle manually from the position of (1) to the position for spindle phase synchronization, then check the number of error pulses between the spindles (No. 416) on the diagnosis (diagnosis screen).
  This value serves as data to be set in the parameter for the shift amount used for spindle phase synchronous control.
(4) Set the number of pulses found by (3) as shift amount parameter data (No. 4034) for spindle phase synchronous control of the 2nd spindle.
  In general, set 0 in the parameter for the shift amount for spindle phase synchronous control for the 1st spindle.
(5) After canceling the spindle synchronous control command, perform another spindle phase synchronization operation, according to the following settings, to check that phase synchronization has been established as expected:
  (a) SFR (or SRV)=1 for the 1st and 2nd spindles : M03 (M04)
  (b) Spindle synchronous speed command = 0 min^{-1} : S0

2.5.12 Diagnosis (Diagnosis Screen)

Address		Description	Unit
16*i*	30*i*		
0414	-	Position error on spindle synchronous control mode (1st spindle)	Pulse
0415	-	Position error on spindle synchronous control mode (2nd spindle)	Pulse
0416	-	Absolute value of a synchronous error between the 1st spindle and 2nd spindle	Pulse
-	0418	Positional error of each spindle in spindle synchronous control mode	Pulse
-	0425	Synchronous error of each spindle in spindle synchronous control mode	Pulse

2.5.13 Alarm

This Subsection provides a list of the alarms related to spindle synchronous control only. For details of alarms, refer to the Connection Manual (Function) of each CNC.
(a) For Series 16*i*/18*i*/21*i*
  "FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
  Refer to Section 9.12, "SPINDLE SYNCHRONOUS CONTROL."
(b) For Series 30*i*/31*i*/32*i*
  "FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
  Refer to Section 11.13, "SPINDLE SYNCHRONOUS CONTROL."
(c) For Series 0*i*

"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.11, "SPINDLE SYNCHRONOUS CONTROL."

(d) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.14, "SPINDLE SYNCHRONOUS CONTROL."

(e) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.14, "SPINDLE SYNCHRONOUS CONTROL."

(1) Series 16*i*

Alarm No.	Description
194	Cs contouring control is specified in serial spindle synchronous control mode.

(2) Series 30*i*

Alarm No.	Description
PS194	Cs contouring control is specified in serial spindle synchronous control mode.

2.6 SPECIFICATIONS COMMON TO ALL OPERATION MODES

2.6.1 Overview

This section describes the I/O signals (CNC↔PMC), parameters, diagnosis signals, and alarms common to all operation modes.

2.6.2 List of I/O Signals (CNC↔PMC)

This Subsection provides a list of the I/O signals related to spindle speed control only. For details of each signal, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."

(b) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, "SPINDLE SPEED CONTROL."

(c) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."

(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."

(e) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.4, "SPINDLE SPEED CONTROL."

(f) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.6, "SPINDLE SPEED CONTROL."

For details of the I/O signals common to the CNCs, see Chapter 3, "I/O SIGNALS (CNC↔PMC)", in Part I.

(1) Input signals (PMC→CNC)

(a) Series 16*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(b) Series 30*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G005							FIN	
1st-	G024	RI7A	RI6A	RI5A	RI4A	RI3A	RI2A	RI1A	RI0A
2nd-	G232	RI7B	RI6B	RI5B	RI4B	RI3B	RI2B	RI1B	RI0B
1st-	G025	RISGNA			RI12A	RI11A	RI10A	RI9A	RI8A
2nd-	G233	RISGNB			RI12B	RI11B	RI10B	RI9B	RI8B
1st-	G026		GS4A	GS2A	GS1A				
2nd-	G272		GS4B	GS2B	GS1B				

(d) Common to CNCs

	15i	16i	30i	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA		SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA
2nd-	G235	G074	G074	MRDYB		SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB
1st-	G226	G071	G071							*ESPA	ARSTA
2nd-	G234	G075	G075							*ESPB	ARSTB
1st-	G228	G073	G073				DSCNA		MPOFA		
2nd-	G236	G077	G077				DSCNB		MPOFB		

(2) Output signals (CNC→PMC)

(a) Series 16i

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O

NOTE
1 These signals are valid with the M series only.

(b) Series 30i

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O

NOTE
1 These signals are valid with the M series only.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F008							SF	
Common to all axes	F020	S7	S6	S5	S4	S3	S2	S1	S0
Common to all axes	F021	S15	S14	S13	S12	S11	S10	S09	S08
Common to all axes	F022	S23	S22	S21	S20	S19	S18	S17	S16
Common to all axes	F023	S31	S30	S29	S28	S27	S26	S25	S24
Common to all axes	F045			SRSRDY					
1st-	F010	RO7A	RO6A	RO5A	RO4A	RO3A	RO2A	RO1A	RO0A
2nd-	F320	RO7B	RO6B	RO5B	RO4B	RO3B	RO2B	RO1B	RO0B
1st-	F11	RO15A	RO14A	RO13A	RO12A	RO11A	RO11A	RO10A	RO9A
2nd-	F321	RO15B	RO14B	RO13B	RO12B	RO11B	RO11B	RO10B	RO9B
1st-	F014	MR7A	MR6A	MR5A	MR4A	MR3A	MR2A	MR1A	MR0A
2nd-	F324	MR7B	MR6B	MR5B	MR4B	MR3B	MR2B	MR1B	MR0B
1st-	F015	MR15A	MR14A	MR13A	MR12A	MR11A	MR10A	MR9A	MR8A
2nd-	F325	MR15B	MR14B	MR13B	MR12B	MR11B	MR10B	MR9B	MR8B
1st-	F234	SSPD7A	SSPD6A	SSPD5A	SSPD4A	SSPD3A	SSPD2A	SSPD1A	SSPD0A
2nd-	F250	SSPD7B	SSPD6B	SSPD5B	SSPD4B	SSPD3B	SSPD2B	SSPD1B	SSPD0B
1st-	F235	SSPD15A	SSPD14A	SSPD13A	SSPD12A	SSPD11A	SSPD10A	SSPD9A	SSPD8A
2nd-	F251	SSPD15B	SSPD14B	SSPD13B	SSPD12B	SSPD11B	SSPD10B	SSPD9B	SSPD8B
1st-	F341								SRRDYA
2nd-	F342								SRRDYB

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045		TLMA	LDT2A	LDT1A	SARA	SDTA	SSTA	ALMA
2nd-	F245	F049	F049		TLMB	LDT2B	LDT1B	SARB	SDTB	SSTB	ALMB
1st-	F231	F047	F047				EXOFA				PC1DTA
2nd-	F247	F051	F051				EXOFB				PC1DTB

2.6.3 Parameters

This Subsection describes those parameters that are common to all operation modes by dividing them into several types.

> **NOTE**
> For the detector-related parameters, see Section 1.3, "PARAMETERS RELATED TO DETECTORS", in Part I.

(1) List of parameters specific to spindle motor driving

This item provides a list of the motor parameters specific to spindle motor driving (with no speed range switching). Usually, the settings of these parameters need not be changed. Use the values indicated on a parameter table for each motor model without modification.

Parameter No.			Description
15*i*	16*i*	30*i*	
3006#2	4006#2	4006#2	Sets the unit of speed.
3008#4	4008#4	4008#4	Sets the method of output control.
3011#3	4011#3	4011#3	Sets the number of motor poles.
3011#4	4011#4	4011#4	Sets a maximum output for acceleration/deceleration.
3011#7	4011#7	4011#7	Sets the number of motor poles.
3012#2,#1,#0	4012#2,#1,#0	4012#2,#1,#0	Sets a PWM carrier frequency.
3012#7	4012#7	4012#7	Sets the spindle HRV function.
3013#6 to #2	4013#6 to #2	4013#6 to #2	Sets current dead-band data.
3013#7	4013#7	4013#7	Sets a PWM carrier frequency in low-speed characteristics area of speed range switching.
3020	4020	4020	Maximum motor speed
3039	4039	4039	Slip compensation coefficient
3080	4080	4080	High-speed area regenerative power limit/regenerative power limit
3083	4083	4083	Motor voltage on velocity control
3084	4084	4084	Motor voltage on orientation
3085	4085	4085	Motor voltage on servo mode/spindle synchronous control
3086	4086	4086	Motor voltage on Cs contouring control
3100	4100	4100	Base speed for motor output specification
3101	4101	4101	Torque limitation value for motor output specification
3102	4102	4102	Excitation voltage saturation speed with no load
3103	4103	4103	Base speed limit ratio
3104	4104	4104	Current loop proportional gain
3106	4106	4106	Current loop integral gain
3108	4108	4108	Current loop integral gain zero speed
3109	4109	4109	Filter time constant in voltage command saturation processing
3110	4110	4110	Current conversion constant
3111	4111	4111	Secondary current coefficient
3112	4112	4112	Voltage command saturation decision level/PWM command clamp value
3113	4113	4113	Slip constant
3114	4114	4114	Slip compensation coefficient for a high-speed area/slip compensation coefficient at deceleration time
3115	4115	4115	PWM command clamp value at deceleration time
3116	4116	4116	Motor leakage constraint
3117	4117	4117	Voltage compensation coefficient for a high-speed area in steady state/motor voltage coefficient in steady state
3118	4118	4118	Voltage compensation coefficient for a high-speed area at deceleration time/motor voltage coefficient at deceleration time
3119	4119	4119	Time constant for excitation current change at deceleration time/time constant for excitation current change
3120	4120	4120	Dead-band rectangular wave component zero voltage/dead-band data
3127	4127	4127	Load meter indication value at maximum output time
3128	4128	4128	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient
3129	4129	4129	Secondary current coefficient on rigid tapping
3130	4130	4130	Current loop proportional gain velocity coefficient/current phase delay compensation constant

Parameter No.			Description
15*i*	16*i*	30*i*	
3133	4133	4133	Motor model code
3134	4134	4134	Motor overheat level (2 words)
3169	4169	4169	Temperature monitoring time constant
3362	4362	4362	Load meter compensation 1
3363	4363	4363	Load meter compensation 2
3364	4364	4364	Load meter compensation 3

(2) List of parameters related to alarm detection

This item provides a list of the parameters related to alarm detection conditions.

Parameter No.			Description
15*i*	16*i*	30*i*	
3009#2	4009#2	4009#2	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued
3087	4087	4087	Overspeed level
3088	4088	4088	Velocity error excess detection level when the motor is bound
3089	4089	4089	Velocity error excess detection level when the motor is rotating
3090	4090	4090	Overload detection level
3123	4123	4123	Short-time overload detection period
3464	4464	4464	Velocity command-dependent over speed (spindle alarm 92) detection offset level
3465	4465	4465	Excessive speed deviation level 2
3466	4466	4466	Excessive speed deviation detection time 2
3527	4527	4527	Temperature difference between warning level and alarm level

(3) Other parameters

This item provides a list of the parameters common to all operation modes except the parameters listed in Items (1) and (2) above.

Parameter No.			Description
15*i*	16*i*	30*i*	
—	3706#1,0	-	Gear ratio between the spindle and position coder (cases of ×1, ×2, ×4, ×8)
5602#3	—	—	Whether to indicate an alarm detected by the spindle amplifier (Usually, set 0.)
5807#0	—	—	Enables/disables the spindle alarms (SPxxxx) of all spindles. (Usually, set 0.)
5842	—	3720	Number of position coder pulses
5850	—	—	Spindle number selected at power-on/reset time
3001#0	4001#0	4001#0	Whether to use the MRDY signal (machine ready signal)
3006#1	4006#1	4006#1	Gear ratio increment system
3006#2	4006#2	4006#2	Sets the unit of speed.
3009#0	4009#0	4009#0	Velocity loop gain increment system
3009#4	4009#4	4009#4	Whether to output the load detection signals (LDT1, LDT2) during acceleration/deceleration
3012#7	4012#7	4012#7	Sets the spindle HRV function
3019#2	4019#2	4019#2	Whether to perform torque clamping when the speed is zero
3019#7	4019#7	4019#7	Automatic parameter setting function
3352#1	4352#1	4352#1	Sets the peak hold function for load meter output.
3395#3	4395#3	4395#3	Sets parameter transfer from the CNC to spindle software.
3020	4020	4020	Maximum motor speed
3022	4022	4022	Speed arrival detection signal
3023	4023	4023	Speed detection level
3024	4024	4024	Speed zero detection level
3025	4025	4025	Torque limitation value.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3026	4026	4026	Load detection level 1
3027	4027	4027	Load detection level 2
3056	4056	4056	Gear ratio (High)
3057	4057	4057	Gear ratio (Medium High)
3058	4058	4058	Gear ratio (Medium Low)
3059	4059	4059	Gear ratio (Low)
3095	4095	4095	Speedometer output voltage adjustment value
3096	4096	4096	Load meter output voltage adjustment value
3122	4122	4122	Speed detection filter time constant
3170	4170	4170	Overload current alarm detection level
3345	4345	4345	Detection level of the spindle motor speed command
3346	4346	4346	Incomplete integral coefficient
3351	4351	4351	Current detection offset compensation

2.6.4 Details of Parameters

This Subsection details the serial spindle parameters (in the four thousands for 16*i*, in the four thousands for 30*i*, and in the three thousands for 15*i*) among the parameters common to all operation modes. For details of other parameters, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”

(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, “SPINDLE SPEED CONTROL.”

(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”

(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”

(e) For Series 30*i*/31*i*/32*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.4, “SPINDLE SPEED CONTROL.”

(f) For Series 0*i*-D
“FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.6, “SPINDLE SPEED CONTROL.”

(1) List of parameters specific to spindle motor driving

Usually, the settings of the motor parameters specific to spindle motor driving need not be changed. Their details are omitted.

(2) List of parameters related to alarm detection

This item details the parameters related to alarm detection conditions.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3009	4009	4009						ALSP		

ALSP Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued
0 : Turns off the power after the motor is decelerated and stopped.
1 : Turns off the power to the motor immediately.

Set this parameter to 1 to turn off the power to the motor immediately when any spindle alarm is issued

15*i*	16*i*	30*i*	
3087	4087	4087	**Overspeed level**

Unit of data : 1%
Valid data range : 0 to 115
Standard setting value : 115

This parameter sets an overspeed level.

When the speed exceeds [maximum motor speed (No. 4020) × setting data (%)], the overspeed alarm (spindle alarm 07) is issued.

> ⚠ **WARNING**
> Make sure this parameter is set to the standard setting value. Do not change the value.

15*i*	16*i*	30*i*	
3088	4088	4088	**Velocity error excess detection level when the motor is bound**

Unit of data : 0.01%
Valid data range : 0 to 10000
Standard setting value : 75

This parameter sets a velocity error excess (spindle alarm 31) detection level when the motor is bound.

If a velocity error equal to or greater than [maximum motor speed (No. 4020) × setting data (%)] occurs when the motor is bound, for example, the motor binding alarm (spindle alarm 31) is issued.

15*i*	16*i*	30*i*	
3089	4089	4089	**Velocity error excess detection level when the motor is rotating**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 200

This parameter sets a velocity error excess detection level when the motor is rotating.

If a velocity error equal to or greater than [maximum motor speed (No. 4020) × setting data (%)] occurs, the velocity error excess alarm (spindle alarm 02) is issued.

15*i*	16*i*	30*i*	
3090	4090	4090	**Overload detection level**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 90

This parameter sets a condition for detecting the short-time overload alarm (spindle alarm 29).

If the state where a load equal to or greater than setting data (%) (maximum motor output [load meter full scale] = 100%) is imposed on the spindle motor lasts for a specified period (set in No. 4123) or more, the short-time overload alarm (spindle alarm 29) is issued.

15*i*	16*i*	30*i*	
3123	4123	4123	**Short-time overload detection period**

Unit of data : 1sec
Valid data range : 0 to 500
Standard setting value : 30

This parameter sets the timing for detecting the short-time overload alarm (spindle alarm 29).

If the state where a load equal to or greater than the specified value (set in parameter No. 4090) is imposed on the spindle motor lasts for at least the period specified in this parameter, the short-time overload alarm (spindle alarm 29) is issued.

15*i*	16*i*	30*i*	
3464	4464	4464	**Velocity command-dependent over speed detection offset level**

Unit of data : 0.1%
Valid data range : -1, 0 to 500
Standard setting value : 0

This parameter sets the offset speed level for detecting the over speed (spindle alarm 92) according to the velocity command.

When the spindle motor reaches the velocity command plus the maximum motor speed (No. 4020) × setting data% the velocity command-dependent over speed alarm (spindle alarm 92) is issued. This detection level is automatically updated if the velocity command increases or changes to 0 or if control mode (such as speed mode or orientation mode) changes.

If the setting is "0", the offset level is 15%.

If spindle alarm 92 must be invalidated temporarily for adjustment and other purposes, set this parameter to "-1 (alarm 92 is invalid)".

NOTE

This parameter is valid with
9D50 series R (18) edition or later
9D70 series H (08) edition or later
9D80 series B (02) edition or later
9D90 series A (01) edition or later
9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3465	4465	4465	**Excessive speed deviation level 2**

Unit of data : If the setting is positive, 1 min^{-1}
(When bit 2 (SPDUNT) of parameter No. 4006 is 1, 10 min^{-1})
If the setting is negative: 0.1%
Valid data range : -1000 to 32767
Standard setting value : 0

This parameter sets the alarm level for excessive speed deviation alarms (spindle alarms 02 and 31) in units of 1 min^{-1} (motor speed) or as a ratio to the motor velocity command.

Depending on the setting of this parameter, the alarm level (min^{-1}) for the excessive speed deviation alarms is as follows:

- If the setting is positive: Setting of parameter No. 4465 (min^{-1})
- If the setting is negative: |Velocity command × Setting of parameter No. 4465/1000| (min^{-1})

If the setting is "0", this parameter is excluded from the excessive speed deviation alarm detection conditions.

> **NOTE**
> This parameter is valid with
> 9D50 series S (19) edition or later
> 9D70 series I (09) edition or later
> 9D80 series C (03) edition or later.

15*i*	16*i*	30*i*	
3466	4466	4466	**Excessive speed deviation detection time 2**

Unit of data : 0.1sec
Valid data range : 0 to 1000
Standard setting value : 0

This parameter sets the period from the time the motor speed deviation exceeds the alarm level of the excessive speed deviation alarm set in parameter No. 4465 until an excessive speed deviation alarm (spindle alarm 02 or 31) is issued.

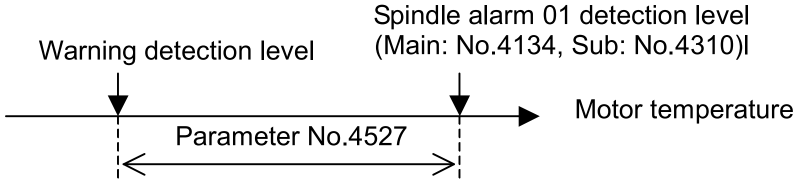
If the motor speed deviation goes below the alarm level within the period of time set in this parameter, the period of time is reset.

> **NOTE**
> This parameter is valid with
> 9D50 series S (19) edition or later
> 9D70 series I (09) edition or later
> 9D80 series C (03) edition or later
> 9D90 series A (01) edition or later
> 9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3527	4527	4527	**Temperature difference between warning level and alarm level**

Unit of data : 1K
Valid data range : 0 to 50
Standard setting value : 0

This parameter sets the difference between motor overheat alarm detection temperature and the warning detection temperature. If the parameter setting is 0, the spindle motor overheat warning function is disabled.
While the motor temperature exceeds the warning detection temperature, the motor overheat warning (warning number 01) is issued.



(3) Other parameters

This item details the parameters common to all operation modes except the parameters listed in Items (1) and (2) above.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3001	4001	4001								MRDY1

MRDY1 Whether to use the MRDYA signal (machine ready signal)
0 : Does not uses the MRDYA signal (MRDYA = 1 at all times).
1 : Uses the MRDYA signal.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3006	4006	4006						SPDUNT	GRUNIT	

GRUNIT Sets a gear ratio setting resolution:
0 : 1/100 unit
1 : 1/1000 unit
Select a gear ratio data setting resolution from the following:
(a) Resolution based on motor speed increased by a factor of 100 relative to one spindle rotation
(b) Resolution based on motor speed increased by a factor of 1000 relative to one spindle rotation
Depending on the setting of this parameter, the increment system of the parameters indicated in the table below changes.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3056 to 3059	4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data

NOTE
Usually, use the 1/100 unit (setting “0”).

SPDUNT Sets the unit of speed.
0 : Sets the 1 min^{-1} unit.
1 : Sets the 10 min^{-1} unit.
When a type of motor whose maximum speed exceeds 32767 min^{-1} is used, set this parameter to 1.
The setting of this parameter changes the increment systems of the parameters listed in the table below.

Parameter No.			Description	Increment system of parameter	
15*i*	16*i*	30*i*		1 min^{-1} unit	10 min^{-1} unit
3020	4020	4020	Maximum motor speed	1min^{-1}	10min^{-1}
3021	4021	4021	Maximum spindle speed on Cs contouring control	1min^{-1}	10min^{-1}
3030	4030	4030	Soft start/stop setting time	1min^{-1}/sec	10min^{-1}/sec
3032	4032	4032	Acceleration on spindle synchronous control	1min^{-1}/sec	10min^{-1}/sec
3033	4033	4033	Spindle synchronous speed arrival level	1min^{-1}	10min^{-1}
3074	4074	4074	Reference position return speed on Cs contouring control/servo mode	1min^{-1}	10min^{-1}
3098	4098	4098	Maximum speed for position feedback signal detection	1min^{-1}	10min^{-1}
3100	4100	4100	Base speed for motor output specification	1min^{-1}	10min^{-1}
3102	4102	4102	Excitation voltage saturation speed with no load	1min^{-1}	10min^{-1}
3108	4108	4108	Current loop integral gain zero speed	1min^{-1}	10min^{-1}
Low-speed characteristics parameters (when the speed range switching control function is used)					
3108	4108	4108	Current loop integral gain zero speed	1min^{-1}	10min^{-1}
3138	4138	4138	Base speed for motor output specification	1min^{-1}	10min^{-1}
3140	4140	4140	Excitation voltage saturation speed with no load	1min^{-1}	10min^{-1}
3144	4144	4144	Current loop integral gain zero speed	1min^{-1}	10min^{-1}
3160	4160	4160	Speed detection level hysteresis	1min^{-1}	10min^{-1}

NOTE
1 Usually, set the 1 min^{-1} unit (by setting the parameter to 0).
2 After changing the setting of this parameter, turn the CNC off, then on again.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3009	4009	4009				LDTOUT				VLPGAN

VLPGAN Velocity control loop gain increment system
0 : Uses ordinary setting.
1 : Divides ordinary setting data by 16 for processing.

NOTE
Usually, set this parameter to 0.

LDTOUT Whether to output the load detection signals (LDT1, LDT2) during acceleration/deceleration
0 : Does not output the load detection signals during acceleration/ deceleration (standard setting value).
1 : Outputs the load detection signals during acceleration/ deceleration (at all times) when the parameter-set level is exceeded.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3012	4012	4012	SPHRV							

SPHRV Sets the spindle HRV control function.
0 : Disables spindle HRV control.
1 : Enables spindle HRV control. (standard setting value)
Set this parameter to 1.

NOTE
The control method usable with the αi series spindle is spindle HRV control only.
The conventional control method is not supported.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3019	4019	4019	PRLOAD					SSTTRQ		

SSTTRQ Whether to perform torque clamping when the speed is zero
0 : Performs clamping.
1 : Does not perform clamping.

NOTE
Usually, set this parameter to 1 not to perform clamping.

PRLOAD Automatic parameter setting function
0 : Does not perform automatic parameter setting (standard setting value).
1 : Performs automatic parameter setting.
After setting a desired motor model code in parameter No. 4133 and setting this bit to 1, turn off the power to the CNC, then turn on the power to the CNC again. The parameters (No. 4000 to No. 4175) for the αi series spindle corresponding to the model code are automatically initialized. Upon completion of automatic setting, this bit is automatically set to 0.

NOTE
With FS15*i*, the parameter address of this function is different, namely, bit 0 of No. 5607 is used. Moreover, note that the meanings of settings are reversed as follows.
0: Performs automatic parameter setting.
1: Does not perform automatic parameter setting.
In this case, set a model code in parameter No. 3133.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3352	4352	4352							PKHALW	

PKHALW Sets the peak hold function for load meter output.
0 : Does not use the peak hold function. (standard setting value)
1 : Uses the peak hold function.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3395	4395	4395					PRIMED			

PRIMED Sets parameter transfer from the CNC to spindle software.
0 : Regards parameters as valid one second after they are transferred from the CNC. (Standard setting value)
1 : Regards parameters as valid as soon as they are transferred from the CNC.

> **NOTE**
> This parameter is valid with 9D50 series F (06) edition or later, 9D70 series A (01) edition or later, 9D80 series A (01) edition or later, 9D90 A (01) edition or later, and 9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3020	4020	4020	**Maximum motor speed**

Unit of data : 1min^{-1} (Unit of 10 min^{-1} when bit 2 (SPDUNT) of parameter No. 4006 = 1)
Valid data range : 0 to 32767
Standard setting value :Depends on the motor model.

This parameter sets a maximum spindle motor speed.

15*i*	16*i*	30*i*	
3022	4022	4022	**Speed arrival detection level**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value :150

This parameter sets a speed arrival signal (SARA) detection range.
When the motor speed reaches within ±(setting data/10)% of a specified speed, the speed arrival signal (SARA) is set to 1.

15*i*	16*i*	30*i*	
3023	4023	4023	**Speed detection level**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value :30

This parameter sets a speed detection signal (SDTA) detection range.
When the motor speed is (setting data/10)% of a maximum speed or less, the speed detection signal (SDTA) is set to 1.

15*i*	16*i*	30*i*	
3024	4024	4024	**Speed zero detection level**

Unit of data : 0.01%
Valid data range : 0 to 10000
Standard setting value :75

This parameter sets a speed zero detection signal (SSTA) detection range.
When the motor speed is (setting data/100)% of a maximum speed or less, the speed zero detection signal (SSTA) is set to 1.

15*i*	16*i*	30*i*	
3025	4025	4025	**Torque limitation value.**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value :50

This parameter sets a torque limitation value to be applied when the torque limitation command HIGH (TLMHA) or the torque limitation command LOW (TLMLA) is specified.

The data indicates limitation values when the maximum torque is 100%.

Torque limitation command LOW(TLMLA)	Torque limitation command HIGH(TLMHA)	Description
0	0	No torque limitation is imposed.
0	1	The torque is limited to the value set in this parameter.
1	0	The torque is limited to a half of the value set in this parameter.
1	1	

15*i*	16*i*	30*i*	
3026	4026	4026	**Load detection level 1**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value :83

This parameter sets a load detection signal 1 (LDT1A) detection range. When the output of the spindle motor is (setting data)% of the maximum output or more, load detection signal 1 (LDT1A) is set to 1.

15*i*	16*i*	30*i*	
3027	4027	4027	**Load detection level 2**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value :95

This parameter sets a load detection signal 2 (LDT2A) detection range. When the output of the spindle motor is (setting data)% of the maximum output or more, load detection signal 2 (LDT2A) is set to 1.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These data are used to set the gear ratio between spindle and spindle motor.
Example :
When the spindle rotates once, set “250” as the data when the motor rotates 2.5 times.
A parameter is selected with the CTH1A and CTH2A input signals.
Set the gear or clutch status to correspond to the clutch/gear signal (CTH1A, CTH2A) in input signals.

NOTE

When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*	
3095	4095	4095	**Speedometer output voltage adjustment value**

Unit of data : 0.1%
Valid data range : -1000 to +100 (-100% to +10%)
Standard setting value :0

Set this parameter when making a fine adjustment of speedometer output voltage. Positive (+) data increases the output voltage.

> **NOTE**
> Usually, this parameter need not be adjusted.

15*i*	16*i*	30*i*	
3096	4096	4096	**Load meter output voltage adjustment value**

Unit of data : 0.1%
Valid data range : -1000 to +100 (-100% to +10%)
Standard setting value :0

Set this parameter when making a fine adjustment of load meter output voltage. Positive (+) data increases the output voltage.

> **NOTE**
> Usually, this parameter need not be adjusted.

15*i*	16*i*	30*i*	
3122	4122	4122	**Speed detection filter time constant**

Unit of data : 0.1ms
Valid data range : 0 to 10000
Standard setting value :0

This parameter sets a time constant for a filter to be applied to the velocity feedback signal.

> **NOTE**
> Usually, this parameter need not be adjusted.

15*i*	16*i*	30*i*	
3170	4170	4170	**Overload current alarm detection level**

Unit of data :
Valid data range : 0 to 32767
Standard setting value :Depends on the motor model.

> **NOTE**
> Usually, this parameter need not be adjusted.

15*i*	16*i*	30*i*	
3345	4345	4345	**Specified detection level of the spindle motor speed**

Unit of data : 1 $\min^{-1}$
Valid data range : 0 to 32767
Standard setting value :0

This parameter sets the detection level of the spindle motor speed detection function. If the specified spindle motor speed is greater than the set value, the level of the speed specification detection signal output from the spindle amplifier to the CNC becomes 1.
If the set value is 0, the level of the speed specification detection signal is always 0.

15*i*	16*i*	30*i*	
3346	4346	4346	**Incomplete integral coefficient**

Unit of data :
Valid data range : 0 to 32767
Standard setting value :0

Set this parameter to use incomplete integral function for velocity loop integral control.

> **NOTE**
> Usually, this parameter need not be adjusted.

15*i*	16*i*	30*i*	
3351	4351	4351	**Current detection offset compensation**

Unit of data :
Valid data range : 0 to ±32767
Standard setting value :0

> **NOTE**
> Usually, this parameter need not be adjusted.

2.6.5 Diagnosis (Diagnosis Screen)

This Subsection provides a list of the diagnosis (diagnosis screen) indications common to all operation modes only. For details, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B MAINTENANCE MANUAL : B-63525EN
Refer to Section 1.8, “DISPLAYING DIAGNOSTIC PAGE.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A MAINTENANCE MANUAL : B-63945EN
Refer to Section 1.3, “DIAGNOSIS FUNCTION.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B MAINTENANCE MANUAL : B-63785EN
Refer to Section 1.3, “DIAGNOSIS FUNCTION.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C MAINTENANCE MANUAL : B-64115EN
Refer to Section 1.8, “DISPLAYING DIAGNOSTIC PAGE.”
(e) For Series 30*i*/31*i*/32*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.4, “SPINDLE SPEED CONTROL.”
(f) For Series 0*i*-D
“FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.6, “SPINDLE SPEED CONTROL.”

(1) Series 16*i*

Address	Description
400	Information including spindle control information

Address	Description
401	Serial spindle alarm state of the first spindle
402	Serial spindle alarm state of the second spindle
403	First spindle motor temperature [°C] (*1)
404	Second spindle motor temperature [°C] (*1)
408	Information related to spindle serial output interface communication errors
409	Information related to spindle serial output interface activation
410	Load meter indication for the first spindle [%]
411	Speedometer indication for the first spindle [min^{-1}]
412	Load meter indication for the second spindle [%]
413	Speedometer indication for the second spindle [min^{-1}]
417	Position coder feedback signal for the first spindle [pulse]
419	Position coder feedback signal for the second spindle [pulse]
445	First spindle position data
446	Second spindle position data
710	First spindle error state (*1)
711	Second spindle error state (*1)
712	First spindle warning state (*1)
713	Second spindle warning state (*1)

NOTE

1 The indications are provided only when the MODEL B CNC is combined with the αi spindle.

(2) Series 30*i*

Address	Description
400	Information including spindle control information
403	First spindle motor temperature [°C]
408	Information related to spindle serial output interface communication errors
410	Load meter indication for the spindle [%]
411	Speedometer indication for the spindle [min^{-1}]
417	Position coder feedback signal for the spindle [pulse]
445	Spindle position data
710	Spindle error state
712	Spindle warning state

(3) Series 15*i*

Address	Description
1500	Information about spindle serial output interface communication errors
1504	Spindle motor torque data
1505	Spindle motor speed data
1561	Spindle state error number (*1)
1562	Spindle warning number (*1)
1563	Spindle motor temperature information (*1)

NOTE

1 The indications are provided only when the MODEL B CNC is combined with the αi spindle.

3 I/O SIGNALS (CNC↔PMC)

This chapter explains the functions of the signals directly input from the PMC to spindle amplifier (SP) via the CNC and the address for signals of the first spindle or second spindle. For other spindle-related I/O signals, refer to the Connection Manual (Function) of the relevant CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Chapter 9, “SPINDLE SPEED FUNCTION.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Chapter 11, “SPINDLE SPEED FUNCTION.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7, “SPINDLE SPEED FUNCTION.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Chapter 9, “SPINDLE SPEED FUNCTION.”
(e) For Series 30*i*/31*i*/32*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Chapter 11, “SPINDLE SPEED FUNCTION.”
(f) For Series 0*i*-D
“FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Chapter 10, “SPINDLE SPEED FUNCTION.”

⚠ **WARNING**

1 Operation of each signal described in this chapter is not guaranteed if an alarm is issued or if a hardware failure or abnormal operation occurs.
2 A signal described in this chapter can be used as a safety function only when it is described that “the signal can be used as a safety function”.

⚠ **CAUTION**

Each signal described in this chapter is disabled and its operation is not guaranteed after power-on until the parameters have been transferred from the CNC to the spindle amplifier. After checking spindle operation ready signal SRSRDY and other signals (refer to the Connection Manual for the relevant CNC) to see the ready status, use the signals described in this chapter.

3.1 INPUT SIGNALS (PMC→CNC→SP)

This section describes the functions of the signals directly input from the PMC to spindle amplifier (SP) via the CNC and also describes the signal addresses of the first spindle and second spindle. For other spindle-related input signals, refer to the Connection Manual (Function) of the relevant CNC.
(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Chapter 9, “SPINDLE SPEED FUNCTION.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Chapter 11, “SPINDLE SPEED FUNCTION.”
(c) For Series 15*i*

"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7, "SPINDLE SPEED FUNCTION."

(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Chapter 9, "SPINDLE SPEED FUNCTION."

(e) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Chapter 11, "SPINDLE SPEED FUNCTION."

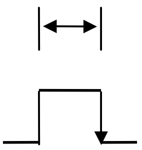
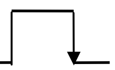
(f) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Chapter 10, "SPINDLE SPEED FUNCTION."

3.1.1 List of Input Signals

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA	ORCMA	SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA
2nd-	G235	G074	G074	MRDYB	ORCMB	SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB
1st-	G226	G071	G071	RCHA	RSLA	INTGA	SOCNA	MCFNA	SPSLA	*ESPA	ARSTA
2nd-	G234	G075	G075	RCHB	RSLB	INTGB	SOCNB	MCFNB	SPSLB	*ESPB	ARSTB
1st-	G229	G072	G072	RCHHGA	MFNHGA	INCMDA	OVRA	DEFMDA	NRROA	ROTAA	INDXA
2nd-	G237	G076	G076	RCHHGB	MFNHGB	INCMDB	OVRB	DEFMDB	NRROB	ROTAB	INDXB
1st-	G228	G073	G073				DSCNA	SORSLA	MPOFA	SLVA	
2nd-	G236	G077	G077				DSCNB	SORSLB	MPOFB	SLVB	

3.1.2 Explanation of Input Signals

Symbol	Name	Description
TLMLA, B	Torque limit command LOW	These signals limit the output torque of the spindle motor. The limit value is set in spindle parameter No. 4025. TLML TLMH 0 0 : Torque not limited 0 1 : Limited to the parameter-set value 1 0 : Limited to about half of the parameter-set value 1 1 : Limited to about half of the parameter-set value
TLMHA, B	Torque limit command HIGH	

Symbol	Name	Description
CTH1A, B CHT2A, B	Clutch/gear signal	These signals set the conditions listed below according to the clutch or gear status. The signals can also be used for selecting spindle control parameters. The names such as HIGH GEAR are given for convenience, and the correspondence to the actual gears is free. CTH1 CTH2 0 0 : HIGH GEAR 0 1 : MEDIUM HIGH GEAR 1 0 : MEDIUM LOW GEAR 1 1 : LOW GEAR
SRVA, B	Reverse rotation command	These signals set the rotation direction of the spindle motor when viewed from the shaft side. SRV SFR 0 0 : Stopped 0 1 : Forward rotation (CCW: Counterclockwise direction) 1 0 : Reverse rotation (CW: Clockwise direction) 1 1 : Stopped
SFRA, B	Forward rotation command	
ORCMA, B	Spindle orientation command	This signal is used to perform spindle orientation control. 0: Turns off the spindle orientation command. 1: Performs spindle orientation control.
MRDYA, B	Machine ready signal	0: Motor excitation is off. 1: Ready for operation
ARSTA, B	Spindle alarm reset signal	This signal is used to reset spindle alarms. 32 msec min. "1" "0"  An alarm is reset when the signal status changes from "1" to "0".
*ESPA, B	Emergency stop signal	0: Emergency stop 1: Normal operation
SPSLA, B	Spindle switching request signal	This signal is used to select a spindle motor in spindle switching control. 0: Selects the main spindle motor. 1: Selects the sub-spindle motor.
MCFNA, B	Magnetic contactor status signal for the sub-spindle motor	This signal is used in spindle switching control. 0: The MCC on the sub-spindle motor side is OFF (the main spindle motor is selected). 1: The MCC on the sub-spindle motor side is ON (the sub-spindle motor is selected).
SOCNA, B	Soft start/stop signal	0: Disables the soft start/stop function. 1: Enables the soft start/stop function.
INTGA, B	Velocity integral control signal	0: Enables velocity integral control. 1: Disables velocity integral control.
RSLA, B	Speed range switching request signal	This signal is used to select output characteristics in speed range switching control. 0: Selects the high-speed range characteristics. 1: Selects the low-speed range characteristics.
RCHA, B	Magnetic contactor status signal for the low-speed characteristics	This signal is used in speed range switching control. 0: The MCC on the low-speed characteristics side is OFF (the high-speed characteristics are selected). 1: The MCC on the low-speed characteristics side is ON (the low-speed characteristics are selected).
INDXA, B	Orientation stop position change command	"1" "0"  This signal is used in orientation with the stop position set external setting type. When the status of this signal changes from "1" to "0", new position stop data is input, and a movement to the new position then a stop take place.

Symbol	Name	Description
ROTAA, B	Rotation direction command at orientation stop position change	This signal is used in orientation with the stop position set external setting type. 0: CCW (counterclockwise) 1: CW (clockwise)
NRROA, B	Shortcut command at orientation stop position change	This signal is used in orientation with the stop position set external setting type. 0: The rotation direction depends on the ROTA signal setting. 1: Shortcut control (within ±180°)
OVRA, B	Analog override command	0: Disables analog override. 1: Enables analog override.
INCMDA, B	Incremental command	1: Incremental command spindle orientation 0: Ordinary orientation
MFNHGA, B	Magnetic contactor status signal for the main spindle motor	0: The MCC on the main spindle motor side is OFF. 1: The MCC on the main spindle motor side is ON.
RCHHGA, B	Magnetic contactor status signal for the high-speed characteristics	0: The MCC on the high-speed characteristics side is OFF. 1: The MCC on the high-speed characteristics side is ON.
MPOFA, B	Motor power turn-off signal	1: Turns off the motor power.
SORSLA, B	Synchronous orientation request command	This signal requests a synchronous orientation operation. 0: Cancels synchronous orientation. 1: Requests synchronous orientation.
DSCNA, B	Disconnection detection disable signal	This signal is used to detach the feedback cable between the amplifier and motor. 0: Enables disconnection and overheat detection. 1: Disables disconnection and overheat detection.
DEFMDA, B	Differential speed mode command signal	0: Disables differential speed mode. 1: Enables differential speed mode.
SLVA, B	Tandem operation command	0: Disables tandem operation. 1: Enables tandem operation.

3.1.3 Details of Input Signals

(a) Torque limit command signals (TLMLA, TLMHA)

(1) A torque limit is used to rotate the spindle motor by decreasing the output torque of the spindle motor temporarily at the time of mechanical spindle orientation and so forth.

(2) For each machine, the machine tool builder must set the output torque and speed applied at the time of orientation so that hitting against the machine stopper produces less impact.

(3) The output torque at orientation can be adjusted with parameter No. 4025.

(4) If the torque limit command signals are set to 1, the torque limit state is entered. (Even when 1 is specified during motor rotation, it becomes valid immediately.) As soon as the torque limit state is entered, the torque limit status signal (TLMA) is output externally.

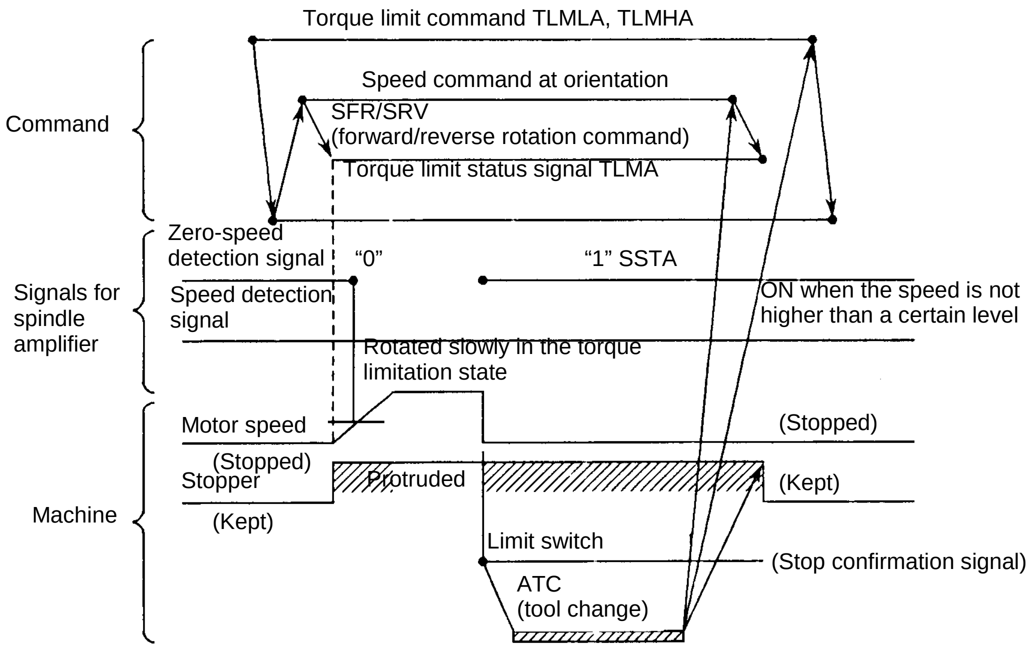
(5) When mechanical orientation is to be performed at the time of ATC of a machining center, the power magnetic sequence design must take the following into consideration not to damage the machine stopper:

<1> The output torque at orientation time must not be excessively large.

<2> The speed at orientation time must not be excessively high. Interlock must be provided so that, for example, when the speed detection signal detects an excessively high speed, the protrusion of the stopper is suppressed.

<3> When the torque limit is canceled, the stopper must have been certainly kept in place.

Example of a mechanical orientation sequence



* If the above conditions are hard to satisfy, employ purely electrical spindle orientation (a CNC software option is required), which does not use the stopper.

(b) Clutch/gear signals (CTH1A, CTH2A)

(1) When there are two or more gear change stages between the spindle and spindle motor, these signals are used to select spindle control parameters (position gain, gear ratio, and velocity loop gain) for each gear. These signals are also used for a motor having an speed range switching function to select control parameters for each winding.

(2) Make settings as listed in the table below according to the state of the clutch or gear. The names such as HIGH GEAR are given for convenience, and the correspondence to the actual gears is free.

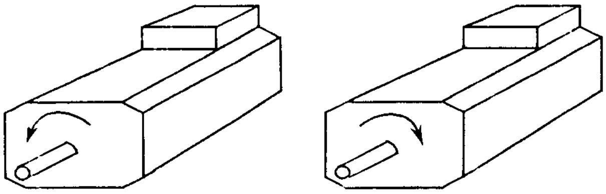
CTH1A	CTH2A	
0	0	HIGH GEAR
0	1	MEDIUM HIGH GEAR
1	0	MEDIUM LOW GEAR
1	1	LOW GEAR

(c) Forward rotation command signal (SFRA) and reverse rotation command signal (SRVA)

(1) When the following four conditions are satisfied, the spindle motor starts forward or reverse rotation according to the speed command (a positive value):

<1> Emergency stop signal *ESPA is set to 1.
<2> Machine ready signal MRDYA is set to 1.
<3> Forward rotation command signal SFRA or reverse rotation command signal SRVA is 1.
<4> The contact signal between ESP and 24 V (CX4 of the common power supply (PS)) is ON (closed).

(2) While SFRA is 1, the spindle motor rotates counterclockwise as viewed from the shaft side at a specified speed (a positive value).
While SRVA is 1, the spindle motor rotates clockwise as viewed from the shaft side according to the speed command (a positive value).



When SFR = 1 When SRV = 1

(3) When SFRA is set to 0 or when SRVA is set to 0, the spindle motor is stopped by regenerative braking. After the spindle motor is stopped, the power element excitation signal is turned off to interrupt power supply to the spindle motor.

> ⚠ **CAUTION**
> This signal is disabled while the spindle motor is rotating in the free-running (coast) mode. The spindle motor is not stopped with control even if this signal is set to 0 and it does not rotate at the specified speed even if the signal is set to 1.

> **NOTE**
> If the forward rotation command signal (SFRA) and reverse rotation command signal (SRVA) are specified at the same time, the spindle status error (error 14) occurs, and the spindle motor is stopped.

(d) Spindle orientation command (ORCMA)

For details of this signal, see Section 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION", in Part I.

(e) Machine ready signal (MRDYA)

(1) This signal is used as follows according to the parameter settings:

Mode	Parameter setting FS16*i* : 4001 #0 FS30*i* : 4001 #0 FS15*i* : 3001 #0	Description
A	0	The machine ready signal is not used. In this case, the spindle motor is made ready only by inputting the emergency stop signal.
B	1	The machine ready signal is used so that the spindle motor can be made ready by two signals. When MRDYA = 0, the excitation signal for the power element of the inverter is turned off to interrupt power.

(2) Mode A
Mode A is used to minimize input signals.

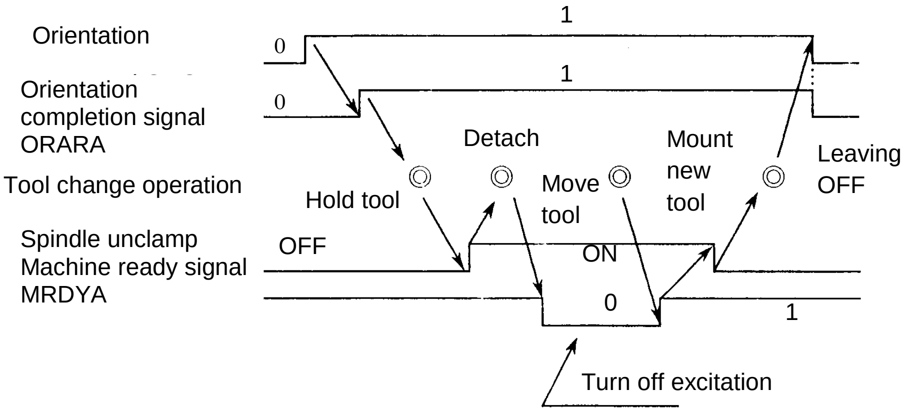
(3) Mode B

<1> In a machine in which the spindle motor is clamped by the tool unclamp signal during an orientation operation for automatic tool change (ATC), a slight displacement from the orientation stop position may increase the load meter indication, allowing a large motor current to flow.
To prevent this, set MRDYA to 0 to release the orientation state while the tool unclamp state is present. At the end of the tool unclamp state, setting MRDYA to 1 can restore the orientation state.

<2> In the application explained <1> above, if the orientation command signal ORCMA is kept 1, setting MRDYA to 0/1 causes a movement just by the amount of the displacement from the

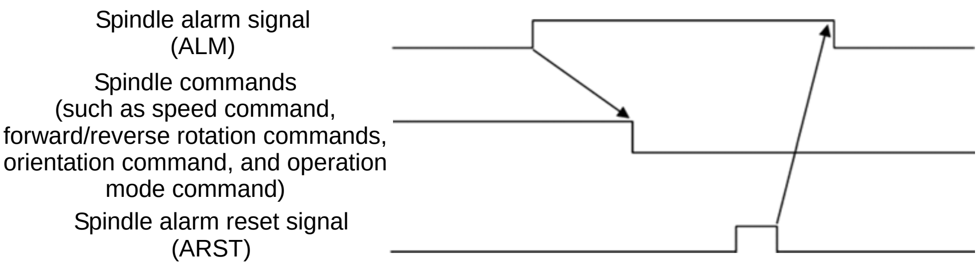
stop position, so another one-rotation operation and orientation operation need not be performed.

Timing chart (mode B)



(f) Spindle alarm reset signal (ARSTA)

(1) After the cause of an alarm such as a motor overheat, excessively large velocity error, over speed, and overload is removed, inputting this alarm reset signal releases the alarm, making the spindle usable.
(2) When no alarm is issued, inputting this signal causes nothing.
(3) Alarms detected in the common power supply (PS) and part of spindle alarms (such as overcurrent) cannot be released by this signal. (The power must be turned off once.)
(4) If a spindle alarm is issued, cancel the spindle commands (such as the speed command, forward/reverse rotation commands, orientation command, and operation mode command), then reset the alarm.



NOTE
With the following series and editions, the alarm reset signal is valid only in the velocity control mode (in other modes, inputting the alarm reset signal does not release the alarm):
Series 9D50 P (16) and subsequent editions
Series 9D70 G (07) and subsequent editions
Series 9D80 A (01) and subsequent editions
Series 9D90 A (01) and subsequent editions
Series 9DA0 A (01) and subsequent editions

(g) Emergency stop signal (*ESPA)

(1) When *ESPA = 1, the spindle motor and spindle amplifier become ready for operation. When *ESPA = 0, the spindle amplifier outputs to the common power supply (PS) a signal for turning off the MCC, and the spindle motor does not operate.
(2) As soon as *ESPA is set to 0 during motor rotation, the spindle motor decelerates and stops. When the zero speed detection signal SSTA is set to 1, the motor is deactivated, and a signal for turning off the MCC is output.

(3) When *ESPA is set to 1 again, the spindle motor becomes ready for rotation, so the spindle motor will start rotating as soon as a rotation command is issued. Therefore, when inputting the emergency stop signal, reset the command signals (speed command, forward and reverse rotation commands) to the spindle amplifier at the same time.

(4) This signal (*ESPA) and the emergency stop signal (connector CX4) of the common power supply (PS) function as signals having the same meaning for the spindle amplifier (SP).

⚠ **WARNING**

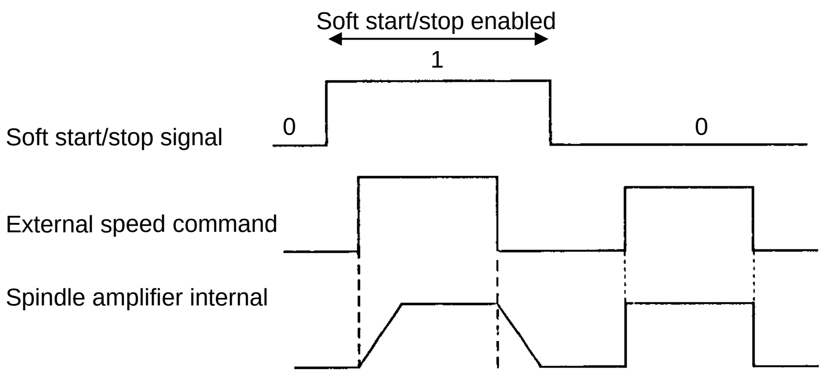
1 The spindle motor runs freely (coasts) due to a power failure, alarm, or command from the ladder program (MPOFA signal). While the spindle motor runs in the free-running mode, it does not stop even when the emergency stop signal is input.
2 When the power is off, the spindle motor may also run freely.
3 The emergency stop signal receive circuit in the amplifier is an electronic circuit. For this reason, the motor may not stop due to a failure in the electronic circuit even when the emergency stop signal is input to the amplifier.

(h) Spindle switching request signal (SPSLA), magnetic contactor status signal for the sub-spindle motor (MCFNA), and magnetic contactor status signal for the main spindle motor (MFNHGA)

For details of these signals, see Section 5.2, "SPINDLE SWITCHING CONTROL", in Part I.

(i) Soft start/stop signal (SOCNA)

(1) The soft start/stop function makes acceleration/deceleration of the spindle motor gradual. When the soft start/stop signal is set to 1, the soft start/stop function is enabled, which allows the speed command change rate at acceleration/deceleration to be set as shown below.



(2) The soft start/stop function is valid in the velocity control mode. This signal is also used for enabling the acceleration/deceleration time constant at return to the reference position in Cs contouring control or rigid tapping (parameter No. 4406), however.

(3) When emergency stop signal *ESPA or machine ready signal MRDYA is set to 0, the soft start/stop function is disabled automatically.

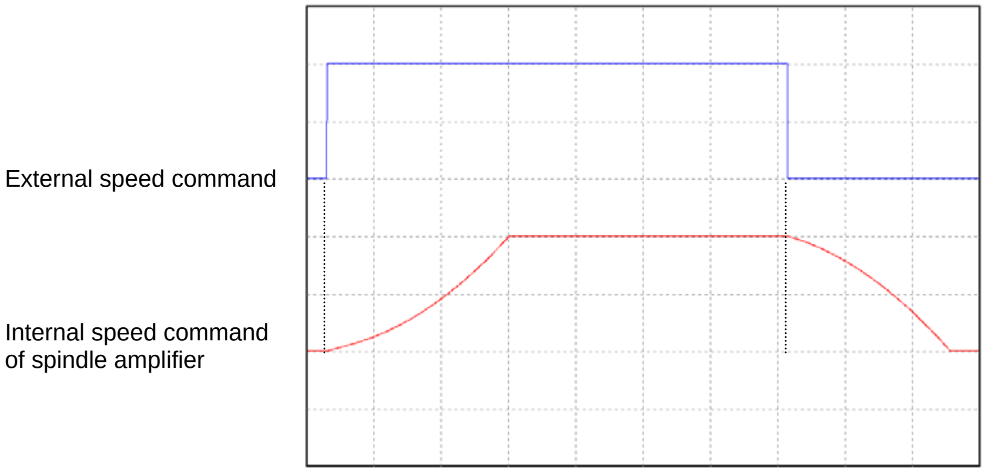
NOTE

With the following series and editions, setting the relevant parameter (bit 2 of parameter No. 4399 to 1) enables the soft start/stop function even when the spindle motor is being decelerated according to *ESPA = 0 or MRDYA = 0:

Series 9D50 O (15) and subsequent editions
Series 9D70 F (06) and subsequent editions
Series 9D80 A (01) and subsequent editions
Series 9D90 A (01) and subsequent editions
Series 9DA0 A (01) and subsequent editions

(4) The speed command change rate is set in parameter No. 4030. When 0 is set in the parameter, the soft start/stop function is disabled.

(5) When the rate of the change in acceleration command (parameter No. 4508) is set, a quadratic function type speed command can be given in the spindle amplifier (quadratic function type soft start/stop function).
Use this function when you want to reduce the shock due to a change in speed specified at the start of acceleration/deceleration.
In this case, the internal speed command of the spindle amplifier changes as follows:



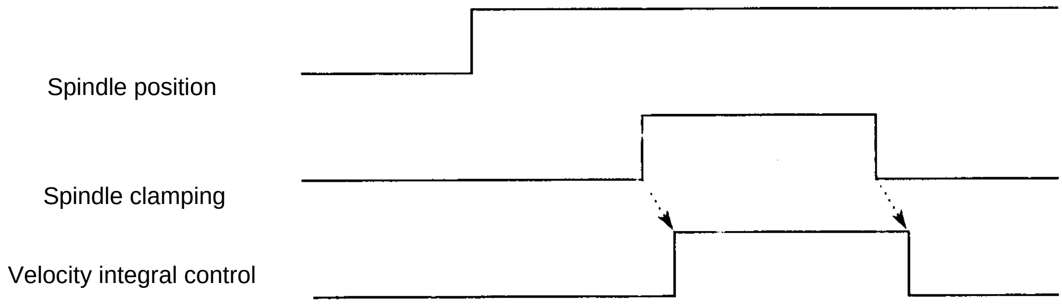
NOTE

With the following series and editions, the quadratic function type soft start/stop function can be used:

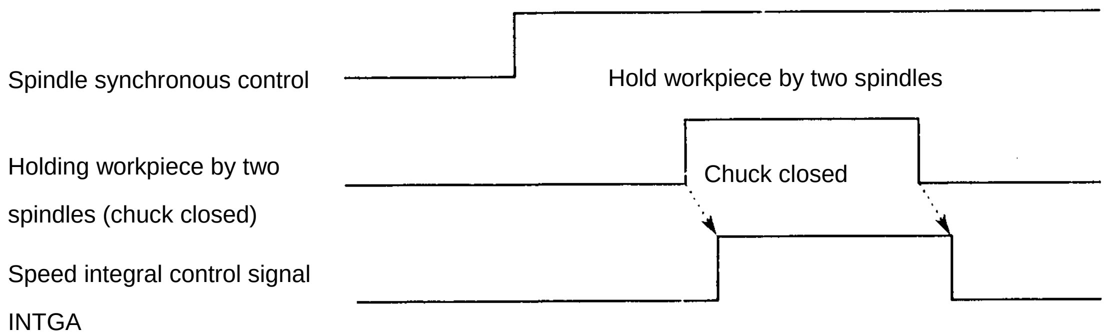
Series 9D50 G (07) and subsequent editions
Series 9D70 A (01) and subsequent editions
Series 9D80 A (01) and subsequent editions
Series 9D90 A (01) and subsequent editions
Series 9DA0 A (01) and subsequent editions

(j) Velocity integral control signal (INTGA)

(1) When spindle position control (spindle orientation control, spindle positioning control, Cs contour control, and so on) is performed, the spindle is sometimes clamped by the brake or the like. If the spindle is kept clamped with a minute position error, velocity integral control may allow an excessively large current to flow into the motor, attempting to eliminate the position error to zero.
In such a case, use of this signal disables velocity integral control to prevent an excessively large current from flowing into the motor even when a minute position error occurs.



(2) Also when two spindles are used to hold a workpiece in spindle synchronous control, a minute synchronous error generated at the time of the hold operation may cause velocity integral control to attempt to eliminate the error to zero, and as a result, an excessively large current may flow into the motor.
In this case, this signal can be used to disable velocity integral control and prevent an excessively large current from flowing into the motor even when a minute synchronous error occurs.



(k) Speed range switching request signal (RSLA), magnetic contactor status signal for low-speed characteristics (RCHA), and magnetic contactor status signal for high-speed characteristics (RCHHGA)

For details of these signals, see Section 5.1, “SPEED RANGE SWITCHING CONTROL”, in Part I.

(l) Orientation stop position change command (INDXA), rotation direction command at orientation stop position change (ROTAA), shortcut command at orientation stop position change (NRROA), and incremental command (INCMDA)

For details of these signals, see Section 2.2, “POSITION CODER METHOD SPINDLE ORIENTATION”, in Part I and Section 5.3, “INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION”, in Part I.

(m) Spindle analog override command (OVRA)

(1) In the velocity control mode, the speed command can be overridden with the voltage externally applied to the spindle amplifier directly in an analog form.
(2) The analog override function is valid when this signal is 1. The function is valid only in the velocity control mode (including the soft start/stop function).
(3) The upper limit (100% or 120%) of analog override is parameter-set as follows:

Parameter No.			Description
FS15*i*	**FS16*i***	**FS30*i***	
3006 #5	4006 #5	4006 #5	Sets the input range of spindle analog override. 0 : 0 to 100% 1 : 0 to 120%

The upper limit of analog override input voltages is +4.5 V. When the speed command value obtained by multiplication by the override value exceeds the parameter-set maximum speed, the speed is clamped at the maximum speed.

(4) The override type is parameter-set as follows:

Parameter No.			Description
FS15*i*	**FS16*i***	**FS30*i***	
3009 #6	4009 #6	4009 #6	Sets the override type. 0: Linear function type override 1: Quadratic function type override

<1> Linear function type override

The override value actually used corresponds to the input override value on a one-to-one basis.

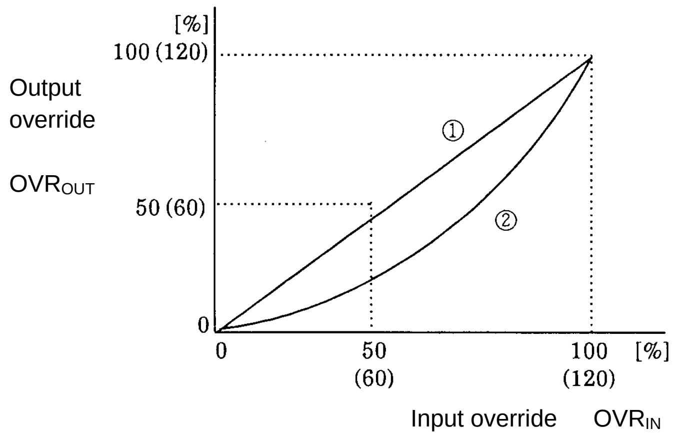
$OVR_{OUT} = OVR_{IN}$

<2> Quadratic function type override

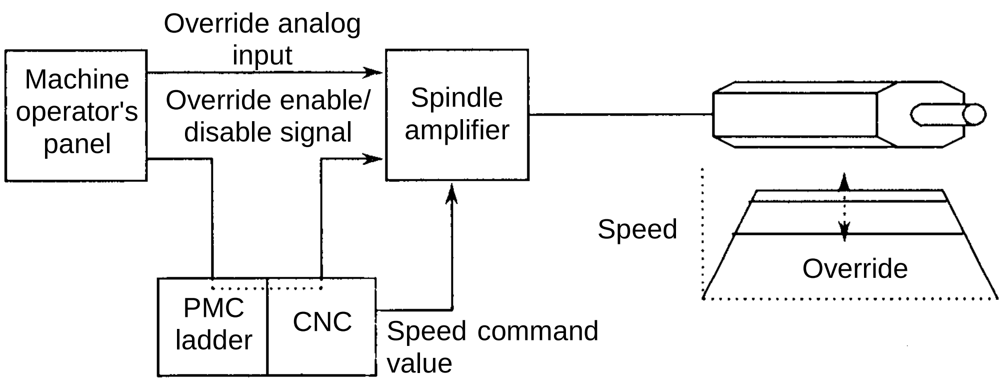
The override value actually used corresponds to the input override value in the quadratic function manner.

When compared with the linear function type, the quadratic function type has rougher speed resolution for the input override in the high-speed region and has a finer speed resolution in the low-speed region.

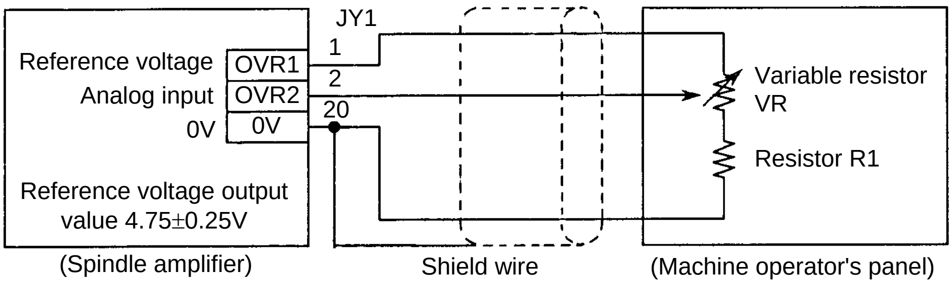
$$OVR_{OUT} = OVR_{MAX} \times \left(\frac{OVR_{IN}}{OVR_{MAX}}\right)^2$$



(5) The following shows the system configuration when attention is focused on the analog override function:



(6) The analog override input is connected as shown in the figure below. The input voltage equivalent to the upper override limit (100% or 120%) to OVR2 is 4.5 V. Override values are set in steps of 1%.



Use resistors so that the total resistance of VR and R1 ranges from 2 KΩ to 10 KΩ.

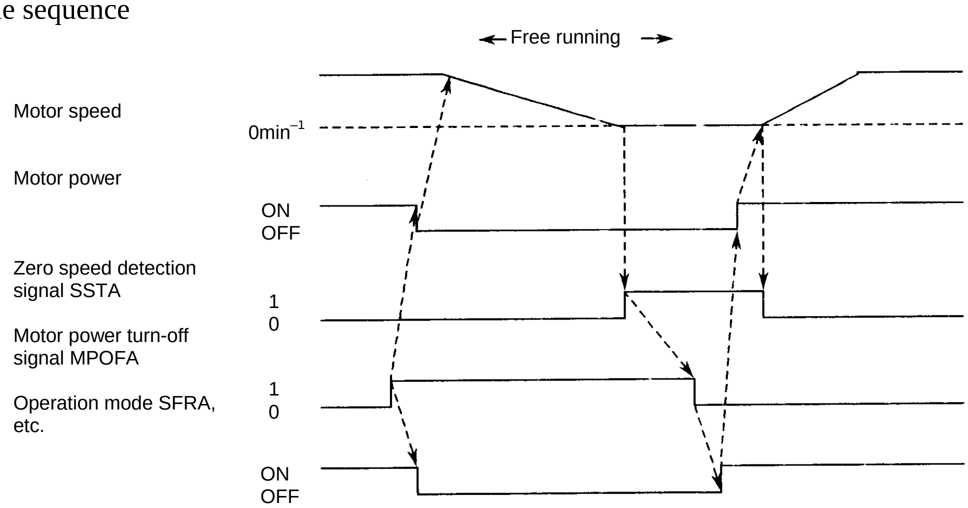
(7) Because the hysteresis characteristic is provided to prevent override fluctuation, an override of 0% is not set even when the input voltage is 0 V.
(8) When a signal for enabling or disabling the status of the analog override function is issued, or the setting of the upper override limit parameter is changed, the motor speed may change largely. So, before changing the status or setting, stop the motor.

(n) Motor power turn-off signal (MPOFA)

(1) When an abnormality occurs during spindle synchronous control or during machining with a machine such as a gear machining tool, this signal is used to immediately turn off the power to the spindle motor and allow the motor to run freely.
(2) This signal turns off the motor power only.
(3) The motor power can be supplied again after the motor is stopped (zero speed signal SSTA = 1). Even when this signal is canceled, the power cannot be supplied while the motor is rotating (SSTA = 0).
(4) After turning off the motor power, cancel all operation modes to ensure safety. After the motor is stopped (SSTA = 1), specify operation modes again.
When the power is turned off during position control, the position control operation is performed continuously, so an alarm such as an alarm due to an excessively large position error may be issued.

Operation mode examples:
- Forward rotation command (SFRA)
- Reverse rotation command (SRVA)
- Spindle orientation (ORCMA)
- Rigid tapping (RGTP, RGTAP)
- Spindle synchronous control (SPSYC, SPPHS)
- Spindle positioning
- Cs contour control (CON, SCNTR1, SCNTR2, and so on)
- Speed difference mode (DEFMDA)

(5) Sample sequence



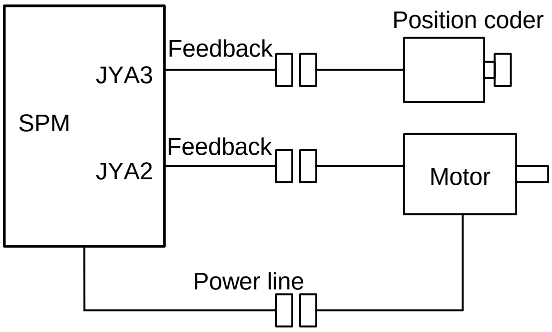
(6) If bit 2 of parameter No. 4009 is set to 1, the motor power can be turned off immediately when spindle alarm 24 (serial transfer data error) occurs. Normally, when spindle alarm 24 occurs, the spindle motor is decelerated then stopped.

(o) Synchronous orientation request command (SORSLA)

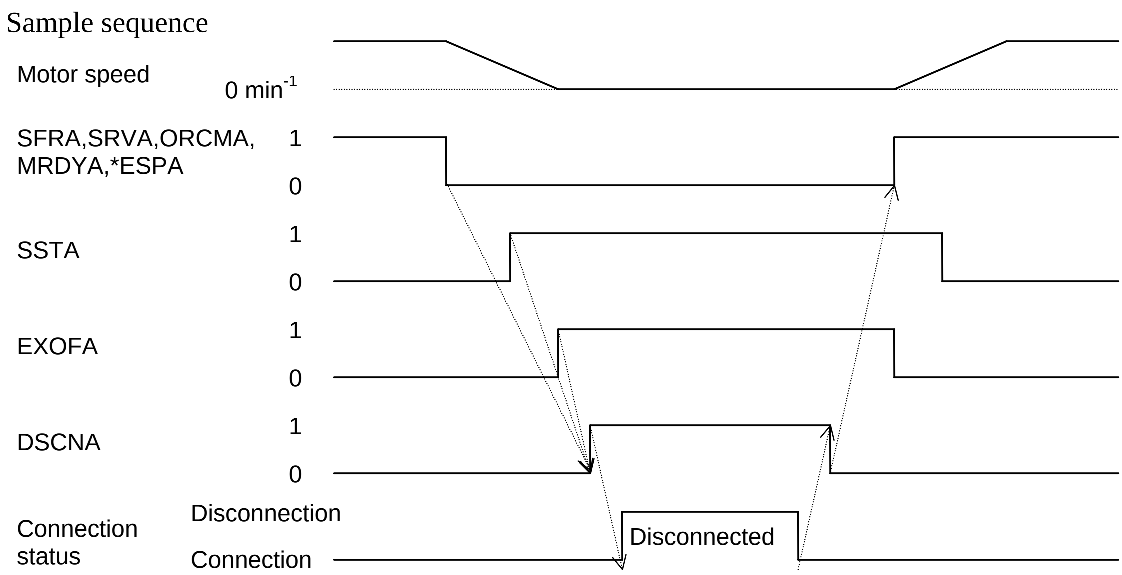
For details of this signal, see Section 5.5, “SPINDLE ORIENTATION DURING SPINDLE SYNCHRONIZATION CONTROL”, in Part I.

(p) Disconnection detection disable signal (DSCNA)

(1) This signal is used when the connection between the spindle amplifier and spindle motor needs to be disconnected temporarily.



(2) When this signal is used to detach the feedback signal, motor overheat and the issuance of a feedback signal disconnection alarm can be prevented.
(3) A motor excitation OFF state confirmation signal (EXOFA) is provided to confirm that the motor is not excited before the connected power line is detached.
(4) Before setting this signal to 1 and disconnecting the feedback signals and power line, set all the SFRA, SRVA, ORCMA, MRDYA, and *ESPA commands to 0, and confirm that the motor excitation OFF state confirmation signal (EXOFA) has been set to 1. After completing re-connection, reset this signal to 0.



⚠ CAUTION

When this signal is set to 1, a motor overheat or feedback signal error is not detected, and a status signal related to a feedback signal may not be output correctly. When the motor is driven, be sure to set this signal to 0.

NOTE

1 When the dual check safety function is enabled, this signal is disabled.
When the αiCZ sensor (serial) is used, this signal is disabled.

(q) Differential speed mode command signal (DEFMDA)

For details of this signal, see Section 5.9, "DIFFERENTIAL SPINDLE SPEED CONTROL" in Part I.

(r) Tandem operation command (SLVA)

For details of this signal, see Section 5.11, "TORQUE TANDEM CONTROL FUNCTION" in Part I.

3.2 OUTPUT SIGNALS (SP→CNC→PMC)

This section describes the functions of the signals directly input from the PMC to spindle amplifier (SP) via the CNC and also describes the signal addresses of the first spindle and second spindle. For other spindle-related output signals, refer to the Connection Manual (Function) of the relevant CNC.

(a) For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Chapter 9, "SPINDLE SPEED FUNCTION."

(b) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Chapter 11, "SPINDLE SPEED FUNCTION."

(c) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7, "SPINDLE SPEED FUNCTION."

(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Chapter 9, "SPINDLE SPEED FUNCTION."

(e) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Chapter 11, "SPINDLE SPEED FUNCTION."
(f) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Chapter 10, "SPINDLE SPEED FUNCTION."

3.2.1 List of Output Signals

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA	TLMA	LDT2A	LDT1A	SARA	SDTA	SSTA	ALMA
2nd-	F245	F049	F049	ORARB	TLMB	LDT2B	LDT1B	SARB	SDTB	SSTB	ALMB
1st-	F228	F046	F046				SLVSA	RCFNA	RCHPA	CFINA	CHPA
2nd-	F244	F050	F050				SLVSB	RCFNB	RCHPB	CFINB	CHPB
1st-	F231	F047	F047				EXOFA	SORENA		INCSTA	PC1DTA
2nd-	F247	F051	F051				EXOFB	SORENB		INCSTB	PC1DTB
1st-	F230	F048	F048				CSPENA				
2nd-	F246	F052	F052				CSPENB				

3.2.2 Explanation of Output Signals

Symbol	Name	Description
ALMA, B	Spindle alarm signal	This signal is output when a spindle alarm is issued. 0: Normal state 1: Alarm state
SSTA, B	Zero-speed detection signal	This signal is output when the actual rotation speed of the spindle motor has decreased to the zero-speed detection level or lower. 0: Rotating 1: Zero-speed state
SDTA, B	Speed detection signal	This signal is output when the actual rotation speed of the spindle motor has decreased to a predetermined rotation speed or lower. 0: Above predetermined speed 1: Predetermined speed or lower
SARA, B	Speed arrival signal	This signal is output when the actual rotation speed of the spindle motor has achieved a predetermined range for a speed command. 0: Speed not achieved 1: Speed achieved
LDT1A, B	Load detection signal 1	These signals are output when load at a set load detection level or higher is detected. Different levels can be set for LDT1A and LDT2A. 0: Lower than the set load 1: Set load or higher
LDT2A, B	Load detection signal 2	
TLMA, B	Torque limit status signal	This signal is output when the torque is being limited by the TLMLA or TLMHA signal. 0: Torque not being limited 1: Torque being limited
ORARA, B	Orientation completion signal	This signal is output when the spindle stops in the neighborhood of a predetermined position after an orientation command is input. 0: Orientation not completed 1: Orientation completed

Symbol	Name	Description
CHPA, B	Power line switching signal	This signal is used in spindle switching control. 0: Selects the MCC on the main spindle motor side. 1: Selects the MCC on the sub-spindle motor side.
CFINA, B	Spindle switching completion signal	This signal is used in spindle switching control. 0: Controls the main spindle motor. 1: Controls the sub-spindle motor.
RCHPA, B	Power line switching signal	This signal is used in speed range switching control. 0: Selects the MCC on the high-speed range characteristics side. 1: Selects the MCC on the low-speed range characteristics side.
RCFNA, B	Speed range switching completion signal	This signal is used in speed range switching control. 0: Control with high-speed range characteristics 1: Control with low-speed range characteristics
PC1DTA, B	Position coder one-rotation signal detection state signal	This signal is used to confirm whether the position coder one-rotation signal is detected or not. 0: Position coder one-rotation signal not detected 1: Position coder one-rotation signal detected
INCSTA, B	Incremental orientation signal	This signal is used to confirm whether incremental spindle orientation is being performed or not. 0: Incremental spindle orientation is not in progress. 1: Incremental spindle orientation is in progress.
SORENA, B	Synchronous orientation enable signal	This signal is used to confirm whether synchronous orientation is enabled or not. 0: Disables synchronous orientation. 1: Enables synchronous orientation.
EXOFA, B	Motor excitation off state signal	This signal is used to confirm whether motor excitation is off. 0: Motor excitation is in progress. 1: Motor excitation is off.
SLVSA, B	Tandem operation state signal	This signal is used with the spindle tandem function. 0: Tandem operation is not in progress. 1: Tandem operation is in progress.
CSPENA, B	Cs reference position establishment state signal	This signal is used to indicate whether Cs axis coordinate establishment processing is possible. 0: Coordinate establishment processing is impossible (with a reference position not established). 1: Coordinate establishment processing is possible (with a reference position established).

3.2.3 Details of Output Signals

(a) Spindle alarm signal (ALMA)

(1) When continuation of spindle motor operation becomes impossible, the power to the spindle motor is turned off to stop the spindle motor.

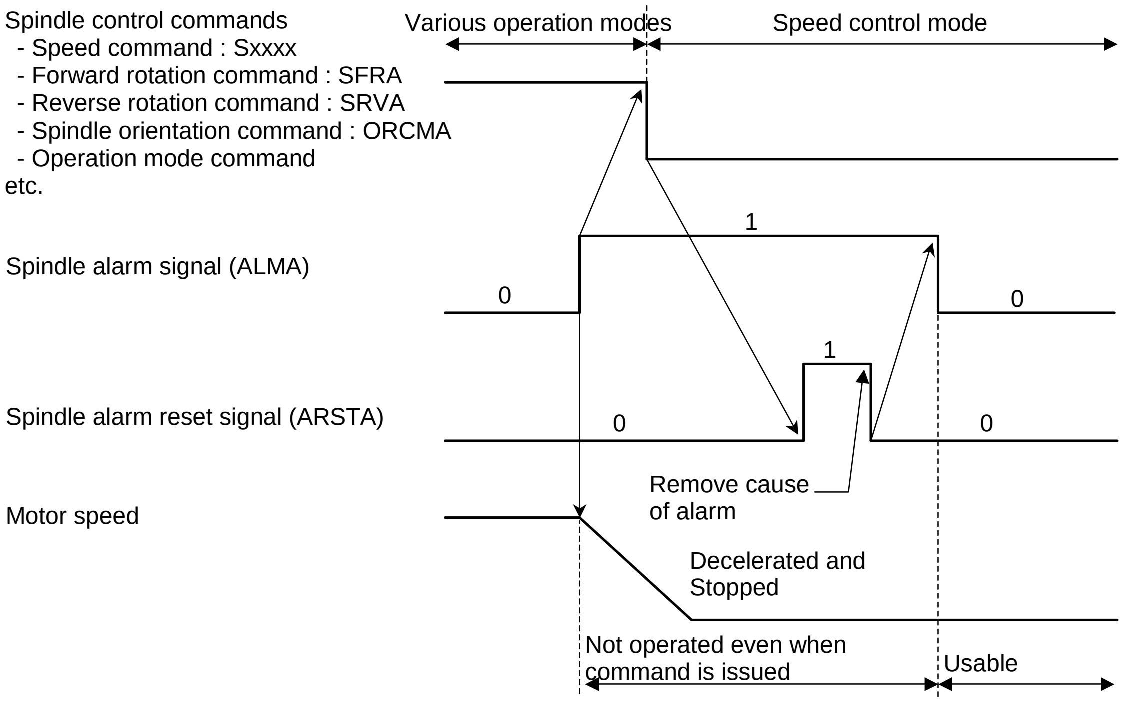
(2) At the same time, spindle alarm signal ALMA is set to 1. For the meaning of the alarm, check the CNC screen and the indicator of the spindle amplifier.

(3) Use the alarm signal output to reset the command signals sent to the spindle amplifier (speed command, forward and reverse rotation commands, spindle orientation command, operation mode command and so on). Unless the reset state has been entered (the signals issued from the PMC have been all cleared), the spindle motor may rotate when the alarm on the spindle amplifier is released, which presents a dangerous situation.

(4) At the same time when the alarm signal is output, the power to the spindle motor is turned off, and the spindle motor coasts. Therefore, it is necessary to enter the feed hold state by setting the emergency stop state on the CNC or power magnetic cabinet.

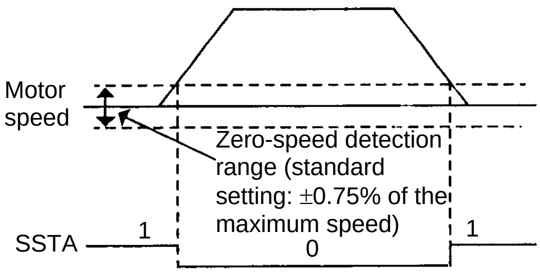
(5) When the alarm state is entered, ALMA is set to 1. While the alarm signal is 1, the spindle motor is placed in the coast state regardless of external commands.

(6) The following diagram shows the relationship between the alarm signal and alarm reset signal:



(b) Zero-speed detection signal (SSTA)

(1) When the actual rotation speed of the spindle motor has decreased to the zero-speed detection level or lower for a stop command, SSTA is set to 1.



(2) The zero-speed detection point is 0.75% (initial standard setting in the parameter) of the maximum speed. For a motor of which maximum speed is 6000 min^{-1}, for example, the zero-speed detection point is 45 min^{-1}.

(3) When the above condition is satisfied, this signal is output regardless of the rotation command (SFR, SRV).

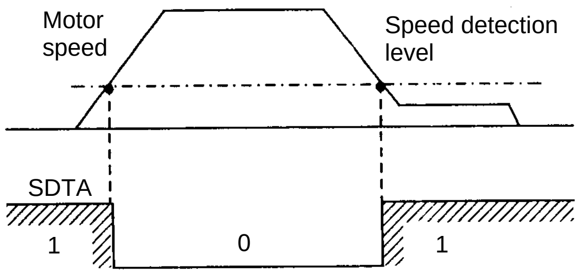
(4) The minimum pulse width of this signal is approximately 40 ms.

> ⚠ **CAUTION**
>
> 1 If a motor feedback signal disconnection alarm (spindle alarm 73) is issued, the status of this signal is undefined.
>
> 2 When bit 5 of parameter No. 4007 is set to "1", the detection operation of the feedback signal disconnection alarm is not performed.
> Set the parameter to "0" when not required, to enable alarm detection.
>
> 3 If an error which cannot be detected in the motor free-running (coast) state occurs in the motor feedback system, this signal may not be output correctly in the motor free-running mode after an alarm is reset.

(c) Speed detection signal (SDTA)

(1) When the spindle motor speed has decreased to a parameter-set speed level or lower, SDTA is set to 1.

(2) This signal is used to confirm that the speed has decreased to a predetermined speed such as a clutch changeable speed or gear changeable speed.

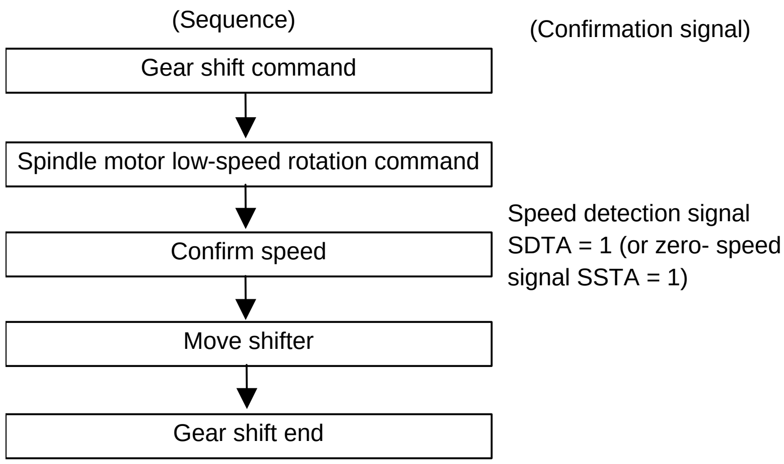


(3) This signal is output regardless of the rotation command (SFR, SRV).

<Reference> Gear shift sequence

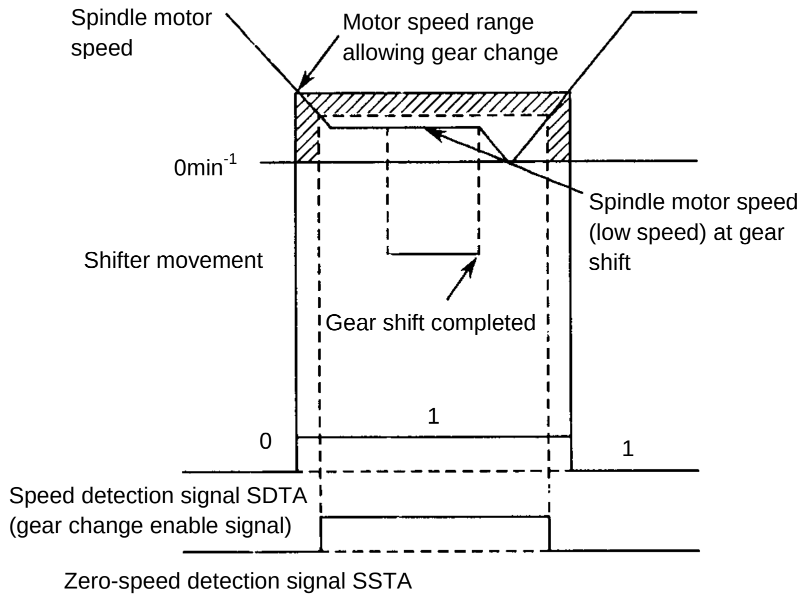
In CNC machine tools, gear shift, which is one of sequence controls, causes a shift of the gear section of a spindle, which is an important component of a machine. In this case, to perform gear change safely, it is necessary to confirm that the spindle motor is rotated at a low speed.

A sample gear shift sequence using the speed detection signal (gear change enable signal) is given below. Please use this sample as a reference material when designing gear shift power magnetic sequence.



To perform a gear change safely, confirm that the spindle motor speed is low by using the speed detection signal before moving the shifter. When the zero-speed detection signal is also used, duplicate checking for safety can be made.

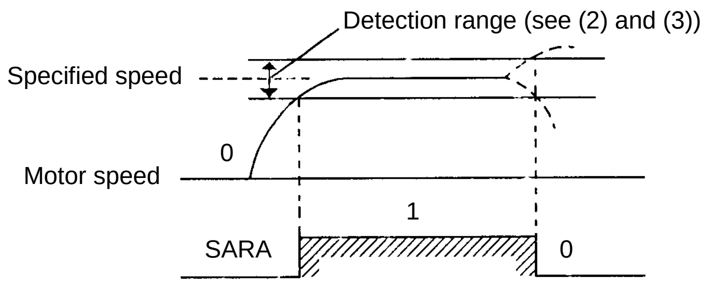
(Why the confirmation is required) If the shifter moves while the spindle motor rotates, the gear is damaged.

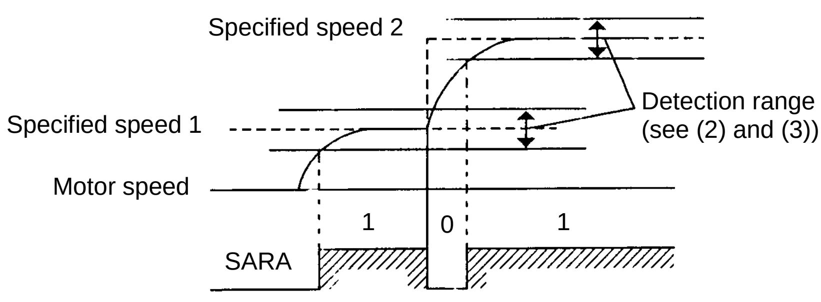


> ⚠ **CAUTION**
> 1 If a motor feedback signal disconnection alarm (spindle alarm 73) is issued, the status of this signal is undefined.
> 2 When bit 5 of parameter No. 4007 is set to "1", the detection operation of the feedback signal disconnection alarm is not performed.
> Set the parameter to "0" when not required, to enable alarm detection.
> 3 If an error which cannot be detected in the motor free-running (coast) state occurs in the motor feedback system, this signal may not be output correctly in the motor free-running mode after an alarm is reset.

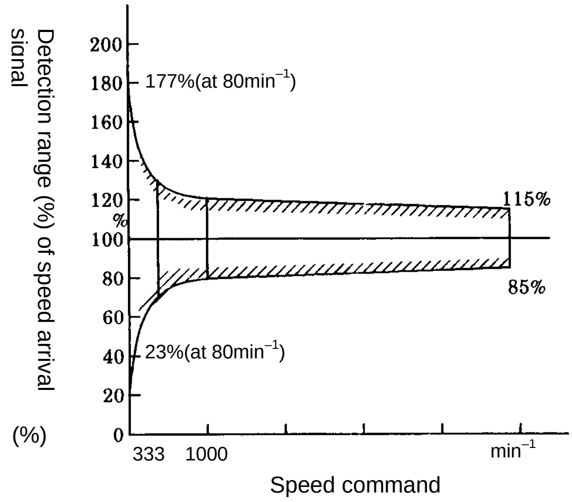
(d) Speed arrival signal (SARA)

(1) When the actual rotation speed of the spindle motor has reached a predetermined range for a speed command, SARA is set to 1.

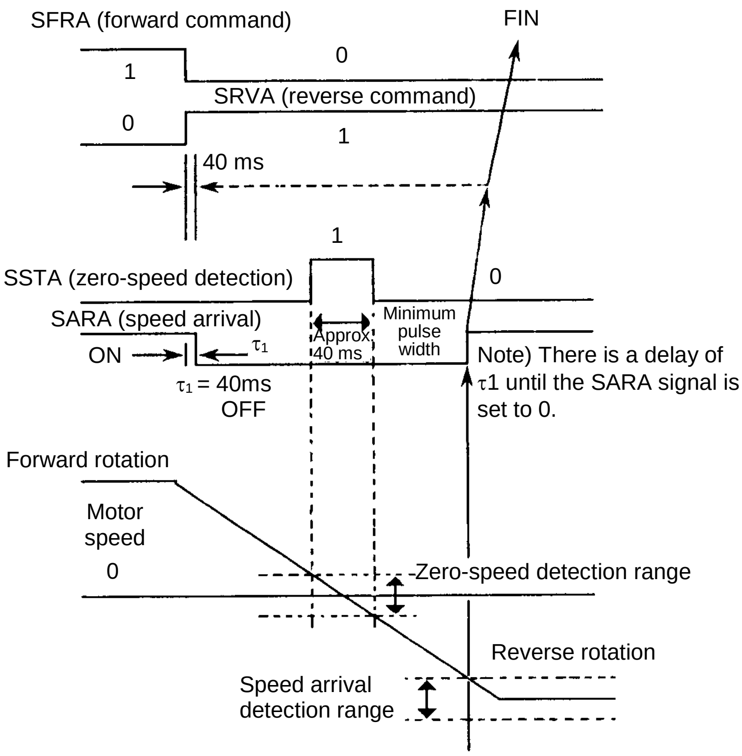




(2) The setting range is ±1 to 100% of a specified speed. When a speed not higher than 10% of the maximum rotation speed is specified, however, the detection range is wider than the set range.
(3) The standard setting is ±15%. The detection range of this speed arrival signal widens for low speeds as shown below.



(4) This signal is output when SFRA or SRVA is set to 1.
(5) This signal can be used to control reverse rotation in a tapping cycle as follows:



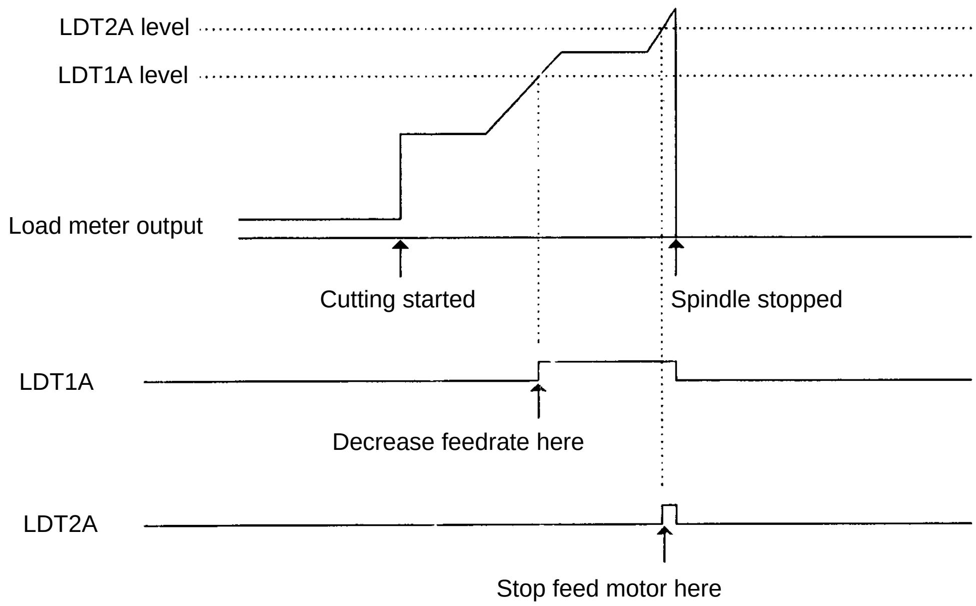
When a reserve rotation command is issued, the spindle motor starts decelerating, and 40 ms later the speed arrival signal is set to 0. Then, after the speed reaches zero, the speed arrival signal being set to 1 is detected. This completes the reverse spindle rotation command.

(6) This signal is used as a confirmation signal (FIN signal) for forward rotation (M03) and reverse rotation (M04) commands.

> ⚠ **CAUTION**
> When a spindle alarm is issued, this signal is disabled.

(e) Load detection signals (LDT1A, LDT2A)

(1) When the maximum output level (10 V) of the load meter (LM) is assumed to be 100%, the load detection signal is set to 1 if the load meter output indicates a parameter-set value (%) or greater.
(2) Two different levels (LDT1A and LDT2A) can be set.
(3) These signals are used in PMC control. For example, to prevent the spindle from stopping when a cutting overload is applied to the spindle during cutting, these signals are used to decrease the feedrate or stop the feedrate.
(4) An application example is given below.
In the following example, two load detection levels are set for control:



(5) The above shows an example of control using two levels. When the feed motor is to be stopped immediately by using just one level, control must be provided according to the machine specification.
(6) By default, these signals are not output in 10 seconds (set in parameter No. 4082) after the status of the speed command signal changes. They are always output when the value on the load meter exceeds the set level according to the parameter setting (bit 4 of parameter No. 4009 to 1), however.

(f) Torque limit status signal (TLMA)

For details of this signal, see Subsection 3.2.2, “Explanation of Output Signals”, in Part I.

(g) Orientation completion signal (ORARA)

For details of this signal, see Section 2.2, “POSITION CODER METHOD SPINDLE ORIENTATION”, in Part I.

(h) Power line switching signal (CHPA) and spindle switching completion signal (CFINA)

For details of these signals, see Section 5.2, “SPINDLE SWITCHING CONTROL”, in Part I.

(i) Power line switching signal (RCHPA) and speed range switching completion signal (RCFNA)

For details of these signals, see Section 5.1, “SPEED RANGE SWITCHING CONTROL”, in Part I.

(j) Position coder one-rotation signal detection state signal (PC1DTA)

For details of this signal, see Subsection 3.2.2, “Explanation of Output Signals”, in Part I.

(k) Incremental orientation signal (INCSTA)

For details of this signal, see Section 5.3, “INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION”, in Part I.

(l) Synchronous orientation enable signal (SORENA)

For details of this signal, see Section 5.5, “SPINDLE ORIENTATION DURING SPINDLE SYNCHRONIZATION CONTROL”, in Part I.

(m) Motor excitation off state signal (EXOFA)

For details of this signal, see Subsection 3.1.3(p), “Disconnection detection disable signal (DSCNA)”, in Part I.

(n) Tandem operation state signal (SLVSA)

For details of this signal, see Section 5.11, “TORQUE TANDEM CONTROL FUNCTION”, in Part I.

(o) Cs reference position establishment state signal (CSPENA)

This signal indicates whether coordinate establishment processing is possible when the Cs axis coordinate establishment function is used with Series 16*i*-MODEL B/Series 30*i*-MODEL A.
If reference position return operation is performed in the Cs mode when bit 5 of parameter No. 4353 is set to 1, this signal is set to 1 from 0 to enable coordinate establishment processing.
This signal is set to 0 when the power is turned off or a spindle alarm is issued.

NOTE

With the following series and editions, this signal can be used:

Series 9D50 G (07) and subsequent editions
Series 9D70 A (01) and subsequent editions
Series 9D80 A (01) and subsequent editions
Series 9D90 A (01) and subsequent editions
Series 9DA0 A (01) and subsequent editions

4 ADJUSTMENT

4.1 VELOCITY LOOP GAIN ADJUSTMENT

4.1.1 Overview

Optimum adjustment of the velocity loop gain increases the position loop gain, therefore significantly enhancing disturbance suppression performance, positioning speed and accuracy. So, the adjustment of the velocity loop gain is very important in servo adjustments, and it should be performed first. This section explains the parameters for velocity loop gain adjustment and the adjustment procedure.

4.1.2 Parameters

There are five operation modes in spindle control: velocity control mode, orientation, servo mode (rigid tapping and spindle positioning), spindle synchronous control, and Cs contour control. There are parameters corresponding to each operation mode and to the clutch/gear signals (CTH1A and CTH2A). The following shows the parameters for each operation mode.

(1) Velocity control mode

15*i*	16*i*	30*i*		
3040	4040	4040	**Velocity loop proportional gain on velocity control mode (HIGH)**	**CTH1A=0**
3041	4041	4041	**Velocity loop proportional gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

15*i*	16*i*	30*i*		
3048	4048	4048	**Velocity loop integral gain on velocity control mode (HIGH)**	**CTH1A=0**
3049	4049	4049	**Velocity loop integral gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

(2) Orientation

15*i*	16*i*	30*i*		
3042	4042	4042	**Velocity loop proportional gain on orientation (HIGH)**	**CTH1A=0**
3043	4043	4043	**Velocity loop proportional gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

15*i*	16*i*	30*i*		
3050	4050	4050	**Velocity loop integral gain on orientation (HIGH)**	**CTH1A=0**
3051	4051	4051	**Velocity loop integral gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767

Standard setting value : 10

(3) Servo mode (Rigid tapping and spindle positioning)

15i	16i	30i		
3044	4044	4044	**Velocity loop proportional gain on servo mode (HIGH)**	**CTH1A=0**
3045	4045	4045	**Velocity loop proportional gain on servo mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

15i	16i	30i		
3052	4052	4052	**Velocity loop integral gain on servo mode (HIGH)**	**CTH1A=0**
3053	4053	4053	**Velocity loop integral gain on servo mode (LOW)**	**CTH1A=1**

Unit of data :
Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

(4) Spindle synchronous control

15i	16i	30i		
-	4044	4044	**Velocity loop proportional gain on spindle synchronous control (HIGH)**	**CTH1A=0**
-	4045	4045	**Velocity loop proportional gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

15i	16i	30i		
-	4052	4052	**Velocity loop integral gain on spindle synchronous control (HIGH)**	**CTH1A=0**
-	4053	4053	**Velocity loop integral gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

15i	16i	30i		
-	-	4550	**Velocity loop proportional gain on spindle synchronous control (HIGH)**	**CTH1A=0**
-	-	4551	**Velocity loop proportional gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

15i	16i	30i		
-	-	4552	**Velocity loop integral gain on spindle synchronous control (HIGH)**	**CTH1A=0**
-	-	4553	**Velocity loop integral gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

NOTE

Parameters Nos. 4550, 4551, 4552, and 4553 are valid with 9D70 series O (15) edition or later, 9D80 series K (11) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
When parameters Nos. 4550, 4551, 4552, and 4553 are set to 0, parameters Nos. 4044, 4045, 4052, and 4053 are valid.
Parameters Nos. 4044, 4045, 4052, and 4053 are common to spindle synchronous control and servo mode.

(5) Cs contour control

15*i*	16*i*	30*i*		
3046	4046	4046	**Velocity loop proportional gain on Cs contouring control (HIGH)**	**CTH1A=0**
3047	4047	4047	**Velocity loop proportional gain on Cs contouring control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 30

15*i*	16*i*	30*i*		
3054	4054	4054	**Velocity loop integral gain in Cs contouring control (HIGH)**	**CTH1A=0**
3055	4055	4055	**Velocity loop integral gain in Cs contouring control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 50

4.1.3 Adjustment Procedure

(1) Start of each operation mode

In preparation for the adjustment, settings must be made so that a stable operation takes place in each mode without overshoot or oscillation.
See Chapter 2, “EXPLANATION OF OPERATION MODES”, temporarily set parameters (acceleration/deceleration time constant, position gain, and so on) to make operations stable in each operation mode, and confirm operations.

NOTE

When a motor with a large torque-to-inertia ratio (for example, low-speed winding of a motor with an speed range switching function) is used, or when the rigidity of the spindle is low, the standard setting of the velocity loop gain may be so high that oscillation can occur. In such a case, decrease the velocity loop gain.

(2) Adjustment

When adjusting the velocity loop gain, check the operation mode and clutch/gear signal, and modify corresponding parameters. Follow the steps below to adjust the parameters:

<1> Determining the oscillation limit
Basically, determine the oscillation limit based on torque commands, position errors, vibration, sound, and so on when the motor is stopped (for orientation, after completion of the operation) or when the motor rotates at a certain speed not higher than the base speed. Normally, increase the proportional gain and integral gain settings in steps of about 5; for a motor with a large torque-to-inertia ratio, increase these settings in steps of about 2. As the settings are increased

gradually, the symptoms below start to appear at a certain setting level. The settings at this level are determined to be the oscillation limit:

- The machine vibrates or produces large sound.
- Vibration of a torque command becomes large.
- Position errors at stop time vary largely.

> **NOTE**
> The oscillation limit varies with the spindle inertia. In a machine in which the inertia varies largely according to the tool and workpiece used, adjustment must be made in the smallest inertia state.

<2> Final settings
Set proportional gain of approximately 70% of the oscillation limit. As the integral gain, the same value as the proportional gain is basically set. When increasing the setting, however, make an adjustment so that the integral gain is typically about twice or five times as high as the proportional gain.

<3> Elimination of machine resonance
At the time of velocity loop gain adjustment, the gain cannot sometimes be increased because of machine resonance. In such a case, the machine resonance elimination function (a torque command filter and resonance elimination filter) described in the next section can be adjusted to increase the velocity loop gain while avoiding machine resonance. See Section 4.2, “MACHINE RESONANCE ELIMINATION”, and make adjustments as necessary.

4.1.4 Additional Information (Position Gain Adjustment)

Although the limit value of the position gain is determined basically depending on the velocity loop characteristics, the setting standards may vary depending on the operation mode. See Chapter 2, “EXPLANATION OF OPERATION MODES”, and make adjustments accordingly.

4.2 MACHINE RESONANCE ELIMINATION

4.2.1 TCMD Filter

(1) Overview

The torque command filter applies a primary low-pass filter to torque commands. When the machine system resonates at frequencies as high as several hundreds Hz or higher, this function can avoid such high-frequency resonance.

(2) Series and editions of applicable spindle software

9D50 series A(01) edition or later
9D70 series A(01) edition or later
9D80 series A(01) edition or later
9D90 series A(01) edition or later
9DA0 series A(01) edition or later

(3) Details

Fig. 4.2.1 shows a velocity loop configuration including the torque command filter.
When the machine system has a high resonance frequency, the speed feedback may include a resonance component, and this component may be amplified by the proportional gain (Kp).
The torque command filter prevents machine resonance by applying a primary low-path filter to the proportional of the torque command to remove high-frequency components of the torque command.

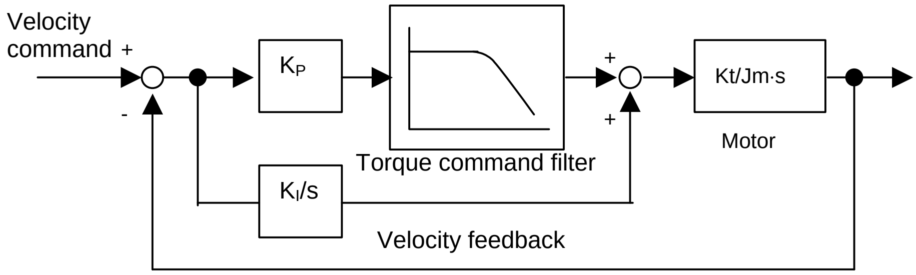


Fig. 4.2.1 velocity loop configuration including the torque command filter

(4) Setting parameters

15*i*	16*i*	30*i*	
3121	4121	4121	**Torque command filter time constant**
3157	4157	4157	**Torque command filter time constant: for low-speed characteristics**

Unit of data : 0.5msec
Valid data range : 0 to 32767
Standard setting value : 5

Basically, use the standard setting value 5 (time constant: 2.5 ms). When a value greater than the standard setting value needs to be set, make an adjustment and typically set a value not greater than 15. When a value greater than 15 needs to be set, decrease the velocity loop gain.

4.2.2 Resonance Elimination Filter

(1) Overview

The resonance elimination filter can attenuate signals which are in certain frequency band. When a strong resonance point is present in an area not lower than 200 Hz, and it is impossible to increase the velocity loop gain, the velocity loop gain can be increased by using this filter.

NOTE
For machines in which the rigidity of the part connecting the spindle and motor is considered to change with time, or for machines whose spindle inertia changes largely depending on the tool or workpiece used, do not use the resonance elimination filter.

(2) Series and editions of applicable spindle software

Spindle software

Series	Edition	Usable CNC
9D50	E (05) edition or later	
9D70	A (01) edition or later	
9D80	A (01) edition or later	
9D90	A (01) edition or later	
9DA0	A (01) edition or later	

* When the resonance elimination filter disable signal is used, the following spindle and CNC software products must be used.

Spindle software

Series	Edition	Usable CNC
9D50	W (23) edition or later	
9D70	L (12) edition or later	
9D80	H (08) edition or later	
9D90	A (08) edition or later	
9DA0	A (08) edition or later	

CNC software (Resonance elimination filter disable signal supported)

Series	Edition	Usable CNC
B0H1	K (11) edition or later	FANUC Series 16*i* /160*i* /160*i*s-MB
BDH1	K (11) edition or later	FANUC Series 18*i* /180*i* /180*i*s-MB
BDH5	B (02) edition or later	FANUC Series 18*i* /180*i* /180*i*s-MB5
DDH1	K (11) edition or later	FANUC Series 21*i* /210*i* /210*i*s-MB
B1H1	K (11) edition or later	FANUC Series 16*i* /160*i* /160*i*s-TB
BEH1	K (11) edition or later	FANUC Series 18*i* /180*i* /180*i*s-TB
DEH1	K (11) edition or later	FANUC Series 21*i* /210*i* /210*i*s-TB
G002/G012/ G022/G032	W (23) edition or later	FANUC Series 30*i* /300*i* /300*i*s-A
G003/G013/ G023/G033	F (06) edition or later	
G121/G131	W (23) edition or later	FANUC Series 31*i* /310*i* /310*i*s-A5
G123/G133	F (06) edition or later	
G101/G111	W (23) edition or later	FANUC Series 31*i* /310*i* /310*i*s-A
G103/G133	F (06) edition or later	
G201	W (23) edition or later	FANUC Series 32*i* /320*i* /320*i*s-A
G203	F (06) edition or later	

(3) Details

Fig. 4.2.2 shows the resonance elimination filter configuration.

The resonance elimination filter is applied to the proportional (the value immediately after the torque command filter in Fig. 4.2.1) of the torque command after the command is passed through the torque command filter. The resonance elimination filter attenuates signals in a set frequency band to avoid machine resonance.

Four filter stages in total can be applied. For each stage, filter characteristics are set by using three parameters including the center frequency, band width, and damping.

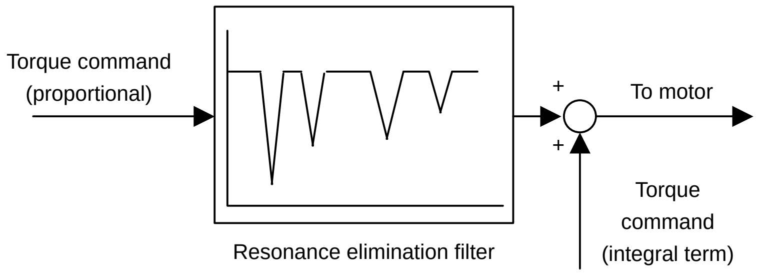


Fig.4.2.2 (a) Resonance elimination filter configuration

(4) I/O Signals (CNC↔PMC)

(4-1) Input signals (PMC→CNC)

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G305	G305					HF4A	HF3A	HF2A	HF1A
2nd-	G309	G309					HF4B	HF3B	HF2B	HF1B

HF1A Resonance elimination filter disable signal 1 (for 1st spindle)
HF1B Resonance elimination filter disable signal 1 (for 2nd spindle)
0: Enables resonance elimination filter 1
1: Disables resonance elimination filter 1
Resonance elimination filter 1 (set with parameter Nos. 4391 to 4393) is disabled.

HF2A Resonance elimination filter disable signal 2 (for 1st spindle)
HF2B Resonance elimination filter disable signal 2 (for 2nd spindle)
0: Enables resonance elimination filter 2
1: Disables resonance elimination filter 2
Resonance elimination filter 2 (set with parameter Nos. 4416 to 4418) is disabled.

HF3A Resonance elimination filter disable signal 3 (for 1st spindle)
HF3B Resonance elimination filter disable signal 3 (for 2nd spindle)
0: Enables resonance elimination filter 3
1: Disables resonance elimination filter 3
Resonance elimination filter 3 (set with parameter Nos. 4419 to 4421) is disabled.

HF4A Resonance elimination filter disable signal 4 (for 1st spindle)
HF4B Resonance elimination filter disable signal 4 (for 2nd spindle)
0: Enables resonance elimination filter 4
1: Disables resonance elimination filter 4
Resonance elimination filter 4 (set with parameter Nos. 4422 to 4424) is disabled.

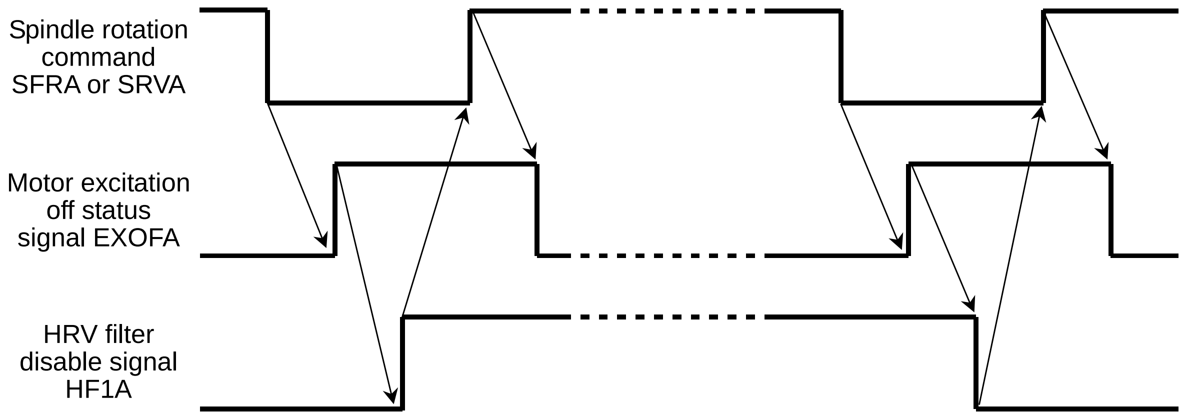
CAUTION
When motor excitation is in progress (motor excitation off state signal: EXOFx = 0), do not change the status of the following signals:
HF1x, HF2x, HF3x, and HF4x

(4-2) Output signals (CNC→PMC)

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F047	F047				EXOFA				
2nd-	F051	F051				EXOFB				

EXOFA Motor excitation off status signal (for 1st spindle)
EXOFB Motor excitation off status signal (for 2nd spindle)
0: Motor excitation is on.
1: Motor excitation is off.
Make sure that status of this signal is ‘1’ before changing status of resonance elimination filter disable signal HF1x, HF2x, HF3x and HF4x.

(4-3) Examples of Sequences



(5) Setting parameters

15*i*	16*i*	30*i*	
3391	4391	4391	**Resonance elimination filter 1 - attenuation center frequency**
3392	4392	4392	**Resonance elimination filter 1 - attenuation bandwidth**
3393	4393	4393	**Resonance elimination filter 1 - damping**

15*i*	16*i*	30*i*	
3416	4416	4416	**Resonance elimination filter 2 - attenuation center frequency**
3417	4417	4417	**Resonance elimination filter 2 - attenuation bandwidth**
3418	4418	4418	**Resonance elimination filter 2 - damping**

15*i*	16*i*	30*i*	
3419	4419	4419	**Resonance elimination filter 3 - attenuation center frequency**
3420	4420	4420	**Resonance elimination filter 3 - attenuation bandwidth**
3421	4421	4421	**Resonance elimination filter 3 - damping**

15*i*	16*i*	30*i*	
3422	4422	4422	**Resonance elimination filter 4 - attenuation center frequency**
3423	4423	4423	**Resonance elimination filter 4 - attenuation bandwidth**
3424	4424	4424	**Resonance elimination filter 4 - damping**

Attenuation center frequency :
Unit of data : 1Hz
Valid data range : 96 to 3000
Standard setting value : 0

Attenuation bandwidth :
Unit of data : 1Hz
Valid data range : 10 to 3000
Standard setting value : 0

Damping :
Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 0

For each filter stage, set three parameters including the attenuation center frequency, attenuation bandwidth, and damping. When a filter stage is not to be used, set 0 (standard setting) in all the three parameters. When input signal HFx (x: 1 to 4) is set to 1, the resonance elimination filter x is disabled.

(6) Adjustment

The disturbance input function (see Subsection 4.2.3, “Disturbance Input Function”) is used for adjustment. After increasing the velocity loop gain until oscillation disappears, use the disturbance input function to observe the frequency (FNCFRQ) and gain (TFUNCG: ratio of the amplitude of the torque command before disturbance application to the amplitude of the disturbance torque command). When there is strong resonance, the gain near the resonance point increases abruptly. So, set the frequency around the peak as the attenuation center frequency, and adjust the attenuation bandwidth and damping. To minimize influences on other bands, make adjustments and set an attenuation bandwidth value as small as possible and a damping value as large as possible.
An example for adjusting the resonance elimination filter using the disturbance input function is given below.
A spindle check board and oscilloscope are required for the adjustment.

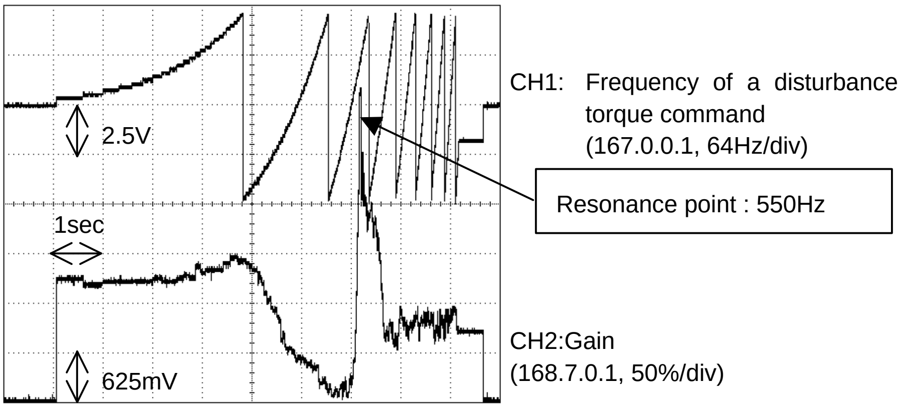


Fig.4.2.2 (b) Before application of the resonance elimination filter

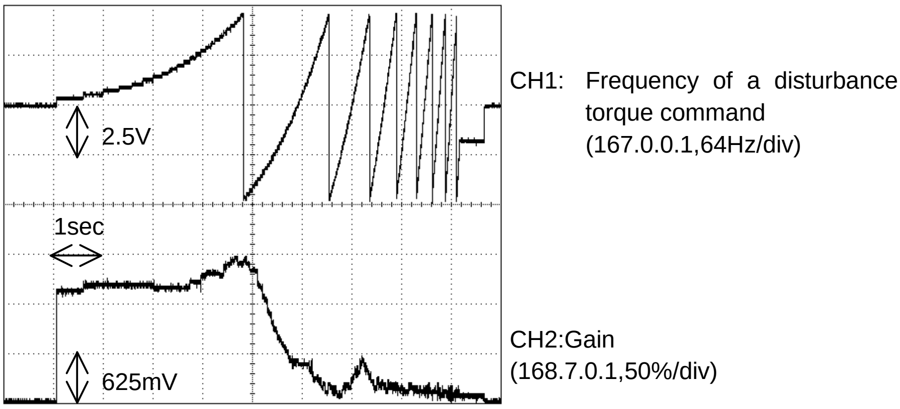


Fig.4.2.2 (c) After application of the resonance elimination filter
(Attenuation center frequency = 550Hz, attenuation bandwidth = 40Hz, damping = 0%)

* Adjustment without the disturbance input function
When adjusting the resonance elimination filter without the disturbance input function, increase the velocity loop gain until oscillation occurs, observe the vibration of a torque command, set its frequency as the attenuation center frequency, and adjust the attenuation bandwidth and damping.

(7) Additional information (cautions)

When the resonance elimination filter is used, inappropriate parameter setting may make velocity loop control unstable, resulting in abnormal oscillation by a torque command. There is a high possibility that velocity loop control becomes unstable when a “low” center frequency, “high” bandwidth, and “small” damping coefficient are set.

1. The motor may accelerate to a speed higher than the specified one with an acceleration/deceleration function depending on the degree of oscillation. Before using the resonance elimination filter, fully consider the following points and adjust the parameters:
   The use of the resonance elimination filter is allowed when the center frequency is 200 Hz or higher.
2. The standard attenuation bandwith is up to 30% of the center frequency. Set as small a value as possible.
3. Set as large a damping coefficient as possible.
4. When the center frequency of machine resonance is 200 Hz or lower, adjust the parameters with observing the instructions described in items (2) and (3) while checking that no torque command causes abnormal oscillation.
5. When you do not use the resonance elimination filter, set all three parameters (attenuation center frequency, attenuation bandwidth, and damping) for resonance elimination filters 1 to 4 to "0."

4.2.3 Disturbance Input Function

(1) Overview

This function is used to measure the gain of the frequency response of a torque command to a disturbance torque command by applying the disturbance torque command in form of a sine wave to the torque command.
With this function, the resonance elimination filter can be adjusted easily.

(2) Series and editions of applicable spindle software

9D50 series E(05) edition or later
9D70 series A(01) edition or later
9D80 series A(01) edition or later
9D90 series A(01) edition or later
9DA0 series A(01) edition or later

(3) Details

Fig. 4.2.3 (a) shows the configuration of the disturbance input function.
A disturbance torque command (DTQCMD) in form of a sine wave is applied to the torque command (TQCMDB), which is the output of the velocity loop controller (including filtering), and the input frequency is increased step by step. While the frequency of the disturbance torque command is being increased, the frequency and the ratio of the amplitude of the torque command to the amplitude of the disturbance torque command (TQCMDB/DTQCMD) (the gain) are observed simultaneously. By doing this, the gain of the frequency response of the torque command to the disturbance torque command can be measured.
If there is strong resonance, an abrupt increase in the gain is observed near the resonance frequency. So, by observing this phenomenon, the resonance elimination filter can be adjusted easily.

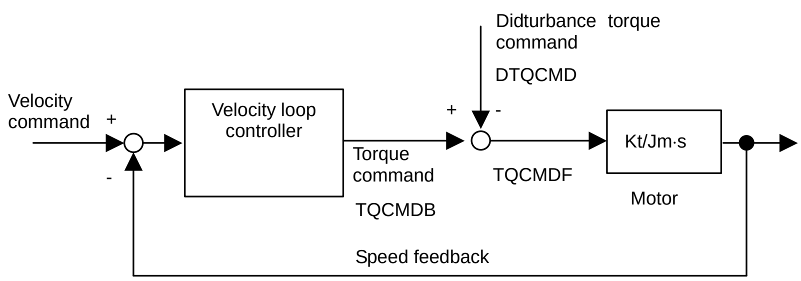


Fig.4.2.3 (a) Configuration of the disturbance input function

(4) Setting parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3395	4395	4395	**DTQFNC**	**DTQTRG**						

DTQFNC Disturbance input function bit
0: Disables the disturbance input function.
1: Enables the disturbance input function.
This bit is valid only when S0 is specified in the velocity control mode. If this bit is set to 1 under conditions other than the above, the spindle amplifier results in a status error (error No. 32), and the excitation of the spindle motor is turned off.

DTQTRG Disturbance input function bit
When this bit is set to ON (0 → 1) while excitation is ON (SFR = 1 or SRV = 1), a measurement starts. When this bit is set to OFF during measurement, the measurement is stopped in the middle.

15*i*	16*i*	30*i*	
3410	4410	4410	**Measurement start frequency**

Unit of data : 1Hz
Valid data range : 0 to 2000
Standard setting value : 0
Set the frequency at which measurements are to start.
When 0 is set, 10 Hz is assumed.

15*i*	16*i*	30*i*	
3411	4411	4411	**Measurement end frequency**

Unit of data : 1Hz
Valid data range : 0 to 2000
Standard setting value : 0
Set the frequency at which measurements are to end.
When 0 is set, 500 Hz is assumed.

15*i*	16*i*	30*i*	
3412	4412	4412	**Measurement frequency interval**

Unit of data : 1Hz
Valid data range : 0 to 20
Standard setting value : 0
Set the interval of measurement frequencies.
When 0 is set, 5 Hz is assumed.

15*i*	16*i*	30*i*	
3413	4413	4413	**Number of measurement times per frequency**

Unit of data : 1 time
Valid data range : 0 to 1000
Standard setting value : 0
Set the number of times a measurement is made per frequency.
When 0 is set, five times are assumed.
Normally, set 0.

15*i*	16*i*	30*i*	
3414	4414	4414	**Disturbance torque command amplitude**

Unit of data : 1% (100% = maximum torque command)
Valid data range : 0 to 50

Standard setting value : 0

Set the amplitude of the disturbance torque command.
When 0 is set, 5% is assumed.
Normally, set 0.

15i	16i	30i	
3415	4415	4415	**Motor speed command at measurement time**

Unit of data : 1min^{-1} (Unit of 10min^{-1} when bit 2 (SPDUNT) of parameter No. 4006 = 1)
Valid data range : -32768 to +32767
Standard setting value : 0

Set the motor speed command at measurement time.
The speed is clamped at the maximum speed of the motor.

15i	16i	30i	
3030	4030	4030	**Change rate of motor speed command at measurement**

Unit of data : 1min^{-1}/sec (Unit of 10min^{-1}/sec when bit 2 (SPDUNT) of parameter No. 4006 = 1)
Valid data range : 0 to +32767
Standard setting value : 0

When a non-zero value is to be set as the motor speed command at measurement time, set the change rate of the motor speed command to prevent abrupt acceleration/deceleration. When the disturbance input function is disabled (DTQFNC = 0), this parameter is used as the soft start/stop setting time. So, after the measurements, restore the original value.

(5) Measurement procedure

Follow the steps below to make measurements:
As the operation mode, set the velocity control mode.

<1> Parameter setting (preparation for measurements)
Basically, only bit setting in parameter No. 4395 needs to be performed.
→ Bit 7 (DTQFNC) of parameter No. 4395 = 1, bit 6 (DTQTRG) = 0
For other parameters, although default settings may be used, set appropriate value as necessary. (When the frequency of the resonance point is high, the setting of the measurement end frequency must be increased.)

<2> Issue the S0 command and turn on excitation (SFR = 1 or SRV = 1).

<3> Setting measurement start trigger DTQTRG to 1 starts measurements.
When a non-zero value is set in the motor speed command at the measurement time (parameter No. 4415), the motor accelerates to the set speed before measurements start. When measurements end, the motor decelerates then stops.
If one of the following conditions is satisfied during measurements, measurements are interrupted, and the motor decelerates then stops:
- The measurement start trigger is turned off. (DTQTRG = 0)
- Spindle motor excitation is turned off. (SFR = 0, SRV = 0)
- An emergency stop is applied.

<4> To restart measurements, set measurement start trigger DTQTRG to ON (0 → 1).
In resonance elimination filter adjustment, a measurement and parameter change must be repeated. So adjust the filter by repeating the following steps: starting measurement (DTQTRG = 1) → end of measurement → DTQTRG = 0 → changing the resonance elimination filter parameters → starting measurement (DTQTRG = 1) and so on.

<5> After completing measurements (adjustment), turn off motor excitation, and reset all the parameters for the disturbance input function to 0.

(6) Observing data

The table below shows the setting method for observing measurement data on the spindle check board and descriptions of observation data. At the time of measurement (adjustment), observe data listed in the table by using measuring devices such as the spindle check board and an oscilloscope. Fig. 4.2.3 (b) shows an example of data observation at the time of measurement.

Channel	Setting address	Settings	Descriptions
CH1	d-05 (data number)	167	FNCFRQ : Frequency of disturbance torque command
	d-06 (shift amount)	0 or 1	±128 Hz/±5 V with shift amount 0 ±256 Hz/±5 V with shift amount 1
	d-07 (shift direction)	0	
	d-08 (offset)	1	
CH2	d-09 (data number)	168	TFUNCG : Ratio of amplitude of TQCMDB to amplitude of DTQCMD (gain)
	d-10 (Shift amount)	6 or 7	±200 %/±5 V with shift amount 6 ±400 %/±5 V with shift amount 7
	d-11 (shift direction)	0	
	d-12 (offset)	1	

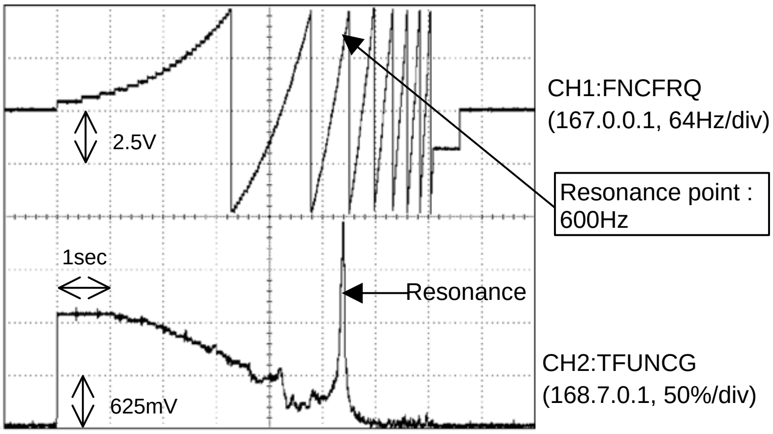


Fig.4.2.3 (b) Example for observing disturbance input function data

* The data shows that strong resonance is present at about 600 Hz.

4.2.4 Adaptive Resonance Elimination Filter

(1) Overview

The adaptive resonance elimination filter function causes one of the four resonance elimination filters to follow up resonance frequency changes.

(2) Series and Editions of Applicable Spindle Software

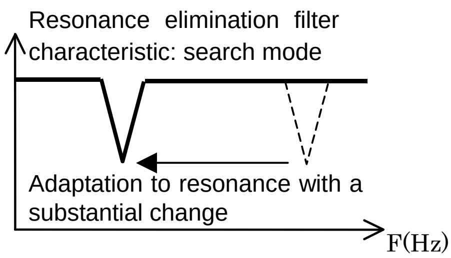
Spindle software

Series	Edition	Usable CNC
9D90	A (01) edition or later	FS0*i*-D, FS30*i* / FS31*i* / FS32*i*
9DA0	A (01) edition or later	FS30*i* / FS31*i* / FS32*i*-B

(3) Details

(1) This function enables searches for resonance frequency changes for:
- Individual differences in machines
- Secular changes in machines
- Individual differences in workpieces

(2) When the search mode signal is input, a search for machine resonance is started within a set search range. Of the frequencies that exceed a set detection level, the one with the largest amplitude is detected as a resonance frequency. The detected frequency is set as a center frequency for resonance elimination filter 1.



(3) While the search mode signal is being input, a search for machine resonance is made continuously. If a different frequency is detected, the setting of the center frequency for resonance elimination filter 1 is updated with the detected frequency.
(4) The detected frequency can be checked on the diagnosis screen.

> **NOTE**
> - This function is enabled only for resonance elimination filter 1 (parameters Nos. 4391, 4392, and 4393).
> - This function is enabled when excitation is on.
> - This function is disabled when the resonance elimination filter 1 disable signal is input (bit 0 of G305 = 1).
> - The center frequency parameter for resonance elimination filter 1 cannot be updated automatically.
> - When the spindle adjustment function of the SERVO GUIDE is used, turn off the search mode signal.

(4) I/O Signals (CNC↔PMC)

(4-1) Input signals (PMC→CNC)

	30i	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G304	FRFSMA							
2nd-	G308	FRFSMB							

FRFSMA : Adaptive resonance elimination filter search mode signal (for 1st spindle)
FRFSMB : Adaptive resonance elimination filter search mode signal (for 2nd spindle)
0 : Stops (disables) the search mode.
1 : Starts the search mode.
When the FRFSM signal is set to 1, a search for a resonance frequency is started.
While the signal is being input, the search is continued even after search completion signal FRDTE becomes 1. If another vibration frequency is detected, the internally set center frequency for resonance elimination filter 1 is updated with the detected frequency.

> **NOTE**
> Even when the FRFSM signal is input, searches cannot be made in any of the following cases:
> 1 Resonance elimination filter 1 disable signal HF1 (bit 0 of G305) is 1.
> 2 Excitation is off.
> 3 The polarity is not detected (for synchronous spindle motor drive).

	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G305								HF1A
2nd-	G309								HF1B

HF1A : Resonance elimination filter 1 disable signal (for 1st spindle)
HF1B : Resonance elimination filter 1 disable signal (for 2nd spindle)

0 : Enabled
1 : Disabled

When the HF1 signal is 1 (disabled), resonance elimination filter 1 set with parameters Nos. 4391, 4392, and 4393 is disabled. In this case, the adaptive resonance elimination filter function is also disabled.

(4-2) Output signals (CNC→PMC)

	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G307								FRDTEA
2nd-	G309								FRDTEB

FRDTEA : Adaptive resonance elimination filter search completion signal (for 1st spindle)
FRDTEB : Adaptive resonance elimination filter search completion signal (for 2nd spindle)

0 : Uncompleted state
1 : Completed state

Once search start signal FRFSM has been input, and when two searches have been finished in the search range specified with the relevant parameters (search start frequency (= parameter No. 4391 - parameter No. 4561) to search end frequency (= parameter No. 4391 + parameter No. 4561) ≤ 2000 Hz), the FRDTE signal becomes 1.

NOTE

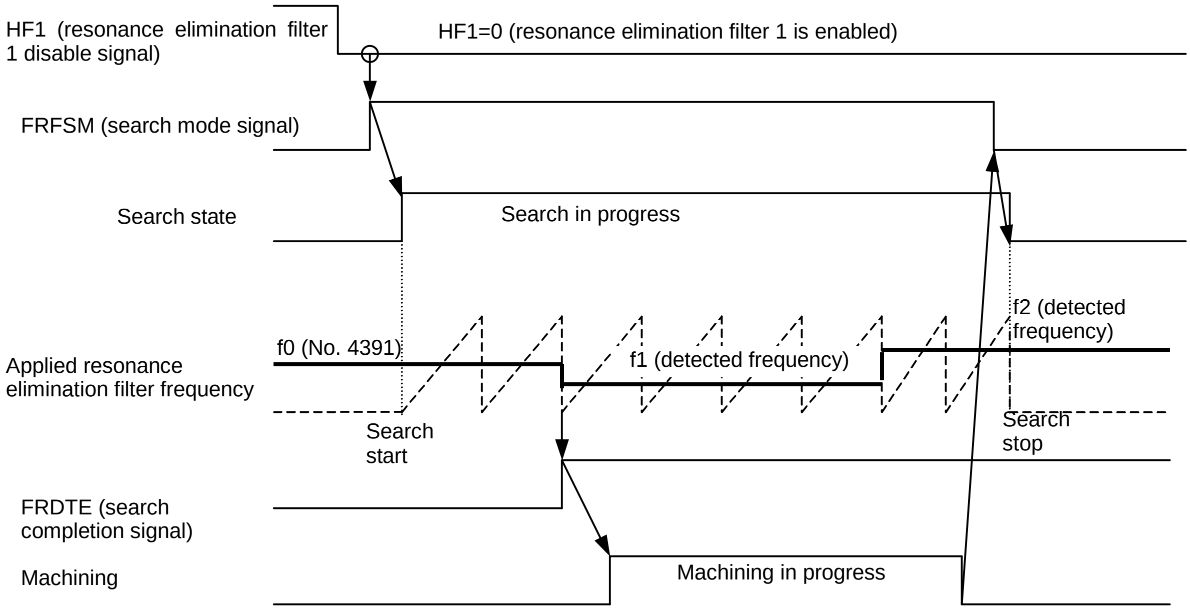
The FRDTE signal is cleared in any of the following cases:

1. Resonance elimination filter 1 disable signal HF1 (bit 0 of G305) is 1 (disabled).
2. The adaptive resonance elimination filter is disabled (bit 3 of parameter No. 4396 = 0).
3. The center frequency (parameter No. 4391) for resonance elimination filter 1 is rewritten.
4. Search start signal FRFSM (bit 7 of G304) rises from 0 to 1.

(4-3) Examples of Sequences

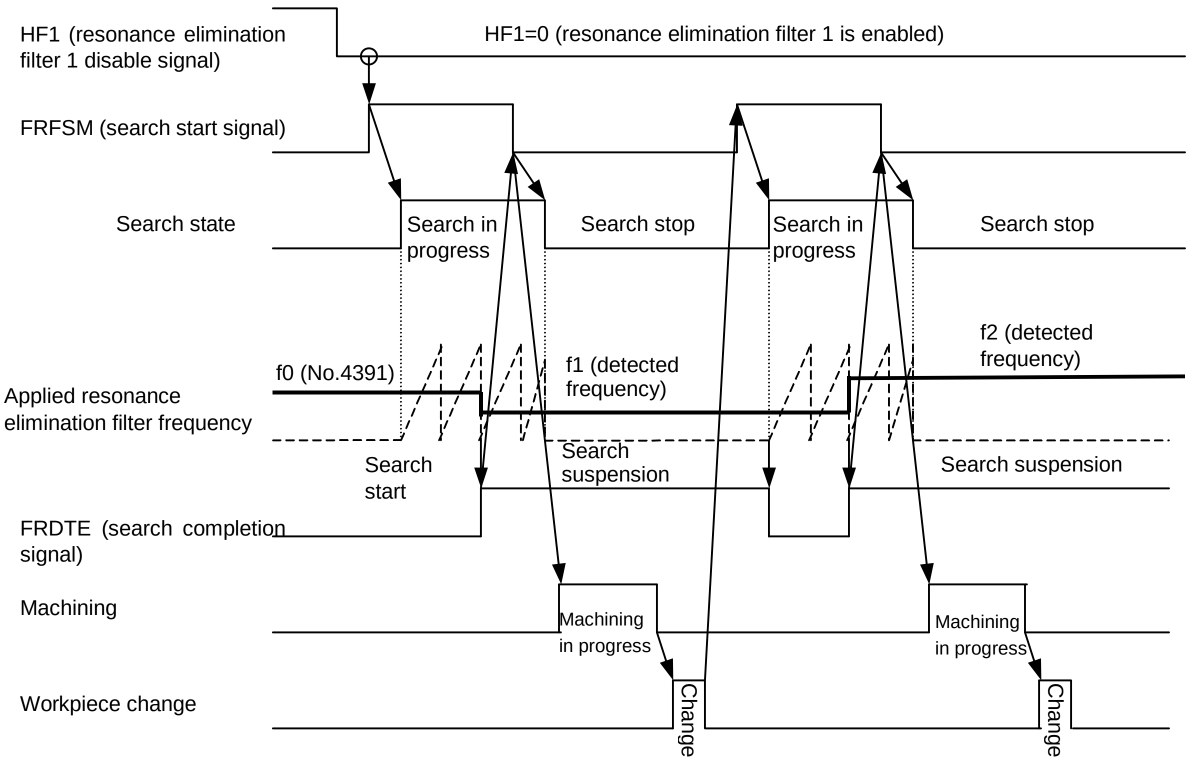
Example 1) To always make a search during machining

When a resonance frequency changes during machining, it is possible to adapt to the frequency changes by continuing a search without turning off the search start signal.



Example 2) To fix the search result during machining

When resonance frequencies are different for individual workpieces, but during machining, you do not want to change the frequency components that should be attenuated, it is possible to fix the center frequency during machining by turning off the search start signal after a search is completed.



(5) Setting parameters

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4396					**ACREF**			

ACREF Adaptive resonance elimination filter function

0 : Disables the adaptive resonance elimination filter function.

1 : Enables the adaptive resonance elimination filter function.

Set this bit to 1 to use the adaptive resonance elimination filter function. This function works for resonance elimination filter 1.

> **NOTE**
> This function is enabled only for resonance elimination filter 1. The function is disabled for the other resonance elimination filters (resonance elimination filter 2 (parameters Nos. 4416, 4417, and 4418), resonance elimination filter 3 (parameters Nos. 4419, 4420, and 4421), and resonance elimination filter 4 (parameters Nos. 4422, 4423, and 4424)).

30*i*	
4391	**Resonance elimination filter 1: center frequency**

Unit of data : 1Hz
Valid data range : 96 to 3000
Standard setting value : 0

When the adaptive resonance elimination filter function is enabled, a search is made around the center frequency set in this parameter in the search range set in parameter No. 4561.

> **NOTE**
> When this parameter is rewritten, search results are discarded.

30*i*	
4392	**Resonance elimination filter 1: band**

Unit of data : 1Hz
Valid data range : 0 to 3000
Standard setting value : 0

> **NOTE**
> When this parameter is 0, the filter function itself is disabled, but searches for resonance frequencies can be made, and search results can be checked on the diagnosis screen.

30*i*	
4393	**Resonance elimination filter 1: attenuation rate**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 0

30*i*	
4560	**Adaptive resonance elimination filter: detection level**

Unit of data : 0.1% Unit [100%⇒maximum torque]
Valid data range : 0 to 1000
Standard setting value : 0

Set the minimum detection level of vibration spectra. When a vibration spectrum is lower than or equal to this level, its wave number is not regarded as a resonance frequency.
When this setting is 0, the detection level is assumed to be 8 (0.8%).

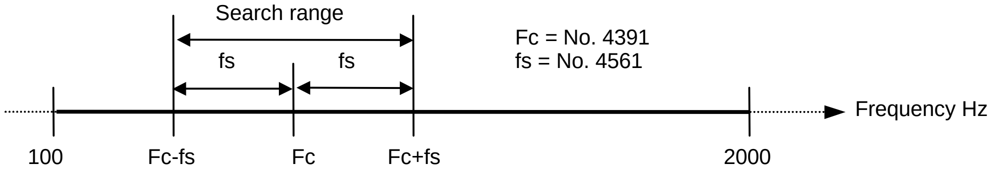
> **NOTE**
> If a small value is set, frequencies may not be detected correctly due to the effect of noise. When applying this parameter, be sure to use the actual machine to check that proper follow-up is performed.

30i	
4561	**Adaptive resonance elimination filter: search range**

Unit of data : 1Hz
Valid data range : 0, 100 to 1900
Standard setting value : 0

Set the search range for the adaptive resonance elimination filter.

A search is made in a frequency range of (parameter No. 4391 ± search range). If a frequency to be found is beyond a range of 100 to 2000 Hz, a search is made within this range. When this setting is 0, the search range is assumed to be fs = 1900.



(6) Checking search results

When the following parameter is set, the results of searches made by the adaptive resonance elimination filter can be checked on the CNC diagnosis screen.

30i	
4532	**Arbitrary data output function number**

Unit of data :
Valid data range : 0 to +32767
Standard setting value : 0

When this parameter is set to 6, the following data for which search processing is performed can be checked on the CNC diagnosis screen display. When diagnosis 722 = 1, the value displayed in diagnosis 720 is the center frequency that has been found.

Diagnosis 720: Displays the center frequency (search result) for resonance elimination filter 1 that has been found and internally set.

Diagnosis 722: Displays the state of search completion signal FRDTE, 0 (search completed state) or 1 (search uncompleted state).

4.3 AMPLITUDE RATIO/PHASE DIFFERENCE COMPENSATION FUNCTION

(1) Overview

This function compensates for errors in speed and position detection due to the amplitude ratio and phase difference of phase A/B of speed and position detection sensors.

By using this function, improvements in positioning and feed accuracy at the time of Cs contour control can be expected.

(2) Series and editions of applicable spindle software

9D50 series C(03) edition or later
9D70 series A(01) edition or later
9D80 series A(01) edition or later

9D90 series A(01) edition or later
9DA0 series A(01) edition or later

> **NOTE**
> When the αiCZ sensor (serial) is used, this function cannot be used.

(3) Details

The feedback signals from the αiM sensor, αiMZ sensor, αiBZ sensor, and αiCZ sensor (analog) are used for speed or position detection in the spindle amplifier, and they are two sine wave signals (phase A/B) having the same amplitude and a phase difference of 90°. Based on these phase A/B signals, the detection circuit of the spindle amplifier generates feedback data used for speed and position detection. If the feedback signals are in the ideal state (having the same amplitude and a phase difference of 90°), accurate feedback data is generated. Actually, however, the amplitude and phase difference are slightly deviated from the ideal state. This deviation causes a feedback data error, which lowers the accuracy of speed and position detection.

When the feedback data has an error due to the deviation in amplitude and phase difference of the feedback signals as described above, this function performs compensation of feedback data generation processing (interpolation processing) of the detection circuit by setting compensation data for the detection circuit to minimize the error.

Use of this function improves the accuracy in speed and position detection. As a result, positioning and feed accuracy can be improved, and also improvement in rigidity can be expected because of the increase in velocity loop gain and position loop gain.

> **NOTE**
> This function does not simplify sensor installation work by directly performing compensation of the feedback signals. The sensor signals must satisfy the specification. So, before using this function, check that the feedback signals satisfy the specification.

(4) Setting parameters

15*i*	16*i*	30*i*	
3355	4355	4355	**Compensation of motor sensor signal amplitude ratio**

Unit of data : 1%
Valid data range : -8 to +8
Standard setting value : 0

15*i*	16*i*	30*i*	
3356	4356	4356	**Compensation of motor sensor signal phase difference**

Unit of data : 1°
Valid data range : -4 to +4
Standard setting value : 0

15*i*	16*i*	30*i*	
3357	4357	4357	**Compensation of spindle sensor signal amplitude ratio**

Unit of data : 1%
Valid data range : -8 to +8
Standard setting value : 0

15*i*	16*i*	30*i*	
3358	4358	4358	**Compensation of spindle sensor signal phase difference**

Unit of data : 1°
Valid data range : -4 to +4
Standard setting value : 0

When compensation of the feedback signal of the motor sensor connected to spindle amplifier JYA2 is performed, the settings of parameter Nos. 4355 and 4356 are adjusted. When compensation of the feedback signal of the spindle sensor connected to JYA4 is performed, the settings of parameter Nos. 4357 and 4358 are adjusted.
When as with a built-in motor the speed sensor and position sensor are the same (the feedback signal of JYA2 is used for speed detection and position detection), compensation is performed for JYA2 only. When the speed sensor and position sensor are provided separately (the feedback signal of JYA2 is used for speed detection, and the feedback signal of JYA4 is used for position detection), compensation is performed for both JYA2 and JYA4.

(5) Preparation for adjustment

With this function, parameters are adjusted by rotating the spindle at a certain speed in the velocity control mode and observing feedback data. The measuring devices required for the adjustment and the settings made at the time of adjustment are explained below.

<1> Measuring devices required for adjustment
For the adjustment by this function, a spindle check board (A06B-6078-H001) and a digital oscilloscope having an averaging function are required.

<2> Speed and rotation direction at adjustment time
For adjustment on the motor sensor side, issue a speed command and rotation direction command (SFR or SRV) so that the motor rotates in the forward direction (counterclockwise) at speed N (see the equation below). For adjustment on the spindle sensor side, issue the commands so that the spindle rotates in the forward direction (counterclockwise) at speed N.
N [min^{-1}] = 4685/Number of sensor gear teeth [λ/rev]
Example: When the number of sensor gear teeth = 256 [λ/rev]
N = 4685/256 = approx.18 [min^{-1}]

<3> Setting observation data
The table given below lists the data items to be observed at the time of adjustment and the settings for output on the spindle check board. For adjustment on the motor sensor (JYA2) side, observe data with data Nos. 313 and 231. For adjustment on the spindle sensor (JYA4) side, observe data with data Nos. 314 and 232.

<table>
<tr><th>Channel</th><th>Setting address</th><th>Setting data</th><th>Description</th></tr>
<tr><td rowspan="5">CH1</td><td rowspan="2">d-05 (data number)</td><td>313</td><td>Motor sensor feedback incremental data</td></tr>
<tr><td>314</td><td>Spindle sensor feedback incremental data</td></tr>
<tr><td>d-06 (shift amount)</td><td>3 to 5</td><td rowspan="3">Incremental data sent every 2 ms for feedback data (data Nos. 231 and 232)
The data weights $1/2^4\lambda$/10V for a shift amount of 4</td></tr>
<tr><td>d-07 (shift direction)</td><td>0</td></tr>
<tr><td>d-08 (offset)</td><td>0 or 1</td></tr>
<tr><td rowspan="5">CH2</td><td rowspan="2">d-09 (data number)</td><td>231</td><td>Motor sensor feedback data</td></tr>
<tr><td>232</td><td>Spindle sensor feedback data</td></tr>
<tr><td>d-10 (Shift amount)</td><td>8</td><td rowspan="3">The data weights 1λ/10V.
During rotation, a saw tooth wave form is observed, and the edge interval is equivalent to data for 1λ of the sensor gear.</td></tr>
<tr><td>d-11 (shift direction)</td><td>0</td></tr>
<tr><td>d-12 (offset)</td><td>0</td></tr>
</table>

<4> Setting the oscilloscope
Connect and set the oscilloscope as shown below to observe data. Use a falling edge of feedback data as a trigger, observe a waveform which averages incremental data, and adjust parameters so that the amplitude of this waveform is minimized.

Channel 1: Connected to the CH1 pin of the check board (0.5 to 1 V/div)
Channel 2: Connected to the CH2 pin of the check board (5 V/div)
Measurement time range: 5 to 10 ms/div
Trigger setting: Falling edge of channel 2
Number of averaging times: About 16 to 64 times

(6) Adjustment procedure

After completing the preparation for adjustment mentioned previously, follow the steps below to adjust parameter settings in the MDI mode.

> **NOTE**
> Note that the αi series does not have the adjustment function using the spindle check board.

<1> Rotation in the velocity control mode
Set all the amplitude ratio and phase difference compensation parameters to 0, and rotate the spindle (motor) in the previously mentioned direction and at speed N in the velocity control mode.

<2> Setting and adjusting the check board and oscilloscope
After disabling the averaging function of the oscilloscope, adjust the settings regarding the shift amount and the presence/absence of an offset for CH1, and the display setting of the oscilloscope so that incremental data does not overflow the check board output range (±5 V) and oscilloscope display range (see Fig. 4.3 (a)).
After completing the adjustment of the check board and oscilloscope, enable the averaging function (See Fig. 4.3 (b)).

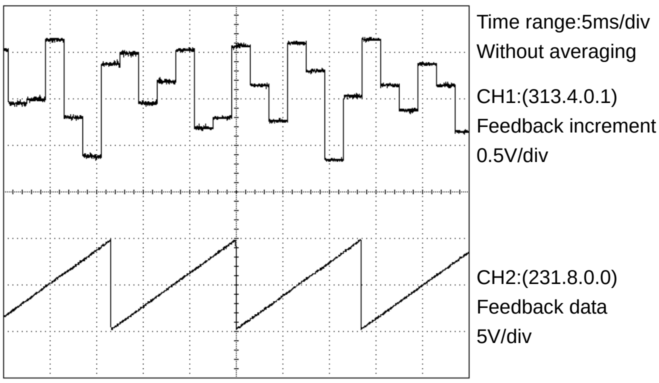


Fig. 4.3 (a) Without averaging

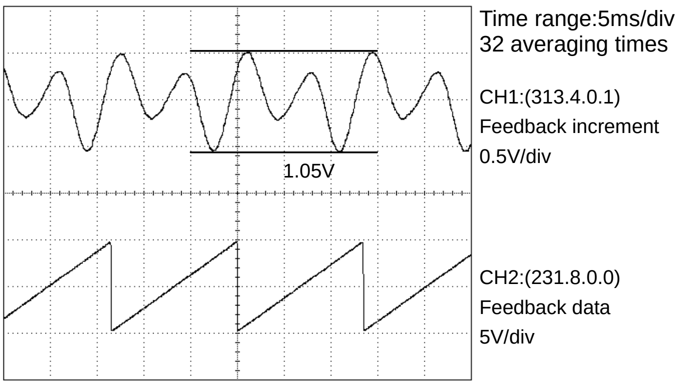


Fig. 4.3 (b) When averaging is performed 32 times

* Sensor: 256 λ/rev, speed 18 min^{-1}

<3> Adjusting the phase difference compensation parameter

Set the parameter for amplitude ratio compensation (parameter No. 4355 or 4357) to 0, and adjust the phase difference compensation parameter (parameter No. 4356 or 4358). Typically, set a value with which the amplitude of averaged incremental data is minimized. First, check the amplitude by entering (+)1 as the parameter value and the amplitude by entering -1. In the direction in which the amplitude becomes smaller, change the parameter value in steps of 1. Then, you can find the optimum value easily. Fig. 4.3 (c) shows the waveform obtained after phase difference compensation adjustment.

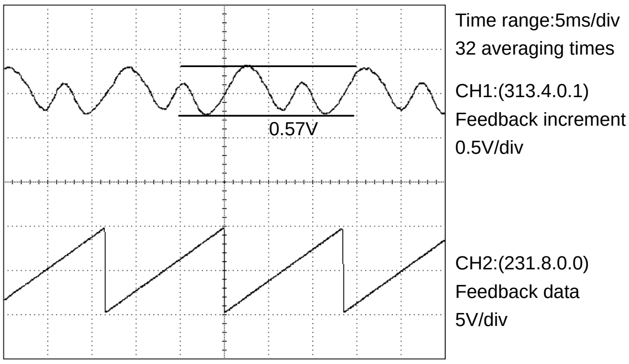


Fig. 4.3 (c) After phase difference compensation

<4> Adjusting the amplitude ratio compensation parameter

After adjusting phase difference compensation to an optimum value, adjust amplitude ratio compensation. The adjustment method and the guideline for adjustment are the same as for phase difference compensation. Perform adjustment so that the amplitude of feedback incremental data becomes smaller. Fig. 4.3 (d) shows the waveform obtained after adjustment of amplitude ratio compensation (and phase difference compensation).

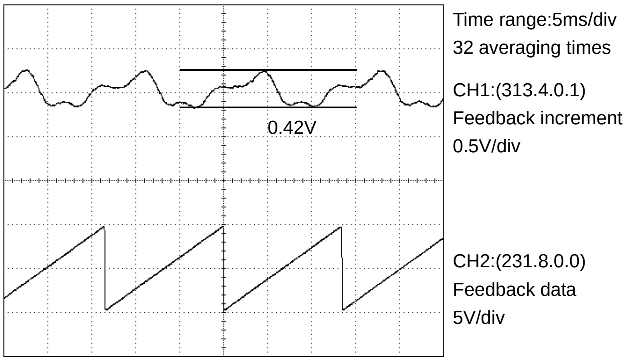


Fig. 4.3 (d) After amplitude ratio (and phase difference) compensation

NOTE

Whichever compensation, amplitude ratio compensation or phase difference compensation, may be adjusted first, the same adjustment result can be obtained. So, steps <3> and <4> may be performed in reverse order.

5 FUNCTION DESCRIPTIONS

5.1 SPEED RANGE SWITCHING CONTROL (OPTIONAL FUNCTION)

5.1.1 Overview

Speed range switching control switches the output characteristic (winding) of a spindle motor (motor designed for speed range switching control) that has two types of windings (winding with low-speed output characteristic and winding with high-speed output characteristic).

NOTE
Using this function requires the CNC software option.

5.1.2 Series and Editions of Applicable Spindle Software

Spindle software

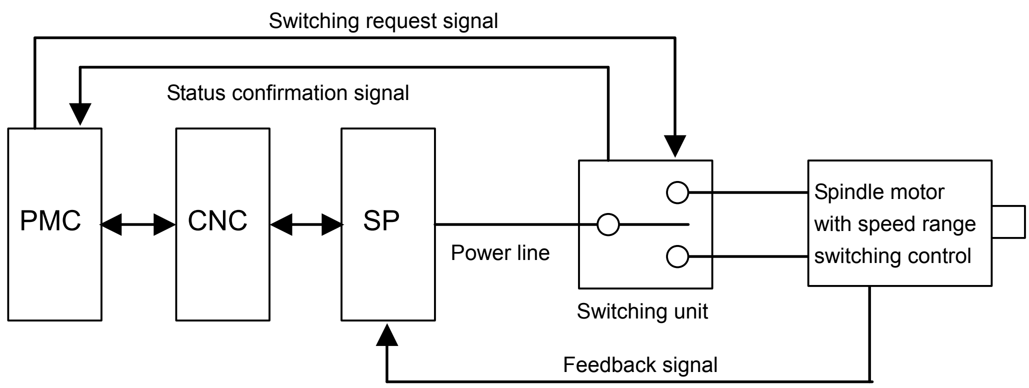
Series	Edition	Usable CNC
9D50	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

5.1.3 Configuration

Shown below is a machine configuration for using speed range switching control.
This function requires the following items in addition to a spindle amplifier (SP).

- Switching unit (a magnetic contactor and a relay for driving it are included)
- Signals between the PMC and switching unit

Refer to "FANUC SERVO AMPLIFIER αi series Descriptions" (B-65282EN) for the specification of the switching unit and detailed descriptions about their connection.

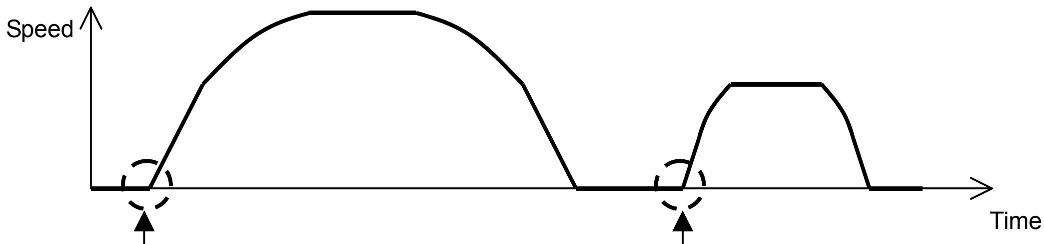


5.1.4 Using Speed Range Switching Control

While there are two methods of using speed range switching control, it is recommended to adopt the method that switches the winding based on the velocity command.

- Switching the winding based on the velocity command (recommended method)
- Switching the winding based on the actual motor speed

With the method that switches the winding based on the velocity command, the winding is selected based on the specified speed while the spindle is stopped and then the spindle is accelerated, as shown in the figure below. Generally, this method enables a short acceleration time before reaching the maximum speed and a smooth acceleration operation. The method is also advantageous in terms of the contact life of the magnetic contactor.



The following table compares the two methods.

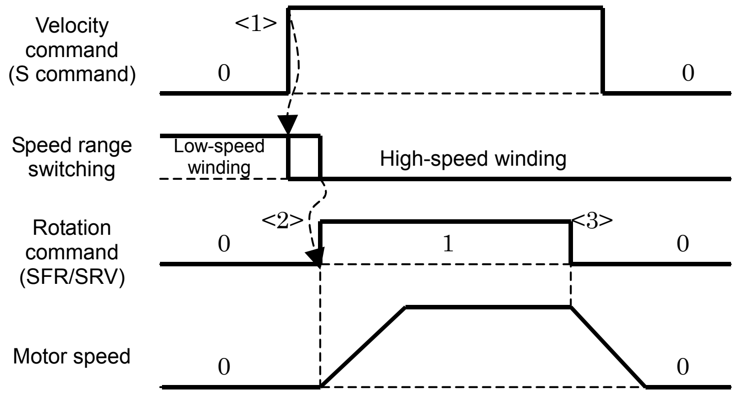
	Method that switches the winding based on the velocity command	Method that switches the winding based on the actual motor speed
Acceleration time from stop state to maximum speed	This method uses only the high-speed winding and does not switch the winding during acceleration. Therefore, the time for the switching operation (typically 200 to 300 ms) is not required and the acceleration time from the start of acceleration generally becomes short.	This method performs the switching from the low-speed winding to the high-speed winding during acceleration. Therefore, the time for the switching operation (typically 200 to 300 ms) is required. In cases where the switching operation time is short relative to the acceleration time, such as when the inertia is large, this method that also uses the low-speed winding may result in a short acceleration time.
Speed fluctuation during acceleration	Since this method does not switch the winding during acceleration, the acceleration operation is not interrupted, resulting in smooth acceleration.	Since this method switches the winding during acceleration, the acceleration operation is interrupted when the switching is performed and acceleration is not smooth.
Life of magnetic contactor	Since this method switches the winding only when necessary, it is advantageous in terms of the contact life of the magnetic contactor.	Since this method switches the winding whenever the spindle is accelerated to the high-speed winding range, it can be said that the method is disadvantageous in terms of the contact life of the magnetic contactor.

(a) Method that switches the winding based on the velocity command

This method references the spindle velocity command (S command) and switches the winding by judging whether the specified speed is the low-speed winding range or high-speed winding range. Determine the winding to be selected, by using the S code output (S31 to S00) or S12 bit code output (R12O to R01O).

(1) Starting and stopping the spindle

<1> Reference the spindle velocity command (S command) and switch to the low-speed winding if the specified speed is the low-speed winding range or to the high-speed winding if the specified speed is the high-speed winding. If the desired winding is already selected, the switching is not necessary and the time is reduced.
<2> Rotate the spindle after the switching is completed.
<3> When stopping the spindle, stop it with the winding that is selected while it is rotating.



(2) Changing the velocity command

If the winding needs to be changed when the velocity command is changed while the spindle is rotating, it is possible to stop the spindle temporarily, change the winding, and then accelerate the spindle to the specified speed, as in mechanical gear switching. Note, however, that this method requires a longer acceleration/deceleration time because it stops the spindle temporarily.
Described below is a method to reduce the operation time by changing the winding during rotation.

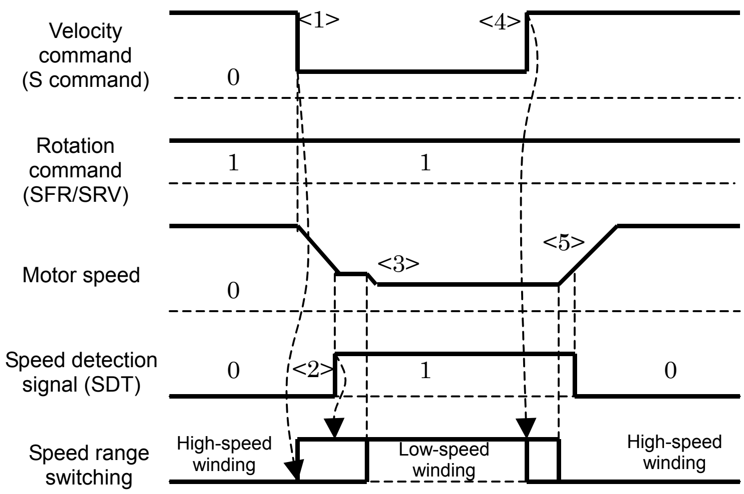
(2)-1 High-speed winding → low-speed winding

To change the velocity command from the high-speed winding area to the low-speed winding area, set bit 4 of parameter No.4019 to 1. Also, set the detection level of the speed detection signal (SDT) to the switching speed.
These settings ensure that the sequence does not proceed until the motor decelerates to the low-speed winding range and the speed detection signal (SDT) is set to 1, even if the switching from the high-speed winding to the low-speed winding starts. This means that they prevent the low-speed winding from being selected in the high-speed winding range.

<1> Reference the spindle velocity command (S command) and start the switching to the low-speed winding if the specified speed is the low-speed winding range.
<2> If the motor decelerates to the set speed level, the speed detection signal (SDT) is set to 1 and the switching operation is performed.
<3> After the switching is completed, the motor decelerates further to the specified speed.

(2)-2 Low-speed winding → high-speed winding

<1> Reference the spindle velocity command (S command) and switch to the high-speed winding if the specified speed is the high-speed winding range.
<2> After the switching is completed, the spindle accelerates to the specified speed.



(b) Method that switches the winding based on the actual motor speed

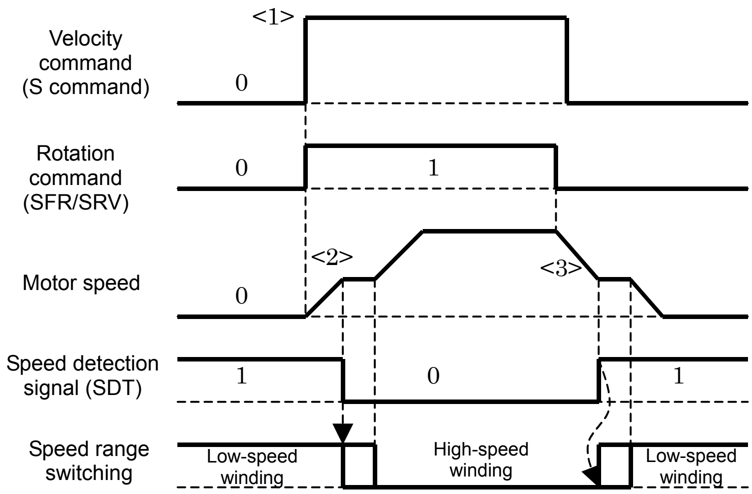
This method switches the winding when the motor reaches the switching speed. Switch the winding when the speed detection signal (SDT) changes. The speed detection signal is set to 1 when the speed level specified by the parameter is lower than the actual motor speed or to 0 when the speed level is higher. Set the detection level (parameter No. 4023) to the switching speed.

(1) Starting and stopping the spindle

<1> Input the spindle velocity command (S command) and rotation command to accelerate the spindle.

<2> Accelerate the spindle until the detection speed of the speed detection signal (SDT) is reached. When the SDT signal changes, perform the speed range switching. When the switching of the winding is completed, the spindle accelerates further to the specified speed.

<3> When the spindle is stopped, the speed detection signal (SDT) also changes during deceleration. When the SDT signal changes, perform the switching of the winding. After the switching to the low-speed winding is completed, the spindle decelerates and stops.



(2) Changing the velocity command

(2)-1 High-speed winding → low-speed winding

<1> Using the spindle velocity command of the low-speed winding range, start deceleration.

<2> When the spindle decelerates to the detection speed of the speed detection signal (SDT) and the SDT signal changes, perform the speed range switching.

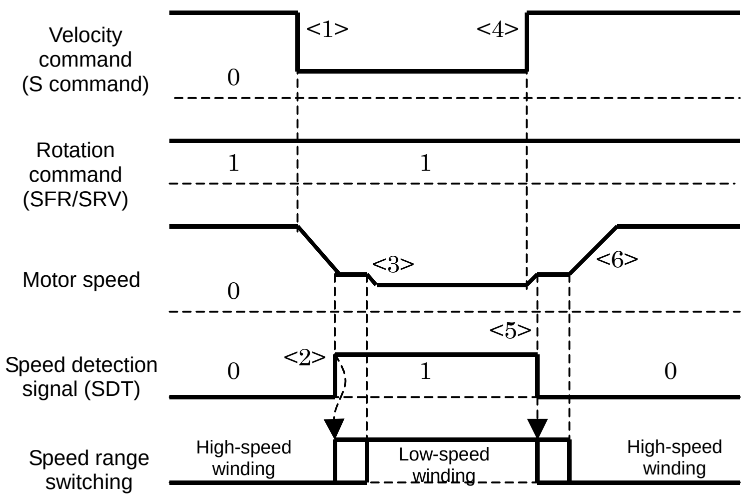
<3> When the switching of the winding is completed, the spindle decelerates further to the specified speed.

(2)-2 Low-speed winding → high-speed winding

<1> Using the spindle velocity command of the high-speed winding range, start acceleration.

<2> When the spindle accelerates to the detection speed of the speed detection signal (SDT) and the SDT signal changes, perform the speed range switching.

<3> When the switching of the winding is completed, the spindle accelerates further to the specified speed.



(c) Cautions

While speed range switching control can be performed regardless of whether the motor is stopped or rotating, it should not be performed during cutting or position control. Since the motor current control is stopped during the switching operation, the motor does not generate torque. For this reason, the motor may become unable to cut or rotate as specified, thus causing an alarm.

Be sure to select the winding before the motor enters any of the following control modes in order to prevent the switching operation from being performed while the motor is operating in one of these modes.

- Spindle orientation (lower than or equal to the orientation speed)
- Rigid tapping
- Cs contouring control
- Spindle synchronous control
- Spindle positioning

The speed detection signal (SDT) may change in the cases described below. Avoid using the SDT signal in these cases.
In constant surface speed control, the spindle speed becomes high to reach the detection level of the SDT signal.
(When performing constant surface speed control with the low-speed winding, it is possible to prevent the speed from reaching the detection level of the SDT signal by clamping the maximum speed using the spindle maximum speed clamp command (G92 and G50).)
During cutting, the cutting load causes a speed fluctuation and the speed reaches the detection level of the SDT signal.

Note that the SDT signal may change when the speed is changed by spindle override.

5.1.5 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070					CTH1A	CTH2A		
2nd-	G235	G074	G074					CTH1B	CTH2B		
1st-	G226	G071	G071	RCHA	RSLA						
2nd-	G234	G075	G075	RCHB	RSLB						
1st-	G229	G072	G072	RCHHGA							
2nd-	G237	G076	G076	RCHHGB							

(2) Details of input signals (PMC→CNC)

(a) Speed range switching request signal (RSLA)

(1) The RSLA signal is used as a command signal for selecting an output characteristic.
0: The high-speed characteristic is selected.
1: The low-speed characteristic is selected.

(2) Method of specifying the RSLA signal according to the speed command (S command)
Input the RSLA signal in such a way that, if the specified speed is lower than or equal to the switching speed, the low-speed characteristic is selected and, if the specified speed is higher than or equal to the switching speed, the high-speed characteristic is selected. When this signal changes from 0 to 1 in a rotation speed range that is higher than or equal to the switching speed, the low-speed characteristic is selected immediately. To avoid this symptom, set, to 1, a parameter (bit 4 of parameter No. 4019) for selecting the low-speed characteristic after the speed detection signal (SDTA) has changed to 1. This method requires that the detection level of the SDTA signal be set to the switching speed.

(3) Method of using the speed-detected signal (SDTA)
Input the speed range switching request signal according to the output of the SDTA signal. This method requires that the detection level of the SDTA signal be set to the switching speed.
Note that the SDTA signal changes in the following cases:
- If the motor speed crosses the speed detection level during constant surface speed control
When the motor is used with the low-speed characteristic, clamping the maximum rotation speed of the spindle under constant surface speed control to the switching speed (using the G50 and G92 commands) prevents speed range switching.
- If the motor speed crosses the speed detection level when the speed is changed under spindle override
- If the motor speed crosses the speed detection level during cutting

(4) Because the motor is switched off during speed range switching, select an output characteristic, whichever is necessary, before entering any of the following control modes. Do not change the speed range switching request signal during operation.
- Rigid tapping
- Cs contouring control
- Spindle synchronous control
- Spindle positioning
- Spindle orientation (lower than or equal to the orientation speed)

(b) Low-speed characteristic magnetic contactor status signal (RCHA)

(1) Input an open/closed status signal for the magnetic contactor (MCC) used for the low-speed characteristic of the spindle motor.
0: The low-speed characteristic magnetic contactor is open (off).
1: The low-speed characteristic magnetic contactor is closed (on).

(2) Usually, specify the status of the auxiliary contact (contact A) of the low-speed characteristic magnetic contactor without modifying it.

(3) If bit 3 of parameter No. 4014 = 0, the RCHA signal is used as a confirmation signal for the status of the power line. So, specify the selected status of the magnetic contactor for switching the output characteristic of the spindle motor.
 0: The high-speed characteristic is selected.
 1: The low-speed characteristic is selected.
 To switch from low-speed characteristic to high-speed characteristic, after making sure that the low-speed characteristic magnetic contactor is switched off and the high-speed characteristic magnetic contactor is switched on, change this signal from 1 to 0. Similarly, to switch from high-speed characteristic to low-speed characteristic, after making sure that the high-speed characteristic magnetic contactor is switched off and the low-speed characteristic magnetic contactor is switched on, change this signal from 0 to 1.

(c) High-speed characteristic magnetic contactor status signal (RCHHGA)

(1) Input an open/closed status signal for the magnetic contactor (MCC) used for the high-speed characteristic of the spindle motor.
 0: The high-speed characteristic magnetic contactor is open (off).
 1: The high-speed characteristic magnetic contactor is closed (on).
(2) Usually, specify the status of the auxiliary contact (contact A) of the high-speed characteristic magnetic contactor without modifying it.
(3) The RCHHGA signal is valid if bit 3 of parameter No. 4014 = 1.

(3) Address list of output signals (CNC→PMC)

	15i	16i	30i	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045						SDTA		
2nd-	F245	F049	F049						SDTB		
1st-	F228	F046	F046					RCFNA	RCHPA		
2nd-	F244	F050	F050					RCFNB	RCHPB		

(4) Details of output signals (CNC→PMC)

(a) Power line switching signal (RCHPA)

(1) The RCHPA signal is a command signal for selecting a magnetic contactor used to switch the output characteristic of the spindle motor.
 0: The high-speed characteristic magnetic contactor is selected.
 1: The low-speed characteristic magnetic contactor is selected.
(2) The RCHPA signal is output in response to an incoming speed range switching request signal (RSLA). Switch the magnetic contactor according to the RCHPA signal.
(3) When the speed range is switched from low speed to high speed, the RCHPA signal changes from 1 to 0 in response to an incoming speed range switching request signal (RSLA). When the speed range switching request signal is received, the motor power is automatically switched off. So, first switch off the low-speed magnetic contactor. After making sure that the low-speed magnetic contactor has been switched off, switch on the high-speed magnetic contactor.
(4) When the speed range is switched from high speed to low speed, the RCHPA signal changes from 0 to 1 in response to an incoming speed range switching request signal (RSLA). When the speed range switching request signal is received, the motor power is automatically switched off. So, first switch off the high-speed magnetic contactor. After making sure that the high-speed magnetic contactor has been switched off, switch on the low-speed magnetic contactor.

(b) Power line switching completion signal (RCFNA)

(1) After spindle motor speed range switching is completed, indicate which speed range is selected.
 0: The spindle is running with the high-speed characteristic.
 1: The spindle is running with the low-speed characteristic.

(2) After making sure that the speed range switching request signal (RSLA) has changed and the RCFNA signal matches the RSLA, go to the next operation.

(c) Speed detection signal (SDTA)

(1) Output a signal for indicating whether the motor speed is not lower than or not higher than the speed level specified in parameter No. 4023.
 0: The motor is rotating at or faster than the specified speed level.
 1: The motor is rotating at or lower than the specified speed level.

(2) The SDTA signal can be used to detect the speed for speed range switching by setting the speed detection level to the switching speed.

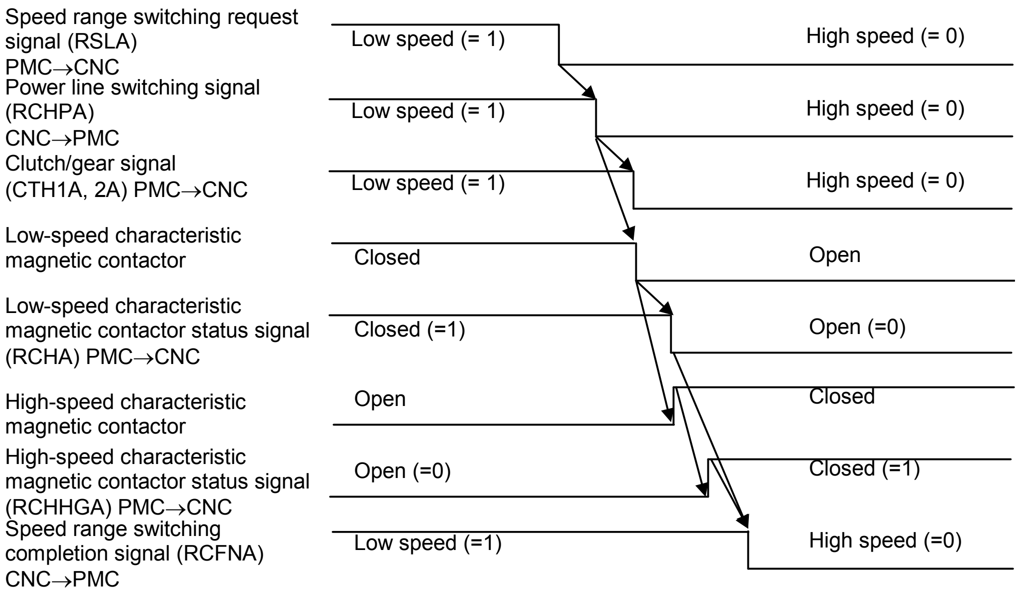
(3) Be careful when using the SDTA signal for speed range switching, because the signal may change because of speed fluctuations when the machine runs at or near the switching speed.

(4) The SDTA signal has hysteresis. The hysteresis width is initially set to 20 min^{-1}. The setting can be changed, using parameter No. 4160. See Subsection 5.1.7, “Details of Related Parameters”, for the setting.

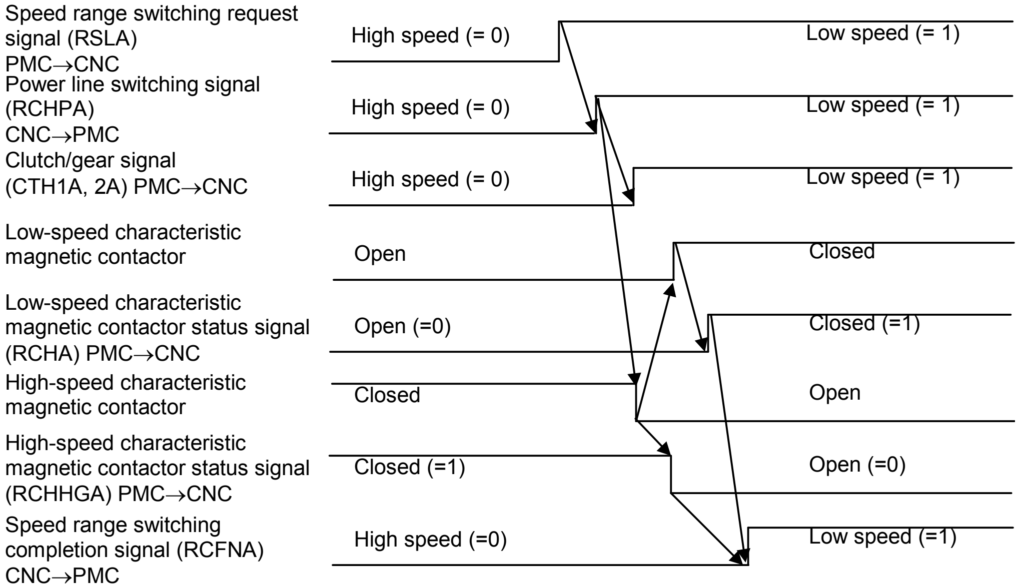
5.1.6 Sequence

(1)Performing speed range switching by checking the status of both contacts of the low-speed characteristic magnetic contactor status signal (RCHA) and high-speed characteristic magnetic contactor status signal (RCHHGA) (bit 3 of parameter No. 4014 = 1)

(a) Switching from low-speed characteristic to high-speed characteristic

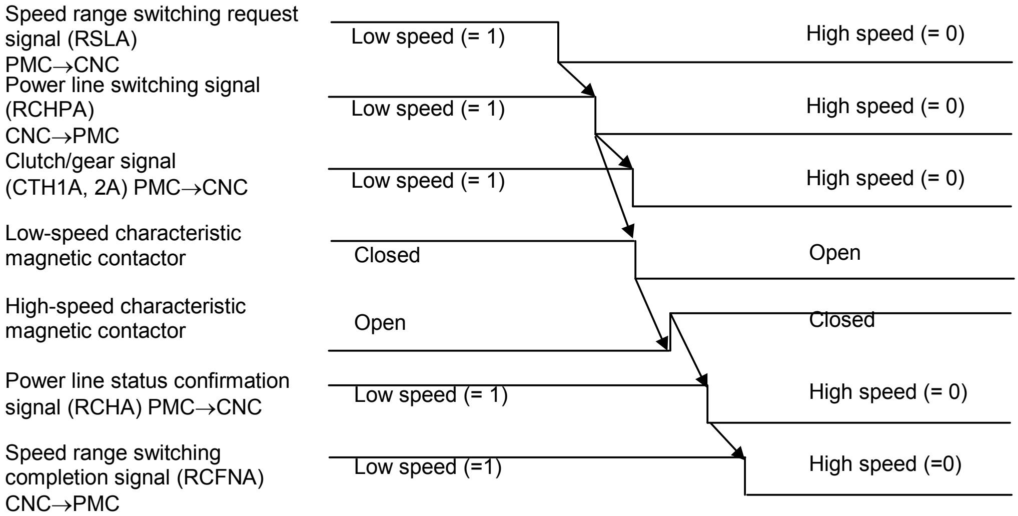


(b) Switching from high-speed characteristic to low-speed characteristic

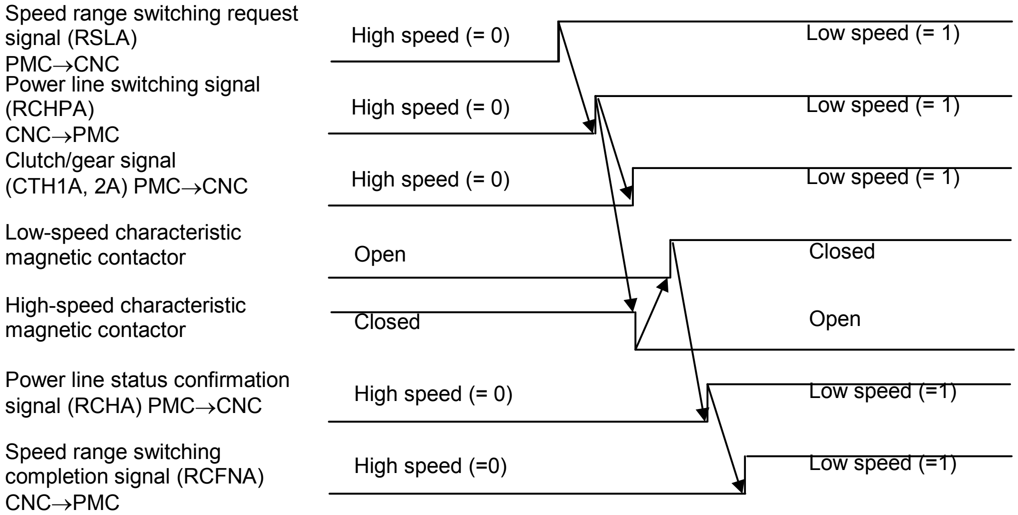


(2)Performing speed range switching by checking only the power line status confirmation signal (RCHA) (bit 3 of parameter No. 4014 = 0)

(a) Switching from low-speed characteristic to high-speed characteristic



(b) Switching from high-speed characteristic to low-speed characteristic



NOTE

1. A parameter can specify that switching from high-speed output characteristic to low-speed output characteristic be not performed at a speed higher than or equal to the switching speed (speed detection signal SDTA = 0) even if a switching request is issued.
2. Switch the clutch/gear signals (CTH1A and CTH2A) in such a way that the velocity loop gain can be specified for low- and high-speed characteristics separately.
3. Spindle alarm 15 is issued unless the magnetic contactor status signal is input within one second after the power line switching signal is output. So, input the magnetic contactor status signal within one second after the power line switching signal is output.
4. If you want to check the selection status of magnetic contactors MCC1 and MCC2 only with the auxiliary contact of magnetic contactor MCC1, allow a delay time of at least 50 ms between the instant when switching between MCC1 and MCC2 is performed with the power line switching signal (RCHPA) and the instant when the power line status confirmation signal (RCHA) changes, because a delay occurs in the operation of the magnetic contactors.

5.1.7 List of Related Parameters

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3015 #2	4015 #2	4015 #2	Whether the speed range switching control function is available (to be set to “1”) (The CNC software option is required.)
3014 #3	4014 #3	4014 #3	Function of checking the both magnetic contactor contacts for high-/low-speed characteristics in speed range switching
3019 #4	4019 #4	4019 #4	Function of checking the speed detection signal when switching is performed from high-speed characteristic to low-speed characteristic
3023	4023	4023	Speed detecting level
3160	4160	4160	Speed detection level hysteresis

5.1.8 Details of Related Parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3015	4015	4015						SPDSW		

SPDSW Presence of speed range switching function (To use this function, the CNC software option is required.)
0 : Without speed range switching function
1 : With speed range switching function (To be set to “1”)

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3014	4014	4014					CHGSLT			

CHGSLT Function of checking the both magnetic contactor contacts for high-/low-speed characteristics in speed range switching
0: A check is made, using the power line status confirmation signal (RCH).
1: The contacts of both high- and low-speed characteristic magnetic contactors are checked.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3019	4019	4019				SDTCHG				

SDTCHG Specifies whether to switch from high-speed range to low-speed range, upon the speed detection signal (SDT) being set to “1”, when speed range switching is used.
0 : Switches from the high-speed to low-speed range regardless of the speed detection signal (SDT).
1 : Switches from the high-speed to low-speed range after the SDT signal has changed to “1”.
If this data is “0”, switching from high-speed characteristic to low-speed characteristic occurs no matter what the status of the speed detection signal (SDT) is.
If this data is “1”, switching from high-speed characteristic to low-speed characteristic does not occur when the speed detected signal (SDT) is “0”. The switching occurs only after the SDT signal has changed to “1”.
To make switching to low-speed characteristic occur securely at or near the switching speed, set the speed detection level (parameter No. 4023) to a level slightly higher than the switching speed level.

15*i*	16*i*	30*i*	
3023	4023	4023	**Speed detecting level**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 0

This data is used to set the detecting level of speed detecting signal (SDT).
When the motor speed reaches (setting data/10) % or less of maximum speed, the speed arrival signal (SDT) is set to “1”.

15*i*	16*i*	30*i*	
3160	4160	4160	**Speed detection level hysteresis**

Unit of data : 1min^{-1} (When parameter No. 4006 #2 (SPDUNT)=1, 10 min^{-1})
Valid data range : 0 to 32767
Standard setting value : 0

Specify the hysteresis of the detection level of the speed detection signal (SDT).

The speed detection signal (SDT) changes from 1 to 0 with the set speed detection level + hysteresis motor speed, and changes from 0 to 1 with the set speed detection level motor speed. If this data is set to 20 $\min^{-1}$ or less, the hysteresis is automatically set to 20 $\min^{-1}$.
If the speed detection signal (SDT) is used in speed range switching control, increase the data setting in situations where the switching circuit is likely to cause chattering close to the motor speed for the speed detection level.
Set the hysteresis width to a speed change measured during switching with a margin (about twice the measured speed change).
A rough estimate of the hysteresis width can be obtained from the following expression (on the assumption that the motor load torque at switching is 20% of the maximum output torque):

$$\text{Hysteresis width}[\min^{-1}] = \frac{\text{Speed range switching time}}{\text{Acceleration time until the maximum rotation speed is reached}} \times \text{Maximum rotation speed} \times 0.2$$

5.1.9 Parameter-specified Switching between High- and Low-speed Characteristics

(1) Clutch/gear signals (CTH1A and CTH2A)
In speed range switching control, clutch/gear signals (CTH1A and CTH2A) are input to switch high- and low-speed velocity loop gain, position gain, and gear ratio data.
Usually, the clutch/gear signals are intended to select spindle parameters (velocity loop gain, position gain, and gear ratio) that correspond to the selected clutch/gears.
In speed range switching control, switching must be done in conjunction with winding selection.

CTH1A	CTH2A	Selection status of clutch/gears	Selection status of winding
0	0	HIGH GEAR (HIGH)	High-speed output characteristic winding
0	1	MEDIUM HIGH GEAR (HIGH)	-
1	0	MEDIUM LOW GEAR (LOW)	-
1	1	LOW GEAR (LOW)	Low-speed output characteristic winding

(2) Relationships between the clutch/gear signals and spindle parameters
(a) When the high-speed output characteristic winding is selected (CTH1A = 0 and CTH2A = 0)

15*i*	16*i*	30*i*	
3040	4040	4040	**Velocity loop proportional gain on the velocity control mode (HIGH)**
3042	4042	4042	**Velocity loop proportional gain on orientation (HIGH)**
3044	4044	4044	**Velocity loop proportional gain on servo mode (HIGH)**
3046	4046	4046	**Velocity loop proportional gain on Cs contouring control (HIGH)**
3048	4048	4048	**Velocity loop integral gain on the velocity control mode (HIGH)**
3050	4050	4050	**Velocity loop integral gain on orientation (HIGH)**
3052	4052	4052	**Velocity loop integral gain on servo mode (HIGH)**
3054	4054	4054	**Velocity loop integral gain on Cs contouring control (HIGH)**
3060	4060	4060	**Position gain on orientation (HIGH)**

3065	4065	4065	**Position gain on servo mode (HIGH)**
3069	4069	4069	**Position gain on Cs contouring control (HIGH)**

(b) When the low-speed output characteristic winding is selected (CTH1A = 1 and CTH2A = 1)

15*i*	16*i*	30*i*	
3041	4041	4041	**Velocity loop proportional gain on the velocity control mode (LOW)**
3043	4043	4043	**Velocity loop proportional gain on orientation (LOW)**
3045	4045	4045	**Velocity loop proportional gain on servo mode (LOW)**
304	4047	4047	**Velocity loop proportional gain on Cs contouring control (LOW)**
3049	4049	4049	**Velocity loop integral gain on the velocity control mode (LOW)**
3051	4051	4051	**Velocity loop integral gain on orientation (LOW)**
3053	4053	4053	**Velocity loop integral gain on servo mode (LOW)**
3055	4055	4055	**Velocity loop integral gain on Cs contouring control (LOW)**
3063	4063	4063	**Position gain on spindle orientation (LOW)**
3068	4068	4068	**Position gain on servo mode (LOW)**
3072	4072	4072	**Position gain on Cs contouring control (LOW)**

(3) Cautions
Keep in mind that the clutch/gear signals (CTH1A and CTH2A) are used to select also parameters for rigid tapping, feed axis position gain under Cs contouring control, the number of teeth of arbitrary gears, time constants, and backlash in the Series 15*i*.

5.2 SPINDLE SWITCHING CONTROL

5.2.1 Overview

Spindle switching control is a function that drives two spindle motors with a single spindle amplifier, one at a time by switching them. The function is suitable for a machine in which two spindle motors are not driven simultaneously.

5.2.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D50	E (05)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*

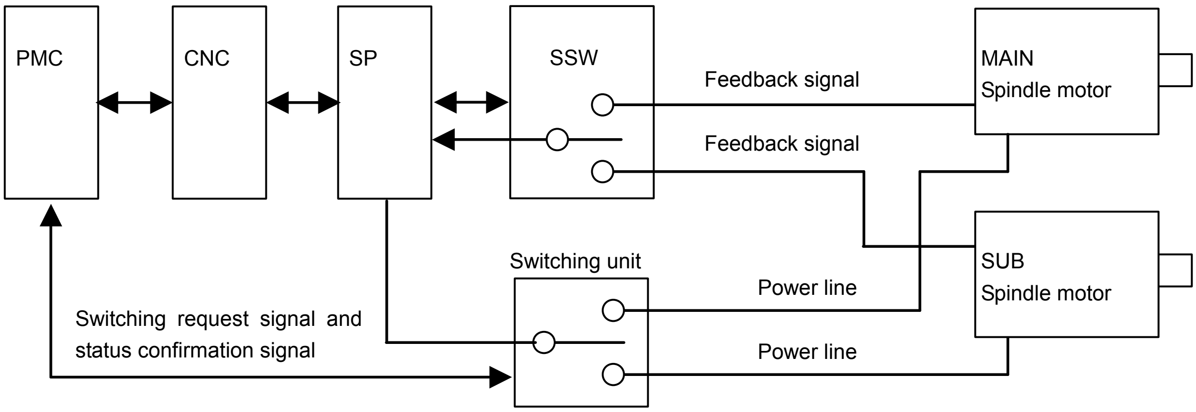
NOTE
When the α*i*CZ sensor (serial) is used, this function cannot be used.

5.2.3 Configuration

Shown below is a machine configuration for using spindle switching control.
The following items are required for spindle switching control in addition to a spindle amplifier (SP) and two spindle motors:

- Sub module SW (SSW)
- Switching unit (a magnetic contactor and a relay for driving it are included)
- Signals between the PMC and switching unit

Refer to "FANUC SERVO AMPLIFIER α*i* series Descriptions" (B-65282EN) for the specification of the submodule SW (hereafter SSW), switching unit, and detailed descriptions about their connection.



5.2.4 Details of Specifications

(1) The spindle amplifier and SSW are used to select one of two spindle motors and drive the selected spindle motor. They cannot be used to drive two spindle motors simultaneously or switch between a motor with a 200 V input and a motor with a 400 V input (HV). Nor can they be used to drive the spindle motor (speed sensor-less motor) of the β*i*Ic or αC*i* series.

(2) Any spindle motors that can be driven with the spindle amplifier can be combined as a main spindle or sub-spindle.
The capacity of the spindle amplifier used for two spindle motors must be large enough for the larger of the two. The required parameters may have to be re-set depending on the combination of the motors and amplifier.

(3) The SSW switches the feedback signal according to the switching command from the spindle amplifier. The detectors that can be used are as follows:
Detectors incorporated in the motor (speed detectors): α*i*M sensor, α*i*MZ sensor, α*i*BZ sensor (for built-in motors), and α*i*CZ sensor (analog) (for built-in motors)
Detectors mounted on the spindle (position detectors): Position coder, α*i*BZ sensor (when SP TYPE B is used), α*i*CZ sensor (analog) (when SP TYPE B is used), and proximity switch

(4) Speed range switch control can be used for both the main spindle and sub-spindle.

(5) Rigid tapping can be used for both the main spindle and sub-spindle.

(6) Position coder-based spindle orientation can be used for both the main spindle and sub-spindle as long as it uses a method of specifying a stop position with a parameter.

(7) The status information about the magnetic contactors of both the main spindle and sub-spindle can be input so that the status of the power line can be checked securely. This function is enabled by setting the following parameters.
FS16*i*: Bit 2 of parameter No. 4014 = 1

FS30*i*: Bit 2 of parameter No. 4014 = 1
FS15*i*: Bit 2 of parameter No. 3014 = 1

(8) A switching error is detected and spindle alarm 15 is issued unless the magnetic contactor status signal (MCFNA or MFNHGA) is not input within one second after the power line switching signal (CHPA) is output.

5.2.5 Restrictions

(1) Stop position external setting type orientation can be used only for the main spindle.
(2) Spindle synchronous control can be used only for the main spindle.
(3) Spindle positioning can be used only for the main spindle.
(4) Cs contouring control can be used only for the main spindle.
(5) For the sub-spindle motor, up to two gear switching stages can be specified using a parameter.
(6) The dual position feedback function can be used on the main side only.

5.2.6 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G226	G071	G071					MCFNA	SPSLA		
2nd-	G234	G075	G075					MCFNB	SPSLB		
1st-	G229	G072	G072		MFNHGA						
2nd-	G237	G076	G076		MFNHGB						

(2) Details of input signals (PMC→CNC)

(a) Spindle switching request signal (SPSLA)

(1) The SPSLA signal is used as a command signal to select a spindle motor.
0: The main spindle motor is selected.
1: The sub-spindle motor is selected.

(2) After stopping the spindle motors, change the SPSLA signal.
The zero-speed signal (SSTA) can be used as an output signal to check that the spindle motors are at a halt.

(3) Reset the rotation commands (SFRA and SRVA) and spindle orientation command (ORCMA) to 0, because switching requires that the motor power be off.

(b) Sub-spindle motor magnetic contactor status signal (MCFNA)

(1) Input the open/closed status of the sub-spindle motor magnetic contactor (MCC).
0: The sub-spindle motor magnetic contactor is open (off).
1: The sub-spindle motor magnetic contactor is closed (on).

(2) Usually, specify the status of the auxiliary contact (contact A) of the sub-spindle motor magnetic contactor without modifying it.

(3) If bit 2 of parameter No. 4014 = 0, the MCFNA signal is used as a confirmation signal for the status of the power line. So, specify the selection status of the magnetic contactor for switching the power line of the spindle motor.
0: The main spindle motor is selected.
1: The sub-spindle motor is selected.
To switch from the sub-motor to the main motor, after making sure that the sub-motor magnetic contactor is switched off and the main motor magnetic contactor is switched on, change this signal from 1 to 0. Similarly, to switch from the main motor to the sub-motor, after making sure that the main motor magnetic contactor is switched off and the sub-motor magnetic contactor is switched on, change this signal from 0 to 1.

(c) Main spindle motor magnetic contactor status signal (MFNHGA)

(1) Input the open/closed status of the main spindle motor magnetic contactor (MCC).
 0: The main spindle motor magnetic contactor is open (off).
 1: The main spindle motor magnetic contactor is closed (on).
(2) Usually, specify the status of the auxiliary contact (contact A) of the main spindle motor magnetic contactor without modifying it.
(3) The MFNHGA signal is valid if bit 2 of parameter No. 4014 = 1.

(3) Address list of output signals (CNC→PMC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045							SSTA	
2nd-	F245	F049	F049							SSTB	
1st-	F228	F046	F046							CFINA	CHPA
2nd-	F244	F050	F050							CFINB	CHPB

(4) Details of output signals (CNC→PMC)

(a) Power line switching signal (CHPA)

(1) The CHPA signal is a command signal for selecting a magnetic contactor used to switch the power line of the spindle motor.
 0: The main spindle motor magnetic contactor is selected.
 1: The sub-spindle motor magnetic contactor is selected.
(2) When the spindle switching request signal (SPSLA) is input, a check is made to see if the motors are at a stop and their power is off. Once it has been confirmed that the motors are at a stop and their power is off, the CHPA signal is output. Switch the magnetic contactor according to the CHPA signal.
(3) When switching from the sub-motor to the main motor occurs, the CHPA signal changes from 1 to 0 in response to an incoming spindle switching request signal (SPSLA) provided that the sub-motor is at a stop and its power is off. After this signal change has occurred, first switch off the sub-motor magnetic contactor. After making sure that the sub-motor magnetic contactor has been switched off, switch on the main motor magnetic contactor.
(4) When switching from the main motor to the sub-motor occurs, the CHPA signal changes from 0 to 1 in response to an incoming spindle switching request signal (SPSLA) provided that the main motor is at a stop and its power is off. After this signal change has occurred, first switch off the main motor magnetic contactor. After making sure that the main motor magnetic contactor has been switched off, switch on the sub-motor magnetic contactor.

(b) Spindle switching completion signal (CFINA)

(1) After spindle switching is completed, it is indicated which spindle motor is currently under control.
 0: The main spindle motor is currently under control.
 1: The sub-spindle motor is currently under control.
(2) After making sure that the spindle switching request signal (SPSLA) has changed and the CFINA signal matches the SPSLA, go to the next operation.
(3) Keep the rotation commands (SFRA and SRVA) and spindle orientation command (ORCMA) turned off during switching, because switching requires that the motor power be off.

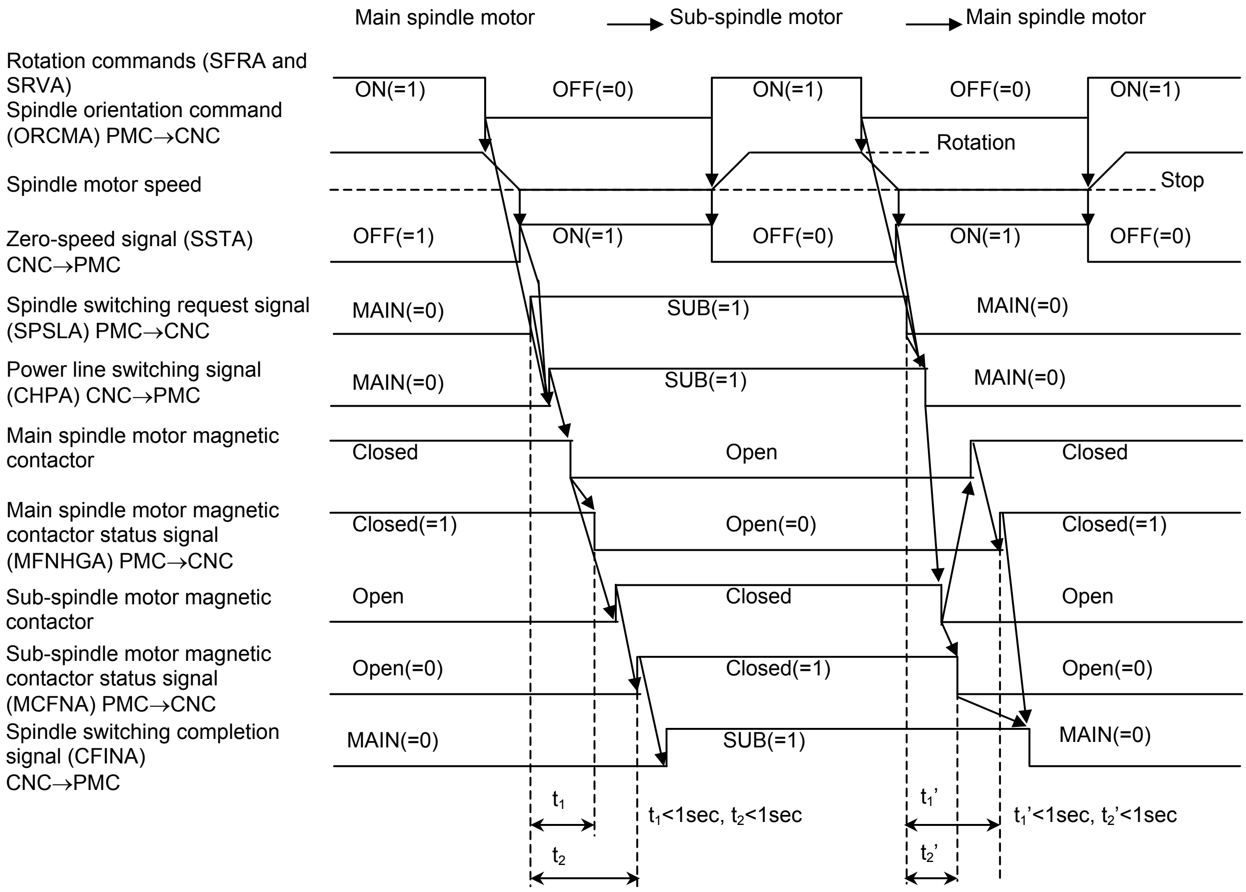
(c) Zero-speed signal (SSTA)

(1) It is indicated whether the spindle motor speed is not lower or not higher than the zero-speed detection level (parameter-specified speed level).
 0: The motor is rotating at or faster than the speed detection level.
 1: The motor is rotating at or slower than the speed detection level.

(2) The motor must be at a halt during spindle switching. Use the SSTA signal to check that that the motor is at a halt.

5.2.7 Sequence

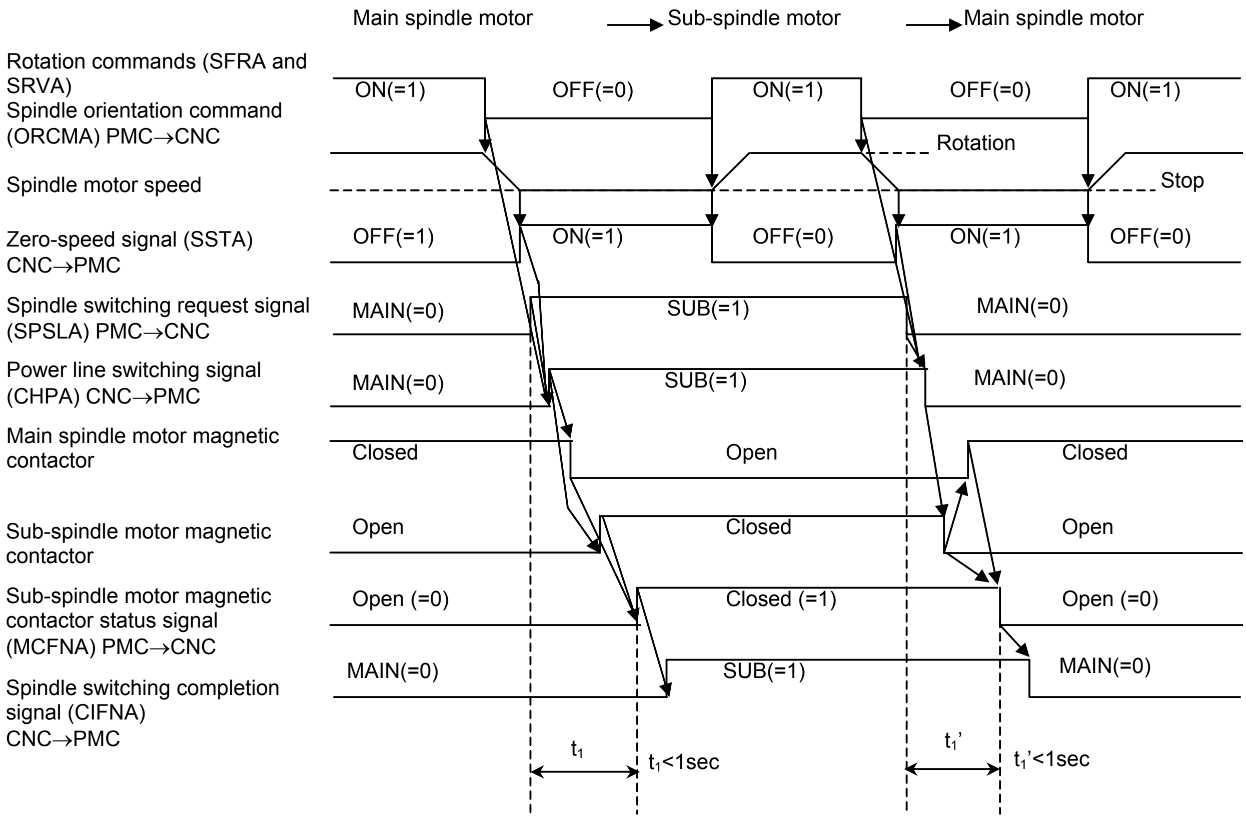
(1)Performing spindle switching by checking the status of both contacts of the sub-spindle motor magnetic contactor status signal (MCFNA) and main spindle motor magnetic contactor status signal (MFNHGA) (bit 2 of parameter No. 4014 = 1)



NOTE

Spindle alarm 15 is issued unless the main spindle motor status signal (MFNHGA) and sub-spindle motor status signal (MCFNA) change within one second after the switching request signal (SPSLA) signal has changed.

(2)Performing spindle switching by checking only with the power line status signal (MCFNA) (bit 2 of parameter No. 4014 = 0)



> **NOTE**
> 1 When checking the selection status of magnetic contactors MCC1 and MCC2 only with the auxiliary contact of magnetic contactor MCC1, allow a delay time of at least 50 ms between the instant when switching between MCC1 and MCC2 is performed with the power line switching signal (CHPA) and the instant when the power line status confirmation signal (MCFN) changes, because a delay occurs in the operation of the magnetic contactors.
> 2 Spindle alarm 15 is issued unless the power line magnetic contactor status signal (MCFNA) changes within one second after the switching request signal (SPSLA) has changed.

5.2.8 List of Related Parameters

Parameter No.			Description
15*i*	**16*i***	**30*i***	
5607#0	4019#7	4019#7	Parameter automatic setting function (MAIN)
3133	4133	4133	Motor model code (MAIN)
5607#0	4195#7	4195#7	Parameter automatic setting function (SUB)
3309	4309	4309	Motor model code (SUB)
3014#0	4014#0	4014#0	Whether the spindle switching function is available (to be set to “1”)
3014#2	4014#2	4014#2	Function of checking the both magnetic contactor contacts for main spindle and sub-spindle motors in spindle switching
3013 #6 to #2	4013 #6 to #2	4013 #6 to #2	Current dead-band data (MAIN)

Parameter No.			Description
15*i*	16*i*	30*i*	
3024	4024	4024	Speed zero detecting level (MAIN)
3110	4110	4110	Current conversion constant (MAIN/high-speed characteristic)
3146	4146	4146	Current conversion constant (MAIN/low-speed characteristic)
3189 #6 to #2	4189 #6 to #2	4189 #6 to #2	Current dead-band data (SUB)
3199	4199	4199	Zero-speed detection level (SUB)
3264	4264	4264	Current conversion constant (SUB/high-speed characteristic)
3294	4294	4294	Current conversion constant (SUB/low-speed characteristic)

NOTE
In the FS15*i*, the parameter automatic setting function is common to the main and sub-spindle motors.

5.2.9 Details of Related Parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3014	4014	4014						AXSLCT		AXISSL

AXISSL Whether the spindle switching control function is available
0: No spindle switching function is available.
1: The spindle switching function is available (to be set to “1”).

AXSLCT Function of checking the contents of both the main spindle and sub-spindle motor magnetic contactor contacts in spindle switching
0: The check is based on the power line status signal (MCFN)
1: The check is made on the contacts (MCFN and MFNHG) of both the main and sub-spindle motor magnetic contactors.

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
MAIN:	3013	4013	4013		DS5	DS4	DS3	DS2	DS1		
SUB:	3189	4189	4189		DS5	DS4	DS3	DS2	DS1		

DS5 to DS1 Current dead-band data
This parameter is determined according to the spindle amplifier model to be used.
In spindle switching control, the amplifier model to be used may differ from the amplifier that supports the motor. In this case, change the parameter setting according to the amplifier to be used, while referencing the following table.

■α*i*SP(A06B-6111(6112,6121,6122)-Hxxx#H550(H553,H570))

Amplifier model		Parameter setting				
200V-input	400V-input	DS5	DS4	DS3	DS2	DS1
α*i*SP2.2 to 15	α*i*SP5.5HV to 15HV	0	0	0	1	1
α*i*SP22 to 37	α*i*SP30HV to 45HV	1	0	1	0	0
α*i*SP45 to 55	α*i*SP75HV to 100HV	0	0	1	1	0

■α*i*SP(A06B-6141(6142,6151,6152)-Hxxx#H580, A06B-6144(6154)-Hxxx#H590)

Amplifier model		Parameter setting				
200V-input	400V-input	DS5	DS4	DS3	DS2	DS1
α*i*SP2.2～55	α*i*SP5.5HV～100HV	0	0	0	1	1

> **NOTE**
> Be careful when no correct data is specified, because it is likely that switching elements in the power circuit may break down.

15*i*	16*i*	30*i*	
3024	4024	4024	**Speed zero detecting level (MAIN side)**
3199	4199	4199	**Speed zero detecting level (SUB side)**

Unit of data : 0.01%
Valid data range : 0 to 10000
Standard setting value : 75

This data is used to set the detecting level of speed zero detection signal (SSTA).
When the motor speed reaches (setting data/100)% or less of maximum speed, the speed zero detection signal (SSTA) is set to “1”.

15*i*	16*i*	30*i*	
3110	4110	4110	**Current conversion constant (MAIN side, high-speed characteristic)**
3146	4146	4146	**Current conversion constant (MAIN side, low-speed characteristic)**
3264	4264	4264	**Current conversion constant (SUB side, high-speed characteristic)**
3294	4294	4294	**Current conversion constant (SUB side, low-speed characteristic)**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : This parameter is intended to specify a current detection weight that varies depending on the motor model to be used.

If a motor and a spindle amplifier are in a combination that is not originally intended, it is necessary to change the setting according to the spindle amplifier to be used. Use the following conversion formula to determine a value to be specified in the parameter.

$$ICONV2 = ICONV1 \times \frac{G1}{G2}$$

ICONV1 : Current conversion constant before change
ICONV2 : Current conversion constant after change
G1 : Current detection gain for the spindle amplifier initially intended for the motor
G2 : Current detection gain for the spindle amplifier to be used in spindle switching

The current detection gains (G1 and G2) vary from one amplifier model to another. The following table lists the current detection gains that correspond to each amplifier model.

Amplifier model		**Current detection gain (G1,G2)**
200V-input	**400V-input**	
αiSP2.2, 5.5	αiSP5.5HV, 11HV	60
αiSP11	αiSP15HV	30
αiSP15	αiSP30HV	20
αiSP22	αiSP45HV	15
αiSP26	-	10
αiSP30, 37	αiSP75HV	7.5
αiSP45	αiSP100HV	6.67
αiSP55	-	4.29

NOTE
If no correct data is specified, the motor fails to deliver the rated power, and it is likely that switching elements in the power circuit may break down.

5.2.10 Parameter Setting Procedure

(1) Motor-specific parameter setting
<1> Motor model code setting
Specify the model code of a motor to be subjected to automatic setting. If the motor has no model code, specify "300" (for a motor with no speed range switching function) or "400" (for a motor with a speed range switching function).

CNC	Parameter No.		Setting value
	MAIN side	SUB side	
15*i*	No.3133	No.3309	Model code
16*i*	No.4133	No.4309	
30*i*	No.4133	No.4309	

<2> Parameter automatic setting
After the following parameters are specified, switch the CNC power off and on again. The spindle parameter specified with a model code is automatically set up. Once automatic setting is completed, the following parameters are re-set to their previous values.

CNC	Parameter No.		Setting value
	MAIN side	SUB side	
15*i*	No.5607#0		0
16*i*	No.4019#7	No.4195#7	1
30*i*	No.4019#7	No.4195#7	1

NOTE
In the FS15*i*, a parameter for the parameter automatic setting function is common to the main and sub-spindle motors. Keep in mind that parameter automatic setting occurs for the main and sub-spindle motors simultaneously.

<3> Motor-specific parameter setting (for motors with no model code)
If the motor has no model code, once automatic setting is completed, specify motor-specific parameters by entering values manually according to the parameter tables for individual motor models.

NOTE
Set the parameters for the sub-spindle according to the list of the motor-specific parameter numbers in Subsection 5.2.11, "Supplementary Descriptions about Parameters," in Part I.

(2) Parameter re-setting for spindle switching
If the motor and spindle amplifier are not in a standard combination, change the current dead-band data and current conversion constant as described in the previous item.

(3) Parameter setting related to detectors
Specify parameters related to detectors according to the system configuration of the spindle.
See Section 1.3 for explanations about how to specify parameters related to detectors.

5.2.11 Supplementary Descriptions about Parameters

(1) The spindle amplifier drives the motor using the relevant parameters according to the selected spindle (main spindle or sub-spindle for spindle switching).

For the parameter numbers for the main spindle and sub-spindle, see Appendix B, "LIST OF SPINDLE PARAMETER NUMBERS."

(2) The following table lists the motor-specific parameter numbers for the main spindle and those for the sub-spindle.
Set a motor-specific parameter for the sub-spindle according to the table below.

Parameter No.						Description
15*i*		16*i*		30*i*		
MAIN	SUB	MAIN	SUB	MAIN	SUB	
3007	3183	4007	4183	4007	4183	Bit type parameter
3008	3184	4008	4184	4008	4184	Bit type parameter
3009	3185	4009	4185	4009	4185	Bit type parameter
3010	3186	4010	4186	4010	4186	Bit type parameter
3011	3187	4011	4187	4011	4187	Bit type parameter
3012	3188	4012	4188	4012	4188	Bit type parameter
3013	3189	4013	4189	4013	4189	Bit type parameter
3019	3195	4019	4195	4019	4195	Bit type parameter
3020	3196	4020	4196	4020	4196	Maximum motor speed
3023	3198	4023	4198	4023	4198	Speed detection level
3039	3254	4039	4254	4039	4254	Slip compensation gain [for high-speed characteristics of speed range switching]
3080	3231	4080	4231	4080	4231	Regenerative power limit for high-speed zone/regenerative power limit [for high-speed characteristics of speed range switching]
3083	3236	4083	4236	4083	4236	Motor voltage on velocity control mode [for high-speed characteristics of speed range switching]
3093	3279	4093	4279	4093	4279	Value displayed on load meter at maximum output [for low-speed characteristics of speed range switching]
3100	3256	4100	4256	4100	4256	Base speed of motor output specifications [for high-speed characteristics of speed range switching]
3101	3257	4101	4257	4101	4257	Output limit for motor output specifications [for high-speed characteristics of speed range switching]
3102	3258	4102	4258	4102	4258	Excitation voltage saturation speed at no-load [for high-speed characteristics of speed range switching]
3103	3259	4103	4259	4103	4259	Base speed limit ratio [for high-speed characteristics of speed range switching]
3104	3260	4104	4260	4104	4260	Current loop proportional gain [for high-speed characteristics of speed range switching]
3106	3261	4106	4261	4106	4261	Current loop integral gain [for high-speed characteristics of speed range switching]
3108	3262	4108	4262	4108	4262	Velocity at which the current loop integral gain is zero [for high-speed characteristics of speed range switching]
3109	3263	4109	4263	4109	4263	Filter time constant for processing saturation related to the voltage command [for high-speed characteristics of speed range switching]
3110	3264	4110	4264	4110	4264	Current conversion constant [for high-speed characteristics of speed range switching]
3111	3265	4111	4265	4111	4265	Secondary current coefficient [for high-speed characteristics of speed range switching]
3112	3266	4112	4266	4112	4266	Criterion level for saturation related to the voltage command/PWM command clamp value [for high-speed characteristics of speed range switching]
3113	3267	4113	4267	4113	4267	Slip constant [for high-speed characteristics of speed range switching]
3114	3268	4114	4268	4114	4268	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration [for high-speed characteristics of speed range switching]
3115	3269	4115	4269	4115	4269	PWM command clamp value at deceleration [for high-speed characteristics of speed range switching]

Parameter No.						Description
15*i*		16*i*		30*i*		
MAIN	SUB	MAIN	SUB	MAIN	SUB	
3116	3270	4116	4270	4116	4270	Motor leakage constant [for high-speed characteristics of speed range switching]
3117	3271	4117	4271	4117	4271	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient [for high-speed characteristics of speed range switching]
3118	3272	4118	4272	4118	4272	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient [for high-speed characteristics of speed range switching]
3119	3280	4119	4280	4119	4280	Deceleration-time excitation current change time constant/excitation current change time constant [for high-speed characteristics of speed range switching]
3127	3274	4127	4274	4127	4274	Value displayed on load meter at maximum output [for high-speed characteristics of speed range switching]
3128	3275	4128	4275	4128	4275	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient [for high-speed characteristics of speed range switching]
3129	3276	4129	4276	4129	4276	Secondary current coefficient for rigid tapping [for high-speed characteristics of speed range switching]
3130	3277	4130	4277	4130	4277	Current loop proportional gain speed coefficient/current phase delay compensation coefficient [for high-speed characteristics of speed range switching]
3134	3310	4134	4310	4134	4310	Motor overheat detect level
3136	3284	4136	4284	4136	4284	Motor voltage on velocity control mode [for low-speed characteristics of speed range switching]
3138	3286	4138	4286	4138	4286	Base speed of motor output specifications [for low-speed characteristics of speed range switching]
3139	3287	4139	4287	4139	4287	Output limit for motor output specifications [for low-speed characteristics of speed range switching]
3140	3288	4140	4288	4140	4288	Excitation voltage saturation speed at no-load [for low-speed characteristics of speed range switching]
3141	3289	4141	4289	4141	4289	Base speed limit ratio [for low-speed characteristics of speed range switching]
3142	3290	4142	4290	4142	4290	Current loop proportional gain [for low-speed characteristics of speed range switching]
3143	3291	4143	4291	4143	4291	Current loop integral gain [for low-speed characteristics of speed range switching]
3144	3292	4144	4292	4144	4292	Velocity at which the current loop integral gain is zero [for low-speed characteristics of speed range switching]
3145	3293	4145	4293	4145	4293	Filter time constant for processing saturation related to the voltage command [for low-speed characteristics of speed range switching]
3146	3294	4146	4294	4146	4294	Current conversion constant [for low-speed characteristics of speed range switching]
3147	3295	4147	4295	4147	4295	Secondary current coefficient [for low-speed characteristics of speed range switching]
3148	3296	4148	4296	4148	4296	Criterion level for saturation related to the voltage command/PWM command clamp value [for low-speed characteristics of speed range switching]
3149	3297	4149	4297	4149	4297	Slip constant [for low-speed characteristics of speed range switching]
3150	3298	4150	4298	4150	4298	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration [for low-speed characteristics of speed range switching]
3151	3299	4151	4299	4151	4299	PWM command clamp value at deceleration [for low-speed characteristics of speed range switching]

Parameter No.						Description
15*i*		16*i*		30*i*		
MAIN	SUB	MAIN	SUB	MAIN	SUB	
3152	3300	4152	4300	4152	4300	Motor leakage constant [for low-speed characteristics of speed range switching]
3153	3301	4153	4301	4153	4301	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient [for low-speed characteristics of speed range switching]
3154	3302	4154	4302	4154	4302	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient [for low-speed characteristics of speed range switching]
3156	3255	4156	4255	4156	4255	Slip compensation gain [for low-speed characteristics of speed range switching]
3158	3304	4158	4304	4158	4304	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient [for low-speed characteristics of speed range switching]
3159	3305	4159	4305	4159	4305	Secondary current coefficient for rigid tapping [for low-speed characteristics of speed range switching]
3161	3306	4161	4306	4161	4306	Current loop proportional gain speed coefficient/current phase delay compensation coefficient [for low-speed characteristics of speed range switching]
3165	3308	4165	4308	4165	4308	Deceleration-time excitation current change time constant/excitation current change time constant [for low-speed characteristics of speed range switching]
3166	3307	4166	4307	4166	4307	Regenerative power limit for high-speed zone/regenerative power limit [for low-speed characteristics of speed range switching]
3169	3349	4169	4349	4169	4349	Temperature monitoring time constant

(3) The following parameters are common to the main and sub-spindle motors. They cannot be specified separately for these motors.

Parameter No.			Description
15*i*	16*i*	30*i*	
3027	4027	4027	Load detecting level 2
3030	4030	4030	Soft start/stop setting time
3087	4087	4087	Overspeed level
3088	4088	4088	Velocity error excess detecting level on motor shaft lock condition
3089	4089	4089	Velocity error excess detecting level on motor rotation
3090	4090	4090	Overload detecting level
3095	4095	4095	Adjustment of speedometer output voltage
3096	4096	4096	The adjustment of load meter output voltage
3098	4098	4098	Maximum speed of position feedback signal detection
3099	4099	4099	Delay time for motor excitation
3123	4123	4123	Setting the overload detection time
3260	4260	4260	Speed detection level hysteresis
3341	4341	4341	Unexpected disturbance torque detection level
3344	4344	4344	Advanced feed-forward coefficient
3346	4346	4346	Incomplete integration coefficient

(4) For the sub-spindle motor, up to two gear switching stages can be specified. The input signal CTH1A is used to select one of the gear stages. (For the main spindle motor, up to four gear switching stages can be specified, using CTH1A and CTH2A.)

Parameter No.			Description	CTH1A
15*i*	16*i*	30*i*		
3216	4216	4216	Gear ratio(SUB side/HIGH)	0
3217	4217	4217	Gear ratio(SUB side /LOW)	1

Parameter No.			Description	CTH1A
15*i*	16*i*	30*i*		
3218	4218	4218	Position gain on orientation(SUB side/HIGH)	0
3219	4219	4219	Position gain on orientation(SUB side/LOW)	1
3221	4221	4221	Position gain on servo mode(SUB side/HIGH)	0
3222	4222	4222	Position gain on servo mode(SUB side/LOW)	1

(5) For the sub-spindle motor, only one velocity integral gain stage can be specified. The CTH1A signal cannot be used for switching.

Parameter No.			Description
15*i*	16*i*	30*i*	
3212	4212	4212	Velocity loop integral gain on the velocity control mode (SUB side)
3213	4213	4213	Velocity loop integral gain on orientation (SUB side)
3214	4214	4214	Velocity loop integral gain on servo mode (SUB side)

5.3 INCRMENTAL COMMAND TYPE SPINDLE ORIENTATION (SPINDLE ROTATION SPEED CONTROL) (OPTIONAL FUNCTION)

5.3.1 Overview

Incremental command type spindle orientation is a function that expands the spindle orientation in which a stop position is specified externally using a position coder.
This function is intended to move the spindle from the position where it was when a spindle orientation command was input to a position specified incrementally. It positions the spindle as follows:
The spindle rotates from the position where it was when a spindle orientation command was input through an incremental angle specified from the PMC via the CNC. When the spindle orientation is completed, a completion signal is sent to the PMC via the CNC.
Using the function enables:

(i) Spindle motor-based turret indexing

(ii) Spindle rotation speed control if a command multiplier value (parameter-specified value) is set to “4096”

NOTE

1 Using this function requires the spindle orientation CNC software option.

2 The maximum spindle speed that can be specified is shown below:
9D50 series N edition or earlier, 9D70 series E edition or earlier: 120 rotations
9D50 series O edition or later, 9D70 series F edition or later, 9D80 series A edition or later: 30000 rotations

5.3.2 Series and Editions of Applicable Spindle Software

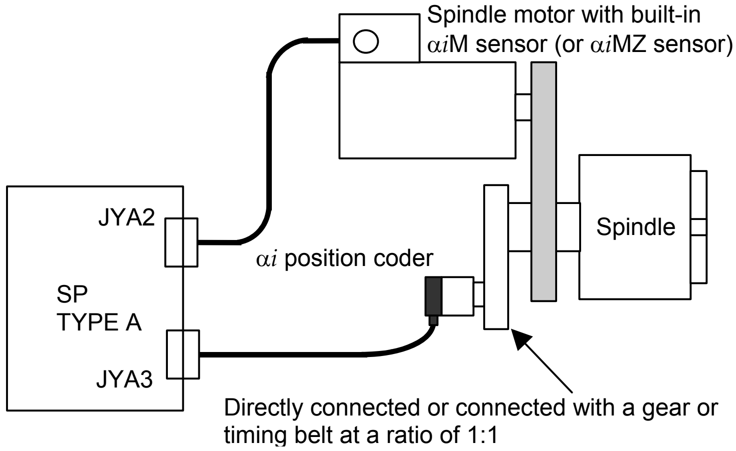
Spindle software

Series	Edition	Usable CNC
9D50	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

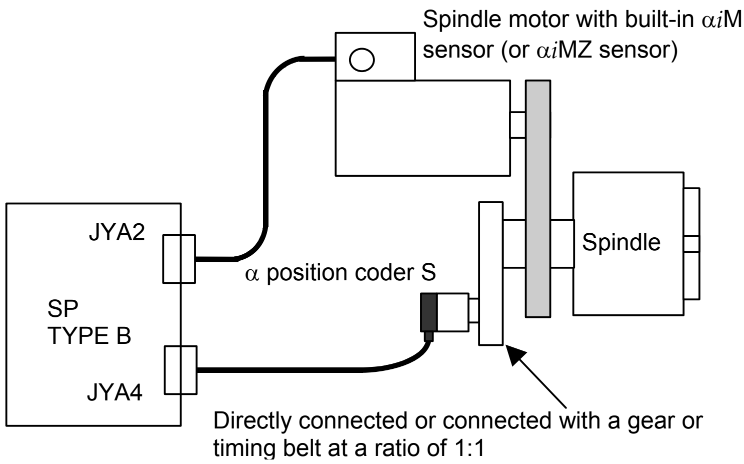
5.3.3 System Configuration

The incremental command type spindle orientation function can be used in the following system configuration.

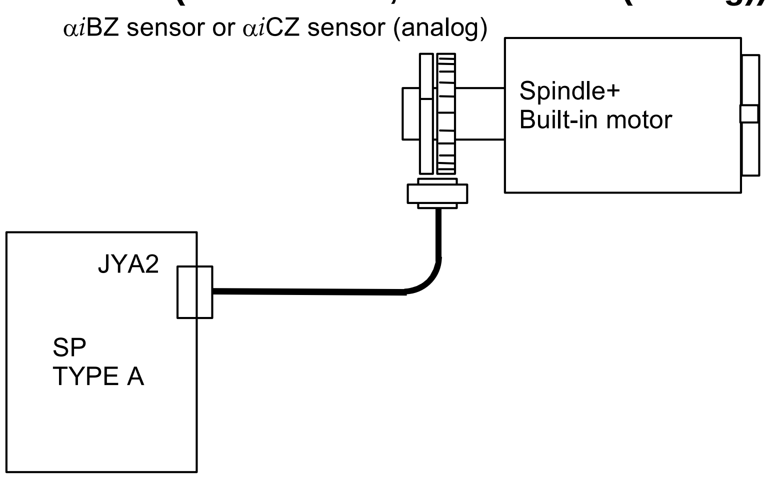
(1) When the α*i* position coder is used



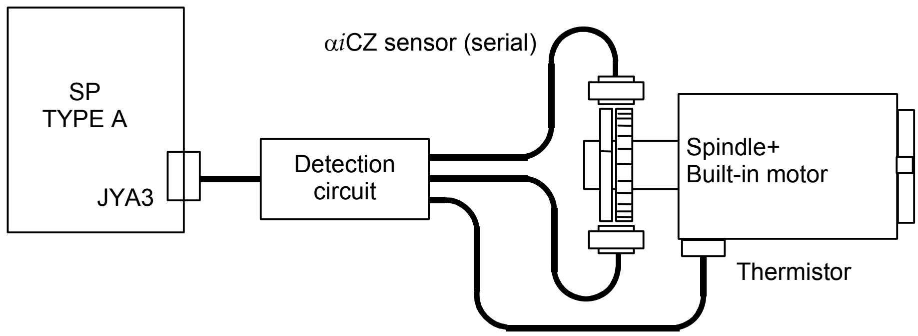
(2) When the α position coder S is used



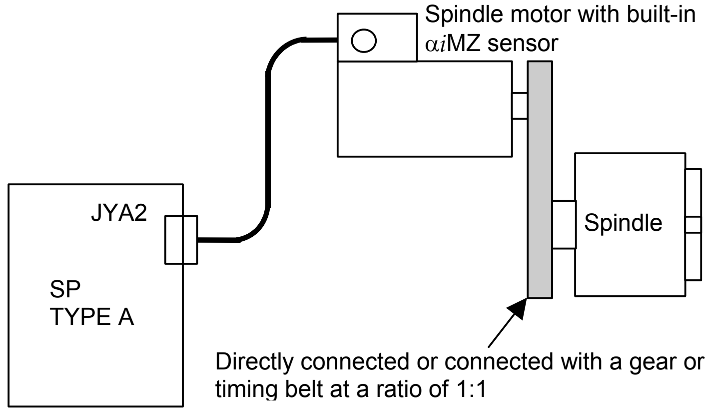
(3) When the built-in motor (α*i*BZ sensor, α*i*CZ sensor (analog)) is used



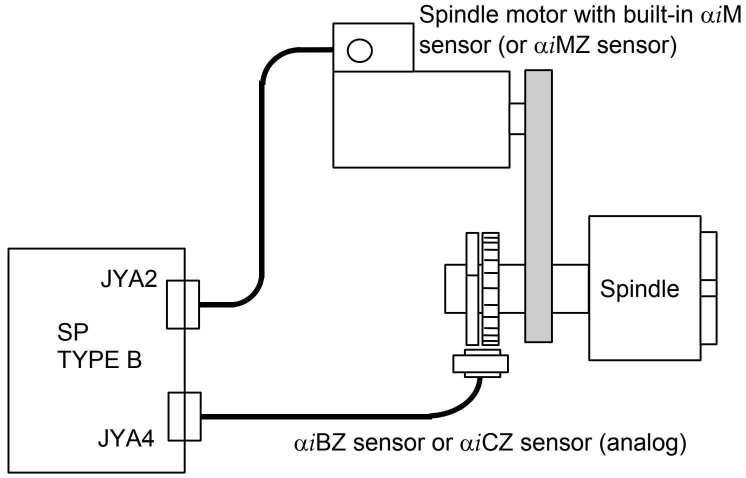
(4) When the built-in motor (αiCZ sensor (serial)) is used



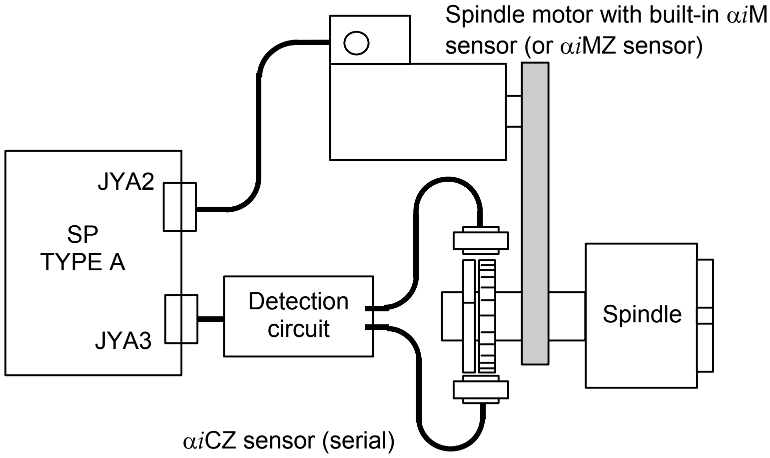
(5) When the spindle motor with built-in αiMZ sensor is used



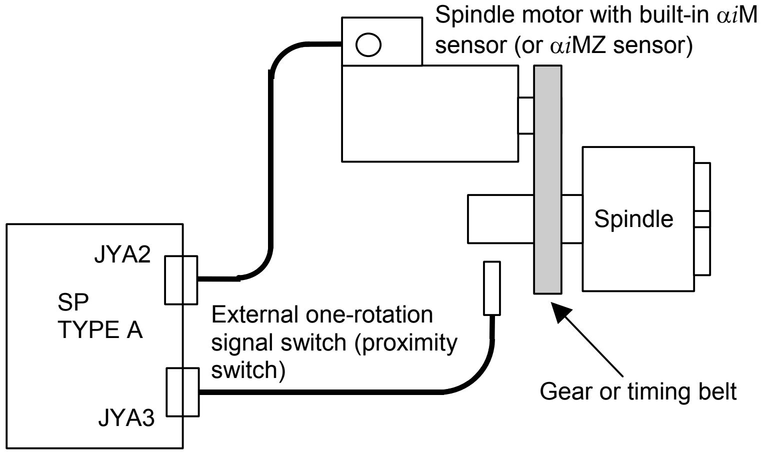
(6) When the separate type αiBZ sensor or the separate type αiCZ sensor (analog) is used



(7) When the separate type αiCZ sensor (serial) is used



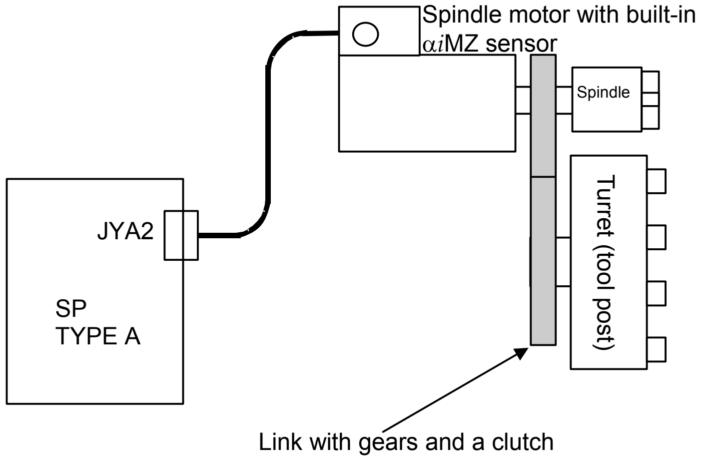
(8) When the external one-rotation signal (proximity switch) is used



NOTE

1. To detect the one-rotation signal securely, fix the direction (bits 3 and 2 of parameter No. 4003) in which the spindle rotates during spindle orientation to one direction.
2. Specify the type (bits 3 and 2 of parameter No. 4004) of an external one-rotation signal (proximity switch).
3. To detect the one-rotation signal securely, set the spindle orientation speed (parameter No. 4038) to a value between 50 and 100 min^{-1} according to the specification of the external one-rotation signal (proximity switch).
4. A sequence for detecting the one-rotation signal is started after the orientation speed has been reached.
5. Specify the denominator/numerator parameters (Nos. 4171 to 4174) of an arbitrary gear ratio between the motor sensor and spindle.

(9) System in which the turret and the motor with a built-in αiMZ sensor are linked with gears and a clutch (for turret indexing)



5.3.4 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

	15i	16i	30i	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070		ORCMA			CTH1A	CTH2A		
2nd-	G235	G074	G074		ORCMB			CTH1B	CTH2B		
1st-	G229	G072	G072			INCMDA			NRROA	ROTAA	INDXA
2nd-	G237	G076	G076			INCMDB			NRROB	ROTAB	INDXB
1st-	G230	G078	G078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
2nd-	G238	G080	G080	SHB07	SHB06	SHB05	SHB04	SHB03	SHB02	SHB01	SHB00
1st-	G231	G079	G079					SHA11	SHA10	SHA09	SHA08
2nd-	G239	G081	G081					SHB11	SHB10	SHB09	SHB08

(2) Details of input signals (PMC→CNC)

(a) Incremental command data selection signal (INCMDA)

The INCMDA signal is for selecting the data type (stop position data or incremental command data) of externally specified data (SHA00 to SHA11).

0: Stop position data
1: Incremental command data

(b) Short-cut command for spindle orientation stop position change (NRROA)

The NRROA signal is disabled if incremental command type spindle orientation is enabled (INCMDA = 1).

(c) Spindle orientation command (ORCMA)
(d) Clutch/gear signals (CT1HA and CTH2A)
(e) Spindle orientation stop position change command (INDXA)
(f) Rotation direction command for spindle orientation stop position change (ROTAA)

The functions of the input signals ORCMA, CTH1A, CTH2A, INDXA, and ROTAA are the same as for position coder-method spindle orientation. See Section 2.2, “POSITION CODER METHOD SPINDLE ORIENTATION” in Part I.

(g) Spindle orientation external stop position commands (SHA11 to SHA00)

These commands are treated as incremental command data if INCMDA = 1.

(3) Address list of output signals (CNC→PMC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA							
2nd-	F245	F049	F049	ORARB							
1st-	F221	F047	F047							INCSTA	
2nd-	F247	F051	F051							INCSTB	

(4) Details of output signals (CNC→PMC)

(a) Incremental command mode status signal (INCSTA)

The INCSTA signal indicates the status of the INCMDA (incremental command data selection signal).

0: INCMDA = 0

1: INCMDA = 1

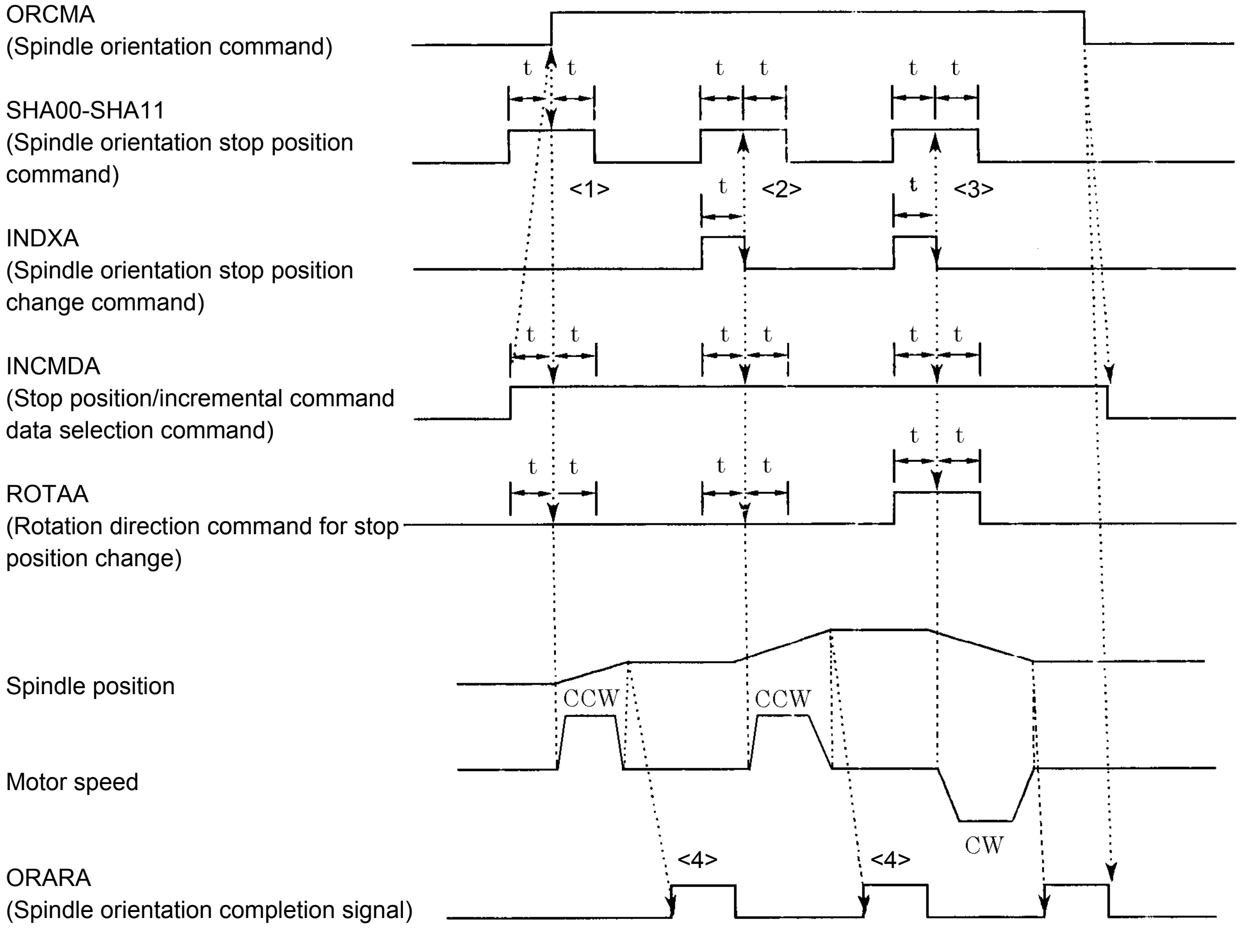
Before performing incremental command type spindle orientation, make sure that this signal is “1”.

(b) Spindle orientation completion signal (ORARA)

The function of the output signal ORARA is the same as for position coder-method spindle orientation. See Section 2.2, “POSITION CODER METHOD SPINDLE ORIENTATION” in Part I.

5.3.5 Examples of Sequences

(1) Incremental operation



> **NOTE**
> Set time t to 50 ms or over so that each signal can be confirmed.

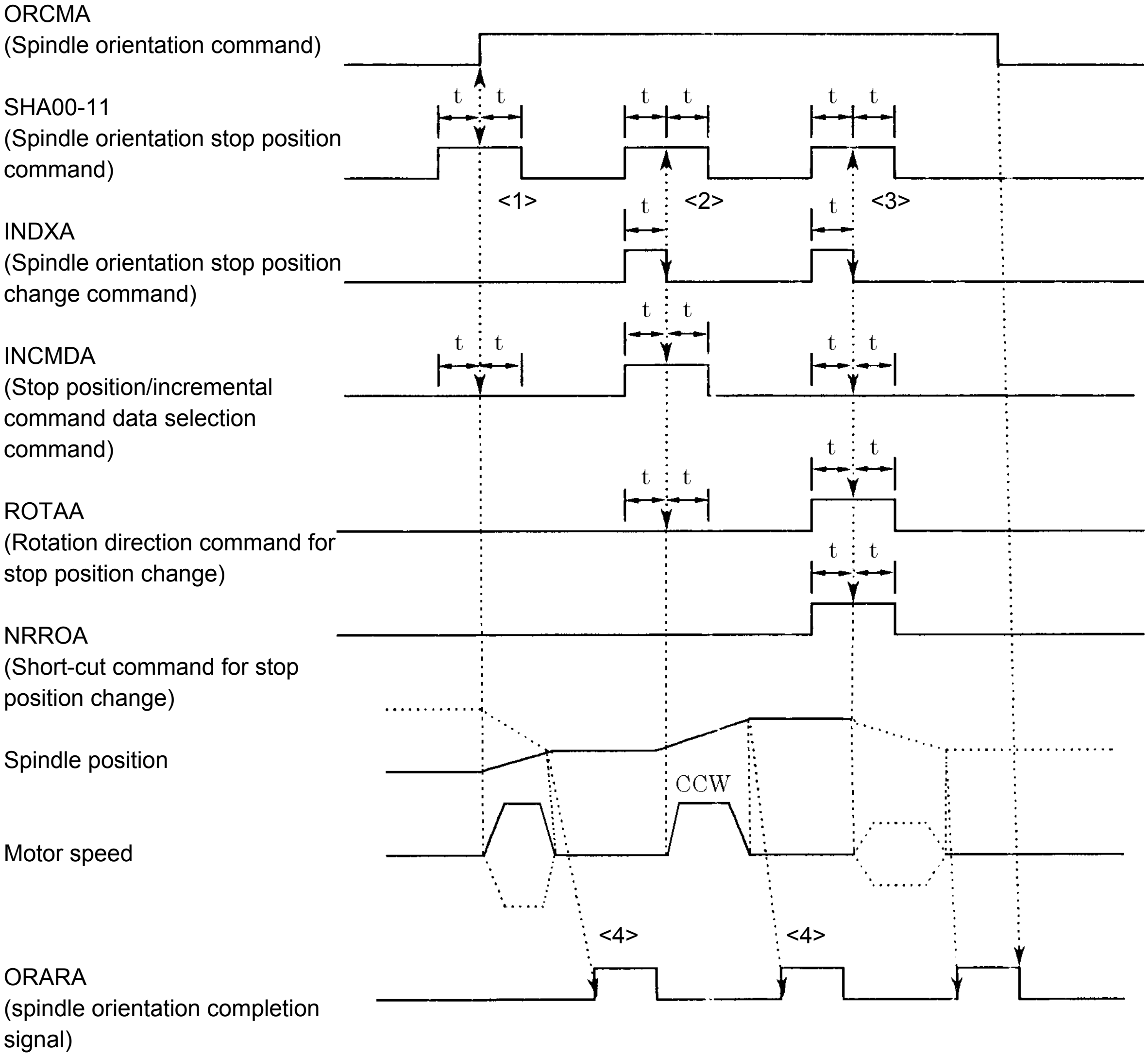
<1> The SHA00 to SHA11 data is read as incremental command data if ORCMA rises under the condition of INCMDA = “1” when the spindle is at a halt (zero-speed detection signal SSTA = “1”). The spindle rotates through the specified incremental angle, starting from the position where it rested, and then stops. Its rotation direction is determined by ROTAA.

<2> If incremental operation is continued, the SHA00 to SHA11 data is read as incremental command data if INDXA falls under the condition of ORCMA = “1” and INCMDA = “1”. The spindle rotates through the specified incremental angle, starting from the position where it rested, and then stops. Its rotation direction is determined by ROTAA.

<3> Incremental command data is specified in pulse units in a range from 0 to +4095 pulses.
The rotation direction of the spindle is determined by ROTAA.
If the command multiplier parameter (No. 4328) is specified, the spindle rotates through [command multiplier parameter] × [incremental command data] and then stops. The rotation direction parameter NRROA (bits 2 and 3 of parameter No. 4003) is disabled during incremental operation.

<4> When the position error gets in a parameter-specified range, the completion signal ORARA is output.

(2) Example of using spindle orientation and incremental movement together



> **NOTE**
> Set time t to 50 ms or over so that each signal can be confirmed.

<1> Stop at a fixed position as directed with an ordinary spindle orientation command

- In the first-time orientation after the power is switched on, the spindle rotates at the orientation speed. After detecting a one-rotation signal, it stops at a fixed position. In the second- and subsequent-time spindle orientation, the spindle stops at a fixed position within one rotation.
- The direction in which the spindle motor rotates depends on the setting of the rotation direction parameter (bits 2 and 3 of parameter No. 4003).
- The SHA00 to SHA11 data is read as stop position command data if ORCMA rises under the condition of INCMDA = “0”. The spindle rotates through the angle determined by [SHA00 to SHA11 value] + [value specified in the orientation stop position shift amount parameter (No. 4077)], and then stops there.

<2> Stop at a fixed position as directed with an incremental command

- See the previous page for incremental operations.
- If the command multiplier parameter (No. 4328) = 4096, spindle rotation speed control can be performed.

<3> Fixed position specified with fixed position stop external setting

- The SHA00 to SHA11 data is read as stop position command data if INDXA falls under the condition of ORCMA = "1" and INCMDA = "0", the spindle rotates to a specified position and then stops there.
- The direction in which the spindle rotates is determined by NRROA and ROTAA.
  If NRROA = "1", the spindle rotates from the current stop position to a specified stop position through the shorter route (within ±180°).
  If NRROA = "0", the direction in which the spindle rotates is determined by ROTAA.

<4> If the position error gets in a parameter-specified range, the completion signal ORARA is output.

5.3.6 List of Related Parameters

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3015 #0	4015 #0	4015 #0	Whether the spindle orientation function is available (to be set to "1") (The CNC software option is required.)
5609#2	3702#3,#2	3729#0	Whether the stop position external setting-type spindle orientation function is available (to be set to "1") (For 16*i*, #2: First spindle, #3: Second spindle)
3328	4328	4328	Command multiplier for incremental command external setting data

NOTE
This subsection describes only the parameters specific to incremental command type spindle orientation. See Section 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION" in Part I, for parameters related to other types of spindle orientation.

5.3.7 Details of Related Parameters

This subsection describes only the parameters specific to incremental command type spindle orientation. See Section 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION" in Part I, for parameters related to other types of spindle orientation.

15*i*	16*i*	30*i*	
3328	4328	4328	**Command multiplier for spindle orientation by a position coder**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

Set a command multiplier for the spindle orientation function with an externally set incremental command.
If this data is "0", the multiplier is automatically assumed to be 1.
Incremental command = incremental command data (SHA11 to SHA00) × data (multiplier) specified in this parameter
To use spindle rotation speed control, set this parameter to "4096", because one rotation of the spindle corresponds to 4096 pulses.

NOTE

The maximum speed (incremental command) that can be specified is:
120 rotations (= 120 × 4096 pulses)
9D50/N edition or earlier, 9D70/E edition or earlier
30000 rotations (= 30000 × 4096 pulses)
9D50/O edition or later, 9D70/F edition or later, 9D80 series

5.4 CONVENTIONAL METHOD ORIENTATION (OPTIONAL FUNCTION)

5.4.1 Overview

Conventional method orientation is a function for stopping the spindle at a specified position by controlling the position using the spindle sensor signal at up to a certain spindle speed.

NOTE

*1 To use this function, the CNC software option is required.

*2 by applying the optimum orientation function, the spindle acceleration command is automatically optimized. This is expected to reduce the positioning time required by conventional method orientation. It is, therefore, recommended to apply the optimum orientation function.
For an explanation of the optimum orientation function, see Section 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION (OPTIMUM ORIENTATION)", in Part I.

5.4.2 Series and Editions of Applicable Spindle Software

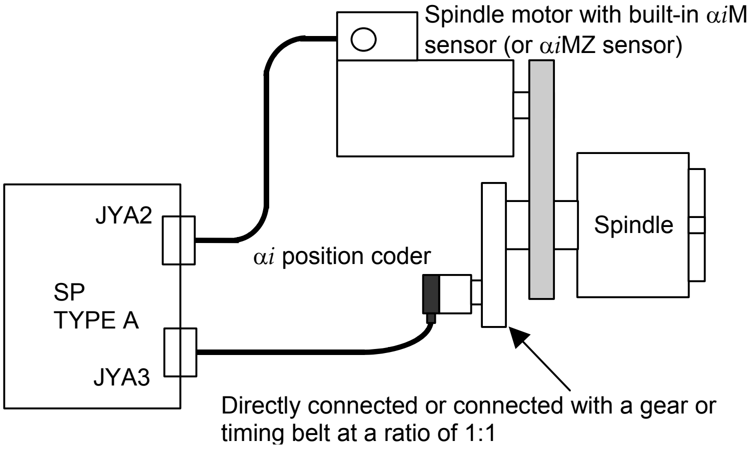
Spindle software

Series	Edition	Usable CNC
9D50	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

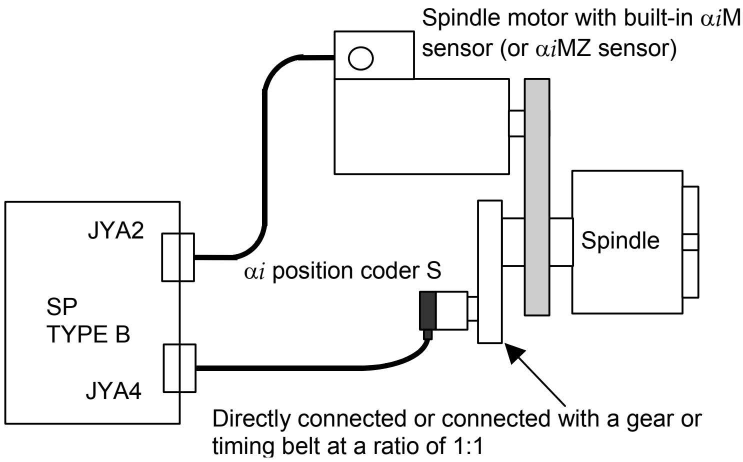
5.4.3 Configuration

Explained below is a system configuration in which the conventional orientation function is usable.

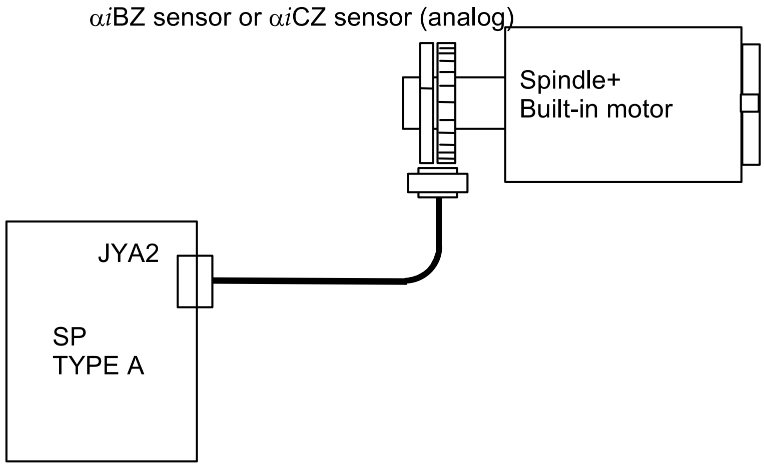
(1) When the α*i* position coder is used



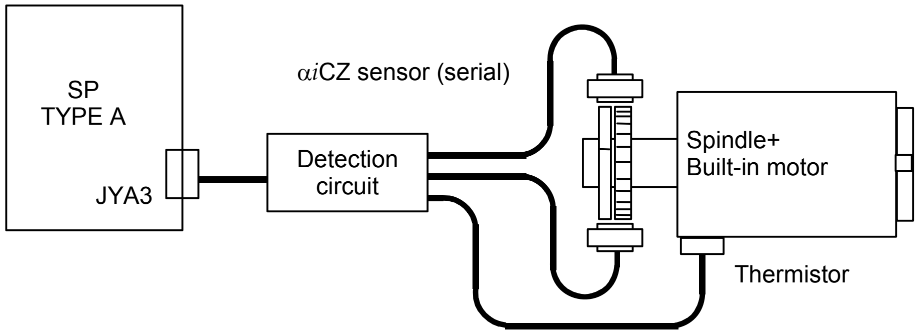
(2) When the α position coder S is used



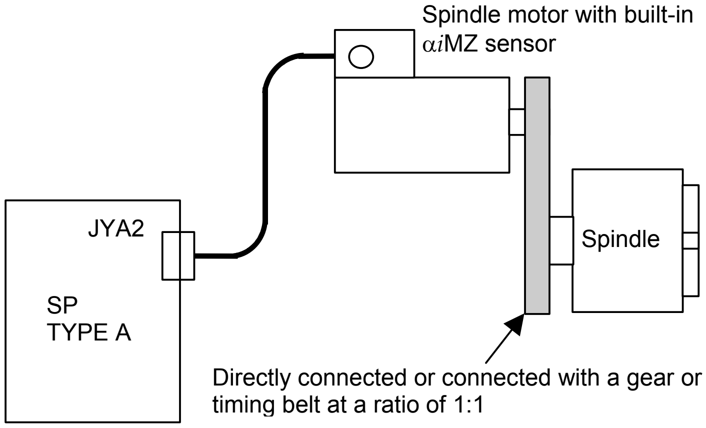
(3) When the built-in motor (α*i*BZ sensor, α*i*CZ sensor (analog)) is used



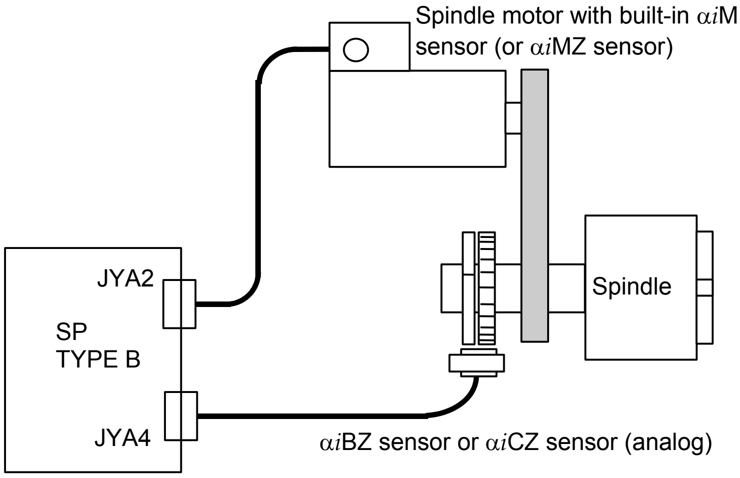
(4) When the built-in motor (α*i*CZ sensor (serial)) is used



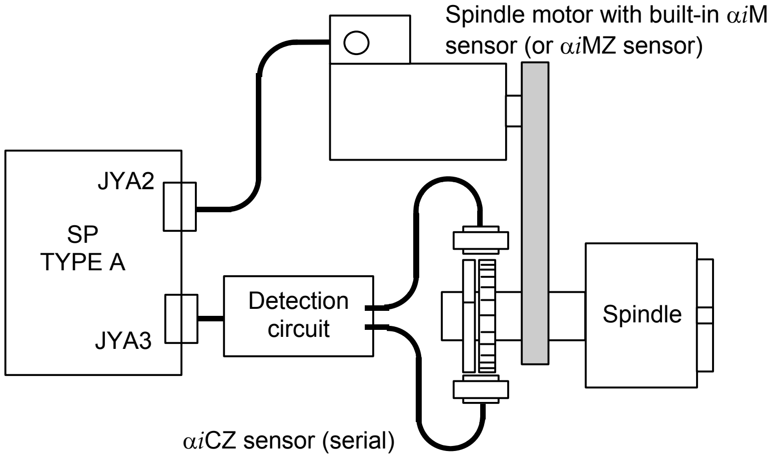
(5) When the spindle motor with built-in α*i*MZ sensor is used



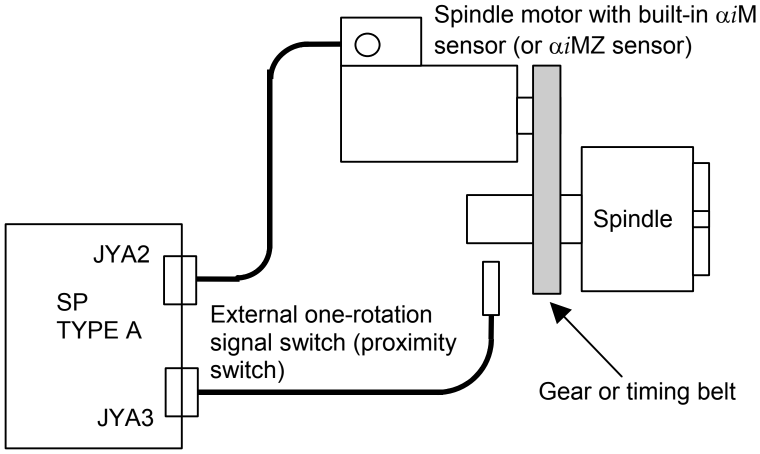
(6) When the separate type α*i*BZ sensor or the separate type α*i*CZ sensor (analog) is used



(7) When the separate type αiCZ sensor (serial) is used



(8) When the external one-rotation signal (proximity switch) is used



NOTE

1. For stable detection of the one-rotation signal, fix the rotation direction (bits 3 and 2 of No. 4003) for orientation at one direction.
2. Set the type (bits 3 and 2 of No. 4004) of the external one-rotation signal (proximity switch).
3. For stable detection of the one-rotation signal, set an orientation speed (No. 4038) from 50 to 100 min-1 according to the specification of the external one-rotation signal (proximity switch).
4. The detection of the one-rotation signal starts after the orientation speed is reached.
5. Set the parameters (No. 4171 to No. 4174) for the numerator/denominator of an arbitrary gear ratio between the motor sensor and spindle.

5.4.4 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070		ORCMA			CTH1A	CTH2A		
2nd-	G235	G074	G074		ORCMB			CTH1B	CTH2B		
1st-	G229	G072	G072			INCMDA			NRROA	ROTAA	INDXA
2nd-	G237	G076	G076			INCMDB			NRROB	ROTAB	INDXB
1st-	G230	G078	G078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
2nd-	G238	G080	G080	SHB07	SHB06	SHB05	SHB04	SHB03	SHB02	SHB01	SHB00
1st-	G231	G079	G079					SHA11	SHA10	SHA09	SHA08
2nd-	G239	G081	G081					SHB11	SHB10	SHB09	SHB08

(2) Details of input signals (PMC→CNC)

(a) Spindle orientation command (ORCMA)
(b) Clutch/gear signals (CTH1A and CTH2A)
(c) Spindle orientation stop position change command (INDXA)
(d) Rotation direction command for spindle orientation stop position change (ROTAA)
(e) Short-cut command for spindle orientation stop position change (NRROA)
(f) Incremental command data selection signal (INCMDA)
(g) Spindle orientation external stop position commands (SHA11 to SHA00)

The functions of the input signals ORCMA, CTH1A, CTH2A, INDXA, ROTAA, NRROA, INCMDA, and SHA11 to SHA00 are the same as for position coder-method spindle orientation and incremental command type spindle orientation. See Sections 2.2, "POSITION CODER-METHOD SPINDLE ORIENTATION," and 5.3, "INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION" in Part I.

(3) Address list of output signals (CNC→PMC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA							
2nd-	F245	F049	F049	ORARB							
1st-	F221	F047	F047							INCSTA	
2nd-	F247	F051	F051							INCSTB	

(4) Details of input signals (CNC → PMC)

(a) Incremental command mode status signal (INCSTA)
(b) Spindle orientation completion signal (ORARA)

The functions of the output signals ORARA and INCSTA are the same as for position coder-method spindle orientation and incremental command type spindle orientation. See Sections 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION," and 5.3, "INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION" in Part I.

5.4.5 Sequence

For this subsection, see Sections 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION (OPTIMUM ORIENTATION)", and 5.3, "INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION (SPINDLE ROTATION SPEED CONTROL)" in Part I.

5.4.6 List of Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
3015#0	4015#0	4015#0	Specifies whether to use the spindle orientation function. (Set this bit to 1.) (The CNC software option is required.)
5609#2	3702#3,#2	3729#0	Specifies whether to use the spindle orientation function with the stop position external setting type. (For 16i, #2: First spindle, #3: Second spindle)
3003#0	4003#0	4003#0	Choice of orientation method (To be set to 0 for the position coder method)
3003#3,#2	4003#3,#2	4003#3,#2	Direction of rotation in spindle orientation
3017#7	4017#7	4017#7	Shortcut function when orientation is specified in stop state
3018#6 #3	4018#6 #3	4018#6 #3	Type of position coder method spindle orientation (Sets bits 6 and 3 to 0,0.)
3031	4031	4031	Stop position for position coder method orientation (This parameter is disabled when spindle orientation with an externally set stop position or an externally set incremental command is used.)
3042 3043	4042 4043	4042 4043	Velocity loop proportional gain for orientation (A parameter is selected by the CTH1A input signal.)
3050 3051	4050 4051	4050 4051	Velocity loop integral gain for orientation (A parameter is selected by the CTH1A input signal.)
3056 to 3059	4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio (A parameter is selected by the CTH1A and CTH2A input signals.)
3060 to 3063	4060 to 4063	4060 to 4063	Position gain for orientation (A parameter is selected by the CTH1A and CTH2A input signals.)
3064	4064	4064	Rate of change in the position gain upon completion of spindle orientation
3075	4075	4075	Detection level for the spindle orientation completion signal
3076	4076	4076	Speed limit ratio for spindle orientation
3077	4077	4077	Spindle orientation stop position shift
3084	4084	4084	Motor voltage for spindle orientation
3038	4038	4038	Spindle orientation speed
3171 3173	4171 4173	4171 4173	Denominator of an arbitrary gear ratio between the motor sensor and spindle (A parameter is selected by the input signal CTH1A.)
3172 3174	4172 4174	4172 4174	Numerator of an arbitrary gear ratio between the motor sensor and spindle (A parameter is selected by the input signal CTH1A.)

NOTE

1. For the parameters related to detectors, see the Section 1.3, "PARAMETERS RELATED TO DETECTORS" in the Part I.
2. For velocity loop proportional/integral gain adjustment, see Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT", in Part I.
3. When using the external one-rotation signal (proximity switch), fix the orientation-time rotation direction (bits 3 and 2 of No. 4003) at one direction.
4. When using the external one-rotation signal (proximity switch), set the type of the external one-rotation signal (bits 3 and 2 of No. 4004).
5. When using the external one-rotation signal (proximity switch), set an orientation speed from 50 to 100 min^{-1} (No. 4038) according to the specification of the used external one-rotation signal.
6. When using the external one-rotation signal (proximity switch), set the numerator/denominator of an arbitrary gear ratio between the motor sensor and spindle (No. 4171 to No. 4174).

5.4.7 Details of Related Parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3003	4003	4003					DIRCT2	DIRCT1		PCMGSL

DIRCT2, DIRCT1 Setting of rotation direction at spindle orientation

DIRCT2	DIRCT1	Rotation direction at spindle orientation
0	0	By rotation direction immediately before (It is CCW at the power on.)
0	1	By rotation direction immediately before (It is CW at the power on.)
1	0	CCW (counterclockwise) direction looking from shaft of motor
1	1	CW (clockwise) direction looking from shaft of motor

NOTE

When using the external one-rotation signal (proximity switch), fix the orientation-time rotation direction at CCW or CW for stable detection of the one-rotation signal.
(Bits 3, 2 of No. 4003) = 1, 0 or 1, 1)

PCMGSL Selects the type of orientation.
Set this bit to 0 (orientation by a position coder).

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3004	4004	4004					RFTYPE	EXTRF		

EXTRF, RFTYPE Sets the external one-rotation signal (proximity switch).

RFTYPE	EXTRF	External one-rotation signal (proximity switch)
0	0	None
0	1	Detects the rising edge.
1	1	Detect the falling edge.

NOTE
When using the external one-rotation signal (proximity switch), set the type of the external one-rotation signal (proximity switch) by using this parameter.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3017	4017	4017	NRROEN							

NRROEN Specifies whether to use the shortcut function when orientation is specified in the stop state.
0 : Does not use the function.
1 : Uses the function.
When this bit is set to 1, short cut operation is performed when the following conditions are satisfied:
- Bit 7 of parameter No. 4016 (RFCHK3) is set to 0.
- Zero speed detection output signal SST is set to 1.
- Shortcut command input signal NRROA is set to 1.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3018	4018	4018		ORTYP1			ORTYP1			

ORTYP1、ORTYP0 Type of position coder method orientation

ORTYP1	ORTYP0	Type of orientation
0	0	Conventional method orientation
0	1	Optimum orientation
1	0	Optimum orientation

Specify "0,0" (conventional method orientation).

15*i*	16*i*	30*i*	
3031	4031	4031	**Position coder method orientation stop position**

Unit of data : 1 pulse unit (360 degrees/4096)
Valid data range : 0 to 4096
Standard setting : 0
This data is used to set the stop position of position coder method spindle orientation. It can be set at every 360 degrees/4096.
When stop position external command type orientation and incremental command external type orientation are set, this parameter becomes invalid.
Stop position command (SHA11-SHA00) of input signal instructed becomes valid.

15*i*	16*i*	30*i*	
3038	4038	4038	**Spindle orientation speed**

Unit of data : 1min^{-1} (10min^{-1} when bit 2 of parameter No.4006(SPDUNT) is set to 1)
Valid data range : 0 to 32767
Standard setting : 0
This parameter sets the orientation speed at the end of the spindle.
When 0 is specified for this parameter, the orientation speed is determined depending on the position gain and the motor speed limit ratio for orientation.

NOTE
When using the external one-rotation signal (proximity switch), set an orientation speed from 50 to 100 min^{-1} according to the specification of the used external one-rotation signal (proximity switch) for stable detection of the one-rotation signal.

15*i*	16*i*	30*i*		
3042	4042	4042	**Velocity loop proportional gain on orientation (HIGH)**	**CTH1A=0**
3043	4043	4043	**Velocity loop proportional gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This parameter sets the velocity loop proportional gain for spindle orientation.
When the CTH1A input signal is set to 0, proportional gain for the HIGH gear is selected.
When the CTH1A input signal is set to 1, proportional gain for the LOW gear is selected.

15*i*	16*i*	30*i*		
3050	4050	4050	**Velocity loop integral gain on orientation (HIGH)**	**CTH1A=0**
3051	4051	4051	**Velocity loop integral gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This parameter sets the velocity loop integral gain for spindle orientation.
When the CTH1A input signal is set to 0, integral gain for the HIGH gear is selected.
When the CTH1A input signal is set to 1, integral gain for the LOW gear is selected.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These parameters set the gear ratio of the spindle motor relative to the spindle.
When the motor rotates 2.5 times, for every rotation of the spindle, for example, set 250 in the parameter.
A parameter is selected by the CTH1A and CTH2A input signals.
The gear or clutch status must correspond to the status of the CTH1A and CTH2A input signals.

NOTE
When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*		
3060	4060	4060	**Position gain on orientation (HIGH)**	**CTH1A=0, CTH2A=0**
3061	4061	4061	**Position gain on orientation (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3062	4062	4062	**Position gain on orientation (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3063	4063	4063	**Position gain on orientation (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : 0.01sec^{-1}
Valid data range : 0 to 32767
Standard setting : 1000
These parameters set the position gain for orientation.
A parameter is selected by the CTH1A and CTH2A input signals.

15*i*	16*i*	30*i*	
3064	4064	4064	**Modification rate of position gain on orientation completion**

Unit of data : 1%
Valid data range : 0 to 799
Standard setting : 100
This data is used to set the modification rate of position gain on spindle orientation completion.

15*i*	16*i*	30*i*	
3075	4075	4075	**Orientation completion signal detection level (limits of in-position)**

Unit of data : ±1 pulse unit (360 degrees/4096)
Valid data range : 0 to 100
Standard setting : 10
This data is used to set the detecting level of orientation completion signal (ORARA).
When the spindle position is located within the setting data on orientation completion, the bit of orientation completion signal (ORARA) in the spindle control signals is set to "1".
When the orientation command (ORCMA) is turned off (= 0), the orientation completion signal (ORARA) is set to "0".

15*i*	16*i*	30*i*	
3076	4076	4076	**Motor speed limit ratio on orientation**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : 33
This data is used to set motor speed limit ratio on orientation.
The value calculated from the position gain (No. 4060 to No. 4063) and this parameter as indicated below is used as an orientation speed and reference position return speed on servo mode (rigid tapping/spindle positioning).

$$\text{Orientation speed of motor (motor speed)} = 60 \times \frac{(\text{Position gain})}{100} \times (\text{Gear ratio}) \times \frac{(\text{Speed limit ratio})}{100} [\text{min}^{-1}]$$

15*i*	16*i*	30*i*	
3077	4077	4077	**Orientation stop position shift value**

Unit of data : ±1 pulse unit (360 degrees/4096)
Valid data range : -4095 to 4095
Standard setting : 0
In the position coder method orientation, set this data to shift stop position.
Spindle is shift numbers of setting pulse in CCW direction, and stops by data (+).

15*i*	16*i*	30*i*	
3084	4084	4084	**Motor voltage setting on orientation**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : 30

This parameter sets the motor voltage for orientation. Usually, set 30. The value may vary, however, depending on the motor model.

15*i*	16*i*	30*i*	
3171	4171	4171	**Denominator of arbitrary gear ratio between motor sensor and spindle (HIGH) CTH1A=0**
3172	4172	4172	**Numerator of arbitrary gear ratio between motor sensor and spindle (HIGH) CTH1A=0**
3173	4173	4173	**Denominator of arbitrary gear ratio between motor sensor and spindle (LOW) CTH1A=1**
3174	4174	4174	**Numerator of arbitrary gear ratio between motor sensor and spindle (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 0

These parameters set conversion coefficients (numerator, denominator) for using the detection arbitrary gear ratio function (DMR function) by multiplying a motor sensor (α*i*M or α*i*MZ sensor) feedback signal by a gear ratio to produce a spindle position feedback signal.

When the spindle rotates Q times while the motor shaft rotates P times (there is no common divisor other than 1 for P and Q), settings are:

No. 4171 (No. 4173 when CTH1A = 1) = P
No. 4172 (No. 4174 when CTH1A = 1) = Q

When 0 is set in any of these parameters, the setting of 1 is assumed.

NOTE
When using the external one-rotation signal (proximity switch), set an arbitrary gear ratio between the motor sensor and spindle by using this parameter.

5.4.8 Adjusting the Orientation Stop Position Shift Parameter

For this subsection, see Section 2.2, “POSITION CODER METHOD SPINDLE ORIENTATION (OPTIMUM ORIENTATION)”, in Part I.

5.4.9 Calculating the Position Gain for Orientation

(1) When the spindle orientation speed parameter (No. 4038) is set to "0", the orientation speed is determined using the following expression:

$Nori = 60 \times PG \times Rori \times GEAR$

where, Nori : Orientation speed (motor speed) [min^{-1}]
Rori : Motor speed limit ratio for orientation (parameter No. 4076)
PG : Position gain on orientation [sec^{-1}] (parameter Nos. 4060 to 4063)
GEAR : Spindle-to-motor gear ratio (parameter Nos. 4056 to 4059)

(2) The position gain for spindle orientation is obtained using the following expression:

$$PG \le \sqrt{\left(\frac{Tm}{2\pi \times (Jm + Jl) \times Rori \times GEAR}\right)}$$

where, PG : Position gain for orientation [sec^{-1}] (parameter Nos. 4060 to 4063)
Tm : 30-min rated torque for the motor when rotating at Nori [min^{-1}] [Nm]
Jm : Rotor inertia [kgm^2]
Jl : Load inertia converted to motor shaft inertia [kgm^2]
Rori : Motor speed limit ratio for orientation (parameter No. 4076)
GEAR : Spindle-to-motor gear ratio (parameter Nos. 4056 to 4059)

(3) Calculation example when motor model αiI6 is being used alone

$$Tm = \frac{7500[W]}{1500[min^{-1}] \times 0.1047} = 47.8[Nm]$$

$$Jm = 0.0179[kgm^2]$$

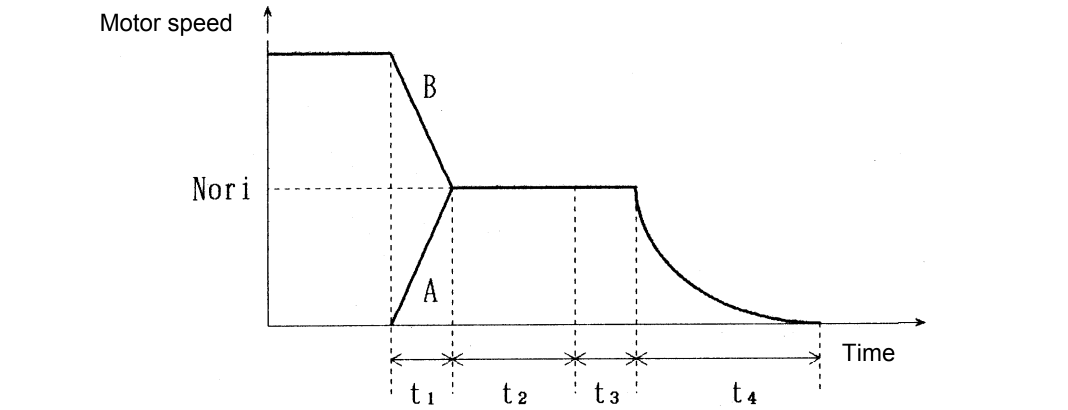
$$Rori = 33[\%]$$

$$\therefore PG \le \sqrt{\left(\frac{47.8}{2\pi \times 0.0179 \times 0.33}\right)} = 35.9[sec^{-1}]$$

5.4.10 Calculating the Orientation Time

The time required for orientation differs between the first orientation (before the one-rotation signal has first been detected) and the second and subsequent orientations (once the one-rotation signal has been detected).

(1) Before the one-rotation signal has first been detected (first orientation)
The time, from the input of an orientation command until orientation stops, is divided into four periods.
In the following figure, A indicates that the motor in the stop state starts rotating and is accelerated to the orientation speed. B indicates that the already rotating motor is decelerated to the orientation speed.



t_1 : Time required to achieve orientation speed Nori [sec]
t_2 : Time from the detection of a one-rotation signal (0 to 1 rotation) after Nori is achieved, until the number of pulses output before the next one-rotation signal has been checked [sec]
t_3 : Time from the completion of the checking of the number of pulses until deceleration starts [sec]
t_4 : Time from the start of deceleration until orientation is completed [sec]

(a) Normally, t_1 is measured on the actual machine.
Orientation speed Nori [min^{-1}] is calculated from position gain PG [sec^{-1}] and motor speed limit ratio for orientation Rori.

$$Nori = PG \times 60 \times Rori$$

(b) t_2 is the time required for the motor to rotate one to two turns at orientation speed Nori [min^{-1}].

$$\frac{1 \times 60}{Nori} \le t_2 \le \frac{2 \times 60}{Nori}$$

$$\therefore \frac{1}{PG \times Rori} \le t_2 \le \frac{2}{PG \times Rori}$$

(c) t_3 is the time required for the motor to rotate zero to one turn at orientation speed Nori [min^{-1}].

$$\frac{0 \times 60}{Nori} \le t_3 \le \frac{1 \times 60}{Nori}$$

$$\therefore 0 \le t_3 \le \frac{1}{PG \times Rori}$$

(d) t_4 is the time from the start of deceleration until orientation has been completed.
Let the orientation completion width be within ±10 pulses. Then, t_4 can be calculated as follows:

$$t_4 = \frac{1}{PG} \times \ln \frac{4096 \times Rori}{10}$$

(e) Therefore, orientation time t [sec] (= $t_1 + t_2 + t_3 + t_4$) can be expressed as follows:

$$t_1 + \frac{1}{PG \times Rori} + \frac{1}{PG} \ln \frac{4096 \times Rori}{10} \le t \le t_1 + \frac{3}{PG \times Rori} + \frac{1}{PG} \ln \frac{4096 \times Rori}{10}$$

(2) Once the one-rotation signal has been detected (second and subsequent orientations)

(a) Once the one-rotation signal has been detected, the time required to detect the signal is no longer necessary.
Therefore, when orientation is started from the rotating state, orientation time t [sec] (= $t_1 + t_3 + t_4$) is expressed as follows:

$$t_1 + \frac{1}{PG} \ln \frac{4096 \times Rori}{10} \le t \le t_1 + \frac{1}{PG \times Rori} + \frac{1}{PG} \ln \frac{4096 \times Rori}{10}$$

(b) Whenever orientation is started from the stop state, orientation must be completed and the motor must enter the stop state within one-rotation. In this case, orientation time t [sec] is expressed as follows:

$$0 \le t \le \frac{1 - Rori}{PG \times Rori} + \frac{1}{PG} \ln \frac{4096 \times Rori}{10}$$

(3) Calculation examples
Time required to achieve orientation speed t_1 = 0.5 [sec]
Position gain PG = 20 [sec^{-1}]
Motor speed limit for orientation Rori = 0.33 (= 33%)

(a) Orientation time before the one-rotation signal has been detected

$$0.5 + \frac{1}{20 \times 0.33} + \frac{1}{20} \times \ln \frac{4096 \times 0.33}{10} \le t \le 0.5 + \frac{3}{20 \times 0.33} + \frac{1}{20} \times \ln \frac{4096 \times 0.33}{10}$$

$$\therefore 0.896[sec] \le t \le 1.196[sec]$$

(b) Orientation time when orientation is started from the rotating state (once the one-rotation signal has been detected)

$$0.5+\frac{1}{20}\times\ln\frac{4096\times 0.33}{10}\le t\le 0.5+\frac{1}{20\times 0.33}+\frac{1}{20}\times\ln\frac{4096\times 0.33}{10}$$

$$\therefore 0.746[\mathrm{sec}]\le t\le 0.896[\mathrm{sec}]$$

(c) Orientation time when orientation is started from the stop state (once the one-rotation signal has been detected)

$$0\le t\le\frac{1-0.33}{20\times 0.33}+\frac{1}{20}\ln\frac{4096\times 0.33}{10}$$

$$\therefore 0[\mathrm{sec}]\le t\le 0.346[\mathrm{sec}]$$

5.5 SPINDLE ORIENTATION DURING SPINDLE SYNCHRONIZATION CONTROL (OPTIONAL FUNCTION)

5.5.1 Overview

This function performs orientation stop operation (orientation during spindle synchronous control) in the direction/stop position specified externally while keeping synchronization between spindles during spindle synchronous control.
Using spindle orientation during spindle synchronous control (hereafter simply called synchronous orientation) enables the following operations:

- Loading/unloading of an irregular-shape workpiece during spindle synchronous control
- Side-facing of a workpiece that must be held at both ends (such as a long workpiece) after it is indexed

NOTE
1. Using this function requires the CNC software option for spindle synchronous control.
2. This function is an add-on to the spindle synchronous control function. This section focuses on the add-on.
3. Using this function requires the enabling of the stop position externally setting spindle orientation function.
4. Some parameter specifications related to the αi series spindle amplifiers differ from those related to the α series. See Subsection 5.5.7, “Details of Related Parameters”.

5.5.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D50	E (05)	FS16*i* / FS18*i* / FS21*i* , FS0*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

5.5.3 Specification

Synchronous orientation

During spindle synchronous control, inputting the synchronous orientation command (SPPHS rising edge when SORENA = 1) can stop spindle orientation with two spindles kept in synchronization.

> **NOTE**
> 1 If bell-shaped Acc./Dec. is already enabled, it is kept enabled during synchronous orientation.
> 2 If you changed parameters or sequences, disconnect each spindle for safety purposes, and then run the machine to check carefully the direction in which each spindle rotates, the position where each spindle stops, and whether a synchronous error occurs.

Reference position (phase) setting

Before issuing a synchronous orientation command, it is necessary to perform reference position (phase) setting for the two spindles.
Set the reference position of each of the spindles using spindle phase synchronous control.
If spindle phase synchronous control is performed with synchronous speed command = “0”, the spindles stop at:

[One-rotation signal position] + [shift amount during spindle synchronous control (parameter No. 4034)]

This position is used as a reference position (stop position where SHA11 to SHA00 are all 0s) for the synchronous orientation stop position.

> **NOTE**
> 1 Before inputting the spindle phase synchronous control command (SPPHS), make sure that both the spindles are rotating at the synchronous speed and they remain synchronized (FSPSY = 1). If the synchronous control command is issued before the spindles start rotating at the synchronous speed, they get out of phase.
> 2 In addition, before inputting the phase synchronous command, disconnect both spindles.

Synchronous orientation stop position

SHA11 to SHA00 are used to specify the spindle stop position for synchronous orientation. Specify the desired shift amount relative from the reference position explained above.

NOTE

1. Be sure to specify the same reference position for both the spindles. If you fail to specify the same spindle position, it is impossible to maintain spindle synchronization.
2. Also specify the direction in which each spindle rotates during synchronous orientation, using ROTAA. The direction in which each spindle must rotate to keep itself in synchronization with the other spindle varies depending on the machine configuration. Be sure to specify the correct direction according to the machine condition so that the spindles are maintained in synchronization. If you fail to specify the correct direction, it is impossible to maintain spindle synchronization.
3. Keep these signals (SHA11 to SHA00 and ROTAA) in the stated status until synchronous orientation is completed.

5.5.4 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

(a) For path 1

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
	G038	G038					SPPHS	SPSYC		
1st-	G072	G072							ROTAA	
2nd-	G076	G076							ROTAB	
1st-	G073	G073					SORSLA			
2nd-	G077	G077					SORSLB			
1st-	G078	G078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
2nd-	G080	G080	SHB07	SHB06	SHB05	SHB04	SHB03	SHB02	SHB01	SHB00
1st-	G079	G079					SHA11	SHA10	SHA09	SHA08
2nd-	G081	G081					SHB11	SHB10	SHB09	SHB08

(b) For path 2

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
	G1038	G1038					SPPHS	SPSYC		
1st-	G1072	G1072							ROTAA	
2nd-	G1076	G1076							ROTAB	
1st-	G1073	G1073					SORSLA			
2nd-	G1077	G1077					SORSLB			
1st-	G1078	G1078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
2nd-	G1080	G1080	SHB07	SHB06	SHB05	SHB04	SHB03	SHB02	SHB01	SHB00
1st-	G1079	G1079					SHA11	SHA10	SHA09	SHA08
2nd-	G1081	G1081					SHB11	SHB10	SHB09	SHB08

(2) Details of input signals (PMC→CNC)

(a) Spindle synchronous control command (SPSYC)

Setting the SPSYC signal to “1” directs the spindles to enter the spindle synchronous control mode. Before issuing this command, specify SORSLA (SORSLA) = “0”.
Maintain the condition of SPSYC = “1” during synchronous orientation.

(b) Spindle phase synchronous control command or synchronous orientation command (SPPHS)

If SORENA (SORENB) = “0”, the spindle phase synchronous control command is issued at the rising edge of the SPPHS signal. (See Section 2.5, “SPINDLE SYNCHRONIZATION CONTROL” in Part I .)
If SORENA (SORENB) = “1”, the synchronous orientation command is issued at the rising edge of the SPPHS signal. When the synchronous orientation command is issued, the synchronous speed command becomes disabled, and synchronous orientation begins.
Keep satisfying synchronous speed command = “0” during synchronous orientation.
Before issuing the synchronous orientation command, make sure that SORSLA (SORSLB) = “1” and SORENA (SORENB) = “1” are satisfied for both the spindles.
Keep in mind that the meaning of the SPPHS signal changes according to the state of the SORENA (SORENB) signal.
To issue the synchronous orientation command after spindle phase synchronous control is performed, it is necessary to reset the SPPHS signal to “0” previously. The spindle phase synchronous control completion signal is kept at “0” while the SPPHS signal is “0”.

(c) Synchronous orientation request command (SORSLA)

The SORSLA signal is a signal for requiring synchronous orientation.
In response to this signal, the spindle amplifier outputs a synchronous orientation permission signal (SORENA or SORENB).
If SORSLA (SORSLB) = “1” is input, the synchronous orientation command (SPPHS) becomes enabled when SORENA (SORENB) = “1” is satisfied.
Keep the current state of the SORSLA signal until synchronous orientation is completed.
If SORSLA (SORSLB) = “0” is input, synchronous orientation is released and the synchronous speed command becomes enabled, when SORENA (SORENB) = “0” is satisfied.

(d) Synchronous orientation external stop position command (SHA11 to SHA00)

This command is used to specify the stop position for synchronous orientation.
If all of the SHA11 to SHA00 signals are “0”, the position where each spindle is to rest (reference position) is as stated below if the spindle phase synchronous command is issued under the condition of synchronous speed command = “0”:

[One-rotation signal position] + [shift amount during spindle synchronous control (parameter No. 4034)]

The shift amount relative from the reference position is:

$$\text{Shift amount (degrees)} = \frac{360}{4096} \times \sum_{i=0}^{11} \left(SHAi \times 2^i \right)$$

Assert the SHA11 to SHA00 signals at least 50 ms before the synchronous orientation command is input, and keep them asserted until synchronous orientation is completed.

(e) Rotation direction command for synchronous (ROTAA)

This command specifies the direction in which the spindle rotates during synchronous orientation.
0: The spindle rotates CCW.
1: The spindle rotates CW.
To make both the spindles rotate in the same direction, it is necessary to input the ROTAA signal correctly. Because the correct rotation direction changes depending on the machine configuration, specify it exactly while paying attention to the way each spindle is linked to its motor and the positional relationship between the spindles.

Assert the ROTAA signals at least 50 ms before the synchronous orientation command is input, and keep it asserted until synchronous orientation is completed.

(3) Address list of output signals (CNC→PMC)

(a) For path 1

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
	F044	F044				SYCAL	FSPPH	FSPSY		
1st-	F047	F047					SORENA			
2nd-	F051	F051					SORENB			

(b) For path 2

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
	F1044	F1044				SYCAL	FSPPH	FSPSY		
1st-	F1047	F1047					SORENA			
2nd-	F1051	F1051					SORENB			

(4) Details of output signals (CNC→PMC)

(a) Synchronous orientation permission signal (SORENA)

If this signal is “1”, the synchronous orientation command is issued at the rising edge of the SPPHS signal.
If this signal is “0”, the spindle phase synchronous command is issued at the rising edge of the SPPHS signal. If this signal becomes “0” during synchronous orientation, the synchronous orientation is released. In this case, reset the synchronous speed command for both the spindles to “0”. SORENA (SORENB) = “1” is output if SORSLA (SORSLB) = “1” is satisfied, and SORENA (SORENB) = “0” is output if SORSLA (SORSLB) = “0” is satisfied.

(b) Spindle speed synchronous control completion signal (FSPSY)

If the spindle synchronous control command is issued, the FSPSY signal becomes “1” when both spindles reach the specified synchronous speed.
Before issuing the spindle phase synchronous control command for reference position setting, make sure that the synchronous speed command is “0” and the FSPSY signal is “1”.
The signal becomes “1” if the velocity error between the spindles is smaller than the value specified in parameter No. 4033.

(c) Spindle phase synchronous control completion signal or synchronous orientation completion signal (FSPPH)

If the spindle phase synchronous control command is issued, the FSPPH signal becomes “1” when phase synchronization is completed.
If the synchronous orientation command is issued, the signal becomes “1” when synchronous orientation is completed.
The signal is kept at “0” while SPPHS (spindle phase synchronous control command or synchronous orientation command) = “0”.
After the spindle phase synchronous control command has been issued, the signal is output if the following conditions are satisfied.

- The velocity error between the spindles is smaller than the value specified in parameter No. 4034.
- The synchronous error between the spindles is smaller than the value specified in parameter No. 4810.

After the synchronous orientation command has been issued, the signal is output if the following conditions are satisfied.

- The synchronous error between the spindles is smaller than the value specified in parameter No. 4810.
- The position error between the spindles is smaller than the value specified in parameter No. 4075.

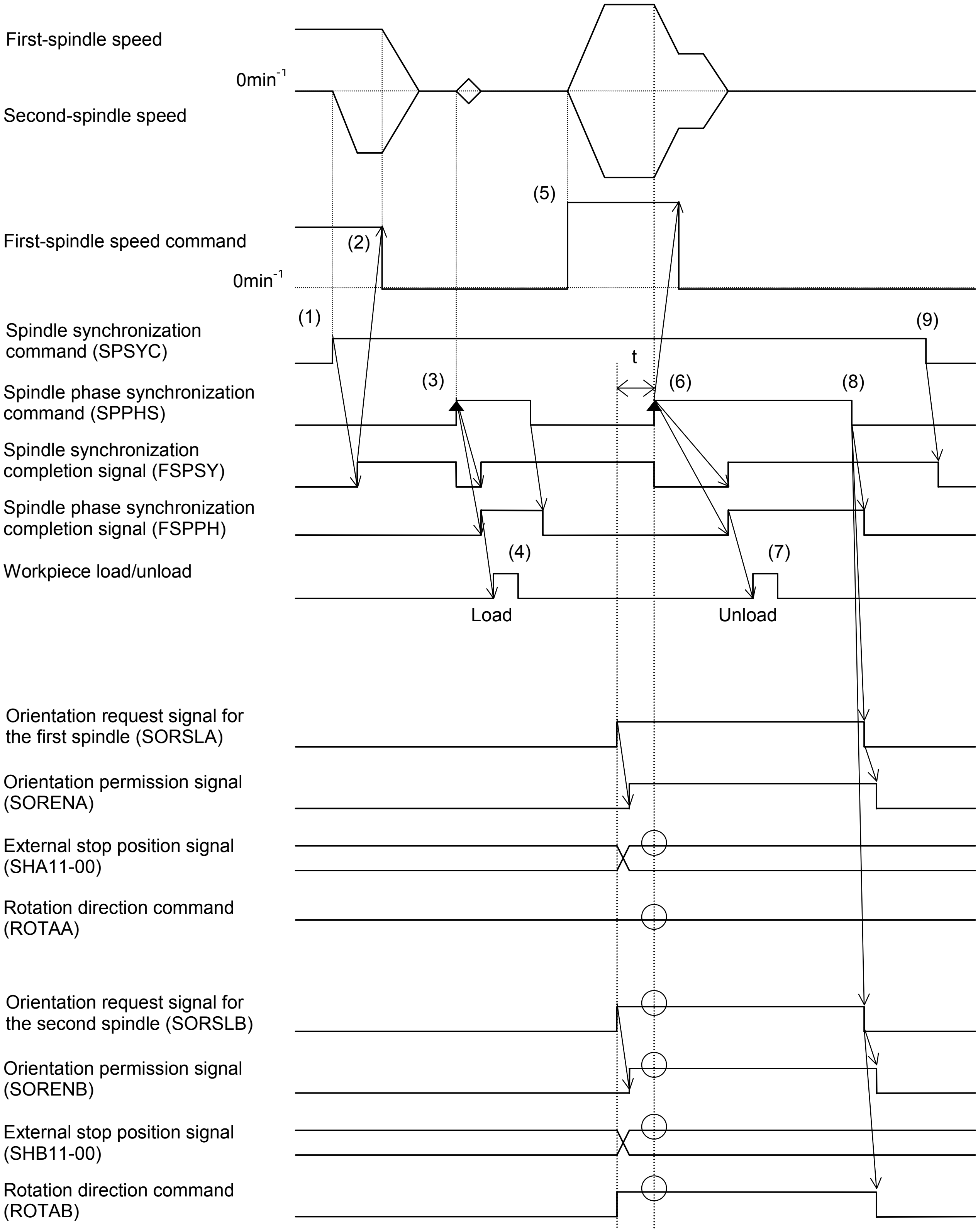
(d) Phase synchronous error monitor signal (SYCAL)

This signal is used to detect when a synchronous error becomes large when the spindles are under synchronous control.
If the signal is detected, the PMC usually performs alarm processing.
The signal becomes "1" if the synchronous error between the two spindles becomes larger than or equal to the value specified in parameter No. 4811 when the spindles are under synchronous control.

5.5.5 Sequence

Shown below is an example of a sequence in which synchronous orientation is used. In this example sequence, the first and second spindles are put under spindle synchronous control to perform the machining described below.

(1) The spindle synchronous control command is issued with the first spindle rotating and the second at rest.
(2) Upon completion of spindle synchronization, synchronous speed command = "0" is specified.
(3) The spindle phase synchronous control command is issued for reference position setting.
(4) Upon completion of spindle phase synchronization, a workpiece is loaded.
(5) The workpiece is machined by running the spindles under spindle synchronous control.
(6) The spindles are stopped at a fixed position, using synchronous orientation.
(7) Upon completion of synchronous orientation, the workpiece is unloaded.
(8) Synchronous orientation is released.
(9) Spindle synchronous control is released.



NOTE
Set time t to at least 50 ms so that each signal can be asserted securely.

5.5.6 List of Related Parameters

Parameter No.		Description
16*i*	30*i*	
4800#1,#0	4801#0	Direction in which each of spindles rotates under spindle synchronous control (For 16*i*: #0: First spindle: #1: Second spindle. For 30*i*: Each spindle)
4810	4810	That error pulse difference between two spindles on which the spindle phase synchronous completion signal is output
4811	4811	That error pulse difference between two spindles on which the spindle phase synchronous error monitor signal is output
3702#3,#2	3729#0	Whether the stop position external setting-type spindle orientation function is available (For 16*i*: #0: First spindle: #1: Second spindle. For 30*i*: Each spindle)
4006#4	4006#4	Setting for disabling automatic detection of a one-rotation signal when the spindle synchronous control mode is switched
4014#6	4014#6	Whether the synchronous orientation function is available
4032	4032	Acceleration at spindle synchronous control (It is necessary to specify the same value for the first and second spindles.)
4033	4033	Spindle synchronous speed arrival level
4034	4034	Shift amount at spindle phase synchronous control
4035	4035	Spindle phase synchronous compensation data
4044 4045	4044 4045	Velocity proportional gain on spindle synchronous control (This parameter is selected with the input signal CTH1A.)
4052 4053	4052 4053	Velocity integral gain on spindle synchronous control (This parameter is selected with the input signal CTH1A.)
4056 to 4059	4056 to 4059	Gear ratio data between spindle and motor (These parameters are selected with the input signals CTH1A and CTH2A.)
4065 to 4068	4065 to 4068	Position gain on spindle synchronous control (It is necessary to specify the same value for the first and second spindles.) (These parameters are selected with the input signals CTH1A and CTH2A.)
4075	4075	Orientation completion signal detection level
4085	4085	Motor voltage setting on spindle synchronous control
4336	4336	Acceleration magnetic flux switching point for spindle synchronous control (It is necessary to specify the same value for the first and second spindles.)
4340	4340	Bell-shaped acceleration/deceleration time constant for spindle synchronous control (It is necessary to specify the same value for the first and second spindles.)
4369	4369	Synchronous orientation deceleration coefficient

NOTE
1 See Section 1.3, “PARAMETERS RELATED TO DETECTORS”, in Part I for parameters related to detectors.
2 See Section 4.1, “VELOCITY LOOP GAIN ADJUSTMENT”, in Part I for velocity loop proportional/integral gain tuning.
3 See “Function Description: Spindle Synchronous Control” for parameters related to the spindle synchronous control function.

5.5.7 Details of Related Parameters

16*i*	-	#7	#6	#5	#4	#3	#2	#1	#0
3702	-					OR2	OR1		

OR1 The stop position external setting-type spindle orientation function (for the first spindle) is:
0 : Disabled
1 : Enabled
Set to "1".

OR2 The stop position external setting-type spindle orientation function (for the second spindle) is:
0 : Disabled
1 : Enabled
Set to "1".

-	30i	#7	#6	#5	#4	#3	#2	#1	#0
-	3729								**ORT_S**

ORT_S The stop position external setting-type spindle orientation function is:
0 : Disabled
1 : Enabled
Set to "1".

16i	30i	#7	#6	#5	#4	#3	#2	#1	#0
4014	4014		**SYCORI**						

SYCORI : The synchronous orientation function is:
0 : Disabled
1 : Enabled
Set to "1" for both the spindles.

16i	30i	
4075	4075	**Orientation completion signal detection level**

Unit of data : 1 pulse unit (360 degrees/4096)
Valid data range : 0 to 100
Standard setting value : 10

This parameter is used to specify the synchronous orientation completion pulse width. When the synchronous orientation command is issued, the synchronous orientation completion signal (FSPPH) becomes "1" if the spindle stop position is within the setting data range.
Specify the same value for both the spindles.
This parameter is used also for regular orientation.

16i	30i	
4369	4369	**Synchronous orientation deceleration coefficient**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 0

This parameter is used to specify a change that occurs in the spindle speed during synchronous orientation as a ratio to the acceleration during spindle synchronous control (parameter No. 4032). If the setting is "0", it is assumed to be 100%. (The change ratio specified in parameter No. 4032 is used without modification.)
Specify the same value for both the spindles.

5.6 SPINDLE FINE ACC./DEC. (FAD) FUNCTION

5.6.1 Overview

The spindle fine Acc./Dec. (FAD) function realizes smooth acceleration/deceleration during rigid tapping and Cs contouring control by performing acceleration/deceleration processing with spindle software. It can reduce mechanical shocks that may accompany acceleration/deceleration.

NOTE
1 This function is usable in a combination of the αi spindle amplifier and the FANUC Series 16*i*/18*i*/21*i*-MODEL B CNC.
2 This function cannot be used with the FANUC Series 15*i* MODEL B.
3 This function cannot be used with the FANUC Series 30*i* /31*i* /32*i*.
4 This function cannot be used together with the spindle EGB function.

5.6.2 Series and Editions of Applicable Spindle Software

Spindle software

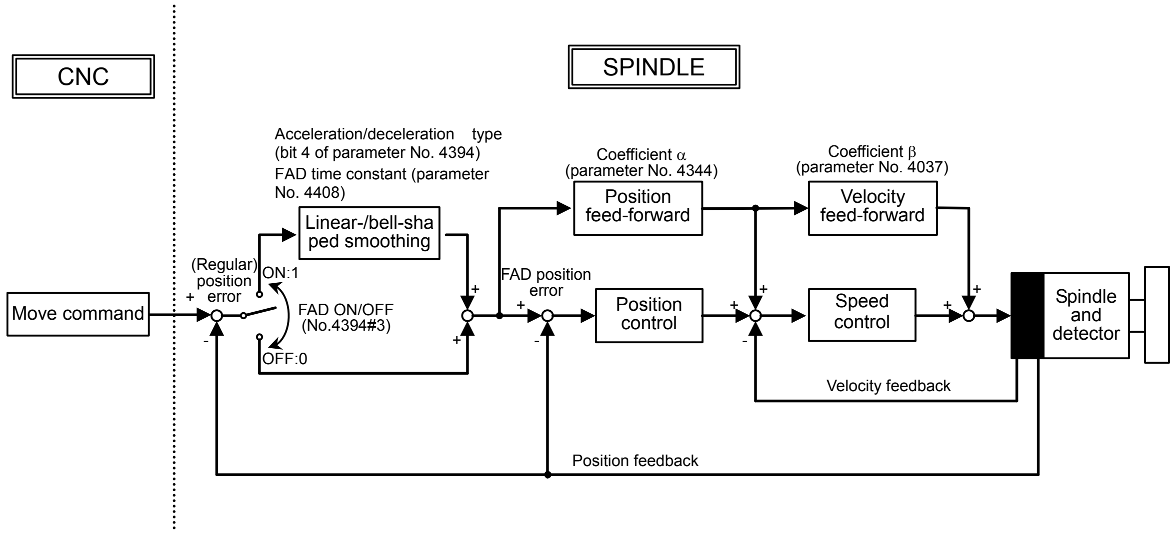
Series	Edition	Remark
9D50	E (05) edition or later	
9D80	A (01) edition or later	
9D90	A (01) edition or later	

CNC software

Series	Edition	Remark
B0H1	M (13) edition or later	For the FANUC Series 16*i*/160*i*/160*i*s-MB
BDH1	M (13) edition or later	For the FANUC Series 18*i*/180*i*/180*i*s-MB
BDH5	C (03) edition or later	For the FANUC Series 18*i*/180*i*/180*i*s-MB5
DDH1	M (13) edition or later	For the FANUC Series 21*i*/210*i*/210*i*s-MB
B1H1	M (13) edition or later	For the FANUC Series 16*i*/160*i*/160*i*s-TB
BEH1	M (13) edition or later	For the FANUC Series 18*i*/180*i*/180*i*s-TB
DEH1	M (13) edition or later	For the FANUC Series 21*i*/210*i*/210*i*s-TB

5.6.3 Block Diagram

Shown below is the block diagram of a system configuration in which spindle fine Acc./Dec. is used. Smooth acceleration/ deceleration is realized by applying linear- or bell-shaped smoothing to the move command from the CNC on small cycles in the spindle software.



5.6.4 Parameters

(1) List of Related Parameters

Parameter No. 16*i*	Description
5205 #7	Setting of fine Acc./Dec. during rigid tapping
4394#3	Spindle fine Acc./Dec. function bit
4394#4	Acceleration/deceleration type during spindle fine Acc./Dec.
4344	Feed-forward coefficient during fine Acc./Dec.
4037	Velocity loop feed-forward coefficient during fine Acc./Dec.
4408	Fine Acc./Dec. time constant
4409	Feed-forward timing adjustment coefficient

(2) Details of parameters related to rigid tapping

16*i*	#7	#6	#5	#4	#3	#2	#1	#0
5205	REF							

REF Setting of fine Acc./Dec. during rigid tapping
- 0 : No fine Acc./Dec. (FAD) is available.
- 1 : Fine Acc./Dec. (FAD) is available.

To be set to "1" if the spindle fine Acc./Dec. (FAD) function is used.

(3) Details of parameters related to serial spindles

16*i*	#7	#6	#5	#4	#3	#2	#1	#0
4394				FADLIN	FADFNC			

FADFNC Spindle fine Acc./Dec. (FAD) function bit
- 0 : The fine Acc./Dec. (FAD) function is disabled.
- 1 : The fine Acc./Dec. (FAD) function is enabled.

To be set to "1" if the spindle fine Acc./Dec. (FAD) function is used.

FADLIN Acceleration/deceleration type during spindle fine Acc./Dec. (FAD)
- 0 : Bell-shaped Acc./Dec.
- 1 : Linear-shaped Acc./Dec.

Specify the same acceleration/deceleration type as for the servo axis for which interpolation is performed simultaneously with this function.

16*i*	
4344	**Feed-forward coefficient during fine Acc./Dec.**

Unit of data : 0.01%
Valid data range :0 to 10000
Standard setting value : 0

This parameter is used to specify the feed-forward coefficient for spindle fine Acc./Dec.
Specify the same setting for the servo axis for which interpolation is performed simultaneously with this function.

16*i*	
4037	**Velocity loop feed-forward coefficient during fine Acc./Dec.**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

This parameter is used to specify the velocity loop feed-forward coefficient during fine Acc./Dec. (FAD). Determine what to specify according to the following calculation.

$$\text{Setting} = 214466 \times \frac{\text{[spindle inertia + rotor inertia] (kgm}^2\text{)}}{\text{motor maximum torque (Nm)}}$$

16*i*	
4408	**Fine Acc./Dec. time constant**

Unit of data : 1msec
Valid data range : 8 to 64
Standard setting value : 0

This parameter is used to specify the time constant for spindle fine Acc./Dec. (FAD). If the specified value is out of the valid data ranging, the setting is clamped to the upper or lower limit.
No cutting/traverse time constant switching function is available.
Specify the same value as for the servo axis (for cutting) for which interpolation is performed simultaneously with this function.

16*i*	
4409	**Feed-forward timing adjustment coefficient**

Unit of data : 0.001msec
Valid data range : -1000 to 1000
Standard setting value : 0

This parameter is used to adjust the timing of the feed-forward term of the velocity command to improve accuracy of the synchronization with the servo axis being accelerated or decelerated.
Setting -1000 advances the timing by 1 ms, and setting +1000 lags the timing by 1 ms.

5.6.5 Diagnosis (Diagnosis Screen)

Address 16*i*	Description
418	1st-spindle (regular) position error
420	2nd-spindle (regular) position error
422	3rd-spindle (regular) position error
424	4th-spindle (regular) position error
714	1st-spindle (FAD) position error
715	2nd-spindle (FAD) position error
734	3rd-spindle (FAD) position error
735	4th-spindle (FAD) position error

5.6.6 Status Errors

Error No.	Description	Measure
31	Invalid hardware configuration	Check the model of the CNC in use.
34	An attempt was made to enable both the spindle FAD function and spindle EGB function.	To use the spindle FAD function, disable the spindle EGB function.

5.6.7 Cautions

(1) Cautions for using the synchronization and fine Acc./Dec. (FAD) functions simultaneously between the servo axis and spindle axis

The following restrictions are placed on the simultaneous use of the synchronization and fine Acc./Dec. (FAD) functions between the servo axis (hereafter SV axis) and spindle axis (hereafter SP axis).

Function	Whether the SV-axis FAD is usable		Cautions about simultaneous use
	If the SP-axis FAD is disabled	If the SP-axis FAD is enabled	
Rigid tapping	Usable	Usable	If the SP-axis FAD is disabled: FAD and feed-forward are kept off during rigid tapping. Establishing synchronization requires changing the position gain for SV-axis rigid tapping (bit 3 of parameter No. 2209 or parameter Nos. 5280 to 5284). (*) If the SP-axis FAD is enabled: It is necessary to use the same FAD time constant, acceleration/deceleration type, feed-forward coefficient, and position gain for both the SV axis (for cutting) and SP axis.
Advanced preview rigid tapping	Unusable	Usable	It is necessary to use the same FAD time constant, acceleration/deceleration type, feed-forward coefficient, and position gain for both the SV axis (for cutting) and SP axis.
Cs contouring control	Unusable	Usable	It is necessary to use the same FAD time constant, acceleration/deceleration type, feed-forward coefficient, and position gain for both the SV axis (for cutting) and SP axis.
Hobbling function	Unusable	Unusable	Disable the SV-axis FAD function.
EGB function	Unusable	Unusable	Disable the SV-axis FAD function.

Function	Whether the SV-axis FAD is usable		Cautions about simultaneous use
	If the SP-axis FAD is disabled	If the SP-axis FAD is enabled	
Flexible synchronization	Unusable	Usable	It is necessary to use the same FAD time constant, acceleration/deceleration type, feed-forward coefficient, and position gain for both the SV axis (for cutting) and SP axis.

NOTE

(*) If the SP-axis FAD is disabled, set bit 3 of parameter No. 2209 to 1, or set parameter Nos. 5280 to 5284 with a value 1 ms higher than otherwise.

If the SP-axis FAD is enabled, reset bit 3 of parameter No. 2209 to 0 and set parameter Nos. 5280 to 5284 with the same value as for the spindle axis.

Refer to the “FANUC AC SERVO MOTOR αis/αi/βis series Parameter Manual (B-65270EN)” for details.

(2) Cautions about position error

When the spindle fine Acc./Dec. (FAD) function is in use, the following two types of position error can occur because the spindle software applies smoothing to a motion command from the CNC.

- Actual position error related to the command from the CNC: (Regular) position error
- Position error used within the spindle software: FAD position error

These position error are used for the following purposes.

- (Regular) position error: Excessive-error check and in-position check
- FAD position error: Error display on the spindle adjustment screen

NOTE

The (regular) position error becomes larger by the amount of an influence of fine Acc./Dec. (FAD) smoothing. So, include this amount when specifying excessive-error and in-position check levels.

An increase in the position error caused by fine Acc./Dec. (FAD) is obtained by:

[When the linear type is used.]

$$\text{Increase in pos. error (pulses)} = \text{detection unit} \times \frac{\text{feedrate (min}^{-1}\text{)}}{60 \times 1000} \times \left[\frac{\text{FAD time constant (ms)} + 1}{2} + 1 \right]$$

[When the bell-shaped type is used.]

$$\text{Increase in pos. error (pulses)} = \text{detection unit} \times \frac{\text{feedrate (min}^{-1}\text{)}}{60 \times 1000} \times \left[\frac{\text{FAD time constant (ms)}}{2} + 1 \right]$$

Letting the FAD time constant and feedrate be, respectively, 64 ms (bell-shaped type) and 3000 min^{-1} for rigid tapping (with a detection unit of 4096 pulses/rev):

$$\text{Increase in pos. error (pulses)} = 4096 \times \frac{3000}{60 \times 1000} \times \left[\frac{64}{2} + 1 \right] = 6758$$

5.7 UNEXPECTED DISTURBANCE TORQUE DETECTION FUNCTION (OPTIONAL FUNCTION)

5.7.1 Overview

The unexpected disturbance torque detection function is intended to monitor friction torque components and those needed in machining by extracting them from the torque output from the spindle motor and eliminating the torque needed in acceleration/deceleration. It can be used to detect a broken tool and to manage the tools for service life.

NOTE
1. Using this function requires the CNC software option for the unexpected disturbance torque detection function.
2. A broken or worn tool may or may not be able to be detected depending on the machine condition.

5.7.2 Series and Editions of Applicable Spindle Software

Series	Edition	Remark
9D50	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

5.7.3 I/O Signals (CNC↔PMC)

(1) Address list of output signals (CNC→PMC)

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
F090	F090					ABTSP3	ABTSP2	ABTSP1	
F091	F091				ABTSP4				

15*i*								
F155	AQSP2	AQSP1						
F154					AQSP4	AQSP3		

(2) Details of output signals (CNC→PMC)

(a) First-spindle unexpected disturbance torque detection signals (ABTSP1 and AQSP1)
(b) Second-spindle unexpected disturbance torque detection signals (ABTSP2 and AQSP2)
(c) Third-spindle unexpected disturbance torque detection signals (ABTSP3 and AQSP3)
(d) Fourth-spindle unexpected disturbance torque detection signals (ABTSP4 and AQSP4)

These signals are output when the estimated load torques on the respective spindles become higher than or equal to the set level.
Refer to an applicable CNC Connection Manual (Function) for details.

(a) For Series 16*i*/18*i*/21*i*

"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 2.10, "ABNORMAL LOAD DETECTION."

(b) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 2.9, "ABNORMAL LOAD DETECTION."

(c) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 2.9, "UNEXPECTED DISTURBANCE TORQUE DETECTION FUNCTION."

(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 2.9, "ABNORMAL LOAD DETECTION."

(e) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 2.9, "UNEXPECTED DISTURBANCE TORQUE DETECTION FUNCTION."

(f) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 2.9, "UNEXPECTED DISTURBANCE TORQUE DETECTION FUNCTION."

5.7.4 List of Related Parameters

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3015 #1	4015 #1	4015 #1	Whether the unexpected disturbance torque detection function is available (The CNC software option is required.)
3248	4248	4248	Torque constant for spindle load torque monitoring (for high-speed output switching characteristics)
3281	4281	4281	Torque constant for spindle load torque monitoring (for low-speed output switching characteristics)
3249	4249	4249	Observer gain 1 for spindle load torque monitoring
3250	4250	4250	Observer gain 2 for spindle load torque monitoring
3341	4341	4341	Unexpected disturbance torque detection level

5.7.5 Details of Related Parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3015	4015	4015							SPLDMT	

SPLDMT : Whether the unexpected disturbance torque detection function is available
0 : Unavailable
1 : Available
This parameter is specified automatically by the software option.

15*i*	16*i*	30*i*	
3248	4248	4248	**Torque constant for spindle load torque monitoring (for high-speed output switching characteristics)**
3281	4281	4281	**Torque constant for spindle load torque monitoring (for low-speed output switching characteristics)**

Unit of data :
Valid data range : 0 to 32767
Standard setting value :

Specify the torque constant Kt for calculating the spindle load torque, using the following calculation:

$$Kt = \frac{T\max}{Jm + Jl} \times 4.889$$

Tmax : Motor maximum output torque [Nm] (Use 120% of the 30-minute rated torque as a rough standard.)
Jm : Motor rotor inertia [kgm^2]
Jl : Spindle inertia (in terms of motor axis inertia) [kgm^2]

15i	16i	30i	
3249	4249	4249	**Observer gain 1 for spindle load torque monitoring**
3250	4250	4250	**Observer gain 2 for spindle load torque monitoring**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 500
Specify the gain (usually “500”) for the spindle load torque estimation observer.

15i	16i	30i	
3341	4341	4341	**Unexpected disturbance torque detection level**

Unit of data : 0.01%
Valid data range : 0 to 10000
Standard setting value : 0
Specify the output level for the spindle unexpected disturbance torque detection signal, using a percentage to the motor maximum output torque. If this parameter is “0”, no spindle unexpected disturbance torque detection signal is output.

5.7.6 Parameter Tuning Procedure

(1) Parameter initialization

Initialize the parameters related to the unexpected disturbance torque detection function as listed below.

No.	Description	Initial setting
4015#1	Whether the unexpected disturbance torque detection function is available (The CNC software option is required.)	1
4248	Torque constant for spindle load torque monitoring	Specify an appropriate value according to the spindle inertia (see the following expression).
4249	Observer gain 1 for spindle load torque monitoring	500
4250	Observer gain 2 for spindle load torque monitoring	500
4341	Unexpected disturbance torque detection level	0 (to be changed to an appropriate value according to the use of the machine)

(2) Initial setting of the torque constant (parameter No. 4248)

Using the following expression, calculate the initial torque constant setting according to the spindle inertia and specify it in the corresponding parameter.

$$Kt = \frac{T\max}{Jm + Jl} \times 4.889$$

Tmax : Motor maximum output torque [Nm] (Use 120% of the 30-minute rated torque as a rough standard.)
Jm : Motor rotor inertia [kgm^2]

Jl : Spindle inertia (in terms of motor axis inertia) [kgm^2]

Example) Initial torque constant setting for the αiI3/10000

Letting motor rotor inertia Jm, motor maximum output torque Tmax, and spindle inertia Jl be, respectively, 0.0148 kgm^2, 35.0 × 1.2 = 42.0 Nm, and 0.0250 kgm^2, the torque constant is:

$$Kt = 42.0/(0.0148 + 0.0250) \times 4.889 = 5159.24$$

So, set parameter No. 4248 to “5159”.

(3) Tuning the torque constant (parameter No. 4248)

Described below is how to tune the torque constant while observing the spindle torque data, using the spindle check board (A06B-6078-H001). Refer to an applicable maintenance manual for detailed explanations about how to use the spindle check board.

First set up the spindle check board as listed below.

Output terminal	Output data	Setting		Resolution
CH1	Motor speed	d-05	19	1638.4 min^{-1}/V
		d-06	18	
		d-07	0	
		d-08	1	
CH2	Spindle load torque	d-09	277	5V = *T*max (motor maximum output torque)
		d-10	7	
		d-11	0	
		d-12	1	

With the above settings, direct the machine to run at a speed that matches your machining program, cause it to perform acceleration/deceleration with no load, and observe the load torque on the spindle.
While observing the waveform of the spindle load torque, tune the torque constant so that the spindle load torque during acceleration will get close (and flat) to 0.
See the following charts for details.

Fig. <1>: Parameter No. 4248 = 10000

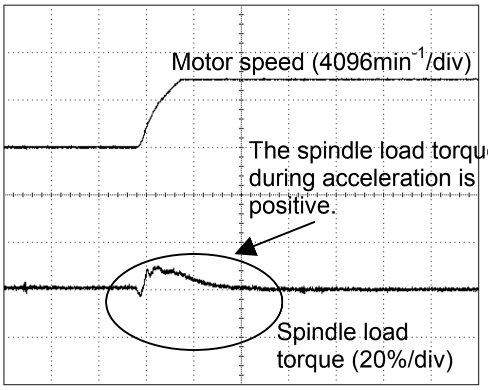


Fig. <2>: Parameter No. 4248 = 15000

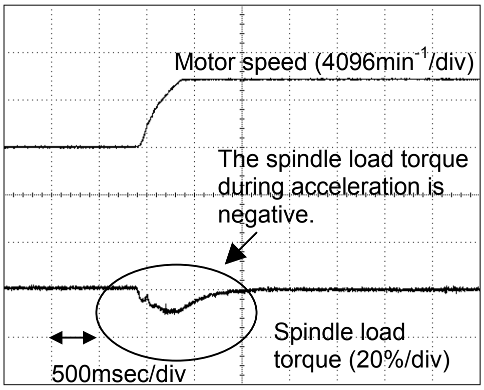
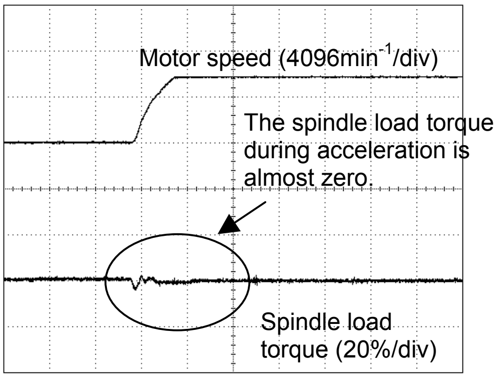


Fig. <3>: Parameter No. 4248 = 12000 (final value)



5.8 SPINDLE EGB (SPINDLE ELECTRONIC GEAR BOX) (OPTIONAL FUNCTION)

5.8.1 Overview

The spindle EGB function is intended to use one of spindles in a pair as a tool axis (master axis) and the other as a workpiece axis (slave axis) and cause the slave axis to rotate in synchronization with the master axis at a specified synchronous ratio. Refer to an applicable CNC Connection Manual (Function) for details of this function.

(a) For Series 16*i*/18*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 1.14.2, “Spindle Electronic Gear Box (M series).”

(b) For Series 30*i*-A/31*i*-A5/31*i*-A
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

(c) For Series 30*i*-B/31*i*-B5/31*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

NOTE

1. Using this function requires the CNC software option.
2. Using this function requires SP TYPE B for both the master and slave axes.
3. For the master and slave axes, use the spindle software of the same series and edition.
4. This function cannot be used together with the spindle fine Acc./Dec. (FAD) function.
5. This function cannot be used together with the toque tandem control function.
6. This function cannot be used with the FANUC Series 15*i*-MODEL B.
7. This function cannot be used with the FANUC Series 32*i*.
8. There are no limitations on the assignment of the master and slave axes.
   For descriptive purposes, this specification assumes:
   Master spindle amplifier: 1st spindle
   Slave spindle amplifier: 2nd spindle

5.8.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Remark
9D50	E (05) edition or later	
9D80	A (01) edition or later	
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9DA0	B (02)	FS30*i* / FS31*i* / FS32*i* -B

NOTE
When using the αiCZ sensor (serial) as the motor or spindle sensor, use 9D80 series H (08) edition.

CNC software

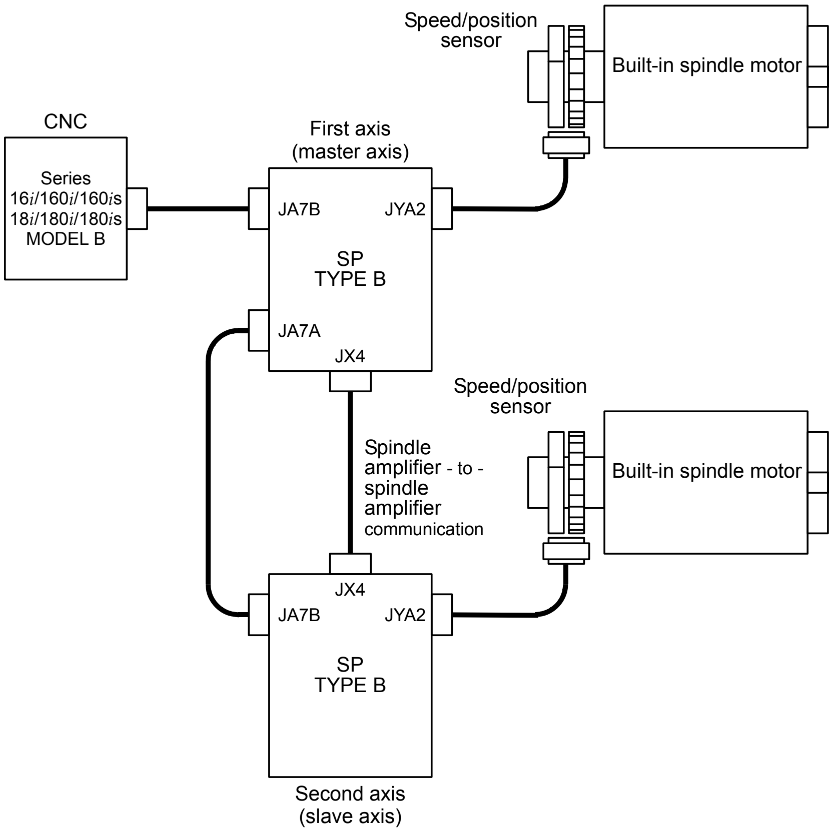
Series	Edition	Remark
B0H1	A (01) edition or later	For FANUC Series 16*i*/160*i*/160*i*s-MB
BDH1	A (01) edition or later	For FANUC Series 18*i*/180*i*/180*i*s-MB
BDH5	A (01) edition or later	For FANUC Series 18*i*/180*i*/180*i*s-MB5
G003/G013/ G023/G033/ G00C/G01C G02C/G03C	28 edition or later	For FANUC Series 30*i*/300*i*/300*i*s-A
G004/G014 G024/G034	01 edition or later	
G123/G133 G12C/G13C	28 edition or later	For FANUC Series 31*i*/310*i*/310*i*s-A5
G124/G134	01 edition or later	
G103/G113	28 edition or later	For FANUC Series 31*i*/310*i*/310*i*s-A
G104/G114	01 edition or later	

5.8.3 System Configuration

The spindle EGB function is usable in the following system configuration.

NOTE
The spindle EGB function is usable between spindles having a different detector configuration.

(1) System configuration with built-in motors



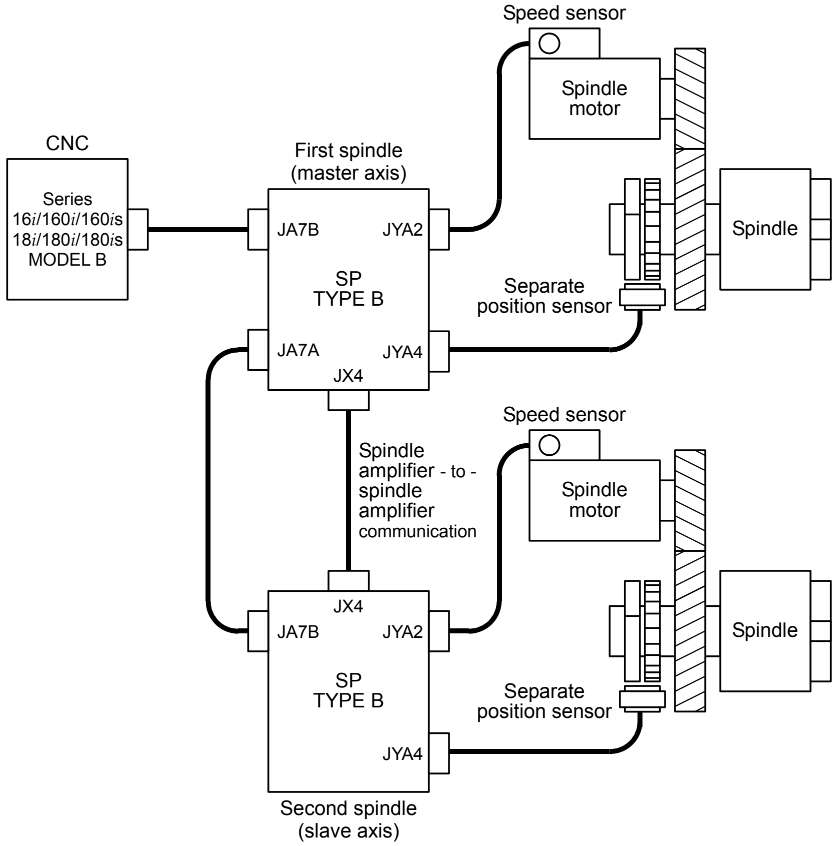
> **NOTE**
> When using the αiCZ sensor (serial) as the speed/position sensor, connect the feedback cable to JYA3.

Parameter settings related to detectors

Parameter	Setting	Description
4000#0	0	The spindle and motor rotates in the same direction.
4002#3,#2,#1,#0	0,0,0,1	The motor sensor is used for position feedback.
4003#7,#6,#5,#4	0,0,0,0	It is unnecessary to specify the number of the spindle sensor teeth.
4010#2,#1,#0	0,0,1	αiMZ/αiBZ/αiCZ sensor (analog)
	0,1,1	αiCZ sensor (serial)
4011#2,#1,#0 or 4334	Depending on the sensor.	Setting for the number of motor sensor (speed sensor) teeth
4056 to 4059	100 or 1000	The spindle-to-motor gear ratio is 1:1. (The settings for these parameters vary depending on the gear ratio increment system specified in bit 1 or parameter No. 4006.)
4386 (*)	Depending on the sensor.	Setting for the number of master-axis motor sensor (speed sensor) teeth

(*) This parameter is valid only for the slave axis (second spindle).

(2) System configuration with separate α*i*BZ sensors or separate α*i*CZ sensors



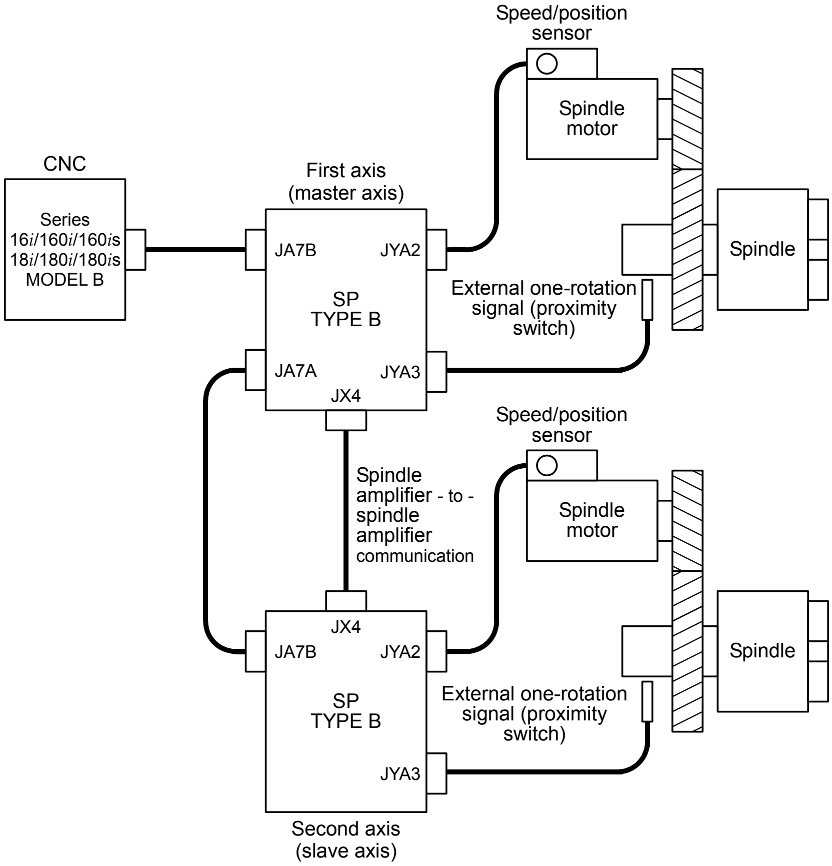
> **NOTE**
> When using the α*i*CZ sensor (serial) as the separate position sensor, connect the feedback cable to JYA3.

Parameter settings related to detectors

Parameter	Setting	Description
4000#0	Depending on the spindle configuration	Setting for the relationship between the rotation directions of the spindle and motor
4001#4	Depending on the spindle configuration	Setting for the orientation in which the spindle sensor is mounted
4002#3,#2,#1,#0	0,0,1,0	α*i*BZ sensor, α*i*CZ sensor (analog)
	0,1,1,0	α*i*CZ sensor (serial)
4003#7,#6,#5,#4 or 4361	Depending on the sensor	Setting for the number of spindle sensor (position sensor) teeth.
4010#2,#1,#0	0,0,0	α*i*M sensor
	0,0,1	α*i*MZ sensor
4011#2,#1,#0 or 4334	Depending on the sensor	Setting for the number of motor sensor (speed sensor) teeth
4056 to 4059	Depending on the spindle configuration	Setting for the spindle-to-motor gear ratio
4386 (*)	Depending on the sensor	Setting for the number of master-axis motor sensor (speed sensor) teeth

(*) This parameter is valid only for the slave axis (second spindle).

(3) System configuration where an external one-rotation signal (proximity switch) is used



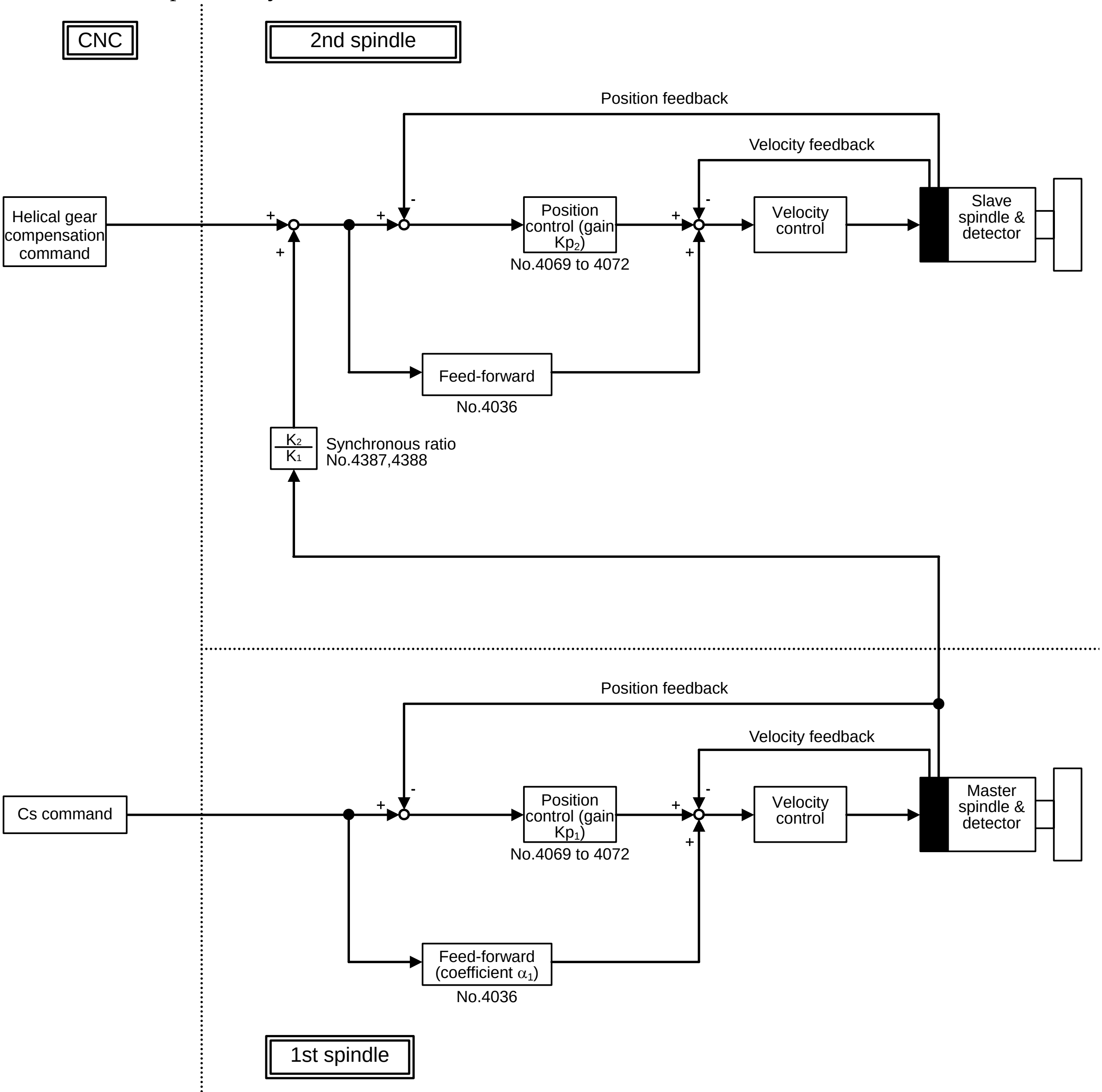
Parameter settings related to detectors

Parameter	Setting	Description
4000#0	Depending on the spindle configuration	Setting for the relationship between the rotation directions of the spindle and motor
4002#3,#2,#1,#0	0,0,0,1	To be used for the position feedback of the motor sensor
4003#7,#6,#5,#4	0,0,0,0	It is unnecessary to specify the number of teeth on the spindle sensor.
4004#2	1	An external one-rotation signal (proximity switch) is used.
4004#3	Depending on the sensor	Setting for the type of the external one-rotation signal (proximity switch)
4010#2,#1,#0	0,0,1	αiMZ/αiBZ/αiCZ sensor (analog)
4011#2,#1,#0 or 4334	Depending on the sensor	Setting for the number of motor sensor (speed sensor) teeth
4056 to 4059	Depending on the spindle configuration	Setting for the spindle-to-motor gear ratio
4171 to 4174	Depending on the spindle configuration	Setting for the spindle-to-motor gear ratio (arbitrary gear ratio).
4386 (*)	Depending on the sensor	Setting for the number of master-axis motor sensor (speed sensor) teeth
4498, 4499 (*)	Depending on the spindle configuration	Setting for the master-axis spindle-to-motor gear ratio (arbitrary gear ratio)

(*) This parameter is valid only for the slave axis (second spindle).

5.8.4 Block Diagram

Shown below is the block diagram of a system configuration in which the spindle EGB is used.
In this system configuration, it is possible to use one of spindles in a pair as a tool axis (master axis) and the other as a workpiece axis (slave axis) and cause the slave axis to rotate in synchronization with the master-axis at a specified synchronous ratio.



NOTE
1. It is possible to drive the master axis (first spindle) on the velocity control mode.
2. To drive the master axis at a constant speed in the Cs contouring control mode, use the position control function for the PMC axis control constant-speed command.

5.8.5 I/O Signals (CNC↔PMC)

This subsection lists only the input/output signals related to the spindle EGB. Refer to an applicable CNC Connection Manual (Function) for details of each signal.

(a) For Series 16*i*/18*i*
FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION): B-63523EN-1
Refer to Subsection 1.14.2, “Spindle Electronic Gear Box (M series).”

(b) For Series 30*i*-A/31*i*-A5/31*i*-A
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

(c) For Series 30*i*-B/31*i*-B5/31*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

(1) Input signals (PMC→CNC)

	#7	#6	#5	#4	#3	#2	#1	#0
G066				RTRCT				

(2) Output signals (CNC→PMC)

	#7	#6	#5	#4	#3	#2	#1	#0
F065		SYNMOD		RTRCTF				

5.8.6 Examples of Sequences

Refer to an applicable CNC Connection Manual (Function) for spindle EGB sequences.

(a) For Series 16*i*/18*i*
FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 1.14.2, “Spindle Electronic Gear Box (M series).”

(b) For Series 30*i*-A/31*i*-A5/31*i*-A
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

(c) For Series 30*i*-B/31*i*-B5/31*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

5.8.7 List of Related Parameters

Parameter No.		Description
16*i*	30*i*	
7700#0	7700#0	Setting for releasing the synchronous control mode at a reset
7700#2	7700#2	Direction for helical compensation
7709	7709	Axis number for helical gear axial feed axis
7710	7710	Spindle EGB slave axis number
7771	-	Spindle EGB master axis number
7772	7772	The number of pulses the position sensor generates at each rotation of the tool axis (master axis) (Specify 360,000 for the IS-B.)
7773	7773	The number of pulses the position sensor generates at each rotation of the workpiece axis (slave axis) (Specify 360,000 for the IS-B.)
8005#4	8005#4	Setting for the type of the PMC axis control constant-speed command function

Parameter No.		Description
16*i*	30*i*	
-	8007#2	Setting for the velocity command for PMC axis control
8028	8028	16*i*: Time constant for linear-shaped Acc./Dec. in speed command-based continuous feed for each axis in PMC-based axis control 30*i*: Time for calculating the acceleration and deceleration for the velocity command for PMC axis control
-	8032	Feedrate for calculating the acceleration rate for the velocity command for PMC axis control
8040	8040	Number of pulses the position sensor generates at each rotation of the spindle on a PMC-controlled axis (Specify 360,000 for the IS-B.)
4016#3	4016#3	Setting for the feed-forward smoothing function
4352#4	4352#4	Feed-forward setting
4352#6	4352#6	Inter-spindle amplifier communication slave axis setting
4352#7	4352#7	Inter-spindle amplifier communication master axis setting
4036	4036	Feed forward coefficient
4037	4037	Velocity loop feed forward coefficient
4046 4047	4046 4047	Velocity proportional gain on Cs contouring control (This parameter is selected with the PMC input signal CTH1A.)
4054 4055	4054 4055	Velocity integral gain on Cs contouring control (This parameter is selected with the PMC input signal CTH1A.)
4069 to 4072	4069 to 4072	Position gain on Cs contouring control (This parameter is selected with the PMC input signal CTH1A.)
4386	4386	Number of master-axis spindle sensor teeth
4387	4387	Synchronous ratio numerator
4388	4388	Synchronous ratio denominator
4498	4498	Denominator of the master-axis motor sensor-to-spindle arbitrary gear ratio
4499	4499	Numerator of the master-axis motor sensor-to-spindle arbitrary gear ratio
4396#2	4396#2	Setting for on-off switching of the EGB command on Cs contouring control

NOTE

1. See Section 1.3, “PARAMETERS RELATED TO DETECTORS”, in Part I for parameters related to detectors.
2. See Section 4.1, “VELOCITY LOOP GAIN ADJUSTMENT”, in Part I for velocity loop proportional/integral gain tuning.

5.8.8 Details of Related Parameters

This subsection details the serial spindle parameters related to the EGB (for the 16*i*, parameter Nos. 4000 to 4999). It also briefly describes the parameters related to the position control function for the PMC axis control constant-speed command. Refer to an applicable CNC Connection Manual (Function) for details of other parameters.

(a) For Series 16*i*/18*i*
FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Subsection 1.14.2, “Spindle Electronic Gear Box (M series).”

(b) For Series 30*i*-A/31*i*-A5/31*i*-A
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

(c) For Series 30*i*-B/31*i*-B5/31*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

(1) Summary of parameters related to the position control function for the PMC axis control constant-speed command

This paragraph summarizes parameters related to the position control function for the PMC axis control constant-speed command. Refer to an applicable CNC manual for details of this function and PMC axis control.

(a) For Series 16*i*/18*i*
"FANUC Series 16*i*/18*i* PMC Axis Control Function Constant-Speed Command Position Control Function Description: A-63542E"
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION): B-63523EN-1
Refer to Section 15.1, "PMC AXIS CONTROL FUNCTION."
(b) For Series 30*i*-A/31*i*-A5/31*i*-A
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 17.1, "PMC AXIS CONTROL FUNCTION."
(c) For Series 30*i*-B/31*i*-B5/31*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 17.1, "PMC AXIS CONTROL FUNCTION."

> **NOTE**
> To drive the master axis at a constant speed in the Cs contouring control mode, use the position control function for the PMC axis control constant-speed command.

16*i*-B	30*i*-A	#7	#6	#5	#4	#3	#2	#1	#0
8005	8005				PMCPOS				

PMCPOS Setting for the type of the PMC axis control constant-speed command function
0 : Velocity control
1 : Position control
To be set to "1"

30*i*-A	#7	#6	#5	#4	#3	#2	#1	#0
8007						VCP		

VCP Velocity command for PMC axis control
0 : FS15 specification
1 : FS16 specification
To be set to "1"

16*i*-B	
8028	**Time constant for linear-shaped Acc./Dec. in speed command-based continuous feed for each axis in PMC-based axis control**

Unit of data : 1msec / 1000min^{-1}
Valid data range : 0 to 32767
Standard setting value : 0
Specify the time constant for linear-shaped Acc./Dec. for the PMC-controlled axis.

30*i*-A	
8028	**Time for calculating the acceleration and deceleration for the velocity command for PMC axis control**

Unit of data : 1msec
Valid data range : 0 to 32767
Standard setting value : 0

Sets the acceleration rate of parameter No. 8032 and this parameter in the velocity command for PMC axis control.

30*i*-A	
8032	**Feedrate for calculating the acceleration and deceleration for the velocity command for PMC axis control**

Unit of data : min^{-1}
Valid data range : 0 to 32767
Standard setting value : 0

Sets the acceleration rate of this parameter and parameter No. 8028 in the velocity command for PMC axis control.

16*i*-B	30*i*-A	
8040	8040	**Number of pulses the position sensor generates at each rotation of the spindle on a PMC-controlled axis**

Unit of data : Minimum detection unit
Valid data range : 1 to 999,999,999
Standard setting value : 0

Specify the number of pulses the position sensor generates at each rotation of the spindle on a PMC-controlled axis.
Specify "360,000" for the IS-B.

(2) Details of parameters related to serial spindles

This paragraph details the serial spindle parameters related to the EGB (for the 16*i*, parameter Nos. 4000 to 4999). See Section 2.4, "Cs CONTOURING CONTROL", in Part I for details of parameters related to Cs contouring control.

16*i*-B	30*i*-A	#7	#6	#5	#4	#3	#2	#1	#0
4016	4016					**FFSMTH**			

FFSMTH Setting of smoothing function on feed forward control

0 : Without smoothing function
1 : With smoothing function

Sets the presence of smoothing function on feed forward control of Cs contouring control.
Specify "1" to use spindle EGB control.

16*i*-B	30*i*-A	#7	#6	#5	#4	#3	#2	#1	#0
4352	4352	**MASTER**	**SLAVE**		**FFALWS**				

MASTER Inter-spindle amplifier communication master axis setting

0 : Non-inter-spindle amplifier communication master axis
1 : Inter-spindle amplifier communication master axis (Set 1 for the master axis.)

SLAVE Inter-spindle amplifier communication slave axis setting

0 : Non-inter-spindle amplifier communication slave axis
1 : Inter-spindle amplifier communication slave axis (Set 1 for the master axis.)

FFALWS Feed-forward setting

0 : Feed-forward is enabled only during cutting feed.
1 : Feed-forward is always enabled.

Set 0 for the spindle EGB master axis (first spindle) and 1 for the slave axis (second spindle).

16*i*-B	30*i*-A	
4036	4036	**Feed-forward coefficient**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 0

Set the feed forward coefficient when feed forward control is executed on Cs contouring control.
Set 100 for the spindle EGB slave axis (second spindle).

16*i*-B	30*i*-A	
4037	4037	**Velocity loop feed forward coefficient**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

Set the velocity loop feed forward coefficient when feed forward control is executed on Cs contouring control. Set the following calculation equation.

$$\text{Setting} = 214466 \times \frac{[\text{spindle inertia} + \text{rotor inertia}]\ (\text{kgm}^2)}{\text{motor maximum torque (Nm)}}$$

16*i*-B	30*i*-A	
4386	4386	**Number of master-axis spindle sensor teeth**

Unit of data : 1λ / rev
Valid data range : 0, 64 to 4096
Standard setting value : 0

Specify the number of master-axis spindle sensor teeth (position sensor). If “0” is specified, EGB synchronous ratio is assumed to be “0”.

> **NOTE**
> This parameter is valid only for the slave axis (second spindle).

16*i*-B	30*i*-A	
4387	4387	**Synchronous ratio numerator**

Valid data range : -32767 to 32767
Standard setting value : 0

Specify the numerator of a synchronous ratio.

> **NOTE**
> This parameter is valid only for the slave axis (second spindle).

16*i*-B	30*i*-A	
4388	4388	**Synchronous ratio denominator**

Valid data range : 1 to 65535
Standard setting value : 0

Specify the denominator of a synchronous ratio.

> **NOTE**
> This parameter is valid only for the slave axis (second spindle).

16i-B	30i-A	
4498	4498	**Denominator of the master-axis motor sensor-to-spindle arbitrary gear ratio**
4499	4499	**Numerator of the master-axis motor sensor-to-spindle arbitrary gear ratio**

Valid data range : 0 to 32767
Standard setting value : 0

Specify conversion coefficients (numerator and denominator) to be used when the detection arbitrary gear ratio function (DMR function) is used where the master-axis spindle position feedback signal is obtained by multiplying the feedback signal of the master-axis motor sensor (αiM or αiMZ sensor) by the gear ratio.
If the spindle makes Q turns while the motor shaft makes P turns (where P and Q are mutually prime), the settings are:
Parameter No. 4498 = P and parameter No. 4499 = Q
If the parameters are “0”, they are assumed to be “1”.

> **NOTE**
> This parameter is valid only for the slave axis (second spindle).

16i-B	30i-A	#7	#6	#5	#4	#3	#2	#1	#0
4396	4396						EGBRNX		

EGBRNX Setting for on-off switching of the EGB command on Cs contouring control
0 : Does not carry the remainder of the EGB move command that is produced when the EGB mode is turned off to the next time.
1 : Carries the remainder of the EGB move command that is produced when the EGB mode is turned off to the next time.
Specifies whether to reflect the remaining data of the EGB move command (= synchronous ratio × travel distance along the master axis) that is produced when the EGB mode is turned off to the next time when the EGB mode is turned on.
Set "1" when repeatedly turning the spindle EGB mode on and off while Cs contouring control is kept on.

> **NOTE**
> *1 This parameter is valid only for the slave axis (second spindle).
> *2 This parameter is valid with 9D50 series X (24) edition or later, 9D70 series M (13) edition or later, 9D80 series I (09) edition or later, 9D90 series A (01) edition or later, and 9DA0 series B (02) edition or later.

5.8.9 Diagnosis Signal Related to Spindle EGB

Address 16i	Description	Unit
0717	Synchronous error between master and slave axes. (Weight is slave side)	Pulse

NOTE
1 Displaying this data on the CNC diagnosis screen requires the αi SP TYPE B and the *i* series MODEL B CNC.
2 Displaying this data on the CNC diagnosis screen requires the following CNC software series/editions.
FS16*i*/160*i*/160*i*s-MB :B0H1 series R(18) edition or later
FS18*i*/180*i*/180*i*s-MB : BDH1 series R(18) edition or later
FS18*i*/180*i*/180*i*s-MB5 : BDH5 series H(08) edition or later

5.8.10 Status Errors Related to Spindle EGB

Error No.	Description	Measure
33	Invalid hardware configuration	Check the model of the CNC in use.
34	An attempt was made to enable both the spindle EGB and FAD functions.	To use the spindle EGB function, disable the spindle FAD function.

5.8.11 Alarms

(1) Spindle alarm

Error No.	Description	Measure
66	An error occurred in inter-spindle amplifier communication.	Check the connection of the cable (JX4).
80	An alarm was issued on the destination amplifier of inter-spindle amplifier communication.	Correct the cause of the alarm on the destination spindle amplifier.

(2) CNC alarm

This subsection lists only the alarms related to the spindle EGB function. Refer to an applicable CNC Connection Manual (Function) for details.

(a) For Series 16*i*/18*i*
FANUC Series 16*i*/18*i*-MODEL B
CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 1.14.2, “Spindle Electronic Gear Box (M series).”

Alarm No.	Description
010	A parameter specified for a G81 command is incorrect.
181	The format of a G81 block is incorrect.
184	A command that should not be issued during synchronous control is issued.
186	Incorrect parameter setting for G81: The slave axis has not been specified as a rotary axis.

(b) For Series 30*i*-A/31*i*-A5/31*i*-A
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”
(c) For Series 30*i*-B/31*i*-B5/31*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

Alarm No.	Description
PS1593	Parameter setting mistake related to the EGB
PS1594	Invalid block format of the EGB command

Alarm No.	Description
PS1595	A command that should not be issued during EGB synchronization was issued.
PS1596	An overflow occurred for the synchronization coefficient calculation.

5.9 DIFFERENTIAL SPINDLE SPEED CONTROL

5.9.1 Overview

The differential spindle speed control function controls the velocity of one spindle (slave axis) relative to the velocity of the other of spindle (master axis).
Applying this function to rigid tapping enables tapping the center of a workpiece while rotating a spindle (master axis) that holds a workpiece at a constant speed. Therefore, the time required for stopping the workpiece axis (master axis) can be reduced.

5.9.2 Series and Editions of Applicable Spindle Software

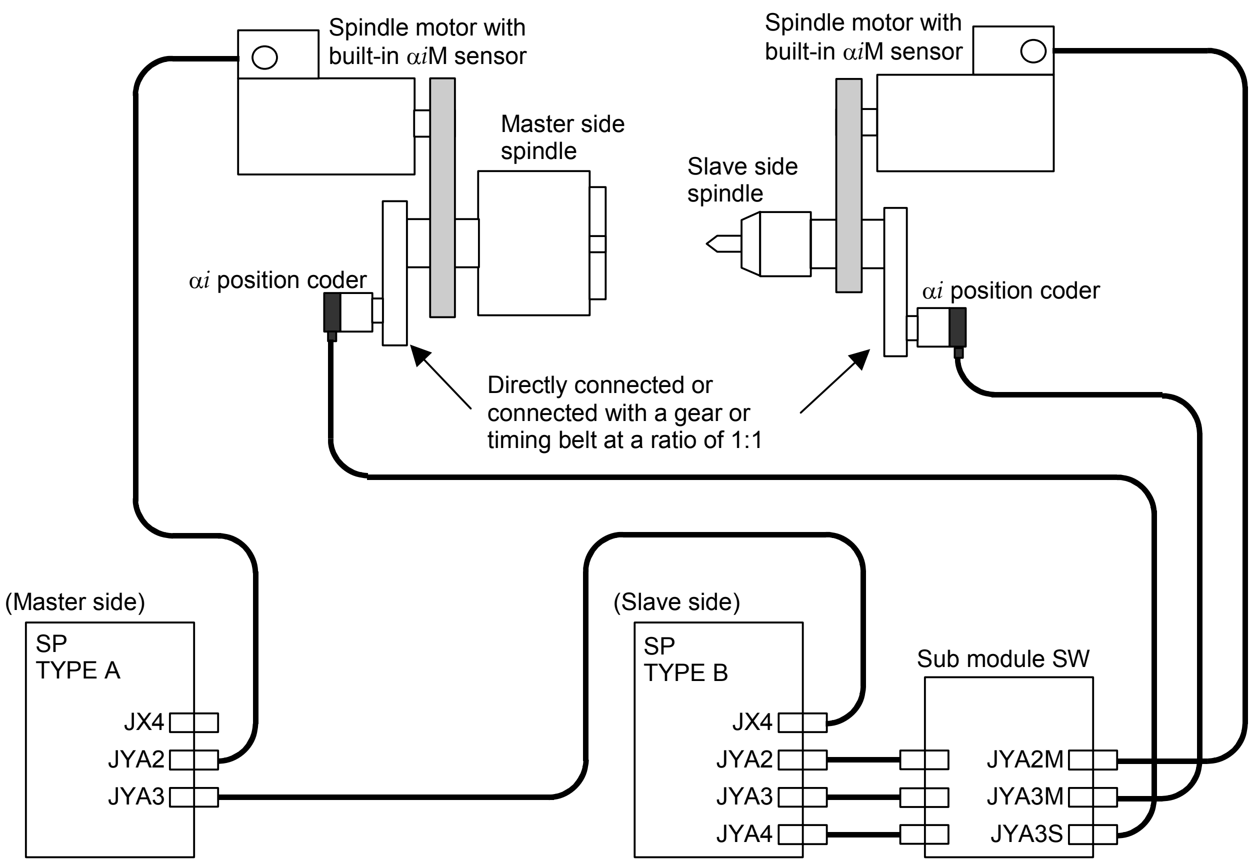
Spindle software

Series	Edition	Usable CNC
9D50	F (06)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*

NOTE
When the α*i*CZ sensor (serial) is used, this function cannot be used.

5.9.3 Configuration

The following figure shows an example of a configuration used for differential spindle speed control.



NOTE

1. The sub module SW (SSW) is required in addition to the spindle amplifier to receive the position coder signal from the master side.
2. When the position coder output of connector JX4 is used, spindle amplifier (SP) TYPE B is used (The maximum speed available for the position coder output is 20000 min^{-1}).

5.9.4 Description

(1) The position coder must be connected to the master side spindle at the ratio of 1:1.
(2) The position coder signal from the master side received by the sub module SW is output from JX4.
(3) Differential spindle speed control can be used only during speed control mode or rigid tapping. It cannot be used during Cs contouring control, spindle synchronous control, or spindle orientation.
(4) When differential spindle speed control is applied to rigid tapping (Differential speed rigid tapping), sum of the velocity of master spindle and the velocity command of rigid tapping for slave spindle must not exceed the maximum speed of slave spindle.
(5) The master side spindle must be kept at a constant speed during rigid tapping. Acceleration or deceleration cannot be performed.
(6) Since the output torque of the motor is normally reduced in high-speed rotation areas, the rigid tapping acceleration/deceleration constant must be set to a greater value.

5.9.5 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G229	G072	G072					DEFMDA			
2nd-	G237	G076	G076					DEFMDB			

(2) Details of input signals (PMC→CNC)

(a) Speed differential mode specification signal (DEFMDA)

This signal is used to specify whether differential spindle speed mode is enabled.

0: Differential spindle speed mode disabled

1: Differential spindle speed mode specified

While this signal is set to 1, the spindle is controlled in differential spindle speed mode.
The velocity of the slave axis in differential spindle speed mode is controlled by the sum of the velocity of the master spindle and the velocity command of the slave spindle.

(3) Output signals (CNC→PMC)

There are no output signals.

5.9.6 Examples of Sequences

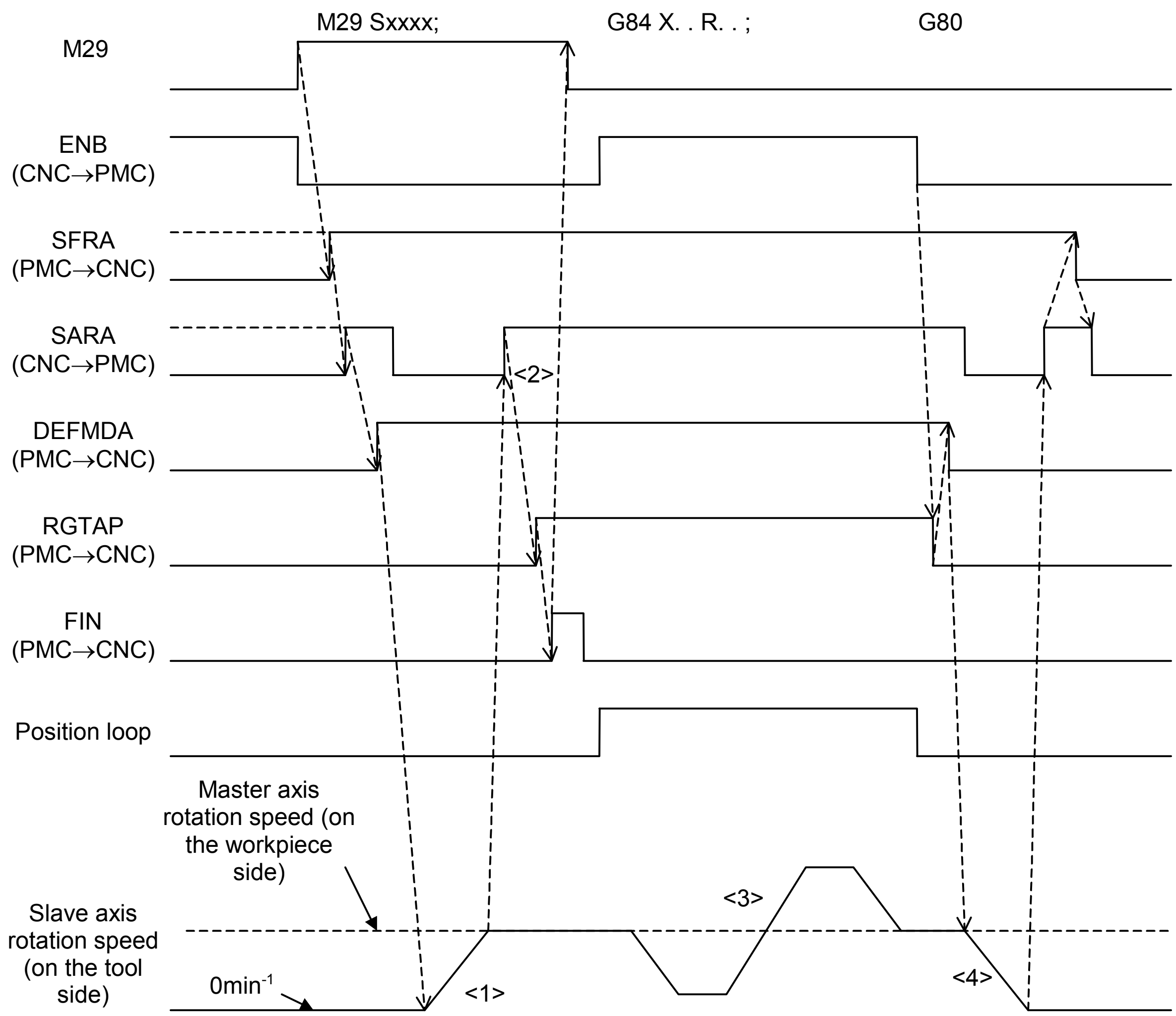
The following shows examples of sequences used when differential speed rigid tapping is performed using the first spindle as the slave axis (on the tool side).

<1> When differential spindle speed mode is commanded to slave spindle, the slave spindle accelerates to the velocity of the master spindle.

<2> After making sure that the slave spindle accelerates to the velocity of the master spindle, start rigid tapping.

<3> Perform differential speed rigid tapping.

<4> When the velocity command of the slave spindle is 0 min^{-1}, if differential spindle speed mode is released upon completion of rigid tapping, the slave spindle stops. If the velocity command of the slave spindle is commanded not equal to 0 min^{-1}, the slave spindle accelerates or decelerates to the velocity commanded.



5.9.7 List of Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
3000 #5	4000 #5	4000 #5	Whether the differential spindle speed control function is available (to be set to 1)
3000 #6	4000 #6	4000 #6	Setting of direction for differential spindle speed control
3017 #0	4017 #0	4017 #0	Setting of speed integration operation when differential spindle speed control is exercised

5.9.8 Details of Related Parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3000	4000	4000		DEFDRT	DEFFNC					

DEFFNC Whether differential spindle speed control function is available
0 : Differential spindle speed control is not available
1 : Differential spindle speed control is available (to be set to 1)

DEFDRT Setting of the direction for differential spindle speed control(feedback polarity on the master side)
0 : Direction same as the feedback signal

1 : Direction opposite to the feedback signal

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3017	4017	4017								VINTDC

VINTDC This parameter sets speed integration operation when differential spindle speed control is exercised.
Set this parameter to 1.

> **NOTE**
> This parameter is valid with 9D50 series M (13) edition or later, 9D70 series C (03) edition or later, and 9D80 series A (01) edition or later.

5.9.9 Status Errors on Differential Spindle Speed Control

Error No.	Description	Measure
10	Differential spindle speed mode and Cs mode are specified at the same time.	Check the sequences.
12	Differential spindle speed mode is specified during spindle synchronous control.	Check the sequences.
13	Differential spindle speed mode is specified during spindle orientation.	Check the sequences.
16	Differential spindle speed mode is specified with speed differential control disabled.	Check the parameter settings and sequences.

5.10 DUAL POSITION FEEDBACK FUNCTION (OPTIONAL FUNCTION)

5.10.1 Overview

When position control is performed by Cs contouring control or rigid tapping with a machine having a large backlash, vibration can be generated in closed loop mode while stable operation is possible in semi-closed loop mode. For such a machine system, the dual position feedback function provides stable control equivalent to control in semi-closed loop mode.

> **NOTE**
> 1 To use this function, a CNC software option for Cs contouring control or rigid tapping is required.
> 2 Here, the semi-closed loop refers to positional control by motor sensor, and the closed loop refers to positional control by spindle sensor.
> 3 The dual position feedback function cannot be used on the spindle switch control SUB side.

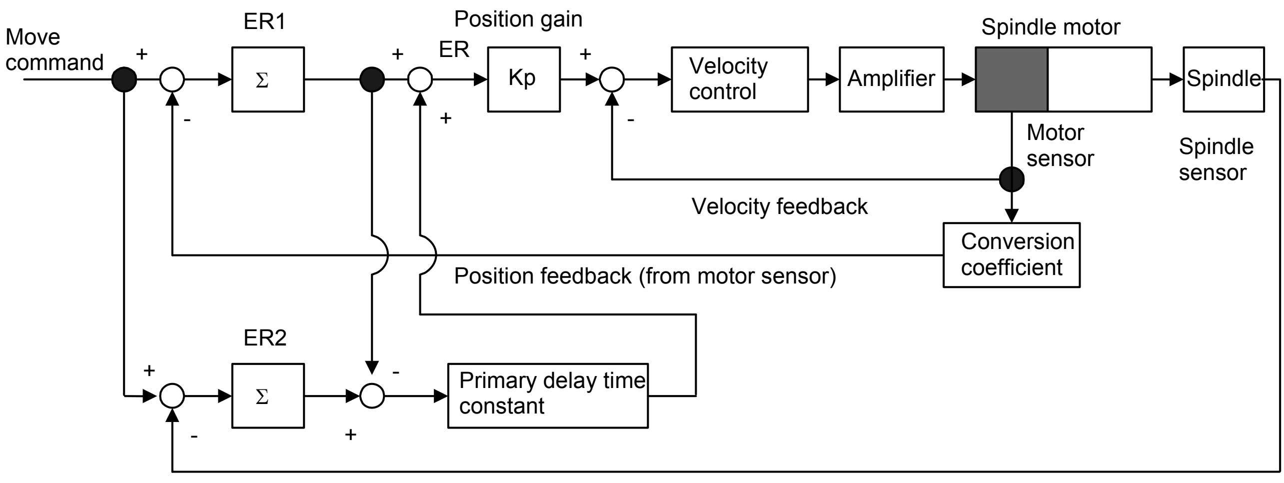
5.10.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC	Remarks
9D50	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i*	Usable only for the dual position feedback function in Cs contouring control
	M (13)		Usable for the dual position feedback function in the servo mode (rigid tapping/spindle positioning)
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*	Usable only for the dual position feedback function in Cs contouring control
	C (03)		Usable for the dual position feedback function in the servo mode (rigid tapping/spindle positioning)
9D80	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*	
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*	
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B	

5.10.3 Block Diagram

The following shows a block diagram of dual position feedback:



As shown in the above diagram, error counter ER1 in the semi-closed loop and error counter ER2 in the closed loop are prepared. The primary delay time constant is expressed as follows:

Primary delay time constant = $(1 + \tau s)^{-1}$

Here, consider actual error ER by time constant.

(1) When time constant $\tau = 0$: $(1 + \tau s)^{-1} = 1$
ER = ER1 + (ER2 - ER1) = ER2 (error counter in the closed loop)

(2) When time constant $\tau = \infty$: $(1 + \tau s)^{-1} = 0$
ER = ER1 (error counter in the semi-closed loop)

From the primary delay time constant, control can be provided in the semi-closed loop when a transition state is present, and control can be provided in the closed loop when positioning is performed. According to this principle, vibration during movement can be suppressed to a level equivalent to the level obtained in the semi-closed loop.

5.10.4 List of Related Parameters

Parameter No.			Description	
15*i*	16*i*	30*i*		
3014#7	4014#7	4014#7	Setting of dual position feedback	
3171 3173	4171 4173	4171 4173	Denominator of conversion coefficient (Selected by spindle control input signal CTH1A)	
3172 3174	4172 4174	4172 4174	Numerator of conversion coefficient (Selected by spindle control input signal CTH1A)	
3215	4215	4215	Primary delay time constant in dual position feedback	[in Cs contouring control]
3224	4224	4224	Maximum amplitude in dual position feedback	[in Cs contouring control]
3225	4225	4225	Dual position feedback zero width	[in Cs contouring control]
3354	4354	4354	Excessive semi-closed loop/closed loop position error alarm detection level	[in Cs contouring control]
3520	4520	4520	Primary delay time constant in dual position feedback	[in servo mode]
3521	4521	4521	Maximum amplitude in dual position feedback	[in servo mode]
3522	4522	4522	Dual position feedback zero width	[in servo mode]
3523	4523	4523	Excessive semi-closed loop/closed loop position error alarm detection level	[in servo mode]

NOTE

1. This subsection lists only those parameters that are specific to dual position feedback. For parameters related to Cs contouring control, see Section 2.4, “Cs CONTOURING CONTROL”, in Part I. For parameters related to rigid tapping, see Section 2.3, “RIGID TAPPING”, in Part I.
2. The dual position feedback function (FS16*i*: No. 4520 to No. 4522) in the servo mode (rigid tapping/spindle positioning) is usable with the following series and editions:
   9D50 series M edition (13 edition) or later
   9D70 series C edition (03 edition) or later
   9D80 series A edition (01 edition) or later
   9D90 series A edition (01 edition) or later
   9DA0 series A edition (01 edition) or later

5.10.5 Details of Related Parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3014	4014	4014	DUALFB							

DUALFB Setting of dual position feedback
0 : Disables dual position feedback.
1 : Enables dual position feedback.
To use the dual position feedback function, set “1”.

15*i*	16*i*	30*i*		
3171	4171	4171	**Denominator of conversion coefficient (HIGH)**	**CTH1A=0**
3172	4172	4172	**Numerator of conversion coefficient (HIGH)**	**CTH1A=0**
3173	4173	4173	**Denominator of conversion coefficient (LOW)**	**CTH1A=1**
3174	4174	4174	**Numerator of conversion coefficient (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

These parameters are used to obtain the feedback amount for one rotation of the spindle from the position feedback signal in the semi-closed loop (the position feedback signal from the motor sensor) when the spindle rotates one turn.
When the spindle rotates Q turns while the motor shaft rotates P turns (P and Q are mutually prime integers), the parameters are set as follows:
No. 4171 (No. 4173 if CTH1A = 1) = P
No. 4172 (No. 4174 if CTH1A = 1) = Q
If these parameters are set to “0”, “1” is assumed to be set in the parameters.

15*i*	16*i*	30*i*		
3215	4215	4215	**Primary delay time constant in dual position feedback**	**[in Cs contouring control]**

Unit of data : 1msec
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets a primary delay time constant in dual position feedback when Cs contouring control is exercised.
If hunting occurs during acceleration/deceleration, set a larger value.
If this parameter is set to 0, the same setting as for a closed loop (= dual position feedback disabled) results.
Setting “32767” provides control equivalent to the semi-closed loop.

15*i*	16*i*	30*i*		
3224	4224	4224	**Maximum amplitude in dual position feedback**	**[in Cs contouring control]**

Unit of data : 64 pulses (=0.064deg)
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets a maximum amplitude in dual position feedback when Cs contouring control is exercised.
If an error between the position in the semi-closed loop and the position in the closed loop exceeds the setting, correction clamping occurs.
If “0” is set, correction clamping does not occur.

15*i*	16*i*	30*i*		
3225	4225	4225	**Dual position feedback zero width**	**[in Cs contouring control**

Unit of data : 1 pulse (=0.001deg)
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets a dual position feedback zero width when Cs contouring control is exercised.
Positioning is performed so that the difference in position between the closed loop and semi-closed loop does not exceed the pulse width equivalent to the parameter-set value.

Set "0" first, and if an unstable condition is observed when the machine is stopped, increase the setting.

15*i*	16*i*	30*i*	
3354	4354	4354	**Excessive semi-closed loop/closed loop position error alarm detection level [in Cs contouring control]**

Unit of data : 64 pulses (=0.064deg)
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets an excessive semi-closed loop/closed loop position error alarm (spindle alarm 61) when Cs contouring control is exercised.
When the position difference (semi-closed loop/closed loop position error) between the semi-closed loop and the closed loop exceeds the value set in this parameter, the alarm (spindle alarm 61) is issued.

15*i*	16*i*	30*i*	
3520	4520	4520	**Primary delay time constant in dual position feedback[in servo mode]**

Unit of data : 1msec
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets a primary delay time constant in dual position feedback in the servo mode (rigid tapping/spindle positioning).
If hunting occurs during acceleration/deceleration, set a larger value.
If this parameter is set to 0, the same setting as for a closed loop (= dual position feedback disabled) results.
Setting "32767" provides control equivalent to the semi-closed loop.

NOTE
This parameter is valid with 9D50 series M (13) edition or later, 9D70 series C (03) edition or later, and 9D80 series A (01) edition or later.

15*i*	16*i*	30*i*	
3521	4521	4521	**Maximum amplitude in dual position feedback [in servo mode]**

Unit of data : 1 pulse unit (=360/4096 degrees)
Valid data range : 0 to 4095
Standard setting value : 0

This parameter sets a maximum amplitude in dual position feedback in the servo mode (rigid tapping/spindle positioning).
If an error between the position in the semi-closed loop and the position in the closed loop exceeds the setting, correction clamping occurs.
If "0" is set, correction clamping does not occur.
If a value not within the valid data range is set, the value is clamped to the maximum allowable value.

NOTE
This parameter is valid with 9D50 series M (13) edition or later, 9D70 series C (03) edition or later, and 9D80 series A (01) edition or later.

15*i*	16*i*	30*i*	
3522	4522	4522	**Dual position feedback zero width [in servo mode]**

Unit of data : 1 pulse unit (=360/4096 degrees)
Valid data range : 0 to 4095
Standard setting value : 0

This parameter sets a dual position feedback zero width in the servo mode (rigid tapping/spindle positioning).
Positioning is performed so that the difference in position between the closed loop and semi-closed loop does not exceed the pulse width equivalent to the parameter-set value.
Set "0" first, and if an unstable condition is observed when the machine is stopped, increase the setting.
If a value not within the valid data range is set, the value is clamped to the maximum allowable value.

> **NOTE**
> This parameter is valid with 9D50 series M (13) edition or later, 9D70 series C (03) edition or later, and 9D80 series A (01) edition or later.

15*i*	16*i*	30*i*	
3523	4523	4523	**Excessive semi-closed loop/closed loop position error alarm detection level [in servo mode]**

Unit of data : 1 pulse unit (=360/4096 degrees)
Valid data range : 0 to 4095
Standard setting value : 0

This parameter sets an excessive semi-closed loop/closed loop position error alarm (spindle alarm 61) in the servo mode (rigid tapping/spindle positioning).
When the position difference (semi-closed loop/closed loop position error) between the semi-closed loop and the closed loop exceeds the value set in this parameter, the alarm (spindle alarm 61) is issued.
If a value not within the valid data range is set, the value is clamped to the maximum allowable value.

> **NOTE**
> This parameter is valid with 9D50 series M (13) edition or later, 9D70 series C (03) edition or later, and 9D80 series A (01) edition or later.

5.10.6 Spindle Alarm

Error No.	Description	Measure
61	The difference (semi-closed loop/closed position error) between the semi-closed loop and the closed loop exceeds the set value.	Correct the cause of the semi-closed loop/closed position error.

5.11 Velocity Tandem Control Function (OPTIONAL FUNCTION)

5.11.1 Overview

Spindle tandem control is a function that drives the spindle with two motors to provide a large output that cannot be obtained with one motor. The following two types are available:

(1) Velocity tandem control
(2) Torque tandem control (induction spindle motor only)

While velocity control is disabled on the slave side in torque tandem control, it is enabled in velocity tandem control. For this reason, velocity tandem control offers greater slave axis stability. Therefore, when applying spindle tandem control, select velocity tandem control under normal circumstances.
Note that, in cases where you do not want the slave axis to exert velocity control (you want both axes to have the same torque although they widely differ in speed), as in wheel lathing, you need to adopt torque tandem control.

The velocity tandem control function drives two spindle motors connected to the spindle using the same velocity command.

NOTE

1 This function has been added to spindle tandem control, which is a CNC software option.
2 When the NC is 30*i*-B, the spindle tandem control function is included in the spindle synchronous control option.
3 To use this function, SP TYPE B is required.
4 For the master and slave axes, use the spindle software of the same series and edition.
5 The motors of both axes must be of the same model (both must be induction spindle motors or synchronous spindle motors).
6 Position and velocity control is exerted by the master axis, and the velocity command and the torque command for the velocity integral term of the master axis are passed to the slave axis. The slave axis outputs the torque of obtaining by adding the velocity integral term and the velocity-controlled velocity proportional term.
7 If the gear ratio to the spindle differs between the two axes, the velocity command that the slave axis receives from the master axis is used by converting it with the gear ratio set for it.
8 The effect of backlash between gears can be reduced by combining the master and slave axes with preloads applied on them.
9 The slave axis preload can be scaled in case the characteristics of the two axes are different.
10 This function can be enabled or disabled by turning on or off the PMC signal to the master and slave axes. When the function is disabled, each motor can be operated individually.
11 This function can be used in velocity control mode, spindle orientation, rigid tapping mode, or Cs contour control.
12 Make sure that the motors of both axes are stopped when performing the speed range switching operation.
13 This function cannot be used together with the following functions:
   - Spindle synchronous control function
   - Spindle switching function
   - Position coder signal output function
   - Spindle EGB function
   - Spindle leaning control function
14 This function cannot be used for twin drives (two-winding motors and induction machines only).
15 No limitation is imposed on master and slave axis assignment.
In the descriptions herein, the following assignment is used for convenience:
Master spindle amplifier: First spindle
Slave spindle amplifier: Second spindle
16 Depending on the type of spindle sensor in use, there may be a limitation on the detection speed for a one-rotation signal.

5.11.2 Series and Editions of Applicable Spindle Software

Spindle software

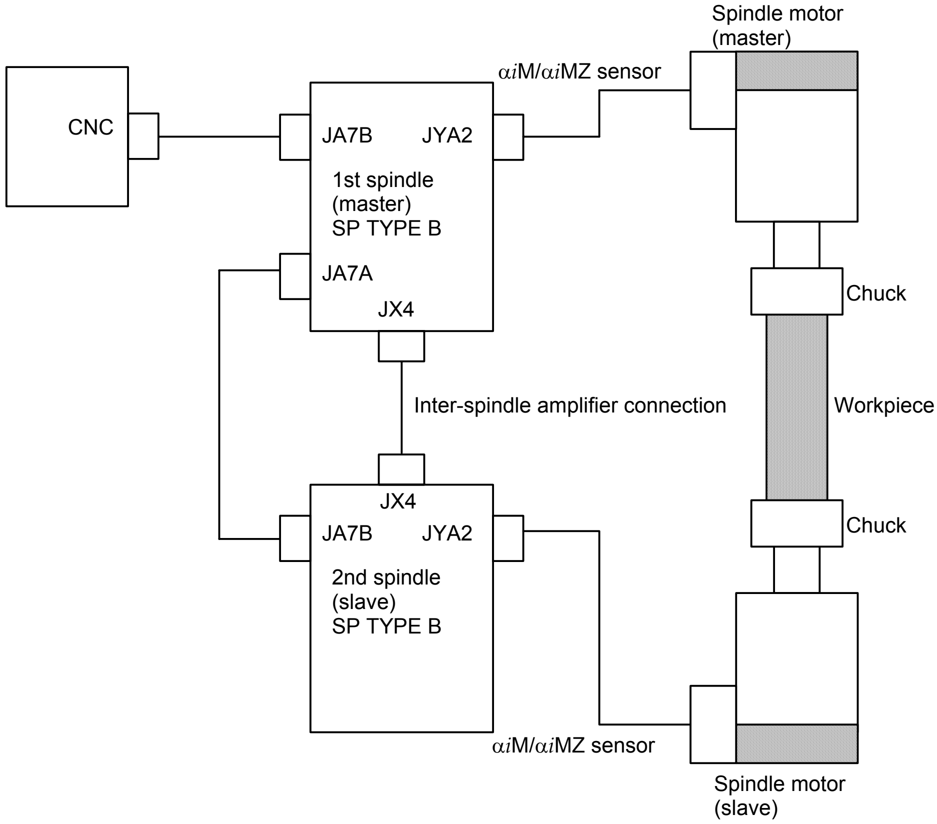
Series	Edition	Usable CNC
9D90	B (02)	FS30*i*-A / FS31*i*-A
9DA0	F (06)	FS30*i*-B / FS31*i*-B

NOTE
To use the αiCZ sensor (serial), the 9D90 series G (07) edition or later or the 9DA0 series I (09) edition or later is required.

5.11.3 System Configuration

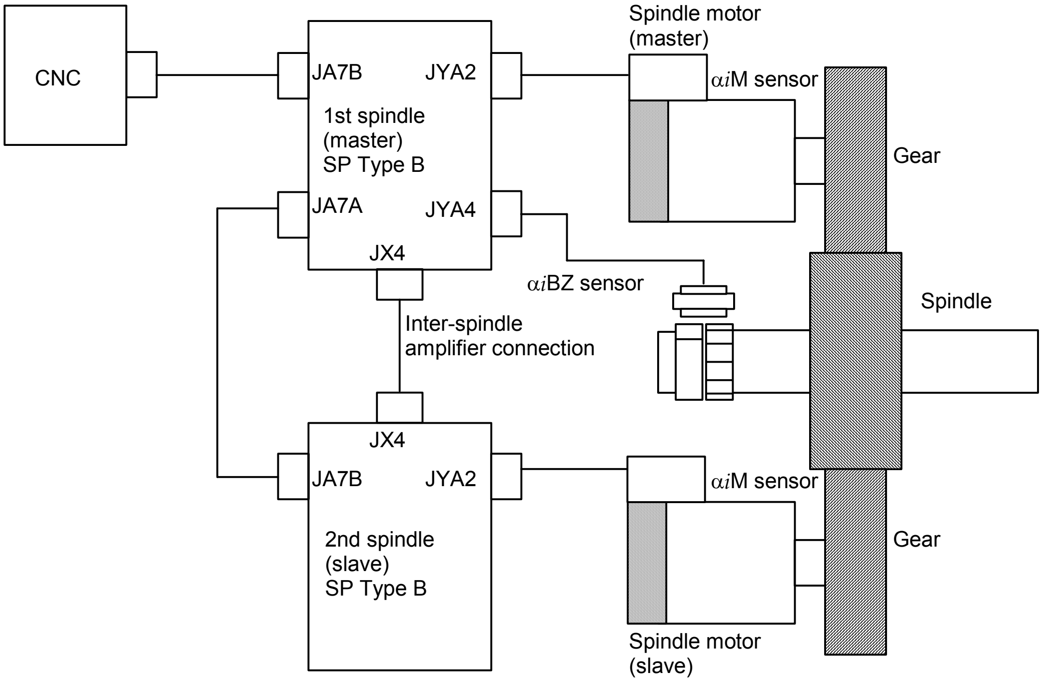
NOTE
1 For connection details of each cable, refer to “FANUC SERVO AMPLIFIER αi series DESCRIPTIONS (B-65282EN)”.
2 The common power supply (PS) emergency stop signal (connector CX4) needs to be input for each common power supply (PS).

(1) Sample configuration 1: System where the master spindle and slave spindle are mechanically connected or disconnected when a workpiece is attached or detached



NOTE
1 When the master and slave are mechanically disconnected, velocity tandem control cannot be used. In this case, cancel the tandem operation mode.
2 When a synchronous spindle motor is used, the power line between the amplifier and the motor needs to be connected via the sub module SM (SSM).
3 To perform pole detection when a synchronous spindle motor is used, release the mechanical connection to free the synchronous spindle motor.

(2) Sample configuration 2: System where the table axis is driven by two motors



NOTE
The synchronous spindle motor BiS series is a built-in motor and cannot be used for a system such as the above one.

5.11.4 I/O Signals (CNC↔PMC)

NOTE
1 A command for the spindles engaged in tandem operation is issued to the master spindle amplifier.
The input signal specifications are the same as for ordinary spindles (for which the torque tandem function is not used).
For details of signals used in each control mode, see Chapter 3, "I/O SIGNALS", in Part I.
2 During tandem operation, no signal needs to be input from the PMC to the tandem function slave spindle amplifier. Those signals that are required to drive the slave spindle amplifier are transferred from the master spindle amplifier by inter-spindle amplifier communication.
3 During tandem operation, use a signal output from the master spindle amplifier for sequence determination (such as speed arrival determination and alarm detection). (No signal output from the slave spindle amplifier is needed.)

(1) Input signals (PMC→CNC)

	30i	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G070				SOCNA		CTH1A	CTH2A	
2nd-	G074				SOCNB		CTH1B	CTH2B	

CTH1A,CTH2A Clutch/gear signal (for the first spindle)
CTH1B,CTH2B Clutch/gear signal (for the second spindle)
0,0 : HIGH GEAR
0,1 : MEDIUM HIGH GEAR
1,0 : MEDIUM LOW GEAR
1,1 : LOW GEAR
Set these signals based on the status of the clutch or gear. They are used to select the spindle control parameters.

NOTE
In the case of velocity tandem control, note the following:
1 In the velocity tandem control mode, the gear signal (CTH1/CTH2)m for the master axis takes effect for both the master and slave axes. This means that the gear signal for the slave axis is internally linked with the gear signal for the master axis (to prevent the input of the wrong gear signal).
2 For the reason mentioned above, make sure that the numbers of the parameters selected by the gear signal in the velocity tandem control mode are the same for both the master and slave axes.
3 In the normal operation (the velocity tandem control mode is off), the respective gear signals (CTH1/CTH2)m and (CTH1/CTH2)s take effect individually for the master and slave axes.
4 In the velocity tandem control mode, the gear signal for the slave axis (CTH1/CTH2)s does not take effect but may be input in the same way as the gear signal for the master axis (CTH1/CTH2)m.
5 The value of bit 2 of parameter No. 4006 for setting the speed unit needs to be the same for both the master and slave axes.

	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G071				SOCNA				
2nd-	G075				SOCNB				

SOCNA Soft start/stop signal (for the first spindle)
SOCNB Soft start/stop signal (for the second spindle)
0 : Disables the soft start/stop function.
1 : Enables the soft start/stop function.
These signals enable or disable the soft start/stop function.
Use these signals when limiting the specified acceleration rate to reduce a mechanical shock during acceleration/deceleration.
During tandem operation (SLVx = 1), the signals need not be input to the slave spindle amplifier.

NOTE
1 When using the soft start/stop function, set the acceleration rate in parameter No. 4030.

	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G073						MPOFA	SLVA	
2nd-	G077						MPOFB	SLVB	

SLVA Tandem operation command (for the first spindle)
SLVB Tandem operation command (for the second spindle)

0 : Makes a request to disable tandem operation.
1 : Makes a request to enable tandem operation.
These signals enable or disable tandem operation.
When using the tandem function, set these signals to 1 for both of the master and slave.

NOTE
1 Both of the master and slave must be stopped before these signals can be switched.
During rotation, these signals cannot be accepted.
2 Switch these signals in the velocity control mode. In a mode other than the velocity control mode, these signals cannot be accepted.
3 When the master and slave are mechanically disconnected with each other, do not set these signals to 1.
4 To input the SLV signal when a synchronous spindle motor is used, make sure that the pole detection complete state EPFIXx is set to 1 for the motors of both axes (first spindle: F048#7 and second spindle: F052#7). Turn off the SLV signal when the pole detection incomplete state is set.

MPOFA Motor power turn-off signal (for the first spindle)
MPOFB Motor power turn-off signal (for the second spindle)
0 : Normal operation
1 : Turns off the power to the motor.
These signals turn off the power to the motor.
During tandem operation (SLVx = 1), these signals need not be input to the slave spindle amplifier.

NOTE
1 If any abnormality, such as an excessive master-slave speed difference, is detected when the velocity tandem operation is enabled, the power to both the master and slave motors needs to be turned off in order to minimize mechanical damage.
Turn off the power to the motors by using these signals.
2 When a synchronous spindle motor is used, the motors decelerate to a stop using the SSM, rather than coast to a stop, even if these signals are input.

(2) Output signals (CNC→PMC)

	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F045							SSTA	
2nd-	F049							SSTB	

SSTA Speed zero detection signal (for the first spindle)
SSTB Speed zero detection signal (for the second spindle)
0 : The spindle motor is rotating.
1 : The spindle motor is in the speed zero (stopped) state.
After checking that these signals are set to 1 with both of the master and slave, switch the tandem operation command SLVx.
When these signals are set to 0, the tandem operation command cannot be accepted.

	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F046				SLVSA				
2nd-	F050				SLVSB				

SLVSA Tandem operation state signal (for the first spindle)
SLVSB Tandem operation state signal (for the second spindle)
0 : Tandem operation is disabled.
1 : Tandem operation is enabled.
After checking that these signals are set to 1 with both of the master and slave, issue a command to the master spindle amplifier.

	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F047						MSOVRA		
2nd-	F051						MSOVRB		

MSOVRA Master-slave speed difference state signal(for the first spindle)
MSOVRB Master-slave speed difference state signal (for the second spindle)
0 : The speed difference between the master and slave is less than the set value.
1 : The speed difference between the master and slave is equal to or greater than the set value.
These signals indicate whether or not the speed difference between the master motor and slave motor is less than the value set in the parameter (FS30*i*: No. 4347).
The signal for the slave spindle amplifier need not be monitored. (At all times, 0 is output.)

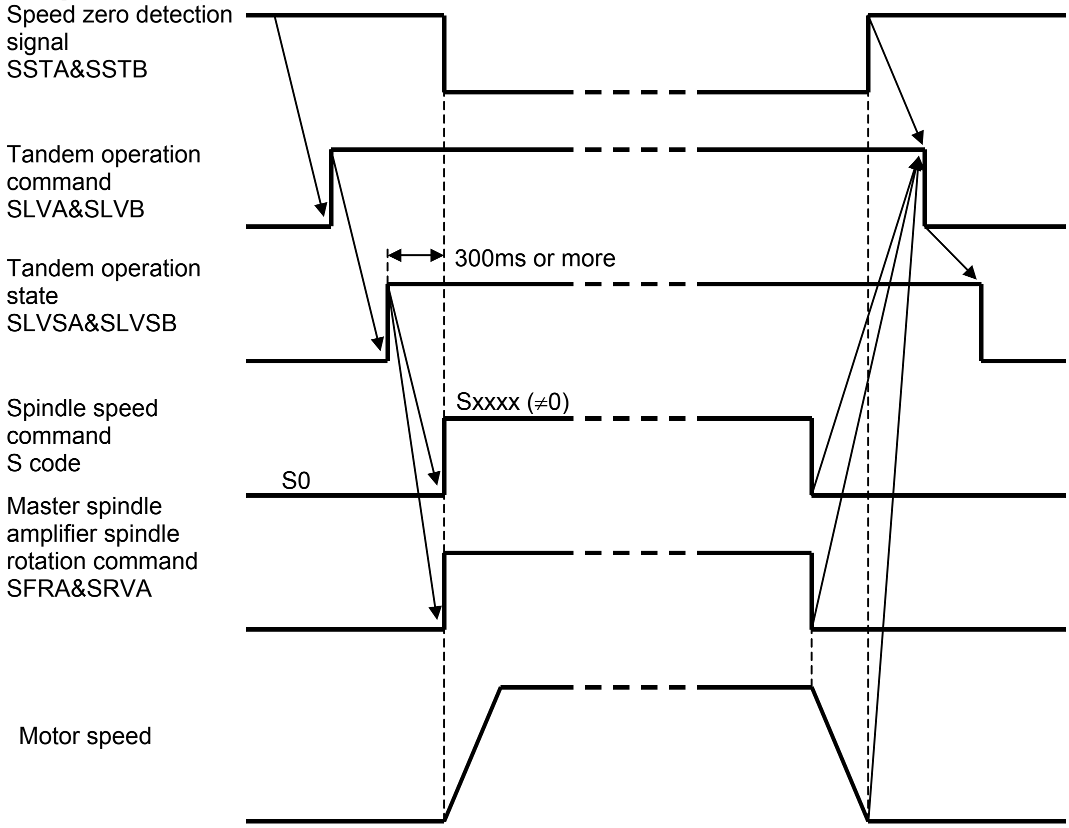
⚠ CAUTION
1 If a motor feedback signal disconnection alarm (spindle alarm 73) is issued, the status of this signal is undefined.
2 When bit 5 of parameter No. 4007 is set to "1", the detection operation of the feedback signal disconnection alarm is not performed.
Set the parameter to "0" when not required, to enable alarm detection.

NOTE
Monitor the states of these signals on the PMC. Ensure that an alarm is issued if an error occurs (for example, if the state of 1 lasts for a certain period of time).

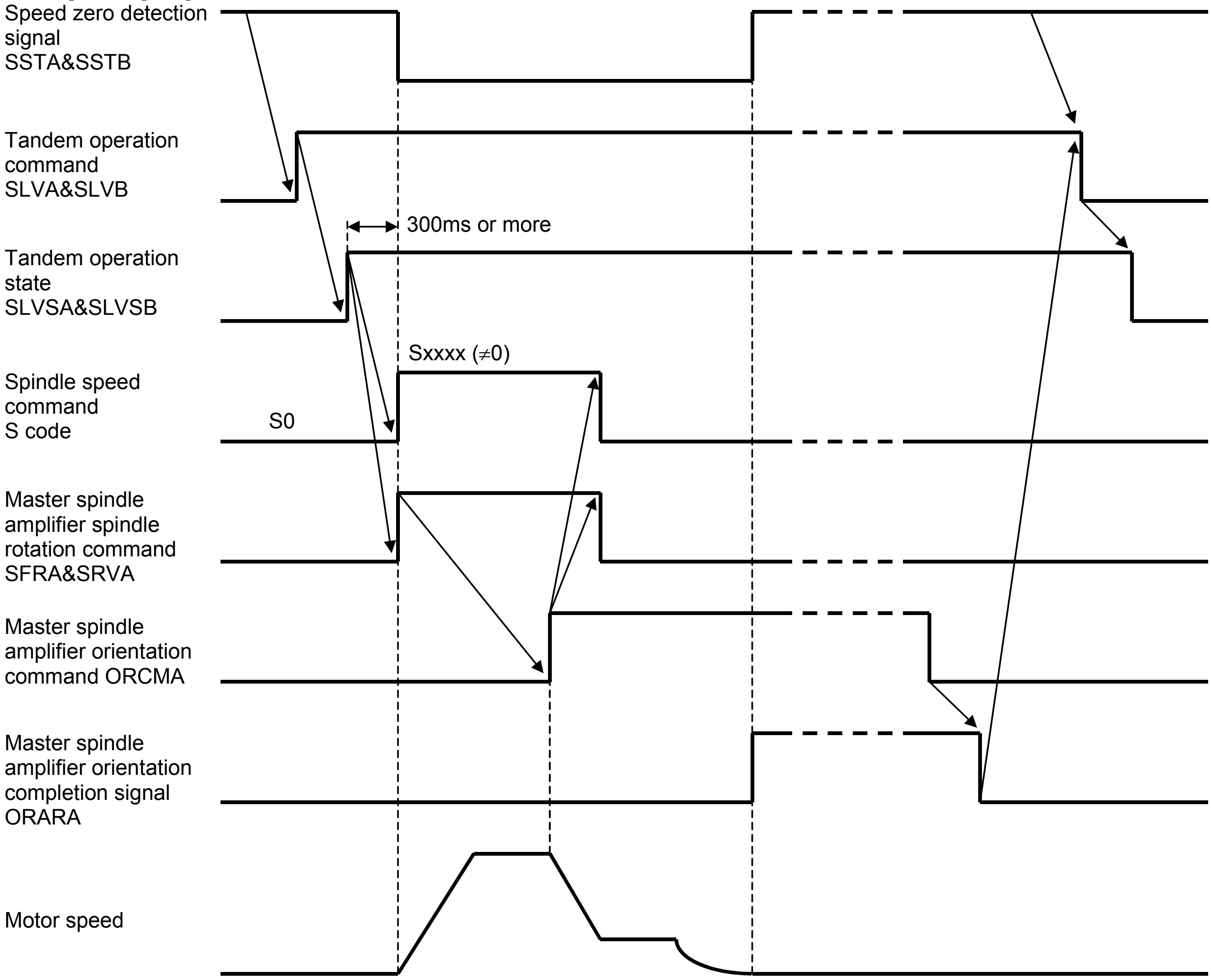
5.11.5 Examples of Sequences

NOTE
Examples of sequences are given below assuming the following:
First spindle: Master spindle amplifier
Second spindle: Slave spindle amplifier

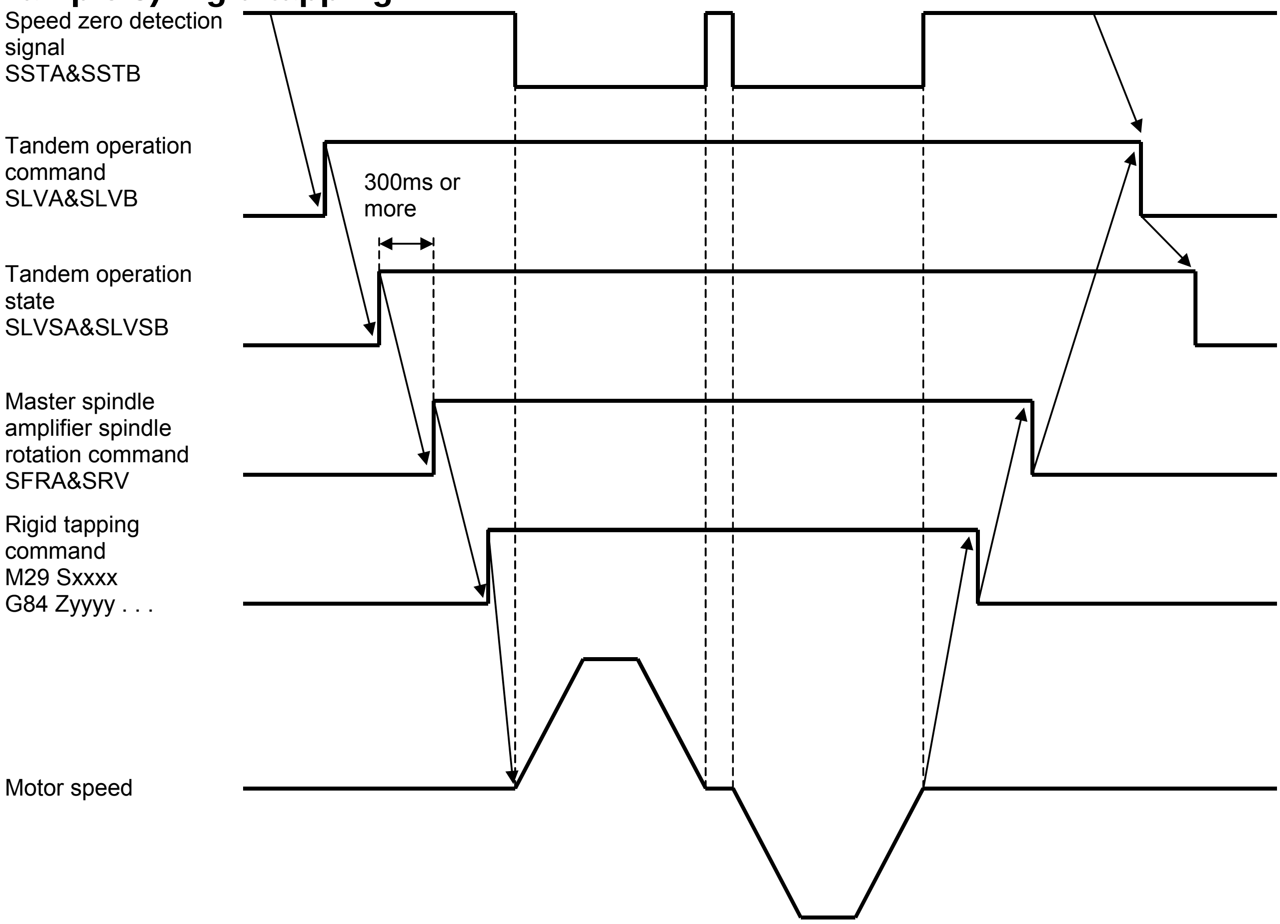
(Example 1) Velocity control mode



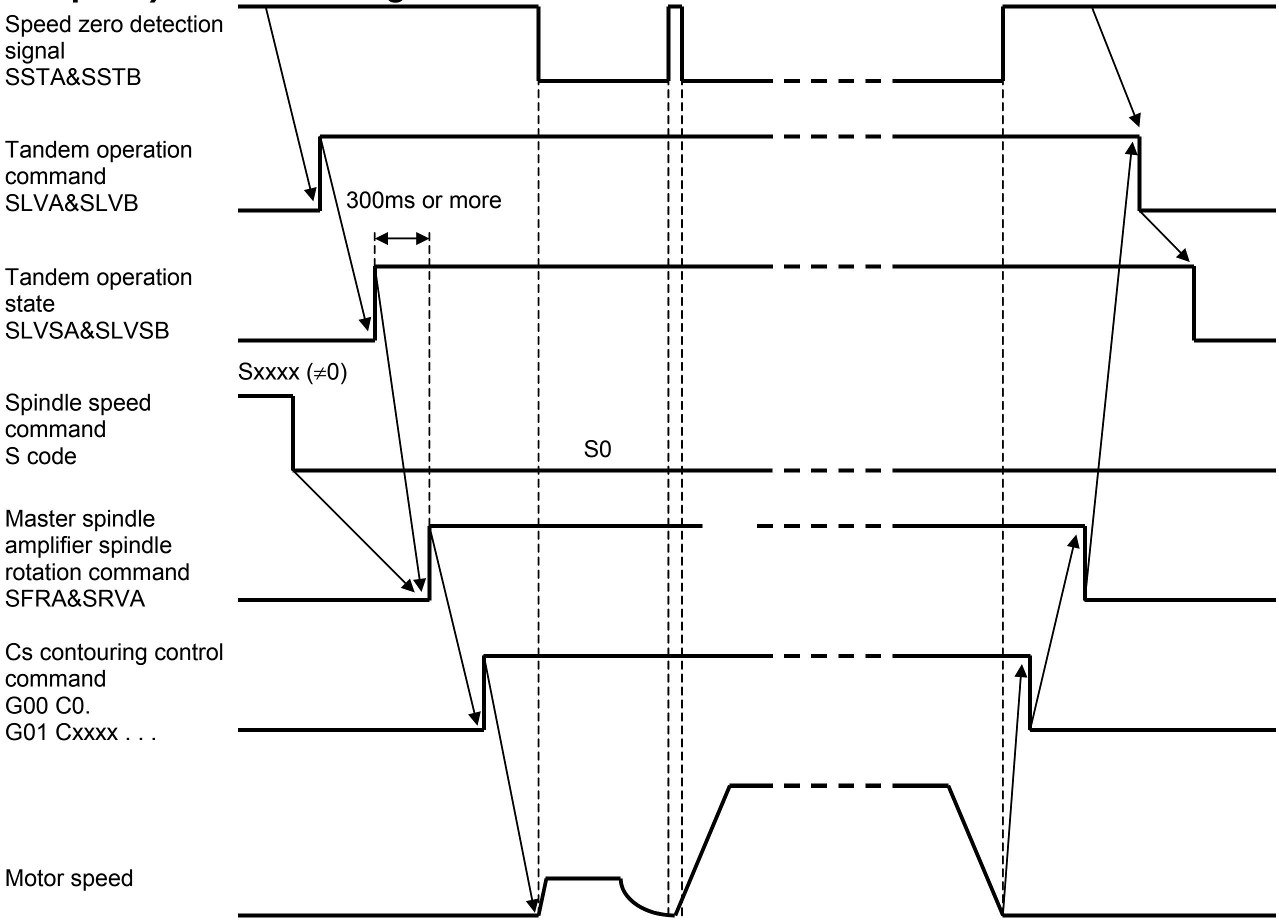
(Example 2) Spindle orientation



(Example 3) Rigid tapping



(Example 4) Cs contouring control



5.11.6 Parameters

(1) Cautions

For the master spindle amplifier and slave spindle amplifier, set the same parameters except for the following specific parameters:

Parameter No. 30i	Description	Master setting	Slave setting
4002#3 to 0	Spindle sensor type	Depending on the spindle configuration	Depending on the spindle configuration
4353#2	Relationship of master/slave motor rotation directions in tandem operation	Depending on the spindle configuration	0
4352#7,6	Inter-spindle amplifier communication setting	1, 0	0, 1
4360	Preload value	Machine by machine (adjustment value)	0
4606	Preload constant	Machine by machine (adjustment value)	0

(2) List of parameters

Parameter No. 30i	Description
4009#2	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued
4015#3	Whether to use the spindle tandem function

Parameter No. 30*i*	Description
4352#7,6	Inter-spindle amplifier communication setting
4353#1	Velocity feedback signal setting in tandem operation
4353#2	Relationship of master/slave motor rotation directions in tandem operation
4398#3	Whether to use the twin drive function
4398#4	Whether to use the velocity tandem function
4398#5	Whether to use the velocity integrator copy function
4398#6	Whether to detect a speed polarity error (spindle alarm d0) in tandem operation
4402#3	Whether to use the torque tandem function (for 30i-B)
4347	Output value for the master-slave speed difference state signal
4360	Preload value
4606	Preload constant
4541#3	Scaling function for the slave axis preload during velocity tandem control
4541#4	Scaling function for the slave axis velocity command during velocity tandem control
4541#5	Tandem command SLV acceptance condition setting
4541#6	Master/slave motor rotation direction relationship for the extended integral copy
4597	Setting for the extended integral copy

(3) Details of Parameters

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4009						ALSP		

ALSP Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued
0 : Turns off the power after the motor is decelerated to a stop.
1 : Turns off the power immediately. (Set this parameter to 1.)

> **NOTE**
> If an alarm is issued during tandem operation, the power to both of the master motor and slave motor must be turned off simultaneously to prevent the machine from being damaged. When using the tandem function, be sure to set this parameter to 1 to turn off the power to the motors immediately if a CNC-SP communication error occurs.

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4015					SPDTDM			

SPDTDM Whether to use the spindle tandem function (The CNC software option is required.)
0 : Does not use the spindle tandem function.
1 : Uses the spindle tandem function.

> **NOTE**
> If this bit is set to 0, the tandem function does not operate normally. When this bit is set to 0, check the software option.

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4352	MASTER	SLAVE						

SLAVE Inter-spindle amplifier communication slave axis setting
0 : Non-inter-spindle amplifier communication slave axis
1 : Inter-spindle amplifier communication slave axis (Set this parameter to 1 for the slave spindle amplifier.)

MASTER Inter-spindle amplifier communication master axis setting
0 : Non-inter-spindle amplifier communication master axis
1 : Inter-spindle amplifier communication master axis (Set this parameter to 1 for the slave spindle amplifier.)

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4353						RVSVC2	VFBAV	

VFBAV Velocity feedback signal setting in tandem operation
0 : For speed control, the master spindle amplifier motor speed only is used.
1 : For speed control, the average speed of the master spindle amplifier and slave spindle amplifier is used.
By exercising speed control using the average speed feedback value of the master and slave, vibration caused by spindle backlash may be suppressed.

RVSVC2 Relationship of master/slave motor rotation directions in tandem operation
0 : The master motor and slave motor rotate in the same direction at spindle rotation time (as viewed from the motor shaft).
1 : The master motor and slave motor rotate in the opposite directions at spindle rotation time (as viewed from the motor shaft).
This parameter sets the polarity for a speed command and feedback signal in torque tandem operation.

NOTE

1 This parameter need not be set for the slave spindle amplifier side. (The setting for the master spindle amplifier is transferred to the slave spindle amplifier by inter-spindle amplifier communication.)
2 If the setting of this parameter is improper, the tandem function does not operate normally.
If the spindle is rotated in this state, the speed polarity error alarm (spindle alarm d0) is issued in tandem operation.

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4398		A130DN	WSVCP	VTAN	WNDTDM			

WNDTDM Whether to use the twin drive function
Set this parameter to 0.

NOTE

If this bit is set to 1, the torque tandem function does not operate normally. Be sure to set this bit to 0.

VTAN Whether to use the velocity tandem function
0 : Does not use the velocity tandem function.
1 : Uses the velocity tandem function.

WSVCP Whether to use the velocity integrator copy function
0 : Does not use the velocity integrator copy function.
1 : Uses the velocity integrator copy function.

When using the velocity tandem function, set WSVCP and VTAN to 0 and 1 (velocity tandem control only) or 1 and 1 (velocity tandem control + velocity integrator copy function), respectively.

A130DN Whether to detect the speed polarity error (spindle alarm d0) during tandem control
0 : Detects the error.
1 : Does not detect the error.

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4402					**TRQTDM**			

TRQTDM Whether to use the torque tandem function
Set this parameter to 0.

> **NOTE**
> 1 While this bit is valid when the NC is 30*i*-B, set it to "0" also when the NC is 30*i*-A.
> 2 When this bit is set to "1", the velocity tandem function does not work normally. Be sure to set it to "0".

30*i*	
4347	**Master-slave speed difference state signal output setting**

Unit of data : 1min^{-1} *(10min^{-1} when bit 2 (SPDUNT) of parameter No. 4006 is set to 1)
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets a level for detecting the master-slave speed difference state signal (MSOVRA:F47#2, MSOVRB:F51#2).
If this parameter is set to 0, the setting of 100 is assumed.

30*i*	
4360	**Preload value**

Unit of data : ±16384 equivalent to a torque command of 100%
Valid data range : -8192 to 8192(-50% to +50%)
Standard setting value : 0

This parameter sets a preload value.
This parameter may suppress stop-time vibration caused by backlash.

NOTE

1. When "0" is set for the slave axis, the value set for the master axis is used as the slave axis preload. Note that its polarity is determined by the polarity set by N4360 for the master axis and N4353#2.
2. When a value other than "0" is set for the slave axis, the value set for the slave axis is used as the slave axis preload.
   Since the preload torque is always added to the torque command, as shown in the block diagram of Subsection 5.11.7, set the preload values depending on the motor rotation directions of the master and slave axes, as follows.
   When the rotation directions are the same: The values set for the master and slave axes have different signs.
   When the rotation directions are different: The values set for the master and slave axes have the same sign.
3. When two motors having different characteristics are used, set the slave axis, taking into consideration the ratio of the maximum torque Tmax of the motor of the master axis to that of the slave axis.
   Absolute value set for the slave axis = (Master axis Tmax/slave axis Tmax)･Absolute value set for the master axis

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4541			NSSTTD	DIFRED	DIFMTC			

DIFMTC Scaling function for the slave axis preload during velocity tandem control

0 : Disables the scaling function for the slave axis preload.

1 : Enables the scaling function for the slave axis preload.

When the motors of the two axes have different characteristics, the preload data of the slave axis is scaled based on the difference in the base speed so that the actual preload values of both axes become equal. To use this function, set "1" for the slave axis.

NOTE

1. When using this function, be sure to set a preload value for the slave axis as well by using N4360.
2. Refer to "Additional information 1: When using two motors having different gear ratios or different characteristics" in this section.

DIFRED Scaling function for the slave axis velocity command during velocity tandem control

0 : Disables the scaling function for the slave axis velocity command.

1 : Enables the scaling function for the slave axis velocity command.

By setting "1" for both axes when the gear ratio between the motor and spindle is different for the two axes, the gear ratio is taken into consideration for the velocity command for the slave axis during velocity tandem control.

NOTE

1. Refer to "Additional information 1: When using two motors having different gear ratios or different characteristics" in this section.

NSSTTD Tandem command SLV acceptance condition setting

0 : Accepts the SLV signal when the speed is 0 (the SLV signal is not accepted when the motor is rotating).

1 : Accepts the SLV signal even when the speed is not 0 (the SLV signal can be accepted even when the motor is rotating).

30*i*	
4606	**Preload time constant**

Unit of data : 100msec
Valid data range : 0～50
Standard setting value : 0

Sets the time constant of the rise of the preload that can be used for spindle tandem control. If this parameter is set to 0, 32 msec is assumed.

> **NOTE**
> 1 If a preload value (No. 4360) is set when spindle tandem control is exerted, a mechanical shock may occur when the preload torque rises after excitation. Setting a larger value in this parameter helps mitigate this mechanical shock.

The following parameter needs to be set when an integral copy is made between two axes that are driven by spindle simple synchronous control during tandem drive using four or more spindle motors (extended integral copy). For information about this setting, see also "Additional information 2: Spindle drive using four or more spindle motors" in Subsection 5.11.9, "Additional Information".

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4541		RVDPOL						

RVDPOL Master/slave motor rotation direction relationship for the extended integral copy

0 : The rotation directions of the master and slave motors are the same during spindle rotation (when viewed from the motor shaft).

1 : The rotation directions of the master and slave motors are opposite during spindle rotation (when viewed from the motor shaft).

Set this parameter for the slave axis for the extended integral copy function.

30*i*	
4597	Setting for the extended integral copy

Standard setting value : 0

Sets the master and slave axes for the extended integral copy.

0: The function is disabled.

-1: : Setting of the master axis: When "-1" is set, the master axis for the extended integral copy is used.

Larger than 0: Setting of the slave axis: Specify the master axis number to be received in data transfer.

(Use a logical spindle number to specify which spindle is to be used as the master axis.)

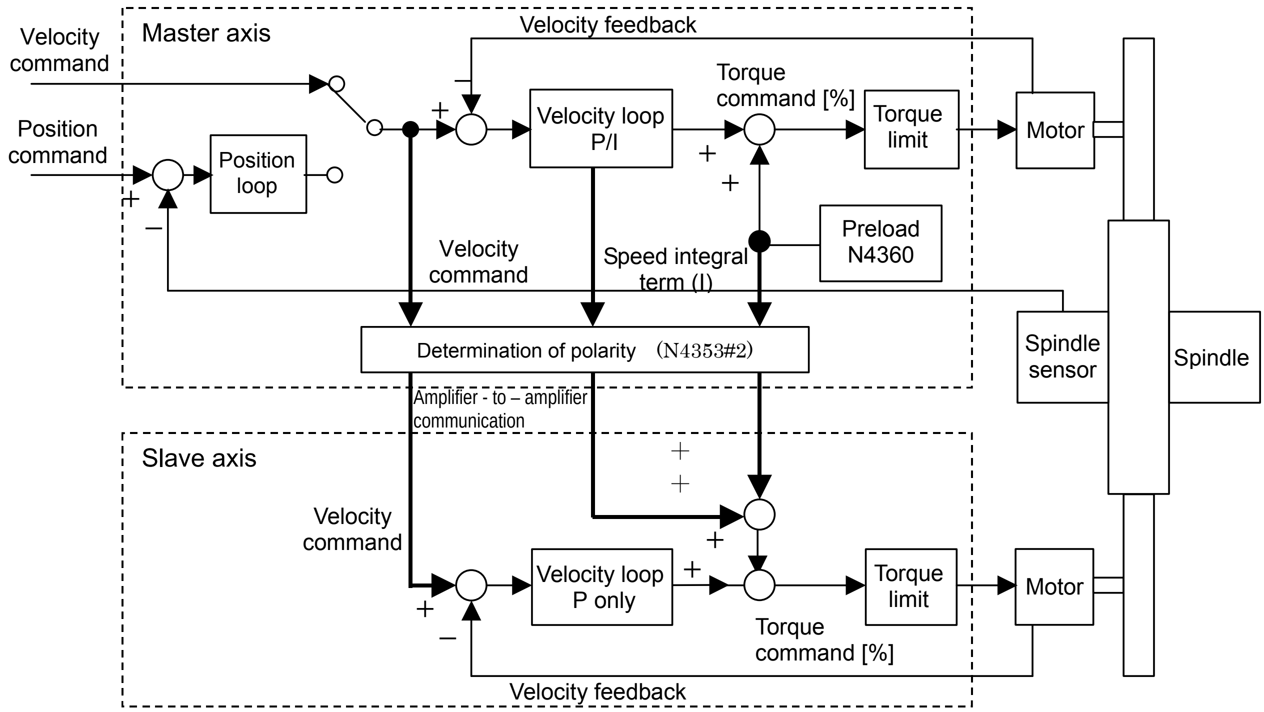
> **NOTE**
> If an invalid value is set in this parameter or a spindle amplifier not supported for this parameter is used, the following alarm occurs:
> SP1252 Invalid spindle parameter setting (tandem)

5.11.7 Block Diagram for the Velocity Tandem Operation

The following figure shows the rough block diagram for the velocity tandem operation.

(1) The velocity command, speed integral term, and preload value are passed from the master axis to the slave axis according to the polarity determined by the parameter that defines the master/slave connection direction.

(2) The slave axis performs proportional term processing based on the received velocity command (when the speed integral copy function is disabled (N4398#5=0), the slave axis also performs integral term processing). It then adds the received speed integral term and preload value to create a torque command.



(*) In the torque command, [%] represents the torque in percentage with the maximum torque of the master and slave motors being 100%.

5.11.8 Alarm and Status Error

(1) Spindle alarm

Alarm No.	Description	Measure
66	An inter-spindle amplifier communication error occurred.	Check the connection of the cable (JX4).
80	An alarm was issued on the destination spindle amplifier of inter-SPM communication.	Correct the cause of the alarm on the destination spindle amplifier.
d0	The relationship between the speed polarity of the master motor and the speed polarity of the slave motor is abnormal.	Check the rotation direction relationship setting (FS16i: Bit 2 of No. 4353).

(2) Spindle amplifier status error

Error No.	Description	Measure
21	A tandem operation command was input when spindle synchronous control is enabled.	Input a tandem operation command after canceling spindle synchronous control.
22	Spindle synchronous control was specified when tandem operation is enabled.	Specify spindle synchronous control after canceling tandem operation.

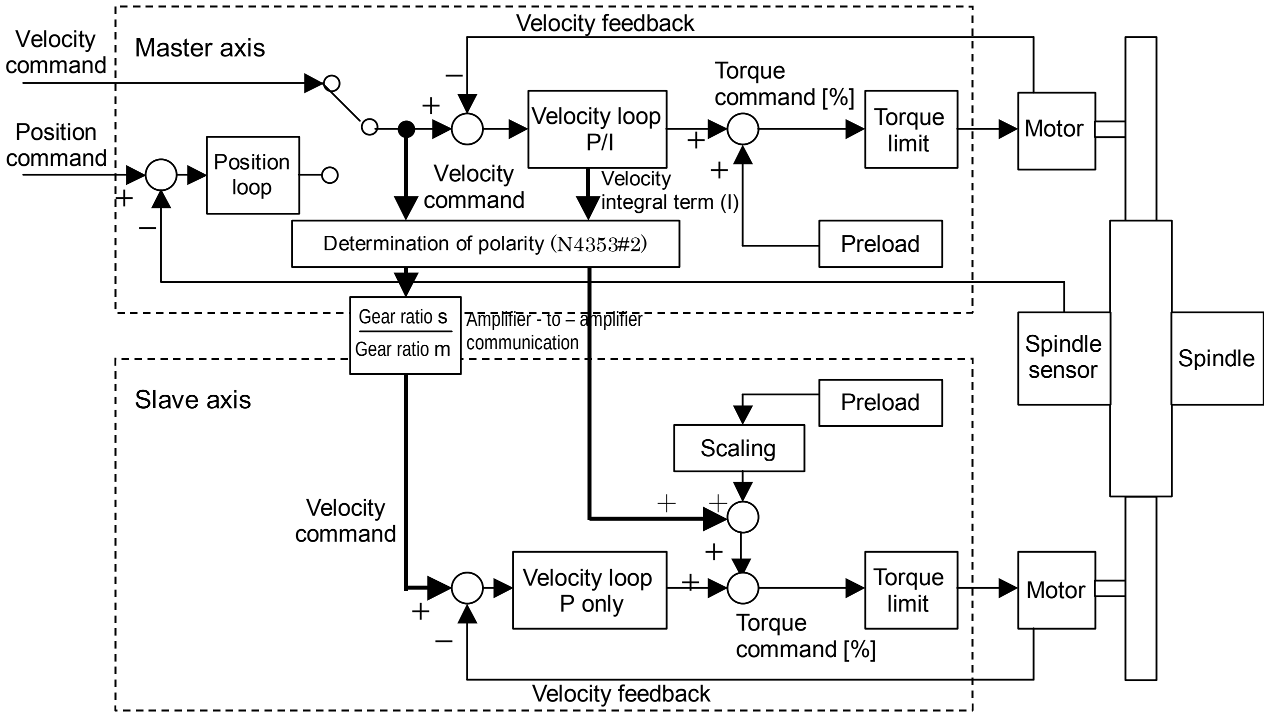
23	A tandem operation command is input even if the option is not specified.	Tandem control requires the CNC software option. Check the option.
38	- Parameters related to inter-spindle amplifier communication are not set correctly. - Functions that cannot be used together with the torque tandem function are set.	Check the parameters.

5.11.9 Additional Information

(1) Additional information 1: When using two motors having different gear ratios or different characteristics

The following additional information applies when two motors having different gear ratios or different characteristics are used in the velocity tandem operation.
During the velocity tandem operation, control is exerted as shown in the rough block diagram below.

Rough block diagram for the velocity tandem operation

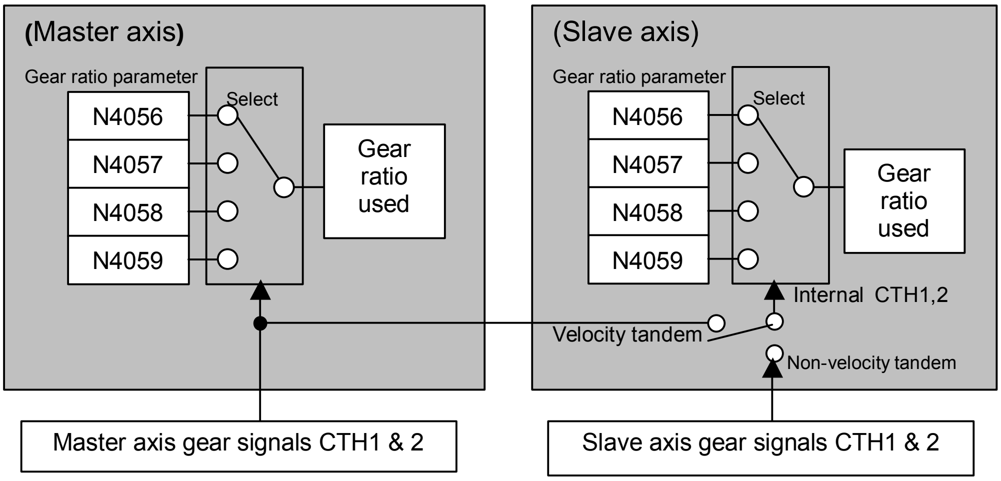


(*) In the torque command, [%] represents the torque in percentage with the maximum torque of the master and slave motors being 100%.

(1) The velocity command and speed integral term are passed from the master axis to the slave axis. The velocity loop of the slave axis is processed only for the proportional term, and the velocity integral term and preload value received from the master axis are added to create a torque command. The polarity of the velocity command and velocity integral term passed to the slave axis is determined by bit 2 of parameter N4353 of the master axis.

(2) If the gear ratio for the spindle differs between the two axes, the scale of the velocity command to be used and the actual speed of the other side can be converted as follows, by enabling the velocity command scaling function. The subscripts m and s represent the master axis and slave axis, respectively.
[Velocity command scaling equation] (Velocity command)s = (Gear ratio)s × (Velocity command)m/(Gear ratio)m

The gear ratios used in the above equation are **the parameter values that the master and slave axes select from their respective gear ratio parameters N4056 to N4059**. Note that, in this case, the gear signals CTH1 and CTH2 of the master axis are copied as the internal gear signals CTH1 and CTH2 of the slave axis, as shown in the following figure. Therefore, the slave axis selects gear ratios according to the gear signals of the master axis.



NOTE

When using the velocity command scaling function, note the following:

1 Since the gear signals CTH1 and CTH2 of the master axis take effect for both the master and slave axes, the gear ratio parameter (N4056 to N4059) for each axis is selected according to the gear signals of the master axis.

2 By using the gear ratio parameters selected as described above, the two axes perform their respective shares of the processing. The sending side carries out the spindle-end conversion of the velocity command (or actual speed) and sends the result and the receiving side carries out the motor-end conversion of the received value, in order to obtain the values appropriate for the two axis ends. Because of this processing, a slight error may occur for the velocity command to be used by the slave axis.

3 If the calculated velocity command exceeds the maximum spindle speed of the slave axis, it is clamped to the maximum spindle speed.

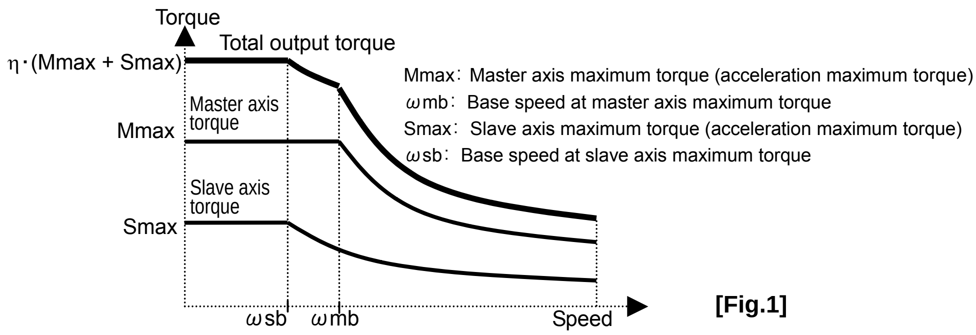
4 The value of bit 2 of parameter N4006 for setting the speed unit needs to be the same for both axes.

(3) When velocity tandem control is used for two motors having different gear ratios or different characteristics, use a slave motor whose maximum torque below the base speed is equal to or smaller than that of the master motor.

(4) The following figure shows a conceptual diagram of the motor output and total output in this case.

NOTE

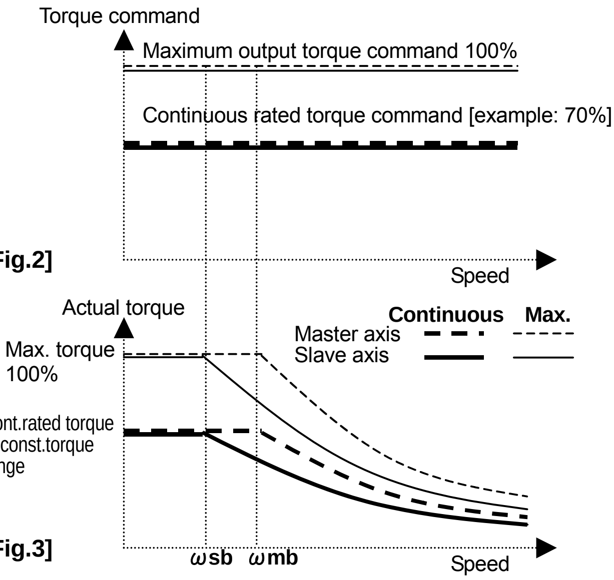
The following conceptual diagram (Fig. 1) shows how the torques of two motors are totaled. In reality, the total value needs to be estimated at a smaller value according to the efficiency η (0% to 100%) of each machine.



[Fig.1]

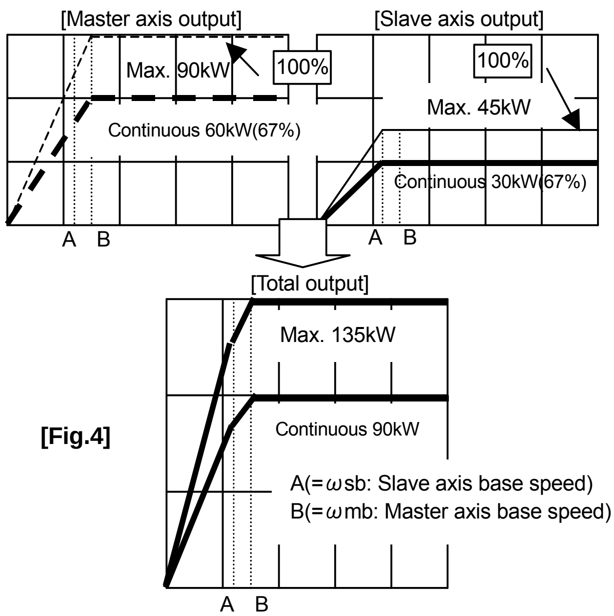
(5) The ratio of the maximum torque and the continuous rated torque is assumed to be the same for both axes (Fig. 2). Therefore, if this torque ratio is widely different, the sharing of motor output may become unbalanced relative to the continuous rated torque.

Note that, even when the torque ratio is the same as shown in Fig. 2, the actual torque of the motor of each axis becomes different as shown in Fig. 3, if the base speeds of the two axes are different. In this case, the total torque characteristics are as shown in Fig. 1, while the output characteristics are as shown in Fig. 4.



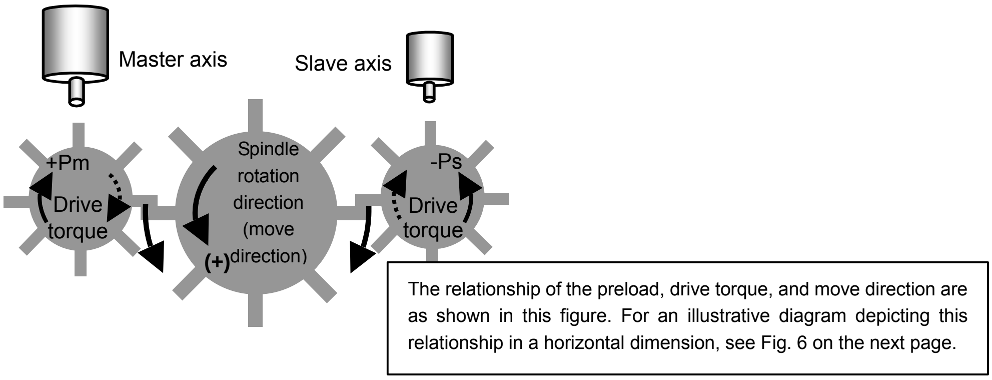
[Fig.2]

[Fig.3]

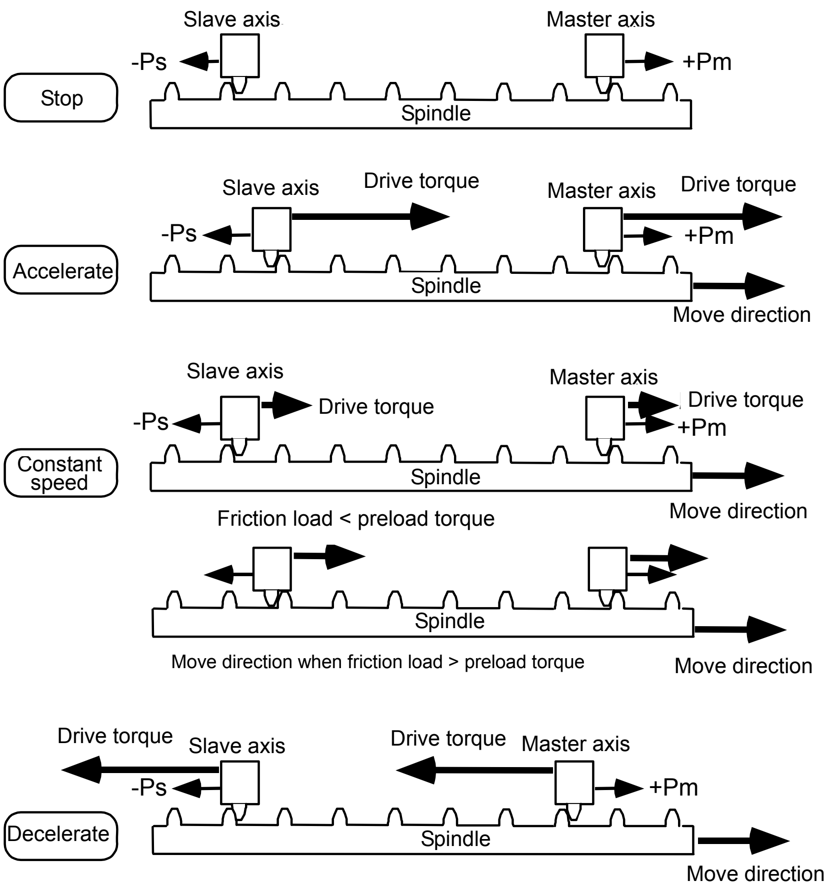


[Fig.4]

(6) The preload is a function that combines the master and slave axes with an offset applied in the direction opposite to that of the motor of each axis in relation to the torque to be controlled so as to reduce the effect of the backlash between the master and slave axes.



For example, when the preload for the master axis is +Pm and that for the slave axis is –Ps, torque is generated as shown in Fig. 5.
When a large torque is necessary in cases such as during acceleration or deceleration, the two motors generate torque in the same direction (load sharing mode).
When almost no torque is necessary in cases such as when the motors are stopped, the motors pull each other (anti-backlash mode).
The preload cannot be used when the anti-backlash mode is always desired.



[Fig. 5: Pattern Diagram of Torque Change When Preload Is Used]

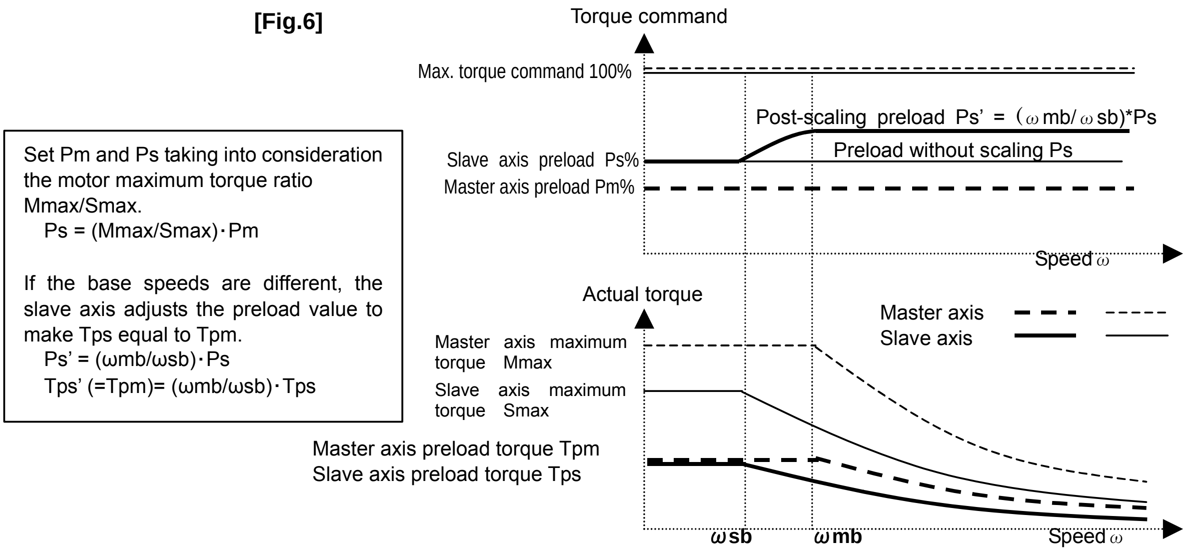
(7) Regarding the setting of the preload, it is necessary to note the following:
Since the actual torque needs to be the same for the preload, it is necessary to take into consideration the ratio of the maximum torques of the two axes when setting the preload. Therefore, set the preload such that the following relationship is established. The subscripts m and s represent the master axis and slave axis, respectively.

(Preload %)m・(Maximum torque Nm)m＝(Preload %)s・(Maximum torque Nm)s

The signs of the preload values are to be set as described below.
As shown in the block diagram at the beginning of this subsection, the preload torque is always added to the torque command. Therefore, set the preloads according to the motor rotation directions of the master and slave axes during spindle rotation, as follows.
When rotation directions are the same: The values set for the master and slave axes have different signs.
When rotation directions are different: The values set for the master and slave axes have the same sign.
Setting example)
When you want to set the master axis maximum torque to 100 Nm, slave axis maximum torque to 80 Nm, and preload to 5 Nm for a machine in which the motor rotation directions of the two axes during spindle rotation are the same, set the preload values as follows:
Master axis preload
5Nm ➔ 5% preload ➔ N4360m = 16384*5/100 = 819
Slave axis preload (Set the – sign because the rotation direction is the same.)
N4360s = - 100 / 80 * 819/16384 * 16384 = -1024 (-6.25%)

(8) If the base speeds of the two axes are different, the slave axis can perform scaling to adjust the difference. See Fig. 6.

[Fig.6]



(9) When using the preload, it is necessary to note the following:
When preloads are set, the torque commands for the motors of the two axes are different in the tandem operation. Therefore, it is necessary to check No. 410 (load meter display) in the diagnosis screen and ensure that the motors of the two axes are used in a range where they operate at the continuous rated torque.
Note also that, in this case, even if the total load value of the two axes is the same for both clockwise and counterclockwise rotation, the total actual torque is different. This is because the torque command of the motor of each axis is different for clockwise and counterclockwise rotation and the maximum torque of the motors are different. See the example below.

[Example] Mmax: Master axis maximum torque, Smax: Slave axis maximum torque
TD: Drive torque [%]
Pm: Master axis preload [%], Ps: Slave axis preload [%]
(Master axis torque command) = TDm＋Pm＝Td＋Pm
(Slave axis torque command) = TDm (received integral term)－Ps＝Td－(Mmax/Smax)･Pm

Smax/Mmax=2/3, Pm=10%	Clockwise rotation		Counterclockwise rotation	
	Torque command (load)	Master axis converted actual torque (%)	Torque command (load)	Master axis converted actual torque (%)
Master axis	70 (%) = 60 + 10	70 (%)	-45 (%) = -55 + 10	-45 (%)
Slave axis	45 (%) = 60 - 15	30 (%) = 45* (2/3)	-70 (%) = -55 - 15	-46.7 (%) = -70* (2/3)
Total value	115 (%) = 70 + 45	100 (%) = 70 + 30	-115 (%) = -45 + (-70)	-91.7 (%) = -45 + (-46.7)

(2) Additional information 2: Spindle drive using four or more spindle motors

A function called velocity tandem control is available that drives the spindle with two spindle motors to gain a large output. If the output from two motors is insufficient, it is necessary to drive a single spindle with multiple velocity tandems. In this case, the master axis of each velocity tandem is controlled by "spindle simple synchronous control (or spindle command synchronous control in the case of 30i-B)".
This section contains information necessary to control a machine that drives the spindle with multiple velocity tandems using spindle simple synchronous control.

When using this function, also refer to Section 11.17, "Spindle Simple Synchronous Control" of B-63943EN (FS30i-A Connection Manual) and Section 11.17, "Spindle Command Synchronous Control" of B64483EN (FS30*i*-B Connection Manual).

NOTE

1. To use this function, the CNC software options "spindle tandem control" and "spindle simple synchronous control" are required.
2. When the CNC is FS30*i* –B, these two functions are included in the CNC software option "spindle synchronous control".
3. To use this function, all the motors to be used need to be of the same specifications.
4. To use this function, the spindle amplifier needs to be of TYPE B because inter-spindle amplifier communication is used.
5. For the master and slave axes, use the spindle software of the same series and edition.

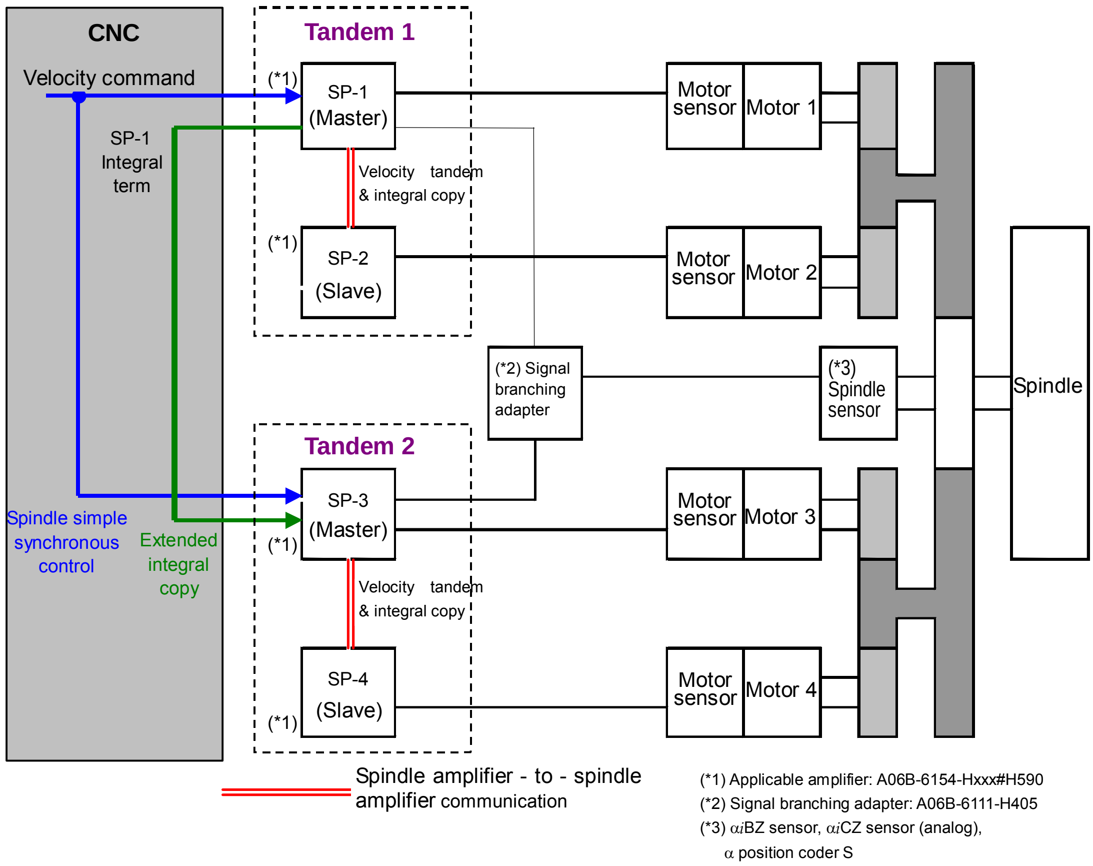
(1) Usable software

Spindle software

Series	Edition	Usable CNC
9D90	B (02)	FS30*i*-A / FS31*i*-A
9DA0	F (06)	FS30*i*-B / FS31*i*-B

(2) System configuration

The following figure shows an example where the velocity tandem function is applied to a machine that drives the spindle with four spindle motors using spindle simple synchronous control.



<1> The spindle is driven by four spindle motors.
<2> The master axes SP-1 and SP-3 of the two tandems are controlled by spindle simple synchronous control.
<3> In this case, the speed integral term can be copied from SP-1 engaged in spindle simple synchronous control to SP-3. This is called "extended integral copy".
<4> The slave axes SP-2 and SP-4 of the two tandems receive the velocity command and speed integral term from the master axes SP-1 and SP-3 of the tandems and use the received values as their own velocity command and velocity integral term (velocity tandem control).

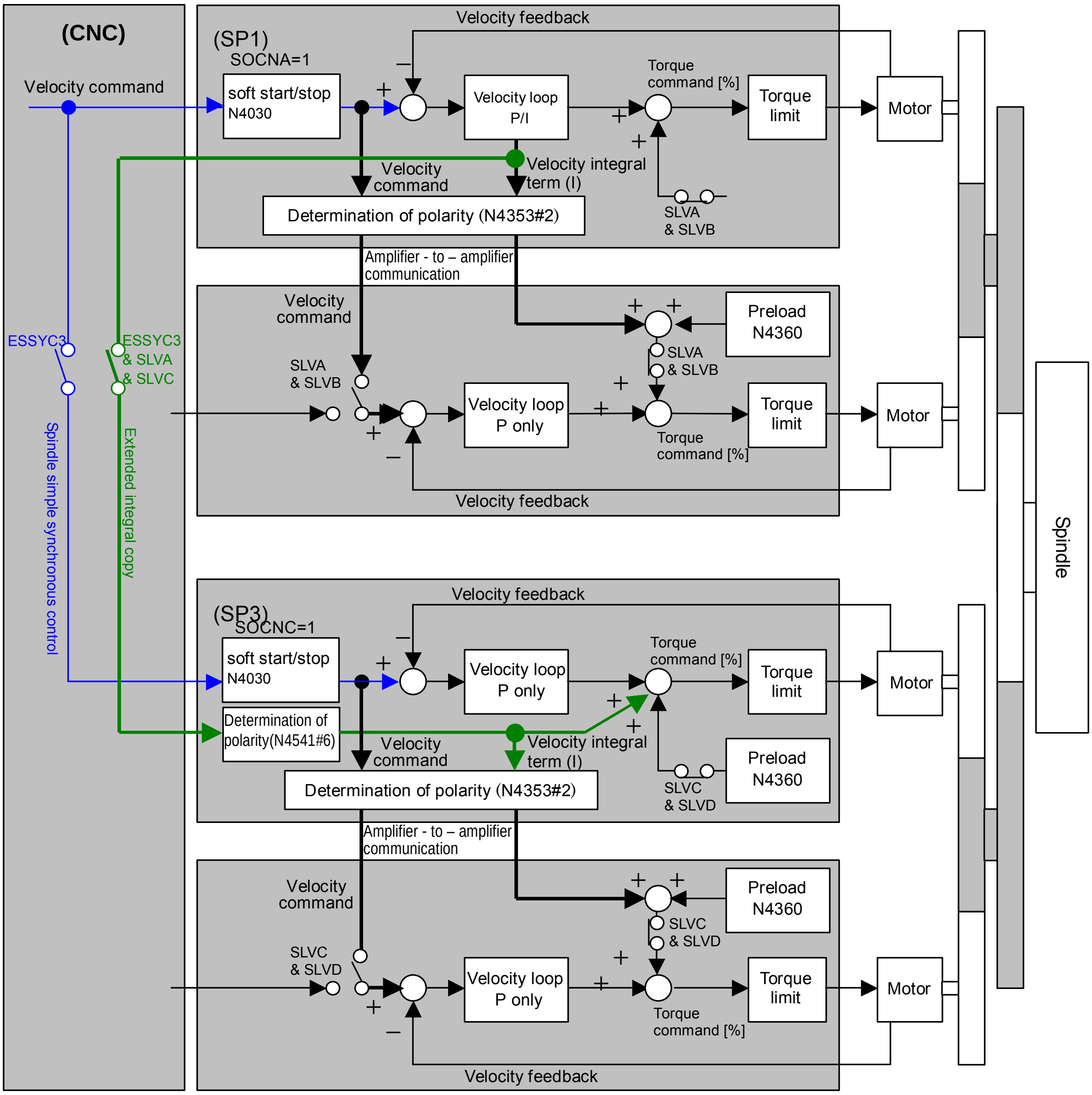
(3) Block diagram

The following figure shows a control block diagram applicable when this function operates using four spindle motors.

<1> The velocity command from the CNC are passed to SP1 and SP3. The soft start/stop function limits the specified acceleration rate to reduce the mechanical shock, and SP1 and SP3 pass the limited command to SP2 and SP4, respectively. Then, each motor exerts velocity control.

<2> SP2 and SP3 receive the integral term from SP1, and SP4 receives the integral term from SP3. They add the received integral term to the proportional term to create a torque command.

<3> Each SP adds the set preload value to this torque command to create a final torque command.



(4) I/O signals (CNC ⇔ PMC)

(4-1) Input signals (PMC → CNC)

	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st SP	G073							**SLVA**	
2nd SP	G077							**SLVB**	
3rd SP	G207							**SLVC**	
4th SP	G269							**SLVD**	

SLVx Tandem operation command for each spindle

0 : Makes a request to disable tandem operation.

1 : Makes a request to enable tandem operation.

These signals specify whether to enable or disable tandem operation.

To use velocity tandem, set "1" for all of the four spindles.

> **NOTE**
> 1 When switching these signals, make sure that the four spindles are stopped. When the spindles are rotating, a request to switch these signals cannot be accepted.
> 2 Switch these signals in the velocity control mode. In a mode other than the velocity control mode, these signals cannot be accepted.
> 3 When the four spindles are mechanically disconnected with each other, do not set these signals to "1".

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
Gn064		**ESRSYC**						

ESRSYC Spindle simple synchronous control signal (when spindle simple synchronous control is exerted by the first and second spindles)

0 : Makes a request to disable spindle simple synchronous control.

1 : Makes a request to enable spindle simple synchronous control.

When "1" is set in this signal, the spindle simple synchronous control mode is enabled, and the second spindle operates as the slave axis of the first spindle.

> **NOTE**
> This signal is valid when "0" is set in bit 5 (SSY) of parameter No. 3704.

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
Gn264					**ESSYC4**	**ESSYC3**	**ESSYC2**	**ESSYC1**

ESSYCx Spindle simple synchronous control signal for each individual spindle

0 : Makes a request to disable spindle simple synchronous control.

1 : Makes a request to enable spindle simple synchronous control.

When "1" is set in any of these signals, the spindle corresponding to that signal operates as the slave axis for spindle simple synchronous control.

> **NOTE**
> 1 These signals are valid when "1" is set in bit 5 (SSY) of parameter No. 3704.
> 2 The master axis with which the slave axis is to be synchronized is defined by parameter No. 4821.

(4-2) Output signals (CNC → PMC)

	30i	#7	#6	#5	#4	#3	#2	#1	#0
1st SP	F045							**SSTA**	
2nd SP	F049							**SSTB**	
3rd SP	F168							**SSTC**	
4th SP	F266							**SSTD**	

SSTx Speed zero detection signal for each individual spindle
0 : The spindle motor is rotating.
1 : The spindle motor is in the speed zero (stopped) state.
When switching the tandem operation command SLVx, make sure that "1" is set in the signals for all the four spindles.
The tandem operation command cannot be accepted when "0" is set in any of these signals.

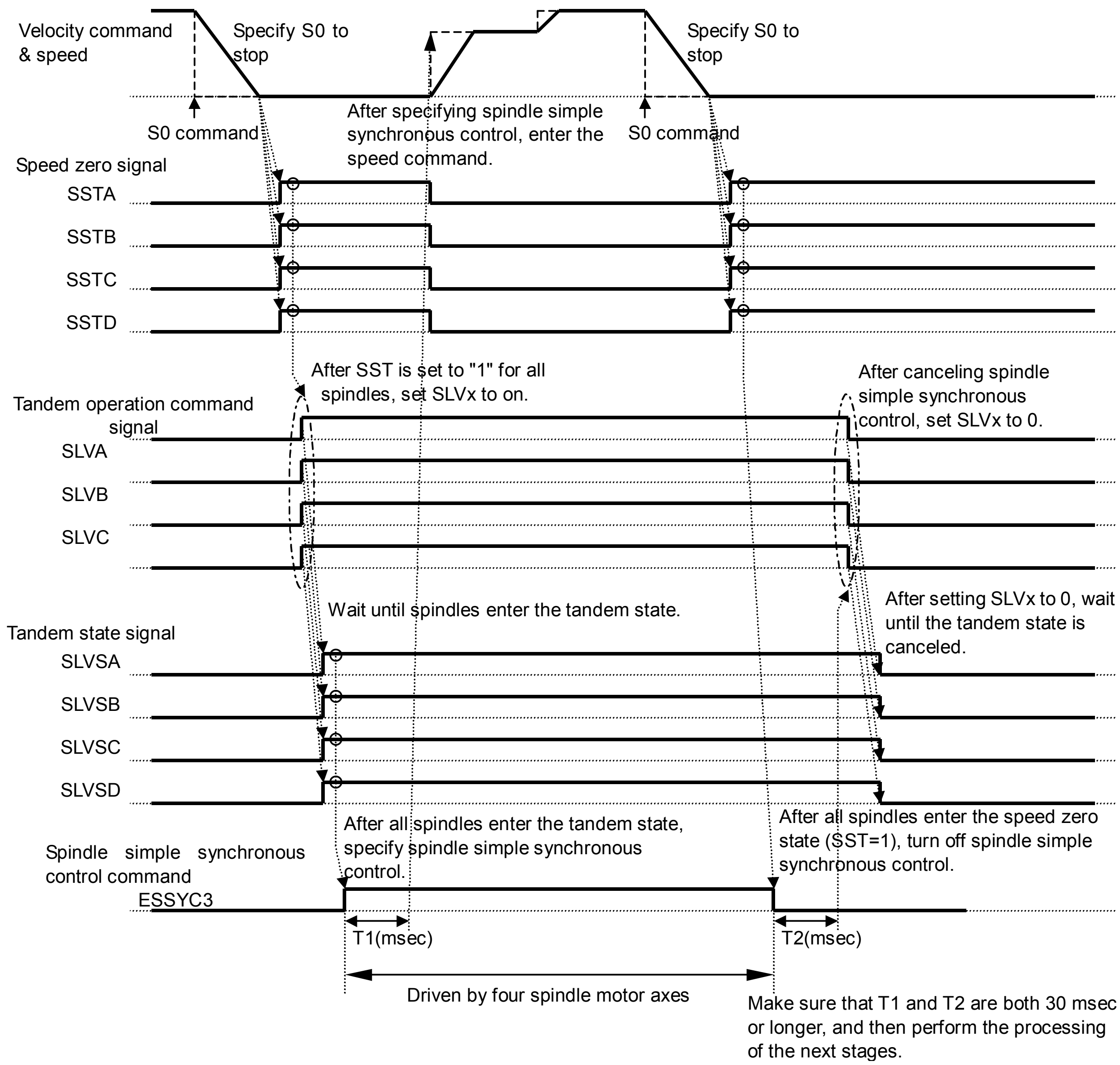
	30i	#7	#6	#5	#4	#3	#2	#1	#0
1st SP	F046				**SLVSA**				
2nd SP	F050				**SLVSB**				
3rd SP	F169				**SLVSC**				
4th SP	F267				**SLVSD**				

SLVSx Tandem operation state signal for each individual spindle
0 : Disables tandem operation.
1 : Enables tandem operation.
Before specifying spindle simple synchronous control for the spindle amplifier that is to operate as the slave axis for spindle simple synchronous control, make sure that "1" is set in the signals for all the four spindles.

(4-3) Examples of Sequences

To switch spindle simple synchronous control or spindle tandem control, you need to have the velocity control mode on, the velocity command set to 0, and the speed zero state (SST = 1) set for the spindle. To reduce the mechanical shock, use also the soft start/stop function (N4030 and G071#4(SOCNA): for the first spindle) for all the tandem master axes.

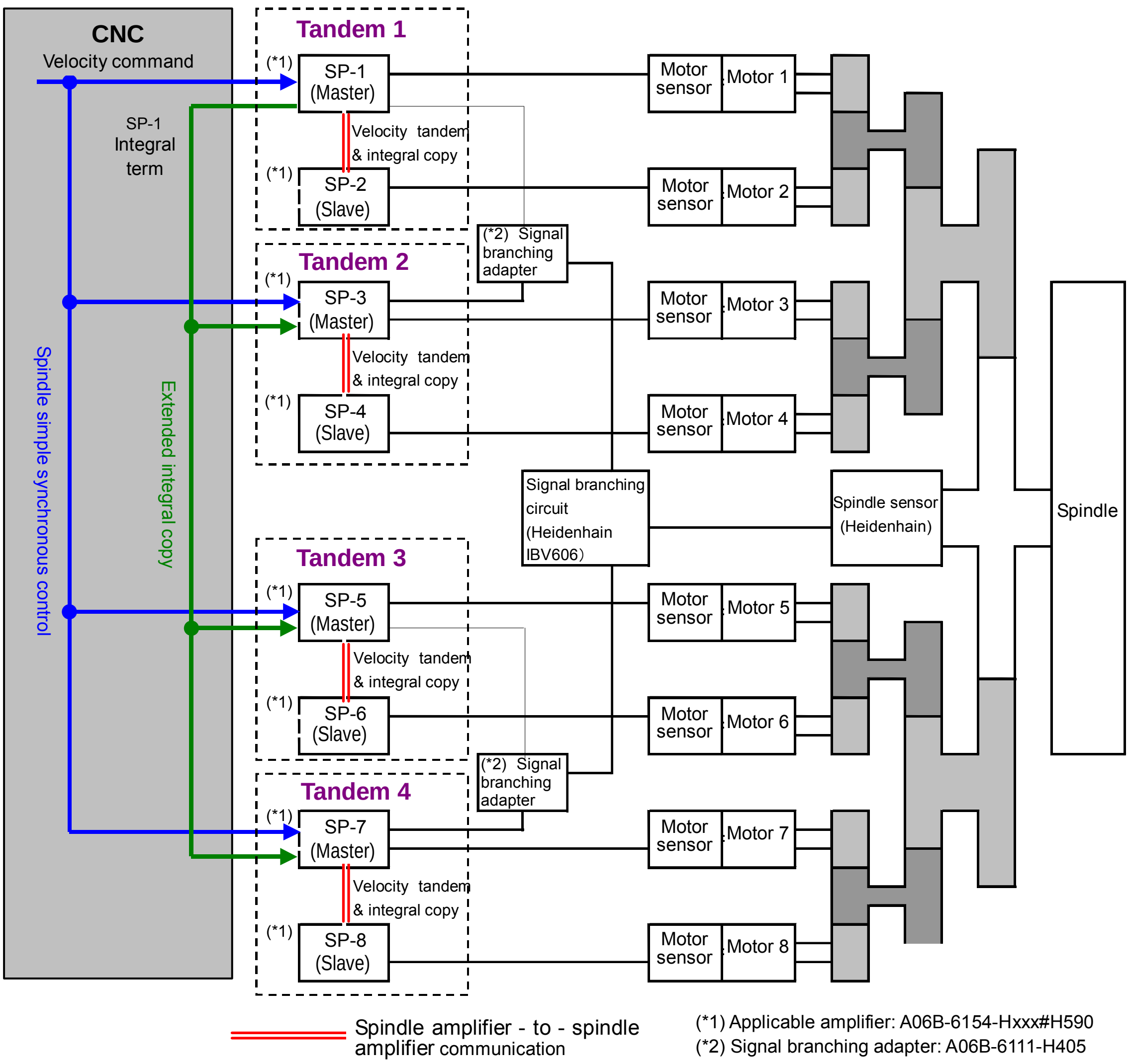
<1> Specify 0 (S0) for the velocity mode to stop all the spindles.
<2> Check that the speed zero signal (SST) is set to the speed zero state (1) for all the spindles.
<3> Specify velocity tandem control for all the spindles of all the tandems (SLVx = 1).
<4> Check that all the spindles are set to the tandem mode (SLVSx = 1).
<5> Next, specify spindle simple synchronous control for the slave axis for spindle simple synchronous control (ESSYC3 = 1).
<6> Check that the parking signal is set to 0, and enter the velocity command to drive the spindles.
<7> When position control is enabled, the phase synchronous error monitor signal SYCAL is output according to the phase error state. By monitoring this signal, the PMC can perform processing appropriate for the phase error state.
<8> Specify 0 to stop the spindles.
<9> Check that the speed zero signal (SST) is set to the speed zero state (1) for all the spindles.
<10> Next, cancel the spindle simple synchronous control state (ESSYC3 = 0).
<11> Cancel velocity tandem control for all the spindles of each tandem (SLVx = 0).
<12> Check that the tandem state has been canceled for all the spindles (SLVSx = 0).


Velocity command & speed
Specify S0 to stop
S0 command
After specifying spindle simple synchronous control, enter the speed command.
Specify S0 to stop
S0 command
Speed zero signal
SSTA
SSTB
SSTC
SSTD
After SST is set to "1" for all spindles, set SLVx to on.
After canceling spindle simple synchronous control, set SLVx to 0.
Tandem operation command signal
SLVA
SLVB
SLVC
Wait until spindles enter the tandem state.
After setting SLVx to 0, wait until the tandem state is canceled.
Tandem state signal
SLVSA
SLVSB
SLVSC
SLVSD
After all spindles enter the tandem state, specify spindle simple synchronous control.
After all spindles enter the speed zero state (SST=1), turn off spindle simple synchronous control.
Spindle simple synchronous control command
ESSYC3
T1(msec)
T2(msec)
Driven by four spindle motor axes
Make sure that T1 and T2 are both 30 msec or longer, and then perform the processing of the next stages.

(5) Setting examples of the parameters related to the integral copy

When the spindle is driven by four velocity tandems (eight motors) as shown in the following figure, the settings related to the velocity integral copy are to be made as indicated by the examples given below.

SP	N4398#5,4,3	N4353#2	N4541#6	N4597	Remarks
SP-1	1,1,0	1	0	-1	Spindle simple synchronous control (+ extended integral copy) master axis Velocity tandem 1 (+ integral copy) master axis
SP-2	1,1,0	-	0	0	Velocity tandem 1 (+ integral copy) slave axis
SP-3	1,1,0	1	0	1	Spindle simple synchronous control (+ extended integral copy) slave axis Velocity tandem 2 (+ integral copy) master axis
SP-4	1,1,0	-	0	0	Velocity tandem 2 (+ integral copy) slave axis
SP-5	1,1,0	1	0	1	Spindle simple synchronous control (+ extended integral copy) slave axis Velocity tandem 3 (+ integral copy) master axis
SP-6	1,1,0	-	0	0	Velocity tandem 3 (+ integral copy) slave axis
SP-7	1,1,0	1	0	1	Spindle simple synchronous control (+ extended integral copy) slave axis Velocity tandem 4 (+ integral copy) master axis
SP-8	1,1,0	-	0	0	Velocity tandem 4 (+ integral copy) slave axis



(*1) Applicable amplifier: A06B-6154-Hxxx#H590
(*2) Signal branching adapter: A06B-6111-H405

(6) Spindle orientation

When the spindle is driven by four velocity tandems (eight motors) as shown in the following figure, the settings related to the velocity integral copy are to be made as indicated by the examples given below.

Spindle orientation can be used in spindle tandem control four, six, or eight spindle motors. The following options are required:

- Spindle orientation
- Spindle orientation extension

The valid spindle orientation command signal (ORCM) and spindle orientation stop position change command signal (INDX) are the signals of the master axis for which the parameter No. 4597 is set to -1. The signals of the slave axis are ignored. The method of setting the stop position for position coder method spindle orientation can be selected using bit 0 (ORT) of parameter No. 3729. In bit 0 (ORT) of parameter No. 3729, set the same value for all the spindles used for spindle tandem control. Set the stop position as follows.

- For orientation with a fixed stop position (bit 0 (ORT) of parameter No. 3729 = 0)
  Set the stop position in parameter Nos. 4031 and 4077. Set the same value for all the spindles used for spindle tandem control.

- For orientation with an externally set stop position (bit 0 (ORT) of parameter No. 3729 = 1)
  Set the stop position using the spindle orientation external stop position command signals (SH00 to SH11). Set the stop position in the signals of the master axis for which the parameter No. 4597 is set to -1. The signals of the slave axis are ignored.

> **NOTE**
> Arrange that a one-rotation signal is detected regardless of the spindle speed.
> If the spindle sensor is a Heidenhain-made 1Vpp encoder, set the parameters as follows:
> Bits 3, 2, 1, and 0 of parameter No.4002 = 1, 1, 1, and 0
> Bit 2 of parameter No. 4394 = 1

5.12 Tandem Disturbance Elimination Control (OPTIONAL FUNCTION)

5.12.1 Overview

This function suppresses the vibration caused by the interference between the master and slave axes when the axes use position tandem (spindle simple synchronous) or velocity tandem control.
The function remains in effect only when the PMC signal indicating whether the two axes are mechanically connected is set to 1 (connected). Note that the function requires the inter-spindle amplifier communication function.

NOTE

1. To use this function, the CNC software option "tandem disturbance elimination control" is required.
2. To use this function, SP TYPE B is required.
3. This function can be used together with velocity tandem control.
4. This function cannot be used together with the spindle EGB.
5. This function cannot be used for twin drives (two-winding motors and induction machines only).
6. This function can be used between a pair of a master and a slave axis connected via inter-spindle amplifier communication.
7. Since inter-spindle amplifier communication is used, prepare SP TYPE B and inter-spindle amplifier communication cables.
8. This function needs to be disabled when the master and slave axes are not mechanically connected. In this case, turn off the machine connection notification signal (tandem command signal) SLV for both axes.

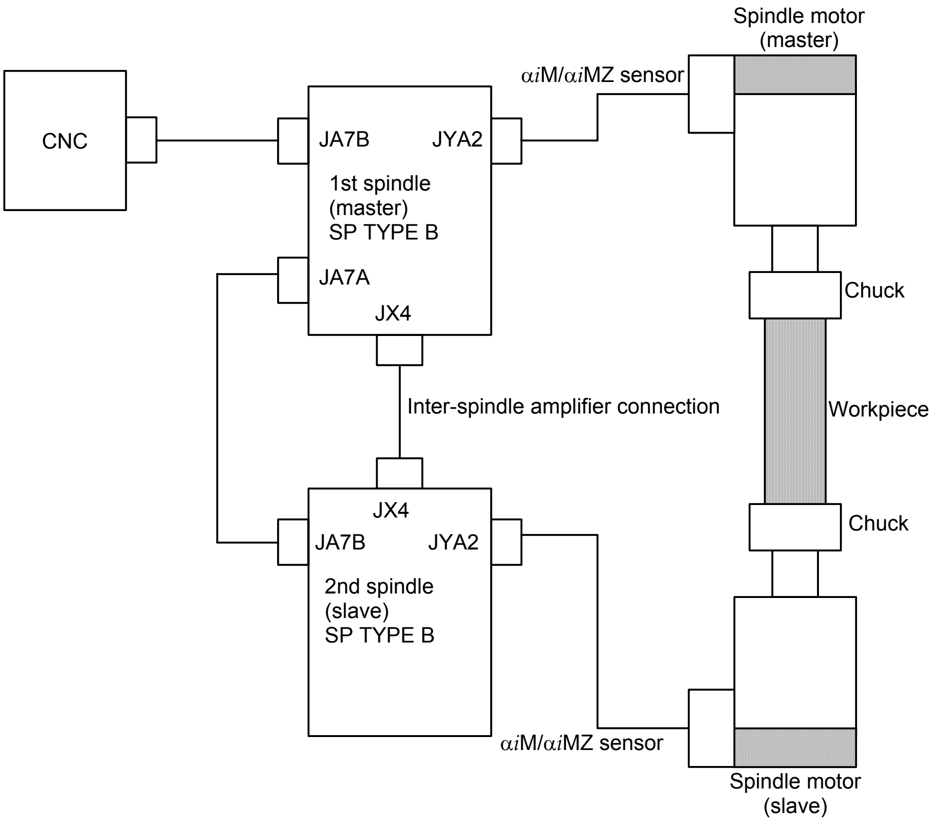
5.12.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D90	B (02)	FS30*i*-A / FS31*i*-A
9DA0	F (06)	FS30*i*-B / FS31*i*-B

5.12.3 System Configuration

A system is assumed to have a configuration like the one shown below in which the machine is driven by two spindles and the connection between the two axes is relatively stiff. In such a configuration, the power interference between the motors may cause vibration. Tandem disturbance elimination control is used for a machine like this.



> **NOTE**
> 1 When the master and slave are mechanically disconnected with each other, cancel the tandem operation mode.
> 2 When the motor to be used is a synchronous spindle motor of the BiS series, the power line between the amplifier and the motor needs to be connected via the sub module SM (SSM).
> 3 To perform pole detection when the motor to be used is a synchronous spindle motor of the BiS series, release the mechanical connection to free the synchronous spindle motor. In this case, cancel the tandem operation mode as well.

5.12.4 I/O Signals (CNC↔PMC)

(1) Input signals (PMC→CNC)

	30i	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G073						MPOFA	SLVA	
2nd-	G077						MPOFB	SLVB	

SLVA Mechanical connection notification signal (for the first spindle)
SLVB Mechanical connection notification signal (for the second spindle)

These signals notify the amplifiers of the two axes whether the axes are mechanically connected.

The two axes are mechanically:

0 : Disconnected (tandem disturbance elimination control is disabled)
1 : Connected (tandem disturbance elimination control is enabled)

> **NOTE**
> While these signals are operation command signals for the tandem function, they are also used for tandem disturbance elimination control.

(1) Before setting SLVx to 1 for the two spindles, set "0" in the position command or velocity command for both spindles to stop them and check that SSTx is set to 1 (speed zero) as well as that the two spindles are mechanically connected.

(2) Before setting SLVx to 0 for the two spindles, set "0" in the position command or velocity command for both spindles to stop them and check that SSTx is set to 1 (speed zero). Then, disconnect the machine.

> **NOTE**
> 1 When the two spindles are mechanically disconnected with each other, do not set these signals to 1.
> 2 When using a synchronous spindle motor, specify the commands with pole detection completed for both axes.
> 3 Before changing the spindle connection state notification signal SLVx, check that "0" is set in the position command or velocity command (position control/velocity control mode) and SSTx is set to 1 (speed zero state) for both spindles.
> 4 To return the axes to the origin in position tandem (spindle simple synchronous control), turn off these signals (SLVx = 0) and return each axis to the origin individually.
> 5 To use the parking signal in position tandem (spindle simple synchronous control), turn off these signals and disable tandem disturbance elimination control.

MPOFA Motor power turn-off signal (for the first spindle)
MPOFB Motor power turn-off signal (for the second spindle)
0 : Normal operation
1 : Turns off the power to the motor.

> **NOTE**
> 1 If any abnormality, such as an excessive master-slave speed difference, is detected when tandem disturbance elimination control is enabled, turn off the power to the motors of both the master and slave axes by using these signals in order to minimize mechanical damage.
> 2 When a synchronous spindle motor is used, the motors decelerate to a stop using the SSM, rather than coast to a stop, even if these signals are input.

(2) Output signals (CNC→PMC)

	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F045							SSTA	
2nd-	F049							SSTB	

SSTA Speed zero detection signal (for the first spindle)
SSTB Speed zero detection signal (for the second spindle)

0 : The spindle motor is rotating.
1 : The spindle motor is in the speed zero (stopped) state.

Check that these signals are set to "1" for both the master and slave axes, before the switching the mechanical connection notification signal SLVx.
If these signals are set to "0", a request to change the switching the mechanical connection notification signal SLVx cannot be accepted.

	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F046				SLVSA				
2nd-	F050				SLVSB				

SLVSA Mechanical connection answer signal (for the first spindle)
SLVSB Mechanical connection answer signal (for the second spindle)
Tandem disturbance elimination control is:
0 : Disabled (received a notification that the two axes are mechanically disconnected)
1 : Enabled (received a notification that the two axes are mechanically connected)
Check that these signals are set to "1" for both the master and slave axes, and then specify the same command for the spindle amplifiers of the two axes.

NOTE
While these signals are operation command signals for the tandem function, they are also used for tandem disturbance elimination control.

	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F047						MSOVRA		
2nd-	F051						MSOVRB		

MSOVRA Master-slave speed difference state signal(for the first spindle)
MSOVRB Master-slave speed difference state signal (for the second spindle)
0 : The speed difference between the master and slave is less than the set value.
1 : The speed difference between the master and slave is equal to or greater than the set value.
These signals indicate whether or not the speed difference between the master motor and slave motor is less than the value set in the parameter (No. 4347). The signal for the slave spindle amplifier need not be monitored. (At all times, 0 is output.)

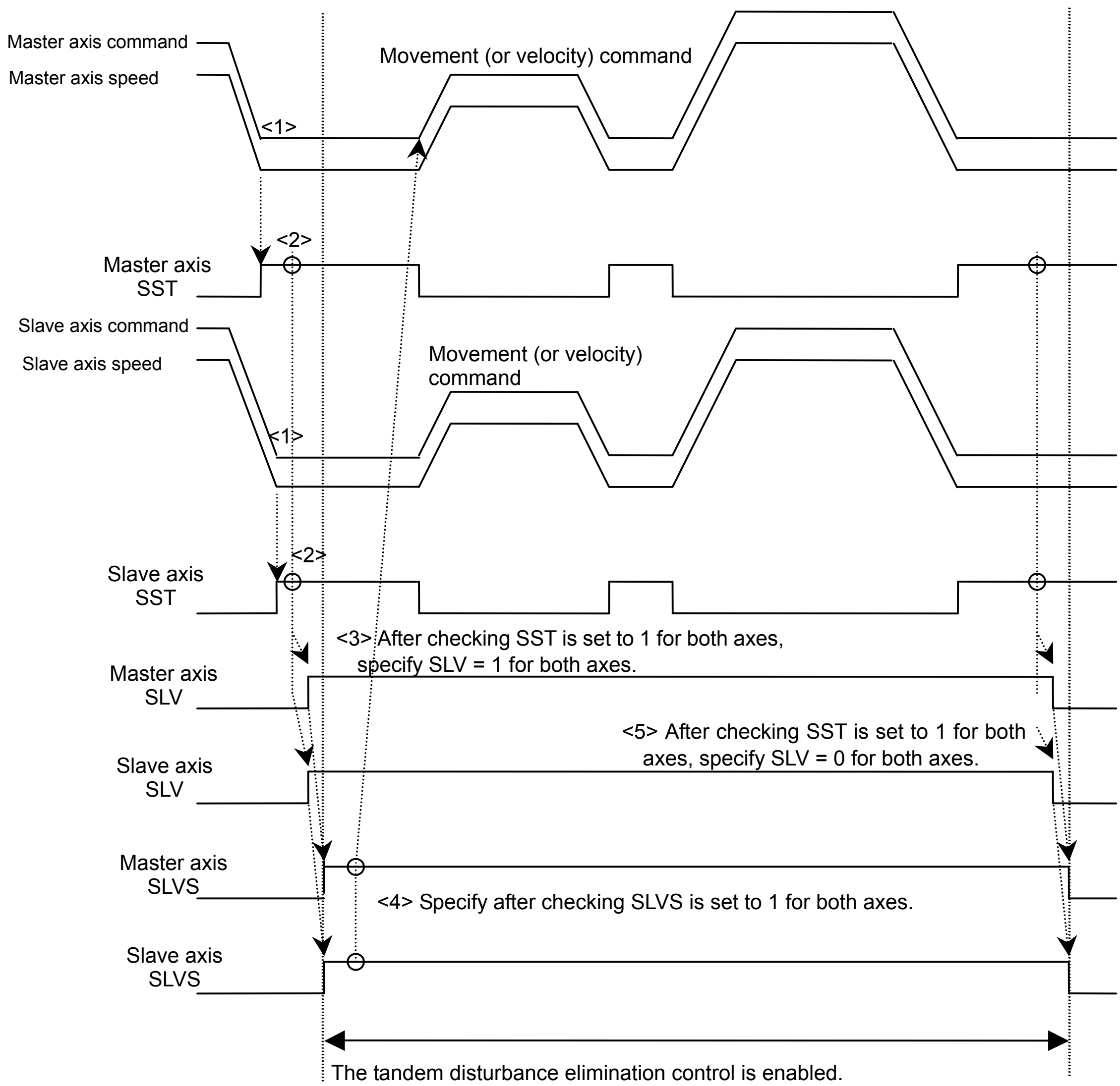
⚠ **CAUTION**
1 If a motor feedback signal disconnection alarm (spindle alarm 73) is issued, the status of this signal is undefined.
2 When bit 5 of parameter No. 4007 is set to "1", the detection operation of the feedback signal disconnection alarm is not performed.
Set "0" in principle to enable alarm detection.

NOTE
Monitor the states of these signals on the PMC. Ensure that an alarm is issued if an error occurs (for example, if the state of 1 lasts for a certain period of time).

5.12.5 Examples of Sequences

The sequence is as follows.

<1> Stop both axes.
<2> After connecting the two axes mechanically, check that SSTx is set 1 (speed zero state) for both axes.
<3> Input the spindle connection notification signal SLVx to the two axes, with the value of 1 set in the signal. When the answer signal SLVSx is set 1 for both axes, tandem disturbance elimination control is enabled.
<4> When tandem disturbance elimination control is enabled, specify the same command for both axes.
<5> To disable the function, check that SSTx is set 1 (speed zero state) for both axes and input the spindle connection notification signal SLV to the two axes, with the value of 0 set in the signal.
<6> After checking that the answer signal SLVSx is set 0 for both axes, disconnect the spindle mechanically.


Master axis command
Master axis speed
Movement (or velocity) command
<1>
<2>
Master axis SST
Slave axis command
Slave axis speed
Movement (or velocity) command
<1>
<2>
Slave axis SST
<3> After checking SST is set to 1 for both axes, specify SLV = 1 for both axes.
Master axis SLV
<5> After checking SST is set to 1 for both axes, specify SLV = 0 for both axes.
Slave axis SLV
Master axis SLVS
<4> Specify after checking SLVS is set to 1 for both axes.
Slave axis SLVS
The tandem disturbance elimination control is enabled.

5.12.6 Parameters

Details of the parameters related to tandem disturbance elimination control are given below.

30i	#7	#6	#5	#4	#3	#2	#1	#0
4015					SPDTDM			

SPDTDM Whether to use the spindle tandem control option (Since this parameter is automatically set, it cannot be set manually; it is only allowed to reference the parameter.)

> **NOTE**
> To use tandem disturbance elimination control for velocity tandem control, the spindle tandem control option is required (SPDTDM needs to be set to 1). If SPDTDM is set to 0, check the software option.

30i	#7	#6	#5	#4	#3	#2	#1	#0
4403								TDEOPT

TDEOPT Whether to use the tandem disturbance elimination control option (Since this parameter is automatically set, it cannot be set manually; it is only allowed to reference the parameter.)

> **NOTE**
> When this bit is set to "0", tandem disturbance elimination control is disabled. If the bit is set to "0", check the software option.

30i	#7	#6	#5	#4	#3	#2	#1	#0
4540			TANDMP					

TANDMP Tandem disturbance elimination control
0 : Tandem disturbance elimination control is disabled.
1 : Tandem disturbance elimination control is enabled.
This parameter is valid when bit 0 (TDEOPT) of parameter No. 4403 is set to 1. To use tandem disturbance elimination control, set "1" in this bit for both the master and slave axes.

30i	#7	#6	#5	#4	#3	#2	#1	#0
4398			WSVCP	VTAN	WNDTDM			

WNDTDM Whether to use the twin drive function (two-winding motor drive and induction machine only)
VTAN Whether to use the velocity tandem function
WSVCP Whether to use the velocity integrator copy function
By combining these bit parameters as shown on the next page, tandem disturbance elimination control can be used.
The settings (1) and (2) are intended for speed tandem operation, and the settings (3) and (4) are intended for position tandem (spindle simple synchronous control) operation.

Setting	TANDMP	TDEOPT	WSVCP	VTAN	WNDTDM	SPDTDM	Enabled function
(1)	1	1	0	1	0	1	Velocity tandem control + Tandem disturbance elimination control

Setting	TANDMP	TDEOPT	WSVCP	VTAN	WNDTDM	SPDTDM	Enabled function
(2)	1	1	1	1	0	1	Velocity tandem control + Velocity integral copy function + Tandem disturbance elimination control
(3)	1	1	0	0	0	0	Tandem disturbance elimination control
(4)	1	1	1	0	0	0	Velocity integral copy function + Tandem disturbance elimination control

Note) WNDTDM is a parameter used for two-winding motors (induction machines only). This function cannot be used for two-winding motors. Be sure to set WNDTDM to 0.

30i	#7	#6	#5	#4	#3	#2	#1	#0
4402					TRQTDM			

TRQTDM Whether to use the torque tandem function
Set this parameter to 0.

NOTE
*1 While this bit assumes the NC for FS30i-B, set "0" for 30i-A as well.
*2 When this bit is set to "1", tandem disturbance elimination control does not work normally. Be sure to set "0".

30i	#7	#6	#5	#4	#3	#2	#1	#0
4352	MASTER	SLAVE						

SLAVE Inter-spindle amplifier communication slave axis setting
0 : Non-inter-spindle amplifier communication slave axis
1 : Inter-spindle amplifier communication slave axis (Set 1 for the master axis.)

MASTER Inter-spindle amplifier communication master axis setting
0 : Non-inter-spindle amplifier communication master axis
1 : Inter-spindle amplifier communication master axis (Set 1 for the master axis.)

NOTE
1 For inter-spindle amplifier communication, set (MASTER,SLAVE)=1,0 for the master axis and (MASTER,SLAVE)=0,1 for the slave axis.
2 Setting (MASTER,SLAVE)=1,1 causes the state error "38".

30i	#7	#6	#5	#4	#3	#2	#1	#0
4353						RVSVC2		

RVSVC2 Relationship of master/slave motor rotation directions when the spindles are connected
0 : The master motor and slave motor rotate in the same direction (when viewed from the motor shaft).
1 : The master motor and slave motor rotate in the opposite directions (when viewed from the motor shaft).

This parameter determines the polarity of the actual motor speed that one spindle receives from the other.

NOTE

1 Set this parameter on the master side. The value set on the master side (the spindle for which bit 7 of parameter No. 4352 is set to 1) is transferred to the slave side via inter-spindle amplifier communication.

2 If this parameter is not set properly, tandem disturbance elimination control does not work normally.

30*i*	
4601	**Tandem disturbance elimination control Proportional gain Kp**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

While this parameter may be used for a machine generating much friction, it is generally not used.

30*i*	
4602	**Tandem disturbance elimination control Integral gain Ki**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

This parameter compensates the spring element of the machine. When stiffness is high, the value becomes large (torque/inertia).
The larger the ratio, the smaller the value.

30*i*	
4603	**Tandem disturbance elimination control Phase compensation α**

Unit of data :
Valid data range : 0, 51 to 512(0.1< α <1)
Standard setting value : 0

This parameter is used with coefficient T below to compensate for the delay of adjustment.
When the parameter is set to 0, the value is internally handled as 512 (α = 1).
When α is 1, phase compensation is not done.

30*i*	
4604	**Tandem disturbance elimination control Phase compensation T**

Unit of data : 1msec
Valid data range : 0 to 20
Standard setting value : 0

This parameter is used with coefficient α above to compensate for the delay of adjustment. If the interference frequency is 100 Hz or higher, try setting α to 102 and T to 3.

30*i*	
4605	**Tandem disturbance elimination control Incomplete integral time constant**

Unit of data :

Valid data range : 0 to 32767
Standard setting value : 0

Setting a large value for integral gain Ki may cause low frequency vibration (10 Hz or lower).
In this case, set a smaller value for the incomplete integral time constant. See the following table for reference. When the parameter is set to 0, the value is internally handled as 32682.

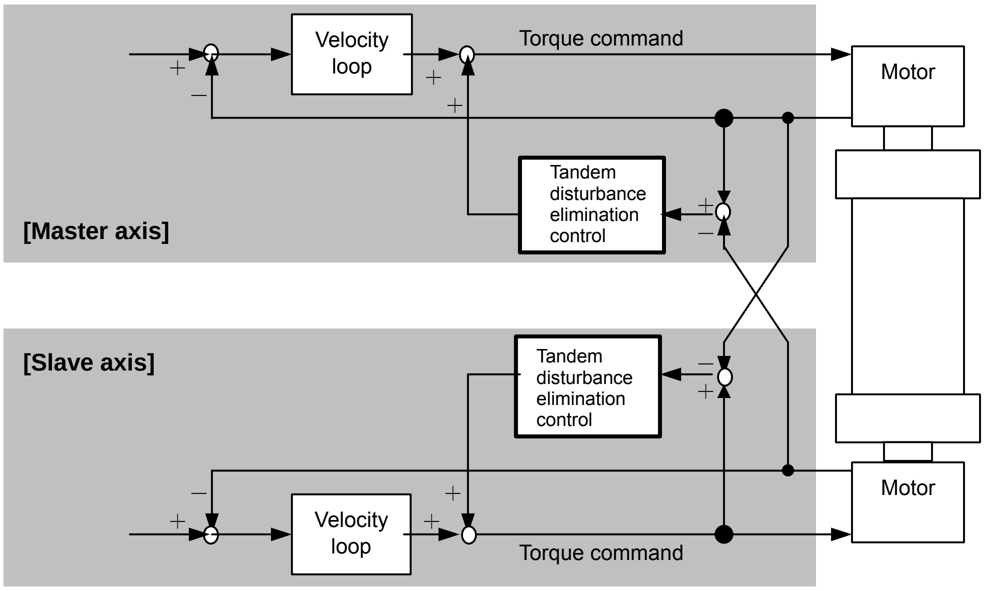
Time constant (sec)	Parameter value
0.1	32682
0.05	32596
0.02	32341

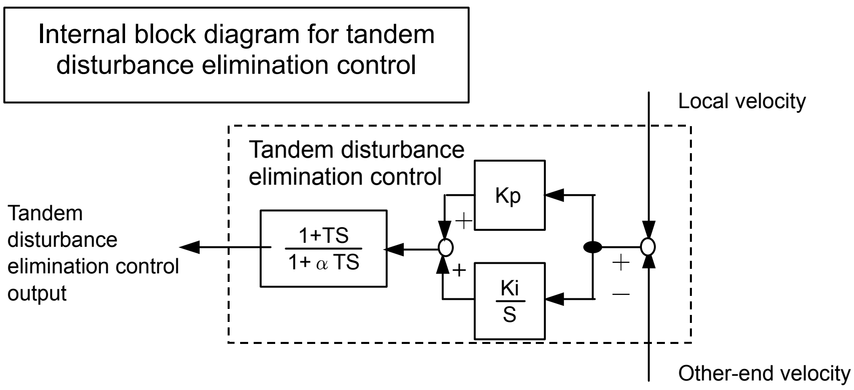
5.12.7 Block Diagram

Details of the parameters related to tandem disturbance elimination control are given below.

The block diagram for tandem disturbance elimination control is as shown below.

<1> Calculate the deviation from the local velocity and the other-end velocity.
<2> Calculate the proportional integral for the calculated deviation.
<3> Perform phase compensation for the result of the proportional integral calculation and add the amount of torque compensation to the torque command for each axis.



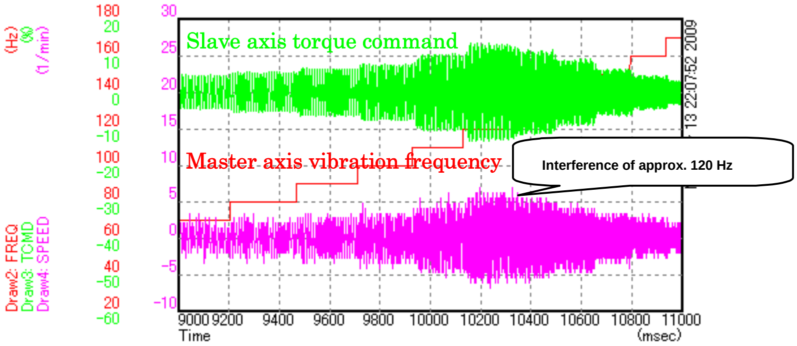


5.12.8 Adjustment

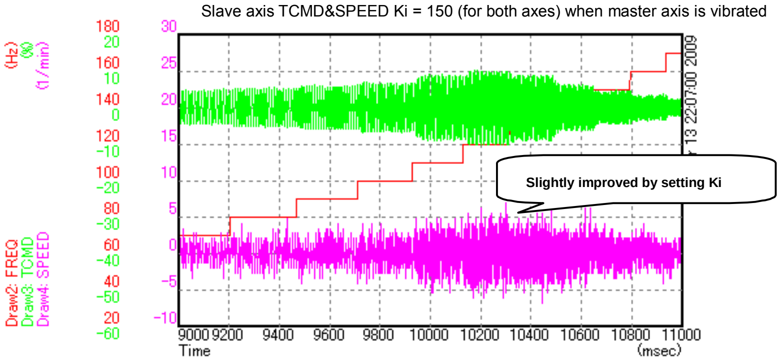
- Check the torque command (or motor speed) of the two axes by using the servo guide.
- If the waveforms of the two axes have opposite phases (in the case of forward connection) or the same phase (in the case of backward connection), it is likely that interference (vibration) is occurring due to the spring element between the axes.
- Enable tandem disturbance elimination control, and adjust integral gain Ki for tandem disturbance elimination control.
- Increment the value of integral gain Ki gradually starting from "0" (set the same value for both axes), and check how the interference (vibration) changes. There should be an optimum value of Ki. Setting too large a value may increase the interference (vibration).
- Since changing the velocity loop gain changes the frequency of the vibration, change Ki to make the vibration weaker.
- If the vibration frequency exceeds 100 Hz, the effect of tandem disturbance elimination control becomes small. This may be improved by setting the phase compensation coefficients, α and T, of the two axes (set the same value for both axes).

(Adjusted waveform example)
Vibration frequency observed when the master axis is vibrated using the disturbance input function and torque command and velocity of the slave axis

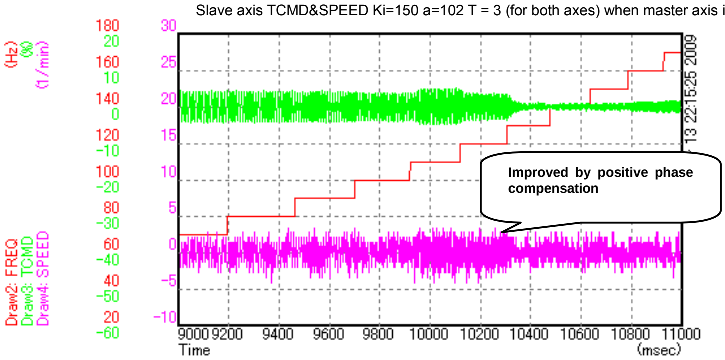
Slave axis TCMD&SPEED Ki = 0 (tandem disturbance elimination control disabled) when master axis is vibrated



Slave axis TCMD&SPEED Ki = 150 (for both axes) when master axis is vibrated



Slave axis TCMD&SPEED Ki=150 a=102 T = 3 (for both axes) when master axis is vibrated



5.13 TORQUE TANDEM CONTROL FUNCTION (OPTIONAL FUNCTION)

5.13.1 Overview

Spindle tandem control is a function that drives the spindle with two motors to provide a large output that cannot be obtained with one motor. The following two types are available:

(1) Velocity tandem control
(2) Torque tandem control (induction spindle motor only)

While speed control is disabled on the slave side in torque tandem control, it is enabled in velocity tandem control. For this reason, velocity tandem control offers greater slave axis stability. Therefore, when employing spindle tandem control, select velocity tandem control under normal circumstances.
Note that, in cases where you do not want the slave axis to exert speed control (you want both axes to have the same torque although they widely differ in speed), as in wheel lathing, you need to adopt torque tandem control.

The torque tandem control function controls two mechanically connected spindle motors by using the same torque command.

NOTE
1 To use this function, the CNC software option (spindle tandem control) is required.
2 When the NC is 30*i*-B, the spindle tandem control function is included in the spindle synchronous control option.
3 To use this function, SP TYPE B is required.
4 When this function is used, the spindle amplifiers and spindle motors of the master and slave must be of the same model.
5 For the master and slave axes, use the spindle software of the same series and edition.
6 This function cannot be used together with the following functions:
- Spindle synchronous control function
- Speed range switching function
- Spindle switching function
- Position coder signal output function
- Spindle EGB function
- Spindle leaning control function
- Synchronous built-in spindle motor driving

7 No limitation is imposed on master and slave axis assignment.
In the descriptions below, the following assignment is used for convenience:
Master spindle amplifier: First spindle
Slave spindle amplifier: Second spindle

5.13.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D50	M (13)	FS16*i* / FS18*i*, FS15*i*
9D70	C (03)	FS30*i* / FS31*i*
9D80	A (01)	FS16*i* / FS18*i* , FS15*i* , FS30*i* / FS31*i*
9D90	A (01)	FS16*i* / FS18*i* , FS15*i* , FS30*i* / FS31*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* –B

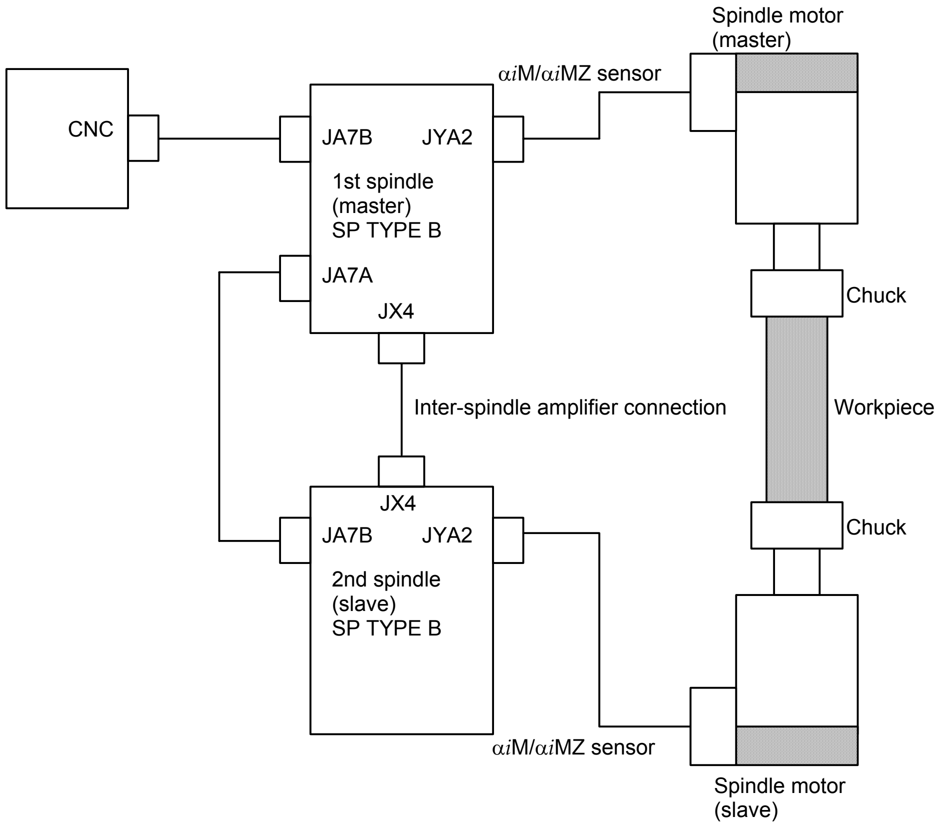
NOTE
To use the αiCZ sensor (serial), the 9D90 series G (07) edition or later or the 9DA0 series I (09) edition or later is required.
This function cannot be used with the 9D50, 9D70, or 9D80 series.

5.13.3 System Configuration

NOTE

1. For connection details of each cable, refer to "FANUC SERVO AMPLIFIER αi series DESCRIPTIONS (B-65282EN)".
2. The common power supply (PS) emergency stop signal (connector CX4) needs to be input for each common power supply (PS).

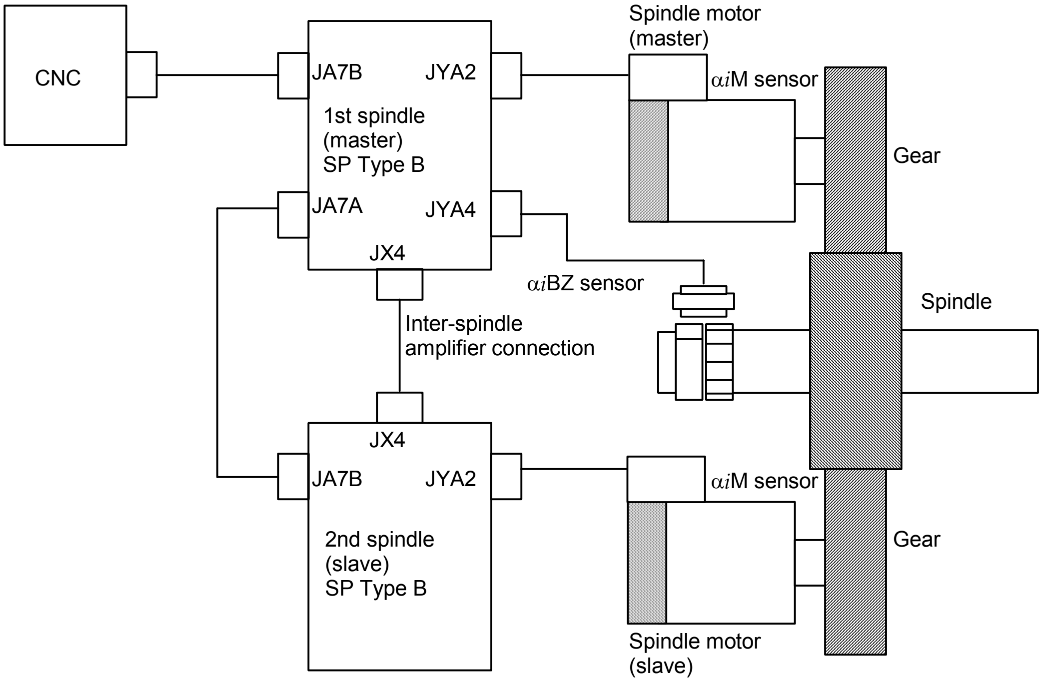
(1) Sample configuration 1: System where the master spindle and slave spindle are mechanically connected or disconnected when a workpiece is attached or detached



NOTE

When the master and slave are mechanically disconnected, torque tandem control cannot be used. In this case, cancel the tandem operation mode.

(2) Sample configuration 2: System where the table axis is driven by two motors



5.13.4 I/O Signals (CNC↔PMC)

NOTE

1. A command for the spindles engaged in tandem operation is issued to the master spindle amplifier.
   The input signal specifications are the same as for ordinary spindles (for which the torque tandem function is not used).
   For details of signals used in each control mode, see Chapter 3, "I/O SIGNALS", in Part I.
2. During tandem operation, no signal needs to be input from the PMC to the tandem function slave spindle amplifier. Those signals that are required to drive the slave spindle amplifier are transferred from the master spindle amplifier by inter-spindle amplifier communication.
3. During tandem operation, use a signal output from the master spindle amplifier for sequence determination (such as speed arrival determination and alarm detection). (No signal output from the slave spindle amplifier is needed.)

(1) Input signals (PMC→CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G226	G071	G071				SOCNA				
2nd-	G234	G075	G075				SOCNB				

SOCNA Soft start/stop signal (for the first spindle)
SOCNB Soft start/stop signal (for the second spindle)

0 : Disables the soft start/stop function.
1 : Enables the soft start/stop function.

These signals enable or disable the soft start/stop function.
Use these signals when limiting the specified acceleration rate to reduce a mechanical shock during acceleration/deceleration.

During tandem operation (SLVx = 1), the signals need not be input to the slave spindle amplifier.

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G228	G073	G073						MPOFA	SLVA	
2nd-	G236	G077	G077						MPOFB	SLVB	

SLVA Tandem operation command (for the first spindle)
SLVB Tandem operation command (for the second spindle)
0 : Makes a request to disable tandem operation.
1 : Makes a request to enable tandem operation.
These signals enable or disable tandem operation.
When using the torque tandem function, set these signals to 1 for both of the master and slave.

NOTE
1 Both of the master and slave must be stopped before these signals can be switched.
During rotation, these signals cannot be accepted.
2 Switch these signals in the speed control mode. In a mode other than the speed control mode, these signals cannot be accepted.
3 When the master and slave are mechanically disconnected with each other, do not set these signals to 1.

MPOFA Motor power turn-off signal (for the first spindle)
MPOFB Motor power turn-off signal (for the second spindle)
0 : Normal operation
1 : Turns off the power to the motor.
These signals turn off the power to the motor.
During tandem operation (SLVx = 1), these signals need not be input to the slave spindle amplifier.

NOTE
If an error such as an excessive master-slave speed difference is detected when torque tandem operation is enabled, the power to both of the master motor and slave motor must be turned off simultaneously to minimize damage to the machine. In such a case, be sure to turn off the power to both motors by using these signals.

(2) Output signals (CNC→PMC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045							SSTA	
2nd-	F245	F049	F049							SSTB	

SSTA Speed zero detection signal (for the first spindle)
SSTB Speed zero detection signal (for the second spindle)
0 : The spindle motor is rotating.
1 : The spindle motor is in the speed zero (stopped) state.
After checking that these signals are set to 1 with both of the master and slave, switch the tandem operation command SLVx.
When these signals are set to 0, the tandem operation command cannot be accepted.

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F228	F046	F046				SLVSA				
2nd-	F244	F050	F050				SLVSB				

SLVSA Tandem operation state signal (for the first spindle)
SLVSB Tandem operation state signal (for the second spindle)
0 : Tandem operation is disabled.
1 : Tandem operation is enabled.
After checking that these signals are set to 1 with both of the master and slave, issue a command to the master spindle amplifier.

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F231	F047	F047						MSOVRA		
2nd-	F247	F051	F051						MSOVRB		

MSOVRA Master-slave speed difference state signal(for the first spindle)
MSOVRB Master-slave speed difference state signal (for the second spindle)
0 : The speed difference between the master and slave is less than the set value.
1 : The speed difference between the master and slave is equal to or greater than the set value.
These signals indicate whether or not the speed difference between the master motor and slave motor is less than the value set in the parameter (FS16*i*: No. 4347).
The signal for the slave spindle amplifier need not be monitored. (At all times, 0 is output.)

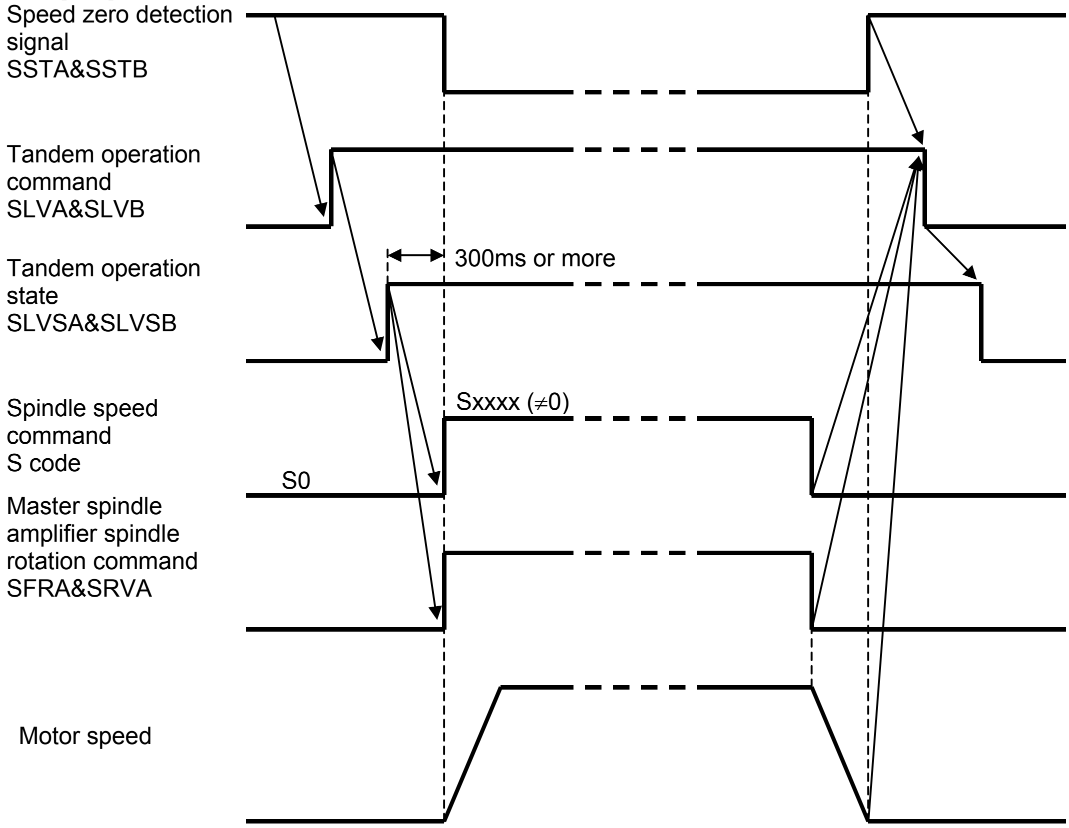
⚠ **CAUTION**
1 If a motor feedback signal disconnection alarm (spindle alarm 73) is issued, the status of this signal is undefined.
2 When bit 5 of parameter No. 4007 is set to "1", the detection operation of the feedback signal disconnection alarm is not performed.
Set the parameter to "0" when not required, to enable alarm detection.

NOTE
Monitor the states of these signals on the PMC. Ensure that an alarm is issued if an error occurs (for example, if the state of 1 lasts for a certain period of time).

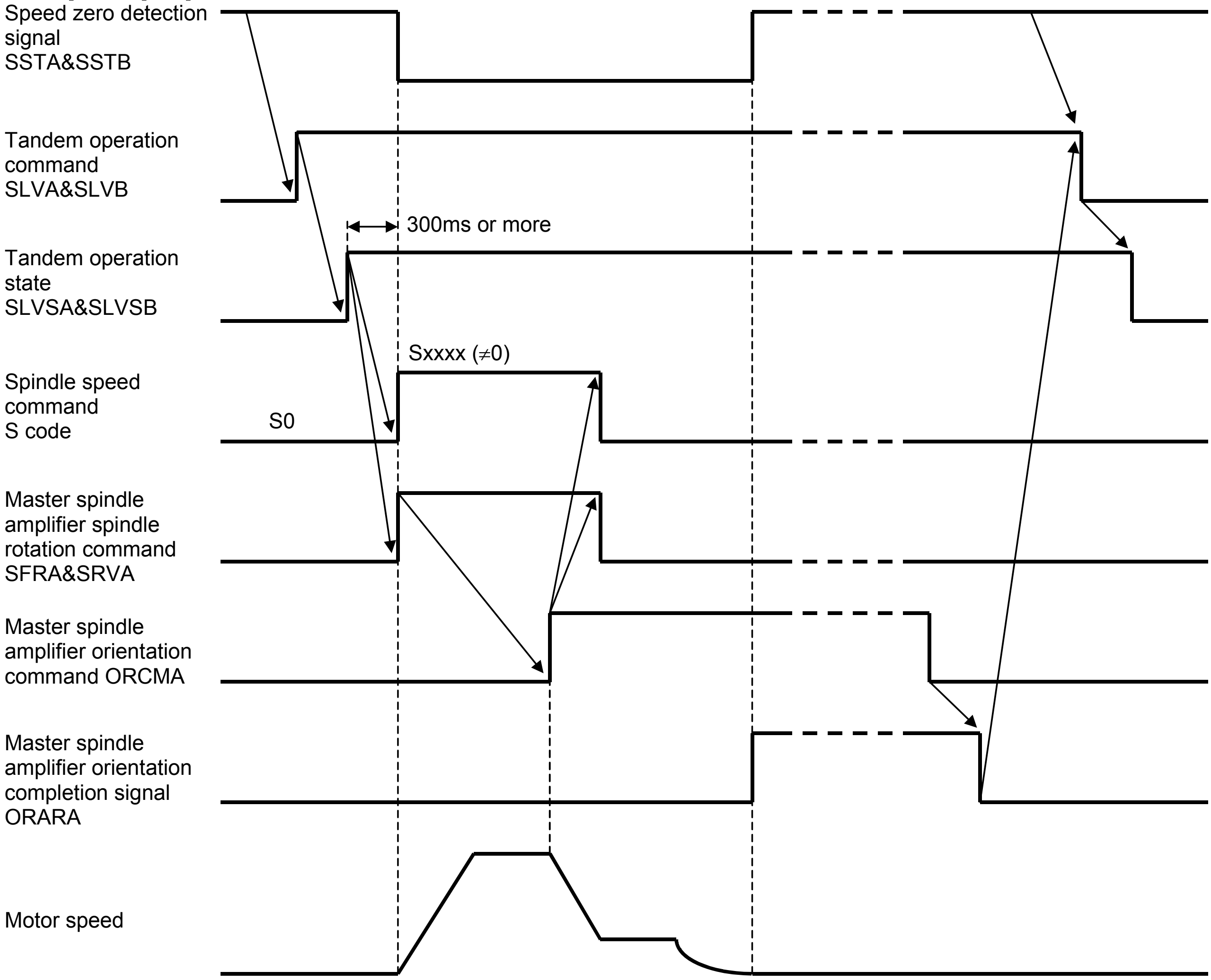
5.13.5 Examples of Sequences

NOTE
Examples of sequences are given below assuming the following:
First spindle: Master spindle amplifier
Second spindle: Slave spindle amplifier

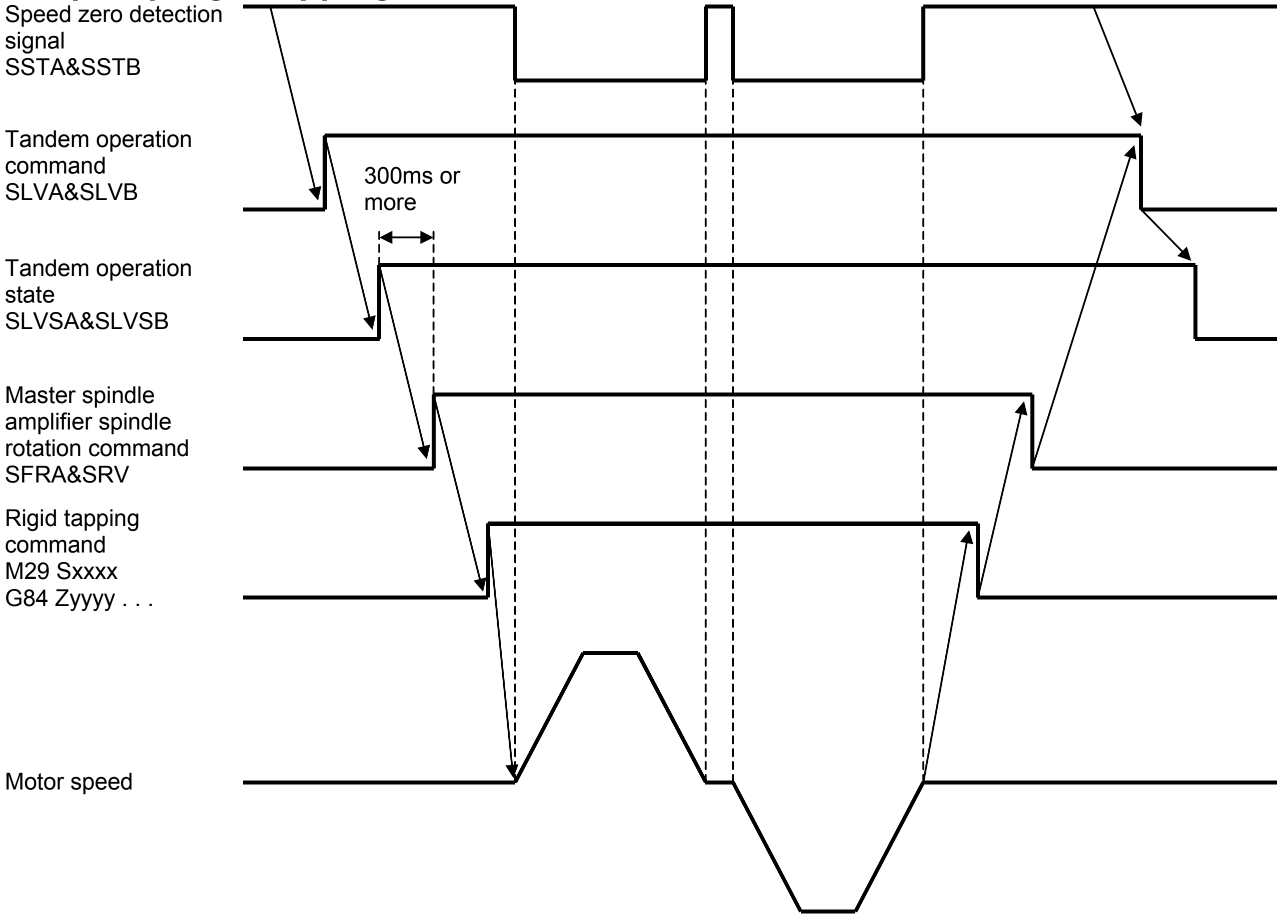
(Example 1) Speed control mode



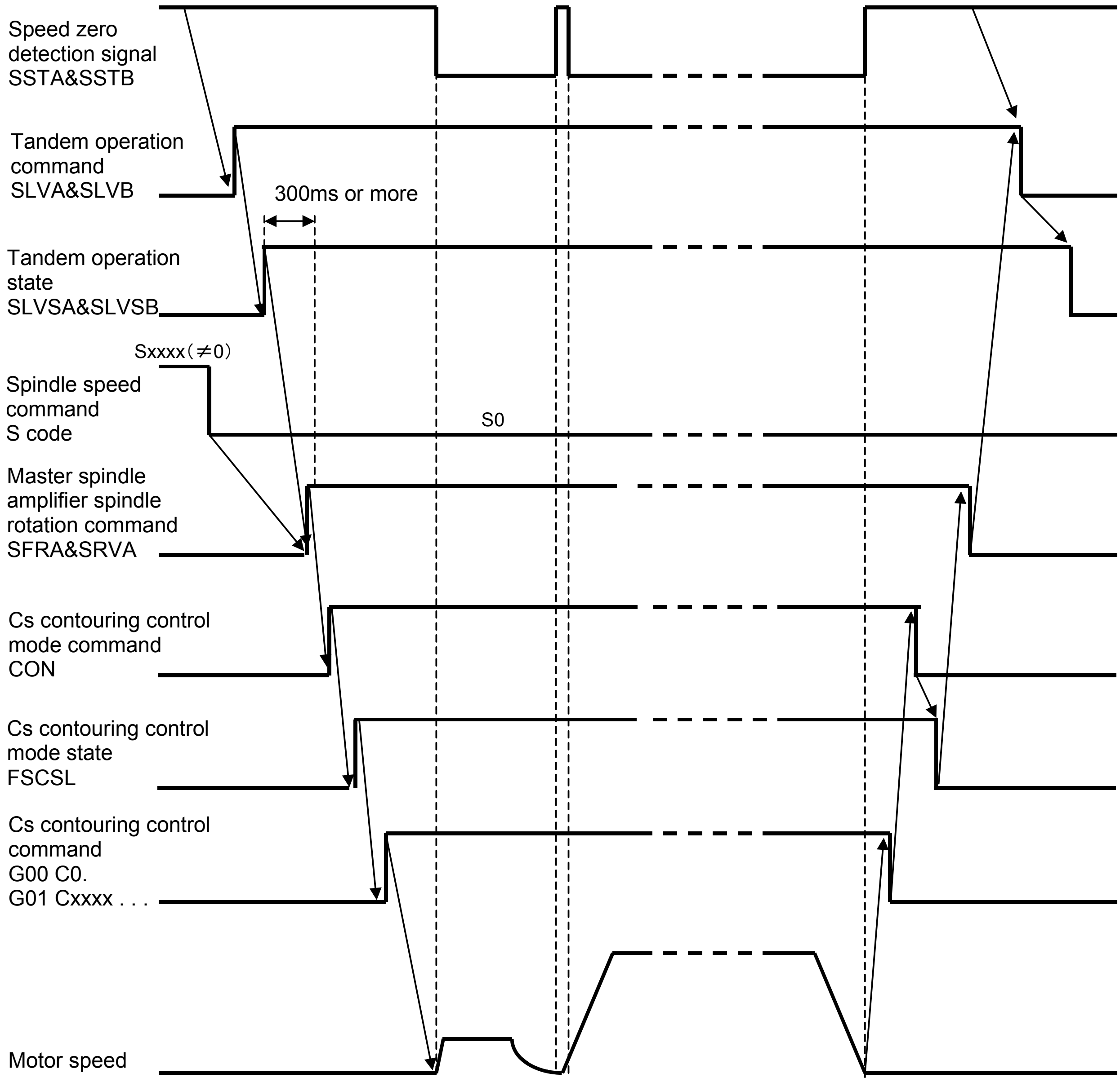
(Example 2) Spindle orientation



(Example 3) Rigid tapping



(Example 4) Cs contouring control



5.13.6 Parameters

(1) Cautions

For the master spindle amplifier and slave spindle amplifier, set the same parameters except for the following specific parameters:

Parameter No.			Description	Master setting	Slave setting
15*i*	16*i*	30*i*			
3002 #3 to #0	4002 #3 to #0	4002 #3 to #0	Spindle sensor type	Depending on the spindle configuration	Depending on the spindle configuration
3353#2	4353#2	4353#2	Relationship of master/slave motor rotation directions in torque tandem operation	Depending on the spindle configuration	0

Parameter No.			Description	Master setting	Slave setting
15*i*	16*i*	30*i*			
3352#7,#6	4352#7,#6	4352#7,#6	Inter-spindle amplifier communication setting	1, 0	0, 1
3360	4360	4360	Preload value	Machine by machine (adjustment value)	0

(2) List of parameters

パラメータ番号			内容
15*i*	16*i*	30*i*	
3009#2	4009#2	4009#2	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued
3353#2	4353#2	4353#2	Relationship of master/slave motor rotation directions in torque tandem operation
3015#3	4015#3	4015#3	Whether to use the spindle tandem function
3353#1	4353#1	4353#1	Velocity feedback signal setting in torque tandem operation
3398#3	4398#3	4398#3	Whether to use the twin drive function
—	—	4398#4	Whether to use the velocity tandem function
—	—	4398#5	Whether to use the velocity integrator copy function
—	—	4402#3	Whether to use the torque tandem function
3398#6	4398#6	4398#6	Whether to detect a speed polarity error (spindle alarm d0) in torque tandem operation
3352#6	4352#6	4352#6	Inter-spindle amplifier communication slave axis setting
3352#7	4352#7	4352#7	Inter-spindle amplifier communication master axis setting
3347	4347	4347	Master-slave speed difference state signal output setting
3360	4360	4360	Preload value

(3) Details of Parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3009	4009	4009						ALSP		

ALSP Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued
- 0 : Turns off the power after the motor is decelerated to a stop.
- 1 : Turns off the power immediately. (Set this parameter to 1.)

NOTE

If an alarm is issued during torque tandem operation, the power to both of the master motor and slave motor must be turned off simultaneously to prevent the machine from being damaged. When using the torque tandem function, be sure to set this parameter to 1 to turn off the power to the motors immediately if a CNC-SP communication error occurs.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3015	4015	4015					SPDTDM			

SPDTDM Whether to use the spindle tandem function (The CNC software option is required.)
- 0 : Does not use the spindle tandem function.
- 1 : Uses the spindle tandem function.

NOTE
If this bit is set to 0, the torque tandem function does not operate normally. When this bit is set to 0, check the software option.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3352	4352	4352	MASTER	SLAVE						

SLAVE Inter-spindle amplifier communication slave axis setting
0 : Non-inter-spindle amplifier communication slave axis
1 : Inter-spindle amplifier communication slave axis (Set this parameter to 1 for the slave spindle amplifier.)

MASTER Inter-spindle amplifier communication master axis setting
0 : Non-inter-spindle amplifier communication master axis
1 : Inter-spindle amplifier communication master axis (Set this parameter to 1 for the slave spindle amplifier.)

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3353	4353	4353						RVSVC2	VFBAV	

VFBAV Velocity feedback signal setting in torque tandem operation
0 : For speed control, the master spindle amplifier motor speed only is used.
1 : For speed control, the average speed of the master spindle amplifier and slave spindle amplifier is used.
By exercising speed control using the average speed feedback value of the master and slave, vibration caused by spindle backlash may be suppressed.

RVSVC2 Relationship of master/slave motor rotation directions in torque tandem operation
0 : The master motor and slave motor rotate in the same direction at spindle rotation time (as viewed from the motor shaft).
1 : The master motor and slave motor rotate in the opposite directions at spindle rotation time (as viewed from the motor shaft).
This parameter sets the polarity for a speed command and feedback signal in torque tandem operation.

NOTE
1 This parameter need not be set for the slave spindle amplifier side. (The setting for the master spindle amplifier is transferred to the slave spindle amplifier by inter-spindle amplifier communication.)
2 If the setting of this parameter is improper, the torque tandem function does not operate normally.
If the spindle is rotated in this state, the speed polarity error alarm (spindle alarm d0) is issued in torque tandem operation.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3398	4398	4398		A130DN	WSVCP	VTAN	WNDTDM			

WNDTDM Whether to use the twin drive function
VTAN Whether to use the velocity tandem function
WSVCP Whether to use the velocity integrator copy function
Set this parameter to 0,0,0.

> **NOTE**
> If "1" is set in these bits, the torque tandem function does not work normally. Be sure to set "0,0,0".

A130DN Whether to detect a speed polarity error (spindle alarm d0) in torque tandem operation
0 : Detects the error.
1 : Does not detect the error.

30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4402					TRQTDM			

TRQTDM Whether to use the torque tandem function
0 : Disables the torque tandem function.
1 : Enables the torque tandem function.

> **NOTE**
> This bit is valid when the NC is FS30*i*-B. Set it to "0" when the NC is FS30*i*-A.

15*i*	16*i*	30*i*	
3347	4347	4347	**Master-slave speed difference state signal output setting**

Unit of data : 1min^{-1} *(10min^{-1} when bit 2 (SPDUNT) of parameter No. 4006 is set to 1)
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets a level for detecting the master-slave speed difference state signal (MSOVRA:F47#2, MSOVRB:F51#2).
If this parameter is set to 0, the setting of 100 is assumed.

15*i*	16*i*	30*i*	
3360	4360	4360	**Preload value**

Unit of data : ±16384 equivalent to a torque command of 100%
Valid data range : -8192 to 8192(-50% to +50%)
Standard setting value : 0

This parameter sets a preload value.
This parameter may suppress stop-time vibration caused by backlash.

> **NOTE**
> This parameter need not be set for the slave spindle amplifier side. (The setting for the master spindle amplifier is transferred to the slave spindle amplifier by inter-spindle amplifier communication.)

5.13.7 Alarm and Status Error

(1) Spindle alarm

Alarm No.	Description	Measure
66	An inter-spindle amplifier communication error occurred.	Check the connection of the cable (JX4).
80	An alarm was issued on the destination spindle amplifier of inter-SPM communication.	Correct the cause of the alarm on the destination spindle amplifier.

d0	The relationship between the speed polarity of the master motor and the speed polarity of the slave motor is abnormal.	Check the rotation direction relationship setting (FS16i: Bit 2 of No. 4353).

(2) Spindle amplifier status error

Error No.	Description	Measure
21	A tandem operation command was input when spindle synchronous control is enabled.	Input a tandem operation command after canceling spindle synchronous control.
22	Spindle synchronous control was specified when tandem operation is enabled.	Specify spindle synchronous control after canceling torque tandem operation.
23	A tandem operation command is input even if the option is not specified.	Torque tandem control requires the CNC software option. Check the option.
38	- Parameters related to inter-spindle amplifier communication are not set correctly. - Functions that cannot be used together with the torque tandem function are set.	Check the parameters.

5.14 MAGNETIC SENSOR METHOD SPINDLE ORIENTATION (OPTIONAL FUNCTION)

5.14.1 Overview

Magnetic sensor method spindle orientation is a function for stopping the spindle at a specified position by receiving a position feedback signal from a magnetic sensor directly attached to the spindle of the machine.

NOTE
1 To use this function, the CNC software option (spindle orientation) is required.
2 To use this function, SP TYPE B is required.

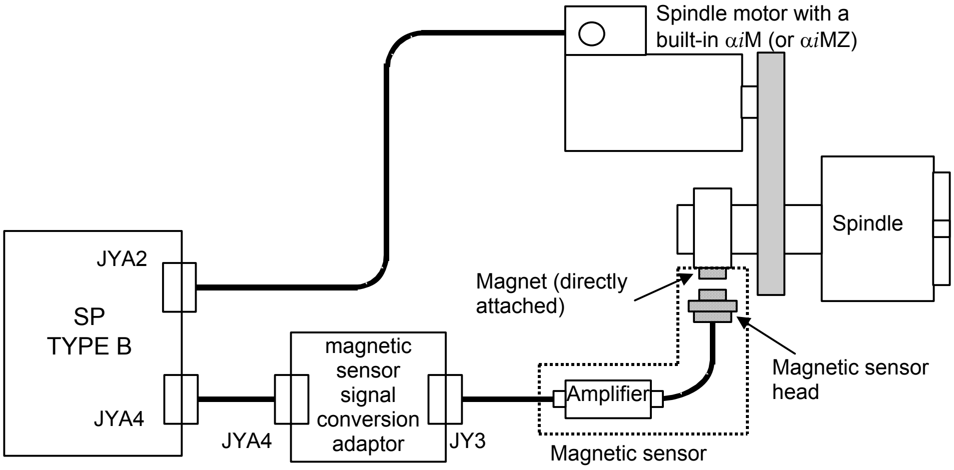
5.14.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D50	F (06)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

5.14.3 System Configuration

The magnetic sensor method spindle orientation function can be used with the following system configuration:



> **NOTE**
> For the hardware specifications of the magnetic sensor and magnetic sensor signal conversion adaptor and connection details of each cable, refer to "FANUC SERVO AMPLIFIER α*i* series DESCRIPTIONS (B-65282EN)".

5.14.4 I/O Signals (CNC↔PMC)

The specifications of I/O signals are the same as for position coder method spindle orientation. For details of the specifications, see Section 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION", in Part I.

(1) Address list of input signals (PMC→CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070		ORCMA			CTH1A	CTH2A		
2nd-	G235	G074	G074		ORCMB			CTH1B	CTH2B		

(2) Address list of output signals (CNC→PMC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA							
2nd-	F245	F049	F049	ORARB							

5.14.5 Examples of Sequences

The sequence is the same as for position coder method spindle orientation. For details of the specifications, see Section 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION", in Part I.

5.14.6 Parameters

(1) List of parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
3015 #0	4015 #0	4015 #0	Whether the spindle orientation function is available (to be set to "1") (The CNC software option is required.)
3001 #3	4001 #3	4001 #3	Magnetic sensor attachment direction
3003 #0	4003 #0	4003 #0	Whether to use the position coder method spindle orientation function or magnetic sensor method spindle orientation function (to be set to 1 to use the magnetic sensor method)

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3003 #3,#2	4003 #3,#2	4003 #3,#2	Rotation direction for spindle orientation
3042 3043	4042 4043	4042 4043	Velocity proportional gain on orientation (These parameters are selected with the input signal CTH1A.)
3050 3051	4050 4051	4050 4051	Velocity integral gain on orientation (These parameters are selected with the input signal CTH1A.)
3056 to 3059	4056 to 4059	4056 to 4059	Gear ratio data between spindle and motor (These parameters are selected with the input signals CTH1A and CTH2A.)
3060 to 3063	4060 to 4063	4060 to 4063	Position gain on orientation (These parameters are selected with the input signals CTH1A and CTH2A.)
3064	4064	4064	Ratio of position gain change upon completion of spindle orientation
3075	4075	4075	Orientation completion signal detection level
3076	4076	4076	Spindle orientation speed limit ratio
3077	4077	4077	Orientation stop position shift value
3078	4078	4078	MS signal constant
3079	4079	4079	MS signal gain adjustment
3084	4084	4084	Motor voltage on spindle orientation
3038	4038	4038	Spindle orientation speed

(2) Details of parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3001	4001	4001					**MGDIR**			

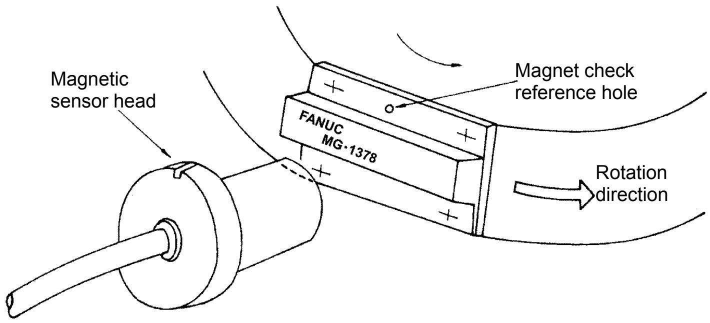
MGDIR Magnetic sensor attachment direction

0 : The motor and magnetic sensor rotate in the opposite directions.

1 : he motor and magnetic sensor rotate in the same direction.

The spindle motor rotates counterclockwise as viewed from the motor shaft when the forward rotation command SFRA = 1.

Make such an arrangement that the check hole of the magnet and the pin groove of the magnetic sensor face each other so that the magnetic sensor and magnet rotate in the directions shown in the figure below when SFRA = 1. In this case, set this bit to 1. If the arrangement is opposite to that shown in the figure below, set this bit to 0.



> **NOTE**
> Note that the specification of this parameter is different from the α series.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3003	4003	4003					**DIRCT2**	**DIRCT1**		**PCMGSL**

DIRCT1, DIRCT2 : Rotation direction at spindle orientation

DIRCT2	DIRCT1	Rotation direction
0	0	By rotation direction immediately before (CCW for the first-time spindle orientation after the power is switched on)
0	1	By rotation direction immediately before (CW for the first-time spindle orientation after the power is switched on)
1	0	CCW direction looking from shaft of motor
1	1	CW direction looking from shaft of motor

PCMGSL : Orientation method selection
Set this bit to 1 (magnetic sensor method).

15*i*	16*i*	30*i*	
3038	4038	4038	**Spindle orientation speed**

Unit of data : $1 min^{-1}$ (*$10 min^{-1}$ when bit 2 (SPDUNT) of parameter No. 4006 is set to 1)
Valid data range : 0 to 32767
Standard setting value : 0

This data is used to set an orientation speed at the spindle end.
If this data is set to 0, an orientation speed is determined from the position gain and the motor speed limit ratio in orientation.

15*i*	16*i*	30*i*		
3042	4042	4042	**Velocity proportional gain on orientation (HIGH)**	**CTH1A=0**
3043	4043	4043	**Velocity proportional gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

This data is used to set the velocity loop proportional gain on spindle orientation.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3050	4050	4050	**Velocity integral gain on orientation (HIGH)**	**CTH1A=0**
3051	4051	4051	**Velocity integral gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

This data is used to specify a velocity loop integral gain for spindle orientation.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : Number of motor rotations per spindle rotation / 100
(Number of motor rotations per spindle rotation / 1000 if bit 1 of parameter No. 4006 (GRUNIT) = 1)
Valid data range : 0 to 32767
Standard setting value : 100

This data is used to set a gear ratio between the spindle and spindle motor.

For example, if the motor makes 2.5 rotations while the spindle makes 1 rotation, set 250 in this parameter.
A parameter is selected according to the values of the input signals CTH1A and CTH2A.
Ensure that the state of the gear or clutch corresponds to the values of CTH1A and CTH2A.

NOTE
If an improper value is set in these parameters, an unexpected operation such as endless spindle rotation at orientation time can result.
So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*		
3060	4060	4060	**Position gain on orientation (HIGH)**	**CTH1A=0, CTH2A=0**
3061	4061	4061	**Position gain on orientation (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3062	4062	4062	**Position gain on orientation (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3063	4063	4063	**Position gain on orientation (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : 0.01sec^{-1}
Valid data range : 0 to 32767
Standard setting value : 1000

These data are used to set the position gain on spindle orientation.
A parameter is selected according to the values of the input signals CTH1A and CTH2A.

15*i*	16*i*	30*i*	
3064	4064	4064	**Ratio of position gain change upon completion of spindle orientation**

Unit of data : 1%
Valid data range : 0 to 1000
Standard setting value : 100

This data is used to set a position gain change ratio upon completion of orientation.

15*i*	16*i*	30*i*	
3075	4075	4075	**Orientation completion signal detection level (effective area for in-position check))**

Unit of data : ±0.1deg
Valid data range : 0 to 100
Standard setting value : 10

This data is used to set the detecting level of orientation completion signal (ORARA).
The orientation completion signal (ORARA) is set to 1 if the spindle position is within the set data range when orientation is stopped.
When the orientation command (ORCMA) is turned off (= 0), the orientation completion signal (ORARA) is set to 0.

15*i*	16*i*	30*i*	
3076	4076	4076	**Spindle orientation speed limit ratio**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 33

This data is used to set an orientation speed limit ratio.

$$\begin{matrix}\text{Orientation speed}\\\text{(motor speed)}\end{matrix} = 60 \times \frac{\text{Position gain}}{100} \times \text{gear ratio} \times \frac{\text{Speed limit ratio}}{100} \quad [\text{min}^{-1}]$$

15*i*	16*i*	30*i*	
3077	4077	4077	**Orientation stop position shift value**

Unit of data : ±0.01deg
Valid data range : -100 to 100
Standard setting value : 0

This data is used to shift the stop position.
When a plus (+) value is set, the spindle stop position is shifted in the CCW direction by the set number of pulses.

15*i*	16*i*	30*i*	
3078	4078	4078	**MS signal constant**

Unit of data :
Valid data range : 81 to 1000
Standard setting value : 200

This data is used to set a value calculated from the expression below.

$$\text{Settings} = \frac{L}{2} \times \frac{1}{2\pi \times H} \times 4096$$

where

L : Magnet length [mm]
H : Distance from the spindle center to magnet [mm]

Example When H = 100 mm and L = 50 mm

$$\text{MS signal constant} = \frac{(50/2)}{2\pi \times 100} \times 4096 \fallingdotseq 163$$

15*i*	16*i*	30*i*	
3079	4079	4079	**MS signal gain adjustment**

Unit of data :
Valid data range : -128 to 127
Standard setting value : 0

This data is used to adjust the amplitude of the MS signal. Usually, use the values indicated in the table below as standard values.

Name	Specification drawing number	Magnet		MS signal gain
		Type	Length [mm]	
Not specified. Standard	A57L-0001-0037	Standard (TYPE II)	50	0
Magnetic sensor N	A57L-0001-0037/N			0
Magnetic sensor P	A57L-0001-0037/P	Compact type (TYPE III)	50	-20
Magnetic sensor Q	A57L-0001-0037/Q	Cylinder type with diameter of ϕ40 (TYPE IV)	31	70
Magnetic sensor R	A57L-0001-0037/R	Cylinder type with diameter of ϕ50 (TYPEV)	37	50
Magnetic sensor S	A57L-0001-0037/S	Cylinder type with diameter of ϕ60 (TYPEVI)	43	70
Magnetic sensor T	A57L-0001-0037/T	Cylinder type with diameter of ϕ70 (TYPEVII)	49	40

15i	16i	30i	
3084	4084	4084	**Motor voltage setting on orientation**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 30

This data is used to specify the motor voltage for spindle orientation.
Depending on the motor model, set 30 usually.

5.15 SPINDLE BACKLASH ACCELERATION FUNCTION (OPTIONAL FUNCTION)

5.15.1 Overview

The spindle backlash acceleration function improves a figure error caused by the delayed reversal along the Cs contouring control axis.

NOTE
1. To use this function, the CNC software option (Cs contouring control) is required.
2. This function is valid for advanced preview feed-forward in the Cs contouring control mode.
3. This function is unavailable for the sub-spindle for spindle switching.
4. This function cannot be used together with the spindle EGB function.

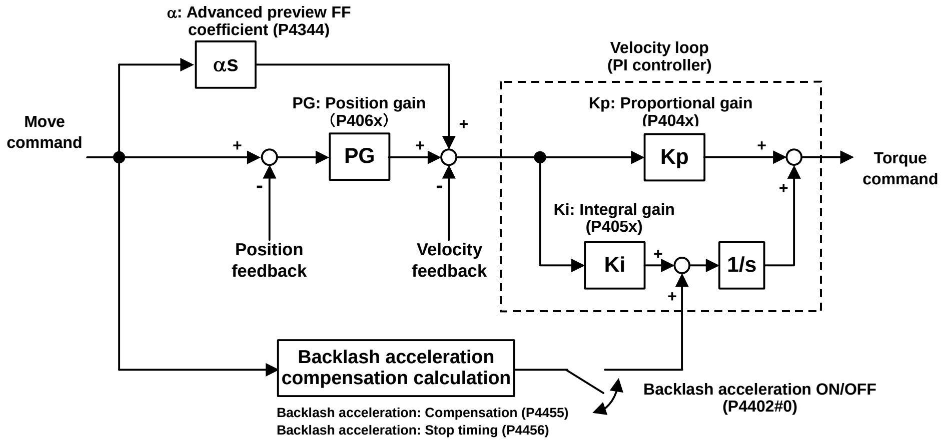
5.15.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D50	O (15)	FS16i / FS18i / FS21i , FS0i , FS15i
9D70	F (06)	FS30i / FS31i / FS32i
9D80	A (01)	FS16i / FS18i / FS21i , FS0i , FS15i , FS30i / FS31i / FS32i.
9D90	A (01)	FS16i / FS18i / FS21i , FS0i , FS15i , FS30i / FS31i / FS32i
9DA0	A (01)	FS30i / FS31i / FS32i -B

5.15.3 Block Diagram

The following shows a block diagram of spindle backlash acceleration.



5.15.4 Parameters

(1) List of parameters

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3402#0	4402#0	4402#0	Whether to enable the backlash acceleration function
3402#1	4402#1	4402#1	Setting of the feed-forward coefficient when the backlash acceleration function is enabled.
3455	4455	4455	Backlash acceleration: Compensation
3456	4456	4456	Backlash acceleration: Stop timing

(2) Details of parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3402	4402	4402							MDLINF	BKAFNC

BKAFNC Whether to enable the backlash acceleration function
0 : Disables the backlash acceleration function.
1 : Enables the backlash acceleration function.

MDLINF Sets the advanced preview feed-forward coefficient when the backlash acceleration function is enabled.
Set “0” when the advanced preview feed-forward coefficient is less than 100% (parameter No. 4344 is not 10000) or
“1” when the coefficient is 100% (parameter No. 4344 is 10000).

15*i*	16*i*	30*i*	
3455	4455	4455	Backlash acceleration: Compensation

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0
This parameter sets the backlash acceleration compensation.

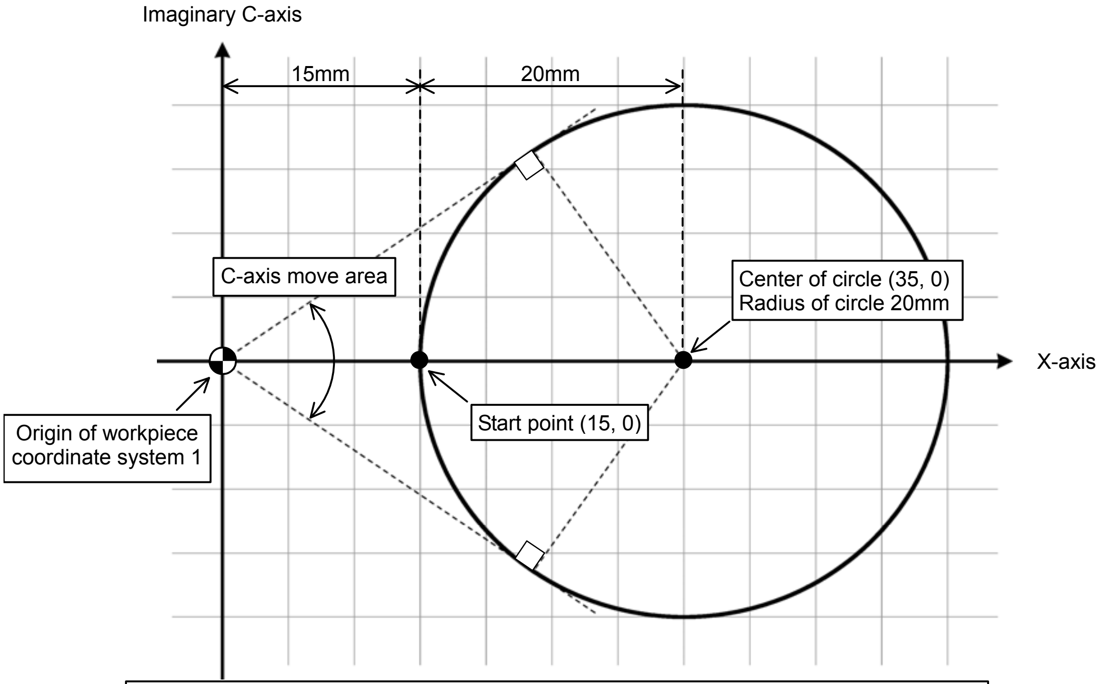
15*i*	16*i*	30*i*	
3456	4456	4456	Backlash acceleration: Stop timing

Unit of data : 0.001deg
Valid data range : 0 to 32767
Standard setting value : 0
This parameter sets the timing of the termination of backlash acceleration.

5.15.5 Example of Adjustment

(1) CNC program

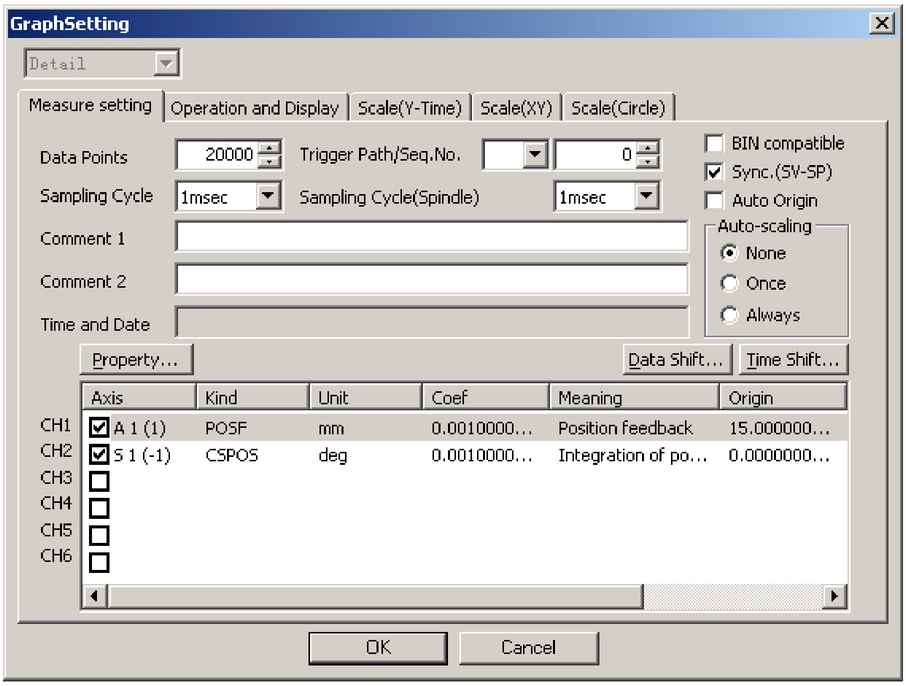
Prepare a program which draws an arc (eccentric arc) with polar coordinate interpolation as shown below:

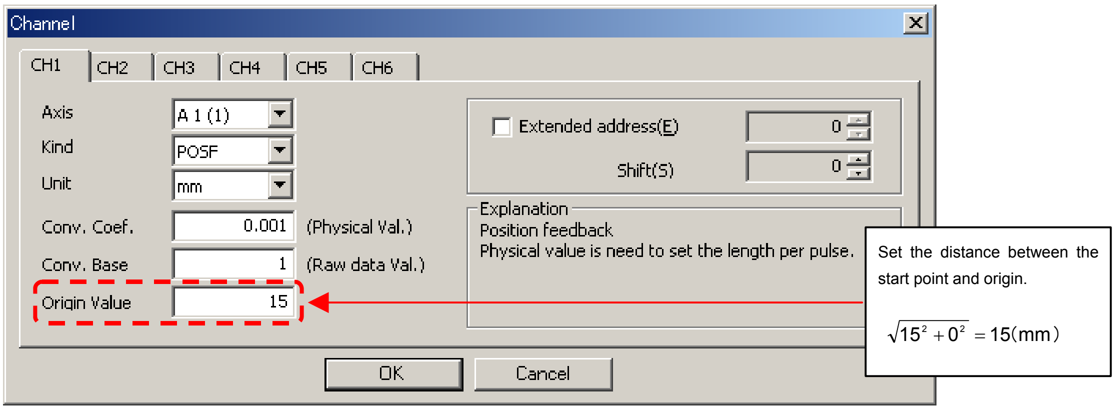


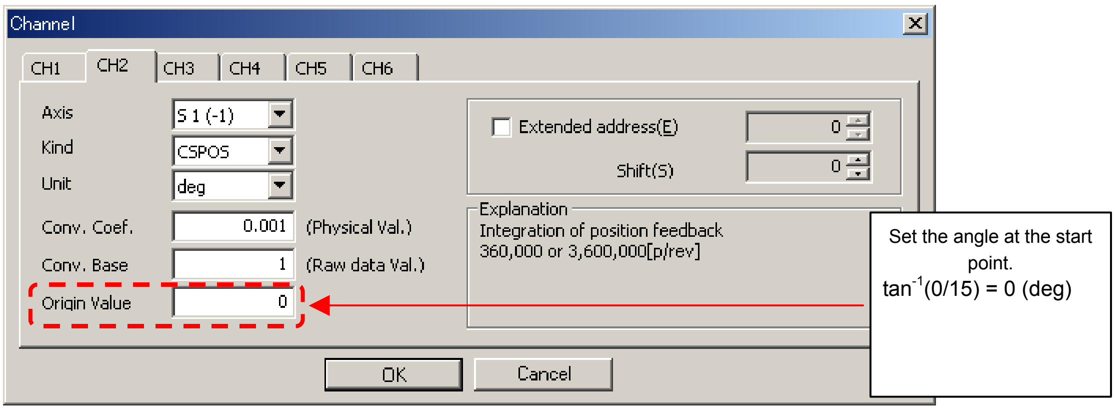
G90	←	Absolute
G54	←	Select workpiece coordinate system 1.
G00 X15. C0.	←	Move to the start point.
G5.1 Q1	←	Turn AI contouring control on.
G12.1	←	Turn polar coordinate interpolation on.
G04 X5.	←	Dwell. Press the “origin” button (see Item (3)).
G02 I20. J0	←	Draw an arc.
G13.1	←	Turn polar coordinate interpolation off.
G5.1 Q0	←	Turn AI contouring control off.
M99	←	End

(2) Preparation for data measurement using the SERVO GUIDE

Open the graph window of the SERVO GUIDE and set channels as follows:





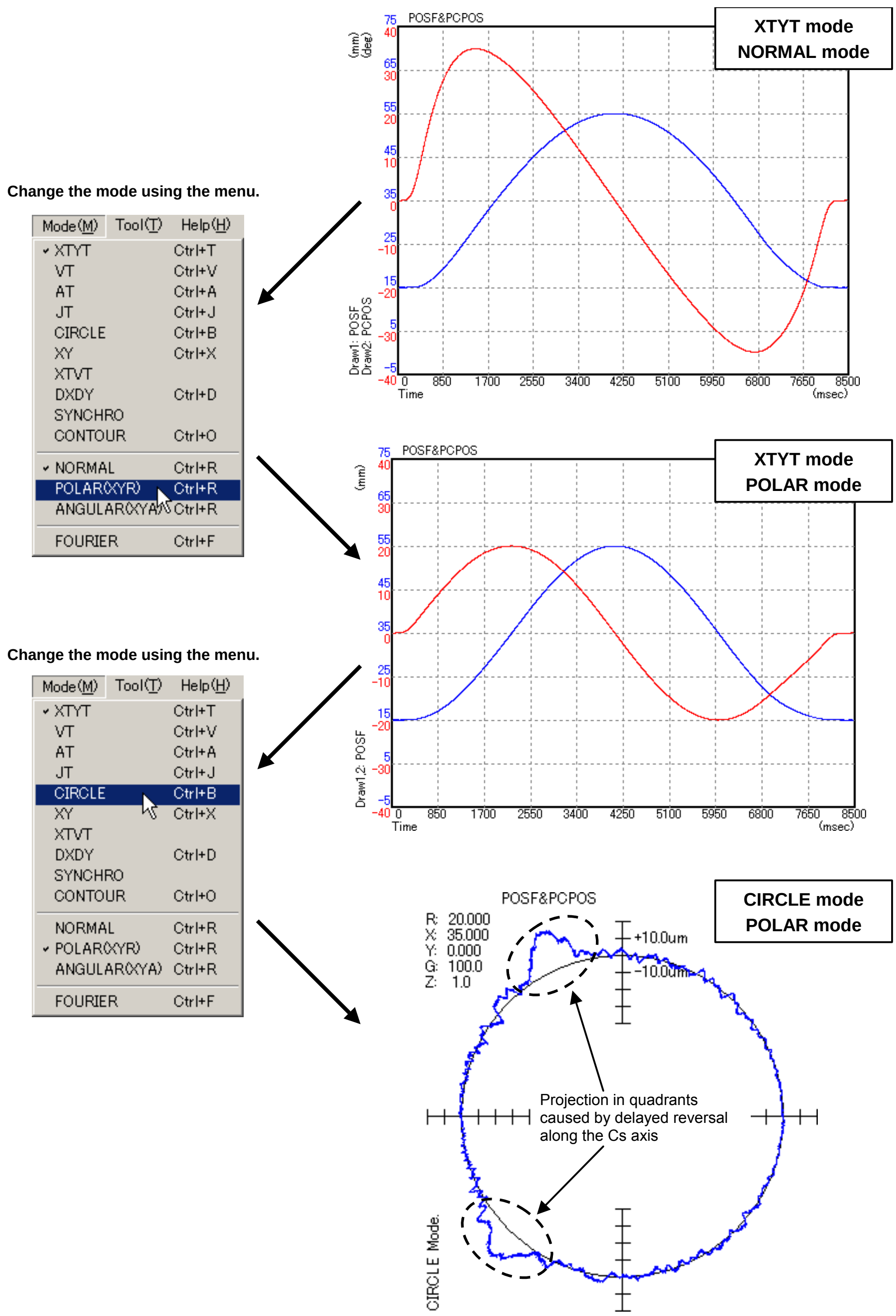


(3) Data measurement and display using the SERVO GUIDE

Execute the program described above and press the button while the spindle stops at the start point to perform origin operation.

Then, press the button before the spindle moves to start measurement.

After the completion of data measurement, change the graph window display mode as follows to display an arc.



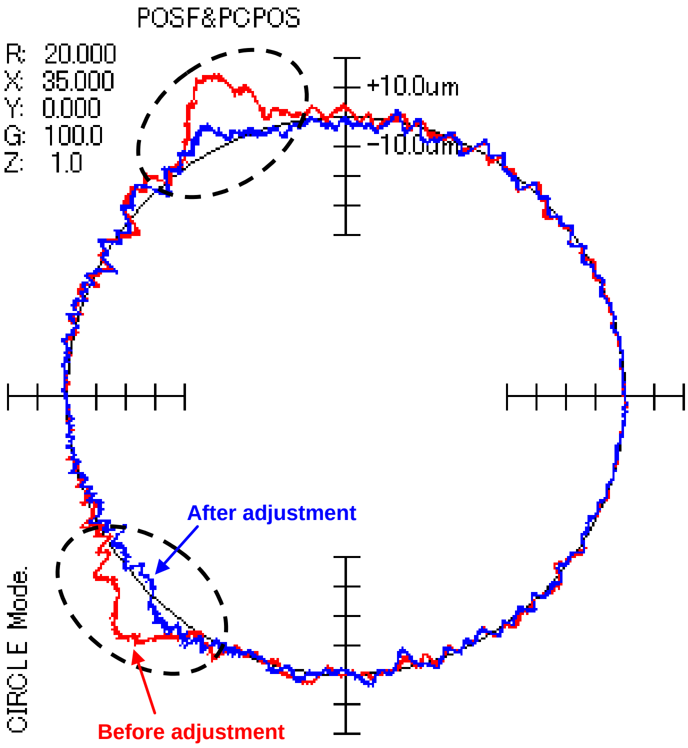
(4) Adjustment

Follow the adjustment steps below while observing the arc figure in the CIRCLE mode in the graph window:

(a) Set the initial values listed below for compensation (parameter No. 4455) and stop timing (parameter No. 4456):
Backlash acceleration compensation (parameter No. 4455): 5
Backlash acceleration stop timing (parameter No. 4456): 100

(b) Increase the compensation value (parameter No. 4455) to minimize the peak value of the projection in each quadrant. If the waveform cuts into the circle, decrease the setting.

(c) Increase the stop timing to minimize the peak value of the projection in each quadrant.
If the waveform cuts into the circle, decrease the setting.



5.16 HIGH-SPEED SPINDLE ORIENTATION (OPTIONAL FUNCTION)

5.16.1 Overview

This high-speed spindle orientation function shortens the time required for spindle orientation of the spindle by:
<1> Making the most of the ability of the motor to decelerate
<2> Increasing the gain of the position loop

NOTE
1 Using this function requires the CNC software option for spindle orientation.
2 This function cannot be used for spindle orientation during spindle synchronous control.
3 This function does not support the speed unit 10 min^{-1} (FS16*i*: Bit 2 of No. 4006 = 1).

5.16.2 Series and Editions of Applicable Spindle Software

Spindle software

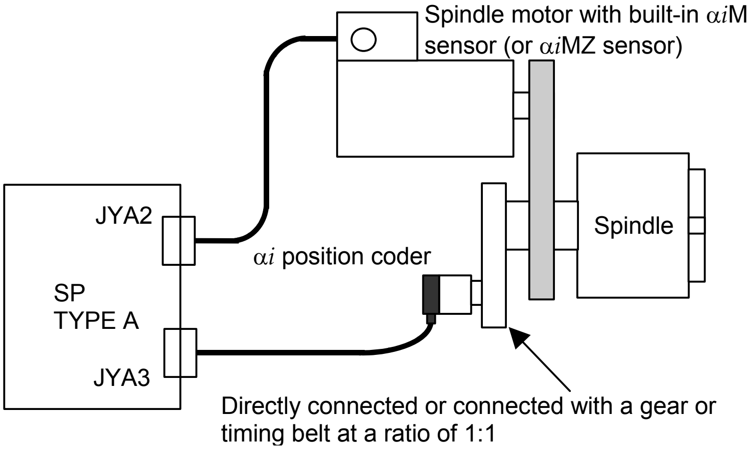
Series	Edition	Usable CNC
9D50	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

5.16.3 System Configuration

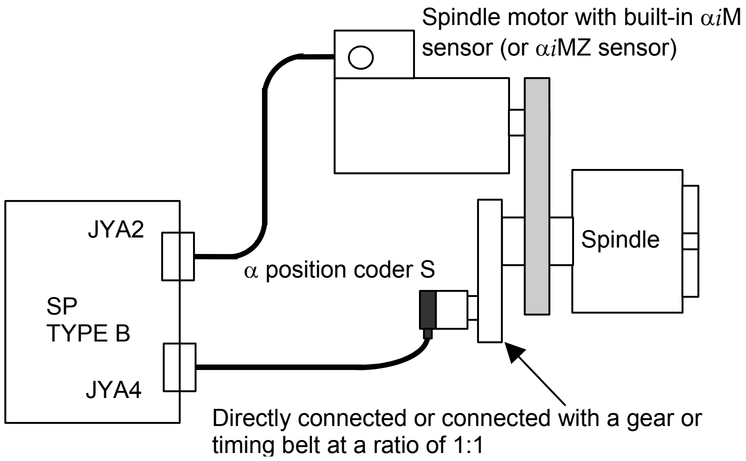
Explained below is a system configuration in which the high-speed spindle orientation function is usable.

> **NOTE**
> This function cannot be used in an external one-rotation signal-based spindle orientation system in which a proximity switch is used.

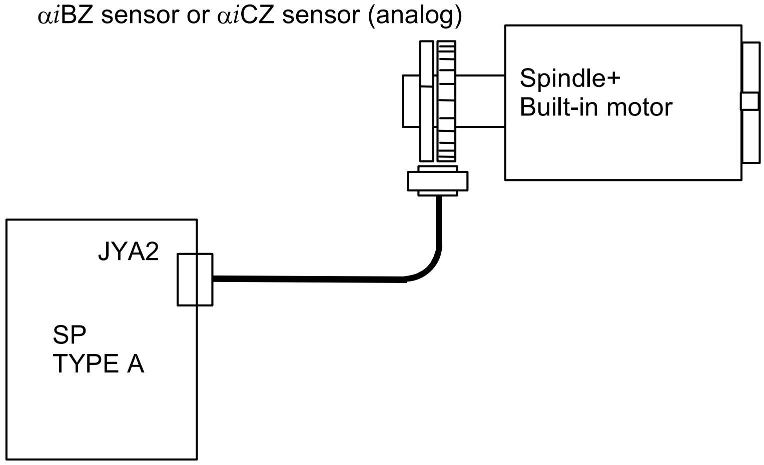
(1) When the αi position coder is used



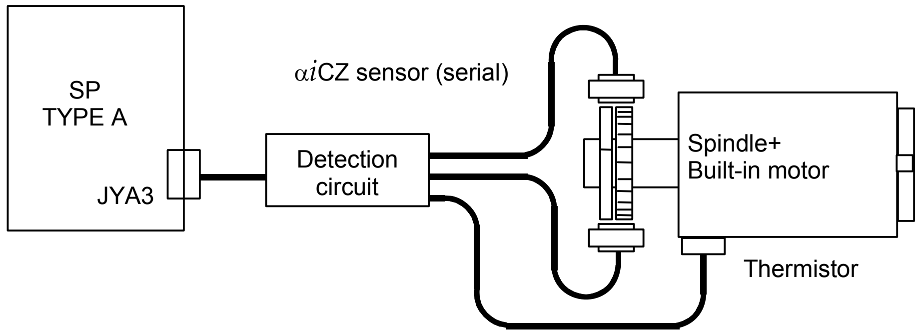
(2) When the α position coder S is used



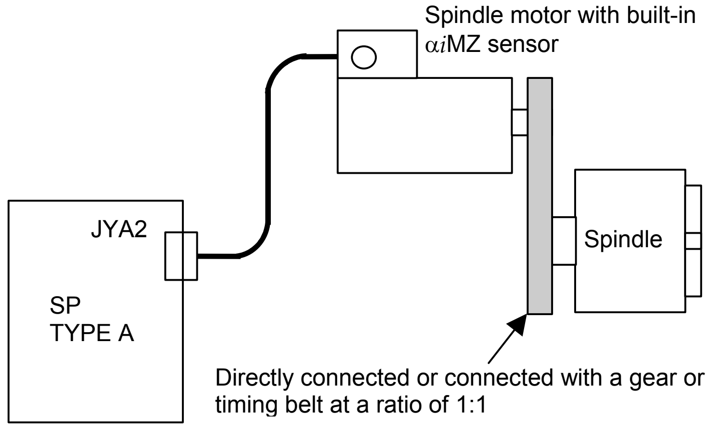
(3) When the built-in motor (αiBZ sensor, αiCZ sensor (analog)) is used



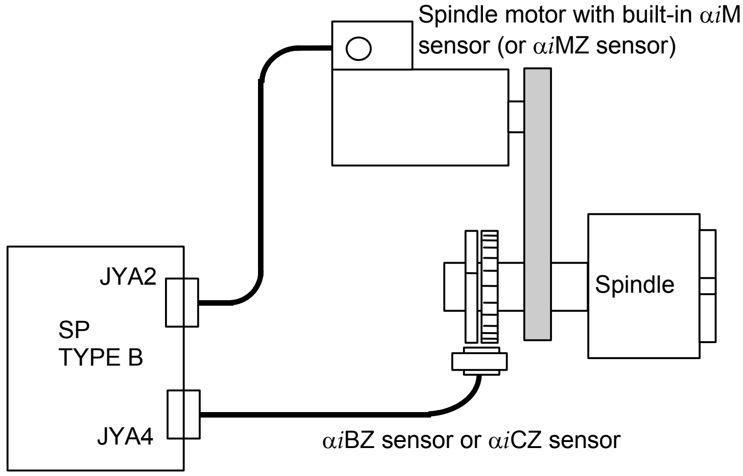
(4) When the built-in motor (αiCZ sensor (serial)) is used



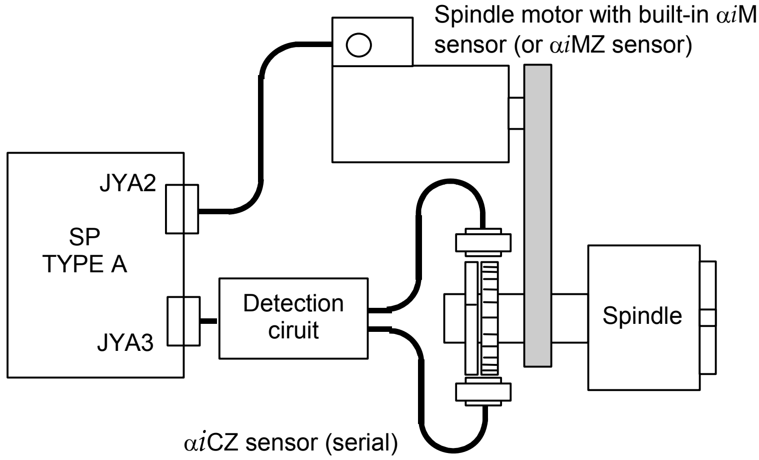
(5) When the spindle motor with built-in αiMZ sensor is used



(6) When the separate type α*i*BZ sensor or separate type α*i*CZ sensor (analog) is used



(7) When the separate type α*i*CZ sensor (serial) is used



5.16.4 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC → CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070		ORCMA			CTH1A	CTH2A		
2nd-	G235	G074	G074		ORCMB			CTH1B	CTH2B		
1st-	G229	G072	G072			INCMDA			NRROA	ROTAA	INDXA
2nd-	G237	G076	G076			INCMDB			NRROB	ROTAB	INDXB
1st-	G230	G078	G078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
2nd-	G238	G080	G080	SHB07	SHB06	SHB05	SHB04	SHB03	SHB02	SHB01	SHB00
1st-	G231	G079	G079					SHA11	SHA10	SHA09	SHA08
2nd-	G239	G081	G081					SHB11	SHB10	SHB09	SHB08

(2) Details of input signals (PMC → CNC)
(a) Spindle orientation command (ORCMA)
(b) Clutch/gear signals (CTH1A and CTH2A)
(c) Spindle orientation stop position change command (INDXA)
(d) Rotation direction command for spindle orientation stop position change (ROTAA)
(e) Short-cut command for spindle orientation stop position change (NRROA)
(f) Incremental command data selection signal (INCMDA)
(g) Spindle orientation external stop position commands (SHA11 to SHA00)

The functions of the input signals ORCMA, CTH1A, CTH2A, INDXA, ROTAA, NRROA, INCMDA, and SHA11 to SHA00 are the same as for position coder-method spindle orientation and incremental command type spindle orientation. See Sections 2.2, "POSITION CODER-METHOD SPINDLE ORIENTATION," and 5.3, "INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION" in Part I.

(3) Address list of input signals (CNC → PMC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA							
2nd-	F245	F049	F049	ORARB							
1st-	F221	F047	F047							INCSTA	
2nd-	F247	F051	F051							INCSTB	

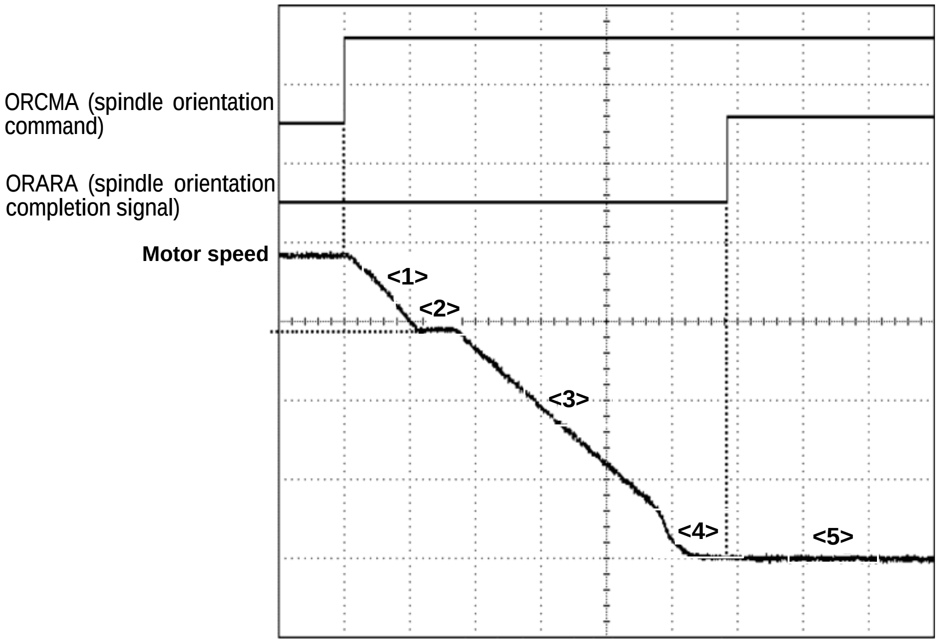
(4) Details of input signals (CNC → PMC)
(a) Incremental command mode status signal (INCSTA)
(b) Spindle orientation completion signal (ORARA)

The functions of the output signals ORARA and INCSTA are the same as for position coder-method spindle orientation and incremental command type spindle orientation. See Sections 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION," and 5.3, "INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION" in Part I.

5.16.5 Sequence

This subsection describes the operations of high-speed spindle orientation. See Sections 2.2, "POSITION CODER-BASED SPINDLE ORIENTATION," and 5.3, "INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION" in Part I, for concrete examples of sequences

(1) Starting spindle orientation when the spindle is rotating at or faster than the orientation speed upper limit



<1> If the spindle orientation command (ORCMA) is input when the spindle is rotating at or faster than the orientation speed upper limit specified in parameter No. 4038, the spindle is decelerated to the orientation speed upper limit.

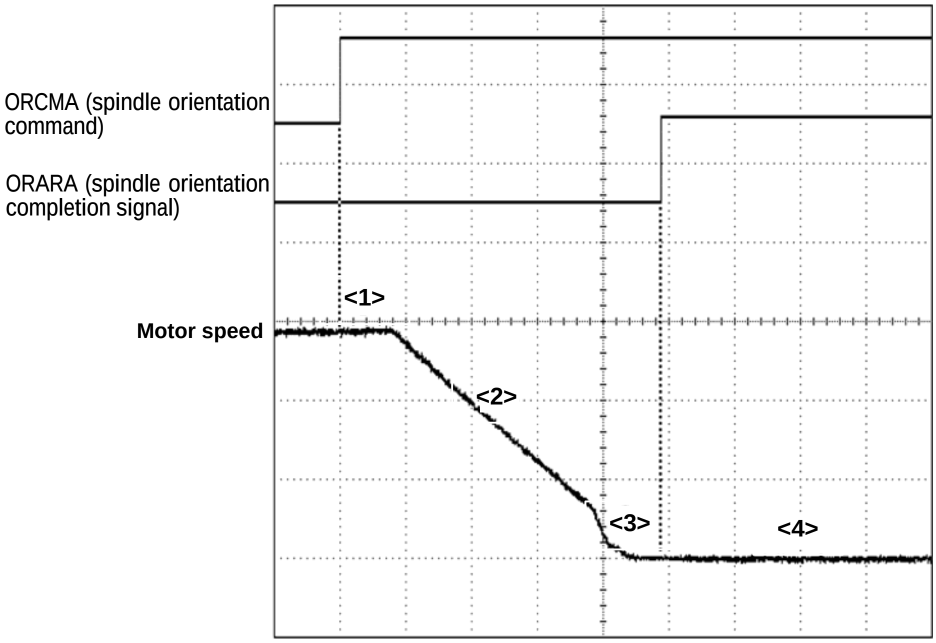
<2> A one-rotation signal is detected (only at the first-time spindle orientation after the power is switched on).

<3> The spindle decelerates at the acceleration specified as an acceleration during motor deceleration in parameter Nos. 4320 to 4323.

<4> When the spindle speed becomes lower than or equal to the value calculated within the software, the position loop is controlled at the position gain specified as a spindle orientation position gain in parameter Nos. 4060 to 4063.

<5> When the position error becomes lower than or equal to the number of pulses specified as a spindle orientation completion signal level in parameter No. 4075, the spindle orientation completion signal (ORARA) is output.

(2) Starting spindle orientation when the spindle is rotating at a speed between the orientation speed lower limit and the orientation speed upper limit



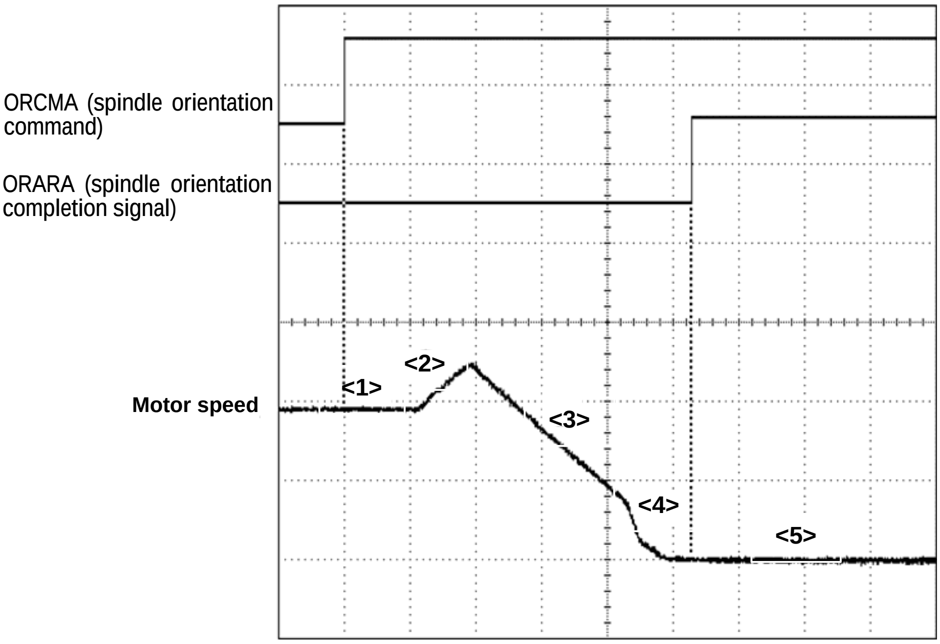
<1> If the spindle orientation command (ORCMA) is input when the spindle is rotating at a speed between the orientation speed upper limit specified in parameter No. 4038 and the orientation speed lower limit (calculated within the software), a one-rotation signal is detected (only at the first-time spindle orientation after the power is switched on).

<2> The spindle decelerates at the acceleration specified as an acceleration during motor deceleration in parameter Nos. 4320 to 4323.

<3> When the spindle speed becomes lower than or equal to the value calculated within the software, the position loop is controlled at the position gain specified as a spindle orientation position gain in parameter Nos. 4060 to 4063.

<4> When the position error becomes lower than or equal to the number of pulses specified as a spindle orientation completion signal level in parameter No. 4075, the spindle orientation completion signal (ORARA) is output.

(3) Starting spindle orientation when the spindle is rotating at or slower than the orientation speed lower limit



<1> If the spindle orientation command (ORCMA) is input when the spindle is rotating at or slower than the orientation speed lower limit (calculated within the software), a one-rotation signal is detected (only at the first-time spindle orientation after the power is switched on).

<2> The spindle accelerates at the acceleration specified as an acceleration during motor deceleration in parameter Nos. 4320 to 4323.

<3> The spindle decelerates at the acceleration specified as an acceleration during motor deceleration in parameter Nos. 4320 to 4323.

<4> When the spindle speed becomes lower than or equal to the value calculated within the software, the position loop is controlled at the position gain specified as a spindle orientation position gain in parameter Nos. 4060 to 4063.

<5> When the position error becomes lower than or equal to the number of pulses specified as a spindle orientation completion signal level in parameter No. 4075, the spindle orientation completion signal (ORARA) is output.

5.16.6 List of Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
3015 #0	4015 #0	4015 #0	Whether the spindle orientation function is available (to be set to "1") (The CNC software option is required.)
3018 #6 #3	4018 #6 #3	4018 #6 #3	Type of position coder method orientation (Set 1 in bit 6 and 0 in bit 3.)
5609#2	3702#3,#2	3729#0	Whether the stop position external setting-type spindle orientation function is available (For 16*i*, #2: First spindle, #3: Second spindle)
3003 #0	4003#0	4003#0	Spindle orientation type selection (to be reset to "0")
3003#3,#2	4003#3,#2	4003#3,#2	Rotation direction for spindle orientation (to be reset to "0, 0" or to be set to "0, 1")
3017#7	4017#7	4017#7	Short-cut function when spindle orientation from stopped state is specified
3018#5	4018#5	4018#5	Whether the speed command correction function for high-speed spindle orientation is available

Parameter No.			Description
15*i*	16*i*	30*i*	
3031	4031	4031	Spindle orientation stop position (This parameter is invalid for stop position external setting type and incremental command external setting type.)
3038	4038	4038	Orientation speed upper limit
3042 3043	4042 4043	4042 4043	Velocity proportional gain on orientation (These parameters are selected with the input signal CTH1A.)
3050 3051	4050 4051	4050 4051	Velocity integral gain on orientation (These parameters are selected with the input signal CTH1A.)
3056 to 3059	4056 to 4059	4056 to 4059	Gear ratio data between spindle and motor (These parameters are selected with the input signals CTH1A and CTH2A.)
3060 to 3063	4060 to 4063	4060 to 4063	Position gain on orientation (These parameters are selected with the input signals CTH1A and CTH2A.)
3064	4064	4064	Percentage limit to an acceleration during deceleration
3075	4075	4075	Orientation completion signal detection level
3077	4077	4077	Orientation stop position shift value
3084	4084	4084	Motor voltage on orientation
3320 to 3223	4320 to 4323	4320 to 4323	Acceleration during motor deceleration (These parameters are selected with the input signals CTH1A and CTH2A.)
3326 3330	4326 4330	4326 4330	Acceleration limitation start speed during deceleration (These parameters are selected with the input signal CTH1A.)
3328	4328	4328	Command multiplier for orientation

NOTE

1. See Section 1.3, "PARAMETERS RELATED TO DETECTORS" in Part I, for parameters related to detectors.
2. See Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT" in Part I, for velocity loop proportional/integral gain tuning.
3. When using the high-speed spindle orientation function, set the parameters (bits 3 and 2 or parameter No. 4003) for rotation direction for spindle orientation with the previous rotation direction (0, 0 or 0, 1).

5.16.7 Details of Related Parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3018	4018	4018		ORTYP1	HSVCM		ORTYP1			

HSVCM: Velocity command compensation function in high-speed spindle orientation is:
0: Disabled.
1: Enabled.
Normally, set 1.

ORTYP1、ORTYP0 Type of position coder method spindle orientation

ORTYP1	ORTYP0	Type of orientation
0	0	Conventional method orientation
0	1	Optimum orientation
1	0	High-speed spindle orientation

Specify "1,0" (high-speed spindle orientation).

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3003	4003	4003					DIRCT2	DIRCT1		PCMGSL

DIRCT1、DIRCT2 Rotation direction at spindle orientation

DIRCT2	DIRCT1	Rotation direction
0	0	By rotation direction immediately before (CCW for the first-time spindle orientation after the power is switched on)
0	1	By rotation direction immediately before (CW for the first-time spindle orientation after the power is switched on)
1	0	CCW direction looking from shaft of motor
1	1	CW direction looking from shaft of motor

NOTE

When using the high-speed spindle orientation function, specify the rotation direction for spindle orientation to be the previous rotation direction (bits 3 and 2 of parameter No. 4003 = 0 and 0 or 0 and 1).

PCMGSL : Orientation method selection
Set to 0.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3017	4017	4017	NRROEN							

NRROEN The short-cut function when spindle orientation from stopped state is specified is:
0: Unavailable
1: Available
If the setting is "1", a short-cut is made provided that the following conditions are satisfied.
i) Bit 7 of parameter No. 4016 (RFCHK3) = 0
ii) Zero-speed detection signal (output signal) SST = 1
iii) Short-cut command (input signal) NRROA = 1

15*i*	16*i*	30*i*	
3031	4031	4031	**Position coder method orientation stop position**

Unit of data : 1 pulse unit (360 degrees/4096)
Valid data range : 0 to 4095
Standard setting value : 0
This data is used to set the stop position of position coder method spindle orientation. This parameter is invalid for stop position external setting-type and incremental command external setting-type spindle orientation. Instead, the stop position commands (SHA11 to SHA00) (input signals) are valid.

15*i*	16*i*	30*i*	
3038	4038	4038	**Spindle orientation speed upper limit**

Unit of data : 1min^{-1}
Valid data range : 0 to 32767
Standard setting value : 0

This data is used to specify the upper limit to the orientation speed of an spindle end. If the setting is "0", the parameter is assumed to be set with a value converted for the spindle from the excitation voltage saturation speed with no load on the motor (parameter No. 4102, low-speed characteristic parameter No. 4140).

15*i*	16*i*	30*i*		
3042	4042	4042	**Velocity proportional gain on orientation (HIGH)**	**CTH1A=0**
3043	4043	4043	**Velocity proportional gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

This data is used to set the velocity loop proportional gain on orientation.

15*i*	16*i*	30*i*		
3050	4050	4050	**Velocity integral gain on orientation (HIGH)**	**CTH1A=0**
3051	4051	4051	**Velocity integral gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

This data is used to specify a velocity loop integral gain for spindle orientation.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : Number of motor rotations per spindle rotation / 100
(Number of motor rotations per spindle rotation / 1000 if bit 1 of parameter No. 4006 (GRUNIT) = 1)
Valid data range : 3 to 3000
(33 to 30000 if bit 1 of parameter No. 4006 (GRUNIT) = 1)
Standard setting value : 100

NOTE
The range of gear ratios supported by this function is:
1:30 to 30:1

15*i*	16*i*	30*i*		
3060	4060	4060	**Position gain on orientation (HIGH)**	**CTH1A=0, CTH2A=0**
3061	4061	4061	**Position gain on orientation (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3062	4062	4062	**Position gain on orientation (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3063	4063	4063	**Position gain on orientation (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : $0.01sec^{-1}$
Valid data range : 0 to 32767
Standard setting value : 1000

These data are used to set the position gain on spindle orientation.

15*i*	16*i*	30*i*	
3064	4064	4064	**Percentage limit to an acceleration during deceleration**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 100

This data is used to specify the percentage limit to an acceleration during deceleration if spindle orientation is started when the spindle speed is lower than or equal to the limitation start seed for an acceleration during deceleration (parameter Nos. 4326 and 4330). Usually, specify "100".

15*i*	16*i*	30*i*	
3075	4075	4075	**Orientation completion signal detection level (effective area for in-position check)**

Unit of data : ±1 pulse unit (360 degrees/4096)
Valid data range : 0 to 100
Standard setting value : 10

This data is used to set the detecting level of orientation completion signal (ORARA). ORARA = 1 is satisfied if the position error is within the setting.

15*i*	16*i*	30*i*	
3077	4077	4077	**Orientation stop position shift value**

Unit of data : ±1 pulse unit (360 degrees/4096)
Valid data range : -4095 to 4095
Standard setting value : 0

This data is used to specify the shift amount of the spindle orientation stop position. If a positive value is specified, the position where the spindle stops is shifted counterclockwise.

15*i*	16*i*	30*i*	
3084	4084	4084	**Motor voltage setting on orientation**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : Depends on the motor model.

This data is used to specify the motor voltage for spindle orientation. For high-speed spindle orientation, usually specify "100".

15*i*	16*i*	30*i*		
3320	4320	4320	**Acceleration during motor deceleration (HIGH)**	**CTH1A=0, CTH2A=0**
3321	4321	4321	**Acceleration during motor deceleration (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3322	4322	4322	**Acceleration during motor deceleration (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3323	4323	4323	**Acceleration during motor deceleration (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : 10min^{-1}/sec
Valid data range : 0 to 6400
Standard setting value : 0

This data is used to specify the acceleration during motor deceleration for high-speed spindle orientation. If the setting is "0", the high-speed spindle orientation function is disabled, and the standard-type spindle orientation function is enabled. The setting for the parameter is obtained, using:

Acceleration during deceleration = $\frac{\tau}{J} \times \frac{60}{2\pi} \times (0.8 \text{ to } 0.9)$

where

τ(Nm) : Motor maximum torque at spindle orientation speed upper limit (parameter No. 4038)

J(kgm2) : Motor inertia + load inertia

15*i*	16*i*	30*i*		
3326	4326	4326	**Acceleration limitation start speed during deceleration (HIGH)**	**CTH1A=0**
3330	4330	4330	**Acceleration limitation start speed during deceleration (LOW)**	**CTH1A=1**

Unit of data : $1 min^{-1}$
Valid data range : 0 to 32767
Standard setting value : 0

This data is used to specify the motor speed at which limitation on the acceleration during deceleration is started. If the setting is "0", the parameter is assumed to be set with the spindle orientation lower limit speed calculated within the software.

15*i*	16*i*	30*i*	
3328	4328	4328	**Command multiplier for spindle orientation by a position coder**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

Set a command multiplier for the spindle orientation function with an externally set incremental command.
When 0 is set in this parameter, 1 is assumed to have been specified.

5.16.8 Spindle Data Used in Tuning

This subsection describes high-speed spindle orientation-related data that can be observed using the spindle check board (A06B-6078-H001). Refer to an applicable maintenance manual for detailed explanations about how to use the spindle check board.

(1) Motor speed (data No. 19) and motor speed command (data No. 16)

These are spindle motor speed data and speed command data. The following table lists the relationships between the shift amount and the check board output value (if shift direction 0 and offset 1 are specified).

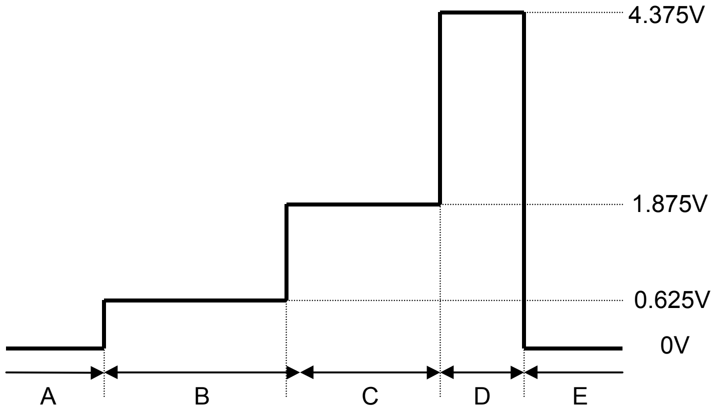
Shift amount	15	16	17	18	19	20
Output value (min^{-1}/5V)	1024	2048	4096	8192	16384	32768

(2) Torque command (data No. 90)

This is motor torque command data. If shift amount 8, shift direction 0, and offset 1 are specified, the check board output value is 100%/2.5 V.

(3) Spindle orientation sequence (data No. 298)

This data represents a high-speed spindle orientation sequence. If shift amount 4, shift direction 1, and offset 1 are specified, the check board output and the state of each sequence interval are as follows:



A : Before spindle orientation begins
B : Interval from the instant when an spindle orientation command is input and the instant which the orientation speed is reached and a one-rotation signal is detected
C : Interval during which the spindle is linearly decelerating with a constant specified for deceleration
D : State in which the position loop is closed
E : Spindle orientation is completed (in-position)

(4) Position error (data No. 136)

This is position error data (4096 pulses/rev) for spindle orientation. The following table lists the relationships between the shift amount and check board output value (when shift direction 0 and offset 1 are specified).

Shift amount	0	1	2	3	4	5
Output value (pulses/5 V)	128	256	512	1024	2048	4096

The position error data is output only in sequence intervals C, D, and E. It is 0 in the other intervals.

(5) Spindle orientation time (data No. 305)

This is the time from the instant when a spindle orientation command is input to the instant when spindle orientation is completed. It is indicated in ms units on the check board indicator (when shift amount 0, shift direction 0, and display format 0 are specified).

5.16.9 Tuning Procedure

Tune the parameters according to the following procedure. The ability of a motor to decelerate varies with the load inertia on the motor. When tuning, mount a tool with the highest possible load inertia on the spindle. If such a tool is unavailable, allow a considerable margin in specifying an acceleration during deceleration.

(1) Parameter initialization

Initialize the parameters related to high-speed spindle orientation as listed below.

No.	Description	Initial setting
4003#0	Selecting a spindle orientation type	0
4003#3,#2	Spindle rotation direction at orientation	Select a rotation direction.
4006#1	Unit of gear ratio setting	Specify an appropriate value depending on the system configuration.
4017#7	Short-cut function when spindle orientation from stopped state is specified	Specify an appropriate value according to the use of the machine.
4018#5	Whether a speed command correction function for high-speed spindle orientation is available	1
4018#6	High-speed spindle orientation function	1
4031	Spindle orientation stop position	Specify a stop position.
4038	Spindle orientation speed upper limit	0
4042 to 4043	Velocity proportional gain on orientation	10
4050 to 4051	Velocity integral gain on orientation	10

No.	Description	Initial setting
4056 to 4059	Gear ratio	Specify an appropriate value depending on the system configuration.
4060 to 4063	Position gain on orientation	3000
4064	Percentage limit to an acceleration during deceleration	100
4075	Orientation completion signal detection level	Specify an appropriate value according to the use of the machine.
4077	Orientation stop position shift value	Specify a stop position.
4084	Motor voltage on orientation	100
4320 to 4323	Acceleration during motor deceleration	Tune according to actual measurements.
4326,4330	Acceleration limitation start speed during deceleration	0
4328	Command multiplier for orientation	Specify an appropriate value according to the use of the machine.

NOTE

1 Spindle alarm 21 is issued if the relation (bit 0 of parameter No. 4000) between the spindle and motor rotation direction and/or the setting of the spindle sensor mounting direction (bit 4 of parameter No. 4001) is incorrect.

2 The time required for spindle orientation may get abnormally long if the gear ratio resolution (bit 1 of parameter No. 4006) setting and/or gear ratio (parameter Nos. 4056 to 4059) setting is incorrect.

3 To switch the winding of the spindle motor with speed range switching control from high-speed winding to low-speed winding during spindle orientation command-specified deceleration, set the orientation speed upper limit (parameter No. 4038) to the base speed of the low-speed winding or lower.
In the sequence enters interval C (where linear deceleration takes place with a parameter-specified time constant), the time required for spindle orientation may get abnormally long.

(2) Initial setting of the acceleration during deceleration (parameter Nos. 4320 to 4323)

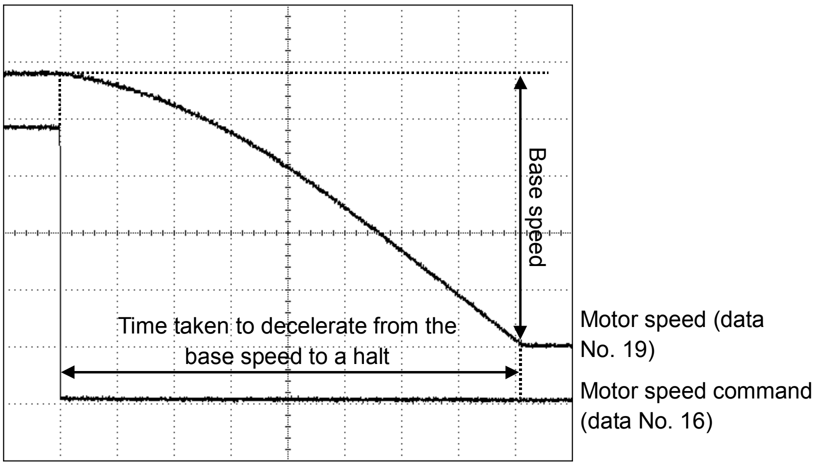
Run a real machine on the velocity control mode (regular operation mode), and decelerate it from the base speed ω_B (see the following expression).

Base speed ω_B = parameter No. 4102 × parameter No. 4117/100 (if parameter No. 4038 = 0), or
= parameter No. 4038 (if parameter No. 4038 ≠ 0)

Then, measure the time the real machine takes to decelerate, set up the initial acceleration during deceleration Tc from the measured deceleration time according to the following expression (see the figure below):

Acceleration during deceleration = base speed/time taken to decelerate from the base speed to a halt/10 (in 10 min^{-1}/s)

Example of setting an initial acceleration during deceleration



(3) Tuning the velocity loop proportional gain (parameter Nos. 4042 and 4043) and integral gain (parameter Nos. 4050 and 4051)

Tune the velocity loop proportional/integral gain while referencing Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT" in Part I.

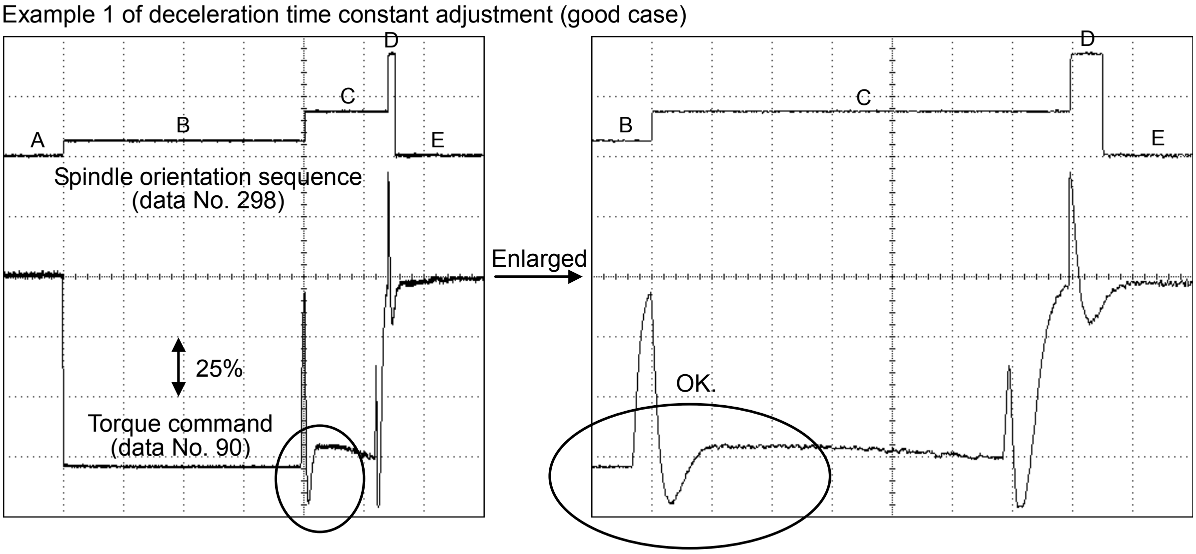
(4) Tuning the position gain

Basically, the position gain needs no adjustment. If you want to increase the setting for the position gain, do not increase it over 4000.

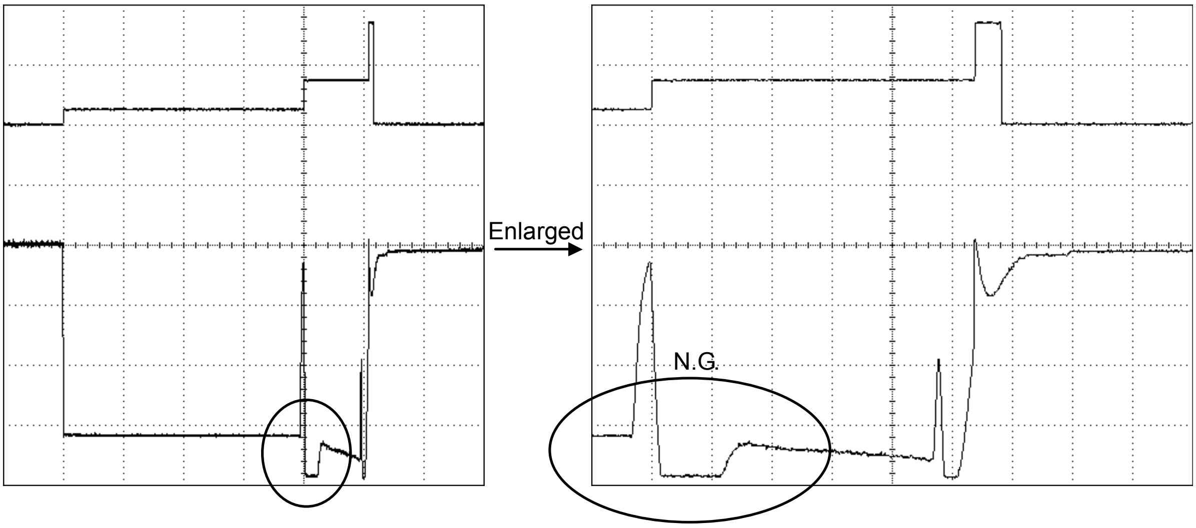
(5) Tuning the acceleration during deceleration (parameter Nos. 4320 to 4323)

Start spindle orientation when the spindle is running at the spindle maximum rotation speed, and tune the acceleration during deceleration so that the torque command will not be saturated when the motor starts linear deceleration (the beginning of interval C in the sequence). (See the following figure.)

Example 1 of deceleration time constant adjustment (good case)



Example 2 of deceleration time constant adjustment (bad case)

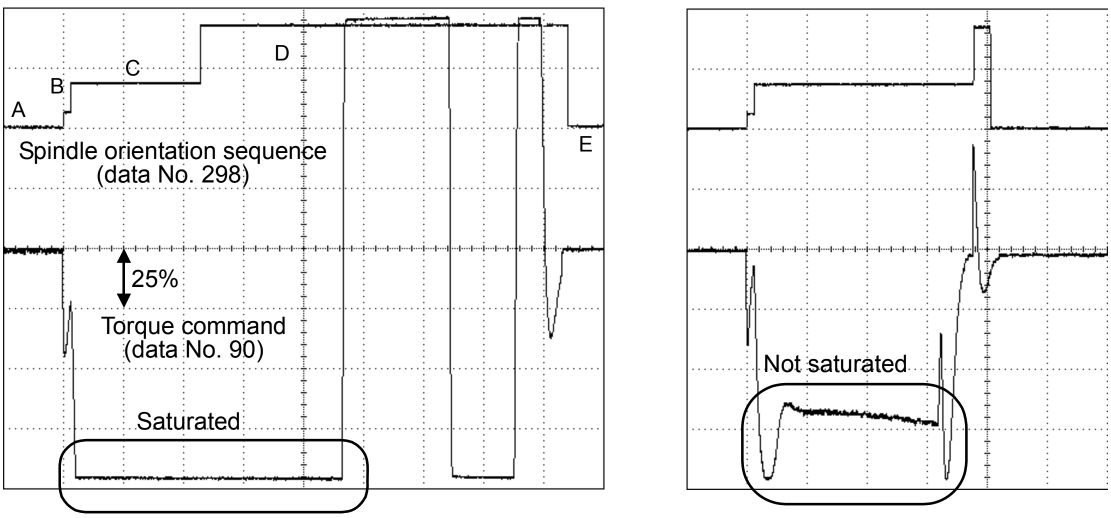


(6) Tuning the percentage limit to an acceleration during deceleration (parameter No. 4064)

(a) Deciding whether or not to tune the percentage limit to an acceleration during deceleration

Start spindle orientation when the spindle is running at the base speed ω_B. (See the figure below.) If the torque command is saturated in sequence intervals C or D, it is necessary to tune the percentage limit to an acceleration during deceleration.

If the torque command is not saturated, stop tuning the spindle orientation.

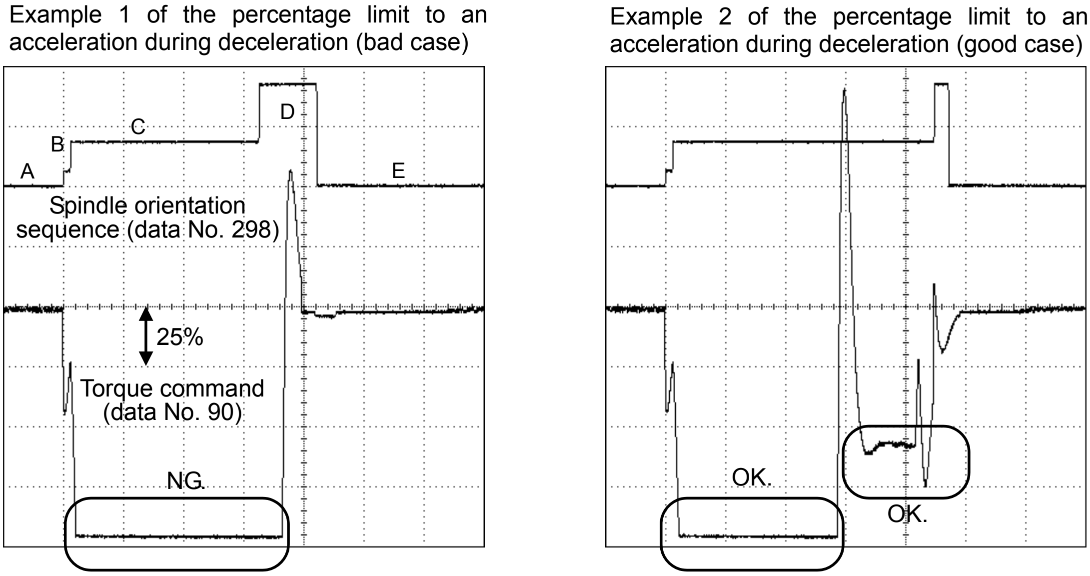


(b) Tuning the percentage limit to an acceleration during deceleration

Specify the acceleration limitation start speed during deceleration ω_{LS} (parameter Nos. 4326 and 4330) as follows:

Acceleration limitation start speed during deceleration ω_{LS} = 1.1 × base speed ω_B

Then, decrease the percentage limit to an acceleration during deceleration (parameter No. 4064) until the torque command will not be saturated at the end of sequence interval C or in sequence interval D. In this case, there is no problem even if the torque command is about to be saturated at the beginning of sequence interval C. (See the following figure.)



(7) Tuning the acceleration limitation start speed during deceleration (parameter Nos. 4326 and 4330)

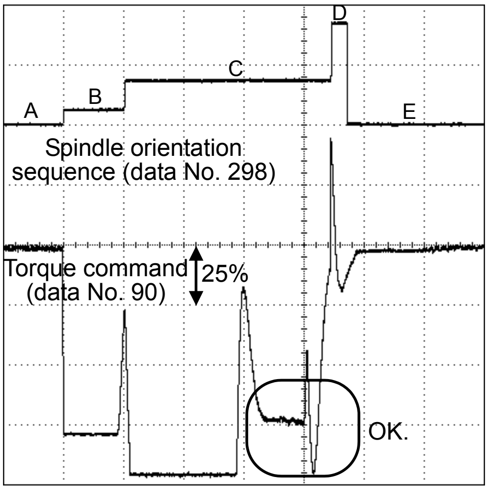
If you tuned the percentage limit to an acceleration during deceleration as explained in item (6), tune also the acceleration limitation start speed during deceleration.

(a) Deciding whether or not to tune the acceleration limitation start speed during deceleration

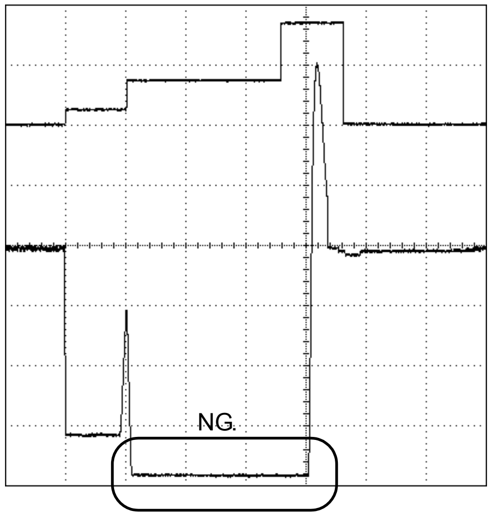
Start spindle orientation when the spindle is running at 10 min^{-1} + acceleration limitation start speed during deceleration ω_{LS}, which is an initial setting used when the percentage limit to an acceleration during deceleration is tuned. (See the following figure.) In this case, it is necessary to tune the percentage limit to an acceleration during deceleration if the torque command is saturated in sequence interval C or D.

If the torque command is not saturated, stop tuning the spindle orientation.

Case in which parameter tuning is necessary



Case in which parameter tuning is unnecessary



(b) Tuning the acceleration limitation start speed during deceleration

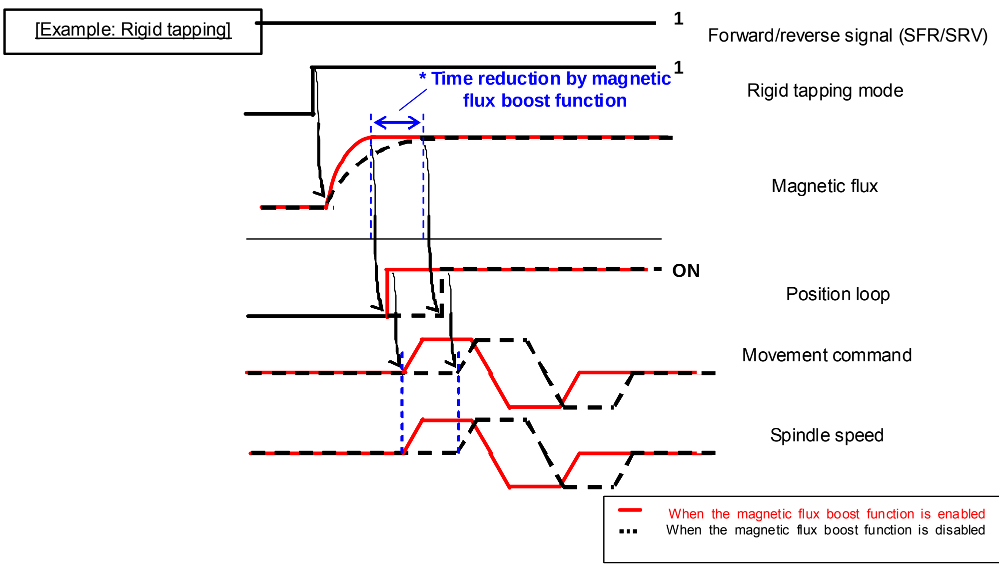
Increase the acceleration limitation start speed during deceleration (parameter Nos. 4326 and 4330) until the torque command will not be saturated at the end of sequence interval C or in sequence interval D even when spindle orientation is started when the spindle is running at 10 min^{-1} + acceleration limitation start speed during deceleration ω_{LS}. Similarly to item (6), there is no problem even if the torque command is about to be saturated at the beginning of sequence interval C.

5.17 MAGNETIC FLUX BOOST FUNCTION

5.17.1 Overview

An induction motor generates a magnetic flux by causing an excitation current to flow. Normally, when no load is applied by the speed mode, the excitation current is kept below the rated level to reduce heat generation. In this case, the magnetic flux is also reduced to below the rated level. To restore the magnetic flux to its rated value takes a certain amount of time. Before changing to a mode in which torque responsiveness is required (rigid tapping, spindle positioning, or Cs contour control mode), the time to restore the magnetic flux to its rated value is necessary No.3099 for 15i or No.4099 for 16i and 30i; typically 300 to 400 ms).

The magnetic flux boost function reduces the time it takes to restore the magnetic flux to its rated value when a changed is made from the speed control mode to rigid tapping (spindle positioning or Cs contour control mode).



5.17.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D80	K (11)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

5.17.3 List of Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
3353 #0	4353 #6	4353 #0	Whether to use the magnetic flux boost function
3124	4124	4124	Magnetic flux boost completion level/magnetic flux boost coefficient
3099	4099	4099	Delay time for motor excitation

5.17.4 Details of Related Parameters

15i	16i	30i	#7	#6	#5	#4	#3	#2	#1	#0
3353	4353	4353		FBTCSC						

FBTCSC : Whether to use the magnetic flux boost function
- 0 : Does not use the magnetic flux boost function.
- 1 : Use the magnetic flux boost function.

15i	16i	30i	
3124	4124	4124	**Magnetic flux boost completion level/magnetic flux boost coefficient**

Set the parameters for using the magnetic flux boost function.
For information about the values to be set, see Subsection 5.15.7, "Adjustment Procedure".

15i	16i	30i	
3099	4099	4099	**Delay time for motor excitation**

Unit of data : 1ms
Valid data range : 0 to 32767
Standard setting value : 0

Set the time it takes before motor excitation becomes stable when changing to rigid tapping or Cs contour control.

> **NOTE**
> Even when you are setting this for using the magnetic flux boost function, specify an appropriate value (typically, 300 to 400 (msec)).

5.17.5 Adjustment Procedure

1. Set parameter No. 4124 (without speed range switching or for high-speed winding) and parameter No. 4155 (for low-speed winding), based on the table below. If your motor model is not indicated in the table, use the following equations to calculate the values to be set:

$$No.4124 = 24320 + MIN\left(255, \sqrt{(No.4111/100)^2 + 1} \times 0.9 \times 100\right)$$

$$No.4155 = 24320 + MIN\left(255, \sqrt{(No.4147/100)^2 + 1} \times 0.9 \times 100\right)$$ (No need to set if speed range switching is not involved)

2. If the vibration of the spindle during magnetic flux boost bothers you, try reducing the values of parameter Nos. 4124 and No.4155 in step of 10 (the lower limit is 24420).

●Parameter Table of Magnetic Flux Boost Coefficient and Magnetic Flux Boost Completion Level by Motor Model

a. SPINDLE MOTOR αiI (200V)

Motor model	Applicable amplifier	Magnetic flux boost coefficient /magnetic flux boost completion level	
		No.4124 (High-speed winding)	No.4155 (Low-speed winding)
αiI 0.5/10000	αiSP2.2	24570	0
αiI 1/10000	αiSP2.2	24448	0
αiI 1.5/10000	αiSP5.5	24535	0
αiI 2/10000	αiSP5.5	24501	0
αiI 3/10000	αiSP5.5	24521	0
αiI 6/10000	αiSP11	24570	0
αiI 8/8000	αiSP11	24497	0
αiI 12/7000	αiSP15	24499	0
αiI 15/7000	αiSP22	24556	0
αiI 18/7000	αiSP22	24575	0
αiI 22/7000	αiSP26	24564	0
αiI 30/6000	αiSP45	24575	0
αiI 40/6000	αiSP45	24575	0
αiI 50/4500	αiSP55	24575	0
αiI 1.5/15000	αiSP15	24505	0
αiI 2/15000	αiSP22	24501	0
αiI 3/12000	αiSP11	24513	0
αiI 6/12000	αiSP11	24464	24570
αiI 8/10000	αiSP11	24493	24497
αiI 12/10000	αiSP15	24499	24499
αiI 15/10000	αiSP22	24515	24556
αiI 18/10000	αiSP22	24570	24575
αiI 22/10000	αiSP26	24477	24531

b. SPINDLE MOTOR α*i*IP (200V)

Motor model	Applicable amplifier	Magnetic flux boost coefficient /magnetic flux boost completion level	
		No.4124 (High-speed winding)	No.4155 (Low-speed winding)
α*i*IP 12/6000	α*i*SP11	24575	24575
α*i*IP 12/8000	α*i*SP11	24575	24575
α*i*IP 15/6000	α*i*SP15	24575	24575
α*i*IP 15/8000	α*i*SP15	24575	24575
α*i*IP 18/6000	α*i*SP15	24541	24575
α*i*IP 18/8000	α*i*SP15	24541	24575
α*i*IP 22/6000	α*i*SP22	24575	24575
α*i*IP 22/8000	α*i*SP22	24575	24575
α*i*IP 30/6000	α*i*SP22	24575	24575
α*i*IP 40/6000	α*i*SP26	24575	24575
α*i*IP 50/6000	α*i*SP26	24575	24575
α*i*IP 60/4500	α*i*SP30	24575	24575

c. SPINDLE MOTOR α*i*IT (200V)

Motor model	Applicable amplifier	Magnetic flux boost coefficient /magnetic flux boost completion level	
		No.4124 (High-speed winding)	No.4155 (Low-speed winding)
α*i*IT 1.5/15000	α*i*SP15	24505	0
α*i*IT 2/15000	α*i*SP22	24501	0
α*i*IT 3/12000	α*i*SP11	24513	0
α*i*IT 6/12000	α*i*SP15	24509	24575
α*i*IT 8/12000	α*i*SP15	24447	24491
α*i*IT 8/15000	α*i*SP26	24450	24514
α*i*IT 15/10000	α*i*SP22	24515	24556
α*i*IT 15/12000	α*i*SP30	24566	24575
α*i*IT 22/10000	α*i*SP26	24477	24531

d. SPINDLE MOTOR α*i*I (400V)

Motor model	Applicable amplifier	Magnetic flux boost coefficient /magnetic flux boost completion level	
		No.4124 (High-speed winding)	No.4155 (Low-speed winding)
α*i*I 0.5/10000HV	α*i*SP5.5HV	24558	0
α*i*I 1/10000HV	α*i*SP5.5HV	24449	0
α*i*I 1.5/10000HV	α*i*SP5.5HV	24537	0
α*i*I 2/10000HV	α*i*SP5.5HV	24575	0
α*i*I 3/10000HV	α*i*SP5.5HV	24551	0
α*i*I 6/10000HV	α*i*SP11HV	24575	0
α*i*I 8/8000HV	α*i*SP11HV	24544	0
α*i*I 12/7000HV	α*i*SP15HV	24562	0
α*i*I 15/7000HV	α*i*SP30HV	24575	0
α*i*I 22/7000HV	α*i*SP30HV	24539	0
α*i*I 30/6000HV	α*i*SP45HV	24575	0
α*i*I 40/6000HV	α*i*SP45HV	24564	0
α*i*I 60/4500HV	α*i*SP75HV	24575	0
α*i*I 100/4000HV	α*i*SP75HV	24533	24553

e. SPINDLE MOTOR α*i*IP (400V)

Motor model	Applicable amplifier	Magnetic flux boost coefficient /magnetic flux boost completion level	
		No.4124 (High-speed winding)	No.4155 (Low-speed winding)
α*i*IP 15/6000HV	α*i*SP15HV	24575	24575
α*i*IP 40/6000HV	α*i*SP30HV	24575	24575
α*i*IP 50/6000HV	α*i*SP30HV	24541	24575

f. SPINDLE MOTOR α*i*IT (400V)

Motor model	Applicable amplifier	Magnetic flux boost coefficient /magnetic flux boost completion level	
		No.4124 (High-speed winding)	No.4155 (Low-speed winding)
α*i*IT 1.5/15000HV	α*i*SP15HV	24548	0
α*i*IT 3/12000HV	α*i*SP11HV	24513	0
α*i*IT 6/12000HV	α*i*SP15HV	24513	24575
α*i*IT 8/12000HV	α*i*SP15HV	24447	24510
α*i*IT 8/15000HV	α*i*SP15HV	24494	24575
α*i*IT15/10000HV	α*i*SP30HV	24544	24575
α*i*IT15/12000HV	α*i*SP30HV	24575	24575
α*i*IT22/10000HV	α*i*SP30HV	24489	24575

g. BUILT-IN SPINDLE MOTOR B*i*I (Standard type)

Motor model	Applicable amplifier	Magnetic flux boost coefficient /magnetic flux boost completion level	
		No.4124 (High-speed winding)	No.4155 (Low-speed winding)
B*i*I 50S/30000	α*i*SP2.2	24575	0
B*i*I 50M/25000	α*i*SP2.2	24551	0
B*i*I 50L/25000	α*i*SP5.5	24575	0
B*i*I 80S/20000	α*i*SP5.5	24506	24569
B*i*I 80M/15000	α*i*SP2.2	24448	0
B*i*I 80L/8000	α*i*SP5.5	24535	0
B*i*I 100S/12500	α*i*SP5.5	24551	0
B*i*I 112SS/20000	α*i*SP11	24575	24575
B*i*I 112S/15000	α*i*SP22	24487	24575
B*i*I 112M/15000	α*i*SP11	24568	0
B*i*I 112L/15000	α*i*SP30	24575	24575
B*i*I 112LL/15000	α*i*SP30	24575	24575
B*i*I 132M/14000	α*i*SP30	24575	24575
B*i*I 132L/14000	α*i*SP30	24575	24575
B*i*I 160S/13000	α*i*SP22	24575	24575
B*i*I 160M/13000	α*i*SP30	24575	24575
B*i*I 160L/13000	α*i*SP22	24575	24575
B*i*I 160LL/13000	α*i*SP30	24575	24575
B*i*I 170S/6000	α*i*SP22	24533	24575
B*i*I 170M/6000	α*i*SP26	24575	24575
B*i*I 180M/6000	α*i*SP30	24575	24575
B*i*I 180L/6000	α*i*SP30	24575	24575
B*i*I 180LL/8000	α*i*SP30	24575	24575
B*i*I 200S/6000	α*i*SP37	24575	24575
B*i*I 200M/6000	α*i*SP30	24575	24575
B*i*I 200L/6000	α*i*SP45	24575	24575
B*i*I 250S/6000	α*i*SP45	24514	24575
B*i*I 250M/3000	α*i*SP55	24575	24575

h. BUILT-IN SPINDLE MOTOR B*i*I (High-speed type)

Motor model	Applicable amplifier	Magnetic flux boost coefficient /magnetic flux boost completion level	
		No.4124 (High-speed winding)	No.4155 (Low-speed winding)
B*i*I 40S/70000	α*i*SP2.2	24467	0
B*i*I 40M/70000	α*i*SP11	24575	0
B*i*I 60SS/50000	α*i*SP11	24575	0
B*i*I 60S/50000	α*i*SP22	24575	24575
B*i*I 80S/40000	α*i*SP45	24575	0
B*i*I 100S/20000	α*i*SP22	24575	24575
B*i*I 100S/30000	α*i*SP30	24569	24575
B*i*I 100L/30000	α*i*SP30	24575	24575
B*i*I 112S/20000	α*i*SP30	24575	24575
B*i*I 112M/20000	α*i*SP30	24499	24575
B*i*I 112L/20000	α*i*SP30	24522	24575
B*i*I 112L/25000	α*i*SP75HV	24575	24575
B*i*I 160M/20000	α*i*SP30	24575	24575
B*i*I 160L/20000	α*i*SP30	24575	24575
B*i*I 160LL/20000	α*i*SP75HV	24575	24575
B*i*I 200S/10000	α*i*SP75HV	24575	24575

II. FANUC AC SPINDLE MOTOR βi series

1 START-UP

1.1 START-UP PROCEDURE

For this subsection, see Section 1.1, “START-UP PROCEDURE”, in Part I.

> **NOTE**
> The CNC applicable to the βi SVSP is the 0i /0i Mate-MODEL B, 0i /0i Mate-MODEL C or 0i /0i Mate-MODEL D.

1.2 SPINDLE SERIAL INTERFACE (OPTIONAL FUNCTION)

1.2.1 Parameters Related to Spindle Serial Output

For this subsection, see Subsection 1.2.1, “Parameters Related to Spindle Serial Output”, in Part I.

1.2.2 Automatic Spindle Parameter Initialization

(1) Parameter list

Parameter No. (0*i*)	Description
4019#7	Function for automatically initializing spindle parameters
4133	Spindle motor model code

(2) Procedure for automatic spindle parameter initialization

Perform automatic spindle parameter initialization by following the procedure below.

<1> Set the model code for the desired motor for automatic parameter initialization.

Parameter No. (0*i*)	Description
4133	Model code

> **NOTE**
> When using a spindle motor that has no model code, set model code “300” for automatic parameter setting, then manually input data according to the model-by-model parameter list.

<2> Set the relevant parameter to enable automatic spindle parameter initialization.

Parameter No. (0*i*)	Description
4019#7	1

> **NOTE**
> This bit is reset to its original value after automatic parameter initialization.

<3> Turn off then turn on again the power to the CNC. The spindle parameter data set with the model code is automatically initialized.

<4> According to the detector configuration, set the detector-related parameters.

<5> In parameter No. 4090 (overload detection level), set the standard value of the β*i* series spindle motor.

Parameter No. (0*i*)	Description
4090	95

1.2.3 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 1.2.4, "Diagnosis (Diagnosis Screen)", in Part I.

1.2.4 Alarm

For this subsection, see Subsection 1.2.5, "Alarm", in Part I.

1.3 PARAMETERS RELATED TO DETECTORS

The following detector configurations can be used with the β*i* SVSP:

Motor sensor	Spindle sensor
α*i*M sensor	None
α*i*M sensor	α*i* position coder
α*i*MZ sensor	None
α*i*M sensor	External one-rotation signal

NOTE
1 Because of the difference in amplifier hardware specifications, the detector configurations that can be used with the β*i* SVSP are limited.
2 Only a position coder or external one-rotation signal can be used as the spindle sensor for the SVSP. (The spindle sensor refers to the detector connected to connector JYA3.)

1.3.1 List of Parameters for Detectors

For this subsection, see Subsection 1.3.1, "List of Parameters for Detectors", in Part I.

1.3.2 Details of Parameters for Detectors

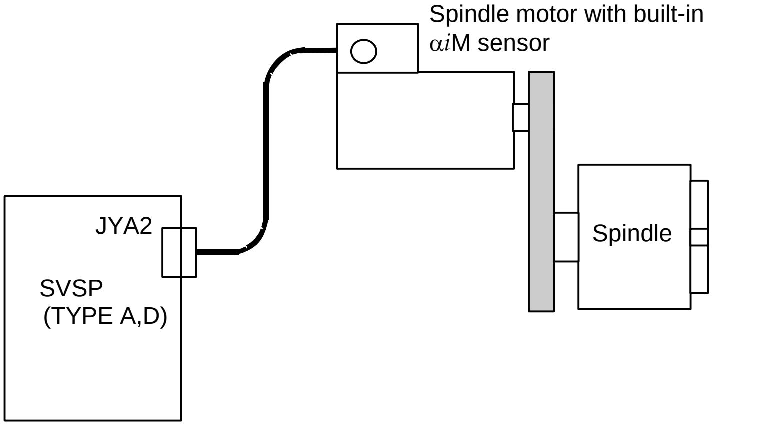
For this subsection, see Subsection 1.3.2, "Details of Parameters for Detectors", in Part I.

1.3.3 Typical Detector Configurations

This subsection presents the spindle detector configurations usable with the β*i* SVSP and describes the procedure for setting parameters in these detector configurations.
With the β*i* SVSP, the detector circuitry hardware is set according to the parameter setting. For this reason, an alarm such as a disconnection alarm may be output while parameters related to detectors are being set.
To initialize the hardware, after setting the parameters related to detectors, turn the power to the amplifier off once.

(1) When position control is not exercised

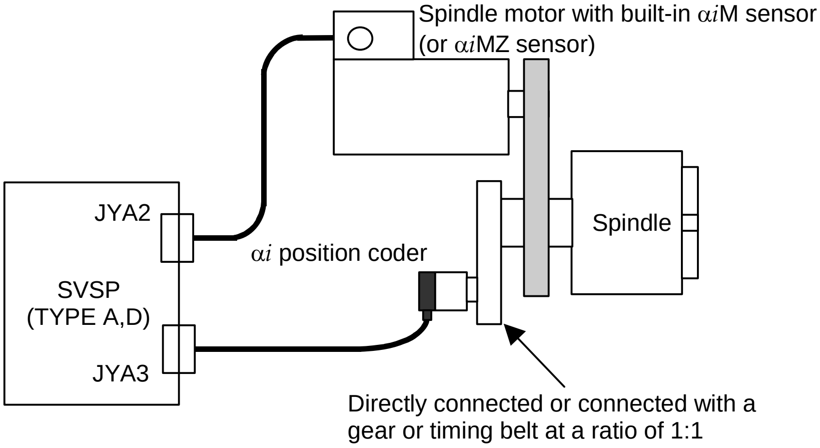
[Sample system configuration]



Parameter (0*i*)	Settings	Description
4002 #3,#2,#1,#0	0,0,0,0	Does not exercise position control.
4010 #2,#1,#0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,#1,#0	Depends on the detector.	Sets the number of motor sensor gear teeth.

(2) When the αi position coder is used

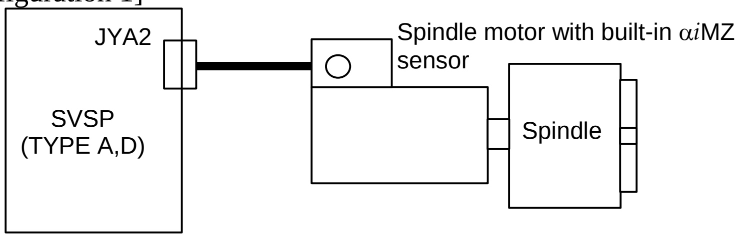
[Sample system configuration]



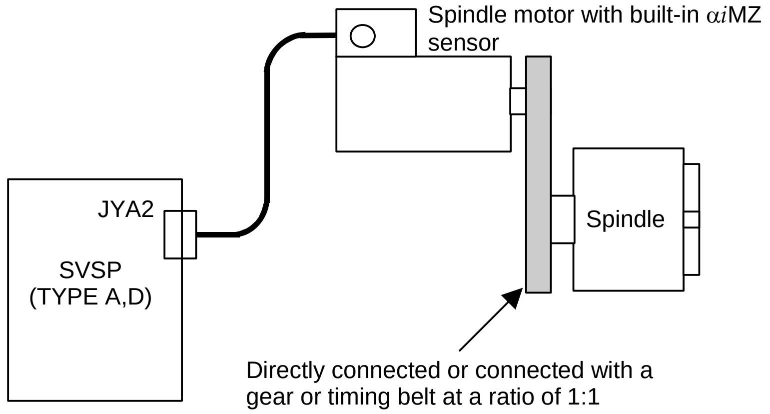
Parameter (0*i*)	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,#2,#1,#0	0,0,1,0	Uses the αi position coder as the spindle sensor.
4003 #7,#6,#5,#4	0,0,0,0	Sets the number of spindle sensor gear teeth.
4010 #2,#1,#0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,#1,#0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056 to 4059	Depends on the configuration.	Gear ratio between the spindle and motor

(3) When the α*i*MZ sensor is used

[Sample system configuration 1]



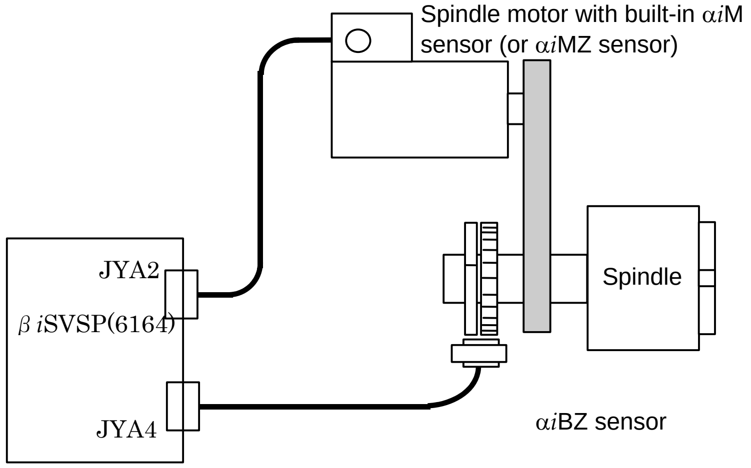
[Sample system configuration 2]



Parameter (0*i*)	Settings	Description
4000 #0	0	Rotation directions of the spindle and motor
4002 #3,#2,#1,#0	0,0,0,1	Uses the motor sensor for position feedback.
4010 #2,#1,#0	0,0,1	Uses the α*i*MZ or α*i*BZ sensor as the motor sensor.
4011 #2,#1,#0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056 to 4059	100 or 1000	Gear ratio between the spindle and motor 1 : 1

(4) When the separate type α*i*BZ sensor is used

[Sample system configuration]

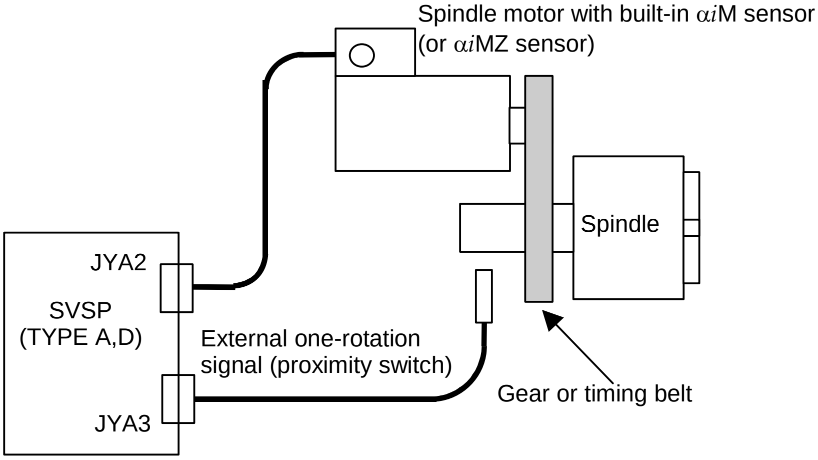


Parameter No.	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,2,1,0	0,0,1,1	Uses the α*i*BZ sensor as the spindle sensor.
4003 #7,6,5,4	Depends on the detector.	Sets the number of spindle sensor gear teeth.

Parameter No.	Settings	Description
4010 #2,1,0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056~4059	Depends on the configuration.	Gear ratio between the spindle and motor

(5) When the external one-rotation signal (proximity switch) is used

[Sample system configuration]



Parameter (0*i*)	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4002 #3,#2,#1,#0	0,0,0,1	Uses the motor sensor for position feedback.
4004 #2	1	Uses the external one-rotation signal.
4004 #3	Depends on the detector.	Sets the external one-rotation signal type.
4010 #2,#1,#0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,#1,#0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056 to 4059	Depends on the configuration.	Gear ratio between the spindle and motor
4171 to 4174	Depends on the configuration.	Arbitrary gear ratio between the motor sensor and spindle

2 EXPLANATION OF OPERATION MODES

2.1 VELOCITY CONTROL MODE

2.1.1 Start-up Procedure

For this subsection, see Subsection 2.1.1, “Start-up Procedure”, in Part I.

2.1.2 Overview

For this subsection, see Subsection 2.1.2, “Overview”, in Part I.

2.1.3 System Configuration

The velocity control mode is applicable to all detector configurations. For system configurations, see Subsection 1.3.3, “Typical Detector Configurations”, in Part II.

2.1.4 List of I/O Signals (CNC↔PMC)

For this subsection, see Subsection 2.1.4, “List of I/O Signals (CNC↔PMC)”, in Part I.

2.1.5 Related Parameters

For this subsection, see Subsection 2.1.5, “Related Parameters”, in Part I.

2.1.6 Details of Related Parameters

For this subsection, see Subsection 2.1.6, “Details of Related Parameters”, in Part I.

2.1.7 Troubleshooting

For this subsection, see Subsection 2.1.7, “Troubleshooting”, in Part I.

2.2 POSITION CODER METHOD SPINDLE ORIENTATION (OPTIMUM ORIENTATION) (OPTIONAL FUNCTION)

2.2.1 Start-up Procedure

For this subsection, see Subsection 2.2.1, “Start-up Procedure”, in Part I.

2.2.2 Overview

For this subsection, see Subsection 2.2.2, “Overview”, in Part I.

2.2.3 Transition from Conventional Method Orientation to Optimum Orientation

For this subsection, see Subsection 2.2.3, “Transition from Conventional Method Orientation to Optimum Orientation”, in Part I.

2.2.4 Feature

For this subsection, see Subsection 2.2.4, “Feature”, in Part I.

2.2.5 Block Diagram

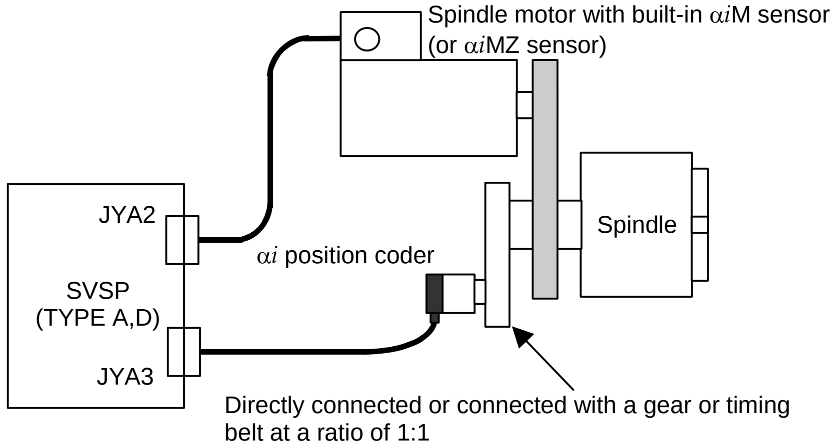
For this subsection, see Subsection 2.2.5, “Block Diagram”, in Part I.

2.2.6 System Configuration

The system configurations that enable the use of the position coder method orientation function are shown below.

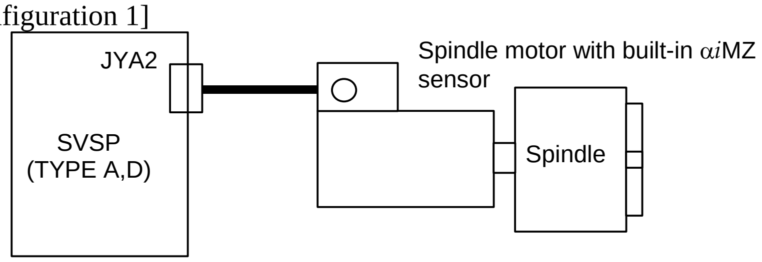
(1) When the αi position coder is used

[Sample system configuration]

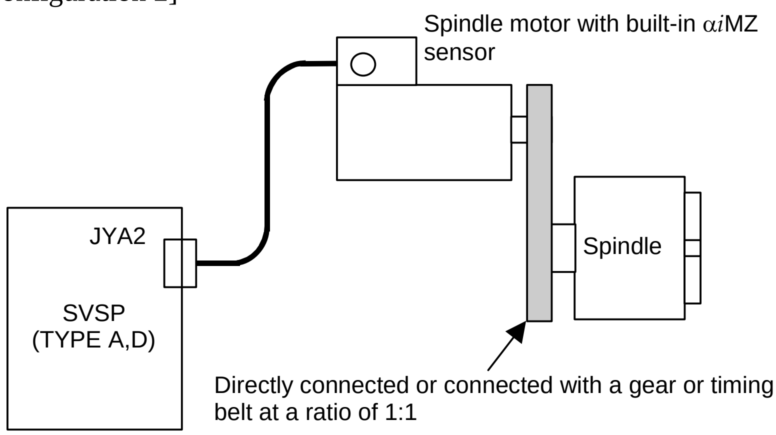


(2) When the αiMZ is used

[Sample system configuration 1]

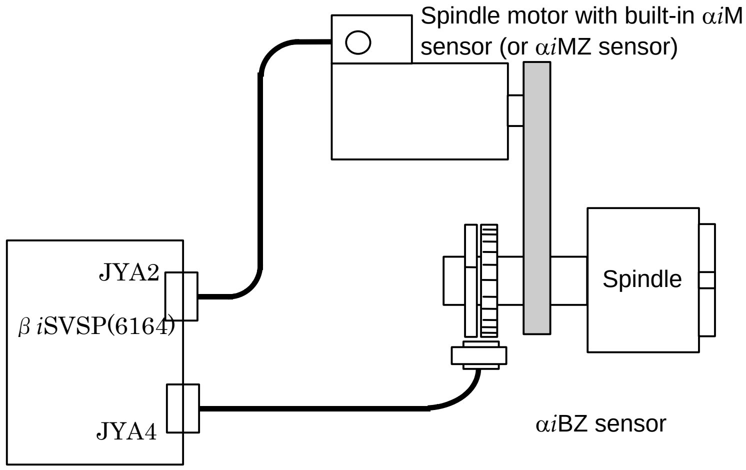


[Sample system configuration 2]



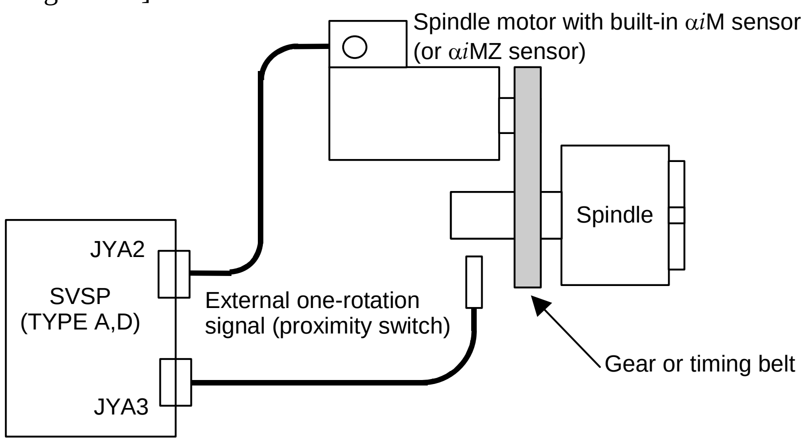
(3) When the separate type αiBZ sensor is used

[Sample system configuration]



(4) When the external one-rotation signal (proximity switch) is used

[Sample system configuration]



NOTE

1. For stable detection of the one-rotation signal, fix the rotation direction (bits 3 and 2 of No. 4003) for orientation at one direction.
2. Set the type (bits 3 and 2 of No. 4004) of the external one-rotation signal (proximity switch).
3. For stable detection of the one-rotation signal, set an orientation speed (No. 4038) from 50 to 100 min^{-1} according to the specification of the external one-rotation signal (proximity switch).
4. The detection of the one-rotation signal starts after the orientation speed is reached.
5. Set the parameters (No. 4171 to No. 4174) for the numerator/denominator of an arbitrary gear ratio between the motor sensor and spindle.

2.2.7 Stop Position Specification Method

For this subsection, see Subsection 2.2.7, “Stop Position Specification Method”, in Part I.

2.2.8 I/O Signals (CNC↔PMC)

For this subsection, see Subsection 2.2.8, “I/O Signals (CNC↔PMC)”, in Part I.

2.2.9 Examples of Sequences

For this subsection, see Subsection 2.2.9, “Examples of Sequences”, in Part I.

2.2.10 Explanation of Operation

For this subsection, see Subsection 2.2.10, “Explanation of Operation”, in Part I.

2.2.11 Related Parameters

For this subsection, see Subsection 2.2.11, “Related Parameters”, in Part I.

2.2.12 Details of Related Parameters

For this subsection, see Subsection 2.2.12, “Details of Related Parameters”, in Part I.

2.2.13 Adjustment Procedure

For this subsection, see Subsection 2.2.13, “Adjustment Procedure”, in Part I.

2.2.14 Adjusting the Orientation Stop Position Shift Parameter

For this subsection, see Subsection 2.2.14, “Adjusting the Orientation Stop Position Shift Parameter”, in Part I.

2.2.15 Supplementary Descriptions

For this subsection, see Subsection 2.2.15, “Supplementary Descriptions”, in Part I.

2.3 RIGID TAPPING (OPTIONAL FUNCTION)

2.3.1 Start-up Procedure

For this subsection, see Subsection 2.3.1, "Start-up Procedure", in Part I.

2.3.2 Overview

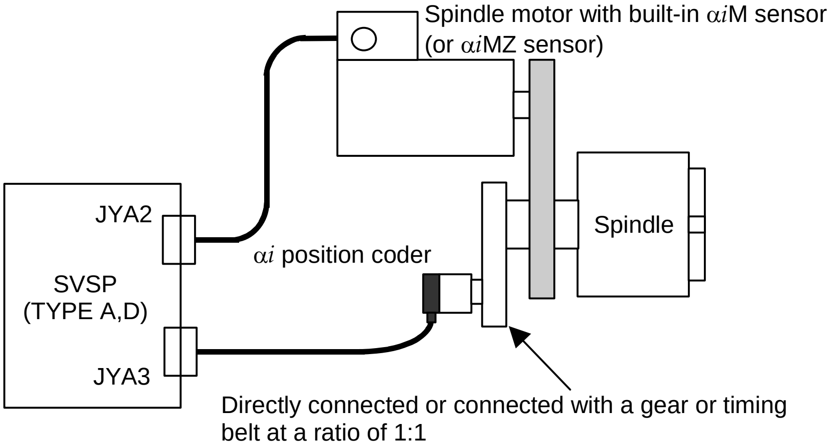
For this subsection, see Subsection 2.3.2, "Overview", in Part I.

2.3.3 System Configuration

The system configurations that enable the use of rigid tapping are shown below.

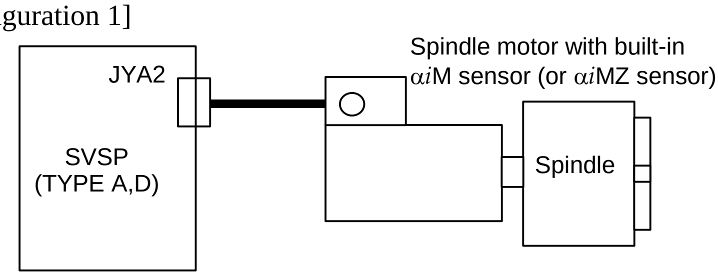
(1) When the αi position coder is used

[Sample system configuration]

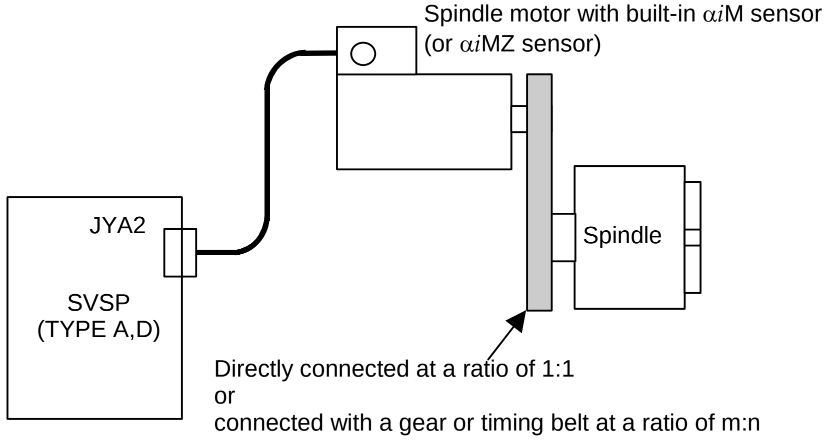


(2) When the spindle motor with built-in αiM sensor (or αiMZ sensor) is used

[Sample system configuration 1]



[Sample system configuration 2]

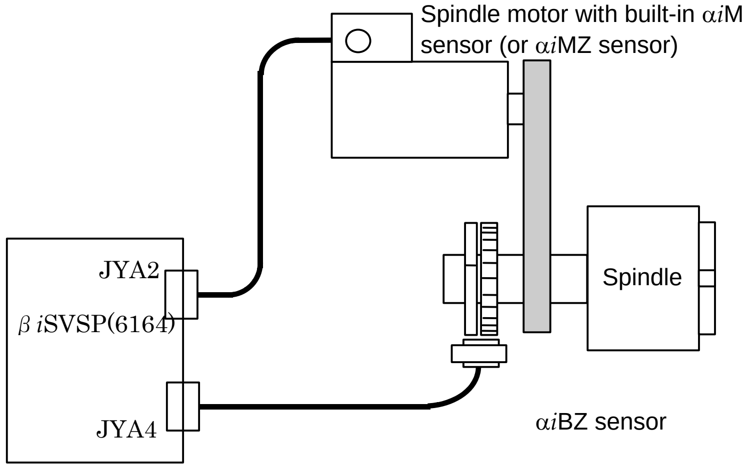


NOTE

1 When performing rigid tapping by using a signal from the sensor built into the motor as a position feedback signal, use one of the following functions if the gear ratio between the motor and spindle is other than 1:1
   (a) Detection arbitrary gear ratio function (DMR function)
   (b) Command arbitrary gear ratio function (CMR function)
2 When using the detection arbitrary gear ratio function (DMR function), set the following:
   - Parameters (No. 4171 to No. 4174) for the numerator/denominator of an arbitrary gear ratio between the motor sensor and spindle
3 When using the detection arbitrary gear ratio function (DMR function) with a motor containing a built-in αiMZ sensor, set bit 6 of No. 4007 to 1 so that the alarms related to the position feedback signal (when non-Cs contouring control is exercised) are not detected.
4 When using the command arbitrary gear ratio function (CMR function) with FS16*i*, set the following:
   - Enable the setting of an arbitrary gear ratio between the spindle and position coder (bit 1 of No. 5200 = 1).
   - Enable the setting of the command arbitrary gear ratio function (CMR) on rigid tapping (bit 7 of No. 4006 = 1).
   - Set the parameters for specifying the number of gear teeth on the spindle side (No. 5221 to No. 5224).
   - Set the parameters for specifying the number of gear teeth on the position coder side (No. 5231 to No. 5234).
5 Reference position return can be performed when a motor with a built-in αiMZ sensor is used and the spindle is directly connected to the motor or the spindle is connected to the motor at a ratio of 1:1.

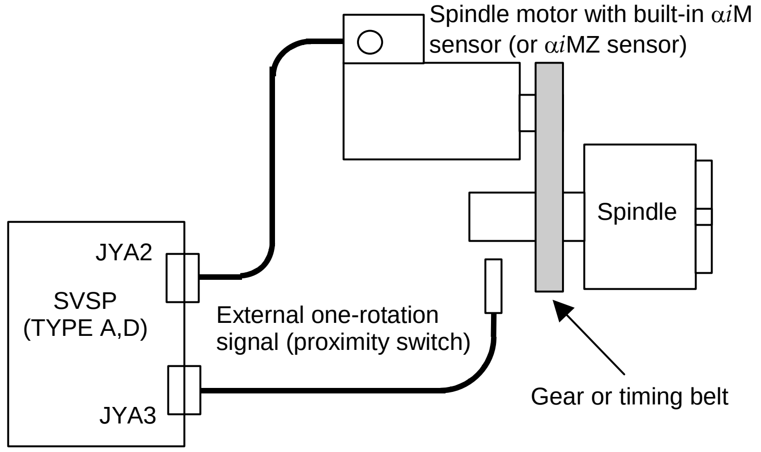
(3) When the separate type α*i*BZ sensor is used

[Sample system configuration]



(4) When the external one-rotation signal (proximity switch) is used

[Sample system configuration]



> **NOTE**
> 1 When using the external one-rotation signal (proximity switch), use the detection arbitrary gear ratio function (DMR function).
> 2 When using the detection arbitrary gear ratio function (DMR function), set the following:
>   - Parameters (No. 4171 to No. 4174) for the numerator/denominator of an arbitrary gear ratio between the motor sensor and spindle
> 3 Set the type of the external one-rotation signal (proximity switch) (bits 3 and 2 of No. 4004).
> 4 For stable detection of the one-rotation signal, set a reference position return speed (No. 4074) from 50 to 100 min^{-1} according to the specification of the used external one-rotation signal (proximity switch).
> 5 When orientation based on the external one-rotation signal is used together, match the reference position return speed and direction with the orientation speed and direction.

2.3.4 List of I/O Signals (CNC↔PMC)

For this subsection, see Subsection 2.3.4, “List of I/O Signals (CNC↔PMC)”, in Part I.

2.3.5 Sequence

For this subsection, see Subsection 2.3.5, “Sequence”, in Part I.

2.3.6 Related Parameters

For this subsection, see Subsection 2.3.6, “Related Parameters”, in Part I.

2.3.7 Details of Related Parameters

For this subsection, see Subsection 2.3.7, “Details of Related Parameters”, in Part I.

2.3.8 Parameter Setting Procedure

For this subsection, see Subsection 2.3.8, “Parameter Setting Procedure”, in Part I.

2.3.9 Adjustment Procedure

For this subsection, see Subsection 2.3.9, “Adjustment Procedure”, in Part I.

2.3.10 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.3.10, “Diagnosis (Diagnosis Screen)”, in Part I.

2.3.11 Alarm

For this subsection, see Subsection 2.3.11, “Alarm”, in Part I.

2.4 Cs CONTOURING CONTROL (OPTIONAL FUNCTION)

2.4.1 Start-up Procedure

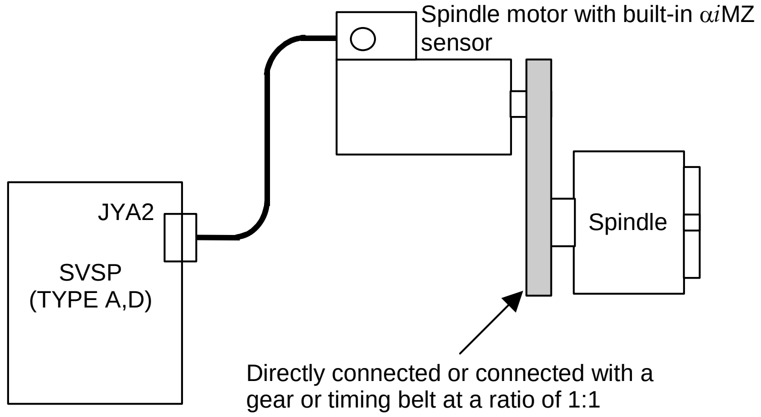
For this subsection, see Subsection 2.4.1, “Start-up Procedure”, in Part I.

2.4.2 Overview

For this subsection, see Subsection 2.4.2, “Overview”, in Part I.

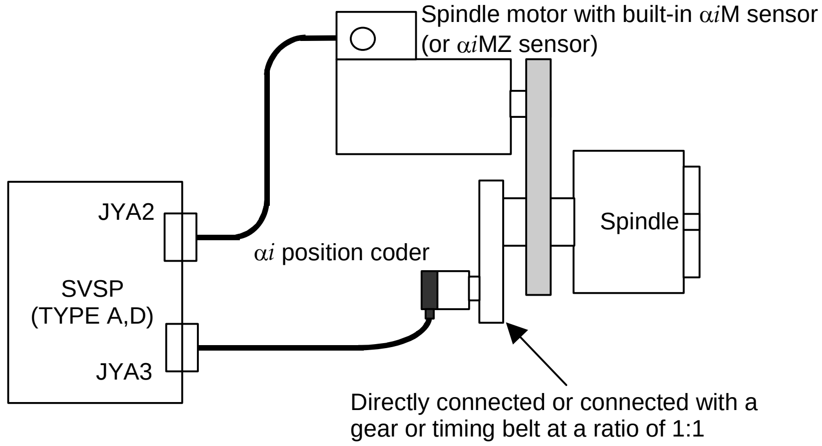
2.4.3 System Configuration

(1) When a motor with a built-in αiMZ sensor is used



Parameter (0i)	Settings	Description
4000 #0	0	Rotation directions of the spindle and motor
4002 #3,#2,#1,#0	0,0,0,1	Uses the motor sensor for position feedback.
4010 #2,#1,#0	0,0,1	Uses the αiMZ sensor as the motor sensor.
4011 #2,#1,#0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056 to 4059	100 or 1000	The spindle-to-motor gear ratio is 1:1.

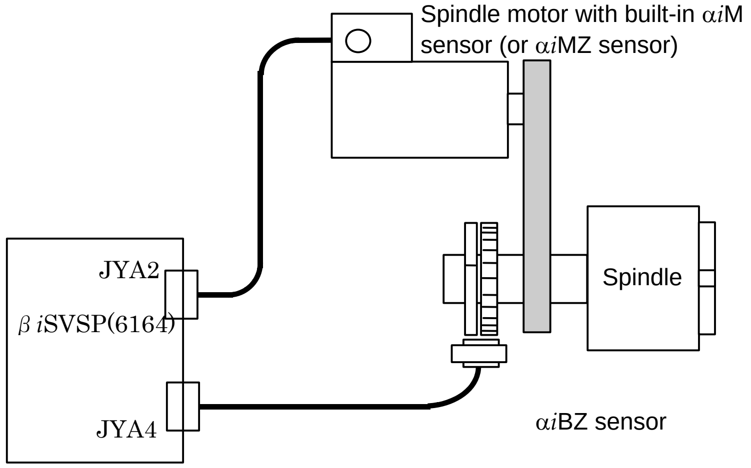
(2) When an αi position coder is used



Parameter (0i)	Settings	Description
4002 #3,#2,#1,#0	0,0,1,0	αi position coder
4003 #7,#6,#5,#1	0,0,0,0	αi position coder
4010 #2,#1,#0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,#1,#0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056 to 4059	Depends on the configuration.	Gear ratio between the spindle and motor
4171 to 4174	Depends on the configuration.	Sets the gear ratio between the spindle and motor when the position coder feedback interpolation function is used.
4398#0	The setting of 1 is recommended.	Sets the position coder feedback interpolation function.

(3) When the separate type α*i*BZ sensor is used

[Sample system configuration]



Parameter	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,2,1,0	0,0,1,1	Uses the α*i*BZ sensor as the spindle sensor.
4003 #7,6,5,4	Depends on the detector.	Sets the number of spindle sensor gear teeth.
4010 #2,1,0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056~4059	Depends on the configuration.	Gear ratio between the spindle and motor

2.4.4 List of I/O Signals (CNC↔PMC)

For this subsection, see Subsection 2.4.4, "List of I/O Signals (CNC↔PMC)", in Part I.

2.4.5 Examples of Sequences

For this subsection, see Subsection 2.4.5, "Examples of Sequences", in Part I.

2.4.6 Velocity Loop Gains Override Function on Cs Contouring Control Mode

For this subsection, see Subsection 2.4.6, "Velocity Loop Gains Override Function on Cs Contouring Control Mode", in Part I.

2.4.7 Related Parameters

For this subsection, see Subsection 2.4.7, "Related Parameters", in Part I.

2.4.8 Details of Related Parameters

For this subsection, see Subsection 2.4.8, "Details of Related Parameters", in Part I.

The βi series spindle motor, however, enables Cs contouring control in a system where an αi position coder is used as the position sensor. In such a case, control improvements such as smooth low-speed feed can be made by using the position coder feedback interpolation function set with the parameter below.

0*i*	#7	#6	#5	#4	#3	#2	#1	#0
4398								PCCSCM

PCCSCM Sets the position coder feedback interpolation function.

0 : Disables the position coder feedback interpolation function.

1 : Enables the position coder feedback interpolation function.

When an αi position coder is used for spindle position feedback to exercise Cs contouring control, this function improves control performance with position coder feedback pulse interpolation using high-resolution motor side feedback. To use this function, set this parameter to 1.

This function is valid only when the spindle sensor is an αi position coder. When the gear ratio between the spindle and motor is not 1:1, be sure to set an arbitrary gear ratio (No. 4171 through No. 4174) between the spindle and motor.

NOTE

1 This parameter is valid with 9D50 series H (08) edition or later.

2 When Cs contouring control is exercised in a system where an αi position coder is used as the position sensor, the position feedback resolution is 0.088 deg. In this case, the position error may not converge to 0, depending on the specified position. So, a value greater than 88 pulses (0.088 deg) must be set as the effective area (No. 1826).

0*i*	
4171	**Denominator of an arbitrary gear ratio between the motor sensor and spindle (HIGH) CTH1A=0**
4172	**Numerator of an arbitrary gear ratio between the motor sensor and spindle (HIGH) CTH1A=0**
4173	**Denominator of an arbitrary gear ratio between the motor sensor and spindle (LOW) CTH1A=1**
4174	**Numerator of an arbitrary gear ratio between the motor sensor and spindle (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

These parameters set conversion coefficients (numerator, denominator) for using the detection arbitrary gear ratio function (DMR function) by multiplying a motor sensor (αiM sensor) feedback signal by a gear ratio to produce a spindle position feedback signal.

When the spindle rotates Q times while the motor shaft rotates P times (there is no common divisor other than 1 for P and Q), the settings are:

No. 4171 (No. 4173 when CTH1A = 1) = P

No. 4172 (No. 4173 when CTH1A = 1) = Q

When 0 is set in any of these parameters, the setting of 1 is assumed.

NOTE
Note that if an improper value is set in this parameter, the position coder feedback interpolation function does not function normally.

2.4.9 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.4.9, "Diagnosis (Diagnosis Screen)", in Part I.

2.4.10 Alarm

For this subsection, see Subsection 2.4.10, "Alarm", in Part I.

2.5 SPINDLE SYNCHRONOUS CONTROL (OPTIONAL FUNCTION)

2.5.1 Start-up Procedure

For this subsection, see Subsection 2.4.1, "Start-up Procedure", in Part I.

2.5.2 Overview

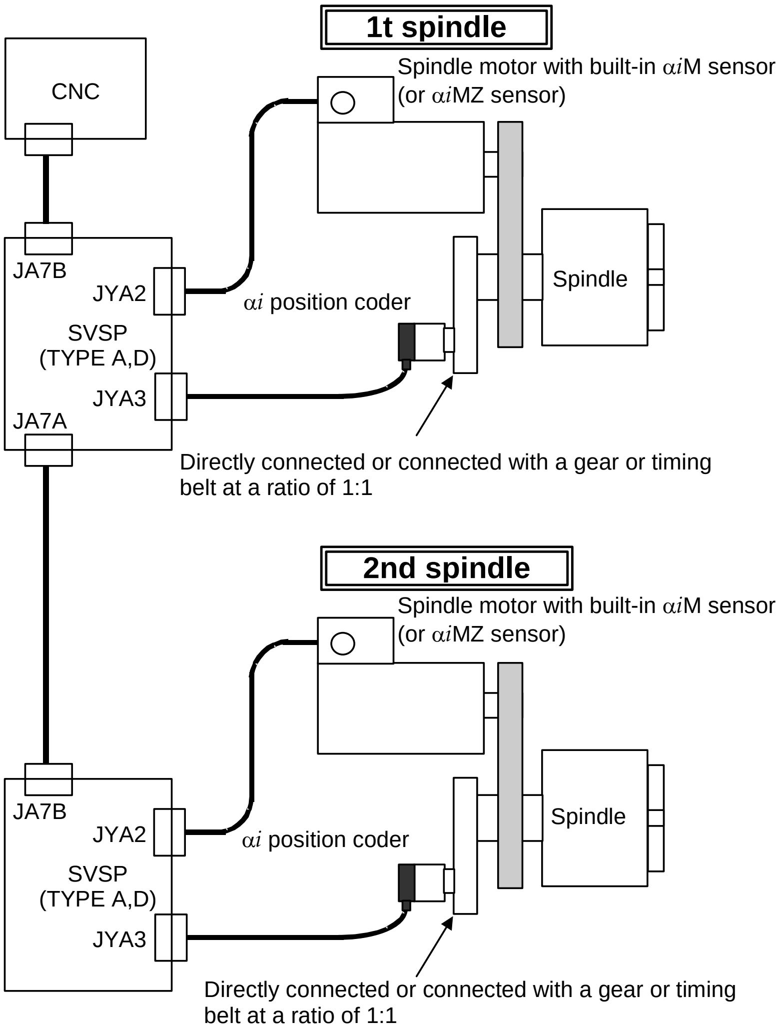
For this subsection, see Subsection 2.5.2, "Overview", in Part I.

2.5.3 System Configuration

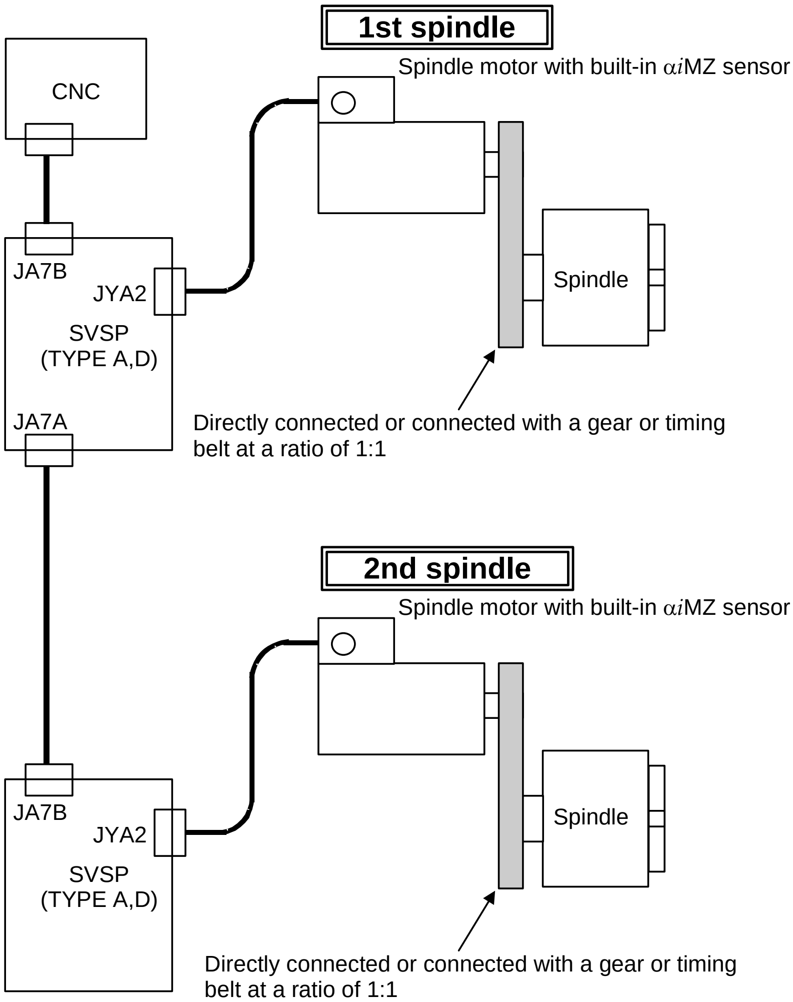
The system configurations that enable the use of the spindle synchronous control function are shown below.

NOTE
Spindle synchronous control between spindles each having a different detector configuration is possible.

(1) When the αi position coder is used

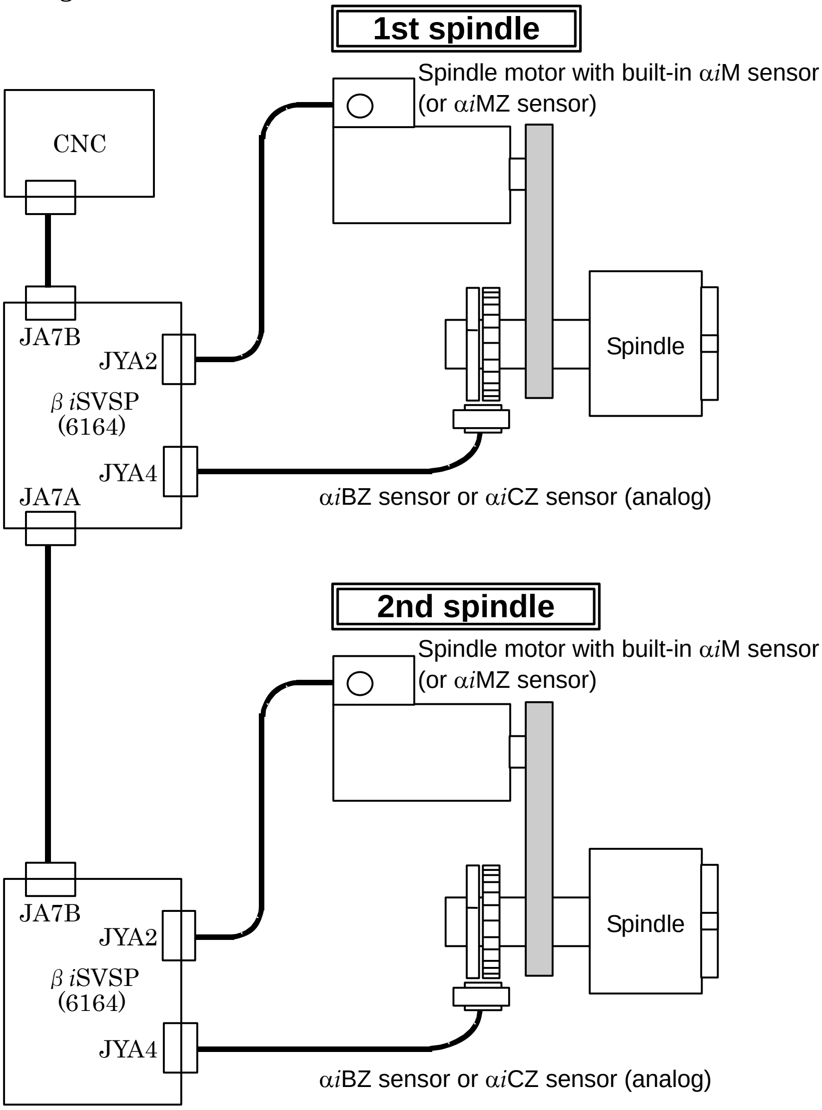


(2) When the spindle motor with built-in αiMZ sensor is used

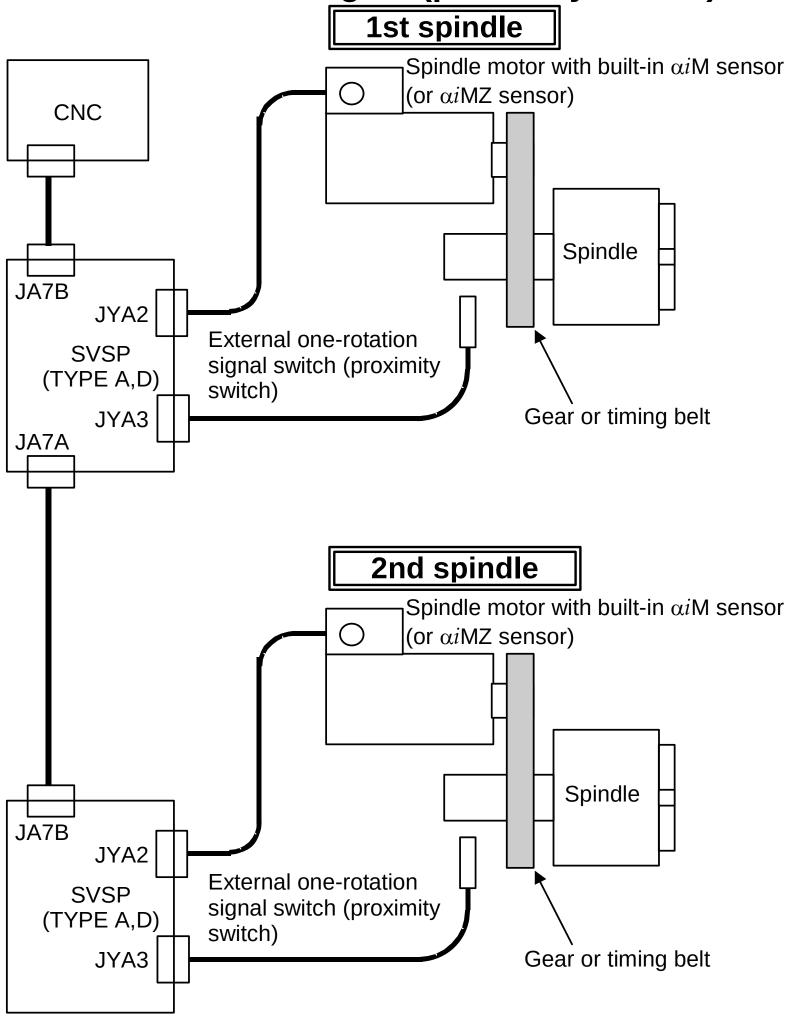


(3) When the separate type αiBZ sensor is used

[Sample system configuration]



(4) When the external one-rotation signal (proximity switch) is used



NOTE

1 When using the external one-rotation signal (proximity switch), use the detection arbitrary gear ratio function (DMR function).

2 When using the detection arbitrary gear ratio function (DMR function), set the following:
- Parameters (No. 4171 to No. 4174) for the numerator/denominator of an arbitrary gear ratio between the motor sensor and spindle

3 Set the type of the external one-rotation signal (proximity switch) (bits 3 and 2 of No. 4004).

4 For stable detection of the one-rotation signal, detect the one-rotation signal by performing spindle orientation before entering spindle synchronous control mode.
For orientation based on the external one-rotation signal, see Section 2.2, “POSITION CODER METHOD ORIENTATION”, in Part I.

2.5.4 Explanation of Operation

For this subsection, see Subsection 2.5.4, “Explanation of Operation”, in Part I.

2.5.5 I/O Signals (CNC↔PMC)

For this subsection, see Subsection 2.5.5, “I/O Signals (CNC↔PMC)”, in Part I.

2.5.6 Examples of Sequences

For this subsection, see Subsection 2.5.6, “Examples of Sequences”, in Part I.

2.5.7 Related Parameters

For this subsection, see Subsection 2.5.7, “Related Parameters”, in Part I.

2.5.8 Details of Related Parameters

For this subsection, see Subsection 2.5.8, “Details of Related Parameters”, in Part I.

2.5.9 Number of Error Pulses in Spindle Synchronous Control

For this subsection, see Subsection 2.5.9, “Number of Error Pulses in Spindle Synchronous Control”, in Part I.

2.5.10 Specifying a Shift Amount for Spindle Phase Synchronous Control

For this subsection, see Subsection 2.5.10, “Specifying a Shift Amount for Spindle Phase Synchronous Control”, in Part I.

2.5.11 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.5.11, “Diagnosis (Diagnosis Screen)”, in Part I.

2.5.12 Alarm

For this subsection, see Subsection 2.5.12, “Alarm”, in Part I.

2.6 SPECIFICATIONS COMMON TO ALL OPERATION MODES

2.6.1 Overview

For this subsection, see Subsection 2.6.1, “Overview”, in Part I.

2.6.2 List of I/O Signals (CNC↔PMC)

For this subsection, see Subsection 2.6.2, “List of I/O Signals (CNC↔PMC)”, in Part I.

2.6.3 Parameters

For this subsection, see Subsection 2.6.3, “Parameters”, in Part I.

2.6.4 Details of parameters

For this subsection, see Subsection 2.6.4, “Details of parameters”, in Part I.

Note that, however, the standard setting value of the following parameter differs among the βi series spindle motors:

0*i*	
4090	**Overload detection level**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 95

This parameter sets the condition for detecting a short-time overload alarm (spindle alarm 29).
If a load more than the set percentage (maximum motor output [load meter full scale] = 100%) is applied to the spindle motor for a predetermined time period (set by parameter No. 4123), a short-time overload alarm (spindle alarm 29) is issued.

2.6.5 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.6.5, “Diagnosis (Diagnosis Screen)”, in Part I.

3 I/O SIGNALS (CNC↔PMC)

This chapter explains the functions of the signals directly input from the PMC to SVSP via the CNC and the signals directly output from the SVSP to PMC. For other spindle-related I/O signals, refer to the manual of the relevant CNC.

3.1 INPUT SIGNALS (PMC→CNC→SVSP)

This section explains the functions of the signals directly input from the PMC to SVSP via the CNC. For other spindle-related input signals, refer to the manual of the relevant CNC.

3.1.1 List of Input Signals

	0*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G070	MRDYA	ORCMA	SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA
2nd-	G074	MRDYB	ORCMB	SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB
1st-	G071			INTGA	SOCNA			*ESPA	ARSTA
2nd-	G075			INTGB	SOCNB			*ESPB	ARSTB
1st-	G072			INCMDA	OVRA		NRROA	ROTAA	INDXA
2nd-	G076			INCMDB	OVRB		NRROB	ROTAB	INDXB
1st-	G073				DSCNA		MPOFA		
2nd-	G077				DSCNB		MPOFB		

3.1.2 Explanation of Input Signals

For information about the signals listed in Subsection 3.1.1, “List of Input Signals”, in Part II, see Subsection 3.1.2, “Explanation of Input Signals”, in Part I.
Those signals that are not listed in Subsection 3.1.1, “List of Input Signals”, in Part II are not used with the β*i* SVSP series spindle.

3.1.3 Details of input signals

For information about the signals listed in Subsection 3.1.1, “List of Input Signals”, in Part II, see Subsection 3.1.3, “Details of input signals”, in Part I.
Those signals that are not listed in Subsection 3.1.1, “List of Input Signals”, in Part III are not used with the β*i* SVSP series spindle.

3.2 OUTPUT SIGNALS (SVSP→CNC→PMC)

This section explains the functions of the signals directly output from the SVSP to PMC via the CNC. For other spindle-related output signals, refer to the manual of the relevant CNC.

3.2.1 List of Output Signals

	0*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F045	ORARA	TLMA	LDT2A	LDT1A	SARA	SDTA	SSTA	ALMA
2nd-	F049	ORARB	TLMB	LDT2B	LDT1B	SARB	SDTB	SSTB	ALMB
1st-	F047				EXOFA			INCSTA	PC1DTA
2nd-	F051				EXOFB			INCSTB	PC1DTB

3.2.2 Explanation of Output Signals

For information about the signals listed in Subsection 3.2.1, "List of Output Signals", in Part II, see Subsection 3.2.2, "Explanation of Output Signals", in Part I.
Those signals that are not listed in Subsection 3.2.1, "List of Output Signals", in Part II are not used with the β*i* SVSP series spindle.

3.2.3 Details of Output Signals

For information about the signals listed in Subsection 3.2.1, "List of Output Signals", in Part II, see Subsection 3.2.3, "Details of Output Signals", in Part I.
Those signals that are not listed in Subsection 3.2.1, "List of Output Signals", in Part II are not used with the β*i* SVSP series spindle.

4 ADJUSTMENT

4.1 VELOCITY LOOP GAIN ADJUSTMENT

4.1.1 Overview

For this subsection, see Subsection 4.1.1, “Overview”, in Part I.

4.1.2 Parameters

For this subsection, see Subsection 4.1.2, “Parameters”, in Part I.

4.1.3 Adjustment Procedure

For this subsection, see Subsection 4.1.3, “Adjustment Procedure”, in Part I.

4.1.4 Additional Information (Position Gain Adjustment)

For this subsection, see Subsection 4.1.4, “Additional Information (Position Gain Adjustment)”, in Part I.

5 FUNCTION DESCRIPTIONS

5.1 INCRMENTAL COMMAND TYPE SPINDLE ORIENTATION (SPINDLE ROTATION SPEED CONTROL) (OPTIONAL FUNCTION)

5.1.1 Overview

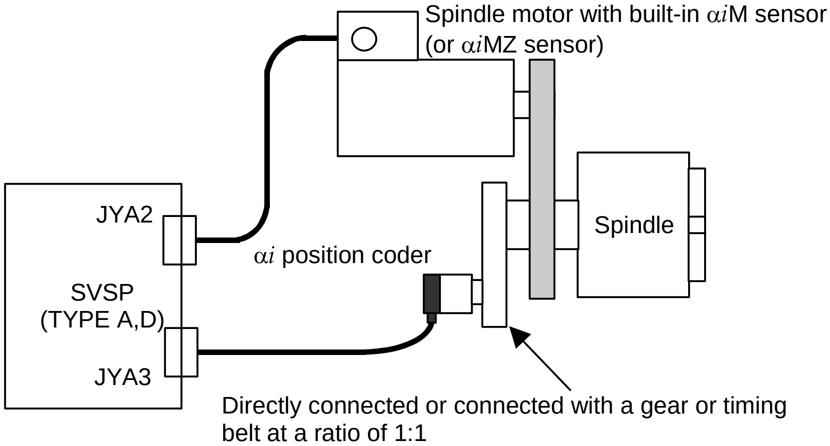
For this subsection, see Subsection 5.3.1, “Overview”, in Part I.

5.1.2 System Configuration

The incremental command type spindle orientation function can be used in the following system configuration.

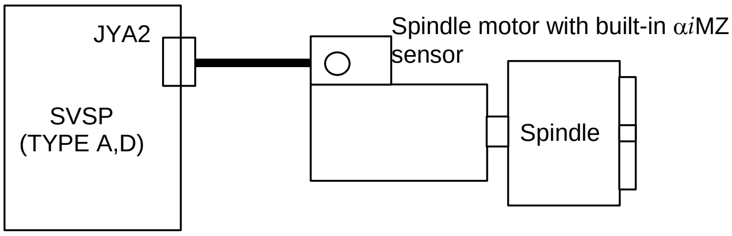
(1) When the αi position coder is used

[Sample system configuration]

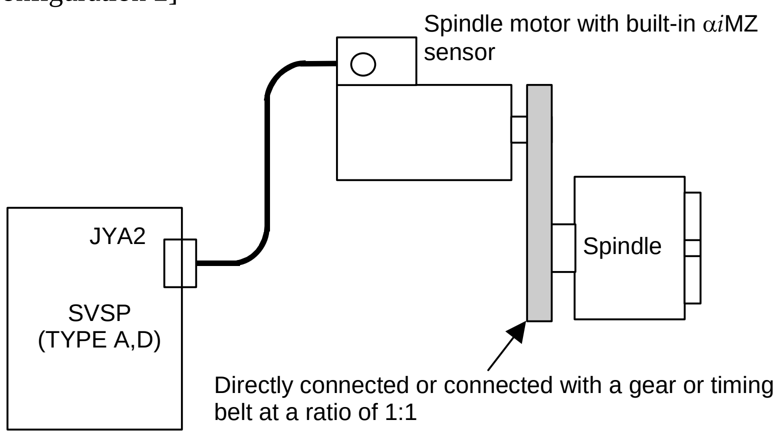


(2) When the spindle motor with built-in αiMZ sensor is used

[Sample system configuration 1]

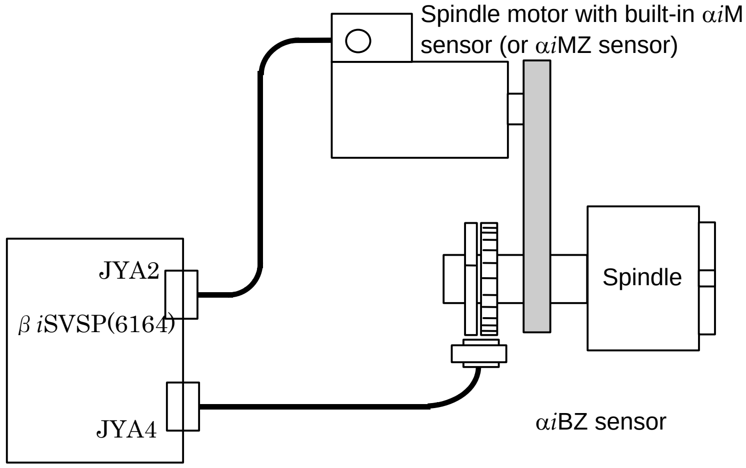


[Sample system configuration 2]



(3) When the separate type αiBZ sensor is used

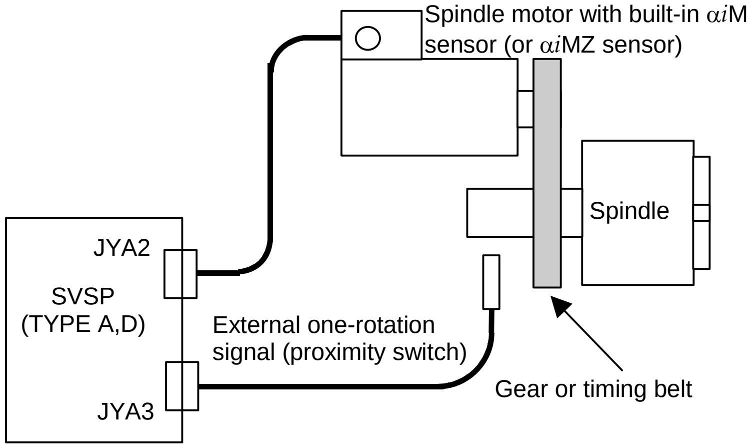
[Sample system configuration]



Parameter	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,2,1,0	0,0,1,1	Uses the αiBZ sensor as the spindle sensor.
4003 #7,6,5,4	Depends on the detector.	Sets the number of spindle sensor gear teeth.
4010 #2,1,0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056~4059	Depends on the configuration.	Gear ratio between the spindle and motor

(4) When the external one-rotation signal (proximity switch) is used

[Sample system configuration]



NOTE

1. To detect the one-rotation signal securely, fix the direction (bits 3 and 2 of parameter No. 4003) in which the spindle rotates during spindle orientation to one direction.
2. Specify the type (bits 3 and 2 of parameter No. 4004) of an external one-rotation signal (proximity switch).
3. To detect the one-rotation signal securely, set the spindle orientation speed (parameter No. 4038) to a value between 50 and 100 min^{-1} according to the specification of the external one-rotation signal (proximity switch).
4. A sequence for detecting the one-rotation signal is started after the orientation speed has been reached.
5. Specify the denominator/numerator parameters (Nos. 4171 to 4174) of an arbitrary gear ratio between the motor sensor and spindle.

5.1.3 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

	0*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G070		ORCMA			CTH1A	CTH2A		
2nd-	G074		ORCMB			CTH1B	CTH2B		
1st-	G072			INCMDA			NRROA	ROTAA	INDXA
2nd-	G076			INCMDB			NRROB	ROTAB	INDXB
1st-	G078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
2nd-	G080	SHB07	SHB06	SHB05	SHB04	SHB03	SHB02	SHB01	SHB00
1st-	G079					SHA11	SHA10	SHA09	SHA08
2nd-	G081					SHB11	SHB10	SHB09	SHB08

(2) Details of input signals (PMC→CNC)

For this subsection, see Item 5.3.4 (2), "Details of input signals (PMC→CNC)", in Part I.

(3) Address list of output signals (CNC→PMC)

	0*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F045	ORARA							
2nd-	F049	ORARB							

	0*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F047							INCSTA	
2nd-	F051							INCSTB	

(4) Details of output signals (CNC→PMC)

For this subsection, see Item 5.3.4 (4), "Details of output signals (CNC→PMC)", in Part I.

5.1.4 Examples of Sequences

For this subsection, see Subsection 5.3.5, "Examples of Sequences", in Part I.

5.1.5 List of Related Parameters

Parameter No. 0*i*	Description
4015 #0	Whether the spindle orientation function is available (to be set to "1") (The CNC software option is required.)
3702#3,#2	Whether the stop position external setting-type spindle orientation function is available (to be set to "1") (Bit 2: 1st spindle. Bit 3: 2nd spindle)
4328	Command multiplier for incremental command external setting data

NOTE

This subsection describes only the parameters specific to incremental command type spindle orientation. See Section 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION" in Part I, for parameters related to other types of spindle orientation.

5.1.6 Details of Related Parameters

For this subsection, see Subsection 5.3.7, "Details of Related Parameters", in Part I.

5.2 CONVENTIONAL METHOD ORIENTATION (OPTIONAL FUNCTION)

5.2.1 Overview

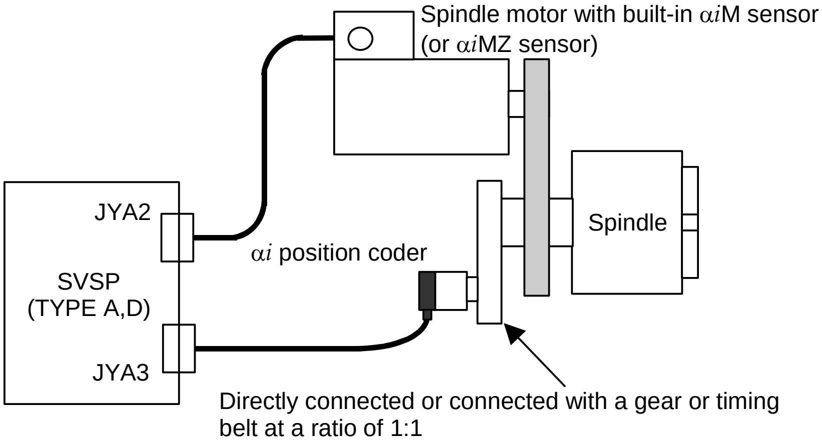
For this subsection, see Subsection 5.4.1, "Overview", in Part I.

5.2.2 System Configuration

Explained below is a system configuration in which the conventional method spindle orientation function is usable.

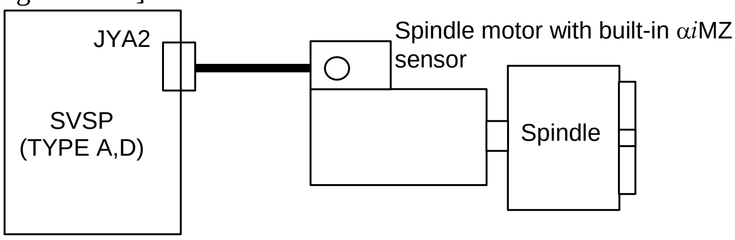
(1) When the αi position coder is used

[Sample system configuration]

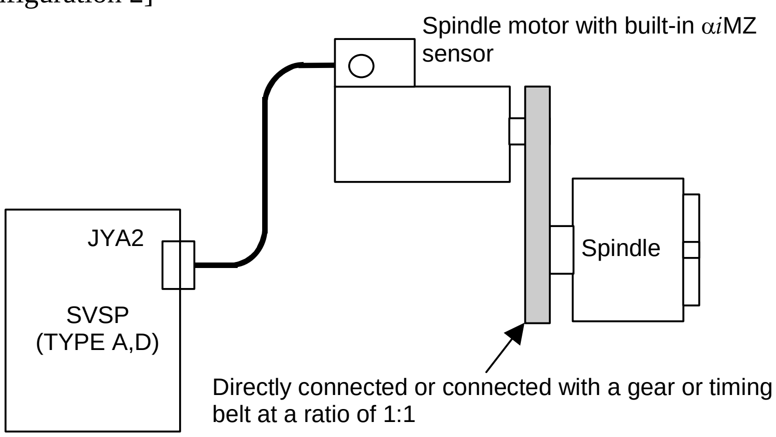


(2) When the spindle motor with built-in αiMZ sensor is used

[Sample system configuration 1]

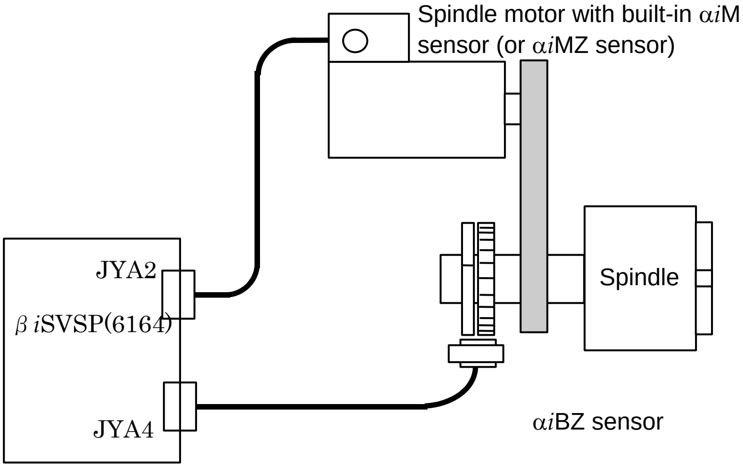


[Sample system configuration 2]



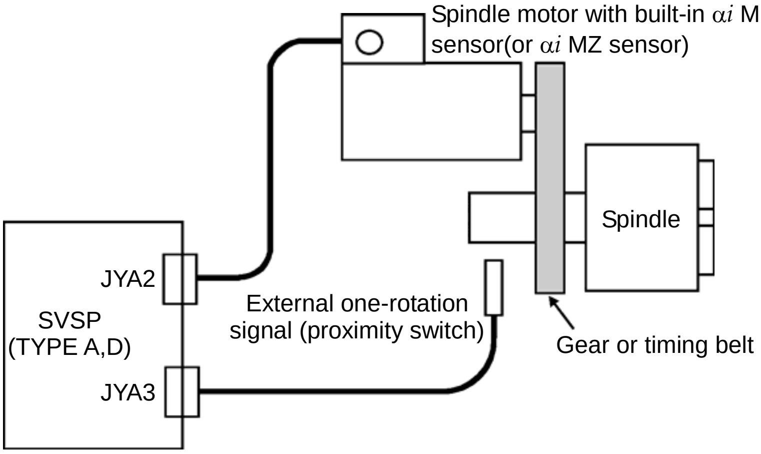
(3) When the separate type αiBZ sensor is used

[Sample system configuration]



Parameter	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,2,1,0	0,0,1,1	Uses the αiBZ sensor as the spindle sensor.
4003 #7,6,5,4	Depends on the detector.	Sets the number of spindle sensor gear teeth.
4010 #2,1,0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056~4059	Depends on the configuration.	Gear ratio between the spindle and motor

(4) When the external one-rotation signal (proximity switch) is used



NOTE

1. To detect the one-rotation signal securely, fix the direction in which the spindle rotates during spindle orientation (bits 3 and 2 of parameter No. 4003) to one direction.
2. Specify the type of external one-rotation signal (proximity switch) (bits 3 and 2 of parameter No. 4004).
3. To detect the one-rotation signal securely, set the spindle orientation speed (parameter No. 4038) to a value between 50 and 100 min^{-1} according to the specification of the external one-rotation signal (proximity switch) you use.
4. A sequence for detecting the one-rotation signal is started after the orientation speed has been reached.
5. Specify the denominator/numerator parameters of an arbitrary gear ratio between the motor sensor and spindle (Nos. 4171 to 4174).

5.2.3 I/O Signals (CNC↔PMC)

For this subsection, see Section 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION", and Section 5.3, "INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION" , in Part I.

5.2.4 Sequence

For this subsection, see Subsection 5.4.5, "Sequence", in Part I.

5.2.5 List of Related Parameters

For this subsection, see Subsection 5.4.6, "List of Related Parameters", in Part I.

5.2.6 Details of Related Parameters

For this subsection, see Subsection 5.4.7, "Details of Related Parameters", in Part I.

5.2.7 Adjusting the Orientation Stop Position Shift Parameter

For this subsection, see Subsection 5.4.8, "Adjusting the Orientation Stop Position Shift Parameter", in Part I.

5.2.8 Calculating the Position Gain for Orientation

For this subsection, see Subsection 5.4.9, "Calculating the Position Gain for Orientation", in Part I.

5.2.9 Calculating the Orientation Time

For this subsection, see Subsection 5.4.10, "Calculating the Orientation Time", in Part I.

5.3 SPINDLE FINE ACC./DEC. (FAD) FUNCTION

5.3.1 Overview

The spindle fine Acc./Dec. (FAD) function realizes smooth acceleration/deceleration during rigid tapping and Cs contouring control by performing acceleration/deceleration processing with spindle software. It can reduce mechanical shocks that may accompany acceleration/deceleration.

NOTE
This function is usable in a combination of the β*i* SVSP and the FANUC Series 0*i* / 0*i* Mate-MODEL B or FANUC Series 0*i* / 0*i* Mate-MODEL C CNC.

5.3.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Remark
9D50	E(05) edition or later	

CNC software

Series	Edition	Remark
D4A1	A(01) edition or later	For the FANUC Series 0*i*-MB
D501	A(01) edition or later	For the FANUC Series 0*i* Mate-MB
D6A1	A(01) edition or later	For the FANUC Series 0*i*-TB
D701	A(01) edition or later	For the FANUC Series 0*i* Mate-TB
D4B1	A(01) edition or later	For the FANUC Series 0*i*-MC
D511	A(01) edition or later	For the FANUC Series 0*i* Mate-MC
D6B1	A(01) edition or later	For the FANUC Series 0*i*-TC
D711	A(01) edition or later	For the FANUC Series 0*i* Mate-TC

5.3.3 Block Diagram

For this subsection, see Subsection 5.6.3, “Block Diagram”, in Part I.

5.3.4 Parameters

(1) List of Related Parameters

Parameter No.	Description
0*i*	
5205 #7	Setting of fine Acc./Dec. during rigid tapping
4394#3	Spindle fine Acc./Dec. function bit
4394#4	Acceleration/deceleration type during spindle fine Acc./Dec.
4344	Feed-forward coefficient during fine Acc./Dec.
4037	Velocity loop feed-forward coefficient during fine Acc./Dec.
4408	Fine Acc./Dec. time constant

(2) Details of parameters related to rigid tapping

For this subsection, see Item 5.6.4 (2), “Details of parameters related to rigid tapping”, in Part I.

(3) Details of parameters related to serial spindles

For this subsection, see Item 5.6.4 (3), “Details of parameters related to serial spindles”, in Part I.

5.3.5 Diagnosis (Diagnosis Screen)

Address 0*i*	Description
418	1st-spindle (regular) position error
420	2nd-spindle (regular) position error
714	1st-spindle (FAD) position error
715	2nd-spindle (FAD) position error

5.3.6 Status Errors

For this subsection, see Subsection 5.6.6, “Status Errors”, in Part I.

5.3.7 Cautions

For this subsection, see Subsection 5.6.7, “Cautions”, in Part I.

5.4 UNEXPECTED DISTURBANCE TORQUE DETECTION FUNCTION (OPTIONAL FUNCTION)

5.4.1 Overview

For this subsection, see Subsection 5.7.1, “Overview”, in Part I.

5.4.2 Series and Editions of Applicable Spindle Software

For this subsection, see Subsection 5.7.2, “Series and Editions of Applicable Spindle Software”, in Part I.

5.4.3 I/O Signals (CNC↔PMC)

(1) Address list of output signals (CNC→PMC)

0*i*	#7	#6	#5	#4	#3	#2	#1	#0
F090						ABTSP2	ABTSP1	

(2) Details of output signals (CNC→PMC)

(a) First-spindle unexpected disturbance torque detection signals (ABTSP1 and AQSP1)

(b) Second-spindle unexpected disturbance torque detection signals (ABTSP2 and AQSP2)

These signals are output when the estimated load torques on the respective spindles become higher than or equal to the set level.
Refer to an applicable CNC Manual for details.

5.4.4 List of Related Parameters

Parameter No. 0i	Description
4015 #1	Whether the unexpected disturbance torque detection function is available (The CNC software option is required.)
4248	Torque constant for spindle load torque monitoring
4249	Observer gain 1 for spindle load torque monitoring
4250	Observer gain 2 for spindle load torque monitoring
4341	Unexpected disturbance torque detection level

5.4.5 Details of Related Parameters

For this subsection, see Subsection 5.7.5, "Details of Related Parameters", in Part I.

5.4.6 Parameter Tuning Procedure

For this subsection, see Subsection 5.7.6, "Parameter Tuning Procedure", in Part I.

5.5 HIGH-SPEED SPINDLE ORIENTATION (OPTIONAL FUNCTION)

5.5.1 Overview

For this subsection, see Subsection 5.14.1, "Overview", in Part I.

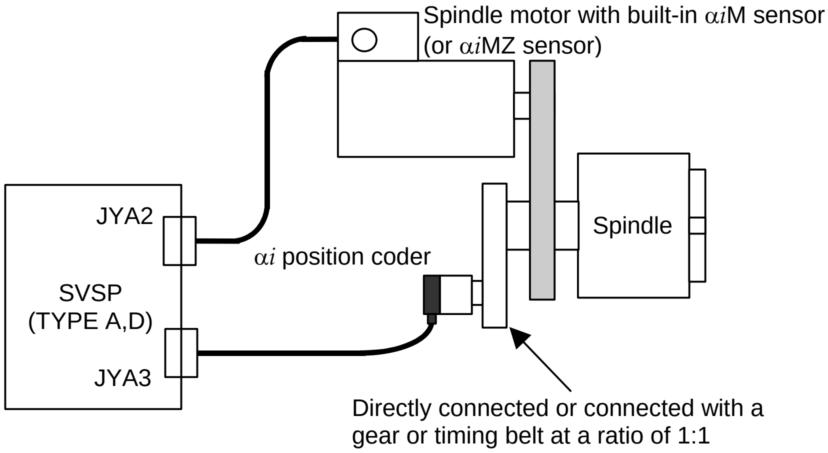
5.5.2 System Configuration

The high-speed spindle orientation function can be used in the following system configuration.

> **NOTE**
> This function cannot be used in an orientation system based on an external one-rotation signal in which a proximity switch is used.

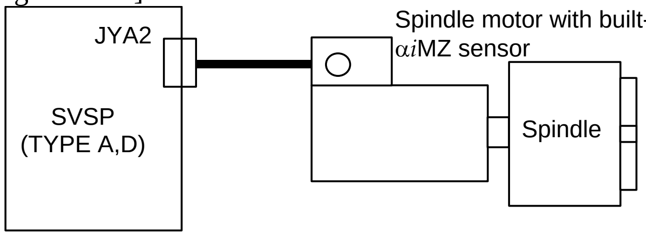
(1) When the αi position coder is used

[Sample system configuration]

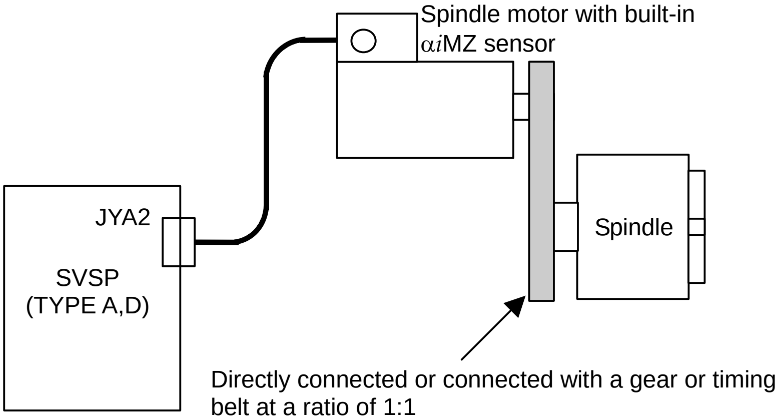


(2) When the αiMZ sensor is used

[Sample system configuration 1]

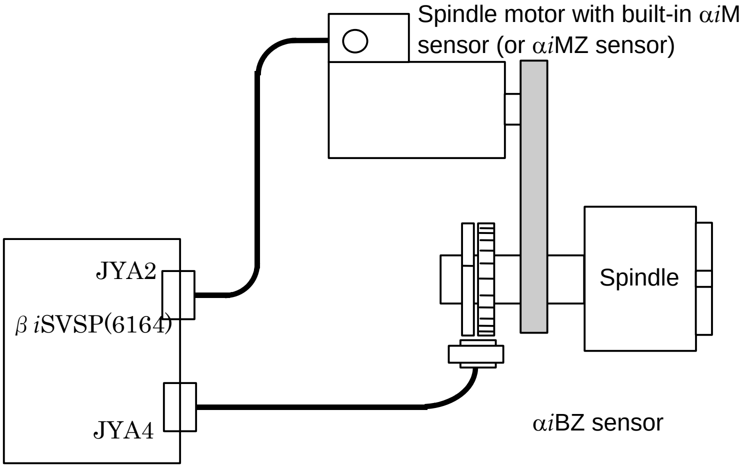


[Sample system configuration 2]



(3) When the separate type αiBZ sensor is used

[Sample system configuration]



Parameter	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,2,1,0	0,0,1,1	Uses the αiBZ sensor as the spindle sensor.
4003 #7,6,5,4	Depends on the detector.	Sets the number of spindle sensor gear teeth.
4010 #2,1,0	Depends on the detector.	Sets the type of motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056~4059	Depends on the configuration.	Gear ratio between the spindle and motor

5.5.3 I/O Signals (CNC↔PMC)

For this subsection, see Section 2.2, “POSITION CODER METHOD SPINDLE ORIENTATION”, and Section 5.3, “INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION”, in Part I.

5.5.4 Sequence

For this subsection, see Subsection 5.14.5, “Sequence”, in Part I.

5.5.5 List of Related Parameters

For this subsection, see Subsection 5.14.6, “List of Related Parameters”, in Part I.

5.5.6 Details of Related Parameters

For this subsection, see Subsection 5.14.7, “Details of Related Parameters”, in Part I.

5.5.7 Spindle Data Used in Tuning

For this subsection, see Subsection 5.14.8, “Spindle Data Used in Tuning”, in Part I.

5.5.8 Tuning Procedure

For this subsection, see Subsection 5.14.9, “Tuning Procedure”, in Part I.

III. FANUC AC SPINDLE MOTOR αC*i* series

1 START-UP

1.1 START-UP PROCEDURE

A. Check the spindle-related specifications.
- CNC model
- Spindle motor
- Common power supply (PS)
- Spindle amplifier
- Detector system

↓

B. Check all connections. (See DESCRIPTIONS)

↓

C. Prepare and check the PMC ladder program.

↓

D. Check the CNC parameter setting for using the αC*i* series (Serial) spindle. (See Subsection 1.2.1.)

↓

E. Perform automatic αC*i* series (Serial) spindle parameter initialization. (See Subsection 1.2.2.)
- Set a motor model code and the parameter enabling use of the automatic parameter initialization function, then turn the CNC off and then on again.

↓

F. Change parameter data (when no model code is used).
- When using a motor with no model code assigned, perform automatic setting with model code "240", then modify the parameter data according to the motor-specific parameter list.

↓

G. Set the parameters related to the detectors. (See Section 1.3.)

1.2 SPINDLE SERIAL INTERFACE (OPTIONAL FUNCTION)

1.2.1 Parameters Related to Spindle Serial Output

For this subsection, see Subsection 1.2.1, “Parameters Related to Spindle Serial Output”, in Part I.

1.2.2 Automatic Spindle Parameter Initialization

(1) Parameter list

Parameter No.			Description
15*i*	**16*i***	**30*i***	
5607#0	4019#7	4019#7	Function for automatically initializing spindle parameters
3133	4133	4133	Spindle motor model code

(2) Procedure for automatic spindle parameter initialization

Perform automatic spindle parameter initialization by following the procedure below.

<1> Set the model code for the desired motor for automatic parameter initialization.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3133	4133	4133	Model code

> **NOTE**
> When using a spindle motor that has no model code, set model code "240" for automatic parameter setting, then manually input data according to the model-by-model parameter list.

<2> Set the relevant parameter to 1 to enable automatic spindle parameter initialization.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
—	4019#7	4019#7	1
5607#0	—	—	0

> **NOTE**
> This bit is reset to its original value after automatic parameter initialization.

<3> Turn the CNC off, then on again. Then, the spindle parameters specified with a model code are automatically initialized.

1.2.3 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 1.2.3, "Diagnosis (Diagnosis Screen)", in Part I.

1.2.4 Alarm

For this subsection, see Subsection 1.2.4, "Alarm", in Part I.

1.3 PARAMETERS RELATED TO DETECTORS

> **NOTE**
> 1 Note that the specifications of parameters related to detectors for the αC*i* series spindle amplifiers differ from those of parameters for the αC series spindle amplifiers.
> 2 The spindle sensor (separate detector) usable with the αC*i* series spindle amplifier is a position coder only. (The spindle sensor is a detector connected to connector JYA3.)

1.3.1 List of Parameters for Detectors

Parameter No.			Description
15*i*	**16*i***	**30*i***	
—	3706#1,#0	—	Gear ratio of spindle to position coder (×1, ×2, ×4, ×8)
5842	—	3720	Number of pulses of the position coder
3000 #0	4000 #0	4000 #0	Direction of spindle and spindle motor rotation

Parameter No. 15*i*	16*i*	30*i*	Description
3001 #4	4001 #4	4001 #4	Spindle sensor (position coder) mounting direction
3002 #3,#2,#1,#0	4002 #3,#2,#1,#0	4002 #3,#2,#1,#0	Spindle sensor type setting (whether to use a position coder)
3003 #7,#6,#5,#4	4003 #7,#6,#5,#4	4003 #7,#6,#5,#4	Setting of the number of spindle sensor (position coder) gear teeth (Set to 0,0,0,0.)
3005 #0	4005 #0	4005 #0	Setting of the velocity feedback method
3006#1	4006#1	4006#1	Gear ratio increment system
3007 #5	4007 #5	4007 #5	Whether to detect disconnection of feedback signals
3007 #6	4007 #6	4007 #6	Whether to detect alarms related to position feedback signals
3016 #6	4016 #6	4016 #6	Whether to detect alarms related to threading feedback
3016 #7	4016 #7	4016 #7	Setting of the function of detecting the one-rotation signal again each time position control mode is set.
3056 to 3059	4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data (This data is selected by spindle control input signals CTH1A and CTH2A.)
3098	4098	4098	Maximum speed for position feedback signal detection

1.3.2 Details of Parameters for Detectors

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3000	4000	4000								ROTA1

ROTA1 Indicates the relationship between the rotation directions of spindle and spindle motor.
0 : Rotates the spindle and spindle motor in the same direction.
1 : Rotates the spindle and spindle motor in the reverse direction.

> **NOTE**
> When using a position coder, be sure to set this parameter. If this parameter is not set correctly, the velocity error excess alarm (spindle alarm 02), motor binding alarm (spindle alarm 31), or gear ratio parameter setting error alarm (spindle alarm 35) may be detected.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3001	4001	4001				SSDIRC				

SSDIRC Indicates the mounting direction of spindle sensor (position coder).
0 : Rotates the spindle and spindle sensor (position coder) in the same direction.
1 : Rotates the spindle and spindle sensor (position coder) in the reverse direction.

> **NOTE**
> When using a position coder, be sure to set this parameter. If this parameter is not set correctly, the velocity error excess alarm (spindle alarm 02), motor binding alarm (spindle alarm 31), or gear ratio parameter setting error alarm (spindle alarm 35) may be detected.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3002	4002	4002					SSTYP3	SSTYP2	SSTYP1	SSTYP0

SSTYP3 to 0 Spindle sensor type

This parameter sets the type of a separate detector to be attached to the spindle (detector to be connected to connector JYA3).
The separate detector usable with the αC*i* series spindle is a position coder only.

SSTYP3	SSTYP2	SSTYP1	SSTYP0	Spindle sensor type
0	0	0	0	None (No position control function is used.)
0	0	1	0	αi position coder

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3003	4003	4003	PCPL2	PCPL1	PCPL0	PCTYPE				

PCPL2, PCPL1, PCPL0, PCTYPE

Gear teeth number setting of the spindle sensor (position coder)
Set to 0,0,0,0.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3005	4005	4005								VCTLPC

VCTLPC Sets the velocity feedback method.

0 : Exercises velocity control with an estimated velocity only.
1 : Uses a velocity calculated from the position coder signal to exercise velocity control.

The feedback signal from a position coder attached to a spindle on a 1:1 basis is converted to motor speed data for velocity control. Set this bit to 1 when performing orientation, rigid tapping, or spindle synchronous control.
By setting this bit to 1 even in ordinary velocity control, the response characteristics and stability of velocity control can be improved.

NOTE

1 The feature may not be fully utilized, depending on the connection ratio between the spindle and spindle motor or between the spindle and position coder, the rigidity of the connection, the precision of position coder attachment, and so forth.

2 When this bit is set to 1 with a spindle that has a gear switch mechanism, the torque limitation command signal (TLMLA) must be input at the start of gear switching. For details, see Chapter 3, “I/O SIGNALS (CNC↔PMC)”, in Part III.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3006	4006	4006							GRUNIT	

GRUNIT Sets a gear ratio setting resolution:

0 : 1/100 unit
1 : 1/1000 unit

Select a gear ratio data setting resolution from the following:
(a) Resolution based on motor speed increased by a factor of 100 relative to one spindle rotation
(b) Resolution based on motor speed increased by a factor of 1000 relative to one spindle rotation
Depending on the setting of this parameter, the increment system of the parameters indicated in the table below changes.

Parameter No.			Description
15*i*	16*i*	30*i*	
3056~3059	4056~4059	4056~4059	Spindle-to-motor gear ratio data

> **NOTE**
> Usually, use the 1/100 unit (setting "0").

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3007	4007	4007		PCALCH	PCLS					

PCLS Determines feedback signal disconnection detection.
0 : Performs disconnection detection.
1 : Does not perform disconnection detection.
When this bit is set to "0", spindle alarm 27 (Position coder signal disconnection) are checked.

> **NOTE**
> Usually, set "0".

PCALCH Determines whether to use alarms related to position feedback signals.
0 : Detects alarms.
1 : Does not detect alarms.
When this bit is set to "0", spindle alarms 41, 42, and 47 are checked.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3016	4016	4016	RFCHK3	RFCHK2						

RFCHK2 Determines whether to detect the alarm related to threading position detection signal feedback (spindle alarm 46).
0 : Does not detect alarms.
1 : Detects alarms.

RFCHK3 Setting of the function of detecting the one-rotation signal again each time position control mode is set.
0 : The one-rotation signal is not detected each time the operating mode changes.
Once the one-rotation signal has been detected, it is not detected again until the power goes off.
1 : The one-rotation signal is detected each time the operating mode changes.

15*i*	16*i*	30*i*		
3056	4056	4056	Gear ratio (HIGH)	CTH1A=0, CTH2A=0
3057	4057	4057	Gear ratio (MEDIUM HIGH)	CTH1A=0, CTH2A=1
3058	4058	4058	Gear ratio (MEDIUM LOW)	CTH1A=1, CTH2A=0
3059	4059	4059	Gear ratio (LOW)	CTH1A=1, CTH2A=1

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100
These parameters set the gear ratio of the spindle motor relative to the spindle.
When the motor rotates 2.5 times, for every rotation of the spindle, for example, set 250 in the parameter.
A parameter is selected by the CTH1A and CTH2A input signals.

The gear or clutch status must correspond to the status of the CTH1A and CTH2A input signals.

> **NOTE**
> 1 When using a position coder, be sure to set these parameters. If these parameters are not set correctly, the velocity error excess alarm (spindle alarm 02), motor binding alarm (spindle alarm 31), or gear ratio parameter setting error alarm (spindle alarm 35) may be detected.
> 2 When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*	
3098	4098	4098	**Maximum speed for position feedback signal detection**

Unit of data : 1min^{-1}
Valid data range : 0 to 32767
Standard setting : 0

This parameter sets a maximum spindle speed that enables the detection of a motor/spindle sensor (position coder) feedback signal.
When “0” is set in this parameter, up to the maximum motor speed can be detected.

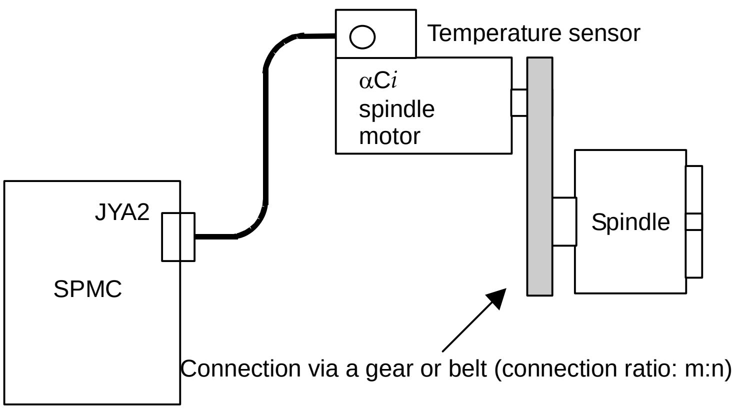
> **NOTE**
> Usually, set “0”.

1.3.3 Typical Detector Configurations

This subsection describes typical detector configurations and the parameter setting procedures for the detector configurations.
With the αC*i* series spindle, the detector circuitry hardware is set according to the parameter setting. For this reason, an alarm such as a disconnection alarm may be output while parameters related to detectors are being set.
To initialize the hardware, after setting the parameters related to detectors, turn the power to the amplifier off once.

(1) When position control is not exercised

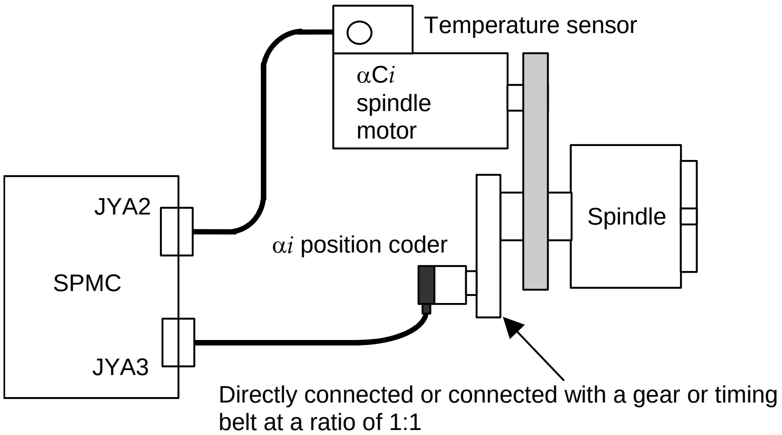
[Sample system configuration]



Parameter No.	Settings	Description
4002 #3,#2,#1,#0	0,0,0,0	Does not exercise position control. (without position coder)
4005#0	0	Exercises velocity control with an estimated velocity only.
4056 to 4059	Depends on the configuration	Gear ratio between the spindle and motor

(2) When the α*i* position coder is used

[Sample system configuration]



Parameter No.	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,#2,#1,#0	0,0,1,0	Uses the α*i* position coder as the spindle sensor.
4003 #7,#6,#5,#4	0,0,0,0	Sets the number of spindle sensor gear teeth.
4005#0	1	Uses the speed calculated from the position coder signal to perform speed control.
4056 to 4059	Depends on the configuration.	Gear ratio between the spindle and motor

2 EXPLANATION OF OPERATION MODES

2.1 VELOCITY CONTROL MODE

2.1.1 Start-up Procedure

A. Check that the serial spindle starts up normally and is ready for operation.

↓

B. Prepare and check the PMC ladder.

↓

C. Set the detector-related parameters according to the system configuration.

↓

D. Set the parameters related to spindle speed specification.

↓

E. Check that the spindle rotates at the desired speed.

↓

F. Execute an acceleration/deceleration function and adjust the acceleration/deceleration constant.
- No.4069 to 4072 : Acceleration/deceleration constant

↓

G. Make a velocity loop gain adjustment as required.
- No.4040, 4041 : Velocity proportional gain
- No.4048, 4049 : Velocity integral gain

2.1.2 Overview

The velocity control mode is a function for exercising velocity control to rotate the spindle motor according to a velocity command from the CNC.

NOTE

On a CNC screen (such as the spindle monitor screen and the adjustment screen), the velocity control mode is indicated as “NORMAL OPERATION MODE”.

2.1.3 System Configuration

The velocity control mode is applicable to all detector configurations. For system configurations, see Subsection 1.3.3, “Typical Detector Configurations”, in Part III.

2.1.4 List of I/O Signals (CNC↔PMC)

This subsection provides a list of the I/O signals related to the velocity control mode only. For details of each signal, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, “SPINDLE SPEED CONTROL.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63833EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”

For details of the I/O signals common to the CNCs, see Chapter 3, “I/O SIGNALS (CNC↔PMC)”, in Part I.

(1) Input signals(PMC→CNC)

(a) Series 16*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(b) Series 30*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G005							FIN	
1st-	G024	RI7A	RI6A	RI5A	RI4A	RI3A	RI2A	RI1A	RI0A
2nd-	G232	RI7B	RI6B	RI5B	RI4B	RI3B	RI2B	RI1B	RI0B
1st-	G025	RISGNA			RI12A	RI11A	RI10A	RI9A	RI8A
2nd-	G233	RISGNB			RI12B	RI11B	RI10B	RI9B	RI8B
1st-	G026		GS4A	GS2A	GS1A				
2nd-	G272		GS4B	GS2B	GS1B				

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA		SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA
2nd-	G235	G074	G074	MRDYB		SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB
1st-	G226	G071	G071							*ESPA	
2nd-	G234	G075	G075							*ESPB	
1st-	G229	G072	G072				OVRA				
2nd-	G237	G076	G076				OVRB				

(2) Output signals (CNC→PMC)

(a) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O

NOTE
1 These signals are valid with the M series only.

(b) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O

NOTE
1 These signals are valid with the M series only.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F008							SF	
Common to all axes	F020	S7	S6	S5	S4	S3	S2	S1	S0
Common to all axes	F021	S15	S14	S13	S12	S11	S10	S09	S08
Common to all axes	F022	S23	S22	S21	S20	S19	S18	S17	S16
Common to all axes	F023	S31	S30	S29	S28	S27	S26	S25	S24
Common to all axes	F045			SRSRDY					
1st-	F010	RO7A	RO6A	RO5A	RO4A	RO3A	RO2A	RO1A	RO0A
2nd-	F320	RO7B	RO6B	RO5B	RO4B	RO3B	RO2B	RO1B	RO0B
1st-	F11	RO15A	RO14A	RO13A	RO12A	RO11A	RO11A	RO10A	RO9A
2nd-	F321	RO15B	RO14B	RO13B	RO12B	RO11B	RO11B	RO10B	RO9B
1st-	F014	MR7A	MR6A	MR5A	MR4A	MR3A	MR2A	MR1A	MR0A
2nd-	F324	MR7B	MR6B	MR5B	MR4B	MR3B	MR2B	MR1B	MR0B
1st-	F015	MR15A	MR14A	MR13A	MR12A	MR11A	MR10A	MR9A	MR8A
2nd-	F325	MR15B	MR14B	MR13B	MR12B	MR11B	MR10B	MR9B	MR8B
1st-	F234	SSPD7A	SSPD6A	SSPD5A	SSPD4A	SSPD3A	SSPD2A	SSPD1A	SSPD0A
2nd-	F250	SSPD7B	SSPD6B	SSPD5B	SSPD4B	SSPD3B	SSPD2B	SSPD1B	SSPD0B
1st-	F235	SSPD15A	SSPD14A	SSPD13A	SSPD12A	SSPD11A	SSPD10A	SSPD9A	SSPD8A
2nd-	F251	SSPD15B	SSPD14B	SSPD13B	SSPD12B	SSPD11B	SSPD10B	SSPD9B	SSPD8B
1st-	F341								SRRDYA
2nd-	F342								SRRDYB

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045		TLMA		LDT1A	SARA	SDTA	SSTA	
2nd-	F245	F049	F049		TLMB		LDT1B	SARB	SDTB	SSTB	

2.1.5 Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
—	3705#0	3705#0	Sets SF signal output and the S code for an S command.
—	3705#2	3705#2	Gear switch method (M series only)
—	3705#4	3705#4	Sets SF signal output and the S code for an S command (T series only).
—	3705#5	3705#5	Sets SF signal output when constant surface speed control is exercised and an S code is specified (M series only).
—	3705#6	3705#6	Sets SF signal output (M series only).
—	3706#4	3706#4	Spindle gear selection method (M series only)
—	3706#7,#6	3706#7,#6	Spindle speed command polarity (valid when input signal SSIN = 0)
—	3709#0	3709#0	Number of sampling operations at spindle speed calculation time (T series only for 16*i*)
—	3735	3735	Minimum clamp speed of the spindle motor (M series only)
—	3736	3736	Maximum clamp speed of the spindle motor (M series only)
—	3740	3740	Time until the spindle speed arrival signal is checked
—	3741	3741	Maximum spindle speed for gear 1
—	3742	3742	Maximum spindle speed for gear 2
—	3743	3743	Maximum spindle speed for gear 3
—	3744	3744	Maximum spindle speed for gear 4 (T series only)
—	3751	3751	Spindle motor speed at the switch point between gear 1 and gear 2 (M series only)
—	3752	3752	Spindle motor speed at the switch point between gear 2 and gear 3 (M series only)
—	3772	3772	Maximum allowable spindle speed
2031	3031	3031	Allowable number of S code characters
2003#1	—	—	Sets an S code polarity.
2204#0	—	—	Sets the display of an actual spindle speed.
2402#6	—	—	Sets the S code specified in a block containing G92.
5602#3	—	—	Whether to provide an indication for an alarm detected with the spindle amplifier. (Set “0” usually.)
5611	—	—	Number of sampling operations when an average spindle speed is to be found.
5612	—	—	Unit of spindle speed output with the DO signal
5807#0	—	—	Enables/disables the spindle alarms (SPxxxx) of all spindles. (Set “0” usually.)
5842	—	3720	Number of position coder pulses
5847	—	3721	Number of gear teeth on the position coder side on velocity control (for feed per revolution, threading, etc.)
5848	—	3722	Number of gear teeth on the spindle side on velocity control (for feed per revolution, threading, etc.)
5850	—	—	Spindle number to be selected at power-on/reset time
5820#4	—	—	Sets the method of spindle speed calculation.
3006#5	4006#5	4006#5	Sets an analog override range.
3009#4	4009#4	4009#4	Whether to output the load detection signal (LDT1) during acceleration/deceleration
3009#6	4009#6	4009#6	Analog override type
5607#0	4019#7	4019#7	Automatic spindle parameter setting function

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3020	4020	4020	Maximum motor speed
3040 3041	4040 4041	4040 4041	Velocity loop proportional gain on the velocity control mode (A parameter is selected by the PMC input signal CTH1A.)
3048 3049	4048 4049	4048 4049	Velocity loop integral gain on the velocity control mode (A parameter is selected by the PMC input signal CTH1A.)
3056 to 3059	4056 to 4059	4056 to 4059	Spindle and motor gear ratio data (A parameter is selected by the PMC input signals CTH1A and CTH2A.)
3069 to 3072	4069 to 4072	4069 to 4072	Acceleration/deceleration constant (A parameter is selected by the PMC input signals CTH1A and CTH2A.)
3081	4081	4081	Delay time until the motor power is turned off
3082	4082	4082	Sets an acceleration/deceleration time.
3083	4083	4083	Motor voltage on the velocity control mode

NOTE

1. For the detector-related parameters, see Section 1.3, "PARAMETERS RELATED TO DETECTORS", in Part III.
2. For velocity loop proportional/integral gain adjustment, see Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT", in Part III.

2.1.6 Details of Related Parameters

This subsection details the serial spindle parameters (in the four thousands for 16*i*, in the four thousands for 30*i*, and in the three thousands for 15*i*) among the parameters related to the velocity control mode. For details of other parameters, refer to the parameter manual of each CNC.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3006	4006	4006			**ALGOVR**					

ALGOVR Sets a spindle analog override range.
0 : 0 to 100% (standard setting value)
1 : 0 to 120%

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3009	4009	4009		**OVRTYP**		**LDTOUT**				

LDTOUT Whether to output the load detection signal (LDT1A) during acceleration/deceleration
0 : Not output during acceleration/deceleration. (standard setting value)
1 : Output (at all times) during acceleration/deceleration if the parameter-set level is exceeded.

OVRTYP Analog override type
0 : Override of linear function type (standard setting value)
1 : Override of quadratic function type

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4019	4019	**PRLOAD**							

PRLOAD Automatic parameter setting function
0 : Does not perform automatic parameter setting. (standard setting value)
1 : Performs automatic parameter setting.

After setting a desired motor model code in parameter No. 4133 and setting this bit to 1, turn off the power to the CNC, then turn on the power to the CNC again. The parameters (No. 4000 to No. 4175) for the αC*i* series spindle corresponding to the model code are automatically initialized. Upon completion of automatic setting, this bit is automatically set to "0".

> **NOTE**
> With FS15*i*, the parameter address of this function is different, namely, bit 0 of No. 5607 is used. Moreover, note that the meanings of settings are reversed as follows.
> 0 : Performs automatic parameter setting.
> 1 : Does not perform automatic parameter setting.
> In this case, set a model code in parameter No. 3133.

15*i*	16*i*	30*i*	
3020	4020	4020	**Maximum motor speed**

Unit of data : $1min^{-1}$
Valid data range : 0 to 32767
Standard setting : Depends on the motor model.
This parameter sets a maximum spindle motor speed.

> ⚠ **WARNING**
> The spindle motor may rotate at the maximum spindle motor speed specified by this parameter. Therefore, this parameter must not be set to a value greater than the maximum rotation speed indicated by the specification of the spindle motor.

15*i*	16*i*	30*i*		
3040	4040	4040	**Velocity loop proportional gain on velocity control mode (HIGH)**	**CTH1A=0**
3041	4041	4041	**Velocity loop proportional gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : Depends on the motor model.
This data is used to set the velocity loop proportional gain on velocity control mode.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3048	4048	4048	**Velocity integral gain on velocity control mode (HIGH)**	**CTH1A=0**
3049	4049	4049	**Velocity integral gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : Depends on the motor model.
This data is used to set the velocity loop integral gain on velocity control mode.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100
These data are used to set the gear ratio between spindle and spindle motor.
Example :
When the spindle rotates once, set “250” as the data when the motor rotates 2.5 times.

NOTE

1. A parameter is selected by the input signals CTH1A and CTH2A. Ensure that the gear or clutch state corresponds to the input signals CTH1A and CTH2A. When the signals are not input correctly, the overcurrent alarm (spindle alarm 12) can be issued.
2. When using a position coder, be sure to set this parameter. If this parameter is not set correctly, the velocity error excess alarm (spindle alarm 02), motor binding alarm (spindle alarm 31), or gear ratio parameter setting error alarm (spindle alarm 35) may be detected.
3. When an improper value is set in this parameter, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*		
3069	4069	4069	**Acceleration/deceleration constant (HIGH)**	**CTH1A=0, CTH2A=0**
3070	4070	4070	**Acceleration/deceleration constant (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3071	4071	4071	**Acceleration/deceleration constant (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3071	4072	4072	**Acceleration/deceleration constant (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : 1min^{-1} / sec
Valid data range : 0 to 32767
Standard setting value : 900

These parameters set an acceleration/deceleration constant calculated from the motor output torque and spindle inertia and adjust acceleration/deceleration time.

A parameter is selected by the input signals CTH1A and CTH2A. The initial setting value “900” assumes that linear acceleration/ deceleration is performed with the 30-minute rated torque at the maximum motor speed, with an inertia three times as large as the rotor inertia of the motor. It is assumed that all (αCi series spindle motors satisfy this initial value. So, there is a margin with some motor models.

For each machine, find a load inertia, and assign the found value to the following expression to calculate an acceleration/deceleration constant for setting:

$$Tc = T/(Jm+Jl) \times (60/2\pi)$$
$$= P/N \times (60/2\pi) /(Jm+Jl) \times (60/2\pi)$$
$$= P/N/(Jm+Jl) \times (60/2\pi)^2$$

Tc [min^{-1}/sec] : Acceleration/deceleration constant
Jm [kgm^2] : Motor rotor inertia
Jl [kgm^2] : Load inertia in terms of motor axis
T [Nm] : 30-minute rated torque
P [kW] : 30-minute rated output
N [min^{-1}] : Motor speed

[Rotor inertia and torque data of standard models]

Motor model	αC1*i*	αC2*i*	αC3*i*	αC6*i*	αC8*i*	αC12*i*	αC15*i*
Rotor inertia Jm [kgm^2]	0.003	0.0078	0.0148	0.0179	0.0275	0.07	0.09
30-minute rated torque at base speed T [Nm]	14.01	23.55	35.01	47.75	70.03	95.49	117.77

NOTE
1. The initial setting value satisfies a value calculated with N = maximum speed and Jl = Jm×3.
2. A maximum specifiable acceleration/deceleration constant is based on N = base speed.

15*i*	16*i*	30*i*	
3081	4081	4081	**Delay time until the motor power is turned off**

Unit of data : 10ms
Valid data range : 0 to 1000
Standard setting value : 20(200ms)

If SFRA = 0 or SRVA = 0 is specified, this parameter sets a period of time from the stop of the motor (detection of the speed zero detection signal SSTA = 1) until the power to the motor is turned off.

NOTE
When a small value is set in this parameter, the motor can coast after the power to the motor is turned off.

15*i*	16*i*	30*i*	
3082	4082	4082	**Setting of acceleration/deceleration time**

Unit of data : 1sec
Valid data range : 0 to 255
Standard setting value : 10

This parameter sets a period of time in which alarm detection is disabled by assuming that the spindle motor is being accelerated or decelerated even if the velocity error exceeds the velocity error excess alarm (spindle alarm 02) level after start of acceleration/deceleration on the velocity control mode.
In the velocity control mode, a step-by-step speed command is specified. So, the spindle motor cannot follow up the command immediately after start of acceleration/deceleration, and the velocity error exceeds the velocity error excess alarm level. This parameter is used to prevent the velocity error excess alarm (spindle alarm 02) from being detected incorrectly immediately after start of acceleration/deceleration.

> **NOTE**
> With a machine tool such as a lathe that has a large load inertia, the acceleration/deceleration time becomes longer. In such a case, set the value corresponding to the acceleration/deceleration time of the machine in this parameter.

15*i*	16*i*	30*i*	
3083	4083	4083	**Motor voltage setting on velocity control mode**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : 60

This parameter is used to set a motor voltage on velocity control mode. Usually, this parameter need not be adjusted. Use the standard setting.

2.1.7 Troubleshooting

If the spindle motor does not operate normally, take an action by referencing the items listed below according to the state of trouble.
For an action to be taken when an alarm is issued, refer to the maintenance manual.

	State of trouble
(i)	When the motor does not rotate
(ii)	When the motor does not rotate at a specified speed
(iii)	When the motor vibrates and makes an abnormal sound when rotating
(iv)	When an overshoot or hunting occurs
(v)	When the cutting capability is degraded
(vi)	When the acceleration/deceleration time is long

(i) When the motor does not rotate

(1) Check the connections. (Refer to Descriptions (B-65372EN).)
- (a) Motor power line phase order
- (b) Connection of the position coder signal cable (shielding, grounding)
- (c) DC link connection between the common power supply (PS) and amplifier

(2) Check the parameter settings.
- (a) Parameter data for each motor model
- (b) Detector-related parameter data (Refer to Section 1.3, “PARAMETERS RELATED TO DETECTORS”, in Part III)
- (c) Setting of a maximum motor speed

15*i*	16*i*	30*i*	Description
3020	4020	4020	Maximum motor speed

- (d) Parameters related to spindle speed specification
  Refer to Subsection 2.1.5, “Related Parameters”, in Part III.

(3) Check the input signals.
- (a) Input signals for spindle control (PMC$\rightarrow$CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA		SFRA	SRVA				
2nd-	G235	G074	G074	MRDYB		SFRB	SRVB				

1st-	G226	G071	G071							*ESPA	
2nd-	G234	G075	G075							*ESPB	

(ii) When the motor does not rotate at a specified speed

(1) Check the connections. (Refer to Descriptions (B-65372EN).)
   (a) Motor power line connection
   (b) Connection of the position coder signal cable (shielding, grounding)

(2) Check the parameter settings.
   (a) Parameter data for each motor model
   (b) Detector-related parameter data (Refer to Section 1.3, "PARAMETERS RELATED TO DETECTORS", in Part III)
   (c) Setting of a maximum motor speed

15*i*	16*i*	30*i*	Description
3020	4020	4020	Maximum motor speed

   (d) Parameters related to spindle speed specification

For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B
CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."

For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A
CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, "SPINDLE SPEED CONTROL."

For Series 15*i*
"FANUC Series 15*i*-MODEL B
CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."

For Series 0*i*
"FANUC Series 0*i*-MODEL B
CONNECTION MANUAL (FUNCTION) : B-63833EN-1
Refer to Section 9.3, "SPINDLE SPEED CONTROL."

(iii) When the motor vibrates and makes an abnormal sound when rotating

(1) Check the connections. (Refer to Descriptions (B-65372EN).)
   (a) Connection of the position coder signal cable (shielding, grounding)

(2) Check the parameter settings.
The velocity loop gain may be too large. Adjust the following parameters:

15*i*	16*i*	30*i*	Description	Setting data
3040	4040	4040	Velocity proportional gain (HIGH)	Decrease the setting values.
3041	4041	4041	Velocity proportional gain (LOW)	
3048	4048	4048	Velocity integral gain (HIGH)	
3049	4049	4049	Velocity integral gain (LOW)	

(3) Make a comparison with the case of motor coasting.
If vibration and sound produced when the motor coasts are extremely smaller than those produced when the motor is driven, the control circuit is faulty. If sound produced remains unchanged, the motor or the machine may be faulty. If the overheat signal cable from the motor is disconnected during motor rotation, an alarm is issued, and the motor coasts. Before performing the coasting of the motor, consult with the machine tool builder for confirmation. Depending on the sequence, the brake may be applied.

(iv) When an overshoot or hunting occurs

(1) Check the parameter settings.
(a) The velocity loop gain may be too large. Adjust the following parameters:

15*i*	16*i*	30*i*	Description	Setting data
3040	4040	4040	Velocity proportional gain(HIGH)	Decrease the setting values.
3041	4041	4041	Velocity proportional gain(LOW)	
3048	4048	4048	Velocity integral gain (HIGH)	
3049	4049	4049	Velocity integral gain (LOW)	

(b) The acceleration/deceleration constant may be too large. Adjust the following parameters:

15*i*	16*i*	30*i*	Description	Setting data
3069	4069	4069	Acceleration/deceleration constant (HIGH)	Decrease the setting values.
3070	4070	4070	Acceleration/deceleration constant (MEDIUM HIGH)	
3071	4071	4071	Acceleration/deceleration constant (MEDIUM LOW)	
3072	4072	4072	Acceleration/deceleration constant (LOW)	

(v) When the cutting capability is degraded

(1) Check the parameter settings.
(a) Parameter data for each motor model

(2) Check the input signals.
(a) Torque limitation command (TLMHA)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070							TLMHA	
2nd-	G235	G074	G074							TLMHB	

(3) Check the machine.
(a) Belt tension, and so forth

(vi) When the acceleration/deceleration time is long

(1) Check the parameter settings.
(a) Parameter data for each motor model

(b) The acceleration/deceleration constant may be too small. Adjust the following parameters:

15*i*	16*i*	30*i*	Description	Setting data
3069	4069	4069	Acceleration/deceleration constant (HIGH)	Increase the setting values.
3070	4070	4070	Acceleration/deceleration constant (MEDIUM HIGH)	
3071	4071	4071	Acceleration/deceleration constant (MEDIUM LOW)	
3072	4072	4072	Acceleration/deceleration constant (LOW)	

(c) Regenerative power limitation (Check if the same value as in the parameter table for each motor model is set.)

15*i*	16*i*	30*i*	Description
3080	4080	4080	Regenerative power limitation

(2) Check the input signals.

(a) Torque limitation commands (TLMH)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070							TLMHA	
2nd-	G235	G074	G074							TLMHB	

2.2 POSITION CODER METHOD SPINDLE ORIENTATION (OPTIONAL FUNCTION)

2.2.1 Start-up Procedure

A. Check that operation in the velocity control mode is enabled.

B. Prepare and check the ladder program for spindle orientation.

C. Set the parameters related to spindle orientation or detector.

D. Check the position detect signal (position coder signal).

E. Check whether orientation is performed.

NG

OK

F. Set and check the direction used for orientation.
- Set the direction of rotation used for orientation.

G. Adjust the orientation stop position.
- Detection level for the orientation completion signal
- Orientation stop position shift
- Orientation stop position

H. Adjust the orientation speed.
- Position gain for orientation
- Orientation speed

I. Adjust the orientation stop (to eliminate overshoot and ensure stop-time rigidity).
- Position gain for orientation
- Velocity loop proportional gain for orientation
- Velocity loop integral gain for orientation
- Motor voltage for orientation
- Rate of change in position gain upon orientation completion

J. Check ATC operation.

2.2.2 Overview

For this subsection, see Subsection 5.4.1, “Overview”, in Part I.

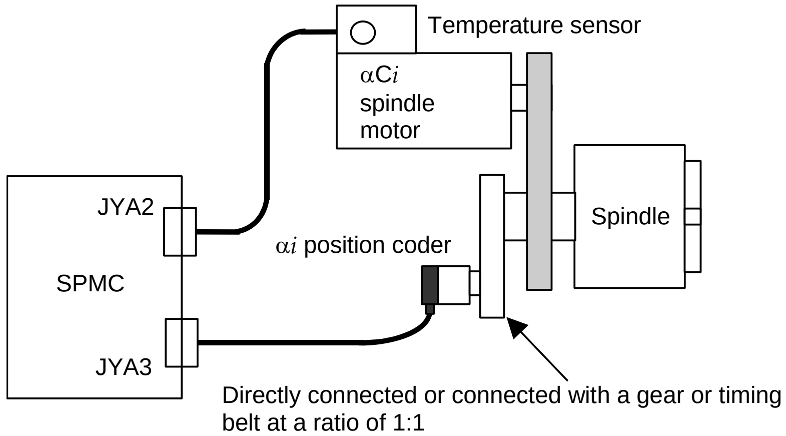
2.2.3 Feature

For this subsection, see Subsection 2.2.4, “ Feature”, in Part I.

2.2.4 System Configuration

The system configurations that enable the use of the position coder method orientation function are shown below.

(1) When the α*i* position coder is used



> **NOTE**
> The spindle sensor (separate detector) usable with the αC*i* series spindle amplifier is a position coder only.

2.2.5 Stop Position Specification Method

For this subsection, see Subsection 2.2.7, "Stop Position Specification Method ", in Part I.

2.2.6 I/O Signals (CNC↔PMC)

(1) Address list of Input signals (PMC→CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070		ORCMA			CTH1A	CTH2A		
2nd-	G235	G074	G074		ORCMB			CTH1B	CTH2B		
1st-	G229	G072	G072						NRROA	ROTAA	INDXA
2nd-	G237	G076	G076						NRROB	ROTAB	INDXB
1st-	G230	G078	G078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
2nd-	G238	G080	G080	SHB07	SHB06	SHB05	SHB04	SHB03	SHB02	SHB01	SHB00
1st-	G231	G079	G079					SHA11	SHA10	SHA09	SHA08
2nd-	G239	G081	G081					SHB11	SHB10	SHB09	SHB08

(2) Details of input signals (PMC→CNC)

With the αC*i* series, the signals indicated in the item above are valid. For details of each signal, see Subsection 2.2.8(2), "Details of input signals (PMC→CNC)", in Part I.

(3) Address list of output signals (CNC→PMC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA							
2nd-	F245	F049	F049	ORARB							

(4) Details of output signals (CNC→PMC)

With the αC*i* series, the signals indicated in the item above are valid. For details of each signal, see Subsection 2.2.8(4), “Details of output signals (CNC→PMC)”, in Part I.

2.2.7 Examples of Sequences

For this subsection, see Subsection 2.2.9, “ Examples of Sequences “, in Part I.

2.2.8 Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
3015 #0	4015 #0	4015 #0	Specifies whether to use the spindle orientation function. (Set this bit to 1.) (The CNC software option is required.)
5609#2	3702#3,#2	3729#0	Specifies whether to use the spindle orientation function with the stop position external setting type. (For 16*i*, #2: First spindle, #3: Second spindle)
3003#3,#2	4003#3,#2	4003#3,#2	Direction of rotation in spindle orientation (Set to 0 and 0 or 0 and 1.)
3005#0	4005#0	4005#0	Setting of the velocity feedback method (Set to 1.)
3017 #7	4017 #7	4017 #7	Shortcut function when orientation is specified in stop state
3031	4031	4031	Stop position for position coder method orientation (This parameter is disabled when spindle orientation with an externally set stop position or an externally set incremental command is used.)
3038	4038	4038	Spindle orientation speed
3042 3043	4042 4043	4042 4043	Velocity proportional gain on orientation (A parameter is selected by the CTH1A input signal.)
3050 3051	4050 4051	4050 4051	Velocity integral gain on orientation (A parameter is selected by the CTH1A input signal.)
3056 to 3059	4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio (A parameter is selected by the CTH1A and CTH2A input signals.)
3060 to 3063	4060 to 4063	4060 to 4063	Position gain for orientation (A parameter is selected by the CTH1A and CTH2A input signals.)
3064	4064	4064	Acceleration limitation ratio at deceleration time (Set to 100.)
3075	4075	4075	Detection level for the spindle orientation completion signal
3077	4077	4077	Spindle orientation stop position shift
3084	4084	4084	Motor voltage for spindle orientation
3320 to 3323	4320 to 4323	4320 to 4323	Acceleration at orientation deceleration time (A parameter is selected by the CTH1A and CTH2A input signals.)

NOTE
1 For the parameters related to detectors, see Section 1.3, “PARAMETERS RELATED TO DETECTORS” in the Part III.
2 For velocity loop proportional/integral gain adjustment, see Section 4.1, “VELOCITY LOOP GAIN ADJUSTMENT”, in Part III.

2.2.9 Details of Related Parameters

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3003	4003	4003					DIRCT2	DIRCT1		

DIRCT2, DIRCT1 Setting of rotation direction at spindle orientation

DIRCT2	DIRCT1	Rotation direction at spindle orientation
0	0	By rotation direction immediately before (It is CCW at the power on.)
0	1	By rotation direction immediately before (It is CW at the power on.)

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3005	4005	4005								VCTLPC

VCTLPC Sets the velocity feedback method.

0 : Exercises velocity control with an estimated velocity only.

1 : Uses a velocity calculated from the position coder signal to exercise velocity control.

Set to 1.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3017	4017	4017	NRROEN							

NRROEN Specifies whether to use the shortcut function when orientation is specified in the stop state.

0 : Does not use the function.

1 : Uses the function.

When this bit is set to 1, short cut operation is performed when the following conditions are satisfied:

- Bit 7 of parameter No. 4016 (RFCHK3) is set to 0.
- Zero speed detection output signal SSTA is set to 1.
- Shortcut command input signal NRROA is set to 1.

15*i*	16*i*	30*i*	
3031	4031	4031	Position coder method orientation stop position

Unit of data : 1 pulse (360°/4096)

Valid data range : 0 to 4096

Standard setting : 0

This data is used to set the stop position of position coder method spindle orientation. It can be set at every 360 degrees/4096.

When stop position external command type orientation and incremental command external type orientation are set, this parameter becomes invalid.

Stop position command (SHA11-SHA00) of input signal instructed becomes valid.

15*i*	16*i*	30*i*	
3038	4038	4038	Spindle orientation speed

Unit of data : 1min^{-1}

Valid data range : 0 to 32767

Standard setting : 0

This parameter sets the orientation speed at the end of the spindle.

When this data is set to 0, 200 min^{-1} is set.

15*i*	16*i*	30*i*		
3042	4042	4042	**Velocity loop proportional gain on orientation (HIGH)**	**CTH1A=0**
3043	4043	4043	**Velocity loop proportional gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : Depends on the motor model.

This parameter sets the velocity loop proportional gain for spindle orientation.
When the CTH1A input signal is set to 0, proportional gain for the HIGH gear is selected.
When the CTH1A input signal is set to 1, proportional gain for the LOW gear is selected.

15*i*	16*i*	30*i*		
3050	4050	4050	**Velocity loop integral gain on orientation (HIGH)**	**CTH1A=0**
3051	4051	4051	**Velocity loop integral gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : Depends on the motor model.

This parameter sets the velocity loop integral gain for spindle orientation.
When the CTH1A input signal is set to 0, integral gain for the HIGH gear is selected.
When the CTH1A input signal is set to 1, integral gain for the LOW gear is selected.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These parameters set the gear ratio of the spindle motor relative to the spindle.
When the motor rotates 2.5 times, for every rotation of the spindle, for example, set 250 in the parameter.

NOTE

1 A parameter is selected by the input signals CTH1A and CTH2A. Ensure that the gear or clutch state corresponds to the input signals CTH1A and CTH2A. When the signals are not input correctly, the overcurrent alarm (spindle alarm 12) can be issued.
2 When using a position coder, be sure to set this parameter. If this parameter is not set correctly, the velocity error excess alarm (spindle alarm 02), motor binding alarm (spindle alarm 31), or gear ratio parameter setting error alarm (spindle alarm 35) may be detected.
3 When an improper value is set in this parameter, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*		
3060	4060	4060	**Position gain on orientation (HIGH)**	**CTH1A=0, CTH2A=0**
3061	4061	4061	**Position gain on orientation (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3062	4062	4062	**Position gain on orientation (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3063	4063	4063	**Position gain on orientation (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : $0.01 sec^{-1}$
Valid data range : 0 to 32767
Standard setting : 1000
These parameters set the position gain for orientation.
A parameter is selected by the CTH1A and CTH2A input signals.

15*i*	16*i*	30*i*	
3064	4064	4064	**Acceleration limitation ratio at deceleration time**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : 100
Set to 100.

15*i*	16*i*	30*i*	
3075	4075	4075	**Orientation completion signal detection level (limits of in-position)**

Unit of data : ± 1 pulse unit (360degrees/4096)
Valid data range : 0 to 100
Standard setting : 10
This data is used to set the detecting level of orientation completion signal (ORARA).
When the spindle position is located within the setting data on orientation completion, the bit of orientation completion signal (ORARA) in the spindle control signals is set to “1”.
When the orientation command (ORCMA) is turned off (= 0), the orientation completion signal (ORARA) is set to “0”.

15*i*	16*i*	30*i*	
3077	4077	4077	**Orientation stop position shift value**

Unit of data : ± 1 pulse unit (360degrees/4096)
Valid data range : -4095 to 4095

Standard setting : 0

In the position coder method orientation, set this data to shift stop position.
Spindle is shift No. of setting pulse in CCW direction, and stops by data (+).

15*i*	16*i*	30*i*	
3084	4084	4084	**Motor voltage setting on orientation**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : 60

This parameter sets the motor voltage for orientation. Usually, set 60.

15*i*	16*i*	30*i*		
3320	4320	4320	**Acceleration at orientation deceleration time (HIGH)**	**CTH1A=0, CTH2A=0**
3321	4321	4321	**Acceleration at orientation deceleration time (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3322	4322	4322	**Acceleration at orientation deceleration time (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3323	4323	4323	**Acceleration at orientation deceleration time (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : $10min^{-1}/sec$
Valid data range : 0 to 6400
Standard setting : 0

These parameters set a motor acceleration value at deceleration time in orientation. When 0 is set, an acceleration value of 520 min^{-1}/sec (corresponding to setting = 52 or equivalent to the standard setting for the αC series spindle) is set.

2.2.10 Adjusting the Orientation Stop Position Shift Parameter

For this subsection, see Subsection 2.2.14, “Adjusting the Orientation Stop Position Shift Parameter”, in Part I.

2.3 RIGID TAPPING (OPTIONAL FUNCTION)

2.3.1 Start-up Procedure

A. Check that operation in the velocity control mode is enabled..

↓

B. Prepare and check the rigid tapping ladder program.

↓

C. Set up the detector-related parameters according to the system configuration.
- Specify to use the spndile sensor and spindle motor.
- Specify the rotation direction of the spindle and motor and that of the spindle and position coder.
- Set up the gear ratio between the spindle and motor.

↓

D. Adjust the parameters according to the adjustment procedure.
- Maximum rotation speed and acceleration/deceleration time constant for rigid tapping
- Position gain for rigid tapping
- Velocity loop proportional and integral gains for rigid tapping
- Motor voltage for rigid tapping
- Motor activation delay

↓

E. Check the precision by actually performing cutting.
If there is a problem with the precision of the machine, adjust the acceleration/deceleration time constant and velocity loop gains again.

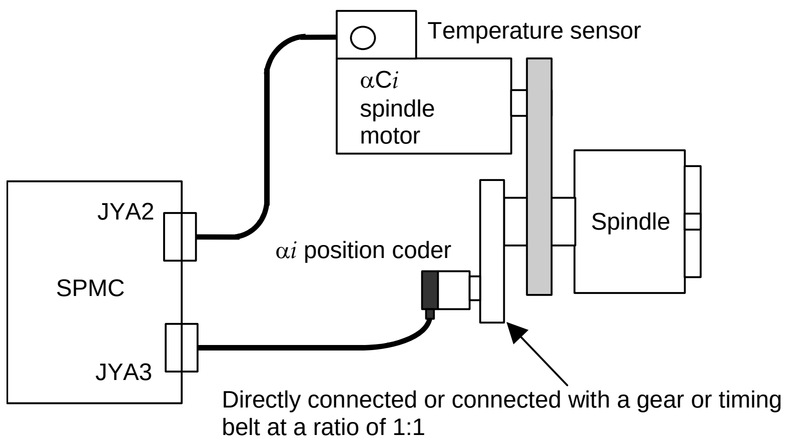
2.3.2 Overview

For this subsection, see Subsection 2.3.2, "Overview", in Part I.

2.3.3 System Configuration

The system configurations that enable the use of rigid tapping are shown below.

(1) When the α*i* position coder is used



NOTE
The spindle sensor (separate detector) usable with the αC*i* series spindle amplifier is a position coder only.

2.3.4 List of I/O Signals (CNC↔PMC)

This subsection provides a list of the I/O signals related to rigid tapping only. For details of each signal, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.11, “RIGID TAPPING.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.11, “RIGID TAPPING.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.8, “RIGID TAPPING.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63833EN-1
Refer to Section 9.10, “RIGID TAPPING.”

For details of the I/O signals common to the CNCs, see Chapter 3, “I/O SIGNALS (CNC↔PMC)”, in Part I.

(1) Input signals (PMC→CNC)

(a) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
G027							SWS2 (*1)	SWS1 (*1)
G028						GR2	GR1	
G029								GR21 (*2)
G061								RGTAP

NOTE
1 The rigid tapping of the 2nd spindle is available by the multi-spindle control function.
When SWS1 is set to 1 (regardless of whether SWS2 is set to 0 or 1), rigid tapping is performed using the 1st spindle. When SWS1 is set to 0, and SWS2 is set to 1, rigid tapping is performed using the 2nd spindle.
2 This signal is used when the rigid tapping of the second spindle.
According to the GR21 signal, the individual gear parameters for gear 1 or 2, also used for the 1st spindle, are selected.

(b) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
G027							SWS2 (*1)	SWS1 (*1)
G028						GR2	GR1	
G029							GR22 (*2)	GR21 (*2)
G061								RGTAP

NOTE
1. The rigid tapping of the 2nd spindle is available by the multi-spindle control function.
   When SWS1 is set to 1 (regardless of whether SWS2 is set to 0 or 1), rigid tapping is performed using the 1st spindle. When SWS1 is set to 0, and SWS2 is set to 1, rigid tapping is performed using the 2nd spindle.
2. This signal is used when the rigid tapping of the second spindle.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
1st-	G026								SPSTPA
2nd-	G272								SPSTPB

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070			SFRA	SRVA	CTH1A	CTH2A		
2nd-	G235	G074	G074			SFRB	SRVB	CTH1B	CTH2B		

(2) Output signals (CNC→PMC)

(a) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F065							RGSPM (*1)	RGSPP (*1)
F076					RTAP			

NOTE
1. These signals are effective when M series.

(b) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F065							RGSPM (*1)	RGSPP (*1)
F076					RTAP			

NOTE
1. These signals are effective when M series.

(c) Series 15*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F040				RTAP				
F155						RSPC	RSPM	RSPP

2.3.5 Sequence

For a rigid tapping sequence, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.11, “RIGID TAPPING.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.11, “RIGID TAPPING.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.8, “RIGID TAPPING.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63833EN-1
Refer to Section 9.10, “RIGID TAPPING.”

2.3.6 Related Parameters

Parameter No.			Description
15*i*	**16*i***	**30*i***	
-	5210	5210	M code of rigid tapping command
5606#6	5202#0 (M series only)	5202#0	Whether to perform orientation (reference position return) when starting rigid tapping
-	3706#1,#0 3707#1,0	-	Gear ratio between spindle and position coder, 1:1, 1:2, 1:4, 1:8
5842	-	3720	Number of pulse of the position coder
3065 to 3068	5280 5281 to 5284	5280 5281 to 5284	Position gain of tapping axis at rigid tapping (16*i* /30*i*: No. 5284 is used for the T series only.)
5605#1	-	-	Acc./Dec. type (Set to 1.)
5711	5241 5242 5243 5244	5241 5242 5243 5244	Spindle maximum speed at rigid tapping (16*i*: No. 5244 is used for the T series only.)
5605#2 5757 5886 5889 5892	- - - - -	- - - - -	Spindle speed for determining an acceleration value for cutting feed on rigid tapping
5605#2 5751 5884 5887 5890 5893	5261 5262 5263 5264	5261 5262 5263 5264	Acc./Dec. time constant (16*i*: No. 5264 is used for the T series only.)

Parameter No.			Description
15*i*	16*i*	30*i*	
5605#2 5752 5885 5888 5891 5894	- - - - -	- - - - -	FL speed for spindle and drilling axis acceleration/deceleration on rigid tapping
-	5200#4	5200#4	Override selection at extracting
5883	5211	5211	Override value at extracting
-	5201#2 5271 to 5274	5201#2 5271 to 5274	Time constant at extracting (No. 5274 is used for the T series only.)
1827	5300	5300	In-position width of tapping axis
5875	5301	5301	In-position width of spindle
1837	5310 5341	5310	Allowable level of position error of tapping axis at moving
5876	5311	5311	Allowable level of position error of spindle at moving
1829	5312	5312	Allowable level of position error of tapping axis at stop
5877	5313	5313	Allowable level of position error of spindle at stop
5853 5856 5859 5862	5321 5322 to 5324	5321 5322 to 5324	Backlash of spindle (16*i*: Nos.5322 to 5324, 30*i*: No. 5324 is used for the T series only.)
3000#4	4000#4	4000#4	Reference position return direction on servo mode
3002#5	4002#5	4002#5	Whether to enable the rotation direction signal (SFR/SRV) on servo mode
3005#0	4005#0	4005#0	Setting of the velocity feedback method (Set to 1.)
3044 3045	4044 4045	4044 4045	Velocity loop proportional gain on servo mode/spindle synchronous control (It is selected by input signal CTH1A/B.)
3052 3053	4052 4053	4052 4053	Velocity loop integral gain on servo mode/spindle synchronous control (It is selected by input signal CTH1A/B.)
3056 to 3059	4056 to 4059	4056 to 4059	Gear ratio between spindle and motor (It is selected by input signal CTH1A or CTH2A)
3065 to 3068	4065 to 4068	4065 to 4068	Spindle position gain on servo mode/spindle synchronous control (It is selected by input signal CTH1A or CTH2A)
3073	4073	4073	Grid shift amount on servo mode
3074	4074	4074	Reference position return speed on servo mode
3091	4091	4091	Position gain change ratio at reference position return time on servo mode
3085	4085	4085	Motor voltage on servo mode/spindle synchronous control
3099	4099	4099	Delay time for stable motor excitation

NOTE

1 For the parameters related to detectors, see Section 1.3, “PARAMETERS RELATED TO DETECTORS” in the Part III.

2 For velocity loop proportional/integral gain adjustment, see Section 4.1, “VELOCITY LOOP GAIN ADJUSTMENT”, in Part III.

2.3.7 Details of Related Parameters

This subsection details the serial spindle parameters (in the four thousands for 16*i* , in the four thousands for 30*i*, and in the three thousands for 15*i*) among the parameters related to rigid tapping. For details of other parameters, refer to the parameter manual of each CNC.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3000	4000	4000				RETSV				

RETSV Reference position return direction on servo mode (rigid tapping/spindle positioning)
0 : The spindle performs a reference position return operation in the CCW(counterclockwise) direction.
1 : The spindle performs a reference position return operation in the CW(clockwise) direction.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3002	4002	4002			SVMDRT					

SVMDRT Whether to enable the rotation direction signal (SFR/SRV) function on servo mode (rigid tapping/spindle positioning)
0 : Enables the rotation direction function.
If a move command from the CNC is positive (+),
(a) The spindle rotates in the CCW direction when the input signal SFR (bit 5 of G70) = 1.
(b) The spindle rotates in the CW direction when the input signal SRV (bit 4 of G70) = 1.
1 : Disables the rotation direction function.
If a move command from the CNC is positive (+), the spindle rotates in the CCW direction when the input signal SFR = 1 or SRV = 1.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3005	4005	4005								VCTLPC

VCTLPC Sets the velocity feedback method.
0 : Exercises velocity control with an estimated velocity only.
1 : Uses a velocity calculated from the position coder signal to exercise velocity control.
Set to 1.

15*i*	16*i*	30*i*	
3044	4044	4044	**Velocity loop proportional gain on servo mode/spindle synchronous control (HIGH) CTH1A=0**
3045	4045	4045	**Velocity loop proportional gain on servo mode/spindle synchronous control (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.
These parameters set a velocity loop proportional gain on servo mode (rigid tapping/spindle positioning) or spindle synchronous control.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*	
3052	4052	4052	**Velocity loop integral gain on servo mode/spindle synchronous control (HIGH) CTH1A=0**
3053	4053	4053	**Velocity loop integral gain on servo mode/spindle synchronous control (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

These parameters set a velocity loop integral gain on servo mode (rigid tapping/spindle positioning) or spindle synchronous control.

When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

> **NOTE**
> For velocity loop gain setting on spindle synchronous control and servo mode, the common parameters are used.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These parameters set the gear ratio of the spindle motor relative to the spindle.

When the motor rotates 2.5 times, for every rotation of the spindle, for example, set 250 in the parameter.

> **NOTE**
> 1 A parameter is selected by the input signals CTH1A and CTH2A. Ensure that the gear or clutch state corresponds to the input signals CTH1A and CTH2A. When the signals are not input correctly, the overcurrent alarm (spindle alarm 12) can be issued.
> 2 When using a position coder, be sure to set this parameter. If this parameter is not set correctly, the velocity error excess alarm (spindle alarm 02), motor binding alarm (spindle alarm 31), or gear ratio parameter setting error alarm (spindle alarm 35) may be detected.

15*i*	16*i*	30*i*	
3065	4065	4065	**Spindle position gain on servo mode/spindle synchronous control (HIGH) CTH1A=0, CTH2A=0**
3066	4066	4066	**Spindle position gain on servo mode/spindle synchronous control (MEDIUM HIGH) CTH1A=0, CTH2A=1**
3067	4067	4067	**Spindle position gain on servo mode/spindle synchronous control (MEDIUM LOW) CTH1A=1, CTH2A=0**
3068	4068	4068	**Spindle position gain on servo mode/spindle synchronous control (LOW) CTH1A=1, CTH2A=1**

Unit of data : $0.01sec^{-1}$
Valid data range : 0 to 32767
Standard setting value : 1000

These parameters set a position gain on servo mode (rigid tapping/spindle positioning) or spindle synchronous control.
A parameter is selected according to the input signals CTH1A and CTH2A.

NOTE
For velocity loop gain setting on spindle synchronous control and servo mode, the common parameters are used.

15*i*	16*i*	30*i*	
3073	4073	4073	**Grid shift amount on servo mode**

Unit of data : 1 pulse (=360°/4096)
Valid data range : 0 to 4095
Standard setting value : 0

This parameter is used to shift the reference position on servo mode (rigid tapping/spindle positioning).
The reference position of the spindle is shifted in the CCW direction by the specified number of pulses.

15*i*	16*i*	30*i*	
3074	4074	4074	**Reference position return speed on servo mode**

Unit of data : $1min^{-1}$
Valid data range : 0 to 32767
Standard setting value : 0

To perform a reference position return operation, set a reference position return speed in this parameter.

15*i*	16*i*	30*i*	
3085	4085	4085	**Motor voltage on servo mode/spindle synchronous control**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 60

These parameters set a motor voltage on rigid tapping. Usually, set 60.

15*i*	16*i*	30*i*	
3091	4091	4091	**Position gain change ratio at reference position return time on servo mode**

Unit of data : 1%

Valid data range : 0 to 100
Standard setting value : 100

This parameter sets a position gain change ratio at reference position return time on servo mode (rigid tapping, spindle positioning, and so forth).

> **NOTE**
> An overshoot can occur at reference position return time for a cause such as an excessively high reference position return speed and an excessively large spindle inertia. In this case, an overshoot can be avoided by setting a small value in this parameter.

15*i*	16*i*	30*i*	
3099	4099	4099	**Delay time for stable motor excitation**

Unit of data : 1ms
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets a period of time required until motor excitation becomes stable on rigid tapping.

> **NOTE**
> In switching from the velocity control mode to rigid tapping mode, the stop time excessive error alarm can be issued intermittently. This is because the excitation state of the spindle motor changes abruptly, and therefore a transient state occurs in the motor, thus moving the motor shaft slightly.
> In such a case, set this parameter. In general, set a value from about 300 to 400 (300 to 400 msec).

2.3.8 Parameter Setting Procedure

(1) Gear ratio between the spindle and the motor

The loop gain constant parameter is not used in the αC*i* series (Serial) spindle system.
"Gear ratio between the spindle and the motor" parameter should be set instead of it.
Each parameter is selected according to the gear selection signal (CTH1A/B, CTH2A/B).

[1st. sp]

Gear signal		Parameter No.		
CTH1A	CTH2A	15*i*	16*i*	30*i*
0	0	3056(S1)	4056(S1)	4056(S1)
0	1	3057(S1)	4057(S1)	4057(S1)
1	0	3058(S1)	4058(S1)	4058(S1)
1	1	3059(S1)	4059(S1)	4059(S1)

[2nd. sp]

Gear signal		Parameter No.		
CTH1B	CTH2B	15*i*	16*i*	30*i*
0	0	3056(S2)	4056(S2)	4056(S2)
0	1	3057(S2)	4057(S2)	4057(S2)
1	0	3058(S2)	4058(S2)	4058(S2)
1	1	3059(S2)	4059(S2)	4059(S2)

(2) Position gain

In rigid tapping, the tapping axis and spindle are controlled to be synchronized. So, the position gains of the tapping axis and spindle must be set to the same value.

[Series 16*i*]

The position gain parameter of the tapping axis in the rigid tapping is selected as follows according to the gear selection signal.

Standard machining [M series]: GR3O, GR2O, GR1O
Turning [T series] and machining [M series] with surface speed constant option: GR2, GR1
Second spindle of turning [T series]: GR21(Multi-spindle control option is needed)

Standard machining [M series]

Gear signal			Parameter No.
GR1O	GR2O	GR3O	
			5280 (*1)
1	0	0	5281
0	1	0	5282
0	0	1	5283

Turning [T series] and machining [M series] with surface speed constant

Gear signal			Parameter No.	
1st. sp		2nd. sp		
GR1	GR2	GR21	T	M
			5280 (*1)	
0	0	0	5281	
1	0	1	5282	
0	1		5283	
1	1		5284	5283

NOTE
1 When this parameter is "0", each gear parameter becomes valid.
When this parameter is not "0", each gear parameter becomes invalid, and this parameter is always used.

The position gain parameter of the spindle in the rigid tapping is selected as follows according to the gear selection signal (CTH1A/B, CTH2A/B). (This is common T series and M series)

[1st. sp]

Gear signal		Parameter No.
CTH1A	CTH2A	
0	0	4065 (S1)
0	1	4066 (S1)
1	0	4067 (S1)
1	1	4068 (S1)

[2nd. sp]

Gear signal		Parameter No.
CTH1B	CTH2B	
0	0	4065 (S2)
0	1	4066 (S2)
1	0	4067 (S2)
1	1	4068 (S2)

⚠ CAUTION
Take care to input the gear selection signal GR1, GR2, GR21, GR1O, GR2O, GR3O and CTH1A/B, CTH2A/B according to the real gear state in order to get the same position gain of the tapping axis and that of the spindle, because GR1, GR2, GR21, GR1O, GR2O, GR3O and CTH1A/B, CTH2A/B are inputted independently.

[Series 30*i*]

The position gain parameter of the tapping axis in the rigid tapping is selected as follows according to the gear selection signal.
Standard machining[M series]: GR3O, GR2O, GR1O
Turning [T series] and machining [M series] with surface speed constant option : GR2, GR1
Second spindle : GR22, GR21(Multi-spindle control option is needed)

Standard machining [M series]

Gear signal			Parameter No.
GR1O	GR2O	GR3O	
1	0	0	5231
0	1	0	5232
0	0	1	5233

Turning [T series] and machining [M series] with surface speed constant

Gear signal		Parameter No.	
GRs1*	GRs2*	T	M
		5280(*1)	
0	0	5281	
1	0	5282	
0	1	5283	
1	1	5284	5283

* First spindle: GR1, GR2 / Second spindle: GR21, GR22

NOTE

*1 When this parameter is "0", each gear parameter becomes valid.
When this parameter is not "0", each gear parameter becomes invalid, and this parameter is always used.

The position gain parameter of the spindle in the rigid tapping is selected as follows according to the gear selection signal (CTH1A/B, CTH2A/B). (This is common T series and M series)

[1st. sp]

Gear signal		Parameter No.
CTH1A	CTH2A	
0	0	4065 (S1)
0	1	4066 (S1)
1	0	4067 (S1)
1	1	4068 (S1)

[2nd. sp]

Gear signal		Parameter No.
CTH1B	CTH2B	
0	0	4065 (S2)
0	1	4066 (S2)
1	0	4067 (S2)
1	1	4068 (S2)

⚠ **CAUTION**

Take care to input the gear selection signal GR1, GR2, GR21, GR22, GR1O, GR2O, GR3O and CTH1A/B, CTH2A/B according to the real gear state in order to get the same position gain of the tapping axis and that of the spindle, because GR1, GR2, GR21, GR22, GR1O, GR2O, GR3O and CTH1A/B, CTH2A/B are inputted independently.

[Series 15*i*]

In the rigid tapping, the same parameter address data is used for the position gain of the tapping axis and the spindle.
Each position gain is selected as follows according to the gear selection signal (CTH1A, CTH2A).

Gear signal		Parameter No.
CTH1A	CTH2A	
0	0	3065
0	1	3066
1	0	3067
1	1	3068

(3) Acceleration/deceleration time constant

[Series 16*i*]

(1) Each parameter can be set for each gear and is selected according to the gear selection signal.
By setting the following parameter, the different time constant between the cutting in and cutting out (extracting) becomes available.

5201 #2

0 : The same time constant between cutting in and out. (No. 5261 to 5264)

1 : The different time constant between cutting in and out.
Cutting in : No. 5261 to 5264
Cutting out: No. 5271 to 5274

Standard Machining [M series]: GR3O, GR2O, GR1O
Turning [T series] and Machining [M series] with surface speed constant : GR2, GR1
2nd. sp of Turning [T series] : GR21 (Multi-spindle control option is needed)

Standard machining [M series]

Gear signal			Time constant (Cutting in) Parameter No.	Time constant (Cutting out) Parameter No.	Spindle max. speed at rigid tapping Parameter No.
GR1O	GR2O	GR3O			
1	0	0	5261	5271	5241
0	1	0	5262	5272	5242
0	0	1	5263	5273	5243

Turning [T series] and machining [M series] with surface speed constant

Gear signal			Time constant (Cutting in) Parameter No.	Time constant (Cutting out) Parameter No.	Spindle max. speed at rigid tapping Parameter No.	
1st. sp		2nd. sp				
GR1	GR2	GR21			T/TT	M
0	0	0	5261	5271	5241	5241
1	0	1	5262	5272	5242	5242
0	1	-	5263	5273	5243	5243
1	1	-	5264 (*1)	5274 (*1)	5244 (*1)	-

NOTE
1 This is not available for Machining (M series).

(2) The override at extracting.

5200 #4

0 : The override at extracting is not valid.
1 : The override at extracting is valid.
(Set override value at No. 5211)

[Series 30*i*]

(1) Each parameter can be set for each gear and is selected according to the gear selection signal.
By setting the following parameter, the different time constant between the cutting in and cutting out (extracting) becomes available.

5201 #2

0 : The same time constant between cutting in and out. (No. 5261 to 5264)

1 : The different time constant between cutting in and out.
Cutting in : No. 5261 to 5264
Cutting out: No. 5271 to 5274

Standard Machining [M series]: GR3O, GR2O, GR1O
Turning [T series] and Machining [M series] with surface speed constant : GR2, GR1
2nd. sp : GR21, GR21 (Multi- spindle control option is needed)

Standard machining [M series]

Gear signal			Time constant (Cutting in) Parameter No.	Time constant (Cutting out) Parameter No.	Spindle max. speed at rigid tapping Parameter No.
GR1O	GR2O	GR3O			
1	0	0	5261	5271	5241
0	1	0	5262	5272	5242
0	0	1	5263	5273	5243

Turning [T series] and machining [M series] with surface speed constant

Gear signal		Time constant (Cutting in) Parameter No.	Time constant (Cutting out) Parameter No.	Spindle max. speed at rigid tapping Parameter No.	
GRs1*	GRs2*			T	M
0	0	5261	5271	5241	5241
1	0	5262	5272	5242	5242
0	1	5263	5273	5243	5243
1	1	5264 (*1)	5274 (*1)	5244 (*1)	-

* First spindle: GR1, GR2 / Second spindle: GR21, GR22

NOTE
1 This is not available for Machining (M series).

(2) The override at extracting.

5200 #4

0 : The override at extracting is not valid.
1 : The override at extracting is valid.
(Set override value at No. 5211)

[Series 15*i*]

(1) Acc./Dec. type

5605 #1

0 : Exponential type Acc./Dec.
1 : Linear type Acc./Dec. (Standard setting)

NOTE
Usually, linear type acceleration/deceleration (bit 1 of No. 5605 = 1) is used.

(2) Set Acc./Dec. the time constant of the rigid tapping mode.
<i> The time constant is a fixed value if bit 2 of parameter No. 5605 = 0.

Acc./Dec. time constant	5751
Spindle speed	5757

<ii> When bit 2 of parameter No.5605 is set to 1, one of the four acceleration/deceleration time constants is selected, depending on the spindle speed.

	Spindle speed	Acc./Dec. time constant
Gear 1	5886	5884
Gear 2	5889	5887
Gear 3	5892	5890
Gear 4	-	5893

2.3.9 Adjustment Procedure

(1) Parameters used for adjustment

The table below lists and describes the parameters used for adjusting rigid tapping.

Parameter No.(FS16*i*)	Description
5241 to 5244	Maximum spindle speed on rigid tapping (Depends on the GR signal. 5244 is for the T series only.)
5261 to 5264	Acceleration/deceleration time constant on rigid tapping (Depends on the GR signal. 5264 is for the T series only.)
5280 to 5284	Position gain of tapping axis on rigid tapping (5280 is for all gears. 5281 to 5284 depend on the GR signal. 5284 is for T series only.)
4065 to 4068	Spindle position gain on rigid tapping (depends on CTH1 and CTH2 signals)
4044 to 4045	Velocity proportional gain on rigid tapping (depends on CTH1A signal)
4052 to 4053	Velocity integral gain on rigid tapping (depends on CTH1A signal)
4085	Motor voltage on rigid tapping (Set to 60.)
4099	Delay time for motor excitation (Specify a value around 300 to 400.)

(2) Spindle data used for adjustment

For this item, see Item 2.3.9-(3), “Spindle data used for adjustment”, in Part I.

(3) Adjustment procedure

For this item, see Item 2.3.9-(4), “Adjustment procedure”, in Part I.

2.3.10 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.3.10, “Diagnosis (Diagnosis Screen)”, in Part I.

2.3.11 Alarm

For this subsection, see Subsection 2.3.11, “Alarm”, in Part I.

2.4 SPINDLE SYNCHRONOUS CONTROL (OPTIONAL FUNCTION)

2.4.1 Start-up Procedure

A. Check that operation in velocity control mode is ready.

↓

B. Prepare and check the ladder programs for the spindle synchronous control function.

↓

C. Set the parameters related to spindle synchronous control.

↓

D. Connect a position coder and check the feedback signal.

↓

E. Check the spindle synchronous speed.

↓

F. Check the direction of spindle rotation when spindle synchronous control is applied.
- Direction of spindle motor rotation when spindle synchronous control is applied.

↓

G. Check that errors such as overshoot or hunting do not occur before the spindle achieves the maximum speed for synchronization.
- Position gain for spindle synchronous control
- Acceleration/deceleration time constant used for spindle synchronous control

↓

H. Check that the error pulse difference between the spindles is within ±5 pulses.
- Position gain for spindle synchronous control
- Spindle-to-motor gear ratio data
- Velocity loop proportional gain for spindle synchronous control
- Velocity loop integral gain for spindle synchronous control
- Bell-shaped acceleration/deceleration time constant for spindle synchronous control
- Motor voltage for spindle synchronous control

↓

I. Check the operation of spindle phase synchronization control.
- Shift amount for spindle phase synchronization
- Compensation data for spindle phase synchronization

↓

J. End the checking of spindle synchronous control operation.

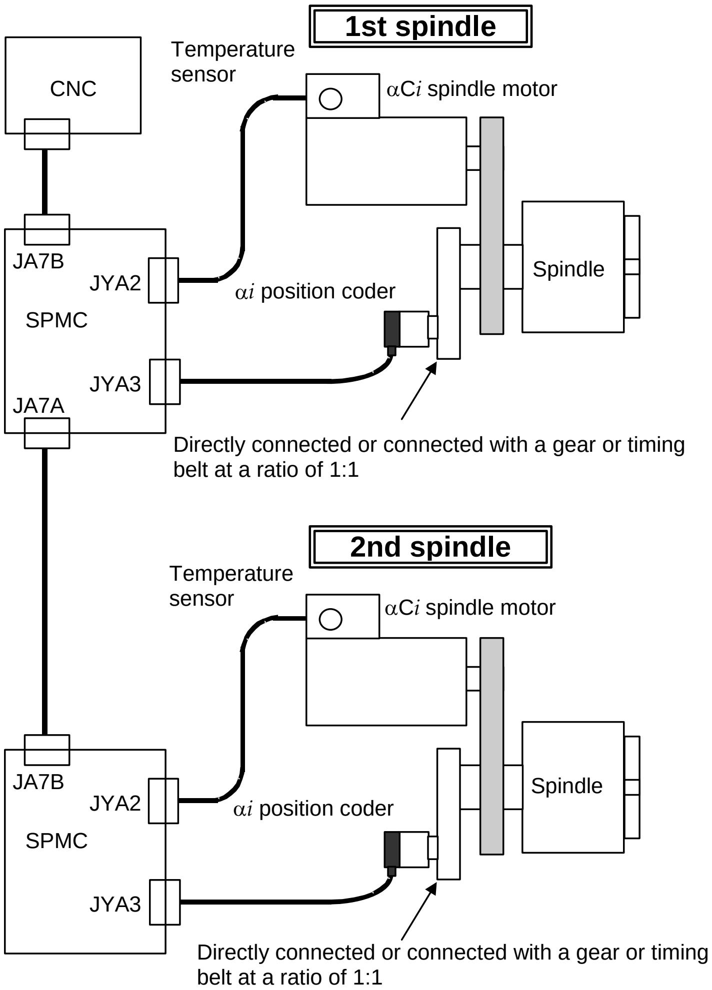
2.4.2 Overview

For this subsection, see Subsection 2.5.2, " Overview ", in Part I.

2.4.3 System Configuration

The system configurations that enable the use of the spindle synchronous control function are shown below.

(1) When the α*i* position coder is used



> **NOTE**
> The spindle sensor (separate detector) usable with the αC*i* series spindle amplifier is a position coder only.

2.4.4 Explanation of Operation

For this subsection, see Subsection 2.5.4, “Explanation of Operation “, in Part I.

2.4.5 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G038	G038					SPPHS	SPSYC		
Common to all axes	G032	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
Common to all axes	G033	G033			SSGN		R12I	R11I	R10I	R09I
1st-	G070	G070			SFRA	SRVA	CTH1A	CTH2A		
2nd-	G074	G074			SFRB	SRVB	CTH1B	CTH2B		
1st-	G071	G071			INTGA					
2nd-	G075	G075			INTGB					

(2) Details of input signals (PMC→CNC)

With the αC*i* series, the signals indicated in the item above are valid. For details of each signal, see Item 2.5.5-(2), “Details of input signals (PMC→CNC)”, in Part I.

(3) Address list of output signals (CNC→PMC)

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F044	F044				SYCAL	FSPPH	FSPSY		
1st-	F045	F045					SARA			
2nd-	F049	F049					SARB			

(4) Details of output signals (CNC→PMC)

With the αC*i* series, the signals indicated in the item above are valid. For details of each signal, see Item 2.5.5-(4), “Details of output signals (CNC→PMC)”, in Part I.

2.4.6 Examples of Sequences

For this subsection, see Subsection 2.5.6, “Examples of Sequences”, in Part I.

2.4.7 Related Parameters

Parameter No.		Description
16*i*	30*i*	
4800#0	-	Direction of rotation of the 1st spindle motor while spindle synchronous control is applied
4800#1	-	Direction of rotation of the 2nd spindle motor while spindle synchronous control is applied
-	4801#0	Direction of rotation of each spindle motor while spindle synchronous control is applied
4810	4810	Error pulse difference between the two spindles for turning on the spindle phase synchronous completion signal
4811	4811	Error pulse difference between the two spindles for issuing an alarm on spindle synchronous control
4002#6	4002#6	Whether to enable the rotation direction signal (SFR/SRV) function on spindle synchronous control

Parameter No.		Description
16*i*	30*i*	
4005#0	4005#0	Setting of the velocity feedback method
4006#1	4006#1	Gear ratio increment system
4006#3	4006#3	Setting for disabling automatic one-rotation signal detection at spindle synchronous control mode switching time
4032	4032	Acceleration used for spindle synchronous control (The same value must be set for both the 1st and 2nd spindles.)
4033	4033	Spindle synchronous speed arrival level
4034	4034	Shift amount for spindle phase synchronous control
4035	4035	Compensation data for spindle phase synchronous control
4044 4045	4044 4045	Velocity proportional gain on spindle synchronous control (A parameter is selected by the CTH1A PMC input signal.)
4052 4053	4052 4053	Velocity integral gain on spindle synchronous control (A parameter is selected by the CTH1A PMC input signal.)
4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data (A parameter is selected by the CTH1A and CTH2A PMC input signals.)
4065 to 4068	4065 to 4068	Position gain on spindle synchronous control (The same value must be specified for both the 1st and 2nd spindles.) (A parameter is selected by the CTH1A and CTH2A PMC input signals.)
4085	4085	Motor voltage on spindle synchronous control
4336	4336	Magnetic flux switching point used for calculating an acceleration/deceleration time constant used on spindle synchronous control (The same value must be specified for both the 1st and 2nd spindles.)
4340	4340	Bell-shaped acceleration/deceleration time constant on spindle synchronous control (The same value must be specified for both the first and second spindles.)

NOTE

1 For the detector-related parameters, see Section 1.3, "PARAMETERS RELATED TO DETECTORS", in Part III.

2 For velocity loop proportional/integral gain adjustment, see Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT", in Part III.

2.4.8 Details of Related Parameters

This subsection details the serial spindle parameters (in the four thousands for 16*i* and 30*i*) among the parameters related to spindle synchronous control. For details of other parameters, refer to the parameter manual of each CNC.

(a) For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.12, "SPINDLE SYNCHRONOUS CONTROL."

(b) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.13, "SPINDLE SYNCHRONOUS CONTROL."

(c) For Series 0*i*
"FANUC Series 0*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63833EN-1
Refer to Section 9.11, "SPINDLE SYNCHRONOUS CONTROL."

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4002	4002		SYCDRT						

SYCDRT Whether to enable the rotation direction signal (SFR/SRV) function on spindle synchronous control

0 : Enables the rotation direction function.
If a move command from the CNC is positive (+),

(a) The spindle rotates in the CCW direction when the input signal SFR (bit 5 of G70) = 1.

(b) The spindle rotates in the CW direction when the input signal SRV (bit 4 of G70) = 1.

1 : Disables the rotation direction function.
If a move command from the CNC is positive (+), the spindle rotates in the CCW direction when the input signal SFR = 1 or SRV = 1.

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4005	4005								VCTLPC

VCTLPC Sets the velocity feedback method.

0 : Exercises velocity control with an estimated velocity only.

1 : Uses a velocity calculated from the position coder signal to exercise velocity control.

Set to 1.

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4006	4006					SYCREF		GRUNIT	

GRUNIT Sets a gear ratio setting resolution:

0 : 1/100 unit

1 : 1/1000 unit

Select a gear ratio data setting resolution from the following:

(a) Resolution based on motor speed increased by a factor of 100 relative to one spindle rotation

(b) Resolution based on motor speed increased by a factor of 1000 relative to one spindle rotation

Depending on the setting of this parameter, the increment system of the parameters indicated in the table below changes.

Parameter No.		Description
16*i*	**30*i***	
4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data

NOTE

1 Usually, use the 1/100 unit (setting “0”).

2 When the 1/100 unit is set as the gear ratio setting resolution (with the bit set to 0), a steady-state synchronous error may be indicated due to the fraction of the gear ratio.
In such a case, the synchronous error can be improved when the 1/1000 unit is set as the gear ratio setting resolution (with the bit set to 1).

SYCREF Setting for function performing automatic detection of the one-rotation signal on spindle synchronous control

0 : Automatic detection of the one-rotation signal carried out

1 : Automatic detection of the one-rotation signal not carried out. (When spindle phase synchronization is not carried out)

When the mode is switched to spindle synchronous control mode after power-on, the two spindles automatically perform a one-rotation signal detection operation. So, the spindles automatically make two to three turns even if such turns are not intended.

This operation is required because the one-rotation signal must be detected to enable spindle phase synchronous control.

If the two spindles are mechanically connected to disable each spindle from performing a one-rotation signal detection operation, or if spindle phase synchronous control is not exercised, the operation above can be disabled by setting this bit to 1.

When this parameter is set to 1, check that the one-rotation signal has been detected for both spindles (output signal PC1DTA = 1) before applying the spindle phase synchronous control signal (SPPHS).

If the one-rotation signal is not detected, specify a speed of several ten min^{-1} or higher in spindle synchronous control mode, and wait until the one-rotation signal is detected. (See sequence example (4).)

16*i*	30*i*	
4032	4032	**Acceleration at spindle synchronous control**

Unit of data : $1min^{-1}/sec$

Valid data range : 0 to 32767

Standard setting : 0

This parameter sets an acceleration value for linear acceleration/deceleration when the synchronous speed command for spindle synchronous control is changed.

NOTE

1 Set exactly the same data for 1st spindle and 2nd spindle. When different data is set, synchronization between the two spindles is not guaranteed.

2 When this parameter is set to 0, the spindle doesn't accelerate or decelerate, so, be sure to set proper value in this parameter.

16*i*	30*i*	
4033	4033	**Spindle synchronous speed arrival level**

Unit of data : $1min^{-1}$

Valid data range : 0 to 32767

Standard setting : 10

For the synchronous speed command at spindle synchronous control, if the error of the respective spindle motor speeds are within the setting level, the spindle synchronous control complete signal (FSPSY) becomes "1".

16*i*	30*i*	
4034	4034	**Shift amount at spindle phase synchronous control**

Unit of data : 1 pulse unit (360°/4096)

Valid data range : 0 to 4095

Standard setting : 0

Sets the shift amount from the reference point at spindle phase synchronous control (one-rotation signal).

16*i*	30*i*	
4035	4035	**Spindle phase synchronous compensation data**

Unit of data : 1 pulse/2msec
Valid data range : 0 to 4095
Standard setting : 10

This parameter reduces speed fluctuations when aligning phase of spindles in spindle phase synchronous control.
When this parameter is “0”, since the phase alignment amount is only issued once, the position error quickly becomes large, and there are large speed changes on phase alignment.
It is possible to perform smooth phase alignments through issuing separate commands for phase alignment amounts for the number of 2 msec pulses set in this parameter.

16*i*	30*i*		
4044	4044	**Velocity loop proportional gain on servo mode/on spindle synchronous control (HIGH)**	**CTH1A=0**
4045	4045	**Velocity loop proportional gain on servo mode/on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : Varies with the motor model.

This parameter sets a velocity loop proportional gain on servo mode (rigid tapping/spindle positioning) or spindle synchronous control.
It is selected HIGH when CTH1A=0 of input signal, and It is selected LOW when CTH1A=1 of input signal.

16*i*	30*i*		
4052	4052	**Velocity integral gain on servo mode/on spindle synchronous control (HIGH)**	**CTH1A=0**
4053	4053	**Velocity integral gain on servo mode/on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : Depend on motor model.

This parameter sets a velocity loop integral gain on servo mode (rigid tapping/spindle positioning) or spindle synchronous control.
It is selected HIGH when CTH1A=0 of input signal, and It is selected LOW when CTH1A=1 of input signal.

NOTE
For velocity loop gain setting on spindle synchronous control and servo mode, the common parameters are used.

16*i*	30*i*		
4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100

(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)

Valid data range : 0 to 32767

Standard setting : 100

These parameters set the gear ratio of the spindle motor to the spindle.

When the motor rotates 2.5 times for each turn of the spindle, for example, set 250 in the parameter.

> **NOTE**
> 1 A parameter is selected by the input signals CTH1A and CTH2A. Ensure that the gear or clutch state corresponds to the input signals CTH1A and CTH2A. When the signals are not input correctly, the overcurrent alarm (spindle alarm 12) can be issued.
> 2 When using a position coder, be sure to set this parameter. If this parameter is not set correctly, the velocity error excess alarm (spindle alarm 02), motor binding alarm (spindle alarm 31), or gear ratio parameter setting error alarm (spindle alarm 35) may be detected.

16*i*	30*i*	
4065	4065	**Position gain on servo mode/on spindle synchronous control (HIGH) CTH1A=0, CTH2A=0**
4066	4066	**Position gain on servo mode/on spindle synchronous control (MEDIUM HIGH) CTH1A=0, CTH2A=1**
4067	4067	**Position gain on servo mode/on spindle synchronous control (MEDIUM LOW) CTH1A=1, CTH2A=0**
4068	4068	**Position gain on servo mode/on spindle synchronous control (LOW) CTH1A=1, CTH2A=1**

Unit of data : $0.01sec^{-1}$

Valid data range : 0 to 32767

Standard setting : 1000

This sets position gain on servo mode (rigid tapping/spindle positioning). It is selected by CTH1A or CTH2A of input signal.

> **NOTE**
> For velocity loop gain setting on spindle synchronous control and servo mode, the common parameters are used.

16*i*	30*i*	
4085	4085	**Motor voltage setting on spindle synchronous control**

Unit of data : 1%

Valid data range : 0 to 100

Standard setting : 60

Set a motor voltage for spindle synchronous control.

Usually, set to 60.

16*i*	30*i*	
4336	4336	**Acceleration switch point on spindle synchronous control**

Unit of data $1min^{-1}$

Valid data range : 0 to 32767

Standard setting : 0

This parameter sets a switching speed for acceleration on spindle synchronous control.

- Area above the set speed
  Linear acceleration/deceleration is performed according to the acceleration value set in the acceleration parameter (No. 4032) on spindle synchronous control.
- Area below the set speed
  Acceleration changes according to the torque characteristics of the spindle motor.

> **NOTE**
> 1 Set the same data for the first spindle and second spindle. If different data is set, synchronization between the two spindles is not guaranteed.
> 2 When this parameter is set to 0, linear acceleration/deceleration is performed.

16*i*	30*i*	
4340	4340	**Bell-shaped acceleration/deceleration time constant for spindle synchronous control**

Unit of data : 1msec
Valid data range : 0 to 512
Standard setting : 0

Set a bell-shaped acceleration/deceleration time constant used when the specified synchronous speed for spindle synchronous control is changed.
This parameter is applied to a move command after the acceleration/deceleration time constant at spindle synchronous control set in parameter No. 4032 is applied. Consequently, linear acceleration/deceleration is performed according to the time constant set in this parameter when 0 is set in parameter No. 4032.
When this parameter is set, the spindle synchronous speed control completion signal (FSPSY), output when the synchronous speed is first reached after the spindle synchronous control mode is entered, is delayed by the set time.

> **NOTE**
> Set the same data for the first spindle and second spindle. If different data is set, synchronization between the two spindles is not guaranteed.

2.4.9 Number of Error Pulses in Spindle Synchronous Control

For this subsection, see Subsection 2.5.9, “Number of Error Pulses in Spindle synchronous Control”, in Part I.

2.4.10 Specifying a Shift Amount for Spindle Phase Synchronous Control

For this subsection, see Subsection 2.5.10, “Specifying a Shift Amount for Spindle Phase Synchronous Control”, in Part I.

2.4.11 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.5.11, “Diagnosis (Diagnosis Screen)”, in Part I.

2.4.12 Alarm

For this subsection, see Subsection 2.5.12, “Alarm “, in Part I.

2.5 SPECIFICATIONS COMMON TO ALL OPERATION MODES

2.5.1 Overview

This section describes the I/O signals (CNC↔PMC), parameters, diagnosis signals, and alarms common to all operation modes.

2.5.2 List of I/O Signals (CNC↔PMC)

This subsection provides a list of the I/O signals related to spindle speed control only. For details of each signal, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, “SPINDLE SPEED CONTROL.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63833EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”

For details of the I/O signals common to the CNCs, see Chapter 3, “I/O SIGNALS (CNC↔PMC)”, in Part I.

(1) Input signals (PMC→CNC)

(a) Series 16*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(b) Series 30*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0

		#7	#6	#5	#4	#3	#2	#1	#0
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2

		#7	#6	#5	#4	#3	#2	#1	#0
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G005							FIN	

		#7	#6	#5	#4	#3	#2	#1	#0
1st-	G024	RI7A	RI6A	RI5A	RI4A	RI3A	RI2A	RI1A	RI0A
2nd-	G232	RI7B	RI6B	RI5B	RI4B	RI3B	RI2B	RI1B	RI0B

		#7	#6	#5	#4	#3	#2	#1	#0
1st-	G025	RISGNA			RI12A	RI11A	RI10A	RI9A	RI8A
2nd-	G233	RISGNB			RI12B	RI11B	RI10B	RI9B	RI8B

		#7	#6	#5	#4	#3	#2	#1	#0
1st-	G026		GS4A	GS2A	GS1A				
2nd-	G272		GS4B	GS2B	GS1B				

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA		SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA (*1)
2nd-	G235	G074	G074	MRDYB		SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB (*1)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G226	G071	G071							*ESPA	ARSTA
2nd-	G234	G075	G075							*ESPB	ARSTB

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G228	G073	G073						MPOFA		
2nd-	G236	G077	G077						MPOFB		

NOTE
1 The signal functions of the αC*i* series differ from those of the α*i* series. For details, see Chapter 3, "I/O SIGNALS (CNC↔PMC)", in Part III.

(2) Output signals (CNC→PMC)

(a) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O

NOTE
1 These signals are valid with the M series only.

(b) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O

NOTE
1 These signals are valid with the M series only.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F008							SF	
Common to all axes	F020	S7	S6	S5	S4	S3	S2	S1	S0
Common to all axes	F021	S15	S14	S13	S12	S11	S10	S09	S08
Common to all axes	F022	S23	S22	S21	S20	S19	S18	S17	S16
Common to all axes	F023	S31	S30	S29	S28	S27	S26	S25	S24
Common to all axes	F045			SRSRDY					
1st-	F010	RO7A	RO6A	RO5A	RO4A	RO3A	RO2A	RO1A	RO0A
2nd-	F320	RO7B	RO6B	RO5B	RO4B	RO3B	RO2B	RO1B	RO0B
1st-	F11	RO15A	RO14A	RO13A	RO12A	RO11A	RO11A	RO10A	RO9A
2nd-	F321	RO15B	RO14B	RO13B	RO12B	RO11B	RO11B	RO10B	RO9B
1st-	F014	MR7A	MR6A	MR5A	MR4A	MR3A	MR2A	MR1A	MR0A
2nd-	F324	MR7B	MR6B	MR5B	MR4B	MR3B	MR2B	MR1B	MR0B
1st-	F015	MR15A	MR14A	MR13A	MR12A	MR11A	MR10A	MR9A	MR8A
2nd-	F325	MR15B	MR14B	MR13B	MR12B	MR11B	MR10B	MR9B	MR8B
1st-	F234	SSPD7A	SSPD6A	SSPD5A	SSPD4A	SSPD3A	SSPD2A	SSPD1A	SSPD0A
2nd-	F250	SSPD7B	SSPD6B	SSPD5B	SSPD4B	SSPD3B	SSPD2B	SSPD1B	SSPD0B
1st-	F235	SSPD15A	SSPD14A	SSPD13A	SSPD12A	SSPD11A	SSPD10A	SSPD9A	SSPD8A
2nd-	F251	SSPD15B	SSPD14B	SSPD13B	SSPD12B	SSPD11B	SSPD10B	SSPD9B	SSPD8B
1st-	F341								SRRDYA
2nd-	F342								SRRDYB

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045		TLMA	LDT2A	LDT1A	SARA	SDTA	SSTA	ALMA
2nd-	F245	F049	F049		TLMB	LDT2B	LDT1B	SARB	SDTB	SSTB	ALMB
1st-	F231	F047	F047								PC1DTA
2nd-	F247	F051	F051								PC1DTB

2.5.3 Parameters

This subsection describes those parameters that are common to all operation modes by dividing them into several types.

> **NOTE**
> For the detector-related parameters, see Section 1.3, "PARAMETERS RELATED TO DETECTORS", in Part III.

(1) List of parameters specific to spindle motor driving

This item provides a list of the motor parameters specific to spindle motor driving. Usually, the settings of these parameters need not be changed. Use the values indicated on a parameter table for each motor model without modification.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3011#3	4011#3	4011#3	Sets the number of motor polarities.
3011#4	4011#4	4011#4	Sets a maximum output for acceleration/deceleration.
3011#7	4011#7	4011#7	Sets the number of motor polarities.
3012#2,#1,#0	4012#2,#1,#0	4012#2,#1,#0	Sets a PWM carrier frequency.
3013#6 to #2	4013#6 to #2	4013#6 to #2	Sets current dead-band data.
3020	4020	4020	Maximum motor speed
3080	4080	4080	High-speed area regenerative power limit/regenerative power limit
3083	4083	4083	Motor voltage on velocity control motor
3100	4100	4100	Base speed for motor output specification
3101	4101	4101	Torque limitation value for motor output specification
3102	4102	4102	Excitation voltage saturation speed with no load
3103	4103	4103	Base speed limit ratio
3104	4104	4104	Current loop proportional gain
3105	4105	4105	Current loop integral gain
3106	4106	4106	D-axis current loop gain
3107	4107	4107	Q-axis current loop gain
3108	4108	4108	Q-axis current deviation limitation coefficient
3109	4109	4109	Filter time constant in voltage command saturation processing
3110	4110	4110	Current conversion constant
3111	4111	4111	Secondary current coefficient
3112	4112	4112	Voltage command saturation decision level/PWM command clamp value
3113	4113	4113	Slip constant
3115	4115	4115	PWM command clamp value at deceleration time
3116	4116	4116	Motor leakage constraint
3117	4117	4117	Voltage compensation coefficient for a high-speed area in steady state/motor voltage coefficient in steady state
3118	4118	4118	Voltage compensation coefficient for a high-speed area at deceleration time/motor voltage coefficient at deceleration time
3119	4119	4119	Time constant for excitation current change at deceleration time/time constant for excitation current change
3120	4120	4120	Dead-band compensation data
3127	4127	4127	Load meter indication value at maximum output time
3128	4128	4128	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient
3130	4130	4130	Current loop proportional gain velocity coefficient/current phase delay compensation constant
3131	4131	4131	Dead-band compensation hysteresis
3133	4133	4133	Motor model code
3134	4134	4134	Motor overheat level (2 words)

(2) List of parameters related to alarm detection

This item provides a list of the parameters related to alarm detection conditions.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3009#2	4009#2	4009#2	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued
3086	4086	4086	Gear ratio parameter setting error alarm (spindle alarm 35) detection level
3088	4088	4088	Velocity error excess detection level when the motor is bound

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3089	4089	4089	Velocity error excess detection level when the motor is rotating
3090	4090	4090	Overload detection level
3123	4123	4123	Short-time overload detection period

(3) Other parameters

This item provides a list of the parameters common to all operation modes except the parameters listed in Items (1) and (2) above.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
-	3706#1,#0	-	Gear ratio between the spindle and position coder (cases of ×1, ×2, ×4, ×8)
5602#3	-	-	Whether to indicate an alarm detected by the spindle amplifier (Usually, set 0.)
5807#0	-	-	Enables/disables the spindle alarms (SPxxxx) of all spindles. (Usually, set 0.)
5842	-	3720	Number of position coder pulses
5850	-	-	Spindle number selected at power-on/reset time
3001#0	4001#0	4001#0	Whether to use the MRDY signal (machine ready signal)
3002#4	4002#4	4002#4	SM pin output data selection
3005#0	4005#0	4005#0	Setting of the velocity feedback method
3006#1	4006#1	4006#1	Gear ratio increment system
3006#2	4006#2	4006#2	Sets the unit of speed.
3009#4	4009#4	4009#4	Whether to output the load detection signal (LDT1A) during acceleration/deceleration
3019#7	4019#7	4019#7	Automatic parameter setting function
3020	4020	4020	Maximum motor speed
3022	4022	4022	Speed arrival detection signal
3023	4023	4023	Speed detection level
3024	4024	4024	Speed zero detection level
3025	4025	4025	Torque limitation value.
3026	4026	4026	Load detection level 1
3056	4056	4056	Gear ratio (High)
3057	4057	4057	Gear ratio (Medium High)
3058	4058	4058	Gear ratio (Medium Low)
3059	4059	4059	Gear ratio (Low)
3078	4078	4078	Gear switch timer
3095	4095	4095	Speedometer output voltage adjustment value
3121	4121	4121	Torque change time constant (torque command filter time constant)

2.5.4 Details of parameters

This subsection details the serial spindle parameters (in the four thousands for 16*i*, in the four thousands for 30*i*, and in the three thousands for 15*i*) among the parameters common to all operation modes. For details of other parameters, refer to the parameter manual of each CNC.

(1) List of parameters specific to spindle motor driving

Usually, the settings of the motor parameters specific to spindle motor driving need not be changed. Their details are omitted.

(2) List of parameters related to alarm detection

This item details the parameters related to alarm detection conditions.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3009	4009	4009						ALSP		

ALSP Motor power turn-off method when serial data transfer error (spindle alarm 24) is issued
0 : Turns off the power after the motor is decelerated and stopped.
1 : Turns off the power to the motor immediately.
Set this parameter to 1 to turn off the power to the motor immediately when any spindle alarm is issued

15*i*	16*i*	30*i*	
3086	4086	4086	**Gear ratio parameter setting error alarm (spindle alarm 35) detection level**

Unit of data : 1min^{-1}
Valid data range : 0 to 32767
Standard setting value : 0 (equivalent to 500 min^{-1})

This parameter sets the detection level of the gear ratio parameter setting error alarm (spindle alarm 35).
When the difference between the motor speed calculated from the position coder feedback and gear ratio parameters (No. 4056 to No. 4059) and the estimated motor speed calculated with control software becomes equal to or greater than the setting, the gear ratio parameter setting error alarm (spindle alarm 35) is issued.
When the standard setting (0) is used, the setting of 500 min^{-1} is assumed.

15*i*	16*i*	30*i*	
3088	4088	4088	**Velocity error excess detection level when the motor is bound**

Unit of data : 0.01%
Valid data range : 0 to 10000
Standard setting value : 75

This parameter sets a velocity error excess (spindle alarm 31) detection level when the motor is bound.
If a velocity error equal to or greater than [maximum motor speed (No. 4020) × setting data (%)] occurs when the motor is bound, for example, the motor binding alarm (spindle alarm 31) is issued.

15*i*	16*i*	30*i*	
3089	4089	4089	**Velocity error excess detection level when the motor is rotating**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 200

This parameter sets a velocity error excess detection level when the motor is rotating.
If a velocity error equal to or greater than [maximum motor speed (No. 4020) × setting data (%)] occurs, the velocity error excess alarm (spindle alarm 02) is issued.

15*i*	16*i*	30*i*	
3090	4090	4090	**Overload detection level**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 90

This parameter sets a condition for detecting the short-time overload alarm (spindle alarm 29).

If the state where a load equal to or greater than setting data (%) (maximum motor output = 100%) is imposed on the spindle motor lasts for a specified period (set in No. 4123) or more, the short-time overload alarm (spindle alarm 29) is issued.

15*i*	16*i*	30*i*	
3123	4123	4123	**Short-time overload detection period**

Unit of data : 1sec
Valid data range : 0 to 500
Standard setting value : 30

This parameter sets the timing for detecting the short-time overload alarm (spindle alarm 29).
If the state where a load equal to or greater than the specified value (set in parameter No. 4090) is imposed on the spindle motor lasts for at least the period specified in this parameter, the short-time overload alarm (spindle alarm 29) is issued.

(3) Other parameters

This item details the parameters common to all operation modes except the parameters listed in Items (1) and (2) above.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3001	4001	4001								**MRDY1**

MRDY1 Whether to use the MRDYA signal (machine ready signal)
0 : Does not uses the MRDYA signal (MRDYA = 1 at all times).
1 : Uses the MRDYA signal.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3002	4002	4002				**SMORLM**				

SMORLM SM pin output data selection
0 : Speedometer data
1 : Load meter data

15*i*	16*i*	30*i*	**#7**	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**
3005	4005	4005								**VCTLPC**

VCTLPC Sets the velocity feedback method.
0 : Exercises velocity control with an estimated velocity only.
1 : Uses a velocity calculated from the position coder signal to exercise velocity control.
The feedback signal from a position coder attached to a spindle on a 1:1 basis is converted to motor speed data for velocity control. Set this bit to 1 when performing orientation, rigid tapping, or spindle synchronous control.
By setting this bit to 1 even in ordinary velocity control, the response characteristics and stability of velocity control can be improved.

NOTE

1 The feature may not be fully utilized, depending on the connection ratio between the spindle and spindle motor or between the spindle and position coder, the rigidity of the connection, the precision of position coder attachment, and so forth.

2 When this bit is set to 1 with a spindle that has a gear switch mechanism, the torque limitation command signal (TLMLA) must be input at the start of gear switching. For details, see Chapter 3, "I/O SIGNALS (CNC↔PMC)", in Part III.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3006	4006	4006						SPDUNT	GRUNIT	

GRUNIT Sets a gear ratio setting resolution:

0 : 1/100 unit

1 : 1/1000 unit

Select a gear ratio data setting resolution from the following:

(a) Resolution based on motor speed increased by a factor of 100 relative to one spindle rotation

(b) Resolution based on motor speed increased by a factor of 1000 relative to one spindle rotation

Depending on the setting of this parameter, the increment system of the parameters indicated in the table below changes.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3056 to 3059	4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data

NOTE

Usually, use the 1/100 unit (setting "0").

SPDUNT Sets the unit of speed.

Set to 0.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3009	4009	4009				LDTOUT				

LDTOUT Whether to output the load detection signal (LDT1A) during acceleration/deceleration

0 : Does not output the load detection signals during acceleration/ deceleration (standard setting value).

1 : Outputs the load detection signals during acceleration/ deceleration (at all times) when the parameter-set level is exceeded.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3019	4019	4019	PRLOAD					SSTTRQ		

SSTTRQ Whether to perform torque clamping when the speed is zero

0 : Performs clamping.

1 : Does not perform clamping.

> **NOTE**
> Usually, set this parameter to 1 not to perform clamping.

PRLOAD Automatic parameter setting function

0 : Does not perform automatic parameter setting (standard setting value).

1 : Performs automatic parameter setting.

After setting a desired motor model code in parameter No. 4133 and setting this bit to 1, turn off the power to the CNC, then turn on the power to the CNC again. The parameters (No. 4000 to No. 4175) for the αC*i* series spindle corresponding to the model code are automatically initialized. Upon completion of automatic setting, this bit is automatically set to 0.

> **NOTE**
> With FS15*i*, the parameter address of this function is different, namely, bit 0 of No. 5607 is used. Moreover, note that the meanings of settings are reversed as follows.
> 0: Performs automatic parameter setting.
> 1: Does not perform automatic parameter setting.
> In this case, set a model code in parameter No. 3133.

15*i*	16*i*	30*i*	
3020	4020	4020	**Maximum motor speed**

Unit of data : $1 min^{-1}$
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

This parameter sets a maximum spindle motor speed.

15*i*	16*i*	30*i*	
3022	4022	4022	**Speed arrival detection signal**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 150

This parameter sets a speed arrival signal (SARA) detection range.
When the motor speed (estimated value) reaches within ±(setting data/10)% of a specified speed, the speed arrival signal (SARA) is set to 1.

15*i*	16*i*	30*i*	
3023	4023	4023	**Speed detection level**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 30

This parameter sets a speed detection signal (SDTA) detection range.
When the motor speed (estimated value) is (setting data/10)% of a maximum speed or less, the speed detection signal (SDTA) is set to 1.

15*i*	16*i*	30*i*	
3024	4024	4024	**Speed zero detection level**

Unit of data : 0.01%

Valid data range : 0 to 10000
Standard setting value : 75

This parameter sets a speed zero detection signal (SSTA) detection range.
When the motor speed (estimated value) is (setting data/100)% of a maximum speed or less, the speed zero detection signal (SSTA) is set to 1.

15*i*	16*i*	30*i*	
3025	4025	4025	**Torque limitation value.**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 50

This parameter sets a torque limitation value to be applied when the torque limitation command HIGH (TLMHA) is specified.
The data indicates limitation values when the maximum torque is 100%.

Torque limitation command HIGH (TLMHA)	Description
0	No torque limitation is imposed.
1	The torque is limited to the value set in this parameter.

15*i*	16*i*	30*i*	
3026	4026	4026	**Load detection level 1**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 83

This parameter sets a load detection signal 1 (LDT1A) detection range.
When the output of the spindle motor is (setting data)% of the maximum output or more, load detection signal 1 (LDT1A) is set to 1.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting value : 100

These data are used to set the gear ratio between spindle and spindle motor.
Example :
When the spindle rotates once, set “250” as the data when the motor rotates 2.5 times.

NOTE

1. A parameter is selected by the input signals CTH1A and CTH2A. Ensure that the gear or clutch state corresponds to the input signals CTH1A and CTH2A. When the signals are not input correctly, the overcurrent alarm (spindle alarm 12) can be issued.
2. When using a position coder, be sure to set this parameter. If this parameter is not set correctly, the velocity error excess alarm (spindle alarm 02), motor binding alarm (spindle alarm 31), or gear ratio parameter setting error alarm (spindle alarm 35) may be detected.
3. When an improper value is set in this parameter, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*	
3078	4078	4078	**Gear switch timer**

Unit of data : 1sec
Valid data range : 0 to 500
Standard setting value : 0

For a spindle that has a gear switch mechanism, this parameter sets a period of time from the start of a gear switch sequence (input of the TLML signal) until the gear shifter is actually started. For details, see Chapter 3, "I/O SIGNALS (CNC↔PMC)", in Part III.
For a spindle that has no gear switch mechanism, set this parameter to 0.

15*i*	16*i*	30*i*	
3095	4095	4095	**Speedometer output voltage adjustment value**

Unit of data : 0.1%
Valid data range : -1000 to +100(-100% to +10%)
Standard setting value : 0

Set this parameter when making a fine adjustment of speedometer terminal output voltage.
Positive (+) data increases the output voltage.

NOTE

Usually, this parameter need not be adjusted.

15*i*	16*i*	30*i*	
3121	4121	4121	**Torque command filter time constant**

Unit of data : 0.5msec
Valid data range : 0 to 32767
Standard setting value : 5

Basically, use the standard setting value 5 (time constant of 2.5 ms).

2.5.5 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.6.5, "Diagnosis (Diagnosis Screen)", in Part I.

3 I/O SIGNALS (CNC↔PMC)

This chapter explains the functions of the signals directly input from the PMC to SPMC via the CNC and the signals directly output from the SPMC to PMC. For other spindle-related I/O signals, refer to the Connection Manual (Function) of the relevant CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Chapter 9 “SPINDLE SPEED FUNCTION.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3 “SPINDLE SPEED CONTROL.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7 “SPINDLE SPEED FUNCTION.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63833EN-1
Refer to Chapter 9 “SPINDLE SPEED FUNCTION.”

3.1 INPUT SIGNALS (PMC→CNC→SPMC)

This section explains the functions of the signals directly input from the PMC to SPMC via the CNC. For other spindle-related input signals, refer to the Connection Manual (Function) of the relevant CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Chapter 9 “SPINDLE SPEED FUNCTION.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Chapter 11 “SPINDLE SPEED FUNCTION.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7 “SPINDLE SPEED FUNCTION.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63833EN-1
Refer to Chapter 9 “SPINDLE SPEED FUNCTION.”

3.1.1 List of Input Signals

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA	ORCMA	SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA
2nd-	G235	G074	G074	MRDYB	ORCMB	SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB
1st-	G226	G071	G071			INTGA				*ESPA	ARSTA
2nd-	G234	G075	G075			INTGB				*ESPB	ARSTB
1st-	G229	G072	G072			INCMDA	OVRA		NRROA	ROTAA	INDXA
2nd-	G237	G076	G076			INCMDB	OVRB		NRROB	ROTAB	INDXB
1st-	G228	G073	G073						MPOFA		
2nd-	G236	G077	G077						MPOFB		

3.1.2 Explanation of Input Signals

For information about the signals listed in Subsection 3.1.1, “List of Input Signals”, in Part III, see Subsection 3.1.2, “Explanation of Input Signals”, in Part I.

Those signals that are not listed in Subsection 3.1.1, “List of Input Signals”, in Part III are not used with the αC*i* series spindle.

This subsection describes only those signals that have different specifications for use with the αC*i* spindle.

Symbol	Name	Description
TLMLA, TLMLB	Torque limitation command LOW	Switches to a speed control method that uses speed estimation during gear switching. 0: - 1: Performs speed control using only speed estimation. (However, there is the delay set by the gear switching timer [No.4078].)

3.1.3 Details of Input Signals

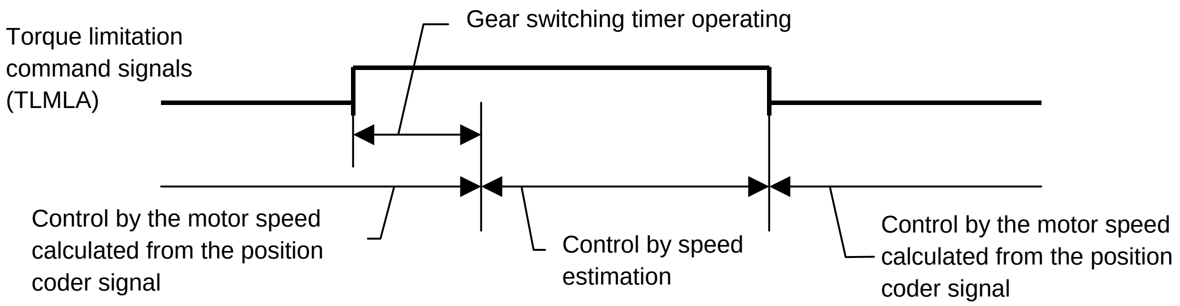
For information about the signals listed in Subsection 3.1.1, “List of Input Signals”, in Part III, see Subsection 3.1.3, “Details of input signals”, in Part I.

Those signals that are not listed in Subsection 3.1.1, “List of Input Signals”, in Part III are not used with the αC*i* series spindle.

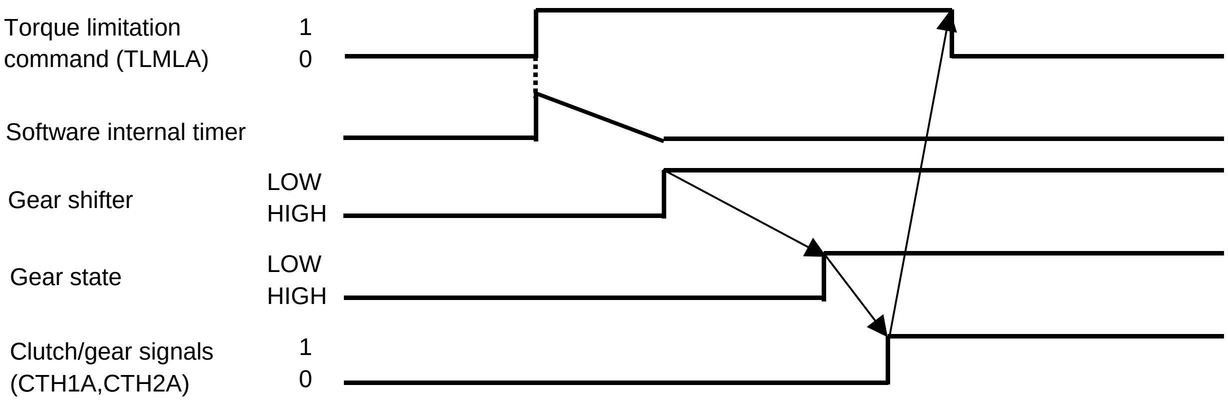
This subsection describes only those signals that have different specifications for use with the αC*i* spindle.

(a) Torque limitation command signals (TLMLA)

If gear switching is performed with the setting (No.4005#0=“1”) that uses motor speed calculated from the position coder signal to perform speed control, the state of machine gear may not match the state of the gear ratio parameter. This can cause an alarm to occur due to speed control using incorrect speed data. Therefore, switch to a control method that uses the speed estimation during gear switching by inputting the torque limitation command signal (TLMLA) upon start of gear switching so that gear switching is performed smoothly. In addition, set the time from when a gear switching sequence starts to when the gear shifter actually operates for parameter No.4078 (gear switching timer). (See below.)



(Example of a recommended sequence)



3.2 OUTPUT SIGNALS (SPMC→CNC→PMC)

This section explains the functions of the signals directly output from the SPMC to PMC via the CNC. For other spindle-related output signals, refer to the Connection Manual (Function) of the relevant CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Chapter 9 “SPINDLE SPEED FUNCTION.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3 “SPINDLE SPEED CONTROL.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7 “SPINDLE SPEED FUNCTION.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63833EN-1
Refer to Chapter 9 “SPINDLE SPEED FUNCTION.”

3.2.1 List of Output Signals

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA	TLMA		LDT1A	SARA	SDTA	SSTA	ALMA
2nd-	F245	F049	F049	ORARB	TLMB		LDT1B	SARB	SDTB	SSTB	ALMB
1st-	F231	F047	F047							INCSTA	PC1DTA
2nd-	F247	F051	F051							INCSTB	PC1DTB

3.2.2 Explanation of Output Signals

For information about the signals listed in Subsection 3.2.1, “List of Output Signals”, in Part III, see Subsection 3.2.2, “Explanation of Output Signals”, in Part I.
Those signals that are not listed in Subsection 3.2.1, “List of Output Signals”, in Part II are not used with the αC*i* series spindle.

3.2.3 Details of Output Signals

For information about the signals listed in Subsection 3.2.1, “List of Output Signals”, in Part III, see Subsection 3.2.3, “Details of Output Signals”, in Part I.
Those signals that are not listed in Subsection 3.2.1, “List of Output Signals”, in Part III are not used with the αC*i* series spindle.

4 ADJUSTMENT

4.1 VELOCITY LOOP GAIN ADJUSTMENT

4.1.1 Overview

Optimum adjustment of the velocity loop gain increases the position loop gain, therefore significantly enhancing disturbance suppression performance, positioning speed and accuracy. So, the adjustment of the velocity loop gain is very important in servo adjustments, and it should be performed first. This section explains the parameters for velocity loop gain adjustment and the adjustment procedure.
To check the waveform of a torque command, position error, or so on, use the spindle check board and an oscilloscope, or the servo guide (see Appendix F).

4.1.2 Parameters

There are four operation modes in spindle control: velocity control mode, orientation, servo mode (rigid tapping and spindle positioning), and spindle synchronous control. There are parameters corresponding to each operation mode and to the clutch/gear signals (CTH1A and CTH2A). The following shows the parameters for each operation mode.

(1) Velocity control mode

15*i*	16*i*	30*i*		
3040	4040	4040	**Velocity loop proportional gain on velocity control mode (HIGH)**	**CTH1A=0**
3041	4041	4041	**Velocity loop proportional gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

15*i*	16*i*	30*i*		
3048	4048	4048	**Velocity loop integral gain on velocity control mode (HIGH)**	**CTH1A=0**
3049	4049	4049	**Velocity loop integral gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

(2) Orientation

15*i*	16*i*	30*i*		
3042	4042	4042	**Velocity loop proportional gain on orientation (HIGH)**	**CTH1A=0**
3043	4043	4043	**Velocity loop proportional gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

15*i*	16*i*	30*i*		
3050	4050	4050	**Velocity loop integral gain on orientation (HIGH)**	**CTH1A=0**
3051	4051	4051	**Velocity loop integral gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

(3) Servo mode (Rigid tapping and spindle positioning)

15*i*	16*i*	30*i*		
3044	4044	4044	**Velocity loop proportional gain on servo mode (HIGH)**	**CTH1A=0**
3045	4045	4045	**Velocity loop proportional gain on servo mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

15*i*	16*i*	30*i*		
3052	4052	4052	**Velocity loop integral gain on servo mode (HIGH)**	**CTH1A=0**
3053	4053	4053	**Velocity loop integral gain on servo mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

(4) Spindle synchronous control

15*i*	16*i*	30*i*		
-	4044	4044	**Velocity loop proportional gain on spindle synchronous control (HIGH)**	**CTH1A=0**
-	4045	4045	**Velocity loop proportional gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

15*i*	16*i*	30*i*		
-	4052	4052	**Velocity loop integral gain on spindle synchronous control (HIGH)**	**CTH1A=0**
-	4053	4053	**Velocity loop integral gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

> **NOTE**
> For the velocity loop gain on spindle synchronous control and on the servo mode, common parameters are used.

4.1.3 Adjustment Procedure

(1) Start of each operation mode

In preparation for the adjustment, settings must be made so that a stable operation takes place in each mode without overshoot or oscillation.

See Chapter 2, “EXPLANATION OF OPERATION MODES”, temporarily set parameters (acceleration/deceleration time constant, position gain, and so on) to make operations stable in each operation mode, and confirm operations.

> **NOTE**
> When the rigidity of the spindle is low, the standard setting of the velocity loop gain may be so high that oscillation can occur. In such a case, decrease the velocity loop gain.

(2) Adjustment

When adjusting the velocity loop gain, check the operation mode and clutch/gear signal, and modify corresponding parameters. Follow the steps below to adjust the parameters:

<1> Determining the oscillation limit

Basically, determine the oscillation limit based on torque commands, position errors, vibration, sound, and so on when the motor is stopped (for orientation, after completion of the operation) or when the motor rotates at a certain speed not higher than the base speed. Usually, increase the settings of the proportional gain and integral gain in steps of about 10. As the settings are increased gradually, the symptoms below start to appear at a certain setting level. The settings at this level are determined to be the oscillation limit:

- The machine vibrates or produces large sound.
- Vibration of a torque command becomes large.
- Position errors at stop time vary largely.

> **NOTE**
> The oscillation limit varies with the spindle inertia. In a machine in which the inertia varies largely according to the tool and workpiece used, adjustment must be made in the smallest inertia state.

<2> Final settings

Set proportional gain of approximately 70% of the oscillation limit. Make an adjustment to set an integral gain that is about four to ten times greater than the proportional gain.

4.1.4 Additional Information (Position Gain Adjustment)

Although the limit value of the position gain is determined basically depending on the velocity loop characteristics, the setting standards may vary depending on the operation mode. See Chapter 2, “EXPLANATION OF OPERATION MODES”, and make adjustments accordingly.

IV. FANUC BUILT-IN SPINDLE MOTOR B*i*S series

1 START-UP

1.1 START-UP PROCEDURE

A. Check the spindle-related specifications.
- CNC model
- Spindle motor
- Power supply (PS)
- Spindle amplifier
- Sub module SM (SSM)
- Detector system

B. Check all connections. (See DESCRIPTIONS.)

C. Prepare and check the PMC ladder program.

D. Check the CNC parameter setting for using the B*i*S series (Serial) spindle. (See Subsection 1.2.1.)

E. Perform automatic B*i*S series (Serial) spindle parameter initialization. (See Subsection 1.2.2.)
- Set a motor model code "300" and the parameter enabling use of the automatic parameter initialization function, then turn the CNC off and then on again.

F. Change parameter data.
- Perform automatic initialization by specifying "300", then change the parameter data according to the parameter list for the motor.

G. Set the parameters related to the detectors. (See Section 1.3.)

H. Set the parameter related to Sub module SM (SSM) and confirm it. (See Section 1.4.)

I. When using a machine in a system that has already been started, load all CNC parameters for the machine. After loading all parameters, set "0" to the parameters (e.g. No.4084, No.4355/No.4356 etc.) which shoud be adjusted in each machine.

J. Check the waveforms of the feedback signals from detectors. (Refer to the MAINTENANCE MANUAL.)

K. Set and check the parameters related to magnetic pole detection and adjust an AMR offset. (See Section 1.5.)

1.2 SPINDLE SERIAL INTERFACE (OPTIONAL FUNCTION)

1.2.1 Parameters Related to Spindle Serial Output

For this subsection, see Subsection 1.2.1, “Parameters Related to Spindle Serial Output”, in Part I.

1.2.2 Automatic Spindle Parameter Initialization

(1) Parameter list

Parameter No.			Description
15*i*	16*i*	30*i*	
5607#0	4019#7	4019#7	Function for automatically initializing spindle parameters
3133	4133	4133	Spindle motor model code

(2) Procedure for automatic spindle parameter initialization

Perform spindle parameter initialization by following the procedure below.

<1> Set model code “300”.

Parameter No.			Description
15*i*	16*i*	30*i*	
3133	4133	4133	Model code

<2> Set the relevant parameter to enable automatic spindle parameter initialization.

Parameter No.			Description
15*i*	16*i*	30*i*	
-	4019#7	4019#7	1
5607#0	-	-	0

> **NOTE**
> This bit is reset to its original value after automatic parameter initialization.

<3> Turn off then turn on again the power to the CNC. The spindle parameter data common to each model is automatically initialized.
<4> Input parameters manually according to the model-by-model parameter list.
<5> Set detector-related parameters according to the detector configuration.

1.2.3 Automatic Setting of the Parameter for Specifying the PS Management Axis

For this subsection, see Subsection 1.2.3, "Automatic Setting of the Parameter for Specifying the PS Management Axis", in Part I.

1.2.4 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 1.2.4, “Diagnosis (Diagnosis Screen)”, in Part I.

1.2.5 Alarm

For this subsection, see Subsection 1.2.5, “Alarm”, in Part I.

1.3 PARAMETERS RELATED TO DETECTORS

> **NOTE**
> 1 Note that the specifications of parameters related to detectors for the αi series spindle amplifiers differ from those of parameters for the α series spindle amplifiers.
> 2 The sensor used with the B*i*S series spindle is an αiBZ sensor or αiCZ sensor (analog or serial). In the case of the αiCZ sensor (serial), however, use spindle software 9D80 series H (08) edition, 9D90 series A (01) edition, or 9DA0 series (01) edition or later.

1.3.1 List of Parameters for Detectors

For this subsection, see Subsection 1.3.1, "List of Parameters for Detectors", in Part I.

1.3.2 Details of Parameters for Detectors

For this subsection, see Subsection 1.3.2, "Details of Parameters for Detectors", in Part I.

1.3.3 Series and Editions of Applicable Spindle Software

・When the αiBZ sensor or αiCZ (analog) sensor is used
 9D53 series A (01) edition or later
 9D70 series A (01) edition or later
 9D80 series B (02) edition or later
 9D90 series A (01) edition or later
 9DA0 series A (01) edition or later

・When the αiCZ (serial) sensor is used
 9D80 series H (08) edition or later
 9D90 series A (01) edition or later
 9DA0 series A (01) edition or later

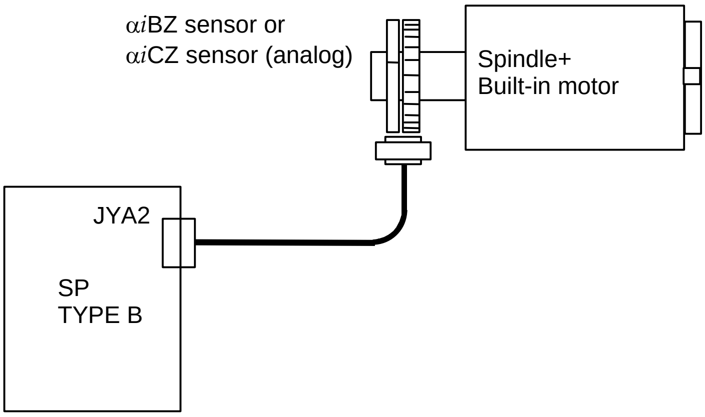
1.3.4 Typical Detector Configurations

This subsection describes the detector configuration of the B*i*S series spindle and the parameter setting procedure applicable to the detector configuration.
With the B*i*S series spindle, the detector circuitry hardware is set according to the parameter setting. For this reason, an alarm such as a disconnection alarm may be output while parameters related to detectors are being set.
To initialize the hardware, after setting the parameters related to detectors, turn the power to the amplifier off once.

> **NOTE**
> In the sample system configurations below, spindle amplifier (SP) TYPE B is used, assuming that the sub module SM is connected.

(1) When the α*i*BZ or α*i*CZ sensor (analog) is used

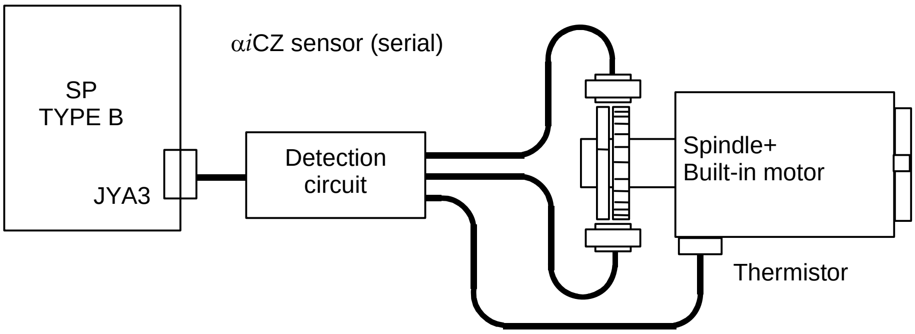
[Sample system configuration]



Parameter	Settings	Description
4000 #0	0	Rotation directions of the spindle and motor
4002 #3,#2,#1,#0	0,0,0,1	Uses the motor sensor for position feedback.
4010 #2,#1,#0	0,0,1	Uses the α*i*BZ or α*i*CZ sensor (analog) as the motor sensor.
4011 #2,#1,#0	Depends on the detector.	Sets the number of motor sensor gear teeth.
4056 to 4059	100 or 1000	Gear ratio between the spindle and motor 1 : 1

(2) When the α*i*CZ sensor (serial) is used

[Sample system configuration]



Parameter	Settings	Description
4000 #0	0	Rotation directions of the spindle and motor
4002 #3,2,1,0	0,0,0,1	Uses the motor sensor for position feedback.
4007 #5	0	Feedback signal disconnection detection is enabled.
4007 #6	0	Alarms related to position feedback signals are enabled.
4010 #2,1,0	0,1,1	Uses the α*i*CZ sensor (serial) as the motor sensor.
4011 #2,1,0	Depends on the detector.	Sets the number of motor sensor gear teeth. (For 512λ/rev)
4016 #5	1	Alarms related to position feedback signals are enabled.
4016 #6	1	Alarms related to threading position feedback signals are enabled.
4056~4059	100 or 1000	Gear ratio between the spindle and motor 1 : 1
4334	Depends on the detector.	Sets the number of motor sensor gear teeth. (For 768λ/rev、1024λ/rev)

NOTE

When using the α*i*CZ sensor (serial), use spindle software of the following series and editions:

- 9D80/08 edition or later
- 9D90/01 edition or later
- 9DA0/01 edition or later

1.4 SUB MODULE SM

1.4.1 Overview

The sub module SM (SSM) protects the amplifier and motor against an overvoltage caused by the motor counter electromotive voltage of the B*i*S series spindle (synchronous built-in spindle motor), for example, when a spindle alarm is issued.

⚠ **CAUTION**

1. This section provides information important to safe use of the B*i*S series spindle (synchronous built-in spindle motor). Be sure to read this section.
2. To use the B*i*S series spindle motor safely, be sure to connect the SSM.
3. Specify the parameter related to the SSM (bit 5 of parameter No. 4008 to 1) and confirm that the SSM operates securely (see Subsection 1.4.7).

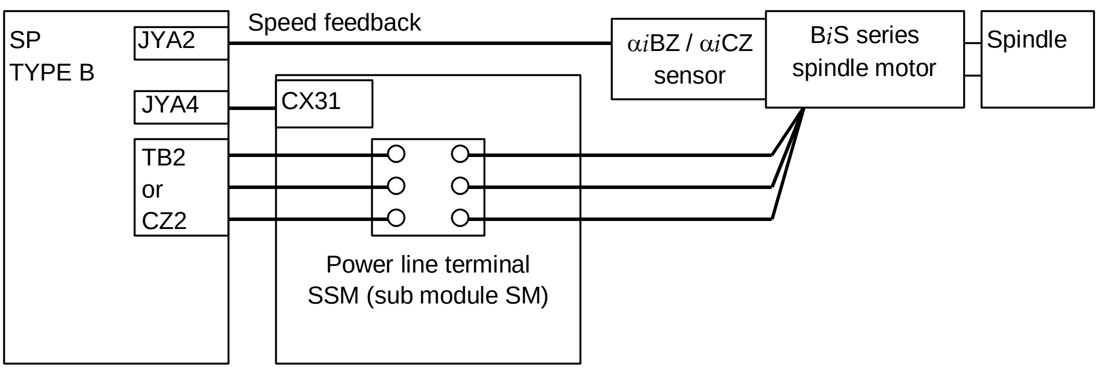
1.4.2 Series and Editions of Applicable Spindle Software

9D53 series B (02) edition or later
9D70 series A (01) edition or later
9D80 series B (02) edition or later
9D90 series A (01) edition or later
9DA0 series A (01) edition or later

1.4.3 Configuration

The following figure shows the connection of the sub module SM.

For the specifications of the sub module SM and connection details, refer to "FANUC SERVO AMPLIFIER α*i* series DESCRIPTIONS (B-65282EN)".



NOTE
To use the sub module SM, spindle amplifier (SP) TYPE B is required.

1.4.4 Related Parameters

⚠ **CAUTION**
This subsection describes the parameters related to the sub module SM (SSM). To use the SSM safely, specify the following parameter related to the SSM and confirm that the SSM operates securely (see Subsection 1.4.7).

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3008	4008	4008			SSMUSE					

SSMUSE This parameter sets whether to use the sub module SM (SSM).
0 : Does not use the sub module SM.
1 : Uses the sub module SM.
To use the synchronous built-in spindle motor safely, connect the SSM securely and set this bit to "1".

1.4.5 Stop Processing When a Sub Module SM Error Occurs

⚠ **CAUTION**
1 This subsection describes stop processing to be performed when a sub module SM (SSM) error occurs.
2 If an SSM error occurs, the function for protecting the amplifier against a spindle alarm does not operate normally. Ensure that when an SSM error occurs, the motor is stopped according to the descriptions of this subsection.

(a) Output signals (CNC→PMC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F230	F048	F048					SSMBRKA			
2nd-	F246	F052	F052					SSMBRKB			

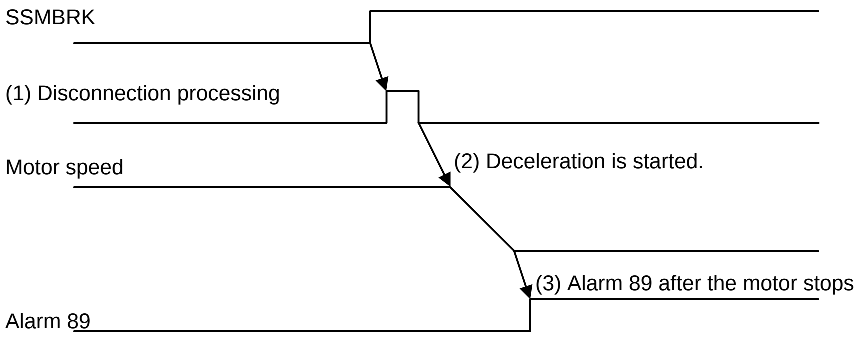
Symbol	Name	Description
SSMBRKA, SSMBRKB	Sub module SM (SSM) error state signal	Output when a sub module SM (SSM) error is detected. 0: Normal state 1: The sub module SM (SSM) is abnormal.

(b) Stop processing

When an SSM error is detected, the SSM error signal SSMBRK is set to 1, and the spindle amplifier (SP) has state error 36 turned on. At this time, decelerate and stop the motor safely by following the procedure below:

(1) Disconnect the spindle for which the SSM error occurs mechanically from other axes. This operation is to prevent the deceleration of the spindle motor from having a mechanical impact on the spindles.
(2) Then, decelerate and stop the target spindle.
(3) When the motor is decelerated and the speed becomes zero (SST = 1), spindle alarm 89 is issued.

(Timing chart)



1.4.6 Alarm and Status Error

(a) Spindle alarm

Alarm No.			LED display	Description	Measure
15*i*	16*i*	30*i*	Spindle amplifier		
SP0089	9089	SP9089	89	The SSM is abnormal. (1) The spindle amplifier (SP) does not support the SSM. (2) No SSM is installed or connected. (3) The interface signal between the spindle amplifier (SP) and SSM is disconnected. (4) The SSM is faulty.	Alarm 89 cannot be reset. Turn the power off, then check whether the SP supports the SSM and whether the SSM and SP are connected properly. If the SSM is faulty, replace the SSM.

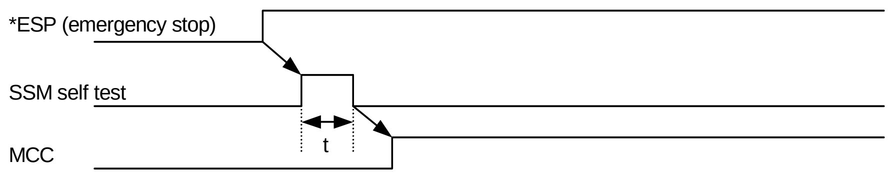
(b) Status error

Status error No.	Description	Measure
36	The SSM is abnormal. (1) The interface signal between the spindle amplifier (SP) and SSM is disconnected. (2) The SSM is faulty.	For PMC processing to be performed when error 36 is issued, see Subsection 1.4.5, “Stop Processing When a Sub Module SM Error Occurs”, in Part IV.

1.4.7 Caution

> ⚠ **CAUTION**
> This subsection provides notes on using the B*i*S series spindle safely. Fully understand the instructions described in this subsection before using the B*i*S series spindle.

(1) To check that the SSM operates normally, conduct an SSM self test at least once a day. An SSM self test is conducted on the rising edge of the emergency stop signal *ESP. The execution time (corresponding to “t” in the figure below) of the self test is about 450 msec (with 9D53 series H (08) edition or later, 9D70 series G (07) edition or later, 9D80 series B (02) edition or later; 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later about 250 msec with any edition earlier than the above).



MCC: The MCC is connected between the power supply and common power supply (PS), and the MCC switch signal line is connected to the CX3 of the common power supply (PS). The MCC is turned on/off by the emergency stop signal *ESP (G071#1).

(2) By conducting the test described below at least once after SSM installation, check that the SSM self test function operates normally. If this test is not conducted, the function for protecting the SSM amplifier and motor can be lost, resulting in damage to the amplifier or motor, for example, when a power failure occurs.
Step 1. Turn off the power to the machine.
Step 2. To prevent the power to the motor from being turned on during testing, detach the CX3 connector on the common power supply (PS) connected to the SSM and also detach the CX31 connector on the sub module SM.
Step 3. Turn on the power to the machine.
Step 4. After the CNC starts up and the indication of “--” on the spindle amplifier (SP) is turned on, set the emergency stop signal (*ESP) to 1.
Step 5. The self test function is operating normally if spindle alarm 89 is issued at emergency stop cancellation time. If the alarm is not issued, the cable, parameter, or spindle amplifier (SP) is abnormal.
Step 6. Turn off the power to the machine. Be sure to reinstall the CX3 and CX31 connectors.

(3) If a spindle alarm is issued and the spindle amplifier (SP) detects the input of the motor power turn-off signal (MPOF), the SSM is activated and the motor is decelerated to a stop. This deceleration differs from ordinary deceleration in that it is dynamic brake operation caused by short-circuits between motor pins by the SSM, however. If the SSM is faulty at this time, the spindle amplifier (SP) can be damaged.

(4) After the SSM is activated, the spindle amplifier (SP) ignores any alarm reset unless the speed zero state (speed zero signal SST = 1) continues for at least 5 sec (with 9D53 series G (07) edition or later, 9D70 series F (06) edition or later, or 9D80 series B (02) edition or later; for at least 120 sec with any edition earlier than the above). For resetting of the alarm, the speed zero state (SST = 1) needs to be set.

(5) After the SSM is activated, the SP ignores any alarm reset during the period described in item (4). When the SSM is active, reset the alarm after the period has elapsed. If the alarm is reset in the state where a command is input, the motor can abruptly start rotation. So, specify such a sequence that all commands are cleared when an alarm is issued or MPOF is input, and the cleared commands are specified again upon completion of alarm resetting.

(6) If the motor power turn-off signal MPOF is input, the SSM is activated. So, a deceleration to a stop (dynamic brake operation, which differs from ordinary deceleration) occurs instead of a free-run stop.

(7) When the SSM is faulty, inputting the motor power turn-off signal MPOF may damage the spindle amplifier (SP). So, ensure that MPOF is not input in a high-speed area where the SSM is needed.

(8) Do not insert a switch element such as an electromagnetic contactor in the power line between the spindle amplifier (SP) and synchronous built-in spindle motor. If the power line is broken during rotation, the amplifier or motor can be damaged.

1.5 POLE POSITION DETECTION

1.5.1 Overview

To control the synchronous built-in spindle motor, information about the pole position (phase) of the rotor is needed. Operation for detecting the pole position (phase) of the rotor is referred to as pole position detection. Immediately after the power is turned on or if pole position information is lost for a cause such as an alarm, pole position detection needs to be performed before the motor can be driven.
Three pole position detection modes are available:

- Minute moving mode (usable with 9D53 series I edition or later, 9D70 series H edition or later, 9D80 series B edition or later, 9D90 series A edition or later, and 9DA0 series A edition or later)
- Auto select mode (usable with 9D53 series C edition or later, 9D70 series B edition or later, 9D80 series B edition or later, 9D90 series A edition or later, and 9DA0 series A edition or later)
- DC current mode

By setting the phase difference between the pole position (phase) of the rotor and the one-rotation signal generation position beforehand in a parameter, control can be exercised using a parameter-set offset value and one-rotation signal position as reference data after one-rotation signal detection (AMR offset function).

⚠ WARNING

1. For the B*i*S series spindle motor, if pole position detection and other basic parameter settings are inappropriate, the correct pole position cannot be detected, and the motor may move unpredictably or the maximum motor speed may be exceeded.
2. To avoid danger due to the above symptom, performing the following action is recommended until normal spindle motor operation is confirmed:
   <1> Specify a value smaller than or equal to 10% of the specified maximum motor speed for the maximum motor speed parameter (No. 4020 for FS30*i*, 16*i* or No. 3020 for FS15*i*).
   <2> Specify a low torque limitation value to limit the torque (for example, specify 10% for the torque limitation parameter (No. 4025) and set torque limitation command signal TLMHA to 1) so that the motor is not accelerated suddenly.
   <3> Be sure to close the protection door during pole position detection and subsequent command input.

   If these conditions are not satisfied and the correct pole position cannot be detected, the motor may move unpredictably with the maximum torque until the SP detects an overspeed alarm.
3. Use the pole detection state signals to create the following sequence with the PMC:
   <1> When the protection door is open, starting pole position detection is prohibited.
   <2> If the protection door is opened during pole position detection (from the start of detection until pole position detection signal EPFIX is set to 1), pole position detection is stopped.
   <3> In the pole position undetected state (when EPFIX is set to 0), no command is input.

1.5.2 Pole Position Detection Operation

(1) Minute moving mode

Usable with 9D53 series I edition or later, 9D70 series H edition or later, 9D80 series B edition or later, 9D90 series A edition or later, and 9DA0 series A edition or later.

In the minute moving mode, pole position detection is performed while the motor is moved in very small steps. When the motor is locked, pole position detection is disabled in principle (spindle alarm 65 is issued).

Usually, pole position detection in this mode is recommended.

(2) Auto select mode

Usable with 9D53 series I edition or later, 9D70 series H edition or later, 9D80 series B edition or later, 9D90 series A edition or later, and 9DA0 series A edition or later.

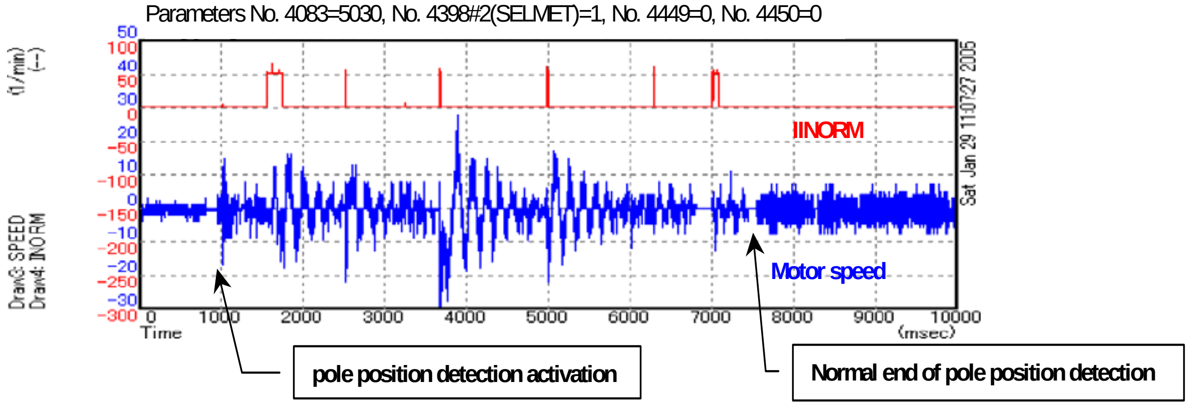
In the auto select mode, pole position detection is performed in either of the following two modes that is selected automatically by the spindle amplifier (SP):

Minute moving mode: In this mode, pole position detection is performed while the motor is moved in very small steps.

Stop mode: In this mode, pole position detection is enabled even when the motor is locked.

In the auto select mode, pole position detection is started in the minute moving mode. When the motor is detected to be locked, the spindle amplifier selects the stop mode and pole position detection is performed.

Example of pole position detection: Auto select mode
Parameters No. 4083=5030, No. 4398#2(SELMET)=1, No. 4449=0, No. 4450=0



> **NOTE**
> In the auto select mode, pole position detection is enabled even when the motor is locked because the stop mode can be selected. To select the stop mode, however, the following conditions must be satisfied:
> - The saliency of the motor is sufficiently large. (Lq-Ld>1mH)
> - At about 70% of the maximum current, a magnetic saturation of 5% or more is generated (the torque constant decreases by 5% or more.)
>
> If either of the above conditions is not satisfied, the precision of detection may be degraded or the pole position may be unable to be detected. So, confirm that operation in the stop mode can be performed normally before using the auto select mode.

When the minute moving mode or auto select mode is used, the velocity feedback may exceed the value set in parameter No. 4450 (velocity feedback threshold) due to noise and a symptom such as the following may occur: Pole position detection is not started or is not completed. In this case, follow the steps below:

<1> First, check the noise level of the velocity feedback.

<2> When the noise level of the velocity feedback is 5.5 min^{-1} or less, set the lower two digits (velocity feedback threshold) of parameter No. 4450 to the standard setting (0: 11 min^{-1}).

<3> When the noise level of the velocity feedback exceeds 5.5 min^{-1}, first reduce the noise by suppressing it. If the noise cannot be reduced to the allowable level by any means, set the lower two digits (velocity feedback threshold) of parameter No. 4450 to about double the noise level.

(3) DC current mode

In the DC current mode, pole position detection is performed while the motor is vibrating to a large extent.

When the motor is locked, pole position detection is disabled.

Operation in the DC current mode is as follows:

<1> A direct current is flowed in 0 deg electric angle.

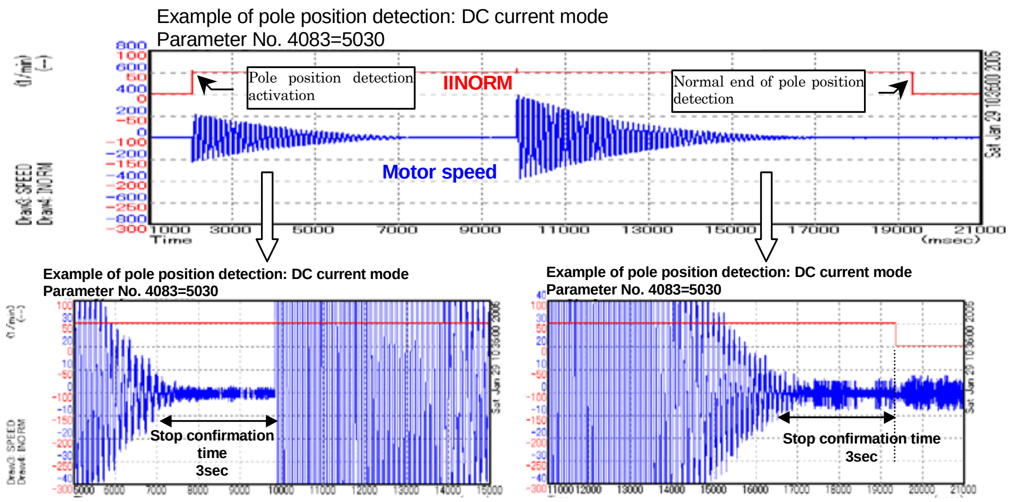
<2> Check that the motor is stopped. The motor is assumed to be stopped when a stop confirmation time (specified using the lower two digits of parameter No. 4083) has elapsed after the motor speed becomes 5 min^{-1} or below.

<3> After checking that the motor is stopped, a direct current is flowed in 90 deg electric angle.

<4> Check that the motor is stopped.

<5> After checking that the motor is stopped, the spindle alarm 65 is issued if the phase difference of the rotor between the cases where direct current activation is performed at the electric angle 0 deg and at the electric angle 90 deg is not within the range 80 to 100 deg.

The maximum travel distance from the start to end of pole position detection is the electric angle 270 deg.



Enlarged view
(activation with the magnetic pole at 0-deg position)

Enlarged view
(activation with the magnetic pole at 90-deg position)

1.5.3 AMR Offset Function

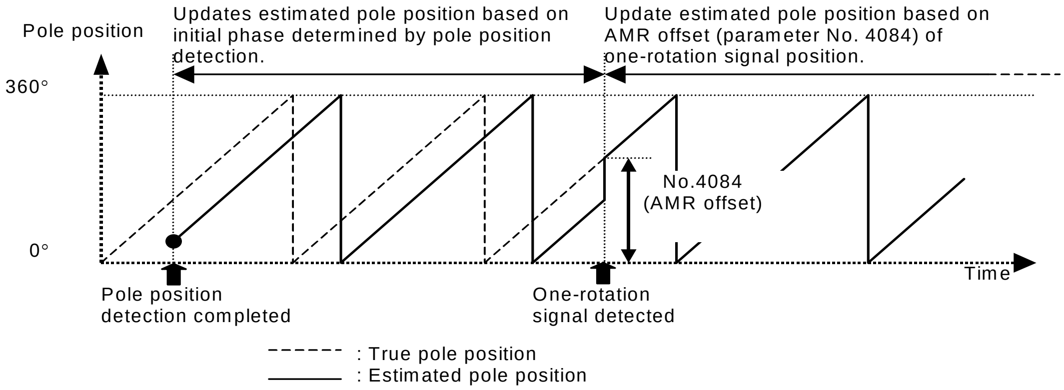
The spindle amplifier controls the motor based on the initial pole position estimated by pole position detection. So, a large error between the estimated and true pole position may affect the motor so that the acceleration/deceleration time during forward rotation differs from that during reverse rotation (torque characteristics during forward rotation differ from those during reverse rotation) or another symptom occurs.
The AMR offset function minimizes the error between these pole positions.
Reading this subsection and using the AMR offset function are recommended.

> ⚠ **WARNING**
> 1. The AMR offset is a parameter indicating the phase relationships between the motor magnetic pole position and motor sensor. After the phase relationships are changed due to a cause such as the replacement of the motor sensor or the loading of parameters of another machine, the AMR offset must be adjusted again.
> 2. If an inappropriate value is set for the AMR offset parameter, after the execution of the AMR offset, the motor may not recognize the correct magnetic pole position, may move unpredictably, and may rotate at a speed higher than the specified speed.

> **NOTE**
> This function can be used with 9D53 series C (03) edition or later, 9D70 series B (02) edition or later, 9D80 series B (02) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.

(1) AMR offset function operation

When the AMR offset function is enabled, the spindle amplifier determines the estimated pole position as follows:



<1> After the power is turned on, pole position detection is performed.
"The precision of the estimated pole position" is "the precision of pole position detection." So, the width of the error between the estimated and true pole positions is determined depending on the precision of pole position detection.

<2> When a rotation command is input, the motor rotates and the estimated pole position is updated using the feedback data of the motor sensor based on the initial pole position determined in step <1>. So, the error of the initial value determined in step <1> is the error of the estimated pole position with no change.

<3> When the AMR offset function is enabled (when bit 6 of parameter No. 4008 is 0 and the value of parameter No. 4084 is the adjustment value and is not 0), the following processing compensates the displacement of the detected pole position above.
When the motor rotates and the one-rotation signal is detected, the estimated pole position is forcibly replaced with AMR offset data (parameter No. 4084). AMR offset processing is executed only when the one-rotation signal is detected for the first time after pole position detection.

(2) Setting of the AMR offset parameters

Set the parameters according to the procedure below.

<1> Set bit 6 (NEGREF) of parameter No. 4008 to 0 and set parameter No. 4084 (AMR offset) to 0.

<2> After performing pole position detection, rotate the motor at about 100 min^{-1} and check the pole position when the one-rotation signal is detected. When the one-rotation signal is detected, data changes from "0" to "the pole position when the one-rotation signal is detected."

<u>(*) Checking the pole position when the one-rotation signal is detected</u>

- On the diagnosis screen :
  Set parameter No. 4532 to 2. The pole position is displayed on diagnosis screen No. 720 (1st spindle). This function may be unavailable depending on the spindle software edition. For details, see Subsection 1.5.5(2), "Parameters related to AMR offset".
- On the spindle check board :
  Make a setting for display. (d-01=977, d-02=0, d-03=0, d-04=0)

<3> The checked pole position contains the detection error. Check the pole position as described in step <2> several times and find the average.

<4> Turn motor excitation off, then set the average found in step <3> in parameter No. 4084.

> ⚠ **WARNING**
> If an inappropriate value is set for the AMR offset (parameter No. 4084), after the execution of the AMR offset, the motor may move unpredictably. So, observe the following rules strictly when setting the parameter:
> - Set the parameter in the emergency stop signal input state.
> - Confirm that the setting is the same as the average found in step <3>.

<5> Turn the power off, then on again and perform pole position detection. Accelerate and decelerate the motor with the forward and reverse rotation commands at about 100 min^{-1}, and check whether the motor rotates normally.

<6> By using the SERVO GUIDE or spindle check board, measure the torque command, actual speed, and the torque command in a constant rotation when acceleration/deceleration operation is performed with the forward (SFR) and reverse (SRV) commands at the maximum speed.

<7> Compare the torque command and actual speed during forward rotation with those during reverse rotation to check whether the AMR offset setting is appropriate. When the acceleration time, deceleration time, and torque command amplitude during forward rotation are almost the same as those during reverse rotation, the AMR offset data setting (parameter No. 4084) is appropriate.

<8> If they are not almost the same, the AMR offset data setting (parameter No. 4084) is inappropriate. In this case, adjust the value of parameter No. 4085 (parameter for checking and fine-adjusting the AMR offset) so that they are almost the same.

<9> After the completion of adjustment, set the following values in parameters Nos. 4084 and 4085:
No.4084 (new) = No.4084 (old) + No.4085 (old)
No.4085 (new) = 0

> ⚠ **WARNING**
> Observe the following rules strictly when setting the parameters for the same reasons as described in WARNING in step <4>:
> - Set the parameters in the emergency stop signal input state.
> - Confirm that the settings are the same as the values in step <9>.

<10> Turn the power off.

1.5.4 I/O Signals (CNC↔PMC)

(1) Address list of Input signals (PMC→CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA		SFRA	SRVA				
2nd-	G235	G074	G074	MRDYB		SFRB	SRVB				
1st-	G226	G071	G071							*ESPA	
2nd-	G234	G075	G075							*ESPB	
1st-	G228	G073	G073	EPFSTRA					MPOFA		
2nd-	G236	G077	G077	EPFSTRB					MPOFB		

(2) Details of input signals (PMC→CNC)

This item provides a list of the input signals related to pole position detection only. Also see Section 3.1, “INPUT SIGNALS (PMC→CNC→SP),” in Part IV.

(a) Machine ready signal (MRDYA)

Set this signal to “1” before starting pole position detection.

(b) Forward rotation command signal (SFRA) and reverse rotation command signal (SRVA)

(1) When bit 7 (EPFSIG) of parameter No. 4007 is set to 0:
One of these signals starts pole position detection operation.

Input one of the signals. The velocity command is ignored while the pole position undetected state (EPFIX = 0). However, as soon as EPFIX is set to 1 (the pole position detection completed), the velocity command is accepted to start rotation.

(2) When bit 7 (EPFSIG) of parameter No. 4007 is set to 1:
When this setting is made, these signals operate not as signals for starting pole position detection, but as those for simply turning excitation on. Before starting pole position detection operation (EPFSTR = 1), input either signal of SFR and SRV.

(c) Emergency stop signal (*ESPA)

Set this signal to “1” before starting pole position detection.

(d) Pole position detection operation start signal (EPFSTRA)

(1) When bit 7 (EPFSIG) of parameter No. 4007 is set to 0:
This signal is disabled. Always set this signal to “0.”

(2) When bit 7 (EPFSIG) of parameter No. 4007 is set to 1:
To make the operator concerned with pole position detection operation, this signal can be used together with EPFIX (pole position detection state signal). While this signal is input, the spindle software ignores a command and displays error 30 (on the spindle amplifier (SP)). So, when EPFIX is set to 1, turn this signal off.

(e) Motor power turn-off signal (MPOFA)

Do not input this signal during pole position detection operation. The motor is not excited and the magnetic pole position cannot be detected.

(3) Address list of output signals (CNC→PMC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F230	F048	F048	EPFIXA							
2nd-	F246	F052	F052	EPFIXB							

(4) Details of output signals (CNC→PMC)

(a) Pole position detection state signal (EPFIXA)

This signal indicates the state of pole position detection.

0 : Pole position undetected
In this state, pole position detection operation is started by a start signal.

1 : Pole position detection completed
This signal is reset to 0 if a spindle alarm indicating the loss of the pole position due to trouble such as a motor sensor disconnection is issued.

If this signal state is indicated using a lamp on the operator’s panel, the operator can recognize the pole position detection state.

If any of the following spindle alarms is issued, the spindle amplifier (SP) loses the pole position and turns off the pole position detection state signal (EPFIX = 0).

Spindle alarm Nos. : 01, 24, 25, 26, 31, 37, 65, 73, 90, 91, 92, 132, 133, 134, 139, 140, 141, 142

1.5.5 Related Parameters

(1) Parameters related to pole position detection

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3007	4007	4007	EPFSIG							

EPFSIG Selects a pole position detection start signal.

0 : Uses SFR or SRV as a pole position detection start signal.
1 : Uses EPFSTR as a pole position detection start signal.
Set this parameter to select a desired start signal.

15*i*	16*i*	30*i*	
3083	4083	4083	**Current ratio/motor stop confirmation time in pole position detection operation**

The upper two digits (thousands and hundreds) indicate a current ratio in pole position detection, and the lower two digits (tens and ones) indicate a motor stop confirmation time.

Current ratio in pole position detection (upper two digits)
Unit of data : 1%
Valid data range : 0 to 99
Standard setting value : Depends on the motor model.
Set the magnitude of a current command value in pole position detection operation as a ratio to the maximum current value.
This parameter is valid in the minute moving mode or DC current mode.

Motor stop confirmation time (lower two digits)
Unit of data : 0.1sec
Valid data range : 0 to 99
Standard setting value : Depends on the motor model.
Set a period of time for confirming the stop of the motor in DC current mode.
This parameter is valid in DC current mode.

> **NOTE**
> If pole detection position precision is insufficient for a cause such as friction, the motor output torque may decrease. In such a case, this parameter needs to be adjusted.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3398	4398	4398						**SELMET**		

SELMET Selects a pole position detection mode.
0 : Performs pole position detection in the DC current mode.
1 : Performs pole position detection in the auto select mode or minute moving mode.

<u>Usually, set this parameter to 1 (auto select or Minute moving mode) to use the function.</u>

> **NOTE**
> This parameter is valid with 9D53 series C (03) edition or later, 9D70 series B (02) edition or later, 9D80 series B (02) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3399	4399	4399		**MINUTE**						

MINUTE Selects a pole position detection mode.
0 : Auto select mode (Minute moving mode + stop mode)
1 : Minute moving mode

Usually, set this parameter to 1 (minute moving mode) to use the function.

> **NOTE**
> This parameter is valid with 9D53 series I (09) edition or later, 9D70 series H (08) edition or later, 9D80 series B (02) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3449	4449	4449	**Direction detection current(Current value B)/polarity determination current(Current value C)**

The upper three digits (ten thousands, thousands, and hundreds) indicate a direction detection current, and the lower two digits (tens and ones) indicate a polarity determination current.

Direction detection current (upper three digits)
Unit of data : 1%
Valid data range : 0 to 320
Standard setting value : 0
Set a current for pole position direction detection in pole position detection operation. When 0 is set, 100% is set.
This parameter is valid in the stop mode.

Polarity determination current (lower two digits)
Unit of data : 1%
Valid data range : 0 to 99
Standard setting value : 0
Set a detection current for determining the polarity of the pole position as a ratio to the maximum current value. When 0 is set, 70% is set internally.
This parameter is valid in the stop mode.

> **NOTE**
> This parameter is valid with 9D53 series C (03) edition or later, 9D70 series B (02) edition or later, 9D80 series B (02) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3450	4450	4450	**Travel distance allowance magnification/velocity feedback threshold**

The upper three digits (ten thousands, thousands, and hundreds) indicate a travel distance allowance magnification, and the lower two digits (tens and ones) indicate a velocity feedback threshold.

Travel distance allowance magnification (upper three digits)
Unit of data : 1%
Valid data range : 0 to 200
Standard setting value : 0
Set a travel distance allowance magnification. Set a ratio relative to a machine angle of 5 deg assumed to be 100%. When 0 is set, 100% (machine angle of 5 deg) is set internally.
This parameter is valid in the minute moving mode.

Velocity feedback threshold (lower two digits)

Unit of data : 1%

Valid data range : 0 to 99

Standard setting value : 0

Set a velocity feedback threshold for determining the stop of the motor, assuming 100% = 110 min^{-1}. When 0 is set, 10% (11 min^{-1}) is set internally.
This parameter is valid in the minute moving mode.

> **NOTE**
> This parameter is valid with 9D53 series C (03) edition or later, 9D70 series B (02) edition or later, 9D80 series B (02) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.

(2) Parameters related to AMR offset

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3008	4008	4008		NEGREF						

NEGREF Sets whether to use a one-rotation signal of the motor sensor as reference pole position data.

0 : Uses the one-rotation signal position of the motor sensor as reference pole position data.

1 : Does not use the one-rotation signal position of the motor sensor as reference pole position data.

When this parameter is set to "1," the spindle amplifier operates based on the initial pole position detected by pole position detection operation regardless of the one-rotation signal position of the motor sensor.
Usually, set this parameter to 0 (uses the AMR offset function) to use the spindle amplifier.

15*i*	16*i*	30*i*	
3084	4084	4084	AMR offset

Unit of data : 1 pulse (8192 pulses = electric angle 360 deg)

Valid data range : 0, 1 to 8192

Standard setting value : 0

Set an AMR offset.
This parameter is valid when bit 6 (NEGREF) of parameter No. 4008 is set to 0. Set an adjustment value to this parameter. When this parameter is set to 0, the AMR offset function is disabled. When setting 0 pulse as an AMR offset, set 8192.
See Subsection 1.5.3, "AMR Offset Function", in Part IV, and adjust this parameter for each motor.

> ⚠ **CAUTION**
> 1 This parameter needs to be adjusted for individual motors. If parameters for another machine are loaded, clear and adjust this parameter after loading the parameters.
> 2 This parameter indicates the phase relationships between the motor and motor sensor. After the phase relationships are changed due to a cause such as the replacement of the motor sensor, adjust the AMR offset again.

NOTE

1 This parameter is valid with 9D53 series C (03) edition or later, 9D70 series B (02) edition or later, 9D80 series B (02) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
2 When the spindle software edition is earlier than the editions above, set this parameter to 0.

15*i*	16*i*	30*i*	
3085	4085	4085	**AMR offset adjustment value**

Unit of data : 1 pulse (8192 pulses = electric angle 360 deg)
Valid data range : -300 to +300 (electric angle: -13.2deg to +13.2deg)
Standard setting value : 0

This parameter is used to adjust the AMR offset. The pole position can be shifted by the specified number of pulses.
After execution of the AMR offset, check the torque command and actual speed during forward rotation/backward rotation at the same speed, and adjust this value so that the same acceleration time and deceleration time are achieved by the same torque command and that the torque commands during constant rotation are almost the same.

⚠ **CAUTION**

1 After the adjustment with this parameter, change the following parameters in the emergency stop state:
2 Add the adjusted value of parameter No. 4085 to the setting of parameter No. 4084, and set the obtained value for parameter No. 4084 as the new AMR offset value.
3 After setting parameter No. 4084 again, set parameter No. 4085 to "0".
4 Turn the power off, then on again.

NOTE

1 This parameter is valid with 9D53 series C (03) edition or later, 9D70 series B (02) edition or later, 9D80 series B (02) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
2 When the spindle software edition is earlier than the editions above, set this parameter to 0.

15*i*	16*i*	30*i*	
3532	4532	4532	**Arbitrary data output function number**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

Set this parameter to 2 when an AMR offset candidate value is to be checked on the diagnosis screen of the CNC. An AMR offset candidate value (pole position corresponding to a one-rotation signal position counted relative to the pole detection position) can be checked with the following numbers on the diagnosis screen of the CNC:

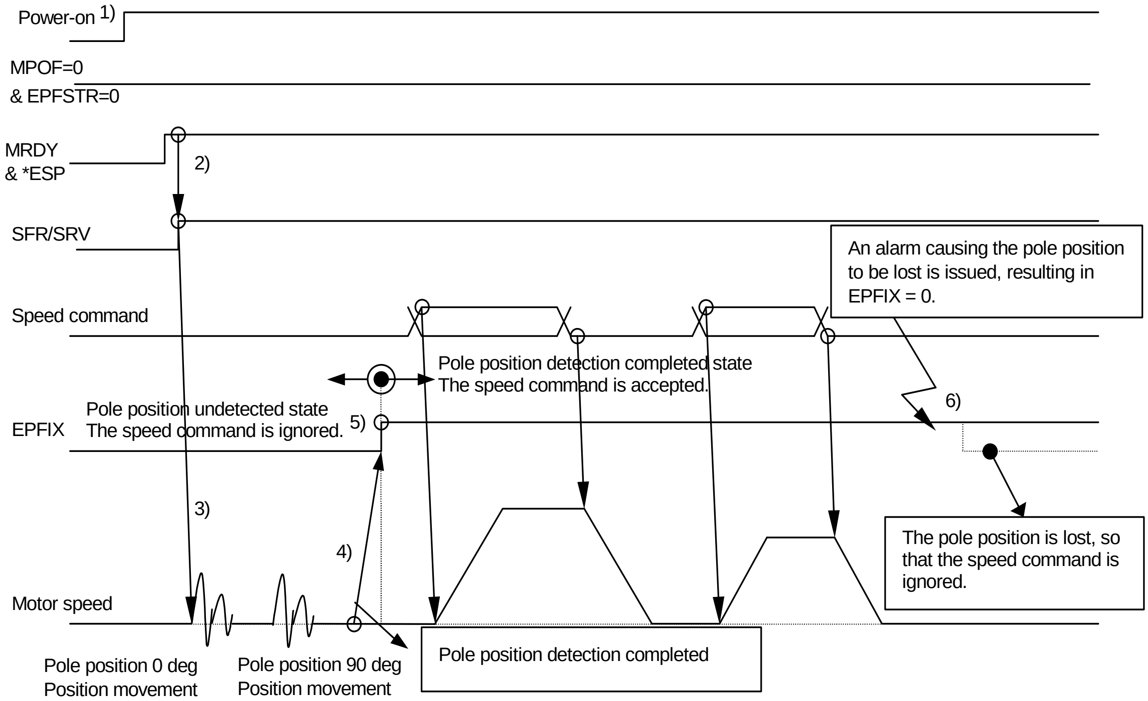
	Diagnosis No. (16*i*)	Diagnosis No. (30*i*)
1st spindle	720	720
2nd spindle	721	720
3rd spindle	740	720
4th spindle	741	720

NOTE

1 When this function is used, the following combinations of spindle software and CNC software must be used:
For spindle software 9D53 series F edition or later and 9D80 series B edition or later
FS16*i* /160*i* /160*i*s-TB : B1HA series V (22) edition or later
FS16*i* /160*i* /160*i*s-MB : B0HA series P (16) edition or later
FS18*i* /180*i* /180*i*s-TB : BEHA series V (22) edition or later
FS18*i* /180*i* /160*i*s-MB : BDHA series P (16) edition or later
FS18*i* /180*i* /180*i*s-MB5 : BDHE series F (06) edition or later
FS21*i* /210*i* /210*i*s-TB : DEHA series V (22) edition or later
FS21*i* /210*i* /210*i*s-MB : DDHA series P (16) edition or later
For spindle software 9D70 series E edition or later and 9D80 series B edition or later
FS30*i* /300*i* /300*i*s-A : G002/G012/G022 series F (6.0) edition or later
FS31*i* /310*i* /310*i*s-A5 : G121/G131 series F (6.0) edition or later
FS31*i* /310*i* /310*i*s-A : G101/G111 series F (6.0) edition or later
FS32*i* /320*i* /320*i*s-A : G201 series F (6.0) edition or later

1.5.6 Sequence

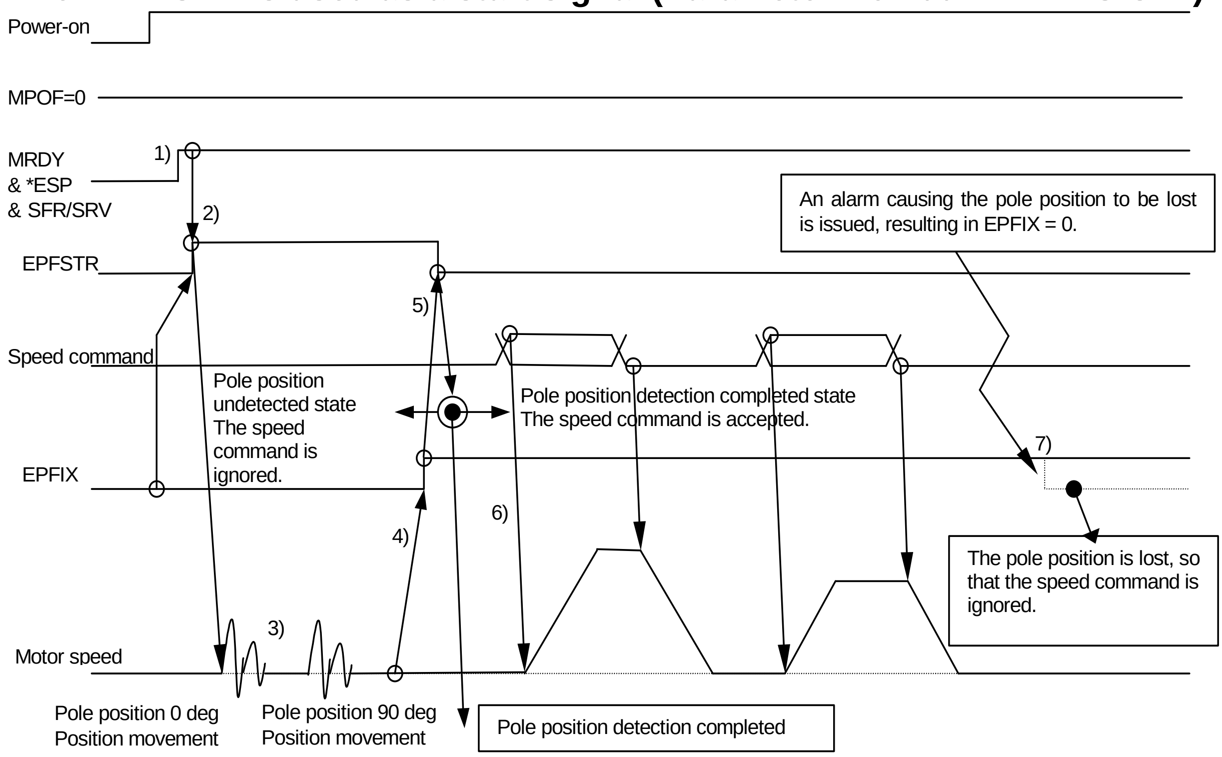
(1) When SFR or SRV is used as a start signal (Parameter No.4007#7:EPFSIG=0)



When SFR or SRV is input in the pole position undetected state (EPFIX = 0), pole position detection starts, ignoring the speed command. The speed command is enabled after pole position detection is completed (EPFIX = 1). Do not input MPOF (motor power turn-off signal) and EPFSTR (pole position detection operation start signal).

(1) After turning on the power, the operator is to make a preparation to activate the motor.
(2) Upon completion of preparation, set SFR (or SRV) to 1.
(3) In the pole position undetected state (EPFIX = 0), magnetic pole detection automatically starts.
(4) When pole position detection operation is started, the motor moves to the pole position 0 deg position then moves to and stops at the pole position 90 deg position (machine angle 90 deg/pole-pair), determining the pole position. (DC current mode)
(5) When the pole position is determined, the motor enters the pole position detection completed state (EPFIXA = 1), which allows the motor to drive. If a command is kept input during pole position detection, the motor starts rotating at the same time the pole position is determined. The operator may feel that this motion is unpredictable. So, provide interlock so that rotation and other commands cannot be input in the pole position undetected state (EPFIX = 0).
(6) If a spindle alarm that causes the pole position to be lost is issued, the pole position undetected state (EPFIX = 0) is set. When specifying the next rotation command, start all over again from the beginning of the sequence.

(2) When EPFSTR is used as a start signal (Parameter No.4007#7:EPFSIG=1)



It is assumed that the pole position determination state signal EPFIX and the pole position determination operation start signal EPFSTR correspond to a lamp and button on the operator's panel. Do not input MPOF (motor power turn-off signal) during pole position detection operation.

(1) The operator recognizes EPFIX = 0 (the lamp turned off on the operator's panel) then makes a preparation for pole position detection operation.
(2) Upon completion of preparation, set EPFSTR = 1 (turn on the button on the operator's panel) to start pole position determination operation.
(3) The motor moves to the pole position 0 deg position then moves to and stops at the pole position 90 deg position (machine angle 90 deg/pole-pair), determining the pole position.
(4) Upon pole position determination, EPFIX = 1 is set (the lamp on the operator's panel is turned on).
(5) The operator recognizes the completion of pole position detection operation and set EPFSTR to 0 (turns the button on the operator's panel off).
(6) When EPFSTR is set to 0, the speed command can be accepted. Confirm that the spindle amplifier is in the pole position detection completed state (EPFIX = 1) and EPFSTR is set to 0 before inputting a rotation or move command.
(7) If a spindle alarm that causes the pole position to be lost is issued, EPFIX = 0 is set (the lamp on the operator's panel is turned off). In this case, start all over again from the beginning of the sequence.

1.5.7 Causes of Spindle Alarm 65

If pole position detection fails, spindle alarm 65 is issued. This alarm may be issued for the causes listed below. If spindle alarm 65 is issued, check the following:

(1) Any of the following parameters is set incorrectly:
No.4011#2,#1,#0,No.4334 (Number of teeth of the motor sensor)
No.4011#7,#3,No.4368 (Number of motor poles)
(2) The activation current ratio in pole position detection is small so that friction impedes movement.
If spindle alarm 65 is issued for this cause, increase the value of the upper three digits (activation current ratio) of parameter No. 4083.
(3) The motor stop confirmation time (lower two digits of parameter No. 4083) is too short.

The motor vibrates when it stops. So, if the set value is too small, an incorrect magnetic pole position is recognized. A sufficiently long time is needed to confirm the stop of the motor.

(4) Motor feedback signal counting is performed incorrectly for a cause such as noise.
(5) The motor is mechanically held and cannot move.
(6) The motor power line is not connected. (Alternatively, the magnetic contactor is off if it is installed between the spindle amplifier and motor.)
(7) The motor power line phase order does not match the motor feedback signal connection phase order.

1.5.8 Cautions

> ⚠ **CAUTION**
> This subsection provides notes on magnetic pole detection. For safety, carefully follow the notes described in this subsection.

(1) After the power is turned on or an alarm that causes the pole position to be lost is issued, pole position detection needs to be performed.
(2) In both the DC current and minute moving modes, the pole position is detected by moving the motor. For this reason, pole position detection is disabled in the motor locked state. So, perform pole position detection when the motor can move.
(3) If the precision of pole position detection is poor, the motor output torque is small.
(4) If pole position detection is not completed, all input rotation and move commands are ignored. However, those commands become valid upon completion of pole position detection. So, if an input command is left uncleared in the pole position undetected state, the motor abruptly rotates upon completion of pole position detection, resulting in a dangerous situation. Prepare such a sequence that commands are input after the pole position determination state signal (F048#7 (EPFIXA)) set to 1 is confirmed.

2 EXPLANATION OF OPERATION MODES

2.1 VELOCITY CONTROL MODE

2.1.1 Start-up Procedure

For this subsection, see Subsection 2.1.1, “Start-up Procedure”, in Part I.

2.1.2 Overview

For this subsection, see Subsection 2.1.2, “Overview”, in Part I.

2.1.3 System Configuration

The velocity control mode is applicable to all detector configurations. For system configurations, see Subsection 1.3.4, “Typical Detector Configurations”, in Part IV.

2.1.4 List of I/O Signals (CNC↔PMC)

For this subsection, see Subsection 2.1.4, “List of I/O Signals (CNC↔PMC)”, in Part I.

2.1.5 Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
-	3705#0	3705#0	Sets SF signal output and the S code for an S command.
-	3705#2	3705#2	Gear switch method (M series only)
-	3705#4	3705#4	Sets SF signal output and the S code for an S command (T series only).
-	3705#5	3705#5	Sets SF signal output when constant surface speed control is exercised and an S code is specified (M series only).
-	3705#6	3705#6	Sets SF signal output (M series only).
-	3706#4	3706#4	Spindle gear selection method (M series only)
-	3706#7,#6	3706#7,#6	Spindle speed command polarity (valid when input signal SSIN = 0)
-	3709#0	3709#0	Number of sampling operations at spindle speed calculation time (T series only for 16*i*)
-	3735	3735	Minimum clamp speed of the spindle motor (M series only)
-	3736	3736	Maximum clamp speed of the spindle motor (M series only)
-	3740	3740	Time until the spindle speed arrival signal is checked
-	3741	3741	Maximum spindle speed for gear 1
-	3742	3742	Maximum spindle speed for gear 2
-	3743	3743	Maximum spindle speed for gear 3
-	3744	3744	Maximum spindle speed for gear 4 (T series only)
-	3751	3751	Spindle motor speed at the switch point between gear 1 and gear 2 (M series only)
-	3752	3752	Spindle motor speed at the switch point between gear 2 and gear 3 (M series only)
-	3772	3772	Maximum allowable spindle speed
2031	3031	3031	Allowable number of S code characters
2003#1	-	-	Sets an S code polarity.
2204#0	-	-	Sets the display of an actual spindle speed.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
2402#6	-	-	Sets the S code specified in a block containing G92.
5602#3	-	-	Whether to provide an indication for an alarm detected with the spindle amplifier. (Set “0” usually.)
5611	-	-	Number of sampling operations when an average spindle speed is to be found.
5612	-	-	Unit of spindle speed output with the DO signal
5807#0	-	-	Enables/disables the spindle alarms (SPxxxx) of all spindles. (Set “0” usually.)
5842	-	3720	Number of position coder pulses
5847	-	3721	Number of gear teeth on the position coder side on velocity control (for feed per revolution, threading, etc.)
5848	-	3722	Number of gear teeth on the spindle side on velocity control (for feed per revolution, threading, etc.)
5850	-	-	Spindle number to be selected at power-on/reset time
5820#4	-	-	Sets the method of spindle speed calculation.
3006#5	4006#5	4006#5	Sets an analog override range.
3009#4	4009#4	4009#4	Whether to output the load detection signals (LDT1, LDT2) during acceleration/deceleration
3009#6	4009#6	4009#6	Analog override type
3012#6	4012#6	4012#6	Sets whether to drive the synchronous built-in spindle motor. (Set “1”.)
3012#7	4012#7	4012#7	Sets the spindle HRV function. (Set “1”.)
5607#0	4019#7	4019#7	Automatic spindle parameter setting function
3352#1	4352#1	4352#1	Sets the peak hold function for load meter output.
3020	4020	4020	Maximum motor speed
3022	4022	4022	Speed arrival detection level
3023	4023	4023	Speed detection level
3024	4024	4024	Speed zero detection level
3025	4025	4025	Torque limitation value.
3026	4026	4026	Load detection level 1
3027	4027	4027	Load detection level 2
3030	4030	4030	Soft start/stop setting time
3040 3041	4040 4041	4040 4041	Velocity loop proportional gain on the velocity control mode (A parameter is selected by the PMC input signal CTH1A.)
3048 3049	4048 4049	4048 4049	Velocity loop integral gain on the velocity control mode (A parameter is selected by the PMC input signal CTH1A.)
3056 to 3059	4056 to 4059	4056 to 4059	Spindle and motor gear ratio data (A parameter is selected by the PMC input signals CTH1A and CTH2A.)
3081	4081	4081	Delay time until the motor power is turned off
3082	4082	4082	Sets an acceleration/deceleration time.
3508	4508	4508	Rate of change in acceleration at soft start/stop

NOTE

1 For the detector-related parameters, see Section 1.3, “PARAMETERS RELATED TO DETECTORS”, in Part IV.

2 For velocity loop proportional/integral gain adjustment, see Section 4.1, “VELOCITY LOOP GAIN ADJUSTMENT”, in Part IV.

2.1.6 Details of Related Parameters

This subsection details the serial spindle parameters (in the four thousands for 16*i* , and in the four thousands for 30*i*, and in the three thousands for 15*i*) among the parameters related to the velocity control mode. For details of other parameters, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, “SPINDLE SPEED CONTROL.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(d) For Series 30*i*/31*i*/32*i*-MODEL B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 11.4, “SPINDLE SPEED CONTROL.”
(e) (d) For Series 0*i*-MODEL B
“FANUC Series 0*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 10.6, “SPINDLE SPEED CONTROL.”

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3006	4006	4006			ALGOVR					

ALGOVR Sets a spindle analog override range.
0 : 0 to 100% (standard setting value)
1 : 0 to 120%

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3008	4008	4008			SSMUSE					

SSMUSE Sets whether to use the sub module SM (SSM).
0 : Does not use the sub module SM.
1 : Uses the sub module SM.

NOTE
To use the B*i*S series spindle motor safely, be sure to connect the SSM and set SSMUSE to “1”.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3009	4009	4009		OVRTYP		LDTOUT				

LDTOUT Whether to output the load detection signals (LDT1 and LDT2) during acceleration/deceleration
0 : Not output during acceleration/deceleration. (standard setting value)
1 : Output (at all times) during acceleration/deceleration if the parameter-set level is exceeded.

OVRTYP Analog override type
0 : Override of linear function type (standard setting value)
1 : Override of quadratic function type

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3012	4012	4012	SPHRV	SYSP						

SYSP Sets whether to drive the synchronous built-in spindle motor.
0 : Enables inductive spindle motor driving. (standard setting value)
1 : Enables synchronous built-in spindle motor driving.
Set to “1”.

SPHRV Sets the spindle HRV control function.
0 : Disables spindle HRV control.
1 : Enables spindle HRV control. (standard setting value)
Set to “1”.

NOTE
When driving the B*i*S series spindle (synchronous built-in spindle motor), be sure to set both of the SYSP and SPHRV bits to 1.

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4019	4019	PRLOAD							

PRLOAD Automatic parameter setting function
0 : Does not perform automatic parameter setting. (standard setting value)
1 : Performs automatic parameter setting.
After setting a desired motor model code in parameter No. 4133 and setting this bit to 1, turn off the power to the CNC, then turn on the power to the CNC again. The parameters (No. 4000 to No. 4175) for the α*i* series spindle corresponding to the model code are automatically initialized. Upon completion of automatic setting, this bit is automatically set to 0.

NOTE
With FS15*i*, the parameter address of this function is different, namely, bit 0 of No. 5607 is used. Moreover, note that the meanings of settings are reversed as follows.
0 : Performs automatic parameter setting.
1 : Does not perform automatic parameter setting.
In this case, set a model code in parameter No. 3133.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3352	4352	4352							PKHALW	

PKHALW Sets the peak hold function for load meter output.
0 : Does not use the peak hold function. (standard setting value)
1 : Uses the peak hold function.

15*i*	16*i*	30*i*	
3020	4020	4020	**Maximum motor speed**

Unit of data : 1min^{-1}
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.
This parameter sets a maximum spindle motor speed.

⚠ WARNING

The spindle motor may rotate at the maximum spindle motor speed specified by this parameter. Therefore, this parameter must not be set to a value greater than the maximum rotation speed indicated by the specification of the spindle motor.

15*i*	16*i*	30*i*	
3022	4022	4022	**Speed arrival detection level**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 150

This parameter sets a speed arrival signal (SARA) detection range.
When the motor speed reaches within ±(setting data/10)% of a specified speed, the speed arrival signal (SARA) is set to 1.

15*i*	16*i*	30*i*	
3023	4023	4023	**Speed detection level**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 30

This parameter sets a speed detection signal (SDTA) detection range.
When the motor speed is (setting data/10)% of a maximum speed or less, the speed detection signal (SDTA) is set to 1.

15*i*	16*i*	30*i*	
3024	4024	4024	**Speed zero detection level**

Unit of data : 0.01%
Valid data range : 0 to 10000
Standard setting value : 75

This parameter sets a speed zero detection signal (SSTA) detection range.
When the motor speed is (setting data/100)% of a maximum speed or less, the speed zero detection signal (SSTA) is set to 1.

NOTE

If a calculated speed zero detection level exceeds 200 min^{-1}, the speed zero detection level is clamped to 200 min^{-1}. (9D53 series B (02) edition or later, 9D70 series A (01) edition or later, 9D80 series B (02) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later)

15*i*	16*i*	30*i*	
3025	4025	4025	**Torque limitation value.**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 50

This parameter sets a torque limitation value to be applied when the torque limitation command HIGH (TLMHA) or the torque limitation command LOW (TLMLA) is specified.
The data indicates limitation values when the maximum torque is 100%.

Torque limitation command LOW (TLMLA)	Torque limitation command HIGH (TLMHA)	Description
0	0	No torque limitation is imposed.
0	1	The torque is limited to the value set in this parameter.
1	0	The torque is limited to a half of the value set in this parameter.
1	1	

15*i*	16*i*	30*i*	
3026	4026	4026	**Load detection level 1**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 83

This parameter sets a load detection signal 1 (LDT1A) detection range.
When the output of the spindle motor is (setting data)% of the maximum output or more, load detection signal 1 (LDT1A) is set to 1.

15*i*	16*i*	30*i*	
3027	4027	4027	**Load detection level 2**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 95

This parameter sets a load detection signal 2 (LDT2A) detection range.
When the output of the spindle motor is (setting data)% of the maximum output or more, load detection signal 2 (LDT2A) is set to 1.

15*i*	16*i*	30*i*	
3030	4030	4030	**Soft start/stop setting time**

Unit of data : 1min^{-1}/sec
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets an acceleration value (speed change rate) when the soft start/stop function is enabled (when the soft start/stop signal SOCNA = 1).

NOTE
When 0 is set, the soft start/stop function is disabled.

15*i*	16*i*	30*i*		
3040	4040	4040	**Velocity loop proportional gain on velocity control mode (HIGH)**	**CTH1A=0**
3041	4041	4041	**Velocity loop proportional gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This data is used to set the velocity loop proportional gain on velocity control mode.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3048	4048	4048	**Velocity loop integral gain on velocity control mode (HIGH)**	**CTH1A=0**
3049	4049	4049	**Velocity loop integral gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This data is used to set the velocity loop integral gain on velocity control mode. When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These data are used to set the gear ratio between spindle and spindle motor.
Usually, set 100.

> **NOTE**
> When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*	
3081	4081	4081	**Delay time until the motor power is turned off**

Unit of data : 10ms
Valid data range : 0 to 1000
Standard setting value : 20(200ms)

This parameter sets a period of time from the stop of the motor (detection of the speed zero detection signal SSTA set to 1) until the power to the motor is turned off if the SFR/SRV signal is off.

> **NOTE**
> When a small value is set in this parameter, the motor can coast after the power to the motor is turned off.

15*i*	16*i*	30*i*	
3082	4082	4082	**Setting of acceleration/deceleration time**

Unit of data : 1sec
Valid data range : 0 to 255
Standard setting value : 10

This parameter sets a period of time in which alarm detection is disabled by assuming that the spindle motor is being accelerated or decelerated even if the velocity error exceeds the velocity error excess alarm (spindle alarm 02) level after start of acceleration/deceleration on the velocity control mode.
In the velocity control mode, a step-by-step speed command is specified. So, the spindle motor cannot follow up the command immediately after start of acceleration/deceleration, and the velocity error exceeds the velocity error excess alarm level. This parameter is used to prevent the velocity error excess alarm (spindle alarm 02) from being detected incorrectly immediately after start of acceleration/deceleration.

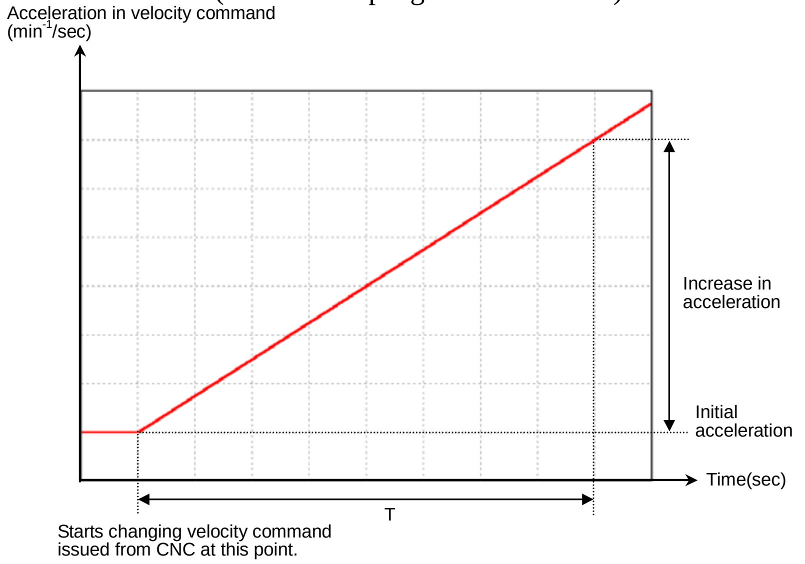
NOTE

With a machine tool such as a lathe that has a large load inertia, the acceleration/deceleration time becomes longer. In such a case, set the value corresponding to the acceleration/deceleration time of the machine in this parameter.

15*i*	16*i*	30*i*	
3508	4508	4508	**Rate of change in acceleration at soft start/stop**

Unit of data : 10min^{-1}/sec^2
Valid data range : 0 to 32767
Standard setting : 0

This parameter sets the jerk (the rate of change in acceleration) when the soft start/stop function is enabled (soft start/stop signal SOCNA = 1).



Increase in acceleration = 10 × setting in parameter No. 4508 × T
Initial acceleration = Setting in parameter No. 4030

NOTE

1 This parameter is valid with 9D53 series B (02) edition or later, 9D70 series A (01) edition or later, 9D80 series B (02) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.
2 If 0 is set, a liner type velocity command is observed when the soft start/stop function is enabled.

2.1.7 Troubleshooting

For this subsection, see Subsection 2.1.7, “Troubleshooting”, in Part I.

2.2 POSITION CODER METHOD SPINDLE ORIENTATION (OPTIMUM ORIENTATION) (OPTIONAL FUNCTION)

2.2.1 Start-up Procedure

For this subsection, see Subsection 2.2.1, “Start-up Procedure”, in Part I.

2.2.2 Overview

For this subsection, see Subsection 2.2.2, “Overview”, in Part I.

> **NOTE**
> *1 When driving the B*i*S series spindle (synchronous built-in spindle motor),
> **parameter No.4084**
> is used for AMR offset function.(The parameter isn’t the motor voltage for spindle orientation)
> Be sure that if an inappropriate value is set for the AMR offset, the motor may move unpredictably.
> *2 For an explanation of AMR offset function, see Subsection 1.5.3, “AMR Offset Function”, in Part IV.

2.2.3 Transition from Conventional Method Orientation to Optimum Orientation

For this subsection, see Subsection 2.2.3, “Transition from Conventional Method Orientation to Optimum Orientation”, in Part I.

2.2.4 Feature

For this subsection, see Subsection 2.2.4, “Feature”, in Part I.

2.2.5 Block Diagram

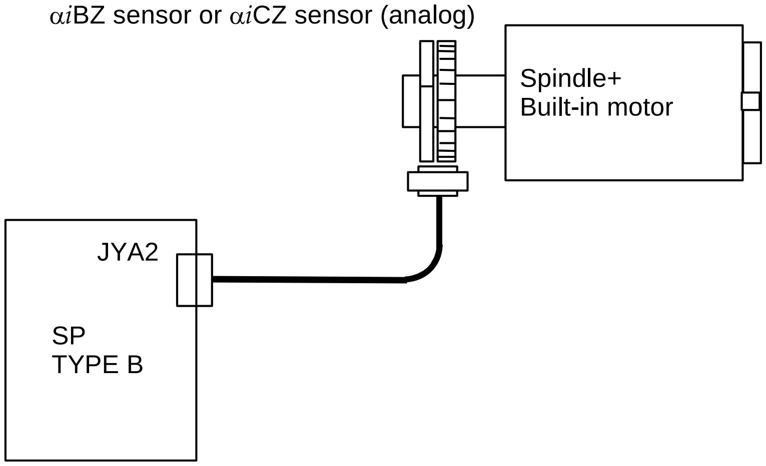
For this subsection, see Subsection 2.2.5, “Block Diagram”, in Part I.

2.2.6 System Configuration

The system configurations that enable the use of the position coder method orientation function are shown below.

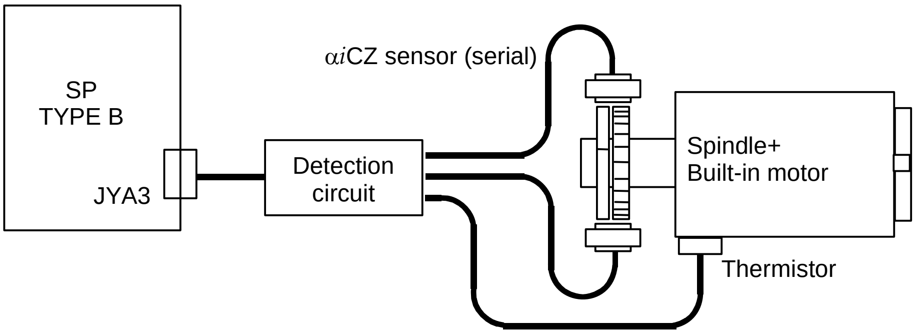
(1) When the α*i*BZ sensor or α*i*CZ (analog) sensor is used

[Sample system configuration]



(2) When the α*i*CZ (serial) sensor is used

[Sample system configuration]



2.2.7 Stop Position Specification Method

For this subsection, see Subsection 2.2.7, “Stop Position Specification Method”, in Part I.

2.2.8 I/O Signals (CNC↔PMC)

For this subsection, see Subsection 2.2.8, “I/O Signals (CNC↔PMC)“, in Part I.

2.2.9 Examples of Sequences

For this subsection, see Subsection 2.2.9, “Examples of Sequences”, in Part I.

2.2.10 Explanation of Operation

For this subsection, see Subsection 2.2.10, “Explanation of Operation”, in Part I.

2.2.11 Related Parameters

For this subsection, see Subsection 2.2.11, “Related Parameters”, in Part I.

2.2.12 Details of Related Parameters

For this subsection, see Subsection 2.2.12, “Details of Related Parameters”, in Part I.

2.2.13 Tuning Procedure

For this subsection, see Subsection 2.2.13, “Tuning Procedure”, in Part I.

2.2.14 Adjusting the Orientation Stop Position Shift Parameter

For this subsection, see Subsection 2.2.14, “Adjusting the Orientation Stop Position Shift Parameter”, in Part I.

2.2.15 Supplementary Descriptions

For this subsection, see Subsection 2.2.15, “Supplementary Descriptions”, in Part I.

2.3 RIGID TAPPING (OPTIONAL FUNCTION)

2.3.1 Start-up Procedure

For this subsection, see Subsection 2.3.1, “Start-up Procedure”, in Part I.

2.3.2 Overview

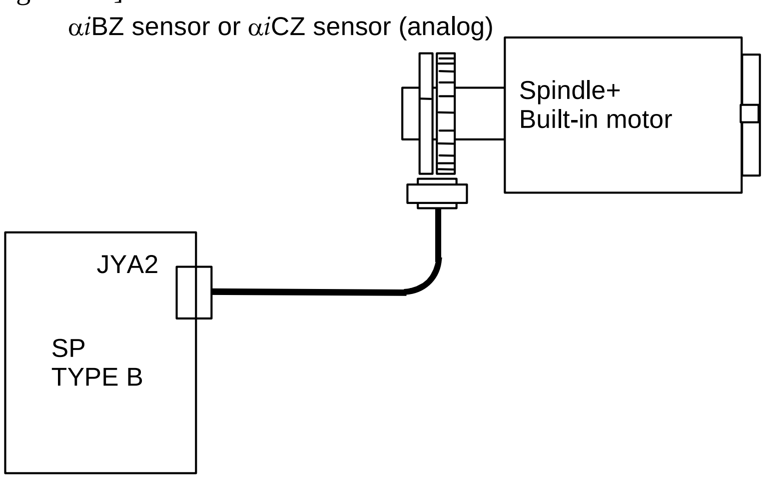
For this subsection, see Subsection 2.3.2, “Overview”, in Part I.

2.3.3 System Configuration

The system configurations that enable the use of rigid tapping are shown below.

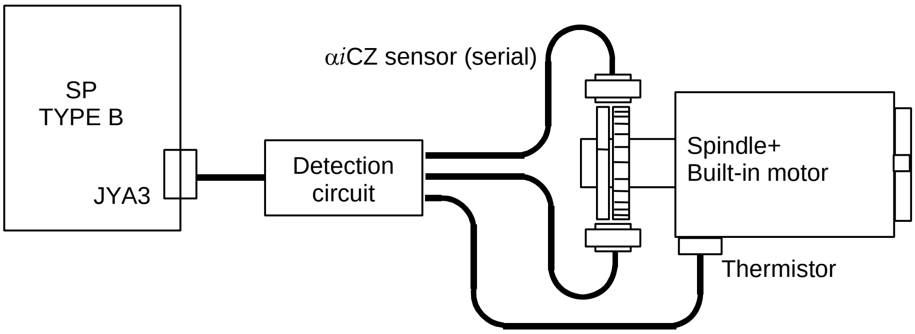
(1) When the α*i*BZ sensor or α*i*CZ sensor (analog) is used

[Sample system configuration]



(2) When the α*i*CZ sensor (serial) is used

[Sample system configuration]



2.3.4 List of I/O Signals (CNC↔PMC)

For this subsection, see Subsection 2.3.4, “List of I/O Signals (CNC↔PMC)”, in Part I.

2.3.5 Sequence

For a rigid tapping sequence, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.11, “RIGID TAPPING.”

(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.11, “RIGID TAPPING.”

(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.8, “RIGID TAPPING.”

(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.10, “RIGID TAPPING.”

2.3.6 Related Parameters

Parameter No.			Description
15*i*	**16*i***	**16*i***	
-	5210	5210	M code of rigid tapping command
5606#6	5202#0 (M series only)	5202#0	Whether to perform orientation (reference position return) when starting rigid tapping
-	3706#1,#0 3707#1,#0	-	Gear ratio between spindle and position coder, 1:1, 1:2, 1:4, 1:8
5842	-	3720	Number of pulse of the position coder
-	5200#1	-	Selection of arbitrary gear ratio between spindle and position coder
5852 5855 5858 5861	5221 5222 5223 5224	5221 5222 5223 5224	Teeth number of spindle side at arbitrary gear ratio (command) setting (16*i*/30*i*: No. 5224 is used for the T series only.)

Parameter No.			Description
15*i*	**16*i***	**16*i***	
5851 5854 5857 5860	5231 5232 5233 5234	5231 5232 5233 5234	Teeth number of position coder side at arbitrary gear ratio (command) setting (16*i*/30*i*: No. 5234 is used for the T series only.)
3065 to 3068	5280 5281 to 5284	5280 5281 to 5284	Position gain of tapping axis at rigid tapping (16*i*/30*i*: No. 5284 is used for the T series only.)
5605#1	-	-	Acc./Dec. type (Set to 1.)
5711	5241 5242 5243 5244	5241 5242 5243 5244	Spindle maximum speed at rigid tapping (16*i*/30*i*: No. 5244 is used for the T series only.)
5605#2 5757 5886 5889 5892	- - - - -	- - - - -	Spindle speed for determining an acceleration value for cutting feed on rigid tapping
5605#2 5751 5886 5889 5892	5261 5262 5263 5264	5261 5262 5263 5264	Acc./Dec. time constant (16*i*/30*i*: No. 5264 is used for the T series only.)
5605#2 5752 5885 5888 5891 5894	- - - - -	- - - - -	FL speed for spindle and drilling axis acceleration/deceleration on rigid tapping
-	5200#4	5200#4	Override selection at extracting
5883	5211	5211	Override value at extracting
-	5201#2 5271 to 5274	5201#2 5271 to 5274	Time constant at extracting (No. 5274 is used for the T series only.)
-	-	5203#2	Feed-forward function at rigid tapping
1827	5300	5300	In-position width of tapping axis
5875	5301	5301	In-position width of spindle
1837	5310 5341	5310	Allowable level of position error of tapping axis at moving
5876	5311	5311	Allowable level of position error of spindle at moving
1829	5312	5312	Allowable level of position error of tapping axis at stop
5877	5313	5313	Allowable level of position error of spindle at stop
5853 5856 5859 5862	5321 to 5324	5321 to 5324	Backlash of spindle (16*i*: No. 5322 and No. 5324 are used for the T series only. 30*i*: No. 5324 is used for the T series only.)
3000#4	4000#4	4000#4	Reference position return direction on servo mode
3002#5	4002#5	4002#5	Whether to enable the rotation direction signal (SFR/SRV) on servo mode
3006#7	4006#7	4006#7	Setting of the command arbitrary gear ratio function (CMR) on rigid tapping
-	-	4037	Velocity loop feed-forward coefficient
3044 3045	4044 4045	4044 4045	Velocity loop proportional gain on servo mode/spindle synchronous control (It is selected by input signal CTH1A/B.)
3052 3053	4052 4053	4052 4053	Velocity loop integral gain on servo mode/spindle synchronous control (It is selected by input signal CTH1A/B.)

Parameter No.			Description
15*i*	**16*i***	**16*i***	
3056 to 3059	4056 to 4059	4056 to 4059	Gear ratio between spindle and motor (It is selected by input signal CTH1A or CTH2A)
3065 to 3068	4065 to 4068	4065 to 4068	Spindle position gain on servo mode/spindle synchronous control (It is selected by input signal CTH1A or CTH2A)
3073	4073	4073	Grid shift amount on servo mode
3074	4074	4074	Reference position return speed on Cs contouring control/servo mode
3091	4091	4091	Position gain change ratio at reference position return time on servo mode
-	-	4344	Advanced preview feed-forward coefficient
3406	4406	4406	Acceleration/deceleration time constant for Cs contouring control/servo mode

NOTE
1 For the parameters related to detectors, see Section 1.3, “PARAMETERS RELATED TO DETECTORS” in the Part I.
2 For velocity loop proportional/integral gain adjustment, see Section 4.1, “VELOCITY LOOP GAIN ADJUSTMENT”, in Part I.

2.3.7 Details of Related Parameters

This subsection details the serial spindle parameters (in the four thousands for 16*i*, and in the four thousands for 30*i*, and in the three thousands for 15*i*) among the parameters related to rigid tapping. For details of other parameters, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.11, “RIGID TAPPING.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.11, “RIGID TAPPING.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.8, “RIGID TAPPING.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.10, “RIGID TAPPING.”

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3000	4000	4000				RETSV				

RETSV Reference position return direction on servo mode (rigid tapping/spindle positioning)
0 : The spindle performs a reference position return operation in the CCW(counterclockwise) direction.
1 : The spindle performs a reference position return operation in the CW(clockwise) direction.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3002	4002	4002			SVMDRT					

SVMDRT Whether to enable the rotation direction signal (SFR/SRV) function on servo mode (rigid tapping/spindle positioning)

0 : Enables the rotation direction function.
If a move command from the CNC is positive (+),
(a) The spindle rotates in the CCW direction when the input signal SFR (bit 5 of G70) = 1.
(b) The spindle rotates in the CW direction when the input signal SRV (bit 4 of G70) = 1.
1 : Disables the rotation direction function.
If a move command from the CNC is positive (+), the spindle rotates in the CCW direction when the input signal SFR = 1 or SRV = 1.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3006	4006	4006	RGTCMR							

RGTCMR Sets the command arbitrary gear ratio function (CMR) on rigid tapping.
0 : Disables the command arbitrary gear ratio function.
1 : Enables the specified arbitrary gear ratio function.
Set this parameter to 1 when rigid tapping is performed using a signal from the sensor built-into the motor as a position feedback signal and the gear ratio between the motor and spindle is other than 1:1.
When using the command arbitrary gear ratio function (CMR function), set the following as well:

- Enabling an arbitrary gear ratio between the spindle and position coder (bit 1 of No. 5200 = 1)
- Parameters for the number of gear teeth on the spindle side (No. 5221 to No. 5224)
- Parameters for the number of gear teeth on the position coder side (No. 5231 to No. 5234)

30*i*	
4037	**Velocity loop feed-forward coefficient**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets a velocity loop feed-forward coefficient for using feed-forward control. Set the result of calculation of the following expression:

$$\text{Setting} = 214466 \times \frac{[\text{spindle inertia + rotor inertia}](\text{kg}\cdot\text{m}^2)}{\text{Maximum motor torque (N}\cdot\text{m)}}$$

15*i*	16*i*	30*i*	
3044	4044	4044	**Velocity loop proportional gain on servo mode/spindle synchronous control (HIGH) CTH1A=0**
3045	4045	4045	**Velocity loop proportional gain on servo mode/spindle synchronous control (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

These parameters set a velocity loop proportional gain on servo mode (rigid tapping/spindle positioning) or spindle synchronous control.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*	
3052	4052	4052	**Velocity loop integral gain on servo mode/spindle synchronous control (HIGH) CTH1A=0**
3053	4053	4053	**Velocity loop integral gain on servo mode/spindle synchronous control (LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 10

These parameters set a velocity loop integral gain on servo mode (rigid tapping/spindle positioning) or spindle synchronous control.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These data are used to set the gear ratio between spindle and spindle motor. Usually, set 100.

NOTE
When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*		
3065	4065	4065	**Spindle position gain on servo mode/spindle synchronous control (HIGH)**	**CTH1A=0, CTH2A=0**
3066	4066	4066	**Spindle position gain on servo mode/spindle synchronous control (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3067	4067	4067	**Spindle position gain on servo mode/spindle synchronous control (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3068	4068	4068	**Spindle position gain on servo mode/spindle synchronous control (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : 0.01sec^{-1}
Valid data range : 0 to 32767
Standard setting value : 1000

These parameters set a position gain on servo mode (rigid tapping/spindle positioning) or spindle synchronous control. A parameter is selected according to the input signals CTH1A and CTH2A.

15*i*	16*i*	30*i*	
3073	4073	4073	**Grid shift amount on servo mode**

Unit of data : 1 pulse unit (360 degrees/4096)
Valid data range : 0 to 4095
Standard setting value : 0

This parameter is used to shift the reference position on servo mode (rigid tapping/spindle positioning).
The reference position of the spindle is shifted in the CCW direction by the specified number of pulses.

15*i*	16*i*	30*i*	
3074	4074	4074	**Reference position return speed on Cs contouring control/servo mode**

Unit of data : 1min^{-1}
Valid data range : 0 to 32767
Standard setting value : 0

- When 0 is set
  The orientation speed is the reference position return speed in servo mode (rigid tapping/spindle positioning).
- When a value other than 0 is set
  The value set in this parameter is used as a reference position return speed on servo mode (rigid tapping/spindle positioning).

15*i*	16*i*	30*i*	
3091	4091	4091	**Position gain change ratio at reference position return time on servo mode**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 100

This parameter sets a position gain change ratio at reference position return time on servo mode (rigid tapping, spindle positioning, and so forth).

NOTE
An overshoot can occur at reference position return time for a cause such as an excessively high reference position return speed and an excessively large spindle inertia. In this case, an overshoot can be avoided by setting a small value in this parameter.

15*i*	16*i*	30*i*	
-	-	4344	**Advanced preview feed-forward coefficient**

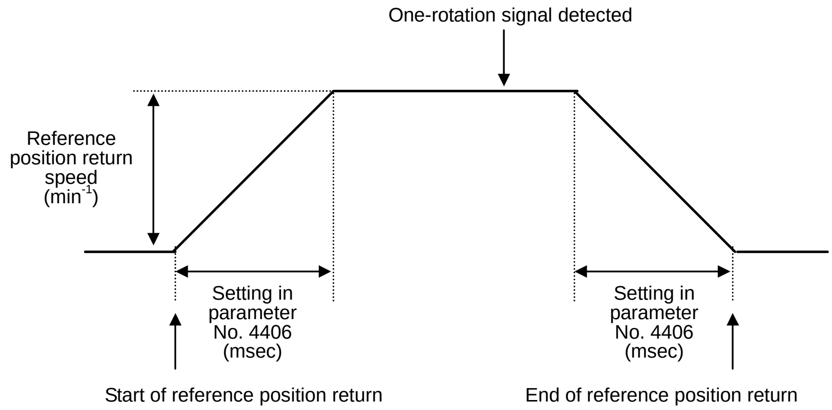
Unit of data : 0.01%
Valid data range : 0~10000
Standard setting value : 0

This parameter sets a feed-forward coefficient for using feed-forward control. Set the same value as for the servo axis simultaneously subjected to interpolation.

15*i*	16*i*	30*i*	
3406	4406	4406	**Acceleration/deceleration time constant for reference position return on Cs contouring control/servo mode**

Unit of data : 1msec
Valid data range : 0~32767
Standard setting value : 0

This parameter sets a reference position return acceleration for Cs contouring control or servo mode (rigid tapping/spindle positioning). Use of this parameter can reduce the shock due to acceleration/deceleration during return to the reference position. The spindle speed command during return to the reference position is then given as follows:



NOTE

1 When 0 is set in this parameter, a velocity command is assumed as follows.
- Before detecting the one-rotation signal: Reference position return speed (step-type velocity command)
- After detecting the one-rotation signal:
  Distance to the reference position × Position gain

2 This parameter is enabled when soft start/stop signal SOCNA is 1.

2.3.8 Parameter Setting Procedure

For this subsection, see Subsection 2.3.9, “Parameter Setting Procedure”, in Part I.

2.3.9 Adjustment Procedure

(1) Parameters used for adjustment

The table below lists and describes the parameters used for adjusting rigid tapping.

Parameter No. (FS16*i*)	Description
5241 to 5244	Maximum spindle speed on rigid tapping (Depends on the GR signal. No. 5244 is for the T series only.)
5261 to 5264	Acceleration/deceleration time constant on rigid tapping (Depends on the GR signal. No. 5264 is for the T series only.)
5280 to 5284	Position gain of tapping axis on rigid tapping (No. 5280 is for all gears. Nos. 5281 to 5284 depend on the GR signal. No. 5284 is for T series only.)
4065 to 4068	Spindle position gain on rigid tapping (depends on CTH1A and CTH2A signals)
4044 to 4045	Velocity loop proportional gain on rigid tapping (depends on CTH1A signal)
4052 to 4053	Velocity loop integral gain on rigid tapping (depends on CTH1A signal)

(2) Spindle data used for adjustment

Adjust the parameters while observing the motor speed, torque command, velocity error, synchronous error, and other waveform by using a spindle check board and oscilloscope or SERVO GUIDE. The table below lists spindle check board settings for observing the waveform.

Check board setting address		Settings	Observing data
Output to CH1	Output to CH2		
d-05	d-09	25	Velocity error ±128 min^{-1} at ±5 V ±256min^{-1} at ±5 V if d-06 (d-10) is set to 13
d-06	d-10	12	
d-07	d-11	0	
d-08	d-12	1	
d-05	d-09	90	Torque command Maximum positive/negative torque command at ±5 V Maximum positive/negative torque command at ±2.5 V if d-06 (d-10) is set to 8
d-06	d-10	7	
d-07	d-11	0	
d-08	d-12	1	
d-05	d-09	68	Synchronous error (value converted for the spindle: 4096 pulses/rev) ±128 pulses at ±5 V ±256 pulses at ±5 V if d-06 (d-10) is set to 1 ±512 pulses at ±5 V if d-06 (d-10) is set to 2
d-06	d-10	0	
d-07	d-11	0	
d-08	d-12	1	
d-05	d-09	19	Motor speed ±8192 min^{-1} at ±5 V ±4096 min^{-1} at ±5 V if d-06 (d-10) is set to 17 ±2048 min^{-1} at ±5 V if d-06 (d-10) is set to 16
d-06	d-10	18	
d-07	d-11	0	
d-08	d-12	1	

NOTE

When observing the synchronous error of Series 16*i*, set the following parameters:

No. 3700, #7 = 1:
Uses the synchronous error output (maintenance function).
(Return the setting to 0 after the observation is completed.)

No. 5203, #7 = 1 :
Sets a synchronous error update cycle.
(Return the setting to 0 after the observation is completed.)

No. 5204, #0 = 0 :
Displays the synchronous error on the diagnosis screen.

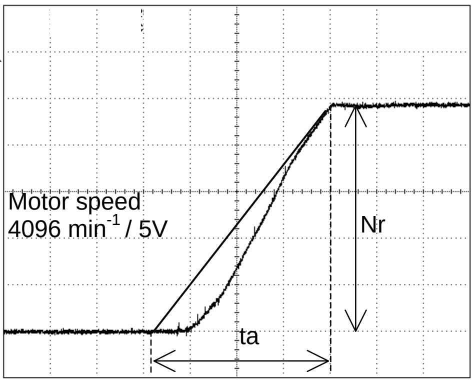
(3) Adjustment procedure

(3)-1 Specifying an acceleration/deceleration time constant (1): Specifying a provisional value

Before optimizing the acceleration/deceleration time constant, adjust the gain to improve the response. Following (a) or (b) below, specify a provisional acceleration/deceleration time constant according to the target maximum speed.

(a) Specifying a provisional time constant according to the velocity waveform in actual acceleration/deceleration

Observe the motor velocity waveform (velocity control mode) in acceleration up to the maximum rigid tapping speed. Specify such a provisional time constant that the inclination (acceleration) during rigid tapping acceleration becomes about a half of the inclination of a tangent to the motor velocity waveform near the location of maximum speed. See the sample waveform shown below.



Nr: Maximum rigid tapping speed (No. 5241 to 5244) 4000 min^{-1} in this example
ta: Time of acceleration by the maximum torque at *Nr* About 400 ms in this example
tr: Rigid tapping acceleration/deceleration time constant (No. 5261 to 5264) 800 ms, which is two times *ta*, in this example

In this example, the maximum rigid tapping speed *Nr* is set to 4000 min^{-1}. To determine the acceleration/deceleration time constant, the motor velocity waveform in acceleration up to 4000 min^{-1} is observed. If the acceleration is performed with the maximum motor torque at 4000 min^{-1}, the acceleration time *ta* needed to attain 4000 min^{-1} is about 400 ms, as shown above. This is the minimum value of acceleration/deceleration time constant *tr*, which can be specified without consideration of cutting load. A time constant that can be specified in consideration of cutting load is usually about 1.2 to 1.5 times this value. As a provisional value for gain adjustment, approximately double (800 ms) is specified here.

(b) Specifying a value calculated from the relationship between the maximum torque and spindle inertia

Specify an acceleration/deceleration time constant calculated from the following expression:

$$tr[\mathrm{ms}] = \frac{Jm[\mathrm{kgm}^2] + JL[\mathrm{kgm}^2]}{T\max(Nr)[\mathrm{Nm}]} \times \frac{2\pi}{60} \times Nr[\mathrm{min}^{-1}] \times GR \times 1000 \times 2$$

tr[ms] : Acceleration/deceleration time constant on rigid tapping (No. 5261 to 5264)
Nr[min^{-1}] : Maximum spindle speed on rigid tapping (No. 5241 to 5244)
GR : Spindle-motor gear ratio (Motor rotation per spindle rotation)
Tmax(Nr) [Nm]: Maximum torque of spindle motor at *Nr*
Jm[kgm^2] : Rotor inertia of spindle motor
JL[kgm^2] : Spindle load inertia(converted for the motor shaft)

(3)-2 Specifying a position gain

Specify an initial value of about 2000(20 sec^{-1}) to 3000(30 sec^{-1}), then adjust the value as needed. Basically, specify identical values for the spindle and tapping axis.

After specifying the position gain, check whether the spindle is operating as designed. For that purpose, check that the position error (value displayed on the CNC screen) during stable rotation at the maximum speed is almost the same as the theoretical value. This theoretical value is calculated as shown below. If the theoretical value is substantially different, re-check the parameters related to position gain, gear ratio, and detector.

$$Perr(Nr)[pulse] = \frac{Nr[\mathrm{min}^{-1}]}{60} \times 4096[pulse/rev] \times \frac{1}{PG[\mathrm{sec}^{-1}]}$$

Perr(Nr) [pulse] : Position error in stable rotation at *Nr*
Nr [min^{-1}] : Maximum speed on rigid tapping
PG [sec^{-1}] : Position gain on rigid tapping

If the gear ratio is 1:1 at *Nr*=4000 min^{-1} and *PG*=3000 (30 sec^{-1}), the position error in stable rigid tapping at *Nr* is calculated as follows:

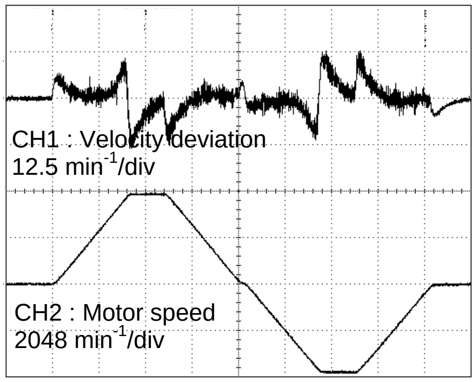
$$Perr(Nr) = \frac{4000}{60} \times 4096 \times \frac{1}{30} = 9102[pulse]$$

(3)-3 Specifying a velocity loop gain

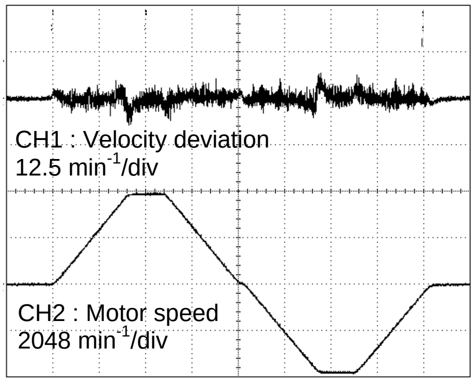
Refer to Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT" for details of the velocity loop proportional/integral gain. Adjust the velocity loop proportional/integral gain so that the velocity error decreases.

During the adjustment, observe the velocity error and motor speed. Sample waveforms before and after the adjustment are shown below:

(a) Waveform before adjustment (No. 4044 = 10, No. 4052 = 10)



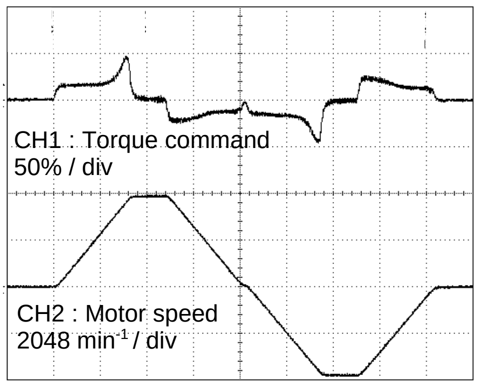
(b) Waveform after adjustment (No. 4044 = 20, No. 4052 = 60)



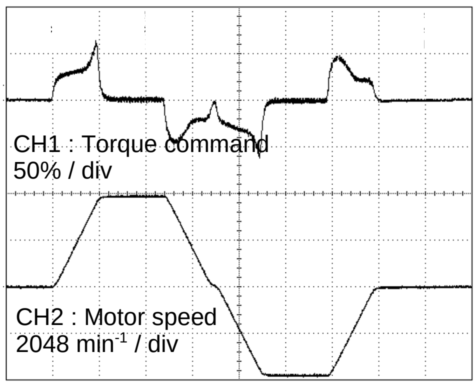
(3)-4 Specifying an acceleration/deceleration time constant (2) : Specifying an optimum value

Observing the torque command and motor speed, make a final adjustment of the time constant. Adjust the time constant in consideration of the actual cutting load, so that the peak torque at air cut becomes about 70% to 80% (3.5 to 4.0 V) of the maximum value. Sample waveforms before and after the adjustment are shown below:

(a) Waveform before adjustment (No. 5261 = 800)



(b) Waveform after adjustment (No. 5261 = 480)



(3)-5Checking the synchronous error

The spindle adjustment ends when the adjustments described in above procedures are completed. After the spindle adjustment, check the synchronous error between the spindle and servo axis, which will be an index of rigid tapping precision.

The synchronous error is a difference between the spindle position error and the servo axis position error converted for the spindle.

$$SYNCER[\text{pulse}] = PERsp[\text{pulse}] - PERsv[\text{pulse}]$$

SYNCER [pulse]:Synchronous error (4096 pulses per spindle rotation)

PERsp [pulse]:Spindle position error

PERsv [pulse]:Servo axis position error converted for the spindle

2.3.10 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.3.11, “Diagnosis (Diagnosis Screen)”, in Part I.

2.3.11 Alarm

For this subsection, see Subsection 2.3.12, “Alarm”, in Part I.

2.4 Cs CONTOURING CONTROL (OPTIONAL FUNCTION)

2.4.1 Start-up Procedure

For this subsection, see Subsection 2.4.1, “Start-up Procedure”, in Part I.

2.4.2 Overview

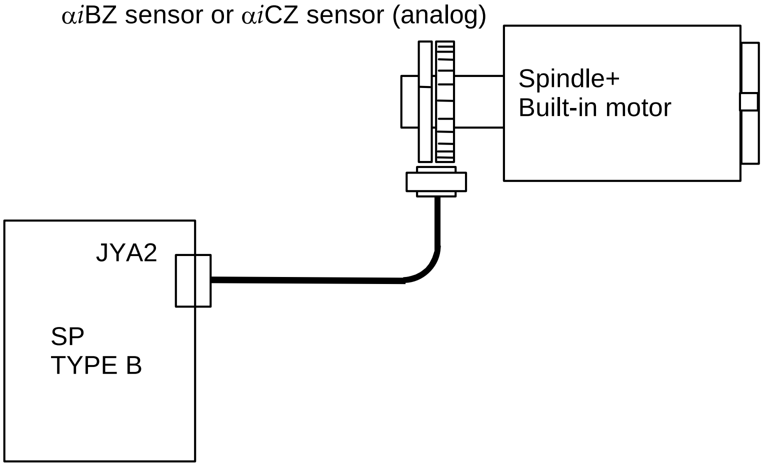
For this subsection, see Subsection 2.4.2, “Overview”, in Part I.

2.4.3 System Configuration

The system configurations that enable the use of the Cs contouring control function are shown below.

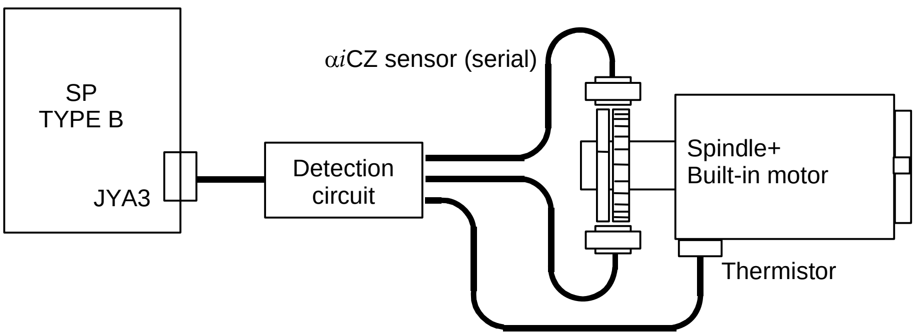
(1) When the α*i*BZ sensor or α*i*CZ (analog) sensor is used

[Sample system configuration]



(2) When the α*i*CZ (serial) sensor is used

[Sample system configuration]



> **NOTE**
> In a configuration in which the α*i*CZ sensor (serial) is used as the motor sensor, if Cs contouring control is to be performed immediately after the power is turned on, use spindle software 9D80 series H (08) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.

2.4.4 List of I/O Signals (CNC↔PMC)

For this subsection, see Subsection 2.4.4, "List of I/O Signals (CNC↔PMC)", in Part I.

2.4.5 Examples of Sequences

For this subsection, see Subsection 2.4.5, "Examples of Sequences", in Part I.

2.4.6 Velocity Loop Gains Override Function on Cs Contouring Control Mode

For this subsection, see Subsection 2.4.6, "Velocity Loop Gains Override Function on Cs Contouring Control Mode", in Part I.

2.4.7 Related Parameters

Parameter No.			Description
15*i*	**16*i***	**30*i***	
1005#0	1005#0	1005#0	Whether to use the reference position return function
1005#2	-	-	Sets automatic reference position return (G28). (Set "0".)
1005#3	-	-	Set workpiece coordinate system preset at automatic reference position return time. (Set "1".)
1600#2,#1,#0	1006#0	1006#0	Sets a linear axis/rotation axis. (Set "1".)
1600#3	-	-	Sets a radius for a move command/rotation axis. (Set "0".)
1804#7	-	-	Sets a Cs contouring control axis with a serial spindle. (Set "1".)
2203#1	-	-	Sets machine position display on the CRT. (Set "1".)
-	3700#1	3700#1	Specifies whether to enable the reference position return function for the first G00 command received after switching to Cs contouring control.
-	3712#2	3712#2	Sets the Cs axis coordinate establishment function.
1012 #3,#2,#1,#0	1004 #1,#0	1013 #3,#2,#1,#0	Increment system (Usually, set and use IS-B.)
1020	1020	1020	Program axis name
-	1022	1022	Sets an axis of the basic coordinate system. (Set "0".)
1023	1023	1023	Servo axis number (Set "-1".)
1028	-	-	Spindle number of Cs contouring control axis
1260	-	1260	Movement per rotation of rotation axis (Set "360.0".)
1420	1420	1420	Rapid traverse rate
1620	1620	1620	Linear acceleration/deceleration time constant for rapid feed
1820	1820	1820	Command multiplication (Usually, set "2" [= CMR 1].)
5879	1826	1826	In-position width
5880	1828	1828	Position error limit during movement
5881	1829	1829	Position error limit when stopped
5882	-	-	Position error limit when the servo system is off
5609#0	-	-	Sets a position gain for a servo axis subject to interpolation with the Cs contouring control axis. ("0": Automatically set, "1": Not automatically set. Usually, set "0".)

Parameter No.			Description
15*i*	**16*i***	**30*i***	
-	3900 3910 3920 3930 3940	3900 3910 3920 3930 3940	Servo axis number subject to interpolation with the Cs contouring control axis
-	3901 to 3904 3911 to 3914 3921 to 3924 3931 to 3934 3941 to 3944	3901 to 3904 3911 to 3914 3921 to 3924 3931 to 3934 3941 to 3944	Position gain of a servo axis subject to interpolation with the Cs contouring control axis
5843	-	-	Number of pulses of position detector for Cs contouring control
3000#1	4000#1	4000#1	Spindle rotation direction for a positive motion command on Cs contouring control mode
3000#3	4000#3	4000#3	Direction of reference position return when the system enters Cs contouring control mode
3002#4	4002#4	4002#4	Whether to use the rotation direction signal (SFR/SRV) function on Cs contouring control
3005#0	4005#0	-	Sets the detection unit for Cs contouring control.
3016#3	4016#3	4016#3	Sets the smoothing function in feed-forward control.
3021	4021	4021	Maximum spindle speed on Cs contouring control mode
3036	4036	-	Feed-forward coefficient
3037	4037	4037	Velocity loop feed-forward coefficient
3046 3047	4046 4047	4046 4047	Velocity loop proportional gain on Cs contouring control mode (A parameter is selected by the CTH1A input signal sent from the PMC.)
3054 3055	4054 4055	4054 4055	Velocity loop integral gain on Cs contouring control mode (A parameter is selected by the CTH1A input signal sent from the PMC.)
3056 to 3059	4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio (A parameter is selected by the CTH1A and CTH2A input signals sent from the PMC.)
3069 to 3072	4069 to 4072	4069 to 4072	Position gain for axes subject to Cs contouring control (A parameter is selected by the CTH1A input signal sent from the PMC.)
3074	4074	4074	Feedrate for reference position return on Cs contouring control mode or servo mode
3092	4092	4092	Rate of change in the position gain when reference position return is performed on Cs contouring control mode
3094	4094	4094	Disturbance torque compensating constant (acceleration feedback gain)
3131	4131	4131	Velocity detection filter time constant (on Cs contouring control)
3135	4135	4135	Grid shift on Cs contouring control mode
3162 3163	4162 4163	4162 4163	Velocity loop integral gain for cutting feed on Cs contouring control (A parameter is selected by the PMC input signal CTH1A.)
3342 3343	4342 4343	4342 4343	Velocity loop gain override in Cs contouring control. (These parameters are selected by the input signal CTH1A of PMC.)
-	-	4344	Advanced preview feed-forward coefficient
-	4353#5	4353#5	Sets the Cs axis position data transfer function.
3406	4406	4406	Acceleration/deceleration time constant at return to the reference position in Cs contouring control/servo mode

NOTE
1 For the detector-related parameters, see Section 1.3, “PARAMETERS RELATED TO DETECTORS”, in Part IV.
2 For velocity loop proportional/integral gain adjustment, see Section 4.1, “VELOCITY LOOP GAIN ADJUSTMENT”, in Part IV.

2.4.8 Details of Related Parameters

This subsection details the serial spindle parameters (in the four thousands for 16*i*, in the four thousands for 30*i*, and in the three thousands for 15*i*) among the parameters related to Cs contouring control. For details of other parameters, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.9, “Cs CONTOUR CONTROL.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.9, “Cs CONTOUR CONTROL.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7, “Cs CONTOUR CONTROL.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.8, “Cs CONTOUR CONTROL.”

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3000	4000	4000					RETRN		ROTA2	

ROTA2 Indicates the spindle direction by the move command (+). (Only effective on Cs contouring control)
0 : When the value of a move command from the CNC is positive (+), the spindle rotates in the CCW direction.
1 : When the value of a move command from the CNC is positive (+), the spindle rotates in the CW direction.
Change the setting of this parameter when changing the rotation direction of the spindle on Cs contouring control.

RETRN Indicates the reference position return direction on Cs contouring control.
0 : Returns the spindle from the CCW direction to the reference position (counterclockwise direction).
1 : Returns the spindle from the CW direction to the reference position (clockwise direction).

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3002	4002	4002				CSDRCT				

CSDRCT Whether to use the rotation direction signal (SFR/SRV) on Cs contouring control
0 : Rotation direction function enabled
(1) When bit 1 (ROTA2) of No. 4000 = 0, and the value of a move command from the CNC is positive (+)
(a) The spindle rotates counterclockwise when input signal SFR(G70#5) is set to 1.
(b) Tithe spindle rotates clockwise when input signal SRV(G70#4) is set to 1.

(2) When bit 1 (ROTA2) of No. 4000 = 1, and the value of a move command from the CNC is positive (+)
(a) The spindle rotates clockwise when input signal SFR(G70#5) is set to 1.
(b) The spindle rotates counterclockwise when input signal SRV(G70#4) is set to 1.

1 : Rotation direction function disabled
The rotation direction function of the SFR/SRV signal is disabled. Only the function for enabling spindle motor excitation is available.
(1) When bit 1 (ROTA2) of parameter No. 4000 is set to 0
When the value of a move command from the CNC is positive (+), and SFR/SRV = 1, the spindle rotates in the CCW direction.
(2) When bit 1 (ROTA2) of parameter No. 4000 is set to 1
When the value of a move command from the CNC is positive (+), and SFR/SRV = 1, the spindle rotates in the CW direction.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3005	4005	4005								**CS360M**

CS360M Sets the detection unit for Cs contouring control.
0 : 0.001°
1 : 0.0001°
Set 0 usually. When a α*i*CZ sensor (analog, serial) is used as the position detector and the setting unit IS-C is used, set 1.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3016	4016	4016					**FFSMTH**			

FFSMTH Specifies whether to use the smoothing function under feed-forward control.
0 : Does not use the smoothing function.
1 : Uses the smoothing function.
This bit specifies whether to use the smoothing function under feed-forward control on Cs contouring control mode.

15*i*	16*i*	30*i*	
3021	4021	4021	**Maximum speed on Cs contouring control mode**

Unit of data : $1 min^{-1}$
Valid data range : 0 to 32767
Standard setting : 100
This parameter specifies the maximum speed of a spindle operating on Cs contouring control mode.
When 0 is specified as the parameter for the feedrate for reference position return on Cs contouring control mode (parameter No. 4074), reference position return is performed at the speed specified as the maximum speed in this parameter.

15*i*	16*i*	30*i*	
3036	4036	-	**Feed-forward coefficient**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : 0
Set the feed-forward coefficient when feed-forward control is executed on Cs contouring control.

15*i*	16*i*	30	
3037	4037	4037	**Velocity loop feed-forward coefficient**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 0

Set a velocity loop feed-forward coefficient when feed-forward control is executed on Cs contouring control. Use the following expression to determine a value to be set:

$$\text{Setting} = 214466 \times \frac{[\text{spindle inertia + rotor inertia}](\text{kg}\cdot\text{m}^2)}{\text{Maximum motor torque (N}\cdot\text{m)}}$$

15*i*	16*i*	30*i*		
3046	4046	4046	**Velocity loop proportional gain on Cs contouring control (HIGH)**	**CTH1A=0**
3047	4047	4047	**Velocity loop proportional gain on Cs contouring control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 30

These parameters specify the proportional gains of the velocity loop on Cs contouring control mode.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3054	4054	4054	**Velocity loop integral gain on Cs contouring control (HIGH)**	**CTH1A=0**
3055	4055	4055	**Velocity loop integral gain on Cs contouring control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 50

These parameters specify the integral gains of the velocity loop for Cs contouring control mode.
When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These parameters set the gear ratio of the spindle motor to the spindle.
Usually, set 100.

> **NOTE**
> When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle does not stop but keeps rotating at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*		
3069	4069	4069	**Position gain on Cs contouring control (HIGH)**	**CTH1A=0, CTH2A=0**
3070	4070	4070	**Position gain on Cs contouring control (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3071	4071	4071	**Position gain on Cs contouring control (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3072	4072	4072	**Position gain on Cs contouring control (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : $0.01sec^{-1}$
Valid data range : 0 to 32767
Standard setting : 3000

These parameters specify the position gains used on Cs contouring control mode.
A parameter is selected by the input signals CTH1A and CTH2A.

15*i*	16*i*	30*i*	
3074	4074	4074	**Speed for return to reference position on Cs contouring control mode/servo mode**

Unit of data : $1min^{-1}$
Valid data range : 0 to 32767
Standard setting : 0

- When 0 is set
  The value set in No. 4021 (maximum spindle speed) is used as a reference position return speed on Cs contouring control.
- When a value other than 0 is set
  The value set in this parameter is used as a reference position return speed on Cs contouring control.

> **NOTE**
> An overshoot can occur at reference position return time for a cause such as an excessively high reference position return speed by setting the parameter No. 4021 (maximum spindle speed on Cs contouring control mode). In this case, set this parameter.

15*i*	16*i*	30*i*	
3092	4092	4092	**The reduction rate of position loop gain in returning to the reference position on Cs contouring mode**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting : 100

This parameter specifies a rate of change in the position gain used for reference position return on Cs contouring control mode.

> **NOTE**
> An overshoot can occur at reference position return time for a cause such as an excessively high reference position return speed and an excessively large spindle inertia. In this case, an overshoot can be avoided by setting a small value in this parameter.

15*i*	16*i*	30*i*	
3094	4094	4094	**The constant of the torque disturbance compensating (Acceleration feedback gain)**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 0

This parameter specifies the constant for compensating for a disturbance torque on Cs contouring control mode.

> **NOTE**
> By setting this parameter, stability in cutting can be improved.
> In this parameter, set a value from 500 to 2000.
> Do not set a value exceeding 4000.

15*i*	16*i*	30*i*	
3131	4131	4131	**Velocity detection filter time constant (on Cs contouring control)**

Unit of data : 0.1ms
Valid data range : 0 to 10000
Standard setting value : 0

This parameter sets a filter time constant for the velocity feedback signal on Cs contouring control. Usually, set 0.

15*i*	16*i*	30*i*	
3135	4135	4135	**Grid shift amount on Cs contouring control**

Unit of data : 1 pulse unit (=0.001°) (0.0001° when bit 0 (CS360M) of parameter No. 4005 is set to 1)
Valid data range : -360000 to +360000
(When parameter No. 4005 #0 (CS360M) is 1, -3,600,000 to +3,600,000)
Standard setting value : 0

Use this parameter to shift the machine reference position on Cs contouring control.
The machine reference position of the spindle shifts by the set number of pulses in the CCW direction.

15*i*	16*i*	30*i*	
3162	4162	4162	**Velocity loop integral gain for cutting feed on Cs contouring control(HIGH) CTH1A=0**
3163	4163	4163	**Velocity loop integral gain for cutting feed on Cs contouring control(LOW) CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

These parameters set a velocity loop integral gain for cutting feed (G01, G02, G03) on Cs contouring control.

When the input signal CTH1A = 0, (HIGH) is selected. When the input signal CTH1A = 1, (LOW) is selected.

> **NOTE**
> When 0 is set in these parameters, the values set in No. 4054 and No. 4055 (velocity loop integral gain on Cs contouring control) are valid.

15*i*	16*i*	30*i*		
3342	4342	4342	**Velocity loop gain override in Cs contouring control (HIGH)**	**CTH1A=0**
3343	4343	4343	**Velocity loop gain override in Cs contouring control (LOW)**	**CTH1A=1**

Unit of data : 1%
Valid data range : 0~3000
Standard setting value : 0

These parameters specify override of velocity loop proportional gain and integral gain for Cs contouring control mode.
If the set value is "0", it is treated as "100".

> **NOTE**
> This parameter is valid with
> 9D53 series J (10) edition or later
> 9D70 series I (09) edition or later
> 9D80 series C (03) edition or later.

15*i*	16*i*	30*i*	
-	-	4344	**Advanced preview feed-forward coefficient**

Unit of data : 0.01%
Valid data range : 0 to 10000
Standard setting value : 0

This parameter sets a feed-forward coefficient for exercising feed-forward control when Cs contouring control is used.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
-	4353	4353			**CSPTRE**					

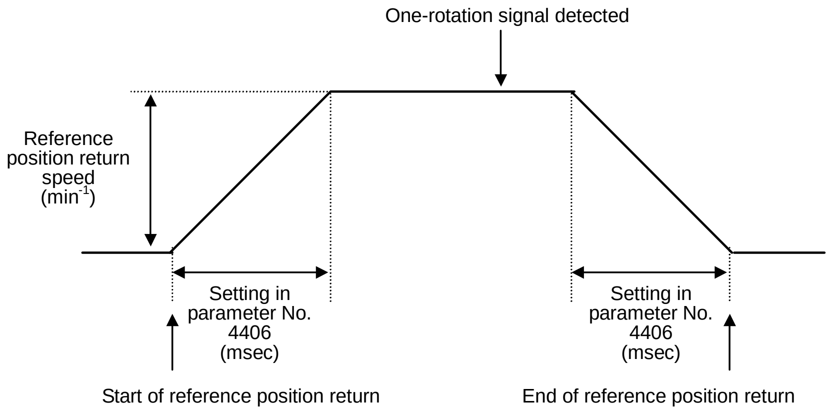
CSPTRE Sets the Cs axis position data transfer function.
0 : Disables the Cs axis position data transfer function.
1 : Enables the Cs axis position data transfer function.
Set this parameter to 1 when using the Cs axis coordinate establishment function.

> **NOTE**
> This parameter is valid with
> 9D53 series B (02) edition or later
> 9D70 series A (01) edition or later
> 9D80 series B (02) edition or later.

15*i*	16*i*	
3406	4406	**Acceleration/deceleration time constant for Cs contouring control/servo mode**

Unit of data : 1msec
Valid data range : 0 to 32767
Standard setting : 0

This parameter set the reference position return acceleration for Cs contouring control or servo mode (rigid tapping/spindle positioning). Use of this parameter can reduce the shock due to acceleration/deceleration during return to the reference position. The spindle speed command during return to the reference position is then given as follows:



NOTE
1 When 0 is set in this parameter, a velocity command is assumed as follows.
- Before detecting the one-rotation signal: Reference position return speed (step-type velocity command)
- After detecting the one-rotation signal: Distance to the reference position × Position gain

2 This parameter is enabled when soft start/stop signal SOCNA is 1.

2.4.9 Adjusting Cs Contouring Control

For this subsection, see Subsection 2.4.9, "Adjusting CS Contour Control", in Part I.

2.4.10 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.4.9, “Diagnosis (Diagnosis Screen)”, in Part I.

2.4.11 Alarm

For this subsection, see Subsection 2.4.10, “Alarm”, in Part I.

2.5 SPINDLE SYNCHRONOUS CONTROL (OPTIONAL FUNCTION)

2.5.1 Start-up Procedure

For this subsection, see Subsection 2.5.1, “Start-up Procedure”, in Part I.

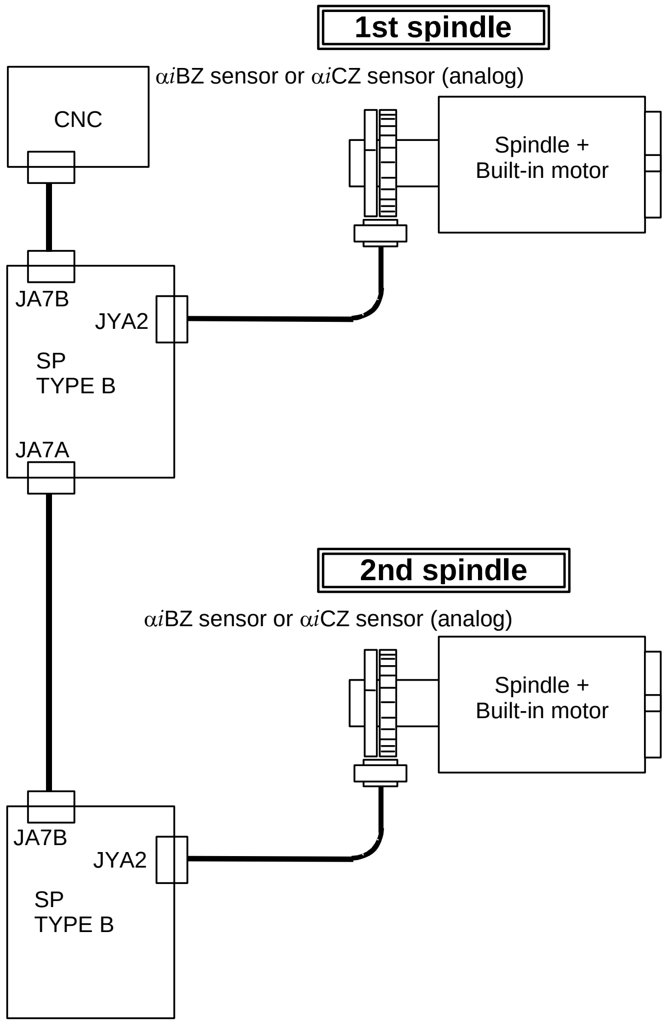
2.5.2 Overview

For this subsection, see Subsection 2.5.2, “Overview”, in Part I.

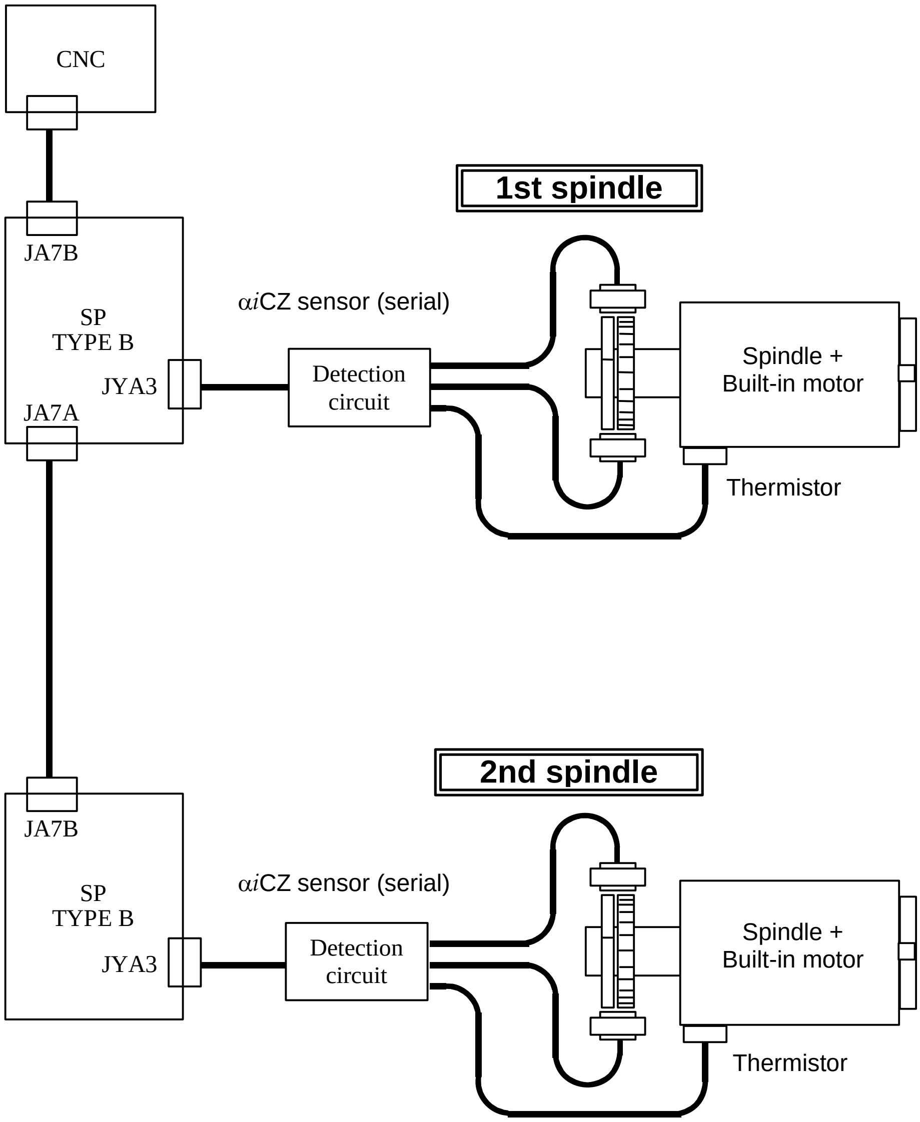
2.5.3 System Configuration

The system configurations that enable the use of the spindle synchronous control function are shown below.

(1) When the α*i*BZ sensor or α*i*CZ (analog) sensor is used



(2) When the αiCZ (serial) sensor is used



2.5.4 Explanation of Operation

For this subsection, see Subsection 2.5.4, “Explanation of Operation”, in Part I.

2.5.5 I/O Signals (CNC↔PMC)

For this subsection, see Subsection 2.5.5, “I/O Signals (CNC↔PMC)”, in Part I.

2.5.6 Examples of Sequences

For this subsection, see Subsection 2.5.6, “Examples of Sequences”, in Part I.

2.5.7 Related Parameters

Parameter No.		Description
16*i*	30*i*	
4800#0	-	Direction of rotation of the 1st spindle motor while spindle synchronous control is applied
4800#1	-	Direction of rotation of the 2nd spindle motor while spindle synchronous control is applied
-	4801#0	Direction of rotation of each spindle motor while spindle synchronous control is applied
4810	4810	Error pulse difference between the two spindles for which to output the spindle phase synchronous control completion signal
4811	4811	Error pulse difference between the two spindles for which to output the phase synchronous error monitor signal (SYCAL)
4002#6	4002#6	Whether to enable the rotation direction signal (SFR/SRV) function on spindle synchronous control
4006#1	4006#1	Gear ratio increment system
4006#3	4006#3	Setting for disabling automatic one-rotation signal detection at spindle synchronous control mode switching time
4032	4032	Acceleration used for spindle synchronous control (The same value must be set for both the 1st and 2nd spindles.)
4033	4033	Spindle synchronous speed arrival level
4034	4034	Shift amount for spindle phase synchronous control
4035	4035	Compensation data for spindle phase synchronization
4044 4045	4044 4045	Velocity loop proportional gain for spindle synchronous control (A parameter is selected by the CTH1A PMC input signal.)
4052 4053	4052 4053	Velocity loop integral gain for spindle synchronous control (A parameter is selected by the CTH1A PMC input signal.)
4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data (A parameter is selected by the CTH1A and CTH2A PMC input signals.)
4065 to 4068	4065 to 4068	Position gain for spindle synchronous control (The same value must be specified for both the 1st and 2nd spindles.) (A parameter is selected by the CTH1A and CTH2A PMC input signals.)
4336	4336	Magnetic flux switching point used for calculating an acceleration/deceleration time constant used for spindle synchronous control (The same value must be specified for both the 1st and 2nd spindles.)
4340	4340	Bell-shaped acceleration/deceleration time constant for spindle synchronous control (The same value must be specified for both the first and second spindles.)
4346	4346	Incomplete integration coefficient
4515	4515	Excessive speed deviation alarm detection level on spindle synchronous control
4516	4516	Excessive positional deviation alarm detection level on spindle synchronous control

NOTE

1 For the detector-related parameters, see Section 1.3, “PARAMETERS RELATED TO DETECTORS”, in Part IV.

2 For velocity loop proportional/integral gain adjustment, see Section 4.1, “VELOCITY LOOP GAIN ADJUSTMENT”, in Part IV.

2.5.8 Details of Related Parameters

This subsection details the serial spindle parameters (in the four thousands for 16*i* and 30*i*) among the parameters related to spindle synchronous control. For details of other parameters, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*

"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.12, "SPINDLE SYNCHRONOUS CONTROL."

(b) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.13, "SPINDLE SYNCHRONOUS CONTROL."

(c) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.11, "SPINDLE SYNCHRONOUS CONTROL."

16*i*	30	#7	#6	#5	#4	#3	#2	#1	#0
4002	4002		SYCDRT						

SYCDRT Whether to enable the rotation direction signal (SFR/SRV) function on spindle synchronous control

0 : Enables the rotation direction function.
If a move command from the CNC is positive (+),
(a) The spindle rotates in the CCW (counterclockwise) direction when the input signal SFR (bit 5 of G70) = 1.
(b) The spindle rotates in the CW (clockwise) direction when the input signal SRV (bit 4 of G70) = 1.

1 : Disables the rotation direction function.
If a move command from the CNC is positive (+), the spindle rotates in the CCW (counterclockwise) direction when the input signal SFR = 1 or SRV = 1.

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
4006	4006					SYCREF		GRUNIT	

GRUNIT Sets a gear ratio setting resolution:

0 : 1/100 unit
1 : 1/1000 unit

Select a gear ratio data setting resolution from the following:
(a) Resolution based on motor speed increased by a factor of 100 relative to one spindle rotation
(b) Resolution based on motor speed increased by a factor of 1000 relative to one spindle rotation

Depending on the setting of this parameter, the increment system of the parameters indicated in the table below changes.

Parameter No.		Description
16*i*	**30*i***	
4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data

NOTE
1 Usually, use the 1/100 unit (setting "0").
2 When the 1/100 unit is set as the gear ratio setting resolution (with the bit set to 0), a steady-state synchronous error may be indicated due to the fraction of the gear ratio.
In such a case, the synchronous error can be improved when the 1/1000 unit is set as the gear ratio setting resolution (with the bit set to 1).

SYCREF Setting for function performing automatic detection of the one-rotation signal on spindle synchronous control

0 : Automatic detection of the one-rotation signal carried out
1 : Automatic detection of the one-rotation signal not carried out. (When spindle phase synchronization is not carried out)
When the mode is switched to spindle synchronous control mode after power-on, the two spindles automatically perform a one-rotation signal detection operation. So, the spindles automatically make two to three turns even if such turns are not intended.
This operation is required because the one-rotation signal must be detected to enable spindle phase synchronous control.
If the two spindles are mechanically connected to disable each spindle from performing a one-rotation signal detection operation, or if spindle phase synchronous control is not exercised, the operation above can be disabled by setting this bit to 1.
When this parameter is set to “1”, check that the one-rotation signal has been detected for both spindles (output signal PC1DTA = 1) before applying the spindle phase synchronous control signal (SPPHS).
If the one-rotation signal is not detected, specify a speed of several ten min^{-1} or higher in spindle synchronous control mode, and wait until the one-rotation signal is detected. (See sequence example (4).)

16*i*	30*i*	
4032	4032	**Acceleration at spindle synchronous control**

Unit of data : $1min^{-1}/sec$
Valid data range : 0 to 32767
Standard setting : 0

This parameter sets an acceleration value for linear acceleration/deceleration when the synchronous speed command for spindle synchronous control is changed.

NOTE
1. Set exactly the same data for 1st spindle and 2nd spindle. When different data is set, synchronization between the two spindles is not guaranteed.
2. When this parameter is set to 0, motor doesn’t accelerate/decelerate, so, be sure to set proper value in this parameter.

16*i*	30*i*	
4033	4033	**Spindle synchronous speed arrival level**

Unit of data : $1min^{-1}/sec$
Valid data range : 0 to 32767
Standard setting : 10

For the synchronous speed command at spindle synchronous control, if the error of the respective spindle motor speeds are within the setting level, the spindle synchronous control complete signal (FSPSY) becomes “1”.

16*i*	30*i*	
4034	4034	**Shift amount at spindle phase synchronous control**

Unit of data : 1 pulse unit (360 degrees/4096)
Valid data range : 0 to 4095
Standard setting : 0

Sets the shift amount from the reference position (one-rotation signal) at spindle phase synchronous control.

16*i*	30*i*	
4035	4035	**Spindle phase synchronous compensation data**

Unit of data : 1 pulse/2msec
Valid data range : 0 to 4095
Standard setting : 10

This parameter reduces speed fluctuations when aligning phase of spindles in spindle phase synchronous control.
When this parameter is “0”, since the phase alignment amount is only issued once, the position error quickly becomes large, and there are large speed changes on phase alignment.
It is possible to perform smooth phase alignments through issuing separate commands for phase alignment amounts for the number of 2 msec pulses set in this parameter.

16*i*	30*i*		
4044	4044	**Velocity loop proportional gain on spindle synchronous control (HIGH)**	**CTH1A=0**
4045	4045	**Velocity loop proportional gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This sets velocity loop proportional gain on spindle synchronous control.
It is selected HIGH when CTH1A=0 of input signal, and It is selected LOW when CTH1A=1 of input signal.

16*i*	30*i*		
4052	4052	**Velocity loop integral gain on spindle synchronous control (HIGH)**	**CTH1A=0**
4053	4053	**Velocity loop integral gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 10

This sets velocity loop integral gain on spindle synchronous control. It is selected HIGH when CTH1A=0 of input signal, and It is selected LOW when CTH1A=1 of input signal.

16*i*	30*i*		
4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These parameters set the gear ratio of the spindle motor to the spindle.
Usually, set 100.

NOTE
When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle does not stop but keeps rotating at the time of orientation. So, be sure to set a proper gear ratio.

16*i*	30*i*	
4065	4065	**Position gain on spindle synchronous control (HIGH) CTH1A=0, CTH2A=0**
4066	4066	**Position gain on spindle synchronous control (MEDIUM HIGH) CTH1A=0, CTH2A=1**
4067	4067	**Position gain on spindle synchronous control (MEDIUM LOW) CTH1A=1, CTH2A=0**
4068	4068	**Position gain on spindle synchronous control (LOW) CTH1A=1, CTH2A=1**

Unit of data : 0.01sec^{-1}
Valid data range : 0 to 32767
Standard setting : 1000

This sets position gain in spindle synchronous control. It is selected by CTH1A or CTH2A of input signal.

16*i*	30*i*	
4336	4336	**Acceleration switch point on spindle synchronous control**

Unit of data 1min^{-1}
Valid data range : 0 to 32767
Standard setting : 0

The acceleration for spindle synchronous control changes according to the speed set in this parameter as follows:

- Area where the spindle speed does not exceed the speed set in this parameter
  The acceleration for spindle synchronous control is constant (as set in parameter No. 4032).
- Area where the spindle speed exceeds the speed set in this parameter
  The acceleration for spindle synchronous control decreases in inverse proportion to the speed.

NOTE
1 Set the same data for the first spindle and second spindle. If different data is set, synchronization between the two spindles is not guaranteed.
2 When this parameter is set to 0, linear acceleration/deceleration (constant acceleration) is performed.

16*i*	30*i*	
4340	4340	**Bell-shaped acceleration/deceleration time constant for spindle synchronous control**

Unit of data : 1msec
Valid data range : 0 to 512
Standard setting : 0

This parameter sets a bell-shaped acceleration/deceleration time constant for spindle synchronous control.
This parameter is applied to the move command after “Acceleration at spindle synchronous control” (parameter No. 4032) is applied.

When this parameter is set, the spindle synchronous speed control completion signal (FSPSY), output when the synchronous speed is first reached after the spindle synchronous control mode is entered, is delayed by the set time.

> **NOTE**
> Set the same data for the first spindle and second spindle. If different data is set, synchronization between the two spindles is not guaranteed.

16*i*	30*i*	
4346	4346	**Incomplete integration coefficient**

Unit of data :
Valid data range : 0 to 32767
Standard setting : 0
Set this parameter to use incomplete integration for velocity loop integration control.

> **NOTE**
> Usually, this parameter need not be adjusted.

16*i*	30*i*	
4515	4515	**Excessive speed deviation alarm detection level on spindle synchronous control**

Unit of data : $1min^{-1}$
Valid data range : 0 to 32767
Standard setting : 0
This parameter sets a level for detecting the excessive speed deviation alarm under spindle synchronous control.
If the positional deviation (position error) or the difference between the speed command for the spindle end calculated from the position gain and the actual spindle speed exceeds the value set in this parameter in the spindle synchronous control mode, the excessive speed deviation alarm under spindle synchronous control (spindle alarm C8) is detected. When this parameter is set to 0, alarm detection is disabled.

If the speed integration control signal (INTG) is used, the speed deviation increases for a cause such as acceleration/deceleration and cutting load. The spindle speed deviation that causes torque command saturation is indicated below. Set an alarm level by using a calculated value as a guideline. (During spindle synchronous control, ensure that torque command saturation does not take place.)

Spindle speed deviation $[min^{-1}] = 1024 \times A / P \times B / G$

where

No.4006#1	No.4009#0	A	B
0	0	1	100
0	1	16	100
1	0	1	1000
1	1	16	1000

P: Velocity loop proportional gain on spindle synchronous control(No.4044, 4045)
G: Gear ratio (No.4056 to 4059)

> **NOTE**
> This parameter is valid with 9D53 series E (05) edition or later, 9D70 series D (04) edition or later, and 9D80 series B (02) edition or later.

16*i*	30*i*	
4516	4516	**Excessive positional deviation alarm detection level on spindle synchronous control**

Unit of data : 100 pulses (weight of 4096 pulses/rev)
Valid data range : 0 to 32767
Standard setting : 0

This parameter sets a level for detecting the excessive positional deviation alarm under spindle synchronous control.
If the positional deviation (position error) exceeds the value set in this parameter in the spindle synchronous control mode, the excessive positional deviation alarm under spindle synchronous control (spindle alarm C9) is detected. When this parameter is set to 0, alarm detection is disabled.

As an alarm level, set a value greater than the positional deviation (position error) equivalent to the spindle speed specified in the spindle synchronous control mode. The positional deviation equivalent to the spindle speed can be calculated from the following expression:

Positional deviation [pulse] =
Spindle speed [min^{-1}] / 60 × 4096 × 100 / PG
where
PG: Position gain on spindle synchronous control (No.4065 to 4068)

> **NOTE**
> This parameter is valid with 9D53 series E (05) edition or later, 9D70 series D (04) edition or later, and 9D80 series B (02) edition or later.

2.5.9 Number of Error Pulses in Spindle Synchronous Control

For this subsection, see Subsection 2.5.10, “Number of Error Pulses in Spindle Synchronous Control”, in Part I.

2.5.10 Specifying a Shift Amount for Spindle Phase Synchronous Control

For this subsection, see Subsection 2.5.11, “Specifying a Shift Amount for Spindle Phase Synchronous Control”, in Part I.

2.5.11 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.5.12, “Diagnosis (Diagnosis Screen)”, in Part I.

2.5.12 Alarm

For this subsection, see Subsection 2.5.13, “Alarm”, in Part I.

2.6 SPECIFICATIONS COMMON TO ALL OPERATION MODES

2.6.1 Overview

For this subsection, see Subsection 2.6.1, “Overview”, in Part I.

2.6.2 List of I/O Signals (CNC↔PMC)

This subsection provides a list of the I/O signals related to spindle speed control only. For details of each signal, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, “SPINDLE SPEED CONTROL.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”

For details of the I/O signals common to the CNCs, see Chapter 3, “I/O SIGNALS (CNC↔PMC)”, in Part IV.

(1) Input signals (PMC→CNC)

(a) Series 16*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(b) Series 30*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G005							FIN	
1st-	G024	RI7A	RI6A	RI5A	RI4A	RI3A	RI2A	RI1A	RI0A
2nd-	G232	RI7B	RI6B	RI5B	RI4B	RI3B	RI2B	RI1B	RI0B
1st-	G025	RISGNA			RI12A	RI11A	RI10A	RI9A	RI8A
2nd-	G233	RISGNB			RI12B	RI11B	RI10B	RI9B	RI8B
1st-	G026		GS4A	GS2A	GS1A				
2nd-	G272		GS4B	GS2B	GS1B				

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA		SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA
2nd-	G235	G074	G074	MRDYB		SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB
1st-	G226	G071	G071							*ESPA	ARSTA
2nd-	G234	G075	G075							*ESPB	ARSTB
1st-	G228	G073	G073	EPFSTRA			DSCNA		MPOFA		
2nd-	G236	G077	G077	EPFSTRB			DSCNB		MPOFB		

(2) Output signals (CNC→PMC)

(a) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O

NOTE
1 These signals are valid with the M series only.

(b) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O

NOTE
1 These signals are valid with the M series only.

(c) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F008							SF	
Common to all axes	F020	S7	S6	S5	S4	S3	S2	S1	S0
Common to all axes	F021	S15	S14	S13	S12	S11	S10	S09	S08
Common to all axes	F022	S23	S22	S21	S20	S19	S18	S17	S16
Common to all axes	F023	S31	S30	S29	S28	S27	S26	S25	S24
Common to all axes	F045			SRSRDY					
1st-	F010	RO7A	RO6A	RO5A	RO4A	RO3A	RO2A	RO1A	RO0A
2nd-	F320	RO7B	RO6B	RO5B	RO4B	RO3B	RO2B	RO1B	RO0B
1st-	F11	RO15A	RO14A	RO13A	RO12A	RO11A	RO11A	RO10A	RO9A
2nd-	F321	RO15B	RO14B	RO13B	RO12B	RO11B	RO11B	RO10B	RO9B
1st-	F014	MR7A	MR6A	MR5A	MR4A	MR3A	MR2A	MR1A	MR0A
2nd-	F324	MR7B	MR6B	MR5B	MR4B	MR3B	MR2B	MR1B	MR0B
1st-	F015	MR15A	MR14A	MR13A	MR12A	MR11A	MR10A	MR9A	MR8A
2nd-	F325	MR15B	MR14B	MR13B	MR12B	MR11B	MR10B	MR9B	MR8B
1st-	F234	SSPD7A	SSPD6A	SSPD5A	SSPD4A	SSPD3A	SSPD2A	SSPD1A	SSPD0A
2nd-	F250	SSPD7B	SSPD6B	SSPD5B	SSPD4B	SSPD3B	SSPD2B	SSPD1B	SSPD0B
1st-	F235	SSPD15A	SSPD14A	SSPD13A	SSPD12A	SSPD11A	SSPD10A	SSPD9A	SSPD8A
2nd-	F251	SSPD15B	SSPD14B	SSPD13B	SSPD12B	SSPD11B	SSPD10B	SSPD9B	SSPD8B
1st-	F341								SRRDYA
2nd-	F342								SRRDYB

(d) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045		TLMA	LDT2A	LDT1A	SARA	SDTA	SSTA	ALMA
2nd-	F245	F049	F049		TLMB	LDT2B	LDT1B	SARB	SDTB	SSTB	ALMB
1st-	F231	F047	F047				EXOFA				PC1DTA
2nd-	F247	F051	F051				EXOFB				PC1DTB
1st-	F230	F048	F048	EPFIXA				SSMBRKA			PC1DTA
2nd-	F246	F052	F052	EPFIXB				SSMBRKB			PC1DTB

2.6.3 Parameters

This subsection describes those parameters that are common to all operation modes by dividing them into several types.

> **NOTE**
> For the detector-related parameters, see Section 1.3, "PARAMETERS RELATED TO DETECTORS", in Part IV.

(1) List of parameters specific to synchronous built-in spindle motor driving

This item provides a list of the motor parameters specific to synchronous built-in spindle motor driving. Usually, the settings of these parameters need not be changed. Use the values indicated on a parameter table for each motor model without modification.

Parameter No.			Description
15*i*	16*i*	30*i*	
3006#4	4006#4	4006#4	Sets the d-phase current command.
3008#3	4008#3	4008#3	Sets the current command.
3008#4	4008#4	4008#4	Sets the method of output control.
3009#5	4009#5	4009#5	Sets base speed (for B*i*S160L4/6000)
3011#3	4011#3	4011#3	Sets the number of motor poles.
3011#4	4011#4	4011#4	Sets a maximum output for acceleration/deceleration.
3011#7	4011#7	4011#7	Sets the number of motor poles.
3012#2,#1,#0	4012#2,#1,#0	4012#2,#1,#0	Sets a PWM carrier frequency.
3012#6	4012#6	4012#6	Sets whether to drive the synchronous built-in spindle motor.
3012#7	4012#7	4012#7	Sets the spindle HRV function.
3013#6 to #2	4013#6 to #2	4013#6 to #2	Sets current dead-band data.
3020	4020	4020	Maximum motor speed
3080	4080	4080	Limits regenerative power.
3083	4083	4083	Current step selection/activation current ratio/stop confirmation time in magnetic pole detection
3084	4084	4084	AMR offset
3085	4085	4085	AMR offset fine adjustment
3086	4086	4086	Inductance ratio
3100	4100	4100	Base speed for motor output specification
3101	4101	4101	Torque limitation value for motor output specification
3102	4102	4102	Base speed at maximum load
3103	4103	4103	Magnetic flux reduction start speed / Current pattern switching speed
3104	4104	4104	Current loop proportional gain
3106	4106	4106	Current loop integral gain
3108	4108	4108	Current loop integral gain zero speed
3109	4109	4109	Filter time constant in voltage command saturation processing
3110	4110	4110	Current conversion constant
3111	4111	4111	Maximum current coefficient
3112	4112	4112	Voltage command saturation decision level/PWM command clamp value
3113	4113	4113	Current coefficient for magnetic flux reduction
3115	4115	4115	PWM command clamp value at deceleration time
3116	4116	4116	Counter electromotive voltage compensation coefficient
3117	4117	4117	Interference voltage compensation coefficient
3119	4119	4119	Interference voltage compensation
3120	4120	4120	Dead-band rectangular wave component zero voltage/dead-band data
3127	4127	4127	Load meter indication value at maximum output time
3130	4130	4130	Current phase delay compensation constant
3133	4133	4133	Motor model code
3134	4134	4134	Motor overheat level (2 words)
3362	4362	4362	Load meter compensation 1
3363	4363	4363	Load meter compensation 2
3364	4364	4364	Load meter compensation 3

(2) List of parameters related to alarm detection

This item provides a list of the parameters related to alarm detection conditions.

Parameter No.			Description
15*i*	16*i*	30*i*	
3009#2	4009#2	4009#2	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued
3087	4087	4087	Overspeed level
3088	4088	4088	Velocity error excess detection level when the motor is bound
3089	4089	4089	Velocity error excess detection level when the motor is rotating
3090	4090	4090	Overload detection level
3123	4123	4123	Short-time overload detection period
3399#5	4399#5	4399#5	Whether to detect magnetic pole position count miss alarm (spindle alarm 91)
3463	4463	4463	Unexpected rotation detection level (spindle Alarm 90)
3464	4464	4464	Velocity command-dependent over speed (spindle alarm 92) detection offset level
3465	4465	4465	Excessive speed deviation level 2
3466	4466	4466	Excessive speed deviation detection time 2
3527	4527	4527	Temperature difference between warning level and alarm level

(3) Other parameters

This item provides a list of the parameters common to all operation modes except the parameters listed in Items (1) and (2) above.

Parameter No.			Description
15*i*	16*i*	30*i*	
-	3706#1,#0	-	Gear ratio between the spindle and position coder (cases of ×1, ×2, ×4, ×8)
5602#3	-	-	Whether to indicate an alarm detected by the spindle amplifier (Usually, set 0.)
5807#0	-	-	Enables/disables the spindle alarms (SPxxxx) of all spindles. (Usually, set 0.)
5842	-	3720	Number of position coder pulses
5850	-	-	Spindle number selected at power-on/reset time
3001#0	4001#0	4001#0	Whether to use the MRDY signal (machine ready signal)
3006#1	4006#1	4006#1	Gear ratio increment system
3009#0	4009#0	4009#0	Velocity loop gain increment system
3009#4	4009#4	4009#4	Whether to output the load detection signals (LDT1, LDT2) during acceleration/deceleration
3012#6	4012#6	4012#6	Sets whether to drive the synchronous built-in spindle motor.
3012#7	4012#7	4012#7	Sets the spindle HRV function.
3019#2	4019#2	4019#2	Whether to perform torque clamping when the speed is zero
3019#7	4019#7	4019#7	Automatic parameter setting function
3352#1	4352#1	4352#1	Sets the peak hold function for load meter output.
3395#3	4395#3	4395#3	Sets parameter transfer from the CNC to spindle software.
3020	4020	4020	Maximum motor speed
3022	4022	4022	Speed arrival detection signal
3023	4023	4023	Speed detection level
3024	4024	4024	Speed zero detection level
3025	4025	4025	Torque limitation value.
3026	4026	4026	Load detection level 1
3027	4027	4027	Load detection level 2
3056	4056	4056	Gear ratio (High)
3057	4057	4057	Gear ratio (Medium High)
3058	4058	4058	Gear ratio (Medium Low)
3059	4059	4059	Gear ratio (Low)
3095	4095	4095	Speedometer output voltage adjustment value
3096	4096	4096	Load meter output voltage adjustment value
3122	4122	4122	Speed detection filter time constant

Parameter No.			Description
15*i*	16*i*	30*i*	
3170	4170	4170	Overload current alarm detection level
3345	4345	4345	Detection level of the spindle motor speed command
3346	4346	4346	Incomplete integral coefficient
3351	4351	4351	Current detection offset compensation

2.6.4 Details of Parameters

This subsection details the serial spindle parameters (in the four thousands for 16*i*, in the four thousands for 30*i*, and in the three thousands for 15*i*) among the parameters common to all operation modes. For details of other parameters, refer to the Connection Manual (Function) of each CNC.

(a) For Series 16*i*/18*i*/21*i*
“FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(b) For Series 30*i*/31*i*/32*i*
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 11.3, “SPINDLE SPEED CONTROL.”
(c) For Series 15*i*
“FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”
(d) For Series 0*i*
“FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 9.3, “SPINDLE SPEED CONTROL.”

(1) List of parameters specific to spindle motor driving

Usually, the settings of the motor parameters specific to synchronous built-in spindle motor driving need not be changed. Their details are omitted.

(2) List of parameters related to alarm detection

This item details the parameters related to alarm detection conditions.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3009	4009	4009						**ALSP**		

ALSP Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued
0 : Turns off the power after the motor is decelerated and stopped.
1 : Turns off the power to the motor immediately.
Set this parameter to 1 to turn off the power to the motor immediately when any spindle alarm is issued

15*i*	16*i*	30*i*	
3087	4087	4087	**Overspeed level**

Unit of data : 1%
Valid data range : 0 to 115
Standard setting value : 115
This parameter sets an overspeed level.
When the speed exceeds [maximum motor speed (No. 4020) × setting data (%)], the overspeed alarm (spindle alarm 07) is issued.

⚠ **WARNING**
Make sure this parameter is set to the standard setting value. Do not change the value.

15*i*	16*i*	30*i*	
3088	4088	4088	**Velocity error excess detection level when the motor is bound**

Unit of data : 0.01%
Valid data range : 0 to 10000
Standard setting value : 75

This parameter sets a velocity error excess (spindle alarm 31) detection level when the motor is bound.

If a velocity error equal to or greater than [maximum motor speed (No. 4020) × setting data (%)] occurs when the motor is bound, for example, the motor binding alarm (spindle alarm 31) is issued.

15*i*	16*i*	30*i*	
3089	4089	4089	**Velocity error excess detection level when the motor is rotating**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 200

This parameter sets a velocity error excess detection level when the motor is rotating.

If a velocity error equal to or greater than [maximum motor speed (No. 4020) × setting data (%)] occurs, the velocity error excess alarm (spindle alarm 02) is issued.

15*i*	16*i*	30*i*	
3090	4090	4090	**Overload detection level**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 90

This parameter sets a condition for detecting the short-time overload alarm (spindle alarm 29).

If the state where a load equal to or greater than setting data (%) (maximum motor output [load meter full scale] = 100%) is imposed on the spindle motor lasts for a specified period (set in No. 4123) or more, the short-time overload alarm (spindle alarm 29) is issued.

15*i*	16*i*	30*i*	
3123	4123	4123	**Short-time overload detection period**

Unit of data : 1sec
Valid data range : 0 to 500
Standard setting value : 30

This parameter sets the timing for detecting the short-time overload alarm (spindle alarm 29).

If the state where a load equal to or greater than the specified value (set in parameter No. 4090) is imposed on the spindle motor lasts for at least the period specified in this parameter, the short-time overload alarm (spindle alarm 29) is issued.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3399	4399	4399			NCHAMR					

NCHAMR Determines whether to detect “pole position count miss alarm (spindle alarm 91)”.

0: Detect alarm 91.

1: Does not detect alarm 91.

When the one-rotation signal is detected, this function monitors the difference between the initial magnetic pole position estimated by magnetic pole detection and AMR offset (parameter No. 4084). If the parameter-set threshold is exceeded, alarm 91 is detected.

If spindle alarm 91 must be invalidated temporarily for adjustment and other purposes, set this parameter to "-1 (alarm 91 is invalid)".

NOTE

1 When the αiCZ sensor (serial) is used, this function cannot be used.

2 This function is valid after executing AMR offset. Therefore, following parameters are needed to be set.
No.4008#6 = “0 (AMR offset is valid)”
No.4084 = “An adjustment value”

3 The magnetic pole undetected state (EPFIX: F048#7) is reset to 0 if spindle alarm 91 is issued.

4 This parameter is valid with
9D53 series I (09) edition or later
9D70 series H (08) edition or later
9D80 series B (02) edition or later
9D90 series A (01) edition or later
9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3463	4463	4463	**Unexpected rotation detection level**

Unit of data : 0.1rev
Valid data range : -1, 0~500
Standard setting value : 0

This parameter specifies the unexpected rotation detection level (Alarm 90 level).

When the sign of unexpected rotation is once detected, spindle amplifier (SP) begins to sum the velocity error. When the motor rotates normally, Sp subtracts the velocity error from the summation. If the parameter-set threshold is exceeded, alarm 90 is detected.

When “0” is set, 1.0rev is set internally.

If spindle alarm 90 must be invalidated temporarily for adjustment and other purposes, set this parameter to "-1 (alarm 90 is invalid)".

NOTE

*1 The magnetic pole undetected state (EPFIX: F048#7) is reset to 0 if spindle alarm 90 is issued.

*2 This parameter is valid with
9D53 series I (09) edition or later
9D70 series H (08) edition or later
9D80 series B (02) edition or later
9D90 series A (01) edition or later
9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3464	4464	4464	**Velocity command-dependent over speed detection offset level**

Unit of data : 0.1%
Valid data range : -1, 0~500
Standard setting value : 0

This parameter sets the offset speed level for detecting the over speed (spindle alarm 92) according to the velocity command.

When the spindle motor reaches the velocity command plus the maximum motor speed (No. 4020) × setting data% the velocity command-dependent over speed alarm (spindle alarm 92) is issued. This detection level is automatically updated if the velocity command increases or changes to 0 or if control mode (such as speed mode or orientation mode) changes.

If the setting is "0", the offset level is 15%.

If spindle alarm 92 must be invalidated temporarily for adjustment and other purposes, set this parameter to "-1 (alarm 92 is invalid)".

NOTE

*1 The magnetic pole undetected state (EPFIX: F048#7) is reset to 0 if spindle alarm 92 is issued.

*2 This parameter is valid with
9D53 series I (09) edition or later
9D70 series H (08) edition or later
9D80 series B (02) edition or later
9D90 series A (01) edition or later
9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3465	4465	4465	**Excessive speed deviation level 2**

Unit of data : If the setting is positive, 1 min^{-1}
(When bit 2 (SPDUNT) of parameter No. 4006 is 1, 10 min^{-1})
If the setting is negative: 0.1%
Valid data range : -1000~32767
Standard setting value : 0

This parameter sets the alarm level for excessive speed deviation alarms (spindle alarms 02 and 31) in units of 1 min^{-1} (motor speed) or as a ratio to the motor velocity command. Depending on the setting of this parameter, the alarm level (min^{-1}) for the excessive speed deviation alarms is as follows:

- If the setting is positive: Setting of parameter No. 4465 (min^{-1})

- If the setting is negative: |Velocity command × Setting of parameter No. 4465/1000| (min^{-1})

If the setting is "0", this parameter is excluded from the excessive speed deviation alarm detection conditions.

> **NOTE**
> This parameter is valid with
> 9D53 series J (10) edition or later
> 9D70 series I (09) edition or later
> 9D80 series C (03) edition or later
> 9D90 series A (01) edition or later
> 9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3466	4466	4466	**Excessive speed deviation detection time 2**

Unit of data : 0.1sec
Valid data range : 0~1000
Standard setting value : 0

This parameter sets the period from the time the motor speed deviation exceeds the alarm level of the excessive speed deviation alarm set in parameter No. 4465 until an excessive speed deviation alarm (spindle alarm 02 or 31) is issued.

If the motor speed deviation goes below the alarm level within the period of time set in this parameter, the period of time is reset.

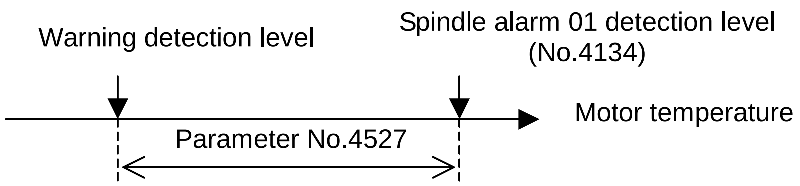
> **NOTE**
> This parameter is valid with
> 9D53 series J (10) edition or later
> 9D70 series I (09) edition or later
> 9D80 series C (03) edition or later
> 9D90 series A (01) edition or later
> 9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3527	4527	4527	**Temperature difference between warning level and alarm level**

Unit of data : 1K
Valid data range : 0~50
Standard setting value : 0

This parameter sets the difference between motor overheat alarm detection temperature and the warning detection temperature. If the parameter setting is 0, the spindle motor overheat warning function is disabled.

While the motor temperature exceeds the warning detection temperature, the motor overheat warning (warning number 01) is issued.



(3) Other parameters

This item details the parameters common to all operation modes except the parameters listed in Items (1) and (2) above.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3001	4001	4001								MRDY1

MRDY1 Whether to use the MRDYA signal (machine ready signal)

0 : Does not uses the MRDYA signal (MRDYA = 1 at all times).

1 : Uses the MRDYA signal.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3006	4006	4006							GRUNIT	

GRUNIT Sets a gear ratio setting resolution:

0 : 1/100 unit

1 : 1/1000 unit

Select a gear ratio data setting resolution from the following:

(a) Resolution based on motor speed increased by a factor of 100 relative to one spindle rotation

(b) Resolution based on motor speed increased by a factor of 1000 relative to one spindle rotation

Depending on the setting of this parameter, the increment system of the parameters indicated in the table below changes.

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3056 to 3059	4056 to 4059	4056 to 4059	Spindle-to-motor gear ratio data

> **NOTE**
> Usually, use the 1/100 unit (setting “0”).

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3009	4009	4009				LDTOUT				VLPGAN

VLPGAN Velocity control loop gain increment system

0 : Uses ordinary setting.

1 : Divides ordinary setting data by 16 for processing.

> **NOTE**
> Usually, set this parameter to 0.

LDTOUT Whether to output the load detection signals (LDT1, LDT2) during acceleration/deceleration

0 : Does not output the load detection signals during acceleration/ deceleration (standard setting value).

1 : Outputs the load detection signals during acceleration/ deceleration (at all times) when the parameter-set level is exceeded.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3012	4012	4012	SPHRV	SYSP						

SYSP Sets whether to drive the synchronous built-in spindle motor.
0 : Enables inductive spindle motor driving. (standard setting value)
1 : Enables synchronous built-in spindle motor driving.
Set this parameter to 1.

SPHRV Sets the spindle HRV control function.
0 : Disables spindle HRV control.
1 : Enables spindle HRV control. (standard setting value)
Set this parameter to 1.

NOTE
When driving the B*i*S series spindle (synchronous built-in spindle motor), be sure to set both of the SYSP and SPHRV bits to 1.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3019	4019	4019	PRLOAD					SSTTRQ		

SSTTRQ Whether to perform torque clamping when the speed is zero
0 : Performs clamping.
1 : Does not perform clamping.

NOTE
Usually, set this parameter to 1 not to perform clamping.

PRLOAD Automatic parameter setting function
0 : Does not perform automatic parameter setting (standard setting value).
1 : Performs automatic parameter setting.
After setting a desired motor model code in parameter No. 4133 and setting this bit to 1, turn off the power to the CNC, then turn on the power to the CNC again. The parameters (No. 4000 to No. 4175) for the αi series spindle corresponding to the model code are automatically initialized. Upon completion of automatic setting, this bit is automatically set to 0.

NOTE
With FS15*i*, the parameter address of this function is different, namely, bit 0 of No. 5607 is used. Moreover, note that the meanings of settings are reversed as follows.
0: Performs automatic parameter setting.
1: Does not perform automatic parameter setting.
In this case, set a model code in parameter No. 3133.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3352	4352	4352							PKHALW	

PKHALW Sets the peak hold function for load meter output.
0 : Does not use the peak hold function. (standard setting value)
1 : Uses the peak hold function.

15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
3395	4395	4395					PRIMED			

PRIMED Sets parameter transfer from the CNC to spindle software.

0 : Regards parameters as valid one second after they are transferred from the CNC. (Standard setting value)
1 : Regards parameters as valid as soon as they are transferred from the CNC.

> **NOTE**
> This parameter is valid with 9D53 series B (02) edition or later, 9D70 series A (01) edition or later, 9D80 series B (02) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later.

15*i*	16*i*	30*i*	
3020	4020	4020	**Maximum motor speed**

Unit of data : $1min^{-1}$
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.
This parameter sets a maximum spindle motor speed.

15*i*	16*i*	30*i*	
3022	4022	4022	**Speed arrival detection level**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 150
This parameter sets a speed arrival signal (SARA) detection range.
When the motor speed reaches within ±(setting data/10)% of a specified speed, the speed arrival signal (SARA) is set to 1.

15*i*	16*i*	30*i*	
3023	4023	4023	**Speed detection level**

Unit of data : 0.1%
Valid data range : 0 to 1000
Standard setting value : 30
This parameter sets a speed detection signal (SDTA) detection range.
When the motor speed is (setting data/10)% of a maximum speed or less, the speed detection signal (SDTA) is set to 1.

15*i*	16*i*	30*i*	
3024	4024	4024	**Speed zero detection level**

Unit of data : 0.01%
Valid data range : 0 to 10000
Standard setting value : 75
This parameter sets a speed zero detection signal (SSTA) detection range.
When the motor speed is (setting data/100)% of a maximum speed or less, the speed zero detection signal (SSTA) is set to 1.

NOTE

If the calculated speed zero detection level exceeds 200 min^{-1}, it is clamped at 200 min^{-1}. (9D53 series B (02) edition or later, 9D70 series A (01) edition or later, 9D80 series B (02) edition or later, 9D90 series A (01) edition or later, and 9DA0 series A (01) edition or later)

15*i*	16*i*	30*i*	
3025	4025	4025	**Torque limitation value.**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 50

This parameter sets a torque limitation value to be applied when the torque limitation command HIGH (TLMHA) or the torque limitation command LOW (TLMLA) is specified.
The data indicates limitation values when the maximum torque is 100%.

Torque limitation command LOW (TLMLA)	Torque limitation command HIGH (TLMHA)	Description
0	0	No torque limitation is imposed.
0	1	The torque is limited to the value set in this parameter.
1	0	The torque is limited to a half of the value set in this parameter.
1	1	

15*i*	16*i*	30*i*	
3026	4026	4026	**Load detection level 1**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 83

This parameter sets a load detection signal 1 (LDT1A) detection range. When the output of the spindle motor is (setting data)% of the maximum output or more, load detection signal 1 (LDT1A) is set to 1.

15*i*	16*i*	30*i*	
3027	4027	4027	**Load detection level 2**

Unit of data : 1%
Valid data range : 0 to 100
Standard setting value : 95

This parameter sets a load detection signal 2 (LDT2A) detection range. When the output of the spindle motor is (setting data)% of the maximum output or more, load detection signal 2 (LDT2A) is set to 1.

15*i*	16*i*	30*i*		
3056	4056	4056	**Gear ratio (HIGH)**	**CTH1A=0, CTH2A=0**
3057	4057	4057	**Gear ratio (MEDIUM HIGH)**	**CTH1A=0, CTH2A=1**
3058	4058	4058	**Gear ratio (MEDIUM LOW)**	**CTH1A=1, CTH2A=0**
3059	4059	4059	**Gear ratio (LOW)**	**CTH1A=1, CTH2A=1**

Unit of data : (Motor rotation for one rotation of spindle) / 100
(When parameter No. 4006 #1 (GRUNIT) is 1, motor rotation / 1000)
Valid data range : 0 to 32767
Standard setting : 100

These data are used to set the gear ratio between spindle and spindle motor.
Example :
When the spindle rotates once, set "250" as the data when the motor rotates 2.5 times.
A parameter is selected with the CTH1A and CTH2A input signals.
Set the gear or clutch status to correspond to the clutch/gear signal (CTH1A, CTH2A) in input signals.

> **NOTE**
> When an improper value is set in these parameters, an unexpected operation can occur. For example, the spindle can continue rotating without stopping at the time of orientation. So, be sure to set a proper gear ratio.

15*i*	16*i*	30*i*	
3095	4095	4095	**Speedometer output voltage adjustment value**

Unit of data : 0.1%
Valid data range : -1000 to +100(-100% to +10%)
Standard setting value : 0

Set this parameter when making a fine adjustment of speedometer output voltage.
Positive (+) data increases the output voltage.

> **NOTE**
> Usually, this parameter need not be adjusted.

15*i*	16*i*	30*i*	
3096	4096	4096	**Load meter output voltage adjustment value**

Unit of data : 0.1%
Valid data range : -1000 to +100(-100% to +10%)
Standard setting value : 0

Set this parameter when making a fine adjustment of load meter output voltage.
Positive (+) data increases the output voltage.

> **NOTE**
> Usually, this parameter need not be adjusted.

15*i*	16*i*	30*i*	
3122	4122	4122	**Speed detection filter time constant**

Unit of data : 0.1ms
Valid data range : 0 to 10000
Standard setting value : 0

This parameter sets a time constant for a filter to be applied to the velocity feedback signal.

> **NOTE**
> Usually, this parameter need not be adjusted.

15*i*	16*i*	30*i*	
3170	4170	4170	**Overload current alarm detection level**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

> **NOTE**
> Usually, this parameter need not be adjusted.

15*i*	16*i*	30*i*	
3345	4345	4345	**Specified detection level of the spindle motor speed**

Unit of data : 1 min^{-1}
Valid data range : 0 to 32767
Standard setting value : 0

This parameter sets the detection level of the spindle motor speed detection function. If the specified spindle motor speed is greater than the set value, the level of the speed specification detection signal output from the spindle amplifier to the CNC becomes 1.
If the set value is 0, the level of the speed specification detection signal is always 0.

15*i*	16*i*	30*i*	
3346	4346	4346	**Incomplete integral coefficient**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : 0

Set this parameter to use incomplete integral function for velocity loop integral control.

> **NOTE**
> Usually, this parameter need not be adjusted.

15*i*	16*i*	30*i*	
3351	4351	4351	**Current detection offset compensation**

Unit of data :
Valid data range : 0 to ±32767
Standard setting value : 0

> **NOTE**
> Usually, this parameter need not be adjusted.

2.6.5 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.6.5, “Diagnosis (Diagnosis Screen)”, in Part I.

3 I/O SIGNALS (CNC↔PMC)

This chapter explains the functions of the signals directly input from the PMC to spindle amplifier (SP) via the CNC and the signals directly output from the spindle amplifier (SP) to PMC. For other spindle-related I/O signals, refer to the Connection Manual (Function) of the relevant CNC.

(a) For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Chapter 9, "SPINDLE SPEED FUNCTION."
(b) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Chapter 11, "SPINDLE SPEED FUNCTION."
(c) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7, "SPINDLE SPEED FUNCTION."
(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Chapter 9, "SPINDLE SPEED FUNCTION."

⚠ **WARNING**

1 Operation of each signal described in this chapter is not guaranteed if an alarm is issued or if a hardware failure or abnormal operation occurs.
2 A signal described in this chapter can be used as a safety function only when it is described that "the signal can be used as a safety function".

⚠ **CAUTION**

Each signal described in this chapter is disabled and its operation is not guaranteed after power-on until the parameters have been transferred from the CNC to the spindle amplifier. After checking spindle operation ready signal SRSRDY and other signals (refer to the Connection Manual for the relevant CNC) to see the ready status, use the signals described in this chapter.

3.1 INPUT SIGNALS (PMC→CNC→SP)

This chapter explains the functions of the signals directly input from the PMC to spindle amplifier (SP) via the CNC and the address for signals of the first spindle or second spindle. For other spindle-related input signals, refer to the Connection Manual (Function) of the relevant CNC.

(a) For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Chapter 9, "SPINDLE SPEED FUNCTION."
(b) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Chapter 11, "SPINDLE SPEED FUNCTION."
(c) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7, "SPINDLE SPEED FUNCTION."
(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Chapter 9, "SPINDLE SPEED FUNCTION."

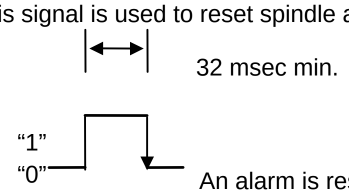
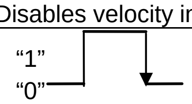
3.1.1 List of Input Signals

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA	ORCMA	SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA
2nd-	G235	G074	G074	MRDYB	ORCMB	SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB
1st-	G226	G071	G071			INTGA	SOCNA			*ESPA	ARSTA
2nd-	G234	G075	G075			INTGB	SOCNB			*ESPB	ARSTB
1st-	G229	G072	G072			INCMDA	OVRA		NRROA	ROTAA	INDXA
2nd-	G237	G076	G076			INCMDB	OVRB		NRROB	ROTAB	INDXB
1st-	G228	G073	G073	EPFSTRA			DSCNA	SORSLA	MPOFA		
2nd-	G236	G077	G077	EPFSTRB			DSCNB	SORSLB	MPOFB		

3.1.2 Explanation of Input Signals

The signals whose names are not listed in Subsection 3.1.1, "List of Input Signals", in Part IV are not supported by the B*i*S series spindle.

Symbol	Name	Description
TLMLA, B TLMHA, B	Torque limitation command LOW Torque limitation command HIGH	These signals limit the output torque of the spindle motor. The limit value is set in spindle parameter No. 4025. TLML TLMH 0 0 : Torque not limited 0 1 : Limited to the parameter-set value 1 0 : Limited to about half of the parameter-set value 1 1 : Limited to about half of the parameter-set value
CTH1A, B CHT2A, B	Clutch/gear signal	These signals set the conditions listed below according to the clutch or gear status. The signals can also be used for selecting spindle control parameters. The names such as HIGH GEAR are given for convenience, and the correspondence to the actual gears is free. CTH1 CTH2 0 0 : HIGH GEAR 0 1 : MEDIUM HIGH GEAR 1 0 : MEDIUM LOW GEAR 1 1 : LOW GEAR
SRVA, B SFRA, B	Reverse rotation command Forward rotation command	These signals set the rotation direction of the spindle motor when viewed from the shaft side. SRV SFR 0 0 : Stopped 0 1 : Forward rotation (CCW: Counterclockwise direction) 1 0 : Reverse rotation (CW: Clockwise direction) 1 1 : Stopped
ORCMA, B	Spindle orientation command	This signal is used to perform spindle orientation control. 0: Turns off the spindle orientation command. 1: Performs spindle orientation control.
MRDYA, B	Machine ready signal	0: Motor excitation is off. 1: Ready for operation

Symbol	Name	Description
ARSTA, B	Spindle alarm reset signal	This signal is used to reset spindle alarms.  An alarm is reset when the signal status changes from "1" to "0".
*ESPA, B	Emergency stop signal	0: Emergency stop 1: Normal operation
SOCNA, B	Soft start/stop signal	0: Disables the soft start/stop function. 1: Enables the soft start/stop function.
INTGA, B	Velocity integral control signal	0: Enables velocity integral control. 1: Disables velocity integral control.
INDXA, B	Orientation stop position change command	 This signal is used in orientation with the stop position set external setting type. When the status of this signal changes from "1" to "0", new position stop data is input, and a movement to the new position then a stop take place.
ROTAA, B	Rotation direction command at orientation stop position change	This signal is used in orientation with the stop position set external setting type. 0: CCW (counterclockwise) 1: CW (clockwise)
NRROA, B	Shortcut command at orientation stop position change	This signal is used in orientation with the stop position set external setting type. 0: The rotation direction depends on the ROTA signal setting. 1: Shortcut control (within ±180°)
OVRA, B	Analog override command	0: Disables analog override. 1: Enables analog override.
INCMDA, B	Incremental command	1: Incremental command spindle orientation 0: Ordinary orientation
MPOFA, B	Motor power turn-off signal	1: Turns off the motor power.
SORSLA, B	Synchronous orientation request command	This signal requests a synchronous orientation operation. 0: Cancels synchronous orientation. 1: Requests synchronous orientation.
DSCNA, B	Disconnection detection disable signal	This signal is used to detach the feedback cable between the amplifier and motor. This signal is disabled in the excitation ON state. 0: Enables disconnection and overheat detection. 1: Disables disconnection and overheat detection.
EPFSTRA, B	Magnetic pole detection operation start signal	Signal for starting magnetic pole detection operation 0: Cancels magnetic pole detection operation. 1: Requests magnetic pole detection operation.

3.1.3 Details of Input Signals

(a) Torque limitation command signals (TLMLA, TLMHA)

For details of these signals, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.

(b) Clutch/gear signals (CTH1A, CTH2A)

For details of these signals, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.

(c) Forward rotation command signal (SFRA) and reverse rotation command signal (SRVA)

For details of these signals, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.
For these signals, see also Section 1.5, "MAGNETIC POLE DETECTION", in Part IV.

(d) Spindle orientation command (ORCMA)

For details of this signal, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.

(e) Machine ready signal (MRDYA)

For details of this signal, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.
For this signal, see also Section 1.5, "MAGNETIC POLE DETECTION", in Part IV.

(f) Spindle alarm reset signal (ARSTA)

For details of this signal, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.

(g) Emergency stop signal (*ESPA)

For details of this signal, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.
For this signal, see also Section 1.5, "MAGNETIC POLE DETECTION", in Part IV.

(h) Soft start/stop signal (SOCNA)

For details of this signal, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.

(i) Velocity integral control signal (INTGA)

For details of this signal, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.

(j) Orientation stop position change command (INDXA), rotation direction command at orientation stop position change (ROTAA), shortcut command at orientation stop position change (NRROA), and incremental command (INCMDA)

For details of these signals, see Section 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION", in Part I and Section 5.3, "INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION", in Part I.

(k) Spindle analog override command (OVRA)

For details of this signal, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.

(l) Motor power turn-off signal (MPOFA)

> **NOTE**
> Some specifications of this signal differ from those with an inductive spindle motor.

For details of this signal, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.
Some specifications of this signal differ from those with an inductive spindle motor, so carefully set this signal for the sub module SM and magnetic pole detection. See Sections 1.4, "SUB MODULE SM," and 1.5, "MAGNETIC POLE DETECTION," in Part IV.

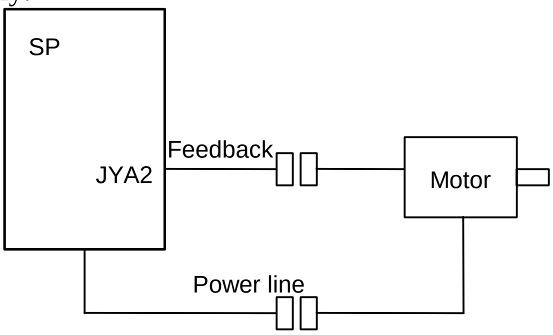
(m) Synchronous orientation request command (SORSLA)

For details of this signal, see Section 5.5, "SPINDLE ORIENTATION DURING SPINDLE SYNCHRONIZATION CONTROL", in Part I.

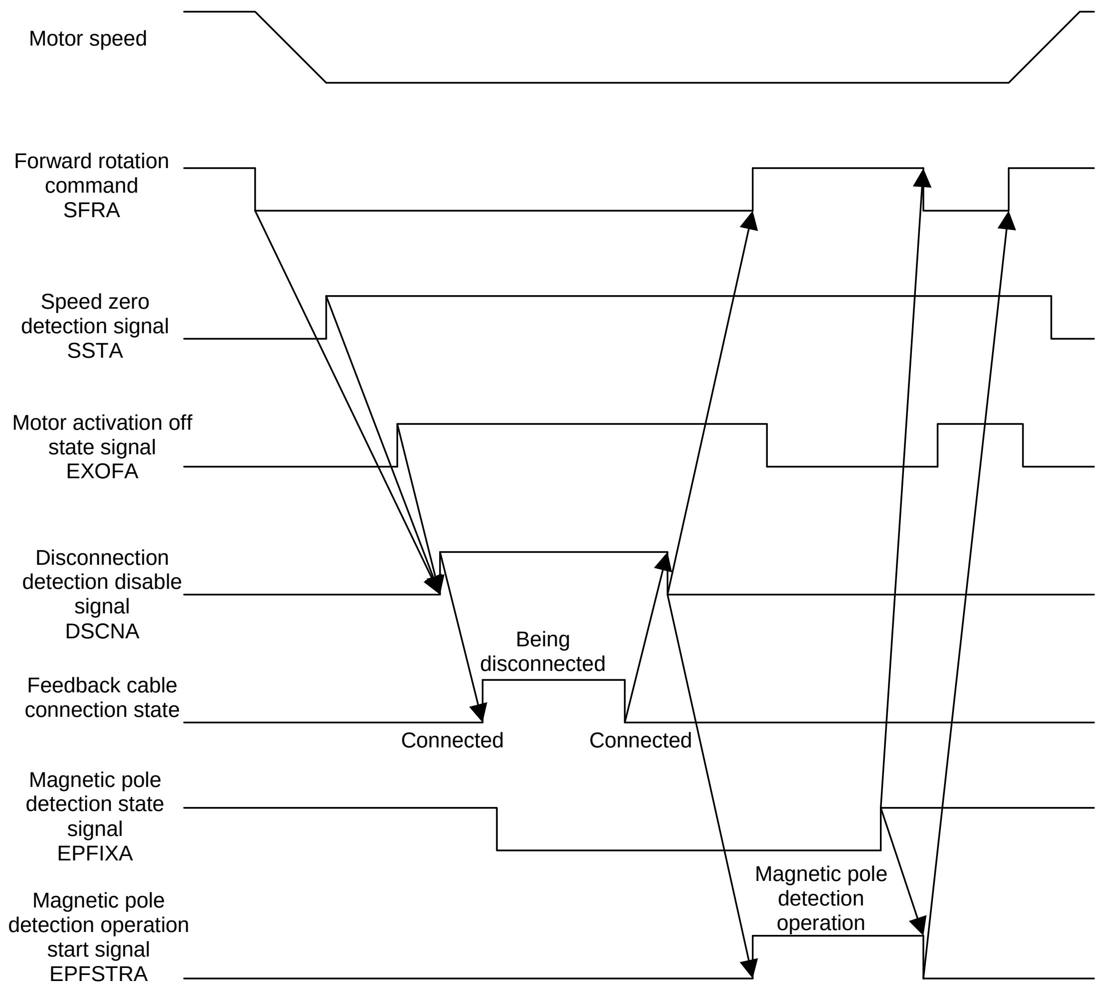
(n) Disconnection detection disable signal (DSCNA)

> **NOTE**
> 1 When the dual check safety function is enabled, this signal is disabled.
> 2 When the αiCZ sensor (serial) is used, this function cannot be used.
> 3 The specifications of this signal partly differ from the specifications for the inductive spindle motor. This signal is disabled in the excitation ON state.

(1) This signal is used when the connection between the spindle amplifier and spindle motor needs to be disconnected temporarily.



(2) When this signal is used to detach the feedback signal, motor overheat and the issuance of a feedback signal disconnection alarm can be prevented.
(3) A motor excitation OFF state confirmation signal (EXOFA) is provided to confirm that the motor is not excited before the connected power line is detached.
(4) Before setting this signal to 1 and disconnecting the feedback signals and power line, set all the SFRA, SRVA, ORCMA, MRDYA, and *ESPA commands to 0, and confirm that the motor excitation OFF state confirmation signal (EXOFA) has been set to 1. After completing re-connection, reset this signal to 0.
(5) With the synchronous built-in spindle motor, the motor sensor disconnection alarm (spindle alarm 73) is issued during activation even if this signal is set to 1.
(6) With the synchronous built-in spindle motor, the motor sensor feedback is monitored for a disconnection even while this signal is set to 1. When a disconnection is detected, the magnetic pole position undetected state (EPFIXA = 0) is set. So, while this signal is set to 1 (not during activation, however,), the motor sensor disconnection alarm (spindle alarm 73) is not detected even if the motor sensor feedback disconnection state is detected. In this case, however, the magnetic pole position undetected state is set.
(7) Sample sequence (for the synchronous built-in spindle motor)



(o) Magnetic pole detection operation start signal (EPFSTRA)

For details of this signal, see Section 1.5, "MAGNETIC POLE DETECTION", in Part IV.

3.2 OUTPUT SIGNALS (SP→CNC→PMC)

This section explains the functions of the signals directly output from the spindle amplifier (SP) to PMC via the CNC. For other spindle-related output signals, refer to the Connection Manual (Function) of the relevant CNC.

(a) For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Chapter 9, "SPINDLE SPEED FUNCTION."

(b) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Chapter 11, "SPINDLE SPEED FUNCTION."

(c) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 9.7, "SPINDLE SPEED FUNCTION."

(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Chapter 9, "SPINDLE SPEED FUNCTION."

3.2.1 List of Output Signals

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA	TLMA	LDT2A	LDT1A	SARA	SDTA	SSTA	ALMA
2nd-	F245	F049	F049	ORARB	TLMB	LDT2B	LDT1B	SARB	SDTB	SSTB	ALMB
1st-	F231	F047	F047				EXOFA	SORENA		INCSTA	PC1DTA
2nd-	F247	F051	F051				EXOFB	SORENB		INCSTB	PC1DTB
1st-	F230	F048	F048	EPFIXA			CSPENA	SSMBRKA			
2nd-	F246	F052	F052	EPFIXB			CSPENB	SSMBRKB			

3.2.2 Explanation of Output Signals

The signals whose names are not listed in Subsection 3.2.1, “List of Output Signals”, in Part IV are not supported by the B*i*S series spindle.

Symbol	Name	Description
ALMA, B	Alarm signal	This signal is output when a spindle alarm is issued. 0: Normal state 1: Alarm state
SSTA, B	Zero speed detection signal	This signal is output when the actual rotation speed of the spindle motor has decreased to the zero speed detection level or lower. 0: Rotating 1: Zero speed state
SDTA, B	Speed detection signal	This signal is output when the actual rotation speed of the spindle motor has decreased to a predetermined rotation speed or lower. 0: Above predetermined speed 1: Predetermined speed or lower
SARA, B	Speed arrival signal	This signal is output when the actual rotation speed of the spindle motor has achieved a predetermined range for a speed command. 0: Speed not achieved 1: Speed achieved
LDT1A, B	Load detection signal 1	These signals are output when load at a set load detection level or higher is detected. Different levels can be set for LDT1A and LDT2A. 0: Lower than the set load 1: Set load or higher
LDT2A, B	Load detection signal 2	
TLMA, B	Torque limitation in-progress signal	This signal is output when the torque is being limited by the TLMLA or TLMHA signal. 0: Torque not being limited 1: Torque being limited
ORARA, B	Orientation completion signal	This signal is output when the spindle stops in the neighborhood of a predetermined position after an orientation command is input. 0: Orientation not completed 1: Orientation completed
PC1DTA, B	Position coder one-rotation signal detection state signal	This signal is used to confirm whether the position coder one-rotation signal is detected or not. 0: Position coder one-rotation signal not detected 1: Position coder one-rotation signal detected

Symbol	Name	Description
INCSTA, B	Incremental orientation signal	This signal is used to confirm whether incremental spindle orientation is being performed or not. 0: Incremental spindle orientation is not in progress. 1: Incremental spindle orientation is in progress.
SORENA, B	Synchronous orientation enable signal	This signal is used to confirm whether synchronous orientation is enabled or not. 0: Disables synchronous orientation. 1: Enables synchronous orientation.
EXOFA, B	Motor excitation off state signal	This signal is used to confirm whether motor excitation is off. 0: Motor excitation is in progress. 1: Motor excitation is off.
SSMBRKA, B	Sub module SM (SSM) error state signal	This signal is used to check the error state of the sub module SM (SSM). 0: The SSM is normal. 1: The SSM is abnormal.
CSPENA, B	Cs reference position establishment state signal	This signal is used to indicate whether Cs axis coordinate establishment processing is possible. 0: Coordinate establishment processing is impossible (with a reference position not established). 1: Coordinate establishment processing is possible (with a reference position established).
EPFIXA, B	Magnetic pole detection state signal	This signal is used to check whether magnetic pole detection is completed or not. 0: Magnetic pole detection is not completed. 1: Magnetic pole detection is completed.

3.2.3 Details of Output Signals

(a) Spindle alarm signal (ALMA)

For details of this signal, see Subsection 3.2.2, "Explanation of Output Signals", in Part I.

(b) Zero speed detection signal (SSTA)

For details of this signal, see Subsection 3.2.2, "Explanation of Output Signals", in Part I.

> ⚠ **CAUTION**
> 1 If a motor feedback signal disconnection alarm (spindle alarm 73) is issued, the status of this signal is undefined.
> 2 When bit 5 of parameter No. 4007 is set to "1", the detection operation of the feedback signal disconnection alarm is not performed.
> Set the parameter to "0" when not required, to enable alarm detection.

(c) Speed detection signal (SDTA)

For details of this signal, see Subsection 3.2.2, "Explanation of Output Signals", in Part I.

> ⚠ **CAUTION**
> 1 If a motor feedback signal disconnection alarm (spindle alarm 73) is issued, the status of this signal is undefined.
> 2 When bit 5 of parameter No. 4007 is set to "1", the detection operation of the feedback signal disconnection alarm is not performed.
> Set the parameter to "0" when not required, to enable alarm detection.

(d) Speed arrival signal (SARA)

For details of this signal, see Subsection 3.2.2, "Explanation of Output Signals", in Part I.

(e) Load detection signals (LDT1A, LDT2A)

For details of these signals, see Subsection 3.2.2, “Explanation of Output Signals”, in Part I.

(f) Torque limitation in-progress signal (TLMA)

For details of this signal, see Subsection 3.2.2, “Explanation of Output Signals”, in Part I.

(g) Orientation completion signal (ORARA)

For details of this signal, see Section 2.2, “POSITION CODER METHOD SPINDLE ORIENTATION”, in Part I.

(h) Position coder one-rotation signal detection state signal (PC1DTA)

For details of this signal, see Subsection 3.2.2, “Explanation of Output Signals”, in Part I.

(i) Incremental orientation signal (INCSTA)

For details of this signal, see Section 5.3, “INCRMENTAL COMMAND TYPE SPINDLE ORIENTATION”, in Part I.

(j) Synchronous orientation enable signal (SORENA)

For details of this signal, see Section 5.5, “SPINDLE ORIENTATION DURING SPINDLE SYNCHRONIZATION CONTROL”, in Part I.

(k) Motor excitation off state signal (EXOFA)

For details of this signal, see Subsection 3.1.3(p), “Disconnection detection disable signal (DSCNA)”, in Part I.

(l) Sub module SM (SSM) error state signal (SSMBRKA)

For details of this signal, see Section 1.4, “SUB MODULE SM”, in Part IV.

(m) Cs reference position establishment state signal (CSPENA)

For details of this signal, see Subsection 3.2.2, “Explanation of Output Signals”, in Part I.

(n) Magnetic pole detection state signal (EPFIXA)

For details of this signal, see Section 1.5, “MAGNETIC POLE DETECTION”, in Part IV.

4 ADJUSTMENT

4.1 VELOCITY LOOP GAIN ADJUSTMENT

4.1.1 Overview

For this subsection, see Subsection 4.1.1, “Overview”, in Part I.

4.1.2 Parameters

For this subsection, see Subsection 4.1.2, “Parameters”, in Part I.

4.1.3 Adjustment Procedure

For this subsection, see Subsection 4.1.3, “Adjustment Procedure”, in Part I.

4.1.4 Additional Information (Position Gain Adjustment)

For this subsection, see Subsection 4.1.4, “Additional Information (Position Gain Adjustment)”, in Part I.

4.2 MACHINE RESONANCE ELIMINATION

4.2.1 TCMD Filter

For this subsection, see Subsection 4.2.1, “TCMD Filter”, in Part I.

4.2.2 Resonance Elimination Filter

For this subsection, see Subsection 4.2.2, “Resonance Elimination Filter”, in Part I.

※When the resonance elimination filter disable signal is used, the following spindle and CNC software products must be used.

Spindle software

Series	Edition	Usable CNC
9D53	L (12) edition or later	
9D70	L (12) edition or later	
9D80	H (08) edition or later	
9D90	A (01) edition or later	
9DA0	A (01) edition or later	

CNC software (Resonance elimination filter disable signal supported)

Series	Edition	Usable CNC
B0H1	K (11) edition or later	FANUC Series 16*i* /160*i* /160*i*s-MB
BDH1	K (11) edition or later	FANUC Series 18*i* /180*i* /180*i*s-MB
BDH5	B (02) edition or later	FANUC Series 18*i* /180*i* /180*i*s-MB5
DDH1	K (11) edition or later	FANUC Series 21*i* /210*i* /210*i*s-MB
B1H1	K (11) edition or later	FANUC Series 16*i* /160*i* /160*i*s-TB
BEH1	K (11) edition or later	FANUC Series 18*i* /180*i* /180*i*s-TB
DEH1	K (11) edition or later	FANUC Series 21*i* /210*i* /210*i*s-TB
G002/G012/ G022/G032	W (23) edition or later	FANUC Series 30*i* /300*i* /300*i*s-A
G003/G013/ G023/G033	F (06) edition or later	
G121/G131	W (23) edition or later	FANUC Series 31*i* /310*i* /310*i*s-A5
G123/G133	F (06) edition or later	
G101/G111	W (23) edition or later	FANUC Series 31*i* /310*i* /310*i*s-A
G103/G133	F (06) edition or later	
G201	W (23) edition or later	FANUC Series 32*i* /320*i* /320*i*s-A
G203	F (06) edition or later	

4.2.3 Disturbance Input Function

For this subsection, see Subsection 4.2.3, “Disturbance Input Function”, in Part I.

4.2.4 Adaptive Resonance Elimination Filter

For this subsection, see Subsection 4.2.4, "Adaptive Resonance Elimination Filter", in Part I.

4.3 AMPLITUDE RATIO/PHASE DIFFERENCE COMPENSATION FUNCTION

For this section, see Subsection 4.3, “AMPLITUDE RATIO/PHASE DIFFERENCE COMPENSATION FUNCTION”, in Part I.

5 FUNCTION DESCRIPTIONS

5.1 SPEED RANGE SWITCHING CONTROL (OPTIONAL FUNCTION)

The B*i*S series spindle (synchronous built-in spindle motor) does not support this function.

5.2 SPINDLE SWITCHING CONTROL

The B*i*S series spindle (synchronous built-in spindle motor) does not support this function.

5.3 INCRMENTAL COMMAND TYPE SPINDLE ORIENTATION (SPINDLE ROTATION SPEED CONTROL) (OPTIONAL FUNCTION)

5.3.1 Overview

For this subsection, see Subsection 5.3.1, “Overview”, in Part I.

5.3.2 Series and Editions of Applicable Spindle Software

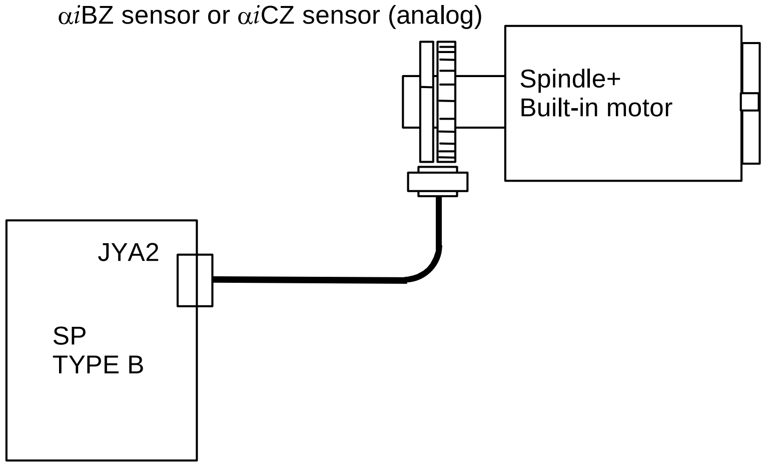
Spindle software

Series	Edition	Usable CNC
9D53	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	B (02)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

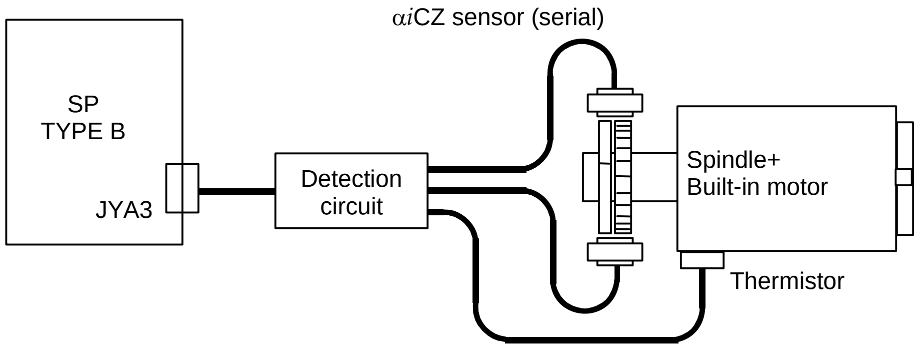
5.3.3 System Configuration

The incremental command type spindle orientation function can be used in the following system configuration.

(1) When the α*i*BZ sensor or α*i*CZ sensor (analog) is used



(2) When the α*i*CZ sensor (serial) is used



5.3.4 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070		ORCMA			CTH1A	CTH2A		
2nd-	G235	G074	G074		ORCMB			CTH1B	CTH2B		
1st-	G229	G072	G072			INCMDA			NRROA	ROTAA	INDXA
2nd-	G237	G076	G076			INCMDB			NRROB	ROTAB	INDXB
1st-	G230	G078	G078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
2nd-	G238	G080	G080	SHB07	SHB06	SHB05	SHB04	SHB03	SHB02	SHB01	SHB00
1st-	G231	G079	G079					SHA11	SHA10	SHA09	SHA08
2nd-	G239	G081	G081					SHB11	SHB10	SHB09	SHB08

(2) Details of input signals (PMC→CNC)

For this item, see Subsection 5.3.4(2), "Details of input signals (PMC→CNC)", in Part I.

(3) Address list of output signals (CNC→PMC)

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA							
2nd-	F245	F049	F049	ORARB							

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F221	F047	F047							INCSTA	
2nd-	F247	F051	F051							INCSTB	

(4) Details of output signals (CNC→PMC)

For this item, see Subsection 5.3.4(4), “Details of output signals (CNC→PMC)”, in Part I.

5.3.5 Examples of Sequences

For this subsection, see Subsection 5.3.5, “Examples of Sequences”, in Part I.

5.3.6 List of Related Parameters

Parameter No.			Description
15*i*	16*i*	30*i*	
3015 #0	4015 #0	4015 #0	Whether the spindle orientation function is available (to be set to “1”) (The CNC software option is required.)
5609#2	3702#3,#2	3702#3,#2	Whether the stop position external setting-type spindle orientation function is available (to be set to “1”) (For 16*i*, #2: First spindle, #3: Second spindle)
3328	4328	4328	Command multiplier for incremental command external setting data

> **NOTE**
> This subsection describes only the parameters specific to incremental command type spindle orientation. See Section 2.2, “POSITION CODER METHOD SPINDLE ORIENTATION” in Part I, for parameters related to other types of spindle orientation.

5.3.7 Details of Related Parameters

For this subsection, see Subsection 5.3.7, “Details of Related Parameters”, in Part I.

5.4 CONVENTIONAL METHOD ORIENTATION (OPTIONAL FUNCTION)

5.4.1 Overview

For this subsection, see Subsection 5.4.1, “Overview”, in Part I.

NOTE

1. For the B*i*S series spindle (synchronous built-in spindle motor),
   Parameter No. 4084
   is used for the AMR offset function (not for the motor voltage on orientation).
   If an inappropriate value is set for the AMR offset, the motor may move unpredictably.
2. For AMR offset function, see Subsection 1.5.3, "AMR Offset Function", in Part IV.

5.4.2 Series and Editions of Applicable Spindle Software

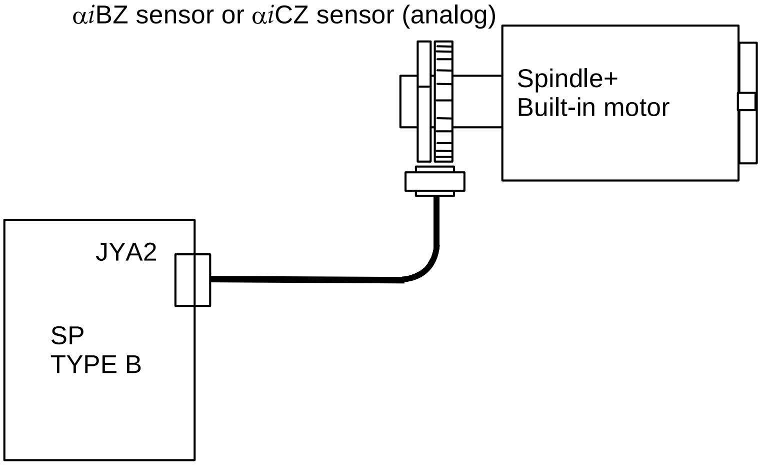
Spindle software

Series	Edition	Usable CNC
9D53	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

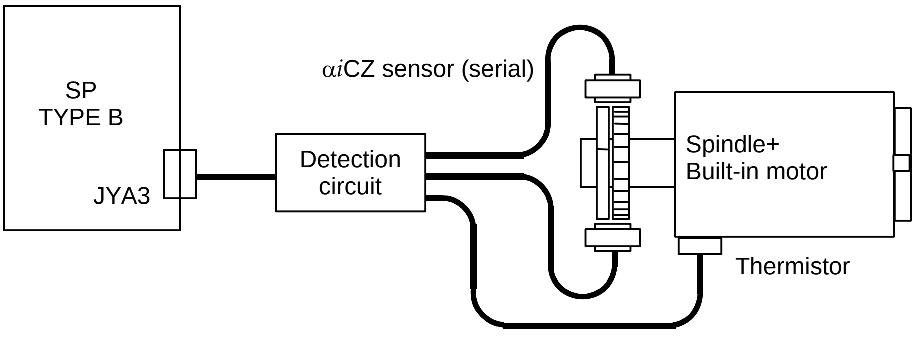
5.4.3 System Configuration

Explained below is a system configuration in which the conventional method orientation function is usable.

(1) When the α*i*BZ sensor or α*i*CZ (analog) sensor is used



(2) When the α*i*CZ (serial) sensor is used



5.4.4 I/O Signals (CNC↔PMC)

For this subsection, see Section 2.2, “POSITION CODER METHOD SPINDLE ORIENTATION”, and Section 5.3, “INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION” , in Part I.

5.4.5 Sequence

For this subsection, see Subsection 5.4.5, “Sequence”, in Part I.

5.4.6 List of Related Parameters

For this subsection, see Subsection 5.4.6, “List of Related Parameters”, in Part I.

5.4.7 Details of Related Parameters

For this subsection, see Subsection 5.4.7, “Details of Related Parameters”, in Part I.

5.4.8 Adjusting the Orientation Stop Position Shift Parameter

For this subsection, see Subsection 5.4.8, “Adjusting the Orientation Stop Position Shift Parameter”, in Part I.

5.4.9 Calculating the Position Gain for Orientation

For this subsection, see Subsection 5.4.9, “Calculating the Position Gain for Orientation”, in Part I.

5.4.10 Calculating the Orientation Time

For this subsection, see Subsection 5.4.10, “Calculating the Orientation Time”, in Part I.

5.5 SPINDLE ORIENTATION DURING SPINDLE SYNCHRONOUS CONTROL (OPTIONAL FUNCTION)

5.5.1 Overview

For this subsection, see Subsection 5.5.1, “Overview”, in Part I.

5.5.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D53	B (02)	FS16*i* / FS18*i* / FS21*i* , FS0*i*
9D70	A (01)	FS30*i* / FS31*i* / FS32*i*
9D80	B (02)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

5.5.3 Specification

For this subsection, see Subsection 5.5.3, “Specification”, in Part I.

5.5.4 I/O Signals (CNC↔PMC)

(1) Address list of input signals (PMC→CNC)

(a) For path 1

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
	G038	G038					SPPHS	SPSYC		
1st-	G072	G072							ROTAA	
2nd-	G076	G076							ROTAB	
1st-	G073	G073					SORSLA			
2nd-	G077	G077					SORSLB			
1st-	G078	G078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
2nd-	G080	G080	SHB07	SHB06	SHB05	SHB04	SHB03	SHB02	SHB01	SHB00
1st-	G079	G079					SHA11	SHA10	SHA09	SHA08
2nd-	G081	G081					SHB11	SHB10	SHB09	SHB08

(b) For path 2

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
	G1038	G1038					SPPHS	SPSYC		
1st-	G1072	G1072							ROTAA	
2nd-	G1076	G1076							ROTAB	
1st-	G1073	G1073					SORSLA			
2nd-	G1077	G1077					SORSLB			
1st-	G1078	G1078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
2nd-	G1080	G1080	SHB07	SHB06	SHB05	SHB04	SHB03	SHB02	SHB01	SHB00
1st-	G1079	G1079					SHA11	SHA10	SHA09	SHA08
2nd-	G1081	G1081					SHB11	SHB10	SHB09	SHB08

(2) Details of input signals (PMC→CNC)

(a) Spindle synchronous control command (SPSYC)
(b) Spindle phase synchronous control command or synchronous orientation command (SPPHS)
(c) Synchronous orientation request command (SORSLA)
(d) Synchronous orientation external stop position command (SHA11 to SHA00)
(e) Rotation direction command for synchronous (ROTAA)

For the input signals SPSYC, SPPHS, SORSLA, SHA11 to SHA00, and ROTAA, see Subsection 5.5.4(2), “Details of input signals (PMC→CNC)”, in Part I.

(3) Address list of output signals (CNC→PMC)

(a) For path 1

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
	F044	F044				SYCAL	FSPPH	FSPSY		
1st-	F047	F047					SORENA			
2nd-	F051	F051					SORENB			

(b) For path 2

	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
	F1044	F1044				SYCAL	FSPPH	FSPSY		
1st-	F1047	F1047					SORENA			
2nd-	F1051	F1051					SORENB			

(4) Details of output signals (CNC→PMC)

(a) Synchronous orientation permission signal (SORENA)
(b) Spindle speed synchronous control completion signal (FSPSY)
(c) Spindle phase synchronous control completion signal or synchronous orientation completion signal (FSPPH)
(d) Phase synchronous error monitor signal (SYCAL)

For the output signals SORENA, FSPSY, FSPPH, and SYCAL, see Subsection 5.5.4 (4), "Details of output signals (CNC→PMC)", in Part I.

5.5.5 Sequence

For this subsection, see Subsection 5.5.5, "Sequence", in Part I.

5.5.6 List of Related Parameters

Parameter No.		Description
16*i*	30*i*	
4800#1,#0	4801#0	Direction in which each of spindles rotates under spindle synchronous control (For 16*i*: #0: First spindle: #1: Second spindle. For 30*i*: Each spindle)
4810	4810	That error pulse difference between two spindles on which the spindle phase synchronous completion signal is output
4811	4811	That error pulse difference between two spindles on which the spindle phase synchronous error monitor signal is output
3702#3,#2	3729#0	Whether the stop position external setting-type spindle orientation function is available (For 16*i*: #0: First spindle: #1: Second spindle. For 30*i*: Each spindle)
4006#4	4006#4	Setting for disabling automatic detection of a one-rotation signal when the spindle synchronous control mode is switched
4014#6	4014#6	Whether the synchronous orientation function is available
4032	4032	Acceleration at spindle synchronous control (It is necessary to specify the same value for the first and second spindles.)
4033	4033	Spindle synchronous speed arrival level
4034	4034	Shift amount at spindle phase synchronous control
4035	4035	Spindle phase synchronous compensation data
4044 4045	4044 4045	Velocity proportional gain on spindle synchronous control (This parameter is selected with the input signal CTH1A.)

Parameter No.		Description
16*i*	30*i*	
4052 4053	4052 4053	Velocity integral gain on spindle synchronous control (This parameter is selected with the input signal CTH1A.)
4056 to 4059	4056 to 4059	Gear ratio data between spindle and motor (These parameters are selected with the input signals CTH1A and CTH2A.)
4065 to 4068	4065 to 4068	Position gain on spindle synchronous control (It is necessary to specify the same value for the first and second spindles.) (These parameters are selected with the input signals CTH1A and CTH2A.)
4075	4075	Orientation completion signal detection level
4336	4336	Acceleration magnetic flux switching point for spindle synchronous control (It is necessary to specify the same value for the first and second spindles.)
4340	4340	Bell-shaped acceleration/deceleration time constant for spindle synchronous control (It is necessary to specify the same value for the first and second spindles.)
4369	4369	Synchronous orientation deceleration coefficient

NOTE

1. See Section 1.3, "PARAMETERS RELATED TO DETECTORS", in Part IV for parameters related to detectors.
2. See Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT", in Part IV for velocity loop proportional/integral gain tuning.
3. See "Function Description: Spindle Synchronous Control" for parameters related to the spindle synchronous control function.

5.5.7 Details of Related Parameters

For this subsection, see Subsection 5.5.7, "Details of Related Parameters", in Part I.

5.6 SPINDLE FINE ACC./DEC. (FAD) FUNCTION

5.6.1 Overview

For this subsection, see Subsection 5.6.1, "Overview", in Part I.

5.6.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Remark
9D53	B (02) edition or later	
9D80	B (02) edition or later	
9D90	A (01) edition or later	

CNC software

Series	Edition	Remark
B0H1	M (13) edition or later	For the FANUC Series 16*i*/160*i*/160*i*s-MB
BDH1	M (13) edition or later	For the FANUC Series 18*i*/180*i*/180*i*s-MB
BDH5	C (03) edition or later	For the FANUC Series 18*i*/180*i*/180*i*s-MB5
DDH1	M (13) edition or later	For the FANUC Series 21*i*/210*i*/210*i*s-MB
B1H1	M (13) edition or later	For the FANUC Series 16*i*/160*i*/160*i*s-TB
BEH1	M (13) edition or later	For the FANUC Series 18*i*/180*i*/180*i*s-TB
DEH1	M (13) edition or later	For the FANUC Series 21*i*/210*i*/210*i*s-TB

5.6.3 Block Diagram

For this subsection, see Subsection 5.6.3, “Block Diagram”, in Part I.

5.6.4 Parameters

For this subsection, see Subsection 5.6.4, “Parameters”, in Part I.

5.6.5 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 5.6.5, “Diagnosis (Diagnosis Screen)”, in Part I.

5.6.6 Status Errors

For this subsection, see Subsection 5.6.6, “Status Errors”, in Part I.

5.6.7 Cautions

For this subsection, see Subsection 5.6.7, “Cautions”, in Part I.

5.7 UNEXPECTED DISTURBANCE TORQUE DETECTION FUNCTION (OPTIONAL FUNCTION)

5.7.1 Overview

For this subsection, see Subsection 5.7.1, “Overview”, in Part I.

5.7.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Remark
9D53	E (05)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i*
9D70	D (04)	FS30*i* / FS31*i* / FS32*i*
9D80	B (02)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

5.7.3 I/O Signals (CNC↔PMC)

(1) Address list of output signals (CNC→PMC)

16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
F090	F090					ABTSP3	ABTSP2	ABTSP1	
F091	F091				ABTSP4				

15*i*	#7	#6	#5	#4	#3	#2	#1	#0
F155	AQSP2	AQSP1						
F154					AQSP4	AQSP3		

(2) Details of output signals (CNC→PMC)

(a) First-spindle unexpected disturbance torque detection signals (ABTSP1 and AQSP1)
(b) Second-spindle unexpected disturbance torque detection signals (ABTSP2 and AQSP2)
(c) Third-spindle unexpected disturbance torque detection signals (ABTSP3 and AQSP3)
(d) Fourth-spindle unexpected disturbance torque detection signals (ABTSP4 and AQSP4)

These signals are output when the estimated load torques on the respective spindles become higher than or equal to the set level.
Refer to an applicable CNC Connection Manual (Function) for details.

(a) For Series 16*i*/18*i*/21*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 2.10, "ABNORMAL LOAD DETECTION."

(b) For Series 15*i*
"FANUC Series 15*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63783EN-1
Refer to Section 2.9, "ABNORMAL LOAD DETECTION."

(c) For Series 30*i*/31*i*/32*i*
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 2.9, "UNEXPECTED DISTURBANCE TORQUE DETECTION FUNCTION."

(d) For Series 0*i*
"FANUC Series 0*i*-MODEL C CONNECTION MANUAL (FUNCTION) : B-64113EN-1
Refer to Section 2.9, "ABNORMAL LOAD DETECTION."

(e) For Series 30*i*/31*i*/32*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 2.9, "UNEXPECTED DISTURBANCE TORQUE DETECTION FUNCTION."

(f) For Series 0*i*-D
"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1
Refer to Section 2.9, "UNEXPECTED DISTURBANCE TORQUE DETECTION FUNCTION."

5.7.4 List of Related Parameters

Parameter No.			Description
15*i*	**16*i***	**30*i***	
3015 #1	4015 #1	4015 #1	Whether the unexpected disturbance torque detection function is available (The CNC software option is required.)
3248	4248	4248	Torque constant for spindle load torque monitoring
3249	4249	4249	Observer gain 1 for spindle load torque monitoring
3250	4250	4250	Observer gain 2 for spindle load torque monitoring
3341	4341	4341	Unexpected disturbance torque detection level

5.7.5 Details of Related Parameters

For this subsection, see Subsection 5.7.5, "Details of Related Parameters", in Part I.

5.7.6 Parameter Tuning Procedure

For this subsection, see Subsection 5.7.6, "Parameter Tuning Procedure", in Part I.

5.8 SPINDLE EGB (SPINDLE ELECTRONIC GEAR BOX) (OPTIONAL FUNCTION)

5.8.1 Overview

The spindle EGB function is intended to use one of spindles in a pair as a tool axis (master axis) and the other as a workpiece axis (slave axis) and cause the slave axis to rotate in synchronization with the master axis at a specified synchronous ratio. Refer to an applicable CNC Connection Manual (Function) for details of this function.

(a) For Series 16*i*/18*i*
"FANUC Series 16*i*/18*i*/21*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 1.14.2, "Spindle Electronic Gear Box (M series)."
(b) For Series 30*i*-A/31*i*-A5/31*i*-A
"FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 1.10.2, "Spindle Electronic Gear Box."
(c) For Series 30*i*-B/31*i*-B5/31*i*-B
"FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 1.10.2, "Spindle Electronic Gear Box."

NOTE
1 Using this function requires the CNC software option.
2 Using this function requires SP TYPE B for both the master and slave axes.
3 For the master and slave axes, use the spindle software of the same series and edition.
4 This function cannot be used together with the spindle fine Acc./Dec. (FAD) function.
5 This function cannot be used together with the spindle tandem control function.
6 This function cannot be used with the FANUC Series 15*i*-MODEL B.
7 This function cannot be used with the FANUC Series 32*i*.
8 There are no limitations on the assignment of the master and slave axes.
For descriptive purposes, this specification assumes:
Master spindle amplifier: First spindle
Slave spindle amplifier: Second spindle

5.8.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Remark
9D53	B (02) edition or later	
9D80	B (02) edition or later	
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* / FS0*i* / FS15*i* / FS30*i* / FS31*i* / FS32*i*
9DA0	B (02)	FS30*i* / FS31*i* / FS32*i* -B

NOTE
When using the αiCZ sensor (serial) as the motor or spindle sensor, use 9D80 series H (08) edition.

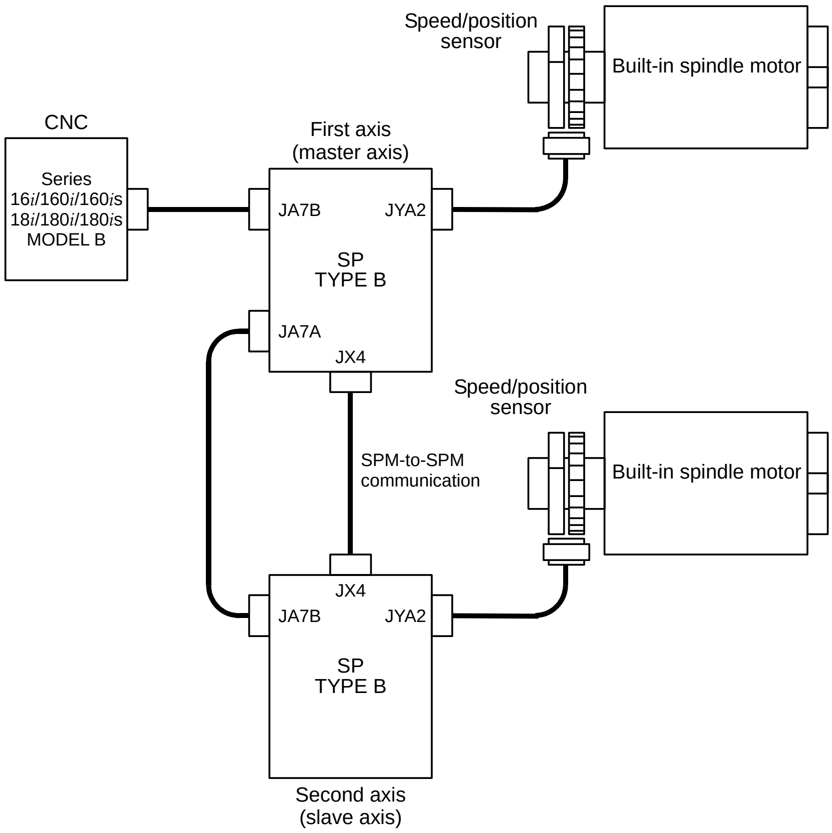
CNC software

Series	Edition	Remark
B0H1	A (01) edition or later	For FANUC Series 16*i*/160*i*/160*is*-MB
BDH1	A (01) edition or later	For FANUC Series 18*i*/180*i*/180*is*-MB
BDH5	A (01) edition or later	For FANUC Series 18*i*/180*i*/180*is*-MB5
G003/G013/ G023/G033/ G00C/G01C G02C/G03C	28 edition or later	For FANUC Series 30*i*/300*i* /300*is*-A
G004/G014 G024/G034	01 edition or later	
G123/G133 G12C/G13C	28 edition or later	For FANUC Series 31*i*/310*i* /310*is*-A5
G124/G134	01 edition or later	
G103/G113	28 edition or later	For FANUC Series 31*i*/310*i* /310*is*-A
G104/G114	01 edition or later	

5.8.3 System Configuration

The spindle EGB function is usable in the following system configuration.

(1) System configuration with built-in motors



> **NOTE**
> When using the α*i*CZ sensor (serial) as the motor sensor, connect the feedback cable to JYA3.

Parameter settings related to detectors

Parameter	Setting	Description
4000#0	0	The spindle and motor rotates in the same direction.
4002#3,#2,#1,#0	0,0,0,1	The motor sensor is used for position feedback.
4003#7,#6,#5,#4	0,0,0,0	It is unnecessary to specify the number of the spindle sensor teeth.
4010#2,#1,#0	0,0,1	α*i*MZ/α*i*BZ/α*i*CZ sensor (analog)
	0,1,1	α*i*CZ sensor (serial)
4011#2,#1,#0 or 4334	Depending on the sensor.	Setting for the number of motor sensor (speed sensor) teeth
4056 to 4059	100 or 1000	The spindle-to-motor gear ratio is 1:1. (The settings for these parameters vary depending on the gear ratio increment system specified in bit 1 or parameter No. 4006.)
4386 (*)	Depending on the sensor.	Setting for the number of master-axis motor sensor (speed sensor) teeth

(*) This parameter is valid only for the slave axis (second spindle).

5.8.4 Block Diagram

For this subsection, see Subsection 5.8.4, “Block Diagram”, in Part I.

5.8.5 I/O Signals (CNC↔PMC)

This subsection lists only the input/output signals related to the spindle EGB. Refer to an applicable CNC Connection Manual (Function) for details of each signal.

(a) For Series 16*i*/18*i*
FANUC Series 16*i*/18*i*/21*i*-MODEL B
Connection Manual (Function): B-63523EN-1
Refer to Subsection 1.14.2, “Spindle Electronic Gear Box (M series).”

(b) For Series 30*i*-A/31*i*-A5/31*i*-A
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

(c) For Series 30*i*-B/31*i*-B5/31*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

(1) Input signals (PMC→CNC)

	#7	#6	#5	#4	#3	#2	#1	#0
G066				RTRCT				

(2) Output signals (CNC→PMC)

	#7	#6	#5	#4	#3	#2	#1	#0
F065		SYNMOD		RTRCTF				

5.8.6 Examples of Sequences

Refer to an applicable CNC Connection Manual (Function) for spindle EGB sequences.

(a) For Series 16*i*/18*i*
FANUC Series 16*i*/18*i*/21*i*-MODEL B
CONNECTION MANUAL (FUNCTION) : B-63523EN-1
Refer to Section 1.14.2, “Spindle Electronic Gear Box (M series).”
(b) For Series 30*i*-A/31*i*-A5/31*i*-A
“FANUC Series 30*i*/31*i*/32*i*-MODEL A CONNECTION MANUAL (FUNCTION) : B-63943EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”
(c) For Series 30*i*-B/31*i*-B5/31*i*-B
“FANUC Series 30*i*/31*i*/32*i*-MODEL B CONNECTION MANUAL (FUNCTION) : B-64483EN-1
Refer to Section 1.10.2, “Spindle Electronic Gear Box.”

5.8.7 List of Related Parameters

Parameter No. 16*i*	Description
7700#0	Direction for helical compensation
7700#2	Setting for releasing the synchronous mode at a reset
7709	Axis number for helical gear axial feed axis
7710	Spindle EGB slave axis number
7771	Spindle EGB master axis number
7772	The number of pulses the position sensor generates at each rotation of the tool axis (master axis) (Specify 360,000 for the IS-B.)
7773	The number of pulses the position sensor generates at each rotation of the workpiece axis (slave axis) (Specify 360,000 for the IS-B.)
8005#4	Setting for the type of the PMC axis control constant-speed command function
8028	Time constant for linear-shaped Acc./Dec. in speed command-based continuous feed for each axis in PMC-based axis control
8040	Number of pulses the position sensor generates at each rotation of the spindle on a PMC-controlled axis (Specify 360,000 for the IS-B.)
4016#3	Setting for the feed-forward smoothing function
4352#4	Feed-forward setting
4352#6	Inter-SPM communication slave axis setting
4352#7	Inter-SPM communication master axis setting
4036	Feed forward coefficient
4037	Velocity loop feed forward coefficient
4046 4047	Velocity proportional gain on Cs contouring control (This parameter is selected with the PMC input signal CTH1A.)
4054 4055	Velocity integral gain on Cs contouring control (This parameter is selected with the PMC input signal CTH1A.)
4069 to 4072	Position gain on Cs contouring control (This parameter is selected with the PMC input signal CTH1A.)
4386	Number of master-axis spindle sensor teeth
4387	Synchronous ratio numerator
4388	Synchronous ratio denominator
4498	Denominator of the master-axis motor sensor-to-spindle arbitrary gear ratio
4499	Numerator of the master-axis motor sensor-to-spindle arbitrary gear ratio
4396#2	Setting for on-off switching of the EGB command in the Cs contouring control mode

NOTE
1 See Section 1.3, "PARAMETERS RELATED TO DETECTORS" in Part IV for parameters related to detectors.
2 See Section 4.1, "VELOCITY LOOP GAIN ADJUSTMENT", in Part IV for velocity loop proportional/integral gain tuning.

5.8.8 Details of Related Parameters

For this subsection, see Subsection 5.8.8, "Details of Related Parameters", in Part I.

5.8.9 Diagnosis Signal Related to Spindle EGB

Address 16*i*	Description	Unit
0717	Synchronous error between master and slave axes. (Weight is slave side)	Pulse

NOTE
1 Displaying this data on the CNC diagnosis screen requires the α*i* spindle amplifier (SP) TYPE B and the *i* series MODEL B CNC.
2 Displaying this data on the CNC diagnosis screen requires the following CNC software series/editions.
FS16*i*/160*i*/160*i*s-MB : B0H1 series R (18) edition or later
FS18*i*/180*i*/180*i*s-MB : BDH1 series R (18) edition or later
FS18*i*/180*i*/180*i*s-MB5 : BDH5 series H (08) edition or later

5.8.10 Status Errors Related to Spindle EGB

Error No.	Description	Measure
33	Invalid hardware configuration	Check the model of the CNC in use.
34	An attempt was made to enable both the spindle EGB and FAD functions.	To use the spindle EGB function, disable the spindle FAD function.

5.8.11 Alarms

For this subsection, see Subsection 5.8.11, "Alarms", in Part I.

5.9 DIFFERENTIAL SPINDLE SPEED CONTROL

The B*i*S series spindle (synchronous built-in spindle motor) does not support this function.

5.10 DUAL POSITION FEEDBACK FUNCTION (OPTIONAL FUNCTION)

The B*i*S series spindle (synchronous built-in spindle motor) does not support this function.

5.11 SPEED TANDEM CONTROL FUNCTION (OPTIONAL FUNCTION)

The B*i*S series spindle (synchronous built-in spindle motor) does not support this function.

5.11.1 Overview

For this subsection, see Subsection 5.11.1, "Overview", in Part I.
For the B*i*S series spindle (synchronous built-in spindle motor), only speed tandem control is applicable and torque tandem control cannot be used.

5.11.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D90	B (02)	FS30*i*-A / FS31*i*-A
9DA0	F (06)	FS30*i*-B / FS31*i*-B

> **NOTE**
> When using the α*i*CZ sensor (serial), 9D90 series G (07) edition or later or 9DA0 series I (09) edition or later is required.

5.11.3 System Configuration

For this subsection, see Subsection 5.11.3, "System Configuration", in Part I.
The B*i*S series spindle is not applicable to "Sample configuration 2: System where the table axis is driven by two motors".

5.11.4 I/O Signals (CNC↔PMC)

For this subsection, see Subsection 5.11.4, "I/O Signals (CNC↔PMC)", in Part I.

5.11.5 Examples of Sequences

For this subsection, see Subsection 5.11.5, "Examples of Sequences", in Part I.

> **NOTE**
> For the B*i*S series spindle (synchronous built-in spindle motor), keep the following in mind when creating a sequence.
> 1 In the synchronous spindle motor, magnetic pole detection needs to be performed after power-on (or after occurrence of an alarm reporting a loss of the magnetic pole detection state). At this time, disconnect both axes mechanically to free the motor of each axis and then perform magnetic pole detection.
> 2 Before entering the tandem operation command SLVx=1, make sure that both axes are in the magnetic pole detection completion state (EPFIXA=1&EPFIXB=1). If the magnetic pole detection incompletion state is detected, set SLVx = 0.

5.11.6 Parameters

For this subsection, see Subsection 5.11.6, “Parameters”, in Part I.

5.11.7 Block Diagram for the Speed Tandem Operation

For this subsection, see Subsection 5.11.7, "Block Diagram for the Speed Tandem Operation", in Part I.

5.11.8 Alarm and Status Error

For this subsection, see Subsection 5.11.8, “Alarm and Status Error”, in Part I.

5.11.9 Additional Information

For this subsection, see Subsection 5.11.9, “Additional Information”, in Part I.

5.12 TANDEM RESONANCE ELIMINATION (OPTIONAL FUNCTION)

5.12.1 Overview

For this subsection, see Subsection 5.12.1, “Overview”, in Part I.

5.12.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D90	B (02)	FS30*i*-A / FS31*i*-A
9DA0	F (06)	FS30*i*-B / FS31*i*-B

5.12.3 System Configuration

For this subsection, see Subsection 5.12.3, “System Configuration”, in Part I.

5.12.4 I/O Signals (CNC↔PMC)

For this subsection, see Subsection 5.12.4, “I/O Signals (CNC↔PMC)”, in Part I.

5.12.5 Examples of Sequences

For this subsection, see Subsection 5.12.5, “Examples of Sequences”, in Part I.

NOTE

For the B*i*S series spindle (synchronous built-in spindle motor), keep the following in mind when creating a sequence.

1. In the synchronous spindle motor, magnetic pole detection needs to be performed after power-on (or after occurrence of an alarm reporting a loss of the magnetic pole detection state). At this time, disconnect both axes mechanically to free the motor of each axis and then perform magnetic pole detection.
2. Before entering the tandem operation command SLVx=1, make sure that both axes are in the magnetic pole detection completion state (EPFIXA=1&EPFIXB=1). If the magnetic pole detection incompletion state is detected, set SLVx = 0.

5.12.6 Parameters

For this subsection, see Subsection 5.12.6, “Parameters”, in Part I.

5.12.7 Block Diagram

For this subsection, see Subsection 5.12.7, “Block Diagram”, in Part I.

5.12.8 Adjustment

For this subsection, see Subsection 5.12.8, "Adjustment", Part I.

5.13 TORQUE TANDEM CONTROL FUNCTION (OPTIONAL FUNCTION)

The B*i*S series spindle (synchronous built-in spindle motor) does not support this function.

5.14 MAGNETIC SENSOR METHOD SPINDLE ORIENTATION (OPTIONAL FUNCTION)

The B*i*S series spindle (synchronous built-in spindle motor) does not support this function.

5.15 SPINDLE BACKLASH ACCELERATION FUNCTION (OPTIONAL FUNCTION)

5.15.1 Overview

For this subsection, see Subsection 5.13.1, “Overview”, in Part I.

5.15.2 Series and Editions of Applicable Spindle Software

Spindle software

Series	Edition	Usable CNC
9D53	G (07)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i*
9D70	F (06)	FS30*i* / FS31*i* / FS32*i*
9D80	B (02)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9D90	A (01)	FS16*i* / FS18*i* / FS21*i* , FS0*i* , FS15*i* , FS30*i* / FS31*i* / FS32*i*
9DA0	A (01)	FS30*i* / FS31*i* / FS32*i* -B

NOTE
When using the α*i*CZ sensor (serial) as the motor or spindle sensor, use 9D80 series H (08) edition.

5.15.3 Block Diagram

For this subsection, see Subsection 5.13.3, “Block Diagram”, in Part I.

5.15.4 Parameters

For this subsection, see Subsection 5.13.4, “Parameters”, in Part I.

5.15.5 Example of Adjustment

For this subsection, see Subsection 5.13.5, “Example of Adjustment”, in Part I.

5.16 HIGH-SPEED SPINDLE ORIENTATION (OPTIONAL FUNCTION)

5.16.1 Overview

For this subsection, see Subsection 5.14.1, “Overview”, in Part I.

NOTE

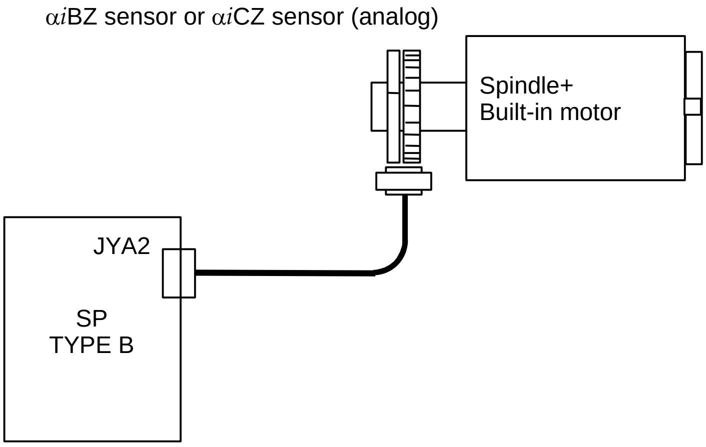
1 When driving the B*i*S series spindle (synchronous built-in spindle motor),
parameter No.4084
is used for AMR offset function.(The parameter isn’t the motor voltage for spindle orientation)
Be sure that if an inappropriate value is set for the AMR offset, the motor may move unpredictably.

2 For AMR offset function, see Subsection 1.5.3, “AMR Offset Function”, in Part IV.

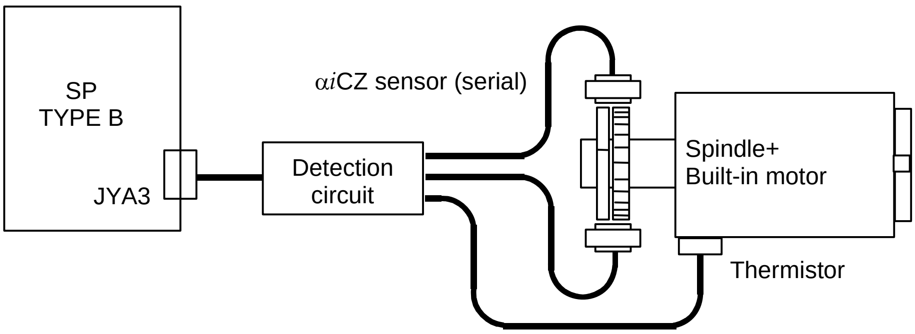
5.16.2 System Configuration

The system configurations that enable the use of the high-speed orientation function are shown below.

(1) When the α*i*BZ sensor or α*i*CZ sensor (analog) is used



(2) When the α*i*CZ sensor (serial) is used



5.16.3 I/O Signals (CNC↔PMC)

For this subsection, see Sections 2.2, "POSITION CODER METHOD SPINDLE ORIENTATION", and 5.3, "INCREMENTAL COMMAND TYPE SPINDLE ORIENTATION (SPINDLE ROTATION SPEED CONTROL)" in Part I.

5.16.4 Sequence

For this subsection, see Subsection 5.14.5, "Sequence", in Part I.

5.16.5 List of Related Parameters

For this subsection, see Subsection 5.14.6, "List of Related Parameters", in Part I.

5.16.6 Details of Related Parameters

For this subsection, see Subsection 5.14.7, "Details of Related Parameters", in Part I.

5.16.7 Spindle Data Used in Tuning

For this subsection, see Subsection 5.14.8, "Spindle Data Used in Tuning", in Part I.

5.16.8 Tuning Procedure

For this subsection, see Subsection 5.14.9, “Tuning Procedure”, in Part I.

V. FANUC SPINDLE MOTOR β*i*Ic series

1 START-UP

1.1 START-UP PROCEDURE

A. Check the spindle-related specifications.
- CNC model
- Spindle motor
- Common power supply (PS)
- Spindle amplifier
- Detector system

↓

B. Check all connections. (See DESCRIPTIONS .)

↓

C. Prepare and check the PMC ladder program.

↓

D. Check the CNC parameter setting for using the β*i*Ic series (Serial) spindle. (See Subsection 1.2.1.)

↓

E. Perform automatic β*i*Ic series (Serial) spindle parameter initialization. (See Subsection 1.2.2.)
- Set a motor model code and the parameter enabling use of the automatic parameter initialization function, then turn the CNC off and then on again.

↓

F. Change parameter data (when no model code is used).
- When using a motor with no model code assigned, perform automatic setting with model code "270", then modify the parameter data according to the motor-specific parameter list.

↓

G. Set the parameters related to the detectors. (See Section 1.3.)

NOTE
The CNC applicable to the β*i*Ic (β*i*SVSPc) is the 0*i* Mate-TD.

1.2 SPINDLE SERIAL INTERFACE (OPTIONAL FUNCTION)

1.2.1 Parameters Related to Spindle Serial Output

For this subsection, see Subsection 1.2.1, “Parameters Related to Spindle Serial Output”, in Part I.

1.2.2 Spindle Parameter Initialization

(1) Parameter list

Parameter No.	Description
4019#7	Function for automatically initializing spindle parameters
4133	Spindle motor model code

(2) Procedure for spindle parameter initialization

Perform spindle parameter initialization by following the procedure below.

<1> Set the model code for the desired motor for automatic parameter initialization.

Parameter No.	Description
4133	Model code

NOTE

For the spindle motor βiIc, which has no model code, set the model code 270 to automatically set the parameter, and then input data manually according to the motor parameter table.

<2> Set the relevant parameter to enable automatic spindle parameter initialization.

Parameter No.	Description
4019#7	1

NOTE

This bit is reset to its original value after automatic parameter initialization.

<3> Turn the CNC off, then on again. Then, the spindle parameters specified with a model code are automatically initialized.

1.2.3 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 1.2.4, “Diagnosis (Diagnosis Screen)”, in Part I.

1.2.4 Alarm

For this subsection, see Subsection 1.2.5, “Alarm”, in Part I.

1.3 PARAMETERS RELATED TO DETECTORS

The spindle detectors applicable to the βiIc series spindle motor (βiSVSPc) are shown below.

Spindle sensor
αi position coder
αiBZ sensor

1.3.1 List of Parameters for Detectors

Parameter No.	Description
3720	Number of pulses of the position coder
4000 #0	Direction of spindle and spindle motor rotation
4001 #4	Spindle sensor mounting direction
4002#3,2,1,0	Spindle sensor type setting
4003#7,6,5,4	Sets the number of spindle sensor gear teeth. (Set to 0,0,0,0.)
4006 #1	Gear ratio increment system
4007 #5	Whether to detect disconnection of feedback signals
4007 #6	Whether to detect alarms related to position feedback signals
4016 #6	Whether to detect alarms related to threading feedback
4016 #7	Setting of the function of detecting the one-rotation signal again each time position control mode is set.
4056~4059	Spindle-to-motor gear ratio data (This data is selected by spindle control input signals CTH1A and CTH2A.)
4098	Maximum speed for position feedback signal detection
4361	(When setting by #7,6,5,4 is impossible) Setting of the arbitrary number of spindle sensor gear teeth

1.3.2 Details of Parameters for Detectors

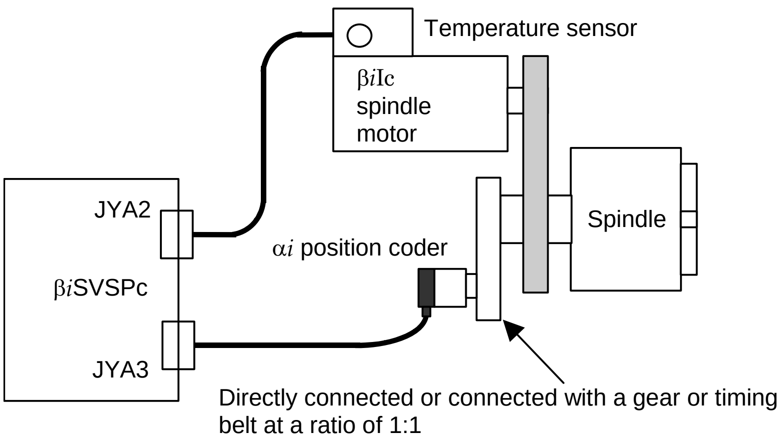
For this subsection, see Subsection 1.3.2, “Details of Parameters for Detectors”, in Part I.

1.3.3 Typical Detector Configurations

This subsection describes the detector configurations for the spindles to which the β*i*Ic series spindle motor (β*i*SVSPc) is applicable and the procedure for setting parameters for the detector configurations.
Since the hardware of the detection circuit is set according to the parameter setting in the β*i*Ic series spindle motor (β*i*SVSPc), a broken wire alarm or the like may be indicated incorrectly during setting of the parameter related to detectors.
To initialize the hardware, after setting the parameters related to detectors, turn the power to the amplifier off once.

(1) When the α*i* position coder is used

[Sample system configuration]

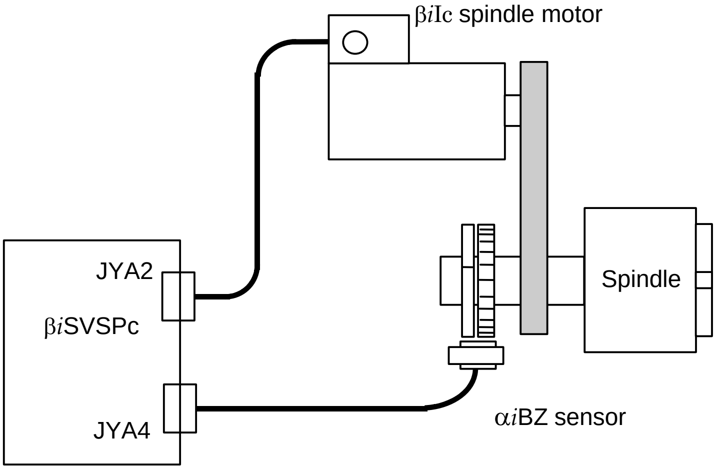


Parameter No.	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction

Parameter No.	Settings	Description
4002 #3,2,1,0	0,0,1,0	Uses the α*i* position coder as the spindle sensor.
4003 #7,6,5,4	0,0,0,0	Sets the number of spindle sensor gear teeth.
4056~4059	Depends on the configuration.	Gear ratio between the spindle and motor

(2) When the separate type α*i*BZ sensor is used

[Sample system configuration]



Parameter No.	Settings	Description
4000 #0	Depends on the configuration.	Rotation directions of the spindle and motor
4001 #4	Depends on the configuration.	Spindle sensor mounting direction
4002 #3,2,1,0	0,0,1,1	Use of the α*i*BZ sensor as the spindle sensor.
4003 #7,6,5,4	Depends on the detector.	Sets the number of spindle sensor gear teeth.
4056~4059	Depends on the configuration.	Gear ratio between the spindle and motor
4361	Depends on the detector.	(When setting by #7,6,5,4 is impossible) Setting of the arbitrary number of spindle sensor gear teeth

2 EXPLANATION OF OPERATION MODES

2.1 VELOCITY CONTROL MODE

2.1.1 Start-up Procedure

For this subsection, see Subsection 2.1.1, “Start-up Procedure”, in Part III.

2.1.2 Overview

For this subsection, see Subsection 2.1.2, “Overview”, in Part III.

2.1.3 System Configuration

For system configurations, see Subsection 1.3.3, “Typical Detector Configurations”, in Part V.

2.1.4 List of I/O Signals (CNC↔PMC)

This Subsection provides a list of the I/O signals related to the velocity control mode only. For details of signal, refer to the Connection Manual (Function) of CNC.

“FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1/02
Refer to Section 10.6, “SPINDLE SPEED CONTROL.”

For details on common input/output signals, see Chapter 3, "I/O SIGNALS (CNC↔PMC)", in Part I.

(1)Input signals (PMC→CNC)

		#7	#6	#5	#4	#3	#2	#1	#0
	G028						GR2	GR1	
	G029		*SSTP	SOR	SAR				
	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
Common signals	G070	MRDYA		SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA
	G071							*ESPA	
	G072				OVRA				

(2) Output signals (CNC→PMC)

		#7	#6	#5	#4	#3	#2	#1	#0
	F001				ENB				
	F007						SF		
	F022	S07	S06	S05	S04	S03	S02	S01	S00
	F023	S15	S14	S13	S12	S11	S10	S09	S08
	F024	S23	S22	S21	S20	S19	S18	S17	S16
	F025	S31	S30	S29	S28	S27	S26	S25	S24
	F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
	F037					R12O	R11O	R10O	R09O
Common signals	F045		TLMA		LDT1A	SARA	SDTA	SSTA	

2.1.5 Related Parameters

For this subsection, see Subsection 2.1.5, “Related Parameters”, in Part III.

2.1.6 Details of Related Parameters

For this subsection, see Subsection 2.1.6, “Details of Related Parameters”, in Part III.

2.1.7 Troubleshooting

For this subsection, see Subsection 2.1.7, “Troubleshooting”, in Part III.

2.2 POSITION CODER METHOD SPINDLE ORIENTATION (OPTIMUM ORIENTATION) (OPTIONAL FUNCTION)

2.2.1 Start-up Procedure

For this subsection, see Subsection 2.2.1, “Start-up Procedure”, in Part III.

2.2.2 Overview

For this subsection, see Subsection 5.4.1, “Overview”, in Part I.

2.2.3 Feature

For this subsection, see Subsection 2.2.4, “Feature”, in Part I.

2.2.4 System Configuration

The position coder method orientation function can be used for all of the configurations listed in Subsection 1.3.3, "Typical Detector Configurations", in Part V.

2.2.5 Stop Position Specification Method

For this subsection, see Subsection 2.2.7, "Stop Position Specification Method", in Part I.

2.2.6 I/O Signals (CNC↔PMC)

(1) List of input signals (PMC→CNC)

	#7	#6	#5	#4	#3	#2	#1	#0
G070		ORCMA			CTH1A	CTH2A		
G072						NRROA	ROTAA	INDXA
G078	SHA07	SHA06	SHA05	SHA04	SHA03	SHA02	SHA01	SHA00
G079					SHA11	SHA10	SHA09	SHA08

(2) Details of output signals (CNC→PMC)

With the βiIc series, the signals indicated in the item above are valid. For details of each signal, see Subsection 2.2.8(2), "Details of input signals (PMC→CNC)", in Part I

(3) Address list of output signals (CNC→PMC)

	#7	#6	#5	#4	#3	#2	#1	#0
F045	ORARA							

(4) Details of output signals (CNC→PMC)

With the βiIc series, the signals indicated in the item above are valid. For details of signal, see Subsection 2.2.8(4), "Details of output signals (CNC→PMC)", in Part I.

2.2.7 Examples of Sequences

For this subsection, see Subsection 2.2.9, " Examples of Sequences ", in Part I.

2.2.8 Related Parameters

For this subsection, see Subsection 2.2.8, "Related Parameters", in Part III.

2.2.9 Details of Related Parameters

For this subsection, see Subsection 2.2.9, "Details of Related Parameters", in Part III.

2.2.10 Adjusting the Orientation Stop Position Shift Parameter

For this subsection, see Subsection 2.2.14, "Adjusting the Orientation Stop Position Shift Parameter", in Part I.

2.3 RIGID TAPPING (OPTIONAL FUNCTION)

2.3.1 Start-up Procedure

For this subsection, see Subsection 2.3.1, "Start-up Procedure", in Part III.

2.3.2 Overview

For this subsection, see Subsection 2.3.2, "Overview", in Part I.

2.3.3 System Configuration

The position coder method orientation function can be used for all of the configurations listed in Subsection 1.3.3, "Typical Detector Configurations", in Part V.

2.3.4 List of I/O Signals (CNC↔PMC)

This subsection provides a list of the I/O signals related to rigid tapping only. For details of signal, refer to the Connection Manual (Function) of CNC.

"FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1/02
Refer to Section 10.13, "RIGID TAPPING."

For details on common input/output signals, see Chapter 3, "I/O SIGNALS (CNC↔PMC)", in Part I.

(1) Input signals (PMC→CNC)

	#7	#6	#5	#4	#3	#2	#1	#0
G028						GR2	GR1	
G061								RGTAP

Common signals

	#7	#6	#5	#4	#3	#2	#1	#0
G070			SFRA	SRVA	CTH1A	CTH2A		

(2) Output signals (CNC→PMC)

	#7	#6	#5	#4	#3	#2	#1	#0
F076					RTAP			

2.3.5 Sequence

For the sequence of rigid tapping, see Section 10.13, "Rigid Tapping" in the FANUC Series 0*i*-MODEL D Connection Manual (Function) (B-64303EN-1/02).

2.3.6 Related Parameters

For this subsection, see Subsection 2.3.6, "Related Parameters", in Part III.

2.3.7 Details of Related Parameters

For this subsection, see Subsection 2.3.7, "Details of Related Parameters", in Part III.

2.3.8 Parameter Setting Procedure

For this subsection, see Subsection 2.3.8, "Parameter Setting Procedure", in Part III.

2.3.9 Adjustment Procedure

For this subsection, see Subsection 2.3.9, "Adjustment Procedure", in Part III.

2.3.10 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.3.10, “Diagnosis (Diagnosis Screen)”, in Part I.

2.3.11 Alarm

For this subsection, see Subsection 2.3.11, “Alarm”, in Part I.

2.4 SPECIFICATIONS COMMON TO ALL OPERATION MODES

2.4.1 Overview

For this subsection, see Subsection 2.5.1, “Overview”, in Part III.

2.4.2 List of I/O Signals (CNC↔PMC)

This Subsection provides a list of the I/O signals related to spindle speed control only. For details of each signal, refer to the “FANUC Series 0*i*-MODEL D CONNECTION MANUAL (FUNCTION) : B-64303EN-1/02 Refer to Section 10.6, “SPINDLE SPEED CONTROL.”

For details on common input/output signals, see Chapter 3, "I/O SIGNALS (CNC↔PMC)", in Part I.

(1) Input signals (PMC→CNC)

	#7	#6	#5	#4	#3	#2	#1	#0
G028						GR2	GR1	
G029		*SSTP	SOR	SAR				
G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I

Common signals

	#7	#6	#5	#4	#3	#2	#1	#0
G070	MRDYA		SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA (*1)
G071							*ESPA	ARSTA
G073						MPOFA		

NOTE

1 In the βiIc series, the functions of the signals are different from those of the α*i* series. For details, see Chapter 3, "I/O SIGNALS (CNC↔PMC) ", in Part III.

(2) Output signals (CNC→PMC)

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O

Common signals

	#7	#6	#5	#4	#3	#2	#1	#0
F045		TLMA		LDT1A	SARA	SDTA	SSTA	ALMA
F047								PC1DTA

2.4.3 Parameters

This Subsection describes those parameters that are common to all operation modes by dividing them into several types.

NOTE
For the detector-related parameters, see Section 1.3, "PARAMETERS RELATED TO DETECTORS", in Part V.

(1) List of parameters specific to spindle motor driving

This item provides a list of the motor parameters specific to spindle motor driving. Usually, the settings of these parameters need not be changed. Use the values indicated on a parameter table for each motor model without modification.

Parameter No.	Description
4011#3	Sets the number of motor poles.
4011#4	Sets a maximum output for acceleration/deceleration.
4011#7	Sets the number of motor poles.
4012#2,1,0	Sets a PWM carrier frequency.
4013#6~2	Sets current dead-band data.
4020	Maximum motor speed
4080	High-speed area regenerative power limit/regenerative power limit
4083	Motor voltage on velocity control
4100	Base speed for motor output specification
4101	Torque limitation value for motor output specification
4102	Excitation voltage saturation speed with no load
4103	Base speed limit ratio
4104	Current loop proportional gain
4105	Current loop integral gain
4106	D-axis current loop gain
4107	Q-axis current loop gain
4108	Q-axis current deviation limitation coefficient
4109	Filter time constant in voltage command saturation processing
4110	Current conversion constant
4111	Secondary current coefficient
4112	Voltage command saturation decision level/PWM command clamp value
4113	Slip constant
4115	PWM command clamp value at deceleration time

Parameter No.	Description
4116	Motor leakage constraint
4117	Voltage compensation coefficient for a high-speed area in steady state/motor voltage coefficient in steady state
4118	Voltage compensation coefficient for a high-speed area at deceleration time/motor voltage coefficient at deceleration time
4119	Time constant for excitation current change at deceleration time/time constant for excitation current change
4120	Dead-band compensation data
4127	Load meter indication value at maximum output time
4128	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient
4130	Current loop proportional gain velocity coefficient/current phase delay compensation constant
4131	Dead-band compensation hysteresis
4133	Motor model code
4134	Motor overheat level (2 words)
4138	Primary frequency clamp velocity1
4139	Primary frequency clamp slip frequency 1
4140	Primary frequency clamp velocity 2
4141	Primary frequency clamp slip frequency 2
4142	Belt slip state detection coefficient 1
4143	Belt slip state detection coefficient 2

(2) List of parameters related to alarm detection

This item provides a list of the parameters related to alarm detection conditions.

Parameter No.	Description
4009#2	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued
4086	Gear ratio parameter setting error alarm (spindle alarm 35) detection level
4088	Velocity error excess detection level when the motor is bound
4089	Velocity error excess detection level when the motor is rotating
4090	Overload detection level
4123	Short-time overload detection period

(3) Other parameters

This item provides a list of the parameters common to all operation modes except the parameters listed in Items (1) and (2) above.

Parameter No.	Description
-	Gear ratio between the spindle and position coder (cases of ×1, ×2, ×4, ×8)
-	Whether to indicate an alarm detected by the spindle amplifier (Usually, set 0.)
-	Enables/disables the spindle alarms (SPxxxx) of all spindles. (Usually, set 0.)
3720	Number of position coder pulses
-	Spindle number selected at power-on/reset time
4001#0	Whether to use the MRDY signal (machine ready signal)
4002#4	SM pin output data selection
4005#0	Setting of the velocity feedback method
4006#1	Gear ratio increment system
4006#2	Sets the unit of speed.
4009#4	Whether to output the load detection signal (LDT1A) during acceleration/deceleration
4019#7	Automatic parameter setting function
4020	Maximum motor speed

Parameter No.	Description
4022	Speed arrival detection signal
4023	Speed detection level
4024	Speed zero detection level
4025	Torque limitation value.
4026	Load detection level 1
4056	Gear ratio (High)
4057	Gear ratio (Medium High)
4058	Gear ratio (Medium Low)
4059	Gear ratio (Low)
4078	Gear switch timer
4095	Speedometer output voltage adjustment value
4121	Torque change time constant (torque command filter time constant)

2.4.4 Details of parameters

For this subsection, see Subsection 2.5.4, “Details of parameters”, in Part III.

2.4.5 Diagnosis (Diagnosis Screen)

For this subsection, see Subsection 2.6.5, “Diagnosis (Diagnosis Screen)”, in Part I.

3 I/O SIGNALS (CNC↔PMC)

This chapter explains the functions of the signals directly input from the PMC to β*i*SVSPc via the CNC and the signals directly output from the β*i*SVSPc to PMC. For other spindle-related I/O signals, refer to the Connection Manual (Function) of the relevant CNC.

See Chapter 10, "SPINDLE FUNCTION" in the FANUC Series 0*i* MODEL D Connection Manual (Function) (B-64303EN-1).

3.1 INPUT SIGNALS (PMC→CNC→β*i*SVSPc)

This section explains the functions of the signals directly input from the PMC to β*i*SVSPc via the CNC. For other spindle-related input signals, refer to the Connection Manual (Function) of the relevant CNC.

See Chapter 10, "SPINDLE FUNCTION" in the FANUC Series 0*i* MODEL D Connection Manual (Function) (B-64303EN-1).

3.1.1 List of Input Signals

	#7	#6	#5	#4	#3	#2	#1	#0
G070	MRDYA	ORCMA	SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA
G071			INTGA				*ESPA	ARSTA
G072			INCMDA	OVRA		NRROA	ROTAA	INDXA
G073						MPOFA		

3.1.2 Explanation of Input Signals

For information about the signals listed in Subsection 3.1.1, "List of Input Signals", in Part V, see Subsection 3.1.2, "Explanation of Input Signals", in Part I.
Those signals that are not listed in Subsection 3.1.1, "List of Input Signals", in Part V are not used with the β*i*Ic series spindle.
This subsection describes only those signals that have different specifications for use with the β*i*Ic spindle.

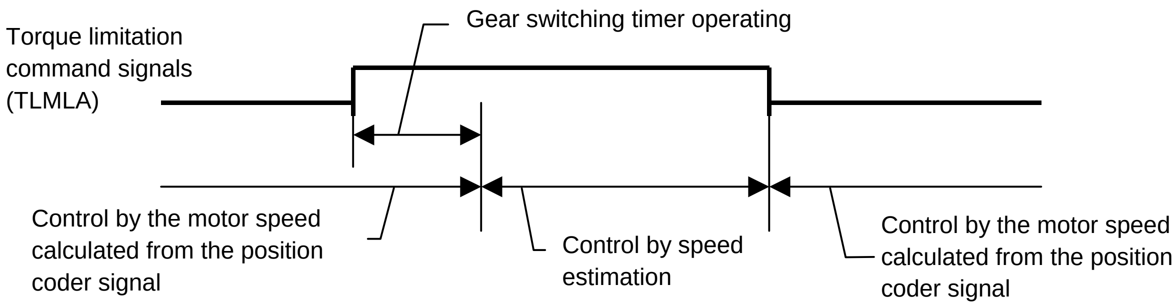
Symbol	Name	Description
TLMLA, B	Torque limitation command LOW	Switches to a speed control method that uses speed estimation during gear switching. 0: - 1: Performs speed control using only speed estimation. (However, there is the delay set by the gear switching timer [No.4078].)

3.1.3 Details of Input Signals

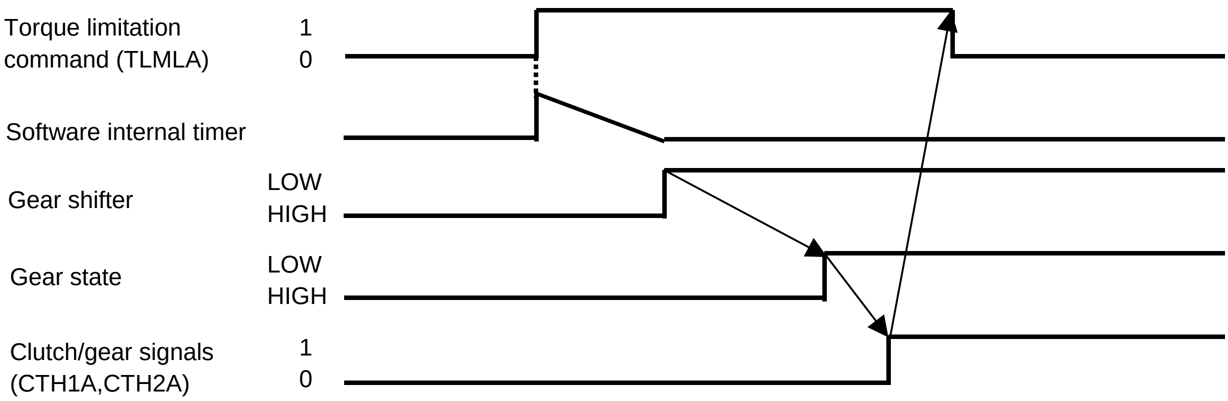
For information about the signals listed in Subsection 3.1.1, "List of Input Signals", in Part V, see Subsection 3.1.3, "Details of input signals", in Part I.
Those signals that are not listed in Subsection 3.1.1, "List of Input Signals", in Part V are not used with the β*i*Ic series spindle.
This subsection describes only those signals that have different specifications for use with the β*i*Ic spindle.

(a) Torque limitation command signals (TLMLA)

If gear switching is performed with the setting (No.4005#0="1") that uses motor speed calculated from the position coder signal to perform speed control, the state of machine gear may not match the state of the gear ratio parameter. This can cause an alarm to occur due to speed control using incorrect speed data. Therefore, switch to a control method that uses the speed estimation during gear switching by inputting the torque limitation command signal (TLMLA) upon start of gear switching so that gear switching is performed smoothly. In addition, set the time from when a gear switching sequence starts to when the gear shifter actually operates for parameter No.4078 (gear switching timer). (See below.)



(Example of a recommended sequence)



3.2 OUTPUT SIGNALS (β*i*SVSPc→CNC→PMC)

This section explains the functions of the signals directly output from the β*i*SVSPc to PMC via the CNC. For other spindle-related output signals, refer to the Connection Manual (Function) of the relevant CNC.

See Chapter 10, "SPINDLE FUNCTION" in the FANUC Series 0*i* MODEL D Connection Manual (Function) (B-64303EN-1).

3.2.1 List of Output Signals

	#7	#6	#5	#4	#3	#2	#1	#0
F045	ORARA	TLMA		LDT1A	SARA	SDTA	SSTA	ALMA
F047							INCSTA	PC1DTA

3.2.2 Explanation of Output Signals

For information about the signals listed in Subsection 3.2.1, "List of Output Signals", in Part V, see Subsection 3.2.2, "Explanation of Output Signals", in Part I.

Those signals that are not listed in Subsection 3.2.1, “List of Output Signals”, in Part V are not used with the β*i*Ic series spindle.

3.2.3 Details of Output Signals

For information about the signals listed in Subsection 3.2.1, “List of Output Signals”, in Part V, see Subsection 3.2.3, “Details of Output Signals”, in Part I.
Those signals that are not listed in Subsection 3.2.1, “List of Output Signals”, in Part V are not used with the β*i*Ic series spindle.

4 ADJUSTMENT

4.1 VELOCITY LOOP GAIN ADJUSTMENT

4.1.1 Overview

Optimum adjustment of the velocity loop gain increases the position loop gain, therefore significantly enhancing disturbance suppression performance, positioning speed and accuracy. So, the adjustment of the velocity loop gain is very important in servo adjustments, and it should be performed first. This section explains the parameters for velocity loop gain adjustment and the adjustment procedure.
To check the waveform of a torque command, position error, or so on, use the spindle check board and an oscilloscope, or the servo guide (see Appendix F).

4.1.2 Parameters

There are four operation modes in spindle control: velocity control mode, orientation, servo mode (rigid tapping and spindle positioning), and spindle synchronous control. There are parameters corresponding to each operation mode and to the clutch/gear signals (CTH1A and CTH2A). The following shows the parameters for each operation mode.

(1) Velocity control mode

4040	**Velocity loop proportional gain on velocity control mode (HIGH)**	**CTH1A=0**
4041	**Velocity loop proportional gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

4048	**Velocity loop integral gain on velocity control mode (HIGH)**	**CTH1A=0**
4049	**Velocity loop integral gain on velocity control mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

(2) Orientation

4042	**Velocity loop proportional gain on orientation (HIGH)**	**CTH1A=0**
4043	**Velocity loop proportional gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

4050	**Velocity loop integral gain on orientation (HIGH)**	**CTH1A=0**
4051	**Velocity loop integral gain on orientation (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

(3) Servo mode (Rigid tapping and spindle positioning)

4044	**Velocity loop proportional gain on servo mode (HIGH)**	**CTH1A=0**
4045	**Velocity loop proportional gain on servo mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

4052	**Velocity loop integral gain on servo mode (HIGH)**	**CTH1A=0**
4053	**Velocity loop integral gain on servo mode (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

(4) Spindle synchronous control

4044	**Velocity loop proportional gain on spindle synchronous control (HIGH)**	**CTH1A=0**
4045	**Velocity loop proportional gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

4052	**Velocity loop integral gain on spindle synchronous control (HIGH)**	**CTH1A=0**
4053	**Velocity loop integral gain on spindle synchronous control (LOW)**	**CTH1A=1**

Unit of data :
Valid data range : 0 to 32767
Standard setting value : Depends on the motor model.

NOTE
For the velocity loop gain on spindle synchronous control and on the servo mode, common parameters are used.

4.1.3 Adjustment Procedure

(1) Start of each operation mode

In preparation for the adjustment, settings must be made so that a stable operation takes place in each mode without overshoot or oscillation.
See Chapter 2, “EXPLANATION OF OPERATION MODES”, temporarily set parameters (acceleration/deceleration time constant, position gain, and so on) to make operations stable in each operation mode, and confirm operations

> **NOTE**
> When the rigidity of the spindle is low, the standard setting of the velocity loop gain may be so high that oscillation can occur. In such a case, decrease the velocity loop gain.

(2) Adjustment

Before adjusting the velocity loop gain, check the operation mode and the clutch/gear signals and then change the corresponding parameters. Follow the steps below to adjust the parameters:

The velocity loop proportional gain and integral gain are parameters to be set according to the load inertia. Set the value according to the following equation.

$$[\text{Proportional/integral gain considering load inertia}] = \left(\frac{\text{JL}\,[\text{kgm}^2]}{\text{Jm}\,[\text{kgm}^2]} + 1\right) \times [\text{Initial value of proportional/integral gain}]$$

JL [kgm^2] : Spindle load inertia (converted for the motor shaft)
Jm [kgm^2] : Rotor inertia of spindle motor

Example) For the βiIc3/6000

The motor rotor inertia Jm is 0.0078 kgm^2.
The initial value of the proportional gain is 24.
The initial value of the integral gain is 607.
If the spindle inertia Jl is 0.0250kgm^2:
The proportional gain considering load inertia is (No.4040 to No.4045) = (0.0250/0.0078+1)×24 = 101.
The integral gain considering load inertia is (No.4048 to No.4053) = (0.0250/0.0078+1)×607 = 2553.

Motor model	Rotor inertia Jm (kgm^2)	Initial value of proportional gain	Initial value of integral gain
βiIc3/6000	0.0078	24	607
βiIc6/6000	0.0148	34	844
βiIc8/6000	0.0179	28	696

If vibration as described below occurs when a value calculated by the above expression is set because, for example, the rigidity of the spindle is low, then set a smaller value (equal to or less than 70% of the calculated value) by providing a margin.
- The vibration sound of spindle occurs.
- Vibration of a torque command becomes large.
- Vibration caused by position error at a stop becomes large.

4.1.4 Additional Information (Position Gain Adjustment)

Although the limit value of the position gain is determined basically depending on the velocity loop characteristics, the setting standards may vary depending on the operation mode. See Chapter 2, “EXPLANATION OF OPERATION MODES”, and make adjustments accordingly.

APPENDIX

A SPINDLE PARAMETER TABLE

A.1 α*i* SERIES SPINDLE PARAMETER TABLE

α*i* series spindle parameters are classified into the following types:

A : Parameters related to the setup of detectors
B : Parameters related to the setup of various functions (operating modes)
C : Unique parameters for the drive of spindle motors (Set the parameter data according to the parameter list for each motor model.)
D : Parameters related to the setting of alarm detection conditions
E : Parameters related to the setting of a power consumption monitor (see the FANUC Series 30*i*/31*i*/32*i*-A Power Consumption Monitor Specification (A-92345).)

MH, ML, SH, and SL in the table represent the following:

MH: Parameter for speed range switch high-speed characteristics on the main side of spindle switching (for standard motors)
ML: Parameter for speed range switch low-speed characteristics on the main side of spindle switching
SH: Parameter for speed range switch high-speed characteristics on the sub-side of spindle switching
SL: Parameter for speed range switch low-speed characteristics on the sub-side of spindle switching

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application				Classification	Reference item
							MH	ML	SH	SL		
0H	3000	4000	4000	#0	0	Rotation direction relationship between the spindle and motor	O	O			A	I-1.3.2
				#1	0	Spindle rotation direction when a positive (+) move command is specified on Cs contouring control	O	O			B	I-2.4.8
				#3	0	Return direction for the reference position on Cs contouring control mode	O	O			B	I-2.4.8
				#4	0	Return direction for the reference position on servo mode	O	O			B	I-2.3.7
				#5	0	Whether to use the differential spindle speed control function	O	O			B	I-5.9.8
				#6	0	Direction for differential spindle speed control	O	O			B	I-5.9.8
0L	3001	4001	4001	#0	1	Whether to use MRDY (machine ready) signal	O	O			B	I-2.6.4
				#3	0	Mounting direction of the magnetic sensor	O	O			B	I-5.12.6
				#4	0	Mounting direction of the spindle sensor	O	O			A	I-1.3.2
1H	3002	4002	4002	#0	0	Spindle sensor type	O	O			A	I-1.3.2
				#1	0	Spindle sensor type	O	O			A	I-1.3.2
				#2	0	Spindle sensor type	O	O			A	I-1.3.2
				#3	0	Spindle sensor type	O	O			A	I-1.3.2
				#4	0	Whether to use the rotation direction signal (SFR/SRV) function on Cs contouring control	O	O			B	I-2.4.8
				#5	0	Whether to use the rotation direction signal (SFR/SRV) function on servo mode	O	O			B	I-2.3.7
				#6	0	Whether to use the rotation direction signal (SFR/SRV) function on spindle synchronous control	O	O			B	I-2.5.8
				#7	0	Whether to use the CMR (servo mode Cs contouring) function in servo mode	O	O			B	
1L	3003	4003	4003	#0	0	Spindle orientation method	O	O			B	I-2.2.12
				#2	0	Rotation direction during spindle orientation	O	O			B	I-2.2.12
				#3	0	Rotation direction during spindle orientation	O	O			B	I-2.2.12
				#4	0	Teeth number setting of spindle sensor	O	O			A	I-1.3.2
				#5	0	Teeth number setting of spindle sensor	O	O			A	I-1.3.2
				#6	0	Teeth number setting of spindle sensor	O	O			A	I-1.3.2

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application MH	ML	SH	SL	Classif i-cation	Reference item
				#7	0	Teeth number setting of spindle sensor	O	O			A	I-1.3.2
2H	3004	4004	4004	#2	0	Setting of external one-rotation signal	O	O			A	I-1.3.2
				#3	0	Setting of external one-rotation signal	O	O			A	I-1.3.2
2L	3005	4005	4005	#0	0	Command resolution for Cs contouring control	O	O			B	I-2.4.8
3H	3006	4006	4006	#1	0	Increment system of gear ratio	O	O			A	I-1.3.2
				#2	Depends on the model	Increment system of spindle speed	O	O			C	I-2.6.4
				#3	0	Automatic detection of one-rotation signal during spindle synchronous control	O	O			B	I-2.5.8
				#5	0	Setting of analog override range	O	O			B	I-2.1.6
				#7	0	Whether to use the command arbitrary gear ratio (CMR) function on rigid tapping	O	O			B	I-2.3.7
3L	3007	4007	4007	#5	0	Whether to detect a feedback signal disconnection	O	O			A	I-1.3.2
				#6	0	Whether to detect the alarms (spindle alarms 41, 42, 47, 81, 82, 83, 85, 86, and 87) related to the position feedback signal (when non-Cs contouring control mode is set)	O	O			A	I-1.3.2
4H	3008	4008	4008	#0	0	Reserved	O				C	
				#1	0	Reserved		O			C	
				#2	0	Reserved	O	O			C	
				#4	Depends on the model	Setting of output limitation method	O	O			C	I-2.6.4
4L	3009	4009	4009	#0	0	Increment system of velocity loop gain	O	O			B	I-2.6.4
				#2	0	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued	O	O			D	I-2.6.4
				#4	0	Whether to output the load detection signals (LDT1, LDT2) during acceleration/deceleration	O	O			B	I-2.1.6
				#6	0	Analog override type	O	O			B	I-2.1.6
5H	3010	4010	4010	#0	Depends on the model	Motor sensor type	O	O			A	I-1.3.2
				#1	Depends on the model	Motor sensor type	O	O			A	I-1.3.2
				#2	Depends on the model	Motor sensor type	O	O			A	I-1.3.2
5L	3011	4011	4011	#0	Depends on the model	Teeth number setting of motor sensor	O	O			A	I-1.3.2
				#1	Depends on the model	Teeth number setting of motor sensor	O	O			A	I-1.3.2
				#2	Depends on the model	Teeth number setting of motor sensor	O	O			A	I-1.3.2
				#3	Depends on the model	Number of motor poles	O	O			C	I-2.6.4
				#4	Depends on the model	Setting of maximum output during acceleration/deceleration	O	O			C	I-2.6.4
				#7	Depends on the model	Number of motor poles	O	O			C	I-2.6.4
6H	3012	4012	4012	#0	Depends on the model	Setting of PWM carrier frequency	O	O			C	I-2.6.4
				#1	Depends on the model	Setting of PWM carrier frequency	O	O			C	I-2.6.4
				#2	Depends on the model	Setting of PWM carrier frequency	O	O			C	I-2.6.4
				#7	1	Setting of spindle HRV function	O	O	O	O	C	I-2.6.4
6L	3013	4013	4013	#2	Depends on the model	Current dead-band data	O	O			C	I-2.6.4
				#3	Depends on the model	Current dead-band data	O	O			C	I-2.6.4
				#4	Depends on the model	Current dead-band data	O	O			C	I-2.6.4
				#5	Depends on the model	Current dead-band data	O	O			C	I-2.6.4
				#6	Depends on the model	Current dead-band data	O	O			C	I-2.6.4

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application MH	ML	SH	SL	Classif i-catio n	Referenc e item
				#7	Depends on the model	Setting of a PWM carrier frequency for low-speed characteristics area		O			C	I-2.6.4
7H	3014	4014	4014	#0	0	Whether to use the spindle switch function	O	O	O	O	B	I-5.2.9
				#2	0	Whether to check both spindle switch main and sub magnetic contactor contacts	O	O	O	O	B	I-5.2.9
				#3	0	Whether to check both magnetic contactor contacts for high-speed /low-speed characteristics in speed range switching	O	O	O	O	B	I-5.1.7
				#6	0	Whether to use the orientation function on spindle synchronous control	O	O			B	I-5.5.6
				#7	0	Setting of dual position feedback	O	O			B	I-5.10.4
7L	3015	4015	4015	#0	0	Whether to use the spindle orientation function	O	O	O	O	B	I-2.2.12
				#1	0	Whether to use the unexpected disturbance torque detection function	O	O	O	O	B	I-5.7.5
				#2	0	Whether to use the speed range switching function	O	O	O	O	B	I-5.1.7
				#3	0	Whether to use the spindle tandem function	O	O	O	O	B	I-5.11.6
8H	3016	4016	4016	#3	0	Setting of the smoothing function in feed-forward control	O	O			B	I-2.4.8 I-5.8.7
				#4	0	Setting related to the motor voltage control characteristics on Cs contouring control or servo mode	O	O			B	I-2.3.7 I-2.4.8
				#5	0	Whether to detect the alarms (spindle alarms 81, 82, 85, 86) related to position feedback (on Cs contouring control mode)	O	O			A	I-1.3.2
				#6	0	Whether to detect the alarm (spindle alarms 46) related to feedback of the position detection signal for threading	O	O			A	I-1.3.2
				#7	0	Function for newly detecting the one-rotation signal before entering position control mode	O	O			A	I-1.3.2
8L	3017	4017	4017	#0	0	This parameter sets speed integration operation when differential spindle speed control is exercised.	O	O			B	I-5.9.8
				#7	0	Setting of shortcut orientation from stop state in position coder method spindle orientation	O	O			B	I-2.2.12
9H	3018	4018	4018	#3	0	Type of position coder method orientation	O	O			B	I-2.2.12
				#4	0	Optimum orientation: Setting of velocity feedforward (CTH1A=0)	O	O			B	I-2.2.12
				#5	0	Optimum orientation: Setting of velocity feedforward (CTH1A=1) High-speed orientation: Velocity command compensation function	O	O			B	I-2.2.12 I-5.14.7
				#6	0	Type of position coder method orientation	O	O			B	I-2.2.12
9L	3019	4019	4019	#2	1	Whether to use torque clamp at zero speed	O	O			B	I-2.6.4
				#4	0	Setting of the function for switching from high-speed characteristics to low-speed characteristics with the speed detection signal SDT = 1 at speed range switching	O	O			B	I-5.1.7
				#6	1	Presence or absence of the compensation of the spindle acceleration command	O	O			B	I-2.2.12
				#7	0	Automatic parameter setting function (16*i*/30*i*)	O	O			B	I-1.1.2 I-2.6.4
10	3020	4020	4020		Depends on the model	Maximum motor speed	O	O			C	I-2.6.4
11	3021	4021	4021		100	Maximum speed on Cs contouring control mode	O	O			B	I-2.4.8
12	3022	4022	4022		150	Speed arrival detection level (SAR)	O	O			B	I-2.6.4
13	3023	4023	4023		30	Speed detection level (SDT)	O	O			B	I-2.6.4
14	3024	4024	4024		75	Zero speed detection level (SST)	O	O			B	I-2.6.4
15	3025	4025	4025		50	Limited torque (TLMH, TLML)	O	O			B	I-2.6.4
16	3026	4026	4026		83	Load detection level 1 (LDT1)	O	O			B	I-2.6.4
17	3027	4027	4027		95	Load detection level 2 (LDT2)	O	O	O	O	B	I-2.6.4
18	3028	4028	4028		0	Limited output pattern	O	O			B	I-2.1.6
19	3029	4029	4029		100	Output limit	O	O			B	I-2.1.6
20	3030	4030	4030		0	Soft start/stop time (SOCN)	O	O	O	O	B	I-2.1.6

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application MH	ML	SH	SL	Classif i-catio n	Referenc e item
21	3031	4031	4031		0	Stop position of position coder method orientation	O	O			B	I-2.2.12
22	3032	4032	4032		0	Acceleration on spindle synchronous control	O	O			B	I-2.5.8
23	3033	4033	4033		10	Spindle synchronous speed arrival level	O	O			B	I-2.5.8
24	3034	4034	4034		0	Shift during synchronous control of spindle phase	O	O			B	I-2.5.8
25	3035	4035	4035		10	Compensation data for spindle phase synchronous control	O	O			B	I-2.5.8
26	3036	4036	4036		0	Feed-forward coefficient	O	O			B	I-2.4.8 I-5.8.8
27	3037	4037	4037		0	Feed-forward coefficient of velocity loop	O				B	I-2.4.8 I-5.6.4 I-5.8.8
28	3038	4038	4038		0	Optimum orientation: Orientation speed upper limit Conventional method orientation, High-speed orientation: Spindle orientation speed upper limit	O	O			B	I-2.2.12 I-5.14.7
29	3039	4039	4039		Depends on the model	Slip compensation gain	O				C	I-2.6.4
30	3040	4040	4040		10	Velocity loop proportional gain on velocity control mode (High)	O	O			B	I-2.1.6
31	3041	4041	4041		10	Velocity loop proportional gain on velocity control mode (Low)	O	O			B	I-2.1.6
32	3042	4042	4042		10	Velocity loop proportional gain on orientation (High)	O	O			B	I-2.2.12
33	3043	4043	4043		10	Velocity loop proportional gain on orientation (Low)	O	O			B	I-2.2.12
34	3044	4044	4044		10	Velocity loop proportional gain on servo mode/spindle synchronous control (High)	O	O			B	I-2.3.7 I-2.5.8
35	3045	4045	4045		10	Velocity loop proportional gain on servo mode/spindle synchronous control (Low)	O	O			B	I-2.3.7 I-2.5.8
36	3046	4046	4046		30	Velocity loop proportional gain on Cs contouring control (High)	O	O			B	I-2.4.8
37	3047	4047	4047		30	Velocity loop proportional gain on Cs contouring control (Low)	O	O			B	I-2.4.8
38	3048	4048	4048		10	Velocity loop integral gain on velocity control mode (High)	O	O			B	I-2.1.6
39	3049	4049	4049		10	Velocity loop integral gain on velocity control mode (Low)	O	O			B	I-2.1.6
40	3050	4050	4050		10	Velocity loop integral gain on orientation (High)	O	O			B	I-2.2.12
41	3051	4051	4051		10	Velocity loop integral gain on orientation (Low)	O	O			B	I-2.2.12
42	3052	4052	4052		10	Velocity loop integral gain on servo mode/spindle synchronous control (High)	O	O			B	I-2.3.7 I-2.5.8
43	3053	4053	4053		10	Velocity loop integral gain on servo mode/spindle synchronous control (Low)	O	O			B	I-2.3.7 I-2.5.8
44	3054	4054	4054		50	Velocity loop integral gain on Cs contouring control (High)	O	O			B	I-2.4.8
45	3055	4055	4055		50	Velocity loop integral gain on Cs contouring control (Low)	O	O			B	I-2.4.8
46	3056	4056	4056		100	Gear ratio (High)	O	O			A	I-1.3.2
47	3057	4057	4057		100	Gear ratio (Medium High)	O	O			A	I-1.3.2
48	3058	4058	4058		100	Gear ratio (Medium Low)	O	O			A	I-1.3.2
49	3059	4059	4059		100	Gear ratio (Low)	O	O			A	I-1.3.2
50	3060	4060	4060		1000	Position gain on orientation (High)	O	O			B	I-2.2.12
51	3061	4061	4061		1000	Position gain on orientation (Medium High)	O	O			B	I-2.2.12
52	3062	4062	4062		1000	Position gain on orientation (Medium Low)	O	O			B	I-2.2.12
53	3063	4063	4063		1000	Position gain on orientation (Low)	O	O			B	I-2.2.12
54	3064	4064	4064		100	Normal orientation: Rate of change in the position gain upon completion of spindle orientation High-speed orientation: Percentage limit to an acceleration during deceleration Optimum orientation: Position feedforward coefficient	O	O			B	I-2.2.12 I-5.4.7
55	3065	4065	4065		1000	Position gain on servo mode/spindle synchronous control (High)	O	O			B	I-2.3.7 I-2.5.8

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application MH	ML	SH	SL	Classif i-catio n	Referenc e item
56	3066	4066	4066		1000	Position gain on servo mode/spindle synchronous control (Medium High)	O	O			B	I-2.3.7 I-2.5.8
57	3067	4067	4067		1000	Position gain on servo mode/spindle synchronous control (Medium Low)	O	O			B	I-2.3.7 I-2.5.8
58	3068	4068	4068		1000	Position gain on servo mode/spindle synchronous control (Low)	O	O			B	I-2.3.7 I-2.5.8
59	3069	4069	4069		3000	Position gain on Cs contouring control (High)	O	O			B	I-2.4.8
60	3070	4070	4070		3000	Position gain on Cs contouring control (Medium High)	O	O			B	I-2.4.8
61	3071	4071	4071		3000	Position gain on Cs contouring control (Medium Low)	O	O			B	I-2.4.8
62	3072	4072	4072		3000	Position gain on Cs contouring control (Low)	O	O			B	I-2.4.8
63	3073	4073	4073		0	Grid shift on servo mode	O	O			B	I-2.3.7
64	3074	4074	4074		0	Reference position return speed on Cs contouring control/servo mode	O	O	O	O	B	I-2.3.7 I-2.4.8
65	3075	4075	4075		10	Detection level for orientation completion signal (ORAR)	O	O			B	I-2.2.12
66	3076	4076	4076		33	Ordinary orientation: Motor speed limit value on orientation High-speed orientation: Reserved Optimum orientation: Bell-shaped acceleration / deceleration time constant	O	O			B	I-2.2.12
67	3077	4077	4077		0	Orientation stop position shift	O	O			B	I-2.2.12
68	3078	4078	4078		200	MS signal constant	O	O			B	I-5.12.6
69	3079	4079	4079		0	MS signal gain adjustment	O	O			B	I-5.12.6
70	3080	4080	4080		Depends on the model	Regenerative power limit for high-speed zone/regenerative power limit	O				C	I-2.6.4
71	3081	4081	4081		20	Delay time until motor power is cut off	O	O			B	I-2.1.6
72	3082	4082	4082		10	Setting of acceleration/deceleration time	O	O			B	I-2.1.6
73	3083	4083	4083		Depends on the model	Motor voltage on velocity control mode	O				C	I-2.1.6
74	3084	4084	4084		Depends on the model	Motor voltage on orientation	O	O			C	I-2.2.12 I-5.4.7
75	3085	4085	4085		Depends on the model	Motor voltage on servo mode/spindle synchronous control mode	O				C	I-2.3.7 I-2.5.8
76	3086	4086	4086		100	Motor voltage on Cs contouring control	O	O			C	I-2.4.8
77	3087	4087	4087		115	Overspeed level	O	O	O	O	D	I-2.6.4
78	3088	4088	4088		75	Level for detecting excess velocity error when motor is restrained	O	O	O	O	D	I-2.6.4
79	3089	4089	4089		200	Level for detecting excess velocity error when motor rotates	O	O	O	O	D	I-2.6.4
80	3090	4090	4090		90	Overload detection level	O	O	O	O	D	I-2.6.4
81	3091	4091	4091		100	Rate of change in position gain during reference position return on servo mode	O	O			B	I-2.3.7
82	3092	4092	4092		100	Rate of change in position gain during reference position return on Cs contouring control	O	O			B	I-2.4.8
83	3093	4093	4093		Depends on the model	Value displayed on load meter at maximum output		O			C	App. B
84	3094	4094	4094		0	Disturbance torque compensation constant (acceleration feedback gain)	O	O			B	I-2.4.8
85	3095	4095	4095		0	Adjusted output voltage of speedometer	O	O	O	O	B	I-2.6.4
86	3096	4096	4096		0	Adjusted output voltage of load meter	O	O	O	O	B	I-2.6.4
87	3097	4097	4097		0	Feedback gain of spindle speed	O	O			B	I-2.4.8
88	3098	4098	4098		0	Maximum speed for position feedback signal detection	O	O	O	O	A	I-1.3.2
89	3099	4099	4099		0	Delay time for motor excitation	O	O	O	O	B	I-2.3.7 I-2.4.8
90	3100	4100	4100		Depends on the model	Base speed of motor output specifications	O				C	I-2.6.4
91	3101	4101	4101		Depends on the model	Output limit for motor output specifications	O				C	I-2.6.4

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application				Classif i-cation	Reference item
							MH	ML	SH	SL		
92	3102	4102	4102		Depends on the model	Excitation voltage saturation speed at no-load	O				C	I-2.6.4
93	3103	4103	4103		Depends on the model	Base speed limit ratio	O				C	I-2.6.4
94	3104	4104	4104		Depends on the model	Current loop proportional gain	O				C	I-2.6.4
95	3105	4105	4105		0	Reserved	O				C	
96	3106	4106	4106		Depends on the model	Current loop integral gain	O				C	I-2.6.4
97	3107	4107	4107		0	Reserved	O				C	
98	3108	4108	4108		Depends on the model	Velocity at which the current loop integral gain is zero	O				C	I-2.6.4
99	3109	4109	4109		Depends on the model	Filter time constant for processing saturation related to the voltage command	O				C	I-2.6.4
100	3110	4110	4110		Depends on the model	Current conversion constant	O				C	I-2.6.4
101	3111	4111	4111		Depends on the model	Secondary current coefficient	O				C	I-2.6.4
102	3112	4112	4112		Depends on the model	Criterion level for saturation related to the voltage command/PWM command clamp value	O				C	I-2.6.4
103	3113	4113	4113		Depends on the model	Slip constant	O				C	I-2.6.4
104	3114	4114	4114		Depends on the model	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration	O				C	I-2.6.4
105	3115	4115	4115		Depends on the model	PWM command clamp value at deceleration	O				C	I-2.6.4
106	3116	4116	4116		Depends on the model	Motor leakage constant	O				C	I-2.6.4
107	3117	4117	4117		Depends on the model	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient	O				C	I-2.6.4
108	3118	4118	4118		Depends on the model	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient	O				C	I-2.6.4
109	3119	4119	4119		Depends on the model	Deceleration-time excitation current change time constant/excitation current change time constant	O				C	I-2.6.4
110	3120	4120	4120		Depends on the model	Dead-band rectangular wave component zero voltage/dead-band data	O	O	O	O	C	I-2.6.4
111	3121	4121	4121		5	Time constant for changing the torque (TCMD filter time constant)	O				B	I-4.2.1
112	3122	4122	4122		0	Time constant for velocity detecting filter	O	O			B	I-2.6.4
113	3123	4123	4123		30	Short-time overload detection time	O	O	O	O	D	I-2.6.4
114	3124	4124	4124		0	Magnetic flux boost completion level/magnetic flux boost coefficient	O				B	I-5.17.4
117	3127	4127	4127		Depends on the model	Value displayed on load meter at maximum output	O				C	I-2.6.4
118	3128	4128	4128		Depends on the model	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient	O				C	I-2.6.4
119	3129	4129	4129		Depends on the model	Secondary current coefficient for rigid tapping	O				C	I-2.6.4
120	3130	4130	4130		Depends on the model	Current loop proportional gain speed coefficient/current phase delay compensation coefficient	O				C	I-2.6.4
121	3131	4131	4131		0	Time constant for velocity detecting filter (on Cs contouring control)	O	O			B	I-2.4.8
123	3133	4133	4133		Depends on the model	Motor model code	O	O			C	I-1.1.2 I-2.6.4
124 125	3134	4134	4134		Depends on the model	Motor overheat detect level (2-word)	O	O			C	I-2.6.4
126 127	3135	4135	4135		0	Grid shift during Cs contouring control mode l (2-word)	O	O			B	I-2.4.8
128	3136	4136	4136		Depends on the model	Motor voltage on velocity control mode		O			C	App. B

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application MH	ML	SH	SL	Classif i-cation	Reference item
129	3137	4137	4137		Depends on the model	Motor voltage on servo mode/spindle synchronous control mode		O			C	App. B
130	3138	4138	4138		Depends on the model	Base speed of motor output specifications		O			C	App. B
131	3139	4139	4139		Depends on the model	Output limit for motor output specifications		O			C	App. B
132	3140	4140	4140		Depends on the model	Excitation voltage saturation speed at no-load		O			C	App. B
133	3141	4141	4141		Depends on the model	Base speed limit ratio		O			C	App. B
134	3142	4142	4142		Depends on the model	Current loop proportional gain		O			C	App. B
135	3143	4143	4143		Depends on the model	Current loop integral gain		O			C	App. B
136	3144	4144	4144		Depends on the model	Velocity at which the current loop integral gain is zero		O			C	App. B
137	3145	4145	4145		Depends on the model	Filter time constant for processing saturation related to the voltage command		O			C	App. B
138	3146	4146	4146		Depends on the model	Current conversion constant		O			C	App. B
139	3147	4147	4147		Depends on the model	Secondary current coefficient		O			C	App. B
140	3148	4148	4148		Depends on the model	Criterion level for saturation related to the voltage command/PWM command clamp value		O			C	App. B
141	3149	4149	4149		Depends on the model	Slip constant		O			C	App. B
142	3150	4150	4150		Depends on the model	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration		O			C	App. B
143	3151	4151	4151		Depends on the model	PWM command clamp value at deceleration		O			C	App. B
144	3152	4152	4152		Depends on the model	Motor leakage constant		O			C	App. B
145	3153	4153	4153		Depends on the model	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient		O			C	App. B
146	3154	4154	4154		Depends on the model	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient		O			C	App. B
147	3155	4155	4155		0	Magnetic flux boost completion level/magnetic flux boost coefficient		O			B	App. B
148	3156	4156	4156		Depends on the model	Slip compensation gain		O			C	App. B
149	3157	4157	4157		5	Time constant for changing the torque (TCMD filter time constant)		O			B	App. B
150	3158	4158	4158		Depends on the model	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient		O			C	App. B
151	3159	4159	4159		Depends on the model	Secondary current coefficient for rigid tapping		O			C	App. B
152	3160	4160	4160		0	Hysteresis of speed detection level	O	O	O	O	B	I-5.1.7
153	3161	4161	4161		Depends on the model	Current loop proportional gain speed coefficient/current phase delay compensation coefficient		O			C	App. B
154	3162	4162	4162		0	Integral gain of velocity loop during cutting feed on Cs contouring control mode (High)	O	O			B	I-2.4.8
155	3163	4163	4163		0	Integral gain of velocity loop during cutting feed on Cs contouring control mode (Low)	O	O			B	I-2.4.8
157	3165	4165	4165		Depends on the model	Deceleration-time excitation current change time constant/excitation current change time constant		O			C	App. B
158	3166	4166	4166		Depends on the model	Regenerative power limit for high-speed zone/regenerative power limit		O			C	App. B
160	3168	4168	4168		0	Current overload alarm detection level		O			D	App. B
161	3169	4169	4169		Depends on the model	Temperature monitoring time constant	O	O			C	I-2.6.4
162	3170	4170	4170		0	Current overload alarm detection level	O				D	I-2.6.4

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application				Classification	Reference item
							MH	ML	SH	SL		
163	3171	4171	4171		0	Denominator of arbitrary gear ratio between motor sensor and spindle (High)	O	O			A	I-1.3.2
164	3172	4172	4172		0	Numerator of arbitrary gear ratio between motor sensor and spindle (High)	O	O			A	I-1.3.2
165	3173	4173	4173		0	Denominator of arbitrary gear ratio between motor sensor and spindle (Low)	O	O			A	I-1.3.2
166	3174	4174	4174		0	Numerator of arbitrary gear ratio between motor sensor and spindle (Low)	O	O			A	I-1.3.2
168H	3176	4176	4176	#0	0	Rotation direction relationship between the spindle and motor			O	O	A	App. B
				#4	0	Return direction for the reference position on servo mode			O	O	B	App. B
168L	3177	4177	4177	#0	1	Whether to use MRDY (machine ready) signal			O	O	B	App. B
				#3	0	Mounting direction of the magnetic sensor	O	O			B	App. B
				#4	0	Mounting direction of the spindle sensor			O	O	A	App. B
169H	3178	4178	4178	#0	0	Spindle sensor type			O	O	A	App. B
				#1	0	Spindle sensor type			O	O	A	App. B
				#2	0	Spindle sensor type			O	O	A	App. B
				#3	0	Spindle sensor type			O	O	A	App. B
				#5	0	Whether to use the rotation direction signal (SFR/SRV) function on servo mode			O	O	B	App. B
169L	3179	4179	4179	#0	0	Spindle orientation method			O	O	B	App. B
				#2	0	Rotation direction during spindle orientation			O	O	B	App. B
				#3	0	Rotation direction during spindle orientation			O	O	B	App. B
				#4	0	Teeth number setting of spindle sensor			O	O	A	App. B
				#5	0	Teeth number setting of spindle sensor			O	O	A	App. B
				#6	0	Teeth number setting of spindle sensor			O	O	A	App. B
				#7	0	Teeth number setting of spindle sensor			O	O	A	App. B
170H	3180	4180	4180	#2	0	Setting of external one-rotation signal			O	O	A	App. B
				#3	0	Setting of external one-rotation signal			O	O	A	App. B
171H	3182	4182	4182	#1	0	Increment system of gear ratio			O	O	A	App. B
				#2	Depends on the model	Increment system of spindle speed			O	O	C	App. B
				#5	0	Setting of analog override range			O	O	B	App. B
				#7	0	Whether to use the command arbitrary gear ratio (CMR) function on rigid tapping			O	O	B	App. B
171L	3183	4183	4183	#5	0	Whether to detect a feedback signal disconnection			O	O	A	App. B
				#6	0	Whether to detect the alarms (spindle alarms 41, 42, 47, 81, 82, 83, 85, 86, and 87) related to the position feedback signal (when Cs contouring control mode is not set)			O	O	A	App. B
172H	3184	4184	4184	#0	0	Reserved			O		C	
				#1	0	Reserved				O	C	
				#2	0	Reserved			O	O	C	
				#4	Depends on the model	Setting of output limitation method			O	O	C	App. B
172L	3185	4185	4185	#0	0	Increment system of velocity loop gain			O	O	B	App. B
				#2	0	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued			O	O	D	App. B
				#4	0	Whether to output the load detection signals (LDT1, LDT2) during acceleration/deceleration			O	O	B	App. B
				#6	0	Analog override type			O	O	B	App. B
173H	3186	4186	4186	#0	Depends on the model	Motor sensor type			O	O	A	App. B
				#1	Depends on the model	Motor sensor type			O	O	A	App. B
				#2	Depends on the model	Motor sensor type			O	O	A	App. B
173L	3187	4187	4187	#0	Depends on the model	Teeth number setting of motor sensor			O	O	A	App. B
				#1	Depends on the model	Teeth number setting of motor sensor			O	O	A	App. B

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application				Classif i-cation	Referenc e item
							MH	ML	SH	SL		
				#2	Depends on the model	Teeth number setting of motor sensor			O	O	A	App. B
				#3	Depends on the model	Number of motor poles			O	O	C	App. B
				#4	Depends on the model	Setting of maximum output during acceleration/deceleration			O	O	C	App. B
				#7	Depends on the model	Number of motor poles			O	O	C	App. B
174H	3188	4188	4188	#0	Depends on the model	Setting of PWM carrier frequency			O	O	C	App. B
				#1	Depends on the model	Setting of PWM carrier frequency			O	O	C	App. B
				#2	Depends on the model	Setting of PWM carrier frequency			O	O	C	App. B
174L	3189	4189	4189	#2	Depends on the model	Current dead-band data			O	O	C	App. B
				#3	Depends on the model	Current dead-band data			O	O	C	App. B
				#4	Depends on the model	Current dead-band data			O	O	C	App. B
				#5	Depends on the model	Current dead-band data			O	O	C	App. B
				#6	Depends on the model	Current dead-band data			O	O	C	App. B
				#7	Depends on the model	Setting of a PWM carrier frequency for low-speed characteristics area				O	C	App. B
176L	3191	4191	4191	#0	0	Whether to use the spindle orientation function					B	
				#1	0	Whether to use the spindle load detection function					B	
				#2	0	Whether to use the output switching function					B	
				#3	0	Whether to use the spindle tandem function					B	
176H	3192	4192	4192	#3	0	Setting of the smoothing function in feed-forward control			O	O	B	App. B
				#4	0	Setting related to control characteristics on servo mode			O	O	B	App. B
				#6	0	Whether to detect the alarm (spindle alarms 46) related to feedback of the position detection signal for threading			O	O	A	App. B
				#7	0	Function for newly detecting the one-rotation signal before entering position control mode			O	O	A	App. B
176L	3193	4193	4193	#7	0	Setting of shortcut orientation from stop state in position coder method spindle orientation			O	O	B	App. B
177H	3194	4194	4194	#3	0	Type of position coder method orientation			O	O	B	App. B
				#4	0	Optimum orientation: Setting of velocity feedforward (CTH1A=0)			O	O	B	App. B
				#5	0	Optimum orientation: Setting of velocity feedforward (CTH1A=1) High-speed orientation: Velocity command compensation function			O	O	B	App. B
				#6	0	Type of position coder method orientation			O	O	B	App. B
177L	3195	4195	4195	#2	1	Whether to use torque clamp at zero speed			O	O	B	App. B
				#4	0	Setting of the function for switching from high-speed characteristics to low-speed characteristics with the speed detection signal SDT = 1 at speed range switching			O	O	B	App. B
				#6	1	Presence or absence of the compensation of the spindle acceleration command			O	O	B	App. B
				#7	0	Automatic parameter setting function (16*i*/30*i*)			O	O	B	App. B
178	3196	4196	4196		Depends on the model	Maximum motor speed			O	O	C	App. B
179	3197	4197	4197		150	Speed arrival detection level (SAR)			O	O	B	App. B
180	3198	4198	4198		30	Speed detection level (SDT)			O	O	B	App. B
181	3199	4199	4199		75	Zero speed detection level (SST)			O	O	B	App. B
182	3200	4200	4200		50	Limited torque (TLMH, TLML)			O	O	B	App. B

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application				Classifi-cation	Reference item
							MH	ML	SH	SL		
183	3201	4201	4201		83	Load detection level 1 (LDT1)			O	O	B	App. B
184	3202	4202	4202		0	Limited output pattern			O	O	B	App. B
185	3203	4203	4203		100	Output limit			O	O	B	App. B
186	3204	4204	4204		0	Stop position of position coder method orientation			O	O	B	App. B
187	3205	4205	4205		0	Optimum orientation: Orientation speed upper limit Conventional method orientation, High-speed orientation: Spindle orientation speed			O	O	B	App. B
188	3206	4206	4206		10	Velocity loop proportional gain on velocity control mode (High)			O	O	B	App. B
189	3207	4207	4207		10	Velocity loop proportional gain on velocity control mode (Low)			O	O	B	App. B
190	3208	4208	4208		10	Velocity loop proportional gain on orientation (High)			O	O	B	App. B
191	3209	4209	4209		10	Velocity loop proportional gain on orientation (Low)			O	O	B	App. B
192	3210	4210	4210		10	Velocity loop proportional gain on servo mode (High)			O	O	B	App. B
193	3211	4211	4211		10	Velocity loop proportional gain on servo mode (Low)			O	O	B	App. B
194	3212	4212	4212		10	Velocity loop integral gain on velocity control mode (common to High and Low)			O	O	B	App. B
195	3213	4213	4213		10	Velocity loop integral gain on orientation (common to High and Low)			O	O	B	App. B
196	3214	4214	4214		10	Velocity loop integral gain on servo mode (common to High and Low)			O	O	B	App. B
197	3215	4215	4215		0	Primary delay time constant in dual position feedback [in Cs contour control]	O	O			B	I-1.5.10
198	3216	4216	4216		100	Gear ratio (High)			O	O	A	App. B
199	3217	4217	4217		100	Gear ratio (Low)			O	O	A	App. B
200	3218	4218	4218		1000	Position gain on orientation (High)			O	O	B	App. B
201	3219	4219	4219		1000	Position gain on orientation (Low)			O	O	B	App. B
202	3220	4220	4220		100	Ordinary orientation: Rate of change in position gain upon completion of orientation High-speed orientation: Rate of change in position gain upon completion of orientation Optimum orientation: Position feedforward coefficient			O	O	B	App. B
203	3221	4221	4221		1000	Position gain on servo mode (High)			O	O	B	App. B
204	3222	4222	4222		1000	Position gain on servo mode (Low)			O	O	B	App. B
205	3223	4223	4223		0	Grid shift on servo mode			O	O	B	App. B
206	3224	4224	4224		0	Maximum amplitude in dual position feedback [in Cs contour control]	O	O			B	I-1.5.10
207	3225	4225	4225		0	Dual position feedback zero width [in Cs contour control]	O	O			B	I-1.5.10
208	3226	4226	4226		10	Detection level for orientation completion signal (ORAR)			O	O	B	App. B
209	3227	4227	4227		33	Ordinary orientation: Motor speed limit value on orientation High-speed orientation: Reserved			O	O	B	App. B
210	3228	4228	4228		0	Orientation stop position shift			O	O	B	App. B
211	3229	4229	4229		200	MS signal constant			O	O	B	App. B
212	3230	4230	4230		0	MS signal gain adjustment			O	O	B	App. B
213	3231	4231	4231		Depends on the model	Regenerative power limit for high-speed zone/regenerative power limit			O		C	App. B
214	3232	4232	4232		20	Delay time until motor power is cut off			O	O	B	App. B
215	3233	4233	4233		10	Setting of acceleration/deceleration time			O	O	B	App. B
216	3234	4234	4234		0	Spindle load monitor observer gain 1			O	O	B	App. B
217	3235	4235	4235		0	Spindle load monitor observer gain 2			O	O	B	App. B
218	3236	4236	4236		Depends on the model	Motor voltage on velocity control mode			O		C	App. B
219	3237	4237	4237		Depends on the model	Motor voltage on orientation			O	O	C	App. B

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application				Classif i-cation	Reference item
							MH	ML	SH	SL		
220	3238	4238	4238		Depends on the model	Motor voltage on servo mode			O		C	App. B
221	3239	4239	4239		100	Rate of change in position gain during reference position return on servo mode			O	O	B	App. B
222	3240	4240	4240		0	Feed-forward coefficient			O	O	B	App. B
223	3241	4241	4241		0	Feed-forward coefficient of velocity loop			O		B	App. B
225	3243	4243	4243		0	Denominator of arbitrary gear ratio between motor sensor and spindle (High)			O	O	A	App. B
226	3244	4244	4244		0	Numerator of arbitrary gear ratio between motor sensor and spindle (High)			O	O	A	App. B
227	3245	4245	4245		0	Denominator of arbitrary gear ratio between motor sensor and spindle (Low)			O	O	A	App. B
228	3246	4246	4246		0	Numerator of arbitrary gear ratio between motor sensor and spindle (Low)			O	O	A	App. B
230	3248	4248	4248		0	Spindle load monitor torque constant	O				B	I-5.7.5
231	3249	4249	4249		0	Spindle load monitor observer gain 1	O	O			B	I-5.7.5
232	3250	4250	4250		0	Spindle load monitor observer gain 2	O	O			B	I-5.7.5
236	3254	4254	4254		Depends on the model	Slip compensation gain			O		C	App. B
237	3255	4255	4255		Depends on the model	Slip compensation gain				O	C	App. B
238	3256	4256	4256		Depends on the model	Base speed of motor output specifications			O		C	App. B
239	3257	4257	4257		Depends on the model	Output limit for motor output specifications			O		C	App. B
240	3258	4258	4258		Depends on the model	Excitation voltage saturation speed at no-load			O		C	App. B
241	3259	4259	4259		Depends on the model	Base speed limit ratio			O		C	App. B
242	3260	4260	4260		Depends on the model	Current loop proportional gain			O		C	App. B
243	3261	4261	4261		Depends on the model	Current loop integral gain			O		C	App. B
244	3262	4262	4262		Depends on the model	Velocity at which the current loop integral gain is zero			O		C	App. B
245	3263	4263	4263		Depends on the model	Filter time constant for processing saturation related to the voltage command			O		C	App. B
246	3264	4264	4264		Depends on the model	Current conversion constant			O		C	App. B
247	3265	4265	4265		Depends on the model	Secondary current coefficient			O		C	App. B
248	3266	4266	4266		Depends on the model	Criterion level for saturation related to the voltage command/PWM command clamp value			O		C	App. B
249	3267	4267	4267		Depends on the model	Slip constant			O		C	App. B
250	3268	4268	4268		Depends on the model	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration			O		C	App. B
251	3269	4269	4269		Depends on the model	PWM command clamp value at deceleration			O		C	App. B
252	3270	4270	4270		Depends on the model	Motor leakage constant			O		C	App. B
253	3271	4271	4271		Depends on the model	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient			O		C	App. B
254	3272	4272	4272		Depends on the model	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient			O		C	App. B
255	3273	4273	4273		5	Time constant for changing the torque (TCMD filter time constant)			O		B	App. B
256	3274	4274	4274		Depends on the model	Value displayed on load meter at maximum output			O		C	App. B
257	3275	4275	4275		Depends on the model	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient			O		C	App. B

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application				Classif i-catio n	Referenc e item
							MH	ML	SH	SL		
258	3276	4276	4276		Depends on the model	Secondary current coefficient for rigid tapping			O		C	App. B
259	3277	4277	4277		Depends on the model	Current loop proportional gain speed coefficient/current phase delay compensation coefficient			O		C	App. B
260	3278	4278	4278		0	Time constant for velocity detecting filter			O	O	B	App. B
261	3279	4279	4279		Depends on the model	Value displayed on load meter at maximum output				O	C	App. B
262	3280	4280	4280		Depends on the model	Deceleration-time excitation current change time constant/excitation current change time constant			O		C	App. B
263	3281	4281	4281		0	Spindle load monitor torque constant		O			B	App. B
264	3282	4282	4282		0	Spindle load monitor torque constant			O		B	App. B
265	3283	4283	4283		0	Spindle load monitor torque constant				O	B	App. B
266	3284	4284	4284		Depends on the model	Motor voltage on velocity control mode				O	C	App. B
267	3285	4285	4285		Depends on the model	Motor voltage on servo mode				O	C	App. B
268	3286	4286	4286		Depends on the model	Base speed of motor output specifications				O	C	App. B
269	3287	4287	4287		Depends on the model	Output limit for motor output specifications				O	C	App. B
270	3288	4288	4288		Depends on the model	Excitation voltage saturation speed at no-load				O	C	App. B
271	3289	4289	4289		Depends on the model	Base speed limit ratio				O	C	App. B
272	3290	4290	4290		Depends on the model	Current loop proportional gain				O	C	App. B
273	3291	4291	4291		Depends on the model	Current loop integral gain				O	C	App. B
274	3292	4292	4292		Depends on the model	Velocity at which the current loop integral gain is zero				O	C	App. B
275	3293	4293	4293		Depends on the model	Filter time constant for processing saturation related to the voltage command				O	C	App. B
276	3294	4294	4294		Depends on the model	Current conversion constant				O	C	App. B
277	3295	4295	4295		Depends on the model	Secondary current coefficient				O	C	App. B
278	3296	4296	4296		Depends on the model	Criterion level for saturation related to the voltage command/PWM command clamp value				O	C	App. B
279	3297	4297	4297		Depends on the model	Slip constant				O	C	App. B
280	3298	4298	4298		Depends on the model	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration				O	C	App. B
281	3299	4299	4299		Depends on the model	PWM command clamp value at deceleration				O	C	App. B
282	3300	4300	4300		Depends on the model	Motor leakage constant				O	C	App. B
283	3301	4301	4301		Depends on the model	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient				O	C	App. B
284	3302	4302	4302		Depends on the model	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient				O	C	App. B
285	3303	4303	4303		5	Time constant for changing the torque (TCMD filter time constant)				O	B	App. B
286	3304	4304	4304		Depends on the model	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient				O	C	App. B
287	3305	4305	4305		Depends on the model	Secondary current coefficient for rigid tapping				O	C	App. B
288	3306	4306	4306		Depends on the model	Current loop proportional gain speed coefficient/current phase delay compensation coefficient				O	C	App. B
289	3307	4307	4307		Depends on the model	Regenerative power limit for high-speed zone/regenerative power limit				O	C	App. B

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application				Classifi-cation	Reference item
							MH	ML	SH	SL		
290	3308	4308	4308		Depends on the model	Deceleration-time excitation current change time constant/excitation current change time constant				O	C	App. B
291	3309	4309	4309		Depends on the model	Motor model code			O	O	C	App. B
292 293	3310	4310	4310		Depends on the model	Motor overheat detect level (2-word)			O	O	C	App. B
304	3320	4320	4320		0	Optimum orientation: Spindle acceleration command (High)	O	O			B	I-2.2.12
						High-speed orientation: Motor acceleration at deceleration time (High)	O	O				I-5.14.7
305	3321	4321	4321		0	Optimum orientation: Spindle acceleration command (Low)	O	O			B	I-2.2.12
						High-speed orientation: Motor acceleration at deceleration time (Medium High)	O	O				I-5.14.7
306	3322	4322	4322		0	Optimum orientation: Spindle acceleration command (High)			O	O	B	App. B
						High-speed orientation: Motor acceleration at deceleration time (Medium Low)	O	O				I-5.14.7
307	3323	4323	4323		0	Optimum orientation: Spindle acceleration command (Low)			O	O	B	App. B
						High-speed orientation: Motor acceleration at deceleration time (Low)	O	O				I-5.14.7
308	3324	4324	4324		0	Optimum orientation: One-rotation signal detection speed	O	O			B	I-2.2.12
						High-speed orientation: Motor acceleration at deceleration time (High)			O	O		App. B
309	3325	4325	4325		0	Optimum orientation: One-rotation signal detection speed			O	O	B	App. B
						High-speed orientation: Motor acceleration at deceleration time (Low)			O	O		App. B
310	3326	4326	4326		0	Optimum orientation: Time constant for overshoot compensation/Limit ratio for acceleration command (High)	O	O			B	I-2.2.12
						High-speed orientation: Acceleration limitation start speed at deceleration time (High)	O	O				I-5.14.7
311	3327	4327	4327		0	Optimum orientation: Time constant for overshoot compensation/Limit ratio for acceleration command (Low)	O	O			B	I-2.2.12
						High-speed orientation: Acceleration limitation start speed at deceleration time (High)			O	O		App. B
312	3328	4328	4328		0	Command multiplication for spindle orientation by position coder	O	O			B	I-5.3.6
313	3329	4329	4329		0	Command multiplication for spindle orientation by position coder			O	O	B	App. B
314	3330	4330	4330		0	Optimum orientation: Time constant for overshoot compensation/Limit ratio for acceleration command (High)			O	O	B	App. B
						High-speed orientation: Acceleration limitation start speed at deceleration time (Low)	O	O				I-5.14.7
315	3331	4331	4331		0	Optimum orientation: Time constant for overshoot compensation/Limit ratio for acceleration command (Low)			O	O	B	App. B
						High-speed orientation: Acceleration limitation start speed at deceleration time (Low)			O	O		App. B
316	3332	4332	4332		0	Magnetic flux boost completion level/magnetic flux boost coefficient			O		B	App. B
317	3333	4333	4333		0	Magnetic flux boost completion level/magnetic flux boost coefficient				O	B	App. B
318	3334	4334	4334		0	Number of motor sensor arbitrary teeth	O	O			A	I-1.3.2
319	3335	4335	4335		0	Number of motor sensor arbitrary teeth			O	O	A	App. B
320	3336	4336	4336		0	Switching point used for an acceleration/deceleration time constant used for spindle synchronous control	O	O	O	O	B	I-2.5.8
324	3340	4340	4340		0	Bell-shaped acceleration/deceleration time constant during spindle synchronous control	O	O	O	O	B	I-2.5.8

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application				Classif i-catio n	Referenc e item
							MH	ML	SH	SL		
326	3342	4342	4342		0	Velocity loop gains override function on Cs contouring control mode (HIGH)	O	O			B	I-2.4.8
327	3343	4343	4343		0	Velocity loop gains override function on Cs contouring control mode (LOW)	O	O			B	I-2.4.8
325	3341	4341	4341		0	Unexpected disturbance torque detection level	O	O	O	O	B	I-5.7.5
328	3344	4344	4344		0	Advanced preview feed-forward coefficient	O	O	O	O	B	I-5.6.4
329	3344	4345	4345		0	Spindle motor speed specification detection level	O	O	O	O	B	I-2.6.4
330	3346	4346	4346		0	Incomplete integration factor	O	O	O	O	B	I-2.5.8 I-2.6.4
331	3347	4347	4347		0	Master-slave speed difference state signal output setting	O	O			B	I-5.10.6
332	3348	4348	4348		0	Current overload alarm detection level				O	D	App. B
333	3349	4349	4349		Depends on the model	Temperature monitoring time constant			O	O	C	App. B
334	3350	4350	4350		0	Current overload alarm detection level			O		D	App. B
335	3351	4351	4351		0	Current detection offset compensation	O	O	O	O	B	I-2.6.4
336H	3352	4352	4352	#1	0	Setting of the peak hold function for load meter output	O	O			B	I-2.1.6
				#4	0	Setting of whether to enable/disable feed forward at all times	O	O			B	I-5.8.8
				#6	0	Inter-spindle amplifier communication slave axis setting	O	O			B	I-5.8.8 I-5.11.4
				#7	0	Inter-spindle amplifier communication master axis setting	O	O			B	I-5.8.8 I-5.11.4
336L	3353	4353	4353	#1	0	Velocity feedback signal setting in torque tandem operation	O	O			B	I-5.11.6
				#2	0	Relationship of master/slave motor rotation directions in torque tandem operation	O	O			B	I-5.11.6
				#5	0	Setting of the Cs axis position data transfer function	O	O			B	I-2.4.8
				#6	0	Whether to use the magnetic flux boost function	O	O			B	I-5.17.4
337	3354	4354	4354		0	Excessive semi-closed loop/closed loop position error alarm detection level [in Cs contour control]	O	O			A	I-1.5.10
338	3355	4355	4355		0	Motor sensor signal amplitude ratio compensation	O	O			A	I-1.3.2 I-4.3
339	3356	4356	4356		0	Motor sensor signal phase difference compensation	O	O			A	I-1.3.2 I-4.3
340	3357	4357	4357		0	Spindle sensor signal amplitude ratio compensation	O	O			A	I-1.3.2 I-4.3
341	3358	4358	4358		0	Spindle sensor signal phase difference compensation	O	O			A	I-1.3.2 I-4.3
343	3360	4360	4360		0	Preload value	O	O			B	I-5.10.6
344	3361	4361	4361		0	Number of spindle sensor arbitrary teeth	O	O			A	I-1.3.2
345	3362	4362	4362		0	Load meter compensation 1	O				C	I-2.6.4
346	3363	4363	4363		0	Load meter compensation 2	O				C	I-2.6.4
347	3364	4364	4364		0	Load meter compensation 3	O				C	I-2.6.4
348	3365	4365	4365		0	Load meter compensation 1		O			C	App. B
349	3366	4366	4366		0	Load meter compensation 2		O			C	App. B
350	3367	4367	4367		0	Load meter compensation 3		O			C	App. B
352	3369	4369	4369		0	Spindle synchronous orientation deceleration coefficient	O	O			B	I-5.5.6
353	3370	4370	4370		0	Filter time constant for spindle acceleration detection	O	O			B	I-2.2.12
354	3371	4371	4371		-1	Reserved						
355	3372	4372	4372		0	Spindle speed limit for safety 1	O	O			D	
356H	3373	4373	4373	#1	0	Setting of the peak hold function for load meter output			O	O	B	App. B
356L			4374	#6	0	Whether to use the magnetic flux boost function			O	O	B	App. B
358	3376	4376	4376		0	Load meter compensation 1			O		C	App. B
359	3377	4377	4377		0	Load meter compensation 2			O		C	App. B
360	3378	4378	4378		0	Load meter compensation 3			O		C	App. B

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application				Classif i-catio n	Referenc e item
							MH	ML	SH	SL		
361	3379	4379	4379		0	Load meter compensation 1				O	C	App. B
362	3380	4380	4380		0	Load meter compensation 2				O	C	App. B
363	3381	4381	4381		0	Load meter compensation 3				O	C	App. B
365	3383	4383	4383		0	Filter time constant for spindle acceleration detection			O	O	B	App. B
366	3384	4384	4384		0	Spindle EGB : Maximum acceleration/deceleration value in automatic phase matching (16*i*)	O	O			B	I-5.8.8
367	3385	4385	4385		0	Spindle EGB : time constant for free-running phase matching (16*i*)	O	O			B	I-5.8.8
368	3386	4386	4386		0	Spindle EGB : master side detector pulse count	O	O			B	I-5.8.8
369	3387	4387	4387		0	Spindle EGB : synchronous ratio numerator	O	O			B	I-5.8.8
370	3388	4388	4388		0	Spindle EGB : synchronous ratio denominator	O	O			B	I-5.8.8
373	3391	4391	4391		0	Resonance elimination filter 1 : attenuation center frequency	O	O			B	I-4.2.2
374	3392	4392	4392		0	Resonance elimination filter 1 : attenuation bandwidth	O	O			B	I-4.2.2
375	3393	4393	4393		0	Resonance elimination filter 1 : damping	O	O			B	I-4.2.2
376H	3394	4394	4394	#2	0	Setting of the detection lower limit of the one-rotation signal	O	O			A	I-1.3.2
				#3	0	Setting of the fine acceleration/deceleration (FAD) function (16*i*)	O	O			B	I-5.6.4
				#4	0	Acceleration/deceleration type of fine acceleration/deceleration (FAD) (16*i*)	O	O			B	I-5.6.4
				#5	0	Whether to detect the alarm related to spindle sensor polarity erroneous setting	O	O			A	I-1.3.2
376L	3395	4395	4395	#3	0	Setting of parameter transfer from the CNC to spindle software	O	O	O	O	B	I-2.6.4
				#6	0	Triggering of the disturbance input function (vibration application function)	O	O			B	I-4.2.3
				#7	0	Setting of the disturbance input function (vibration application function)	O	O			B	I-4.2.3
378H	3398	4398	4398	#3	0	Whether to use the twin drive function	O	O			B	I-5.10.6
				#6	0	Whether to detect a speed polarity error (spindle alarm d0) in torque tandem operation	O	O			B	I-5.10.6
378L	3399	4399	4399	#1	0	Stop method used on detection of a safety speed excess alarm (30*i*)	O	O			D	
				#2	0	Setting of the emergency stop operation of the soft start/stop function	O	O			B	I-2.1.6
383	3406	4406	4406		0	Acceleration/deceleration time constant for Cs contouring control/servo mode	O	O			B	I-2.3.6 I-2.4.8
385	3408	4408	4408		0	Fine acceleration/deceleration time constant (16*i*)	O	O	O	O	B	I-5.6.4
386	3409	4409	4409		0	Feed forward timing adjustment coefficient	O	O			B	I-5.6.4
387	3410	4410	4410		0	Disturbance input function : measurement start frequency	O	O	O	O	B	I-4.2.3
388	3411	4411	4411		0	Disturbance input function : measurement end frequency	O	O	O	O	B	I-4.2.3
389	3412	4412	4412		0	Disturbance input function : measurement frequency interval	O	O	O	O	B	I-4.2.3
390	3413	4413	4413		0	Disturbance input function : number of measurements per frequency	O	O	O	O	B	I-4.2.3
391	3414	4414	4414		0	Disturbance input function : disturbance torque command amplitude	O	O	O	O	B	I-4.2.3
392	3415	4415	4415		0	Disturbance input function : motor speed command for measurement	O	O	O	O	B	I-4.2.3
393	3416	4416	4416		0	Resonance elimination filter 2 : attenuation center frequency	O	O			B	I-4.2.2
394	3417	4417	4417		0	Resonance elimination filter 2 : attenuation bandwidth	O	O			B	I-4.2.2
395	3418	4418	4418		0	Resonance elimination filter 2 : damping	O	O			B	I-4.2.2
396	3419	4419	4419		0	Resonance elimination filter 3 : attenuation center frequency	O	O			B	I-4.2.2
397	3420	4420	4420		0	Resonance elimination filter 3 : attenuation bandwidth	O	O			B	I-4.2.2
398	3421	4421	4421		0	Resonance elimination filter 3 : damping	O	O			B	I-4.2.2

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application				Classif i-catio n	Referenc e item
							MH	ML	SH	SL		
399	3422	4422	4422		0	Resonance elimination filter 4 : attenuation center frequency	O	O			B	I-4.2.2
400	3423	4423	4423		0	Resonance elimination filter 4 : attenuation bandwidth	O	O			B	I-4.2.2
401	3424	4424	4424		0	Resonance elimination filter 4 : damping	O	O			B	I-4.2.2
414	3437	4437	4437		-1	Reserved						
415	3438	4438	4438		0	Spindle speed limit for safety 2	O	O			D	
416	3439	4439	4439		-1	Reserved						
417	3440	4440	4440		0	Spindle speed limit for safety 3	O	O			D	
418	3441	4441	4441		-1	Reserved						
419	3442	4442	4442		0	Spindle speed limit for safety 4	O	O			D	
420	3443	4443	4443		0	Feed-forward coefficient of velocity loop		O			B	App. B
424	3447	4447	4447		-1	Reserved						
425	3448	4448	4448		0	Criterion level for spindle stop (30*i*)	O	O	O	O	D	
441	3464	4464	4464		0	Velocity command-dependent over speed 2 (spindle alarm 92) detection offset level 2	O	O	O	O	D	I-2.6.4
442	3465	4465	4465		0	Excessive speed deviation level2	O	O	O	O	D	I-2.6.4
443	3466	4466	4466		0	Excessive speed deviation detection time 2	O	O	O	O	D	I-2.6.4
424	3447	4447	4447		-1	Reserved						
425	3448	4448	4448		0	Criterion level for spindle stop	O	O			D	
441	3464	4464	4464		0	Velocity command-dependent over speed detection offset level	O	O	O	O	D	I-2.6.4
442	3465	4465	4465		0	Excessive speed deviation level 2	O	O	O	O	D	I-2.6.4
443	3466	4466	4466		0	Excessive speed deviation detection time 2	O	O	O	O	D	I-2.6.4
444H	3467	4467	4467	#2	0	Setting of the detection lower limit of the one-rotation signal			O	O	A	App. B
				#3	0	Setting of the fine acceleration/deceleration (FAD) function (16*i*)			O	O	B	App. B
				#4	0	Acceleration/deceleration type of fine acceleration/deceleration (FAD) (16*i*)			O	O	B	App. B
				#5	0	Whether to detect the alarm related to spindle sensor polarity erroneous setting			O	O	A	App. B
444L	3468	4468	4468	#6	0	Triggering of the disturbance input function (vibration application function)			O	O	B	App. B
				#7	0	Setting of the disturbance input function (vibration application function)			O	O	B	App. B
446L	3472	4472	4472	#1	0	Stop method used on detection of a safety speed excess alarm (30*i*)			O	O	D	
				#2	0	Setting of the emergency stop operation of the soft start/stop function			O	O	B	App. B
453	3481	4481	4481		0	Feed-forward timing adjustment coefficient			O	O	B	App. B
458	3486	4486	4486		0	Feed-forward coefficient of velocity loop				O	B	App. B
470	3498	4498	4498		0	Spindle EGB master side : denominator of arbitrary gear ratio between motor sensor and spindle	O	O			B	I-5.8.8
471	3499	4499	4499		0	Spindle EGB master side : numerator of arbitrary gear ratio between motor sensor and spindle	O	O			B	I-5.8.8
472	3500	4500	4500		0	Denominator of arbitrary gear ratio between spindle sensor and spindle (High)	O	O			A	I-1.3.2
473	3501	4501	4501		0	Numerator of arbitrary gear ratio between spindle sensor and spindle (High)	O	O			A	I-1.3.2
474	3502	4502	4502		0	Denominator of arbitrary gear ratio between spindle sensor and spindle (Low)	O	O			A	I-1.3.2
475	3503	4503	4503		0	Numerator of arbitrary gear ratio between spindle sensor and spindle (Low)	O	O			A	I-1.3.2
480	3508	4508	4508		0	Rate of change in acceleration at soft start/stop	O	O	O	O	B	I-2.1.6
487	3515	4515	4515		0	Excessive speed deviation alarm detection level on spindle synchronous control	O	O			D	I-2.5.8
488	3516	4516	4516		0	Excessive positional deviation alarm detection level on spindle synchronous control	O	O			D	I-2.5.8
492	3520	4520	4520		0	Primary delay time constant in dual position feedback [in servo mode]	O	O			B	I-5.10.5

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Application MH	ML	SH	SL	Classif i-catio n	Referenc e item
493	3521	4521	4521		0	Maximum amplitude in dual position feedback [in servo mode]	O	O			B	I-5.10.5
494	3522	4522	4522		0	Dual position feedback zero width [in servo mode]	O	O			B	I-5.10.5
495	3523	4523	4523		0	Excessive semi-closed loop/closed loop position error alarm detection level [in servo mode]	O	O			B	I-1.5.10
499	3527	4527	4527		0	Temperature difference between warning level and alarm level	O	O	O	O	D	I-2.6.4
512L	-	-	4541	#0		Presence or absence of power consumption calculation	O	O	O	O	E	
				#1		Setting of the output unit of accumulated power consumption	O	O	O	O	E	
				#2		Setting of the output unit of accumulated power consumption	O	O	O	O	E	
557	-	-	4590		0	Orientation speed restriction rate 1/orientation speed restriction rate 2 (HIGH)	O	O			B	I-2.2.12
558	-	-	4591		0	Orientation speed restriction rate 1/orientation speed restriction rate 2 (LOW)	O	O			B	I-2.2.12
560			4593			Spindle amplifier loss coefficient 1	O	O	O	O		
561			4594			Spindle amplifier loss coefficient 2	O	O	O	O		
562			4595			Common power supply loss coefficient 1	O	O	O	O		
563			4596			Common power supply loss coefficient 2	O	O	O	O		
574	-	-	4607		0	Motor voltage after completion of optimum orientation	O	O			B	I-2.2.12
682	-	-	4720		0	Orientation speed restriction rate 1/orientation speed restriction rate 2 (HIGH)			O	O	B	App. B

A.2 αC*i* SERIES SPINDLE PARAMETER TABLE

αC*i* series spindle parameters are classified into the following types:

A : Parameters related to the setup of detectors
B : Parameters related to the setup of various functions (operating modes)
C : Unique parameters for the drive of spindle motors (Set the parameter data according to the parameter list for each motor model.)
D : Parameters related to the setting of alarm detection conditions

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classif i-catio n	Referenc e item
0H	3000	4000	4000	#0	0	Rotation direction relationship between the spindle and motor	A	III-1.3.2
				#4	0	Return direction for the reference position on servo mode	B	III-2.3.7
0L	3001	4001	4001	#0	1	Whether to use MRDY (machine ready) signal	B	III-2.5.4
				#4	0	Spindle sensor (position coder) attachment direction	A	III-1.3.2
1H	3002	4002	4002	#0	0	Spindle sensor type	A	III-1.3.2
				#1	0	Spindle sensor type	A	III-1.3.2
				#2	0	Spindle sensor type	A	III-1.3.2
				#3	0	Spindle sensor type	A	III-1.3.2
				#4	0	SM pin output data selection	B	III-2.5.4
				#5	0	Whether to use the rotation direction signal (SFR/SRV) function on servo mode	B	III-2.3.7
				#6	0	Whether to use the rotation direction signal (SFR/SRV) function on spindle synchronous control	B	III-2.4.8
1L	3003	4003	4003	#2	0	Rotation direction during spindle orientation	B	III-2.2.9
				#3	0	Rotation direction during spindle orientation	B	III-2.2.9
				#4	0	Teeth number setting of spindle sensor	A	III-1.3.2
				#5	0	Teeth number setting of spindle sensor	A	III-1.3.2
				#6	0	Teeth number setting of spindle sensor	A	III-1.3.2
				#7	0	Teeth number setting of spindle sensor	A	III-1.3.2
2L	3005	4005	4005	#0	0	Setting of the velocity feedback method	A	III-1.3.2

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classif i-catio n	Referenc e item
3H	3006	4006	4006	#1	0	Increment system of gear ratio	A	III-1.3.2
				#2	0	Increment system of spindle speed	C	III-2.5.4
				#3	0	Automatic detection of one-rotation signal during spindle synchronous control	B	III-2.4.8
				#5	0	Setting of analog override range	B	III-2.1.6
3L	3007	4007	4007	#5	0	Whether to detect a feedback signal disconnection	A	III-1.3.2
				#6	0	Whether to detect the alarms (spindle alarms 41, 42, and 47) related to the position feedback signal (when non-Cs contouring control mode is set)	A	III-1.3.2
4L	3009	4009	4009	#2	0	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued	D	III-2.5.4
				#4	0	Whether to output the load detection signals (LDT1) during acceleration/deceleration	B	III-2.1.6
				#6	0	Analog override type	B	III-2.1.6
5L	3011	4011	4011	#3	1	Number of motor poles	C	III-2.5.3
				#4	Depends on the model	Setting of maximum output during acceleration/deceleration	C	III-2.5.3
				#7	0	Number of motor poles	C	III-2.5.3
6H	3012	4012	4012	#0	0	Setting of PWM carrier frequency	C	III-2.5.3
				#1	0	Setting of PWM carrier frequency	C	III-2.5.3
				#2	0	Setting of PWM carrier frequency	C	III-2.5.3
6L	3013	4013	4013	#2	Depends on the model	Current dead-band data	C	III-2.5.3
				#3	Depends on the model	Current dead-band data	C	III-2.5.3
				#4	Depends on the model	Current dead-band data	C	III-2.5.3
				#5	Depends on the model	Current dead-band data	C	III-2.5.3
				#6	Depends on the model	Current dead-band data	C	III-2.5.3
7L	3015	4015	4015	#0	0	Whether to use the spindle orientation function	B	III-2.2.8
8H	3016	4016	4016	#6	0	Whether to detect the alarm (spindle alarms 46) related to feedback of the position detection signal for threading	A	III-1.3.2
				#7	0	Function for newly detecting the one-rotation signal before entering position control mode	A	III-1.3.2
8L	3017	4017	4017	#7	0	Setting of shortcut orientation from stop state in position coder method spindle orientation	B	III-2.2.9
9L	3019	4019	4019	#2	1	Whether to use torque clamp at zero speed	B	III-2.5.4
				#7	0	Automatic parameter setting function (16*i*/30*i*)	B	III-2.1.6
10	3020	4020	4020		6000	Maximum motor speed	C	III-2.1.6
12	3022	4022	4022		150	Speed arrival detection level (SAR)	B	III-2.5.4
13	3023	4023	4023		30	Speed detection level (SDT)	B	III-2.5.4
14	3024	4024	4024		75	Zero speed detection level (SST)	B	III-2.5.4
15	3025	4025	4025		50	Limited torque (TLMH)	B	III-2.5.4
16	3026	4026	4026		83	Load detection level 1 (LDT1)	B	III-2.5.4
21	3031	4031	4031		0	Stop position of position coder method orientation	B	III-2.2.9
22	3032	4032	4032		0	Acceleration for spindle synchronous control	B	III-2.4.8
23	3033	4033	4033		10	Spindle synchronous speed arrival level	B	III-2.4.8
24	3034	4034	4034		0	Shift during synchronous control of spindle phase	B	III-2.4.8
25	3035	4035	4035		0	Compensation data for spindle phase synchronous control	B	III-2.4.8
28	3038	4038	4038		0	Spindle orientation speed	B	III-2.2.9
30	3040	4040	4040		Depends on the model	Velocity loop proportional gain on velocity control mode (High)	B	III-2.1.6
31	3041	4041	4041		Depends on the model	Velocity loop proportional gain on velocity control mode (Low)	B	III-2.1.6
32	3042	4042	4042		Depends on the model	Velocity loop proportional gain on orientation (High)	B	III-2.2.9
33	3043	4043	4043		Depends on the model	Velocity loop proportional gain on orientation (Low)	B	III-2.2.9
34	3044	4044	4044		Depends on the model	Velocity loop proportional gain on servo mode/spindle synchronous control (High)	B	III-2.3.7 III-2.4.8

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classif i-catio n	Referenc e item
35	3045	4045	4045		Depends on the model	Velocity loop proportional gain on servo mode/spindle synchronous control (Low)	B	III-2.3.7 III-2.4.8
38	3048	4048	4048		Depends on the model	Velocity loop integral gain on velocity control mode (High)	B	III-2.1.6
39	3049	4049	4049		Depends on the model	Velocity loop integral gain on velocity control mode (Low)	B	III-2.1.6
40	3050	4050	4050		Depends on the model	Velocity loop integral gain on orientation (High)	B	III-2.2.9
41	3051	4051	4051		Depends on the model	Velocity loop integral gain on orientation (Low)	B	III-2.2.9
42	3052	4052	4052		Depends on the model	Velocity loop integral gain on servo mode/spindle synchronous control (High)	B	III-2.3.7 III-2.4.8
43	3053	4053	4053		Depends on the model	Velocity loop integral gain on servo mode/spindle synchronous control (Low)	B	III-2.3.7 III-2.4.8
46	3056	4056	4056		100	Gear ratio (High)	A	III-1.3.2
47	3057	4057	4057		100	Gear ratio (Medium High)	A	III-1.3.2
48	3058	4058	4058		100	Gear ratio (Medium Low)	A	III-1.3.2
49	3059	4059	4059		100	Gear ratio (Low)	A	III-1.3.2
50	3060	4060	4060		1000	Position gain on orientation (High)	B	III-2.2.9
51	3061	4061	4061		1000	Position gain on orientation (Medium High)	B	III-2.2.9
52	3062	4062	4062		1000	Position gain on orientation (Medium Low)	B	III-2.2.9
53	3063	4063	4063		1000	Position gain on orientation (Low)	B	III-2.2.9
54	3064	4064	4064		100	Acceleration limitation ratio at deceleration time	B	III-2.2.9
55	3065	4065	4065		1000	Position gain on servo mode/spindle synchronous control (High)	B	III-2.3.7 III-2.4.8
56	3066	4066	4066		1000	Position gain on servo mode/spindle synchronous control (Medium High)	B	III-2.3.7 III-2.4.8
57	3067	4067	4067		1000	Position gain on servo mode/spindle synchronous control (Medium Low)	B	III-2.3.7 III-2.4.8
58	3068	4068	4068		1000	Position gain on servo mode/spindle synchronous control (Low)	B	III-2.3.7 III-2.4.8
59	3069	4069	4069		900	Acceleration/deceleration constant (High)	B	III-2.1.6
60	3070	4070	4070		900	Acceleration/deceleration constant (Medium High)	B	III-2.1.6
61	3071	4071	4071		900	Acceleration/deceleration constant (Medium Low)	B	III-2.1.6
62	3072	4072	4072		900	Acceleration/deceleration constant (Low)	B	III-2.1.6
63	3073	4073	4073		0	Grid shift on servo mode	B	III-2.3.7
64	3074	4074	4074		0	Reference position return speed on servo mode	B	III-2.3.7
65	3075	4075	4075		10	Detection level for orientation completion signal	B	III-2.2.9
67	3077	4077	4077		0	Orientation stop position shift	B	III-2.2.9
68	3078	4078	4078		0	Gear switch timer	B	III-2.5.4
70	3080	4080	4080		Depends on the model	Regenerative power limit for high-speed zone/regenerative power limit	B	III-2.5.3
71	3081	4081	4081		20	Delay time until motor power is cut off	B	III-2.1.6
72	3082	4082	4082		10	Setting of acceleration/deceleration time	B	III-2.1.6
73	3083	4083	4083		60	Motor voltage on velocity control mode	C	III-2.1.6
74	3084	4084	4084		60	Motor voltage on orientation	C	III-2.2.9
75	3085	4085	4085		60	Motor voltage on servo mode/spindle synchronous control mode	C	III-2.3.7 III-2.4.8
76	3086	4086	4086		0	Gear ratio parameter setting error alarm (spindle alarm 35) detection level	D	III-2.5.4
78	3088	4088	4088		75	Level for detecting excess velocity error when motor is restrained	D	III-2.5.4
79	3089	4089	4089		200	Level for detecting excess velocity error when motor rotates	D	III-2.5.4
80	3090	4090	4090		90	Overload detection level	D	III-2.5.4
81	3091	4091	4091		100	Rate of change in position gain during reference position return on servo mode	B	III-2.3.7
85	3095	4095	4095		0	Speedometer pin output voltage adjustment value	B	III-2.5.4
88	3098	4098	4098		0	Maximum speed for position coder signal detection	A	III-1.3.2
89	3099	4099	4099		0	Delay time for motor excitation	B	III-2.3.7
90	3100	4100	4100		Depends on the model	Base speed of motor output specifications	C	III-2.5.3

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classif i-catio n	Referenc e item
91	3101	4101	4101		Depends on the model	Output limit for motor output specifications	C	III-2.5.3
92	3102	4102	4102		Depends on the model	Excitation voltage saturation speed at no-load	C	III-2.5.3
93	3103	4103	4103		Depends on the model	Compensation data for resistance	C	III-2.5.3
94	3104	4104	4104		Depends on the model	Current loop proportional gain	C	III-2.5.3
95	3105	4105	4105		Depends on the model	Current loop integral gain	C	III-2.5.3
96	3106	4106	4106		Depends on the model	D-axis current loop gain	C	III-2.5.3
97	3107	4107	4107		Depends on the model	Q-axis current loop gain	C	III-2.5.3
98	3108	4108	4108		Depends on the model	Q-axis current deviation limitation coefficient	C	III-2.5.3
99	3109	4109	4109		Depends on the model	Filter time constant for processing saturation related to the voltage command	C	III-2.5.3
100	3110	4110	4110		Depends on the model	Current conversion constant	C	III-2.5.3
101	3111	4111	4111		Depends on the model	Secondary current coefficient	C	III-2.5.3
102	3112	4112	4112		Depends on the model	Criterion level for saturation related to the voltage command/PWM command clamp value	C	III-2.5.3
103	3113	4113	4113		Depends on the model	Slip constant	C	III-2.5.3
105	3115	4115	4115		Depends on the model	PWM command clamp value at deceleration	C	III-2.5.3
106	3116	4116	4116		Depends on the model	Motor leakage constant	C	III-2.5.3
107	3117	4117	4117		Depends on the model	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient	C	III-2.5.3
108	3118	4118	4118		Depends on the model	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient	C	III-2.5.3
109	3119	4119	4119		Depends on the model	Deceleration-time excitation current change time constant/excitation current change time constant	C	III-2.5.3
110	3120	4120	4120		Depends on the model	Dead-band compensation data	C	III-2.5.3
111	3121	4121	4121		5	Time constant for changing the torque (TCMD filter time constant)	B	III-2.5.4
113	3123	4123	4123		30	Short-time overload detection time	D	III-2.5.4
117	3127	4127	4127		Depends on the model	Value displayed on load meter at maximum output	C	III-2.5.3
118	3128	4128	4128		Depends on the model	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient	C	III-2.5.3
120	3130	4130	4130		Depends on the model	Current loop proportional gain speed coefficient/current phase delay compensation coefficient	C	III-2.5.3
121	3131	4131	4131		Depends on the model	Dead-band compensation hysteresis	B	III-2.5.3
123	3133	4133	4133		Depends on the model	Motor model code	C	III-2.5.3
124 125	3134	4134	4134		Depends on the model	Motor overheat detect level (2-word)	C	III-2.5.3
152	3160	4160	4160		0	Hysteresis of speed detection level	B	I-5.1.7
304	3320	4320	4320		0	Acceleration at orientation deceleration time (High)	B	III-2.2.9
305	3321	4321	4321		0	Acceleration at orientation deceleration time (Medium High)	B	III-2.2.9
306	3322	4322	4322		0	Acceleration at orientation deceleration time (Medium Low)	B	III-2.2.9
307	3323	4323	4323		0	Acceleration at orientation deceleration time (Low)	B	III-2.2.9
312	3328	4328	4328		0	Command multiplication for spindle orientation by position coder	B	I-5.3.6
320	3336	4336	4336		0	Switching point used for an acceleration/deceleration time constant used for spindle synchronous control	B	III-2.4.8
324	3340	4340	4340		0	Bell-shaped acceleration/deceleration time constant during spindle synchronous control	B	III-2.4.8

A.3 B*i*S SERIES SPINDLE PARAMETER TABLE

Spindle parameters are classified into the following types:

A : Parameters related to the setup of detectors

B : Parameters related to the setup of various functions (operating modes)

C : Unique parameters for the drive of spindle motors (Set the parameter data according to the parameter list for each motor model.)

D : Parameters related to the setting of alarm detection conditions

E : Parameters related to the setting of a power consumption monitor (see the FANUC Series 30*i*/31*i*/32*i*-A Power Consumption Monitor Specification (A-92345).)

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classification	Reference item
0H	3000	4000	4000	#0	0	Rotation direction relationship between the spindle and motor	A	IV-1.3.2
				#1	0	Spindle rotation direction when a positive (+) move command is specified on Cs contouring control	B	IV-2.4.8
				#3	0	Return direction for the reference position on Cs contouring control mode	B	IV-2.4.8
				#4	0	Return direction for the reference position on servo mode	B	IV-2.3.7
0L	3001	4001	4001	#0	1	Whether to use MRDY (machine ready) signal	B	IV-2.6.4
				#4	0	Mounting direction of the spindle sensor	A	IV-1.3.2
1H	3002	4002	4002	#0	0	Spindle sensor type	A	IV-1.3.2
				#1	0	Spindle sensor type	A	IV-1.3.2
				#2	0	Spindle sensor type	A	IV-1.3.2
				#3	0	Spindle sensor type	A	IV-1.3.2
				#4	0	Whether to use the rotation direction signal (SFR/SRV) function on Cs contouring control	B	IV-2.4.8
				#5	0	Whether to use the rotation direction signal (SFR/SRV) function on servo mode	B	IV-2.3.7
				#6	0	Whether to use the rotation direction signal (SFR/SRV) function on spindle synchronous control	B	IV-2.5.8
				#7	0	Whether to use the CMR (servo mode Cs contouring) function in servo mode	B	
1L	3003	4003	4003	#0	0	Spindle orientation method	B	IV-2.2.12
				#2	0	Rotation direction during spindle orientation	B	IV-2.2.12
				#3	0	Rotation direction during spindle orientation	B	IV-2.2.12
				#4	0	Teeth number setting of spindle sensor	A	IV-1.3.2
				#5	0	Teeth number setting of spindle sensor	A	IV-1.3.2
				#6	0	Teeth number setting of spindle sensor	A	IV-1.3.2
				#7	0	Teeth number setting of spindle sensor	A	IV-1.3.2
2L	3005	4005	4005	#0	0	Command resolution for Cs contouring control	B	IV-2.4.8
3H	3006	4006	4006	#1	0	Increment system of gear ratio	A	IV-1.3.2
				#3	0	Automatic detection of one-rotation signal during spindle synchronous control	B	IV-2.5.8
				#4	0	Sets the D-phase current command.	C	IV-2.6.3
				#5	0	Setting of analog override range	B	IV-2.1.6
				#7	0	Whether to use the command arbitrary gear ratio (CMR) function on rigid tapping	B	IV-2.3.7
3L	3007	4007	4007	#5	0	Whether to detect a feedback signal disconnection	A	IV-1.3.2
				#6	0	Whether to detect the alarms (spindle alarms 41, 42, 47, 81, 82, 83, 85, 86, and 87) related to the position feedback signal (when non-Cs contouring control mode is set)	A	IV-1.3.2
				#7	0	Magnetic pole detection start signal selection	B	IV-1.5.3
4H	3008	4008	4008	#0	0	Reserved	C	
				#1	0	Reserved	C	
				#2	0	Reserved	C	

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classification	Reference item
				#3	0	Sets the current command.	C	IV-2.6.3
				#4	Depends on the model	Setting of output limitation method	C	IV-2.6.3
				#5	0	Whether to use the SSM	B	IV-1.4.4
				#6	0	Reference magnetic pole position selection (Whether to use the AMR offset function)	B	IV-1.5.3 IV-1.5.5
4L	3009	4009	4009	#0	0	Increment system of velocity loop gain	B	IV-2.6.4
				#2	0	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued	D	IV-2.6.4
				#4	0	Whether to output the load detection signals (LDT1, LDT2) during acceleration/deceleration	B	IV-2.1.6
				#5	Depends on the model	Setting related to magnetic flux reduction speed	C	IV-2.6.3
				#6	0	Analog override type	B	IV-2.1.6
5H	3010	4010	4010	#0	Depends on the model	Motor sensor type	A	IV-1.3.2
				#1	Depends on the model	Motor sensor type	A	IV-1.3.2
				#2	Depends on the model	Motor sensor type	A	IV-1.3.2
5L	3011	4011	4011	#0	Depends on the model	Teeth number setting of motor sensor	A	IV-1.3.2
				#1	Depends on the model	Teeth number setting of motor sensor	A	IV-1.3.2
				#2	Depends on the model	Teeth number setting of motor sensor	A	IV-1.3.2
				#3	Depends on the model	Number of motor poles	C	IV-2.6.3
				#4	Depends on the model	Setting of maximum output during acceleration/deceleration	C	IV-2.6.3
				#7	Depends on the model	Number of motor poles	C	IV-2.6.3
6H	3012	4012	4012	#0	Depends on the model	Setting of PWM carrier frequency	C	IV-2.6.3
				#1	Depends on the model	Setting of PWM carrier frequency	C	IV-2.6.3
				#2	Depends on the model	Setting of PWM carrier frequency	C	IV-2.6.3
				#6	1	Setting of the synchronous built-in spindle motor	C	IV-2.6.3
				#7	1	Setting of spindle HRV function	C	IV-2.6.3
6L	3013	4013	4013	#2	Depends on the model	Current dead-band data	C	IV-2.6.3
				#3	Depends on the model	Current dead-band data	C	IV-2.6.3
				#4	Depends on the model	Current dead-band data	C	IV-2.6.3
				#5	Depends on the model	Current dead-band data	C	IV-2.6.3
				#6	Depends on the model	Current dead-band data	C	IV-2.6.3
7H	3014	4014	4014	#7	0	Setting of dual position feedback	B	IV-5.5.6
7L	3015	4015	4015	#0	0	Whether to use the spindle orientation function	B	IV-2.2.12
				#1	0	Whether to use the unexpected disturbance torque detection function	B	IV-5.7.5
8H	3016	4016	4016	#3	0	Setting of the smoothing function in feed-forward control	B	IV-2.4.8 IV-5.8.7
				#5	0	Whether to detect the alarms (spindle alarms 81, 82, 85, 86) related to position feedback (on Cs contouring control mode)	A	IV-1.3.2
				#6	0	Whether to detect the alarm (spindle alarms 46) related to feedback of the position detection signal for threading	A	IV-1.3.2
				#7	0	Function for newly detecting the one-rotation signal before entering position control mode	A	IV-1.3.2

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classification	Reference item
8L	3017	4017	4017	#7	0	Setting of shortcut orientation from stop state in position coder method spindle orientation	B	IV-2.2.12
9H	3018	4018	4018	#3	0	Type of position coder method orientation	B	IV-2.2.12
				#4	0	Optimum orientation: Setting of velocity feedforward (CTH1A=0)	B	IV-2.2.12
				#5	0	Optimum orientation: Setting of velocity feedforward (CTH1A=1) High-speed orientation: Velocity command compensation function	B	IV-2.2.12 IV-5.14.7
				#6	0	Type of position coder method orientation	B	IV-2.2.12
9L	3019	4019	4019	#2	1	Whether to use torque clamp at zero speed	B	IV-2.6.4
				#7	0	Automatic parameter setting function (16*i*/30*i*)	B	IV-1.1.2 IV-2.6.4
10	3020	4020	4020		Depends on the model	Maximum motor speed	C	IV-1.4.4 IV-2.6.3
11	3021	4021	4021		100	Maximum speed on Cs contouring control mode	B	IV-2.4.8
12	3022	4022	4022		150	Speed arrival detection level (SAR)	B	IV-2.6.4
13	3023	4023	4023		30	Speed detection level (SDT)	B	IV-2.6.4
14	3024	4024	4024		75	Zero speed detection level (SST)	B	IV-2.6.4
15	3025	4025	4025		50	Limited torque (TLMH, TLML)	B	IV-2.6.4
16	3026	4026	4026		83	Load detection level 1 (LDT1)	B	IV-2.6.4
17	3027	4027	4027		95	Load detection level 2 (LDT2)	B	IV-2.6.4
20	3030	4030	4030		0	Soft start/stop time (SOCN)	B	IV-2.1.6
21	3031	4031	4031		0	Stop position of position coder method orientation	B	IV-2.2.12
22	3032	4032	4032		0	Acceleration on spindle synchronous control	B	IV-2.5.8
23	3033	4033	4033		10	Spindle synchronous speed arrival level	B	IV-2.5.8
24	3034	4034	4034		0	Shift during synchronous control of spindle phase	B	IV-2.5.8
25	3035	4035	4035		0	Compensation data for spindle phase synchronous control	B	IV-2.5.8
26	3036	4036	4036		0	Feed-forward coefficient	B	IV-2.4.8 IV-5.8.8
27	3037	4037	4037		0	Feed-forward coefficient of velocity loop	B	IV-2.4.8 IV-5.6.4 IV-5.8.8
28	3038	4038	4038		0	Optimum orientation: Orientation speed upper limit Conventional method orientation, High-speed orientation: Spindle orientation speed	B	IV-2.2.12 IV-5.14.7
29	3039	4039	4039		0	Reserved	C	
30	3040	4040	4040		10	Velocity loop proportional gain on velocity control mode (High)	B	IV-2.1.6
31	3041	4041	4041		10	Velocity loop proportional gain on velocity control mode (Low)	B	IV-2.1.6
32	3042	4042	4042		10	Velocity loop proportional gain on orientation (High)	B	IV-2.2.12
33	3043	4043	4043		10	Velocity loop proportional gain on orientation (Low)	B	IV-2.2.12
34	3044	4044	4044		10	Velocity loop proportional gain on servo mode/spindle synchronous control (High)	B	IV-2.3.7 IV-2.5.8
35	3045	4045	4045		10	Velocity loop proportional gain on servo mode/spindle synchronous control (Low)	B	IV-2.3.7 IV-2.5.8
36	3046	4046	4046		30	Velocity loop proportional gain on Cs contouring control (High)	B	IV-2.4.8
37	3047	4047	4047		30	Velocity loop proportional gain on Cs contouring control (Low)	B	IV-2.4.8
38	3048	4048	4048		10	Velocity loop integral gain on velocity control mode (High)	B	IV-2.1.6
39	3049	4049	4049		10	Velocity loop integral gain on velocity control mode (Low)	B	IV-2.1.6
40	3050	4050	4050		10	Velocity loop integral gain on orientation (High)	B	IV-2.2.12
41	3051	4051	4051		10	Velocity loop integral gain on orientation (Low)	B	IV-2.2.12
42	3052	4052	4052		10	Velocity loop integral gain on servo mode/spindle synchronous control (High)	B	IV-2.3.7 IV-2.5.8
43	3053	4053	4053		10	Velocity loop integral gain on servo mode/spindle synchronous control (Low)	B	IV-2.3.7 IV-2.5.8

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classification	Reference item
44	3054	4054	4054		50	Velocity loop integral gain on Cs contouring control (High)	B	IV-2.4.8
45	3055	4055	4055		50	Velocity loop integral gain on Cs contouring control (Low)	B	IV-2.4.8
46	3056	4056	4056		100	Gear ratio (High)	A	IV-1.3.2
47	3057	4057	4057		100	Gear ratio (Medium High)	A	IV-1.3.2
48	3058	4058	4058		100	Gear ratio (Medium Low)	A	IV-1.3.2
49	3059	4059	4059		100	Gear ratio (Low)	A	IV-1.3.2
50	3060	4060	4060		1000	Position gain on orientation (High)	B	IV-2.2.12
51	3061	4061	4061		1000	Position gain on orientation (Medium High)	B	IV-2.2.12
52	3062	4062	4062		1000	Position gain on orientation (Medium Low)	B	IV-2.2.12
53	3063	4063	4063		1000	Position gain on orientation (Low)	B	IV-2.2.12
54	3064	4064	4064		100	Ordinary orientation: Rate of change in position gain upon completion of orientation High-speed orientation: Rate of change in position gain upon completion of orientation Optimum orientation: Position feedforward coefficient	B	IV-2.2.12 IV-5.14.7
55	3065	4065	4065		1000	Position gain on servo mode/spindle synchronous control (High)	B	IV-2.3.7 IV-2.5.8
56	3066	4066	4066		1000	Position gain on servo mode/spindle synchronous control (Medium High)	B	IV-2.3.7 IV-2.5.8
57	3067	4067	4067		1000	Position gain on servo mode/spindle synchronous control (Medium Low)	B	IV-2.3.7 IV-2.5.8
58	3068	4068	4068		1000	Position gain on servo mode/spindle synchronous control (Low)	B	IV-2.3.7 IV-2.5.8
59	3069	4069	4069		3000	Position gain on Cs contouring control (High)	B	IV-2.4.8
60	3070	4070	4070		3000	Position gain on Cs contouring control (Medium High)	B	IV-2.4.8
61	3071	4071	4071		3000	Position gain on Cs contouring control (Medium Low)	B	IV-2.4.8
62	3072	4072	4072		3000	Position gain on Cs contouring control (Low)	B	IV-2.4.8
63	3073	4073	4073		0	Grid shift on servo mode	B	IV-2.3.7
64	3074	4074	4074		0	Reference position return speed on Cs contouring control/servo mode	B	IV-2.3.7 IV-2.4.8
65	3075	4075	4075		10	Detection level for orientation completion signal (ORAR)	B	IV-2.2.12
66	3076	4076	4076		33	Ordinary orientation: Motor speed limit value on orientation High-speed orientation: Reserved Optimum orientation: Bell-shaped acceleration / deceleration time constant	B	IV-2.2.12
67	3077	4077	4077		0	Orientation stop position shift	B	IV-2.2.12
70	3080	4080	4080		Depends on the model	Regenerative power limit for high-speed zone/regenerative power limit	C	IV-2.6.3
71	3081	4081	4081		20	Delay time until motor power is cut off	B	IV-2.1.6
72	3082	4082	4082		10	Setting of acceleration/deceleration time	B	IV-2.1.6
73	3083	4083	4083		0	Current ratio/motor stop confirmation time in magnetic pole detection operation	C	IV-1.5.5 IV-2.6.3
74	3084	4084	4084		0	AMR offset	C	IV-1.5.3 IV-1.5.5 IV-2.6.3
75	3085	4085	4085		0	AMR offset fine adjustment	C	IV-1.5.3 IV-1.5.5 IV-2.6.3
76	3086	4086	4086		Depends on the model	Inductance ratio	C	IV-2.6.3
77	3087	4087	4087		115	Overspeed level	D	IV-2.6.4
78	3088	4088	4088		75	Level for detecting excess velocity error when motor is restrained	D	IV-2.6.4
79	3089	4089	4089		200	Level for detecting excess velocity error when motor rotates	D	IV-2.6.4
80	3090	4090	4090		90	Overload detection level	D	IV-2.6.4
81	3091	4091	4091		100	Rate of change in position gain during reference position return on servo mode	B	IV-2.3.7
82	3092	4092	4092		100	Rate of change in position gain during reference position return on Cs contouring control	B	IV-2.4.8

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classification	Reference item
84	3094	4094	4094		0	Disturbance torque compensation constant (acceleration feedback gain)	B	IV-2.4.8
85	3095	4095	4095		0	Adjusted output voltage of speedometer	B	IV-2.6.4
86	3096	4096	4096		0	Adjusted output voltage of load meter	B	IV-2.6.4
88	3098	4098	4098		0	Maximum speed for position feedback signal detection	A	IV-1.3.2
89	3099	4099	4099		0	Delay time for motor excitation	B	IV-2.3.7 IV-2.4.8
90	3100	4100	4100		Depends on the model	Base speed of motor output specifications	C	IV-2.6.3
91	3101	4101	4101		Depends on the model	Output limit for motor output specifications	C	IV-2.6.3
92	3102	4102	4102		Depends on the model	Base speed	C	IV-2.6.3
93	3103	4103	4103		Depends on the model	Magnetic flux reduction start speed / Current pattern switching speed	C	IV-2.6.3
94	3104	4104	4104		Depends on the model	Current loop proportional gain	C	IV-2.6.3
95	3105	4105	4105		0	Reserved	C	
96	3106	4106	4106		Depends on the model	Current loop integral gain	C	IV-2.6.3
97	3107	4107	4107		0	Reserved	C	
98	3108	4108	4108		Depends on the model	Velocity at which the current loop integral gain is zero	C	IV-2.6.3
99	3109	4109	4109		0	Reserved	C	IV-2.6.3
100	3110	4110	4110		Depends on the model	Current conversion constant	C	IV-2.6.3
101	3111	4111	4111		Depends on the model	Maximum current constant	C	IV-2.6.3
102	3112	4112	4112		Depends on the model	PWM command clamp value	C	IV-2.6.3
103	3113	4113	4113		Depends on the model	Current constant for magnetic flux reduction	C	IV-2.6.3
104	3114	4114	4114		0	Reserved	C	
105	3115	4115	4115		Depends on the model	PWM command clamp value at deceleration	C	IV-2.6.3
106	3116	4116	4116		Depends on the model	Counter electromotive voltage compensation constant for magnetic flux reduction speed at maximum load	C	IV-2.6.3
107	3117	4117	4117		Depends on the model	Interference voltage compensation constant for magnetic flux reduction speed at maximum load	C	IV-2.6.3
108	3118	4118	4118		0	Reserved	C	
109	3119	4119	4119		Depends on the model	Interference voltage compensation	C	IV-2.6.3
110	3120	4120	4120		Depends on the model	Dead-band rectangular wave component zero voltage/dead-band data	C	IV-2.6.3
111	3121	4121	4121		5	Time constant for changing the torque (TCMD filter time constant)	B	IV-4.2.1
112	3122	4122	4122		0	Time constant for velocity detecting filter	B	IV-2.6.4
113	3123	4123	4123		30	Short-time overload detection time	D	IV-2.6.4
114	3124	4124	4124		0	Reserved	C	
117	3127	4127	4127		Depends on the model	Value displayed on load meter at maximum output	C	IV-2.6.3
118	3128	4128	4128		0	Reserved	C	
119	3129	4129	4129		0	Reserved	C	
120	3130	4130	4130		Depends on the model	Current phase delay compensation coefficient	C	IV-2.6.3
121	3131	4131	4131		0	Time constant for velocity detecting filter (on Cs contouring control)	B	IV-2.4.8
123	3133	4133	4133		Depends on the model	Motor model code	C	IV-1.1.2 IV-2.6.3
124 125	3134	4134	4134		Depends on the model	Motor overheat detect level (2-word)	C	IV-2.6.3
126 127	3135	4135	4135		0	Grid shift during Cs contouring control mode I (2-word)	B	IV-2.4.8

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classification	Reference item
152	3160	4160	4160		0	Hysteresis of speed detection level	B	IV-5.1.7
154	3162	4162	4162		0	Integral gain of velocity loop during cutting feed on Cs contouring control mode (High)	B	IV-2.4.8
155	3163	4163	4163		0	Integral gain of velocity loop during cutting feed on Cs contouring control mode (Low)	B	IV-2.4.8
161	3169	4169	4169		Depends on the model	Temperature monitoring time constant	C	IV-2.6.4
162	3170	4170	4170		0	Current overload alarm detection level	D	IV-2.6.4
163	3171	4171	4171		0	Denominator of arbitrary gear ratio between motor sensor and spindle (High)	A	IV-1.3.2
164	3172	4172	4172		0	Numerator of arbitrary gear ratio between motor sensor and spindle (High)	A	IV-1.3.2
165	3173	4173	4173		0	Denominator of arbitrary gear ratio between motor sensor and spindle (Low)	A	IV-1.3.2
166	3174	4174	4174		0	Numerator of arbitrary gear ratio between motor sensor and spindle (Low)	A	IV-1.3.2
230	3248	4248	4248		0	Spindle load monitor torque constant	B	IV-5.7.5
231	3249	4249	4249		0	Spindle load monitor observer gain 1	B	IV-5.7.5
232	3250	4250	4250		0	Spindle load monitor observer gain 2	B	IV-5.7.5
304	3320	4320	4320		0	Optimum orientation: Spindle acceleration command (High) High-speed orientation: Motor acceleration at deceleration time (High)	B	IV-2.2.12 IV-5.14.7
305	3321	4321	4321		0	Optimum orientation: Spindle acceleration command (Low) High-speed orientation: Motor acceleration at deceleration time (Medium High)	B	IV-2.2.12 IV-5.14.7
306	3322	4322	4322		0	High-speed orientation: Motor acceleration at deceleration time (Medium Low)	B	IV-5.14.7
307	3323	4323	4323		0	High-speed orientation: Motor acceleration at deceleration time (Low)	B	IV-5.14.7
308	3324	4324	4324		0	Optimum orientation: One-rotation signal detection speed	B	IV-2.2.12
310	3326	4326	4326		0	Optimum orientation: Time constant for overshoot compensation/Limit ratio for acceleration command (High) High-speed orientation: Acceleration limitation start speed at deceleration time (High)	B	IV-2.2.12 IV-5.14.7
311	3327	4327	4327		0	Optimum orientation: Time constant for overshoot compensation/Limit ratio for acceleration command (Low)	B	IV-2.2.12
312	3328	4328	4328		0	Command multiplication for spindle orientation by position coder	B	IV-5.3.6
314	3330	4330	4330		0	High-speed orientation: Acceleration limitation start speed at deceleration time (Low)	B	IV-5.14.7
318	3334	4334	4334		0	Number of motor sensor arbitrary teeth	A	IV-1.3.2
320	3336	4336	4336		0	Switching point used for an acceleration/deceleration time constant used for spindle synchronous control	B	IV-2.5.8
324	3340	4340	4340		0	Bell-shaped acceleration/deceleration time constant during spindle synchronous control	B	IV-2.5.8
325	3341	4341	4341		0	Unexpected disturbance torque detection level	B	IV-5.7.5
326	3342	4342	4342		0	Velocity loop gains override function on Cs contouring control mode (HIGH)	B	IV-2.4.8
327	3343	4343	4343		0	Velocity loop gains override function on Cs contouring control mode (LOW)	B	IV-2.4.8
328	3344	4344	4344		0	Advanced preview feed-forward coefficient	B	IV-5.6.4
329	3344	4345	4345		0	Spindle motor speed specification detection level	B	IV-2.6.4
330	3346	4346	4346		0	Incomplete integration factor	B	IV-2.5.8 IV-2.6.4
335	3351	4351	4351		0	Current detection offset compensation	B	IV-2.6.4
336H	3352	4352	4352	#1	0	Setting of the peak hold function for load meter output	B	IV-2.1.6
				#4	0	Setting of whether to enable/disable feed forward at all times	B	IV-5.8.8
				#6	0	Inter-spindle amplifier communication slave axis setting	B	IV-5.8.8

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classification	Reference item
				#7	0	Inter-spindle amplifier communication master axis setting	B	IV-5.8.8
336L	3353	4353	4353	#5	0	Setting of the Cs axis position data transfer function	B	IV-2.4.8
338	3355	4355	4355		0	Motor sensor signal amplitude ratio compensation	A	IV-1.3.2 IV-4.3
339	3356	4356	4356		0	Motor sensor signal phase difference compensation	A	IV-1.3.2 IV-4.3
345	3362	4362	4362		0	Load meter compensation 1	C	IV-2.6.3
346	3363	4363	4363		0	Load meter compensation 2	C	IV-2.6.3
347	3364	4364	4364		0	Load meter compensation 3	C	IV-2.6.3
352	3369	4369	4369		0	Spindle synchronous orientation deceleration coefficient	B	IV-5.5.6
353	3370	4370	4370		0	Filter time constant for spindle acceleration detection	B	IV-2.2.12
354	3371	4371	4371		-1	Reserved		
355	4372	4372	4372		0	Spindle speed limit for safety 1	D	
366	3384	4384	4384		0	Spindle EGB: Maximum acceleration/deceleration value in automatic phase matching (16*i*)	B	IV-5.8.8
367	3385	4385	4385		0	Spindle EGB: time constant for free-running phase matching (16*i*)	B	IV-5.8.8
368	3386	4386	4386		0	Spindle EGB: master side detector pulse count	B	IV-5.8.8
369	3387	4387	4387		0	Spindle EGB: synchronous ratio numerator	B	IV-5.8.8
370	3388	4388	4388		0	Spindle EGB: synchronous ratio denominator	B	IV-5.8.8
373	3391	4391	4391		0	Resonance elimination filter 1: attenuation center frequency	B	IV-4.2.2
374	3392	4392	4392		0	Resonance elimination filter 1: attenuation bandwidth	B	IV-4.2.2
375	3393	4393	4393		0	Resonance elimination filter 1: damping	B	IV-4.2.2
376H	3394	4394	4394	#2	0	Setting of the detection lower limit of the one-rotation signal	A	IV-1.3.2
				#3	0	Setting of the fine acceleration/deceleration (FAD) function (16*i*)	B	IV-5.6.4
				#4	0	Acceleration/deceleration type of fine acceleration/deceleration (FAD) (16*i*)	B	IV-5.6.4
				#5	0	Whether to detect the alarm related to spindle sensor polarity erroneous setting	A	IV-1.3.2
376L	3395	4395	4395	#3	0	Setting of parameter transfer from the CNC to spindle software	B	IV-2.6.4
				#6	0	Triggering of the disturbance input function (vibration application function)	B	IV-4.2.3
				#7	0	Setting of the disturbance input function (vibration application function)	B	IV-4.2.3
378H	3398	4398	4398	#2	0	Selects a magnetic pole detection mode 1	C	IV-1.5.5
378L	3399	4399	4399	#2	0	Specifies whether to enable the soft start/stop function when emergency stop operation is performed	B	IV-2.1.6
				#5	0	Determines whether to detect pole position count miss alarm (Alarm 91)	D	IV-2.6.4
				#6	0	Selects a pole position detection mode	C	IV-1.5.5
383	3406	4406	4406		0	Acceleration/deceleration time constant for Cs contouring control/servo mode	B	IV-2.3.6 IV-2.4.8
385	3408	4408	4408		0	Fine acceleration/deceleration time constant (16*i*)	B	IV-5.6.4
386	3409	4409	4409		0	Feed forward timing adjustment coefficient	B	IV-5.6.4
387	3410	4410	4410		0	Disturbance input function: measurement start frequency	B	IV-4.2.3
388	3411	4411	4411		0	Disturbance input function: measurement end frequency	B	IV-4.2.3
389	3412	4412	4412		0	Disturbance input function: measurement frequency interval	B	IV-4.2.3
390	3413	4413	4413		0	Disturbance input function: number of measurements per frequency	B	IV-4.2.3
391	3414	4414	4414		0	Disturbance input function: disturbance torque command amplitude	B	IV-4.2.3
392	3415	4415	4415		0	Disturbance input function: motor speed command for measurement	B	IV-4.2.3
393	3416	4416	4416		0	Resonance elimination filter 2: attenuation center frequency	B	IV-4.2.2
394	3417	4417	4417		0	Resonance elimination filter 2: attenuation bandwidth	B	IV-4.2.2
395	3418	4418	4418		0	Resonance elimination filter 2: damping	B	IV-4.2.2

Internal data No. F-xxx	15*i*	16*i*	30*i*	bit	Standard initial setting data	Contents	Classification	Reference item
396	3419	4419	4419		0	Resonance elimination filter 3: attenuation center frequency	B	IV-4.2.2
397	3420	4420	4420		0	Resonance elimination filter 3: attenuation bandwidth	B	IV-4.2.2
398	3421	4421	4421		0	Resonance elimination filter 3: damping	B	IV-4.2.2
399	3422	4422	4422		0	Resonance elimination filter 4: attenuation center frequency	B	IV-4.2.2
400	3423	4423	4423		0	Resonance elimination filter 4: attenuation bandwidth	B	IV-4.2.2
401	3424	4424	4424		0	Resonance elimination filter 4: damping	B	IV-4.2.2
414	3437	4437	4437		-1	Reserved		
415	3438	4438	4438		0	Spindle speed limit for safety 2	D	
416	3439	4439	4439		-1	Reserved		
417	3440	4440	4440		0	Spindle speed limit for safety 3		
418	3441	4441	4441		-1	Reserved		
419	3442	4442	4442		0	Spindle speed limit for safety 4	D	
424	3447	4447	4447		-1	Reserved		
425	3448	4448	4448		0	Criterion level for spindle stop (30*i*)	D	
426	3449	4449	4449		0	Direction detection current/polarity determination current	C	IV-1.5.5
427	3450	4450	4450		0	Travel distance allowance magnification/velocity feedback threshold	C	IV-1.5.5
428	3451	4451	4451		0	Reserved		
440	3463	4463	4463		0	Unexpected rotation detection level (Alarm 90 detection level)	D	IV-2.6.4
441	3464	4464	4464		0	Velocity command-dependent over speed (spindle alarm 92) detection offset level	D	IV-2.6.4
442	3465	4465	4465		0	Excessive speed deviation level2	D	IV -2.6.4
443	3466	4466	4466		0	Excessive speed deviation detection time 2	D	IV -2.6.4
440	3463	4463	4463		0	Unexpected rotation detection level (Alarm 90 detection level)	D	IV-2.6.4
441	3464	4464	4464		0	Velocity command-dependent over speed detection offset level	D	IV-2.6.4
442	3465	4465	4465		0	Excessive speed deviation level 2	D	IV-2.6.4
443	3466	4466	4466		0	Excessive speed deviation detection time 2	D	IV-2.6.4
470	3498	4498	4498		0	Spindle EGB master side: denominator of arbitrary gear ratio between motor sensor and spindle	B	IV-5.8.8
471	3499	4499	4499		0	Spindle EGB master side: numerator of arbitrary gear ratio between motor sensor and spindle	B	IV-5.8.8
480	3508	4508	4508		0	Rate of change in acceleration at soft start/stop	B	IV-2.1.6
487	3515	4515	4515		0	Excessive speed deviation alarm detection level on spindle synchronous control	D	IV-2.5.8
488	3516	4516	4516		0	Excessive positional deviation alarm detection level on spindle synchronous control	D	IV-2.5.8
499	3527	4527	4527		0	Temperature difference between warning level and alarm level	D	IV-2.6.4
504	-	4532	4532		0	Arbitrary data output function number	B	IV-1.5.5
512L	-	-	4541	#0	0	Presence or absence of power consumption calculation	E	
				#1	0	Setting of the output unit of accumulated power consumption	E	
				#2	0	Setting of the output unit of accumulated power consumption	E	
560			4593		0	Spindle amplifier loss coefficient 1	E	
561			4594		0	Spindle amplifier loss coefficient 2	E	
562			4595		0	Common power supply loss coefficient 1	E	
563			4596		0	Common power supply loss coefficient 2	E	

A.4 β*i*Ic SERIES SPINDLE PARAMETER TABLE

β*i*Ic series spindle parameters are classified into the following types:

A : Parameters related to the setup of detectors

B : Parameters related to the setup of various functions (operating modes)

C : Unique parameters for the drive of spindle motors
(Set the parameter data according to the parameter list for each motor model.)

D : Parameters related to the setting of alarm detection conditions

Internal data No. F-xxx	0*i* Mate-TD	bit	Standard initial setting data	Contents	Classification	Reference item
0H	4000	#0	0	Rotation direction relationship between the spindle and motor	A	III-1.3.2
		#4	0	Return direction for the reference position on servo mode	B	III-2.3.7
0L	4001	#0	1	Whether to use MRDY (machine ready) signal	B	III-2.5.4
		#4	0	Spindle sensor (position coder) attachment direction	A	III-1.3.2
1H	4002	#0	0	Spindle sensor type	A	III-1.3.2
		#1	0	Spindle sensor type	A	III-1.3.2
		#2	0	Spindle sensor type	A	III-1.3.2
		#3	0	Spindle sensor type	A	III-1.3.2
		#4	0	SM pin output data selection	B	III-2.5.4
		#5	0	Whether to use the rotation direction signal (SFR/SRV) function on servo mode	B	III-2.3.7
1L	4003	#2	0	Rotation direction during spindle orientation	B	III-2.2.9
		#3	0	Rotation direction during spindle orientation	B	III-2.2.9
		#4	0	Teeth number setting of spindle sensor	A	III-1.3.2
		#5	0	Teeth number setting of spindle sensor	A	III-1.3.2
		#6	0	Teeth number setting of spindle sensor	A	III-1.3.2
		#7	0	Teeth number setting of spindle sensor	A	III-1.3.2
2L	4005	#0	0	Setting of the velocity feedback method	A	III-1.3.2
3H	4006	#1	0	Increment system of gear ratio	A	III-1.3.2
		#2	0	Increment system of spindle speed	C	III-2.5.4
		#5	0	Setting of analog override range	B	III-2.1.6
3L	4007	#5	0	Whether to detect a feedback signal disconnection	A	III-1.3.2
		#6	0	Whether to detect the alarms (spindle alarms 41, 42, and 47) related to the position feedback signal (when non-Cs contouring control mode is set)	A	III-1.3.2
	4008	#3	0	Presence or absence of measures against a belt slip	C	V-2.5.3
4L	4009	#2	0	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued	D	III-2.5.4
		#4	0	Whether to output the load detection signals (LDT1) during acceleration/deceleration	B	III-2.1.6
		#6	0	Analog override type	B	III-2.1.6
5L	4011	#3	1	Number of motor poles	C	III-2.5.3
		#4	Depends on the model	Setting of maximum output during acceleration/deceleration	C	III-2.5.3
		#7	0	Number of motor poles	C	III-2.5.3
6H	4012	#0	0	Setting of PWM carrier frequency	C	III-2.5.3
		#1	0	Setting of PWM carrier frequency	C	III-2.5.3
		#2	0	Setting of PWM carrier frequency	C	III-2.5.3
6L	4013	#2	Depends on the model	Current dead-band data	C	III-2.5.3
		#3	Depends on the model	Current dead-band data	C	III-2.5.3
		#4	Depends on the model	Current dead-band data	C	III-2.5.3
		#5	Depends on the model	Current dead-band data	C	III-2.5.3
		#6	Depends on the model	Current dead-band data	C	III-2.5.3
7L	4015	#0	0	Whether to use the spindle orientation function	B	III-2.2.8
8H	4016	#6	0	Whether to detect the alarm (spindle alarms 46) related to feedback of the position detection signal for threading	A	III-1.3.2
		#7	0	Function for newly detecting the one-rotation signal before entering position control mode	A	III-1.3.2
8L	4017	#7	0	Setting of shortcut orientation from stop state in position coder method spindle orientation	B	III-2.2.9
9L	4019	#2	1	Whether to use torque clamp at zero speed	B	III-2.5.4

Internal data No. F-xxx	0*i* Mate-TD	bit	Standard initial setting data	Contents	Classification	Reference item
		#7	0	Automatic parameter setting function (16*i*/30*i*)	B	III-2.1.6
10	4020		6000	Maximum motor speed	C	III-2.1.6
12	4022		150	Speed arrival detection level (SAR)	B	III-2.5.4
13	4023		30	Speed detection level (SDT)	B	III-2.5.4
14	4024		75	Zero speed detection level (SST)	B	III-2.5.4
15	4025		50	Limited torque (TLMH)	B	III-2.5.4
16	4026		83	Load detection level 1 (LDT1)	B	III-2.5.4
21	4031		0	Stop position of position coder method orientation	B	III-2.2.9
28	4038		0	Spindle orientation speed	B	III-2.2.9
30	4040		Depends on the model	Velocity loop proportional gain on velocity control mode (High)	B	III-2.1.6
31	4041		Depends on the model	Velocity loop proportional gain on velocity control mode (Low)	B	III-2.1.6
32	4042		Depends on the model	Velocity loop proportional gain on orientation (High)	B	III-2.2.9
33	4043		Depends on the model	Velocity loop proportional gain on orientation (Low)	B	III-2.2.9
34	4044		Depends on the model	Velocity loop proportional gain on servo mode (High)	B	III-2.3.7 III-2.4.8
35	4045		Depends on the model	Velocity loop proportional gain on servo mode (Low)	B	III-2.3.7 III-2.4.8
38	4048		Depends on the model	Velocity loop integral gain on velocity control mode (High)	B	III-2.1.6
39	4049		Depends on the model	Velocity loop integral gain on velocity control mode (Low)	B	III-2.1.6
40	4050		Depends on the model	Velocity loop integral gain on orientation (High)	B	III-2.2.9
41	4051		Depends on the model	Velocity loop integral gain on orientation (Low)	B	III-2.2.9
42	4052		Depends on the model	Velocity loop integral gain on servo mode (High)	B	III-2.3.7 III-2.4.8
43	4053		Depends on the model	Velocity loop integral gain on servo mode (Low)	B	III-2.3.7 III-2.4.8
46	4056		100	Gear ratio (High)	A	III-1.3.2
47	4057		100	Gear ratio (Medium High)	A	III-1.3.2
48	4058		100	Gear ratio (Medium Low)	A	III-1.3.2
49	4059		100	Gear ratio (Low)	A	III-1.3.2
50	4060		1000	Position gain on orientation (High)	B	III-2.2.9
51	4061		1000	Position gain on orientation (Medium High)	B	III-2.2.9
52	4062		1000	Position gain on orientation (Medium Low)	B	III-2.2.9
53	4063		1000	Position gain on orientation (Low)	B	III-2.2.9
54	4064		100	Acceleration limitation ratio at deceleration time	B	III-2.2.9
55	4065		1000	Position gain on servo mode (High)	B	III-2.3.7 III-2.4.8
56	4066		1000	Position gain on servo mode (Medium High)	B	III-2.3.7 III-2.4.8
57	4067		1000	Position gain on servo mode (Medium Low)	B	III-2.3.7 III-2.4.8
58	4068		1000	Position gain on servo mode (Low)	B	III-2.3.7 III-2.4.8
59	4069		900	Acceleration/deceleration constant (High)	B	III-2.1.6
60	4070		900	Acceleration/deceleration constant (Medium High)	B	III-2.1.6
61	4071		900	Acceleration/deceleration constant (Medium Low)	B	III-2.1.6
62	4072		900	Acceleration/deceleration constant (Low)	B	III-2.1.6
63	4073		0	Grid shift on servo mode	B	III-2.3.7
64	4074		0	Reference position return speed on servo mode	B	III-2.3.7
65	4075		10	Detection level for orientation completion signal	B	III-2.2.9
67	4077		0	Orientation stop position shift	B	III-2.2.9
68	4078		0	Gear switch timer	B	III-2.5.4

Internal data No. F-xxx	0*i* Mate-TD	bit	Standard initial setting data	Contents	Classification	Reference item
70	4080		Depends on the model	Regenerative power limit for high-speed zone/regenerative power limit	B	III-2.5.3
71	4081		20	Delay time until motor power is cut off	B	III-2.1.6
72	4082		10	Setting of acceleration/deceleration time	B	III-2.1.6
73	4083		60	Motor voltage on velocity control mode	C	III-2.1.6
74	4084		60	Motor voltage on orientation	C	III-2.2.9
75	4085		60	Motor voltage on servo mode	C	III-2.3.7 III-2.4.8
76	4086		0	Gear ratio parameter setting error alarm (spindle alarm 35) detection level	D	III-2.5.4
78	4088		75	Level for detecting excess velocity error when motor is restrained	D	III-2.5.4
79	4089		200	Level for detecting excess velocity error when motor rotates	D	III-2.5.4
80	4090		90	Overload detection level	D	III-2.5.4
81	4091		100	Rate of change in position gain during reference position return on servo mode	B	III-2.3.7
85	4095		0	Speedometer pin output voltage adjustment value	B	III-2.5.4
88	4098		0	Maximum speed for position coder signal detection	A	III-1.3.2
89	4099		0	Delay time for motor excitation	B	III-2.3.7
90	4100		Depends on the model	Base speed of motor output specifications	C	III-2.5.3
91	4101		Depends on the model	Output limit for motor output specifications	C	III-2.5.3
92	4102		Depends on the model	Excitation voltage saturation speed at no-load	C	III-2.5.3
93	4103		Depends on the model	Compensation data for resistance	C	III-2.5.3
94	4104		Depends on the model	Current loop proportional gain	C	III-2.5.3
95	4105		Depends on the model	Current loop integral gain	C	III-2.5.3
96	4106		Depends on the model	D-axis current loop gain	C	III-2.5.3
97	4107		Depends on the model	Q-axis current loop gain	C	III-2.5.3
98	4108		Depends on the model	Q-axis current deviation limitation coefficient	C	III-2.5.3
99	4109		Depends on the model	Filter time constant for processing saturation related to the voltage command	C	III-2.5.3
100	4110		Depends on the model	Current conversion constant	C	III-2.5.3
101	4111		Depends on the model	Secondary current coefficient	C	III-2.5.3
102	4112		Depends on the model	Criterion level for saturation related to the voltage command/PWM command clamp value	C	III-2.5.3
103	4113		Depends on the model	Slip constant	C	III-2.5.3
105	4115		Depends on the model	PWM command clamp value at deceleration	C	III-2.5.3
106	4116		Depends on the model	Motor leakage constant	C	III-2.5.3
107	4117		Depends on the model	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient	C	III-2.5.3
108	4118		Depends on the model	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient	C	III-2.5.3
109	4119		Depends on the model	Deceleration-time excitation current change time constant/excitation current change time constant	C	III-2.5.3
110	4120		Depends on the model	Dead-band compensation data	C	III-2.5.3
111	4121		5	Time constant for changing the torque (TCMD filter time constant)	B	III-2.5.4
113	4123		30	Short-time overload detection time	D	III-2.5.4
117	4127		Depends on the model	Value displayed on load meter at maximum output	C	III-2.5.3

Internal data No. F-xxx	0*i* Mate-TD	bit	Standard initial setting data	Contents	Classification	Reference item
118	4128		Depends on the model	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient	C	III-2.5.3
120	4130		Depends on the model	Current loop proportional gain speed coefficient/current phase delay compensation coefficient	C	III-2.5.3
121	4131		Depends on the model	Dead-band compensation hysteresis	B	III-2.5.3
123	4133		Depends on the model	Motor model code	C	III-2.5.3
124 125	4134		Depends on the model	Motor overheat detect level (2-word)	C	III-2.5.3
130	4138		Depends on the model	Primary frequency clamp speed 1	C	V-2.5.3
131	4139		Depends on the model	Primary frequency clamp slip frequency 1	C	V-2.5.3
132	4140		Depends on the model	Primary frequency clamp speed 2	C	V-2.5.3
133	4141		Depends on the model	Primary frequency clamp slip frequency 2	C	V-2.5.3
134	4142		Depends on the model	Belt slip state detection coefficient 1	C	V-2.5.3
135	4143		Depends on the model	Belt slip state detection coefficient 2	C	V-2.5.3
152	4160		0	Hysteresis of speed detection level	B	I-5.1.7
304	4320		0	Acceleration at orientation deceleration time (High)	B	III-2.2.9
305	4321		0	Acceleration at orientation deceleration time (Medium High)	B	III-2.2.9
306	4322		0	Acceleration at orientation deceleration time (Medium Low)	B	III-2.2.9
307	4323		0	Acceleration at orientation deceleration time (Low)	B	III-2.2.9
312	4328		0	Command multiplication for spindle orientation by position coder	B	I-5.3.6
345	4362		Depends on the model	Load meter compensation 1	C	V-2.5.3
346	4363		Depends on the model	Load meter compensation 2	C	V-2.5.3
347	4364		Depends on the model	Load meter compensation 3	C	V-2.5.3

B LIST OF SPINDLE PARAMETER NUMBERS

The following shows corresponding of the parameter numbers of parameters for speed range switch high-speed/low-speed characteristics on the main side/sub-side of spindle switching.

MH, ML, SH, and SL in the table represent the following:

- MH: Parameter for speed range switch high-speed characteristics on the main side of spindle switching (for standard motors)
- ML: Parameter for speed range switch low-speed characteristics on the main side of spindle switching
- SH: Parameter for speed range switch high-speed characteristics on the sub-side of spindle switching
- SL: Parameter for speed range switch low-speed characteristics on the sub-side of spindle switching

15*i*				16*i*				30*i*				Contents
MH	ML	SH	SL	MH	ML	SH	SL	MH	ML	SH	SL	
3000	←	3176	←	4000	←	4176	←	4000	←	4176	←	Bit parameter
3001	←	3177	←	4001	←	4177	←	4001	←	4177	←	Bit parameter
3002	←	3178	←	4002	←	4178	←	4002	←	4178	←	Bit parameter
3003	←	3179	←	4003	←	4179	←	4003	←	4179	←	Bit parameter
3004	←	3180	←	4004	←	4180	←	4004	←	4180	←	Bit parameter
3005	←	3181	←	4005	←	4181	←	4005	←	4181	←	Bit parameter
3006	←	3182	←	4006	←	4182	←	4006	←	4182	←	Bit parameter
3007	←	3183	←	4007	←	4183	←	4007	←	4183	←	Bit parameter
3008	←	3184	←	4008	←	4184	←	4008	←	4184	←	Bit parameter
3009	←	3185	←	4009	←	4185	←	4009	←	4185	←	Bit parameter
3010	←	3186	←	4010	←	4186	←	4010	←	4186	←	Bit parameter
3011	←	3187	←	4011	←	4187	←	4011	←	4187	←	Bit parameter
3012	←	3188	←	4012	←	4188	←	4012	←	4188	←	Bit parameter
3013	←	3189	←	4013	←	4189	←	4013	←	4189	←	Bit parameter
3014	←	←	←	4014	←	←	←	4014	←	←	←	Bit parameter
3015	←	←	←	4015	←	←	←	4015	←	←	←	Bit parameter
3016	←	3192	←	4016	←	4192	←	4016	←	4192	←	Bit parameter
3017	←	3193	←	4017	←	4193	←	4017	←	4193	←	Bit parameter
3018	←	3194	←	4018	←	4194	←	4018	←	4194	←	Bit parameter
3019	←	3195	←	4019	←	4195	←	4019	←	4195	←	Bit parameter
3020	←	3196	←	4020	←	4196	←	4020	←	4196	←	Maximum motor speed
3021	←	None	None	4021	←	None	None	4021	←	None	None	Maximum speed on Cs contouring control mode
3022	←	3197	←	4022	←	4197	←	4022	←	4197	←	Speed arrival detection level
3023	←	3198	←	4023	←	4198	←	4023	←	4198	←	Speed detection level
3024	←	3199	←	4024	←	4199	←	4024	←	4199	←	Zero speed detection level
3025	←	3200	←	4025	←	4200	←	4025	←	4200	←	Limited torque
3026	←	3201	←	4026	←	4201	←	4026	←	4201	←	Load detection level 1
3027	←	←	←	4027	←	←	←	4027	←	←	←	Load detection level 2
3028	←	3202	←	4028	←	4202	←	4028	←	4202	←	Limited output pattern
3029	←	3203	←	4029	←	4203	←	4029	←	4203	←	Output limit
3030	←	←	←	4030	←	←	←	4030	←	←	←	Soft start/stop time
3031	←	3204	←	4031	←	4204	←	4031	←	4204	←	Stop position of position coder method orientation
3032	←	None	None	4032	←	None	None	4032	←	None	None	Acceleration on spindle synchronous control
3033	←	None	None	4033	←	None	None	4033	←	None	None	Spindle synchronous speed arrival level
3034	←	None	None	4034	←	None	None	4034	←	None	None	Shift during synchronous control of spindle phase
3035	←	None	None	4035	←	None	None	4035	←	None	None	Compensation data for spindle phase synchronous control
3036	←	3240	←	4036	←	4240	←	4036	←	4240	←	Feed-forward coefficient
3037	3443	3241	3486	4037	4443	4241	4486	4037	4443	4241	4486	Feed-forward coefficient of velocity loop

15*i*				16*i*				30*i*				Contents
MH	ML	SH	SL	MH	ML	SH	SL	MH	ML	SH	SL	
3038	←	3205	←	4038	←	4205	←	4038	←	4205	←	Optimum orientation: Upper limit of orientation speed Conventional method/high-speed orientation: Spindle orientation speed
3039	3156	3254	3255	4039	4156	4254	4255	4039	4156	4254	4255	Slip compensation gain
3040	←	3206	←	4040	←	4206	←	4040	←	4206	←	Velocity loop proportional gain on velocity control mode (High)
3041	←	3207	←	4041	←	4207	←	4041	←	4207	←	Velocity loop proportional gain on velocity control mode (Low)
3042	←	3208	←	4042	←	4208	←	4042	←	4208	←	Velocity loop proportional gain on orientation (High)
3043	←	3209	←	4043	←	4209	←	4043	←	4209	←	Velocity loop proportional gain on orientation (Low)
3044	←	3210	←	4044	←	4210	←	4044	←	4210	←	Velocity loop proportional gain on servo mode (High)
3045	←	3211	←	4045	←	4211	←	4045	←	4211	←	Velocity loop proportional gain on servo mode (Low)
3046	←	None	None	4046	←	None	None	4046	←	None	None	Velocity loop proportional gain on Cs contouring control (High)
3047	←	None	None	4047	←	None	None	4047	←	None	None	Velocity loop proportional gain on Cs contouring control (Low)
3048	←	3212	←	4048	←	4212	←	4048	←	4212	←	Velocity loop integral gain on velocity control mode (High)
3049	←	↑	↑	4049	←	↑	↑	4049	←	↑	↑	Velocity loop integral gain on velocity control mode (Low)
3050	←	3213	←	4050	←	4213	←	4050	←	4213	←	Velocity loop integral gain on orientation (High)
3051	←	↑	↑	4051	←	↑	↑	4051	←	↑	↑	Velocity loop integral gain on orientation (Low)
3052	←	3214	←	4052	←	4214	←	4052	←	4214	←	Velocity loop integral gain on servo mode/spindle synchronous control (High)
3053	←	↑	↑	4053	←	↑	↑	4053	←	↑	↑	Velocity loop integral gain on servo mode/spindle synchronous control (Low)
3054	←	None	None	4054	←	None	None	4054	←	None	None	Velocity loop integral gain on Cs contouring control (High)
3055	←	None	None	4055	←	None	None	4055	←	None	None	Velocity loop integral gain on Cs contouring control (Low)
3056	←	3216	←	4056	←	4216	←	4056	←	4216	←	Gear ratio (High)
3057	←	↑	↑	4057	←	↑	↑	4057	←	↑	↑	Gear ratio (Medium High)
3058	←	↓	↓	4058	←	↓	↓	4058	←	↓	↓	Gear ratio (Medium Low)
3059	←	3217	←	4059	←	4217	←	4059	←	4217	←	Gear ratio (Low)
3060	←	3218	←	4060	←	4218	←	4060	←	4218	←	Position gain on orientation (High)
3061	←	↑	↑	4061	←	↑	↑	4061	←	↑	↑	Position gain on orientation (Medium High)
3062	←	↓	↓	4062	←	↓	↓	4062	←	↓	↓	Position gain on orientation (Medium Low)
3063	←	3219	←	4063	←	4219	←	4063	←	4219	←	Position gain on orientation (Low)
3064	←	3220	←	4064	←	4220	←	4064	←	4220	←	Conventional method orientation: Rate of change in position gain upon completion of orientation High-speed orientation: Percentage limit to an acceleration during deceleration Optimum orientation: Position feedforward coefficient
3065	←	3221	←	4065	←	4221	←	4065	←	4221	←	Position gain on servo mode/spindle synchronous control (High)
3066	←	↑	↑	4066	←	↑	↑	4066	←	↑	↑	Position gain on servo mode/spindle synchronous control (Medium High)
3067	←	↓	↓	4067	←	↓	↓	4067	←	↓	↓	Position gain on servo mode/spindle synchronous control (Medium Low)
3068	←	3222	←	4068	←	4222	←	4068	←	4222	←	Position gain on servo mode/spindle synchronous control (Low)
3069	←	None	None	4069	←	None	None	4069	←	None	None	Position gain on Cs contouring control (High)
3070	←	None	None	4070	←	None	None	4070	←	None	None	Position gain on Cs contouring control (Medium High)

15*i*				16*i*				30*i*				Contents
MH	ML	SH	SL	MH	ML	SH	SL	MH	ML	SH	SL	
3071	←	None	None	4071	←	None	None	4071	←	None	None	Position gain on Cs contouring control (Medium Low)
3072	←	None	None	4072	←	None	None	4072	←	None	None	Position gain on Cs contouring control (Low)
3073	←	3223	←	4073	←	4223	←	4073	←	4223	←	Grid shift on servo mode
3074	←	←	←	4074	←	←	←	4074	←	←	←	Reference position return speed on Cs contouring control/servo mode
3075	←	3226	←	4075	←	4226	←	4075	←	4226	←	Detection level for orientation completion signal
3076	←	3227	←	4076	←	4227	←	4076	←	4227	←	Conventional method orientation: Motor speed limit ratio for orientation High-speed orientation: Reserved Optimum orientation: Delay time for acceleration detection/bell-shaped acceleration/deceleration time constant
3077	←	3228	←	4077	←	4228	←	4077	←	4228	←	Orientation stop position shift
3078	←	3229	←	4078	←	4229	←	4078	←	4229	←	MS signal constant
3079	←	3230	←	4079	←	4230	←	4079	←	4230	←	MS signal gain adjustment
3080	3166	3231	3307	4080	4166	4231	4307	4080	4166	4231	4307	Regenerative power limit for high-speed zone/regenerative power limit
3081	←	3232	←	4081	←	4232	←	4081	←	4232	←	Delay time until motor power is cut off
3082	←	3233	←	4082	←	4233	←	4082	←	4233	←	Setting of acceleration/deceleration time
3083	3136	3236	3284	4083	4136	4236	4284	4083	4136	4236	4284	Motor voltage on velocity control mode
3084	←	3237	←	4084	←	4237	←	4084	←	4237	←	Motor voltage on orientation
3085	3137	3238	3285	4085	4137	4238	4285	4085	4137	4238	4285	Motor voltage on servo mode/spindle synchronous control mode
3086	←	None	None	4086	←	None	None	4086	←	None	None	Motor voltage on Cs contouring control
3087	←	←	←	4087	←	←	←	4087	←	←	←	Overspeed level
3088	←	←	←	4088	←	←	←	4088	←	←	←	Level for detecting excess velocity deviation when motor is restrained
3089	←	←	←	4089	←	←	←	4089	←	←	←	Level for detecting excess velocity deviation when motor rotates
3090	←	←	←	4090	←	←	←	4090	←	←	←	Overload detection level
3091	←	3239	←	4091	←	4239	←	4091	←	4239	←	Rate of change in position gain during reference position return on servo mode
3092	←	None	None	4092	←	None	None	4092	←	None	None	Rate of change in position gain during reference position return on Cs contouring control
3094	←	None	None	4094	←	None	None	4094	←	None	None	Disturbance torque compensation constant (acceleration feedback gain)
3095	←	←	←	4095	←	←	←	4095	←	←	←	Adjusted output voltage of speedometer
3096	←	←	←	4096	←	←	←	4096	←	←	←	Adjusted output voltage of load meter
3097	←	None	None	4097	←	None	None	4097	←	None	None	Feedback gain of spindle speed
3098	←	←	←	4098	←	←	←	4098	←	←	←	Maximum speed for position feedback signal detection
3099	←	←	←	4099	←	←	←	4099	←	←	←	Delay time for motor excitation
3100	3138	3256	3286	4100	4138	4256	4286	4100	4138	4256	4286	Base speed of motor output specifications
3101	3139	3257	3287	4101	4139	4257	4287	4101	4139	4257	4287	Output limit for motor output specifications
3102	3140	3258	3288	4102	4140	4258	4288	4102	4140	4258	4288	Excitation voltage saturation speed at no-load
3103	3141	3259	3289	4103	4141	4259	4289	4103	4141	4259	4289	Base speed limit ratio
3104	3142	3260	3290	4104	4142	4260	4290	4104	4142	4260	4290	Current loop proportional gain
3106	3143	3261	3291	4106	4143	4261	4291	4106	4143	4261	4291	Current loop integral gain
3108	3144	3262	3292	4108	4144	4262	4292	4108	4144	4262	4292	Velocity at which the current loop integral gain is zero
3109	3145	3263	3293	4109	4145	4263	4293	4109	4145	4263	4293	Filter time constant for processing saturation related to the voltage command
3110	3146	3264	3294	4110	4146	4264	4294	4110	4146	4264	4294	Current conversion constant
3111	3147	3265	3295	4111	4147	4265	4295	4111	4147	4265	4295	Secondary current coefficient
3112	3148	3266	3296	4112	4148	4266	4296	4112	4148	4266	4296	Criterion level for saturation related to the voltage command/PWM command clamp value
3113	3149	3267	3297	4113	4149	4267	4297	4113	4149	4267	4297	Slip constant
3114	3150	3268	3298	4114	4150	4268	4298	4114	4150	4268	4298	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration

15*i*				16*i*				30*i*				Contents
MH	ML	SH	SL	MH	ML	SH	SL	MH	ML	SH	SL	
3115	3151	3269	3299	4115	4151	4269	4299	4115	4151	4269	4299	PWM command clamp value at deceleration
3116	3152	3270	3300	4116	4152	4270	4300	4116	4152	4270	4300	Motor leakage constant
3117	3153	3271	3301	4117	4153	4271	4301	4117	4153	4271	4301	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient
3118	3154	3272	3302	4118	4154	4272	4302	4118	4154	4272	4302	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient
3119	3165	3280	3308	4119	4165	4280	4308	4119	4165	4280	4308	Deceleration-time excitation current change time constant/excitation current change time constant
3120	←	←	←	4120	←	←	←	4120	←	←	←	Dead-band rectangular wave component zero voltage/dead-band data
3121	3157	3273	3303	4121	4157	4273	4303	4121	4157	4273	4303	Time constant for changing the torque (TCMD filter time constant)
3122	←	3278	←	4122	←	4278	←	4122	←	4278	←	Time constant for velocity detecting filter
3123	←	←	←	4123	←	←	←	4123	←	←	←	Short-time overload detection time
3124	3155	3332	3333	4124	4155	4332	4333	4124	4155	4332	4333	Magnetic flux boost completion level/magnetic flux boost coefficient
3127	3093	3274	3279	4127	4093	4274	4279	4127	4093	4274	4279	Value displayed on load meter at maximum output
3128	3158	3275	3304	4128	4158	4275	4304	4128	4158	4275	4304	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient
3129	3159	3276	3305	4129	4159	4276	4305	4129	4159	4276	4305	Secondary current coefficient for rigid tapping
3130	3161	3277	3306	4130	4161	4277	4306	4130	4161	4277	4306	Current loop proportional gain speed coefficient/current phase delay compensation coefficient
3131	←	None	None	4131	←	None	None	4131	←	None	None	Time constant for velocity detecting filter (on Cs contouring control)
3133	←	3309	←	4133	←	4309	←	4133	←	4309	←	Motor model code
3134	←	3310	←	4134	←	4310	←	4134	←	4310	←	Motor overheat detect level (2-word)
3135	←	None	None	4135	←	None	None	4135	←	None	None	Grid shift during Cs contouring control mode l (2-word)
3160	←	←	←	4160	←	←	←	4160	←	←	←	Hysteresis of speed detection level
3162	←	None	None	4162	←	None	None	4162	←	None	None	Integral gain of velocity loop during cutting feed on Cs contouring control mode (High)
3163	←	None	None	4163	←	None	None	4163	←	None	None	Integral gain of velocity loop during cutting feed on Cs contouring control mode (Low)
3169	←	3349	←	4169	←	4349	←	4169	←	4349	←	Temperature monitoring time constant
3170	3168	3350	3348	4170	4168	4350	4348	4170	4168	4350	4348	Current overload alarm detection level
3171	←	3243	←	4171	←	4243	←	4171	←	4243	←	Denominator of arbitrary gear ratio between motor sensor and spindle (High)
3172	←	3244	←	4172	←	4244	←	4172	←	4244	←	Numerator of arbitrary gear ratio between motor sensor and spindle (High)
3173	←	3245	←	4173	←	4245	←	4173	←	4245	←	Denominator of arbitrary gear ratio between motor sensor and spindle (Low)
3174	←	3246	←	4174	←	4246	←	4174	←	4246	←	Numerator of arbitrary gear ratio between motor sensor and spindle (Low)
3215	←	None	None	4215	←	None	None	4215	←	None	None	Primary delay time constant in dual position feedback [in Cs contour control]
3224	←	None	None	4224	←	None	None	4224	←	None	None	Maximum amplitude in dual position feedback [in Cs contour control]
3225	←	None	None	4225	←	None	None	4225	←	None	None	Dual position feedback zero width [in Cs contour control]
3248	3281	3282	3283	4248	4281	4282	4283	4248	4281	4282	4283	Spindle load monitor torque constant
3249	←	3234	←	4249	←	4234	←	4249	←	4234	←	Spindle load monitor observer gain 1
3250	←	3235	←	4250	←	4235	←	4250	←	4235	←	Spindle load monitor observer gain 2
3320	←	3322	←	4320	←	4322	←	4320	←	4322	←	Optimum orientation: Spindle acceleration command (High)
3321	←	3323	←	4321	←	4323	←	4321	←	4323	←	Optimum orientation: Spindle acceleration command (Low)
3324	←	3325	←	4324	←	4325	←	4324	←	4325	←	Optimum orientation: one-rotation signal detection speed

15*i*				16*i*				30*i*				Contents
MH	ML	SH	SL	MH	ML	SH	SL	MH	ML	SH	SL	
3320	←	3324	←	4320	←	4324	←	4320	←	4324	←	High-speed orientation: Motor acceleration at deceleration time (High)
3321	←	↑	↑	4321	←	↑	↑	4321	←	↑	↑	High-speed orientation: Motor acceleration at deceleration time (Medium High)
3322	←	↓	↓	4322	←	↓	↓	4322	←	↓	↓	High-speed orientation: Motor acceleration at deceleration time (Medium Low)
3323	←	3325	←	4323	←	4325	←	4323	←	4325	←	High-speed orientation: Motor acceleration at deceleration time (Low)
3326	←	3330	←	4326	←	4330	←	4326	←	4330	←	Optimum orientation: Time constant for overshoot compensation/Limit ratio for spindle acceleration command (High)
3327	←	3331	←	4327	←	4331	←	4327	←	4331	←	Optimum orientation: Time constant for overshoot compensation/Limit ratio for spindle acceleration command (Low)
3326	←	3327	←	4326	←	4327	←	4326	←	4327	←	High-speed orientation: Acceleration limitation start speed at deceleration time (High)
3328	←	3329	←	4328	←	4329	←	4328	←	4329	←	Command multiplication for spindle orientation by position coder
3330	←	3331	←	4330	←	4331	←	4330	←	4331	←	High-speed orientation: Acceleration limitation start speed at deceleration time (Low)
3334	←	3335	←	4334	←	4335	←	4334	←	4335	←	Number of motor sensor arbitrary teeth
3336	←	None	None	4336	←	None	None	4336	←	None	None	Switching point used for an acceleration/deceleration time constant used for spindle synchronous control
3340	←	None	None	4340	←	None	None	4340	←	None	None	Bell-shaped acceleration/deceleration time constant during spindle synchronous control
3341	←	←	←	4341	←	←	←	4341	←	←	←	Unexpected disturbance torque detection level
3342	←	None	None	4342	←	None	None	4342	←	None	None	Velocity loop gain override in Cs contouring control (High)
3343	←	None	None	4343	←	None	None	4343	←	None	None	Velocity loop gain override in Cs contouring control (Low)
3344	←	←	←	4344	←	←	←	4344	←	←	←	Advanced preview feed-forward coefficient
3345	←	←	←	4345	←	←	←	4345	←	←	←	Spindle motor speed command detection level
3346	←	←	←	4346	←	←	←	4346	←	←	←	Incomplete integration factor
3347	←	None	None	4347	←	None	None	4347	←	None	None	Master-slave speed difference state signal output setting
3351	←	←	←	4351	←	←	←	4351	←	←	←	Current detection offset compensation
3352	←	3373	←	4352	←	4373	←	4352	←	4373	←	Bit parameter
3353	←	3374	←	4353	←	4374	←	4353	←	4374	←	Bit parameter
3354	←	None	None	4354	←	None	None	4354	←	None	None	Excessive semi-closed loop/closed loop position error alarm detection level [in Cs contour control]
3355	←	None	None	4355	←	None	None	4355	←	None	None	Motor sensor signal amplitude ratio compensation
3356	←	None	None	4356	←	None	None	4356	←	None	None	Motor sensor signal phase difference compensation
3357	←	None	None	4357	←	None	None	4357	←	None	None	Spindle sensor signal amplitude ratio compensation
3358	←	None	None	4358	←	None	None	4358	←	None	None	Spindle sensor signal phase difference compensation
3360	←	None	None	4360	←	None	None	4360	←	None	None	Preload value
3361	←	None	None	4361	←	None	None	4361	←	None	None	Number of spindle sensor arbitrary teeth
3362	3365	3376	3379	4362	4365	4376	4379	4362	4365	4376	4379	Load meter compensation 1
3363	3366	3377	3380	4363	4366	4377	4380	4363	4366	4377	4380	Load meter compensation 2
3364	3367	3378	3381	4364	4367	4378	4381	4364	4367	4378	4381	Load meter compensation 3
3369	←	None	None	4369	←	None	None	4369	←	None	None	Spindle synchronous orientation deceleration coefficient
3370	←	3383	←	4370	←	4383	←	4370	←	4383	←	Filter time constant for spindle acceleration detection
3372	←	None	None	4372	←	None	None	4372	←	None	None	Spindle speed limit for safety 1

15*i*				16*i*				30*i*				Contents
MH	ML	SH	SL	MH	ML	SH	SL	MH	ML	SH	SL	
3384	←	None	None	4384	←	None	None	4384	←	None	None	Spindle EGB : Maximum acceleration/deceleration value in automatic phase matching
3385	←	None	None	4385	←	None	None	4385	←	None	None	Spindle EGB : time constant for free-running phase matching
3386	←	None	None	4386	←	None	None	4386	←	None	None	Spindle EGB : master side detector pulse count
3387	←	None	None	4387	←	None	None	4387	←	None	None	Spindle EGB : synchronous ratio numerator
3388	←	None	None	4388	←	None	None	4388	←	None	None	Spindle EGB : synchronous ratio denominator
3391	←	None	None	4391	←	None	None	4391	←	None	None	Resonance elimination filter 1 : attenuation center frequency
3392	←	None	None	4392	←	None	None	4392	←	None	None	Resonance elimination filter 1 : attenuation bandwidth
3393	←	None	None	4393	←	None	None	4393	←	None	None	Resonance elimination filter 1 : damping
3394	←	3467	←	4394	←	4467	←	4394	←	4467	←	Bit parameter
3395	←	3468	←	4395	←	4468	←	4395	←	4468	←	Bit parameter
3396	←	3469	←	4396	←	4469	←	4396	←	4469	←	Bit parameter
3397	←	3470	←	4397	←	4470	←	4397	←	4470	←	Bit parameter
3398	←	3471	←	4398	←	4471	←	4398	←	4471	←	Bit parameter
3399	←	3472	←	4399	←	4472	←	4399	←	4472	←	Bit parameter
3438	←	None	None	4438	←	None	None	4438	←	None	None	Spindle speed limit for safety 2
3440	←	None	None	4440	←	None	None	4440	←	None	None	Spindle speed limit for safety 3
3442	←	None	None	4442	←	None	None	4442	←	None	None	Spindle speed limit for safety 4
3448	←	None	None	4448	←	None	None	4448	←	None	None	Criterion level for spindle stop
3464	←	←	←	4464	←	←	←	4464	←	←	←	Velocity command-dependent over speed detection offset level
3465	←	←	←	4465	←	←	←	4465	←	←	←	Excessive speed deviation level 2
3466	←	←	←	4466	←	←	←	4466	←	←	←	Excessive speed deviation detection time 2
3399	←	3472	←	4399	←	4472	←	4399	←	4472	←	Bit parameter
3400	←	3473	←	4400	←	4473	←	4400	←	4473	←	Bit parameter
3401	←	3474	←	4401	←	4474	←	4401	←	4474	←	Bit parameter
3402	←	3475	←	4402	←	4475	←	4402	←	4475	←	Bit parameter
3403	←	3476	←	4403	←	4476	←	4403	←	4476	←	Bit parameter
3406	←	None	None	4406	←	None	None	4406	←	None	None	Acceleration/deceleration time constant for Cs contouring control/servo mode
3408	←	←	←	4408	←	←	←	4408	←	←	←	Fine acceleration/deceleration time constant
3409	←	3481	←	4409	←	4481	←	4409	←	4481	←	Feed-forward timing adjustment coefficient
3410	←	←	←	4410	←	←	←	4410	←	←	←	Disturbance input function : measurement start frequency
3411	←	←	←	4411	←	←	←	4411	←	←	←	Disturbance input function : measurement end frequency
3412	←	←	←	4412	←	←	←	4412	←	←	←	Disturbance input function : measurement frequency interval
3413	←	←	←	4413	←	←	←	4413	←	←	←	Disturbance input function : number of measurements per frequency
3414	←	←	←	4414	←	←	←	4414	←	←	←	Disturbance input function : disturbance torque command amplitude
3415	←	←	←	4415	←	←	←	4415	←	←	←	Disturbance input function : motor speed command for measurement
3416	←	None	None	4416	←	None	None	4416	←	None	None	Resonance elimination filter 2 : attenuation center frequency
3417	←	None	None	4417	←	None	None	4417	←	None	None	Resonance elimination filter 2 : attenuation bandwidth
3418	←	None	None	4418	←	None	None	4418	←	None	None	Resonance elimination filter 2 : damping
3419	←	None	None	4419	←	None	None	4419	←	None	None	Resonance elimination filter 3 : attenuation center frequency
3420	←	None	None	4420	←	None	None	4420	←	None	None	Resonance elimination filter 3 : attenuation bandwidth
3421	←	None	None	4421	←	None	None	4421	←	None	None	Resonance elimination filter 3 : damping
3422	←	None	None	4422	←	None	None	4422	←	None	None	Resonance elimination filter 4 : attenuation center frequency
3423	←	None	None	4423	←	None	None	4423	←	None	None	Resonance elimination filter 4 : attenuation bandwidth
3424	←	None	None	4424	←	None	None	4424	←	None	None	Resonance elimination filter 4 : damping

15*i*				16*i*				30*i*				Contents
MH	ML	SH	SL	MH	ML	SH	SL	MH	ML	SH	SL	
3498	←	None	None	4498	←	None	None	4498	←	None	None	Spindle EGB master side : denominator of arbitrary gear ratio between motor sensor and spindle
3499	←	None	None	4499	←	None	None	4499	←	None	None	Spindle EGB master side : numerator of arbitrary gear ratio between motor sensor and spindle
3500	←	None	None	4500	←	None	None	4500	←	None	None	Denominator of arbitrary gear ratio between spindle sensor and spindle (High)
3501	←	None	None	4501	←	None	None	4501	←	None	None	Numerator of arbitrary gear ratio between spindle sensor and spindle (High)
3502	←	None	None	4502	←	None	None	4502	←	None	None	Denominator of arbitrary gear ratio between spindle sensor and spindle (Low)
3503	←	None	None	4503	←	None	None	4503	←	None	None	Numerator of arbitrary gear ratio between spindle sensor and spindle (Low)
3508	←	←	←	4508	←	←	←	4508	←	←	←	Rate of change in acceleration at soft start/stop
3520	←	None	None	4520	←	None	None	4520	←	None	None	Primary delay time constant in dual position feedback [in servo mode]
3521	←	None	None	4521	←	None	None	4521	←	None	None	Maximum amplitude in dual position feedback [in servo mode]
3522	←	None	None	4522	←	None	None	4522	←	None	None	Dual position feedback zero width [in servo mode]
3523	←	None	None	4523	←	None	None	4523	←	None	None	Excessive semi-closed loop/closed loop position error alarm detection level [in servo mode]
3523	←	←	←	4527	←	←	←	4527	←	←	←	Temperature difference between warning level and alarm level
-	-	-	-	-	-	-	-	4590	←	4720	←	Orientation speed restriction rate 1/orientation speed restriction rate 2 (HIGH)
-	-	-	-	-	-	-	-	4591	←	4721	←	Orientation speed restriction rate 1/orientation speed restriction rate 2 (LOW)
-	-	-	-	-	-	-	-	4593	←	←	←	Spindle amplifier loss coefficient 1
-	-	-	-	-	-	-	-	4594	←	←	←	Spindle amplifier loss coefficient 2
-	-	-	-	-	-	-	-	4595	←	←	←	Common power supply loss coefficient 1
-	-	-	-	-	-	-	-	4596	←	←	←	Common power supply loss coefficient 2
-	-	-	-	-	-	-	-	4607	←	4737	←	Motor voltage after completion of optimum orientation

C PARAMETER TABLE FOR EACH MOTOR MODEL

Unless otherwise annotated, the following spindle amplifiers are applicable to motors for 200 V and 400 V.

Amplifiers for 200 V

Conventional spindle amplifier	(A06B-611x-...)
Level-up spindle amplifier	(A06B-614x-...)
Spindle amplifier for 30*i*-B	(A06B-622x-...)

Amplifiers for 400 V

Conventional spindle amplifier	(A06B-612x-...)
Level-up spindle amplifier	(A06B-615x-...)
Spindle amplifier for 30*i*-B	(A06B-627x-...)

C.1 SPINDLE MOTOR αiI series

Motor model			αi I 0.5/10000	αi I 1/10000	αi I 1.5/10000	αi I 2/10000	αi I 3/10000	αi I 6/10000	αi I 8/8000	αi I 12/7000
Applicable amplifier			αi SP2.2	αi SP2.2	αi SP5.5	αi SP5.5	αi SP5.5	αi SP11	αi SP11	αi SP15
Model code			301	302	304	306	308	310	312	314
Applicable software series and edition			9D50/F	9D50/D	9D50/D	9D50/D	9D50/D	9D50/F	9D50/D	9D50/D
Low-speed winding characteristics			–	–	–	–	–	–	–	–
High-speed winding characteristics			0.55/1.1kW 3000/10000min^{-1}	1.5/2.2kW 3000/10000min^{-1}	1.1/3.7kW 1500/10000min^{-1}	2.2/3.7kW 1500/10000min^{-1}	3.7/5.5kW 1500/10000min^{-1}	5.5/7.5kW 1500/10000min^{-1}	7.5/11kW 1500/8000min^{-1}	11/15kW 1500/7000min^{-1}
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D								
3007	4007	4007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3011	4011	4011	00011000	00011001	00011001	00011001	00011001	00011010	00011010	00011010
3012	4012	4012	10000010	10000010	10000010	10000010	10000010	10000010	10000010	10000010
3013	4013	4013	00001100	00001100	00001100	00001100	00001100	00001100	00001100	00001100
3019	4019	4019	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	10000	10000	10000	10000	10000	10000	8000	7000
3023	4023	4023								
3039	4039	4039	0	0	0	0	0	0	0	0
3040	4040	4040								
3041	4041	4041								
3048	4048	4048								
3049	4049	4049								
3080	4080	4080	90	83 80(*1)	85 65(*1)	77 70(*1)	60 65(*1)	66	75	70
3083	4083	4083	30	30	30	30	30	30	30	30
3093	4093	4093	0	0	0	0	0	0	0	0
3100	4100	4100	3400	3100	1650	1550	1600	1550	1600	1500
3101	4101	4101	100	100	100	100	100	96	100	100
3102	4102	4102	6500	3557	2767	2567	1967	2630	1656	1500
3103	4103	4103	46 0(*1)	87 0(*1)	60 0(*1)	68 0(*1)	75 0(*1)	60	0	0
3104	4104	4104	3000	6000	6000	6000	7000	6000	8000	7000
3105	4105	4105	0	0	0	0	0	0	0	0
3106	4106	4106	7500	6000	6000	6000	7000	6000	8000	7000
3107	4107	4107	0	0	0	0	0	0	0	0
3108	4108	4108	0	0	0	0	0	0	0	0
3109	4109	4109	25	25	25	25	25	25	25	25
3110	4110	4110	1571	690	563	474	475	754	503	595
3111	4111	4111	260	102	217	175	200	260	170	173
3112	4112	4112	200	200	200	200	19400	200	200	200
3113	4113	4113	2077	2100	1635	1192	1077	620	790	311
3114	4114	4114	23040	17920	0	0	0	20480	19200	23040
3115	4115	4115	100	100	100	100	100	100	100	100
3116	4116	4116	13760	10018	9598	9300	7950	8803	8118	5000
3117	4117	4117	90	90	90	90	28250	90	90	90
3118	4118	4118	100	100	100	100	110	100	100	100
3119	4119	4119	5	5	5	8	5	15	12	31
3120	4120	4120	0	0	0	0	0	0	0	0
3124	4124	4124	0	0	0	0	0	0	0	0
3127	4127	4127	240	176	404	202	178	164	176	164
3128	4128	4128	120	0	115	90	0	109	117	0
3129	4129	4129	0	0	0	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700	25700	25700	25700
3134	4134	4134	110	110	110	110	110	130	130	130
3136	4136	4136	0	0	0	0	0	0	0	0
3138	4138	4138	0	0	0	0	0	0	0	0
3139	4139	4139	0	0	0	0	0	0	0	0
3140	4140	4140	0	0	0	0	0	0	0	0
3141	4141	4141	0	0	0	0	0	0	0	0
3142	4142	4142	0	0	0	0	0	0	0	0
3143	4143	4143	0	0	0	0	0	0	0	0
3144	4144	4144	0	0	0	0	0	0	0	0
3145	4145	4145	0	0	0	0	0	0	0	0
3146	4146	4146	0	0	0	0	0	0	0	0
3147	4147	4147	0	0	0	0	0	0	0	0
3148	4148	4148	0	0	0	0	0	0	0	0
3149	4149	4149	0	0	0	0	0	0	0	0
3150	4150	4150	0	0	0	0	0	0	0	0
3151	4151	4151	0	0	0	0	0	0	0	0
3152	4152	4152	0	0	0	0	0	0	0	0
3153	4153	4153	0	0	0	0	0	0	0	0
3154	4154	4154	0	0	0	0	0	0	0	0
3155	4155	4155	0	0	0	0	0	0	0	0
3156	4156	4156	0	0	0	0	0	0	0	0
3158	4158	4158	0	0	0	0	0	0	0	0
3159	4159	4159	0	0	0	0	0	0	0	0
3161	4161	4161	0	0	0	0	0	0	0	0
3165	4165	4165	0	0	0	0	0	0	0	0
3166	4166	4166	0	0	0	0	0	0	0	0
3169	4169	4169	0	0	0	0	0	0	0	0
Maximum output during acceleration (for PS selection)			1.32kW 2.60kW(*1)	2.64kW 2.87kW(*1)	4.44kW 6.7kW(*1)	4.44kW 6.4kW(*1)	6.6kW 7.9kW(*1)	9.0kW	13.2kW	18.0kW
Motor model (old name)			α0.5/10000*i*	α1/10000*i*	α1.5/10000*i*	α2/10000*i*	α3/10000*i*	α6/10000*i*	α8/8000*i*	α12/7000*i*
Applicable amplifier (old name)			SPM-2.2*i*	SPM-2.2*i*	SPM-5.5*i*	SPM-5.5*i*	SPM-5.5*i*	SPM-11*i*	SPM-11*i*	SPM-15*i*

(*1) This setting makes the maximum output during acceleration greater and the acceleration time reduced.

Motor model			αi I 15/7000	αi I 18/7000	αi I 22/7000	αi I 30/6000	αi I 40/6000	αi I 50/4500	αi I 50/5000	αi I 1/15000
Applicable amplifier			αi SP22	αi SP22	αi SP26	αi SP45	αi SP45	αi SP55	αi SP55	αi SP5.5
Model code			316	318	320	322	323	324	–	–
Applicable software series and edition			9D50/D	9D50/F	9D50/D	9D50/E	9D50/E	9D50/F	–	–
Low-speed winding characteristics			–	–	–	–	–	–	–	–
High-speed winding characteristics			15/18.5kW 1500/7000min^{-1}	18.5/22kW 1500/7000min^{-1}	22/26kW 1500/7000min^{-1}	30/37kW 1150/6000min^{-1}	37/45kW 1500/6000min^{-1}	45/55kW 1150/4500min^{-1}	45/55kW 1150/5000min^{-1}	1.5/2.2kW 3000/15000min^{-1}
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D								
3007	4007	4007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000001
3011	4011	4011	00011010	00011010	00011010	00011010	00011010	00011010	00011010	00011001
3012	4012	4012	10000010	10000010	10000010	10000010	10000000	10000000	10000000	10000010
3013	4013	4013	01010000	01010000	01010000	00011000	00011000	00011000	00011000	00001100
3019	4019	4019	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	7000	7000	7000	6000	6000	4500	5000	15000
3023	4023	4023								
3039	4039	4039	0	0	0	0	0	0	0	0
3040	4040	4040								
3041	4041	4041								
3048	4048	4048								
3049	4049	4049								
3080	4080	4080	20555	11615	80	77	80	80	80	85 80(*1)
3083	4083	4083	30	30	30	30	30	30	30	30
3093	4093	4093	0	0	0	0	0	0	0	0
3100	4100	4100	1500	1520	1500	1387	1740	1200	1200	3100
3101	4101	4101	95	100	95	100	100	85	85	93
3102	4102	4102	1710	1813	1756	1387	1740	1201	1201	8015
3103	4103	4103	0	84	0	0	0	89	89	70 0(*1)
3104	4104	4104	5500	3000	4500	6000	3000	3000	3000	2000
3105	4105	4105	0	0	0	0	0	0	0	0
3106	4106	4106	5500	10000	4500	6000	3000	4500	4500	7000
3107	4107	4107	0	0	0	0	0	0	0	0
3108	4108	4108	0	0	0	0	0	0	0	0
3109	4109	4109	25	25	25	25	25	25	25	25
3110	4110	4110	794	943	924	1145	970	1260	1260	343
3111	4111	4111	243	333	252	286	286	320	320	102
3112	4112	4112	200	200	200	200	200	200	200	200
3113	4113	4113	304	308	290	189	190	170	170	1870
3114	4114	4114	23040	0	0	20480	23040	23040	23040	0
3115	4115	4115	100	100	100	100	100	100	100	100
3116	4116	4116	5177	3600	5564	6071	6128	5800	5800	9669
3117	4117	4117	90	90	29530	90	90	90	90	90
3118	4118	4118	100	100	110	100	100	100	100	100
3119	4119	4119	31	31	29	51	48	56	56	5
3120	4120	4120	0	0	0	0	0	0	0	0
3124	4124	4124	0	0	0	0	0	0	0	0
3127	4127	4127	148	143	142	148	146	146	146	176
3128	4128	4128	105	0	105	0	0	114	114	80
3129	4129	4129	0	0	0	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700	25700	25700	25700
3134	4134	4134	130	130	130	130	130	130	130	110
3136	4136	4136	0	0	0	0	0	0	0	0
3138	4138	4138	0	0	0	0	0	0	0	0
3139	4139	4139	0	0	0	0	0	0	0	0
3140	4140	4140	0	0	0	0	0	0	0	0
3141	4141	4141	0	0	0	0	0	0	0	0
3142	4142	4142	0	0	0	0	0	0	0	0
3143	4143	4143	0	0	0	0	0	0	0	0
3144	4144	4144	0	0	0	0	0	0	0	0
3145	4145	4145	0	0	0	0	0	0	0	0
3146	4146	4146	0	0	0	0	0	0	0	0
3147	4147	4147	0	0	0	0	0	0	0	0
3148	4148	4148	0	0	0	0	0	0	0	0
3149	4149	4149	0	0	0	0	0	0	0	0
3150	4150	4150	0	0	0	0	0	0	0	0
3151	4151	4151	0	0	0	0	0	0	0	0
3152	4152	4152	0	0	0	0	0	0	0	0
3153	4153	4153	0	0	0	0	0	0	0	0
3154	4154	4154	0	0	0	0	0	0	0	0
3155	4155	4155	0	0	0	0	0	0	0	0
3156	4156	4156	0	0	0	0	0	0	0	0
3158	4158	4158	0	0	0	0	0	0	0	0
3159	4159	4159	0	0	0	0	0	0	0	0
3161	4161	4161	0	0	0	0	0	0	0	0
3165	4165	4165	0	0	0	0	0	0	0	0
3166	4166	4166	0	0	0	0	0	0	0	0
3169	4169	4169	0	0	0	0	0	0	0	0
Maximum output during acceleration (for PS selection)			22.2kW	26.4kW	31.2kW	44.4kW	54.0kW	66.0KW	66.0kW	5.6kW 7.0kW(*1)
Motor model (old name)			α15/7000*i*	α18/7000*i*	α22/7000*i*	α30/6000*i*	α40/6000*i*	α50/4500*i*	–	α1/15000*i*
Applicable amplifier (old name)			SPM-22*i*	SPM-22*i*	SPM-26*i*	SPM-45*i*	SPM-45*i*	SPM-55*i*	–	SPM-5.5*i*

(*1) This setting makes the maximum output during acceleration greater and the acceleration time reduced.

Motor model			αi I 1.5/15000	αi I 1.5/20000	αi I 2/15000	αi I 2/20000	αi I 3/12000	αi I 6/12000	αi I 6/12000(*4)
Applicable amplifier			αi SP15	αi SP15	αi SP22	αi SP22	αi SP11	αi SP11	αi SP11
Model code			305	–	307	–	309	401	–
Applicable software series and edition			9D50/I	–	9D50/D	–	9D50/F	9D50/D	–
Low-speed winding characteristics			–	–	–	–	–	5.5/7.5kW 1500/12000min^{-1}	5.5/7.5kW 1500/12000min^{-1}
High-speed winding characteristics			1.5/2.2kW 3000/15000min^{-1}	1.5/2.2kW 3000/20000min^{-1}	2.2/3.7kW 3000/15000min^{-1}	2.2/3.7kW 3000/20000min^{-1}	3.7/5.5kW 1500/12000min^{-1}	5.5/7.5kW 4000/12000min^{-1}	–
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D							
3007	4007	4007	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000000	00000001	00000000	00000001	00000000	00000000	00000000
3011	4011	4011	00011001	00011001	00011001	00011001	00011001	00011010	00011010
3012	4012	4012	10000010	10000010	10000010	10000010	10000010	10000010	10000010
3013	4013	4013	00001100	00001100	01010000	01010000	00001100	00001100	00001100
3019	4019	4019	00000100	00000100	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	15000	20000	15000	20000	12000	12000	12000
3023	4023	4023						333(*2)	
3039	4039	4039	0	0	0	0	0	0	0
3040	4040	4040							6(*3)
3041	4041	4041						6(*3)	
3048	4048	4048							6(*3)
3049	4049	4049			.			6(*3)	
3080	4080	4080	14165	14165	12122	19290	16720	82 78(*1)	66
3083	4083	4083	10	10	10	10	30	30	30
3093	4093	4093	0	0	0	0	0	164	0
3100	4100	4100	3250	3250	3200	3200	1500	4000	1550
3101	4101	4101	33	33	45	45	87	81	96
3102	4102	4102	7145	7145	6432	6432	3015	4561	2630
3103	4103	4103	75	75	92	92	82	69 0(*1)	60
3104	4104	4104	2300	2300	3000	3000	3200	4000	6000
3105	4105	4105	0	0	0	0	0	0	0
3106	4106	4106	8700	8700	3000	3000	7500	4000	6000
3107	4107	4107	0	0	0	0	0	0	0
3108	4108	4108	0	0	0	0	0	0	0
3109	4109	4109	25	25	25	25	25	25	25
3110	4110	4110	629	629	588	588	559	431	754
3111	4111	4111	180	180	175	175	190	125	260
3112	4112	4112	200	200	200	200	200	200	200
3113	4113	4113	2227	2227	1800	1800	900	650	620
3114	4114	4114	0	0	0	0	19200	20480	20480
3115	4115	4115	90	90	100	80	100	100	100
3116	4116	4116	10289	10289	16564	16564	7376	8986	8803
3117	4117	4117	90	90	90	90	90	90	90
3118	4118	4118	100	100	100	100	100	100	100
3119	4119	4119	5	5	2	2	9	15	15
3120	4120	4120	0	0	0	0	0	0	0
3124	4124	4124	0	0	0	0	0	0	0
3127	4127	4127	176	176	202	202	178	164	164
3128	4128	4128	73	73	85	85	0	95	109
3129	4129	4129	0	0	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700	25700	25700
3134	4134	4134	110	110	110	110	110	130	130
3136	4136	4136	0	0	0	0	0	30	0
3138	4138	4138	0	0	0	0	0	1550	0
3139	4139	4139	0	0	0	0	0	96	0
3140	4140	4140	0	0	0	0	0	2630	0
3141	4141	4141	0	0	0	0	0	60	0
3142	4142	4142	0	0	0	0	0	6000	0
3143	4143	4143	0	0	0	0	0	6000	0
3144	4144	4144	0	0	0	0	0	0	0
3145	4145	4145	0	0	0	0	0	25	0
3146	4146	4146	0	0	0	0	0	754	0
3147	4147	4147	0	0	0	0	0	260	0
3148	4148	4148	0	0	0	0	0	200	0
3149	4149	4149	0	0	0	0	0	620	0
3150	4150	4150	0	0	0	0	0	20480	0
3151	4151	4151	0	0	0	0	0	100	0
3152	4152	4152	0	0	0	0	0	8803	0
3153	4153	4153	0	0	0	0	0	90	0
3154	4154	4154	0	0	0	0	0	100	0
3155	4155	4155	0	0	0	0	0	0	0
3156	4156	4156	0	0	0	0	0	0	0
3158	4158	4158	0	0	0	0	0	109	0
3159	4159	4159	0	0	0	0	0	0	0
3161	4161	4161	0	0	0	0	0	25700	0
3165	4165	4165	0	0	0	0	0	15	0
3166	4166	4166	0	0	0	0	0	66	0
3169	4169	4169	0	0	0	0	0	0	0
Maximum output during acceleration (for PS selection)			13.0kW	13kW	20.0kW	20kW	13.0kW	9.0kW 14.0kW(*1)	9.0kW
Motor model (old name)			α1.5/15000*i*	–	α2/15000*i*	–	α3/12000*i*	α6/12000*i*	α6/12000*i*
Applicable amplifier (old name)			SPM-15*i*	–	SPM-22*i*	–	SPM-11*i*	SPM-11*i*	SPM-11*i*

(*1) This setting makes the maximum output during acceleration greater and the acceleration time reduced.
(*2) When using the SDT signal, manually change the parameters that were automatically set.
(*3) Set this value as the initial value of the velocity loop gain for low-speed characteristics of speed range switching.
(*4) This setting is used when only a low-speed winding is connected without the output range being switched in the output range switching motor.

Motor model			αi I 8/10000	αi I 8/10000(*4)	αi I 8/12000	αi I 12/10000	αi I 12/10000(*4)	αi I 15/10000	αi I 15/10000(*4)
Applicable amplifier			αi SP11	αi SP11	αi SP15	αi SP15	αi SP15	αi SP22	αi SP22
Model code			402	–	–	403	–	404	–
Applicable software series and edition			9D50/F	–	–	9D50/F	–	9D50/F	–
Low-speed winding characteristics			7.5/11kW 1500/10000min^{-1}	7.5/11kW 1500/10000min^{-1}	7.5/11kW 1500/12000min^{-1}	11/15kW 1500/10000min^{-1}	11/15kW 1500/10000min^{-1}	15/18.5kW 1500/10000min^{-1}	15/18.5kW 1500/10000min^{-1}
High-speed winding characteristics			7.5/11kW 4000/10000min^{-1}	–	7.5/11kW 4000/12000min^{-1}	11/15kW 4000/10000min^{-1}	–	15/18.5kW 4000/10000min^{-1}	–
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D							
3007	4007	4007	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000000	00000000	00000001	00000000	00000000	00000000	00000000
3011	4011	4011	00011010	00011010	00011010	00011010	00011010	00011010	00011010
3012	4012	4012	10000010	10000010	10000010	10000010	10000010	10000010	10000010
3013	4013	4013	00001100	00001100	00001100	00001100	00001100	01010000	01010000
3019	4019	4019	00000100	00000100	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	10000	10000	12000	10000	10000	10000	10000
3023	4023	4023	400(*2)		333(*2)	400(*2)		400(*2)	
3039	4039	4039	0	0	0	0	0	0	0
3040	4040	4040		6(*3)					
3041	4041	4041	6(*3)		6(*3)				
3048	4048	4048		6(*3)					
3049	4049	4049	6(*3)		6(*3)				
3080	4080	4080	12880	14168	70	75	70	80	20555
3083	4083	4083	30	30	30	30	30	30	30
3093	4093	4093	176	0	176	164	0	148	0
3100	4100	4100	3538	1600	3580	3900	1500	4000	1500
3101	4101	4101	100	100	100	80	100	62	95
3102	4102	4102	3538	1656	3580	3593	1500	3482	1710
3103	4103	4103	0	0	0	90	0	75	70
3104	4104	4104	2200	6000	2300	1800	7000	1700	5500
3105	4105	4105	0	0	0	0	0	0	0
3106	4106	4106	8000	18000	2300	6500	7000	5500	5500
3107	4107	4107	0	0	0	0	0	0	0
3108	4108	4108	0	0	0	0	0	0	0
3109	4109	4109	25	25	25	25	25	25	25
3110	4110	4110	503	503	421	595	595	575	794
3111	4111	4111	165	170	100	173	173	193	243
3112	4112	4112	200	200	200	200	200	200	200
3113	4113	4113	480	790	980	280	311	275	304
3114	4114	4114	0	19200	0	0	23040	23040	23040
3115	4115	4115	100	100	100	100	100	100	100
3116	4116	4116	5734	8118	11031	5280	5000	5126	5177
3117	4117	4117	100	90	90	90	90	90	90
3118	4118	4118	100	100	100	100	100	90	100
3119	4119	4119	20	12	522	34	31	35	31
3120	4120	4120	0	0	0	0	0	0	0
3124	4124	4124	0	0	0	0	0	0	0
3127	4127	4127	176	176	176	164	164	148	148
3128	4128	4128	0	117	0	0	0	0	105
3129	4129	4129	0	0	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700	25700	25700
3134	4134	4134	130	130	130	130	130	130	130
3136	4136	4136	30	0	30	30	0	30	0
3138	4138	4138	1600	0	1500	1500	0	1500	0
3139	4139	4139	100	0	89	100	0	95	0
3140	4140	4140	1656	0	1642	1500	0	1710	0
3141	4141	4141	0	0	77	0	0	70	0
3142	4142	4142	6000	0	5000	7000	0	5500	0
3143	4143	4143	18000	0	5000	7000	0	5500	0
3144	4144	4144	0	0	0	0	0	0	0
3145	4145	4145	25	0	25	25	0	25	0
3146	4146	4146	503	0	566	595	0	794	0
3147	4147	4147	170	0	162	173	0	243	0
3148	4148	4148	200	0	200	200	0	200	0
3149	4149	4149	790	0	1090	311	0	304	0
3150	4150	4150	19200	0	19200	23040	0	23040	0
3151	4151	4151	100	0	100	100	0	100	0
3152	4152	4152	8118	0	8000	5000	0	5177	0
3153	4153	4153	90	0	90	90	0	90	0
3154	4154	4154	100	0	100	100	0	100	0
3155	4155	4155	0	0	0	0	0	0	0
3156	4156	4156	0	0	0	0	0	0	0
3158	4158	4158	117	0	0	0	0	105	0
3159	4159	4159	0	0	0	0	0	0	0
3161	4161	4161	25700	0	25700	25700	0	25700	0
3165	4165	4165	12	0	521	31	0	31	0
3166	4166	4166	14168	0	49	70	0	20555	0
3169	4169	4169	0	0	0	0	0	0	0
Maximum output during acceleration (for PS selection)			13.2kW	13.2kW	13.2kW	18.0kW	18.0kW	22.2kW	22.2kW
Motor model (old name)			α8/10000*i*	α8/10000*i*	–	α12/10000*i*	α12/10000*i*	α15/10000*i*	α15/10000*i*
Applicable amplifier (old name)			SPM-11*i*	SPM-11*i*	–	SPM-15*i*	SPM-15*i*	SPM-22*i*	SPM-22*i*

(*2) When using the SDT signal, manually change the parameters that were automatically set.
(*3) Set this value as the initial value of the velocity loop gain for low-speed characteristics of speed range switching.
(*4) This setting is used when only a low-speed winding is connected without the output range being switched in the output range switching motor.

Motor model			αi I 18/10000	αi I 18/10000(*4)	αi I 22/10000	αi I 22/10000(*4)
Applicable amplifier			αi SP22	αi SP22	αi SP26	αi SP26
Model code			405	–	406	–
Applicable software series and edition			9D50/F	–	9D50/E	–
Low-speed winding characteristics			18.5/22kW 1500/10000min^{-1}	18.5/22kW 1500/10000min^{-1}	22/26kW 1500/10000min^{-1}	22/26kW 1500/10000min^{-1}
High-speed winding characteristics			18.5/22kW 4000/10000min^{-1}	–	22/26kW 4000/10000min^{-1}	–
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D				
3007	4007	4007	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000
3010	4010	4010	00000000	00000000	00000000	00000000
3011	4011	4011	00011010	00011010	00011010	00011010
3012	4012	4012	10000010	10000010	10000010	10000010
3013	4013	4013	01010000	01010000	01010000	01010000
3019	4019	4019	00000100	00000100	00000100	00000100
3020	4020	4020	10000	10000	10000	10000
3023	4023	4023	400(*2)		400(*2)	
3039	4039	4039	0	0	0	0
3040	4040	4040				
3041	4041	4041				
3048	4048	4048				
3049	4049	4049				
3080	4080	4080	80	11615	75	56
3083	4083	4083	30	30	30	30
3093	4093	4093	143	0	142	0
3100	4100	4100	4100	1520	4000	1440
3101	4101	4101	100	100	83	96
3102	4102	4102	4582	1813	3504	1709
3103	4103	4103	89	84	0	96
3104	4104	4104	1300	3000	2800	5000
3105	4105	4105	0	0	0	0
3106	4106	4106	5000	10000	2800	5000
3107	4107	4107	0	0	0	0
3108	4108	4108	0	0	0	0
3109	4109	4109	25	25	25	25
3110	4110	4110	754	943	603	823
3111	4111	4111	260	333	143	213
3112	4112	4112	200	200	200	200
3113	4113	4113	319	308	265	300
3114	4114	4114	0	0	24320	19200
3115	4115	4115	100	100	100	100
3116	4116	4116	4100	3600	5523	5593
3117	4117	4117	90	90	90	90
3118	4118	4118	100	100	100	100
3119	4119	4119	30	31	36	341
3120	4120	4120	0	0	0	0
3124	4124	4124	0	0	0	0
3127	4127	4127	143	143	142	142
3128	4128	4128	102	0	0	0
3129	4129	4129	0	0	0	0
3130	4130	4130	25700	25700	25700	25700
3134	4134	4134	130	130	130	130
3136	4136	4136	30	0	30	0
3138	4138	4138	1520	0	1440	0
3139	4139	4139	100	0	96	0
3140	4140	4140	1813	0	1709	0
3141	4141	4141	84	0	96	0
3142	4142	4142	3000	0	5000	0
3143	4143	4143	10000	0	5000	0
3144	4144	4144	0	0	0	0
3145	4145	4145	25	0	25	0
3146	4146	4146	943	0	823	0
3147	4147	4147	333	0	213	0
3148	4148	4148	200	0	200	0
3149	4149	4149	308	0	300	0
3150	4150	4150	0	0	19200	0
3151	4151	4151	100	0	100	0
3152	4152	4152	3600	0	5593	0
3153	4153	4153	90	0	90	0
3154	4154	4154	100	0	100	0
3155	4155	4155	0	0	0	0
3156	4156	4156	0	0	0	0
3158	4158	4158	0	0	0	0
3159	4159	4159	0	0	0	0
3161	4161	4161	25700	0	25700	0
3165	4165	4165	31	0	341	0
3166	4166	4166	11615	0	56	0
3169	4169	4169	0	0	0	0
Maximum output during acceleration (for PS selection)			26.4kW	26.4kW	31.2kW	31.2kW
Motor model (old name)			α18/10000*i*	α18/10000*i*	α22/10000*i*	α22/10000*i*
Applicable amplifier (old name)			SPM-22*i*	SPM-22*i*	SPM-26*i*	SPM-26*i*

(*2) When using the SDT signal, manually change the parameters that were automatically set.
(*4) This setting is used when only a low-speed winding is connected without the output range being switched in the output range switching motor.

C.2 SPINDLE MOTOR αiIp series

Motor model			αi IP 12/6000	αi IP 12/8000	αi IP 15/6000	αi IP 15/8000	αi IP 18/6000	αi IP 18/8000	αi IP 22/6000	αi IP 22/8000
Applicable amplifier			αi SP11	αi SP11	αi SP15	αi SP15	αi SP15	αi SP15	αi SP22	αi SP22
Model code			407	－	408	－	409	－	410	－
Applicable software series and edition			9D50/F	－	9D50/F	－	9D50/F	－	9D50/F	－
Low-speed winding characteristics			3.7/7.5kW 500/1500min^{-1}	3.7/7.5kW 500/1500min^{-1}	5/9kW 500/1500min^{-1}	5/9kW 500/1500min^{-1}	6/11kW 500/1500min^{-1}	6/11kW 500/1500min^{-1}	7.5/15kW 500/1500min^{-1}	7.5/15kW 500/1500min^{-1}
High-speed winding characteristics			5.5/7.5kW 750/6000min^{-1}	5.5/7.5kW 750/8000min^{-1}	7.5/9kW 750/6000min^{-1}	7.5/9kW 750/8000min^{-1}	9/11kW 750/6000min^{-1}	9/11kW 750/8000min^{-1}	11/15kW 750/6000min^{-1}	11/15kW 750/8000min^{-1}
FS15i-B	FS16i-B FS0i-C	FS30i-A FS30i-B FS0i-D								
3007	4007	4007	00000000	←	00000000	←	00000000	←	00000000	←
3008	4008	4008	00000000	←	00000000	←	00000000	←	00000000	←
3009	4009	4009	00000000	←	00000000	←	00000000	←	00000000	←
3010	4010	4010	00000000	←	00000000	←	00000000	←	00000000	←
3011	4011	4011	00011010	←	00011010	←	00011010	←	00011010	←
3012	4012	4012	10000010	←	10000010	←	10000010	←	10000010	←
3013	4013	4013	00001100	←	00001100	←	00001100	←	01010000	←
3019	4019	4019	00000100	←	00000100	←	00000100	←	00000100	←
3020	4020	4020	6000	8000	6000	8000	6000	8000	6000	8000
3023	4023	4023	125(*2)	94(*2)	125(*2)	94(*2)	125(*2)	94(*2)	125(*2)	94(*2)
3039	4039	4039	0	←	0	←	0	←	0	←
3040	4040	4040								
3041	4041	4041								
3048	4048	4048								
3049	4049	4049								
3080	4080	4080	11610	←	16730	←	75	←	18000	←
3083	4083	4083	30	←	30	←	30	←	30	←
3093	4093	4093	243	←	216	←	220	←	240	←
3100	4100	4100	750	←	750	←	740	←	800	←
3101	4101	4101	100	←	90	←	100	←	100	←
3102	4102	4102	1488	←	1431	←	1261	←	1342	←
3103	4103	4103	75	←	65	←	70	←	65	←
3104	4104	4104	4000	←	3800	←	5500	←	5500	←
3105	4105	4105	0	←	0	←	0	←	0	←
3106	4106	4106	10000	←	11000	←	17000	←	5500	←
3107	4107	4107	0	←	0	←	0	←	0	←
3108	4108	4108	0	←	0	←	0	←	0	←
3109	4109	4109	25	←	25	←	25	←	25	←
3110	4110	4110	815	←	1043	←	754	←	914	←
3111	4111	4111	297	←	326	←	225	←	300	←
3112	4112	4112	200	←	200	←	200	←	200	←
3113	4113	4113	240	←	270	←	300	←	300	←
3114	4114	4114	23040	←	23040	←	0	←	23040	←
3115	4115	4115	100	←	100	←	100	←	100	←
3116	4116	4116	5307	←	5171	←	5671	←	6196	←
3117	4117	4117	90	←	90	←	90	←	90	←
3118	4118	4118	100	←	100	←	100	←	100	←
3119	4119	4119	40	←	35	←	32	←	301	←
3120	4120	4120	0	←	0	←	0	←	0	←
3124	4124	4124	0	←	0	←	0	←	0	←
3127	4127	4127	164	←	144	←	147	←	164	←
3128	4128	4128	105	←	105	←	105	←	110	←
3129	4129	4129	0	←	0	←	0	←	0	←
3130	4130	4130	25700	←	25700	←	25700	←	25700	←
3134	4134	4134	130	←	130	←	130	←	130	←
3136	4136	4136	30	←	30	←	30	←	30	←
3138	4138	4138	530	←	560	←	500	←	530	←
3139	4139	4139	90	←	100	←	90	←	100	←
3140	4140	4140	887	←	1143	←	755	←	930	←
3141	4141	4141	0	←	80	←	60	←	0	←
3142	4142	4142	6500	←	5000	←	8000	←	6500	←
3143	4143	4143	15000	←	13000	←	23000	←	15000	←
3144	4144	4144	0	←	0	←	0	←	0	←
3145	4145	4145	25	←	25	←	25	←	25	←
3146	4146	4146	1494	←	2514	←	1489	←	1886	←
3147	4147	4147	565	←	816	←	476	←	617	←
3148	4148	4148	200	←	200	←	200	←	200	←
3149	4149	4149	270	←	280	←	315	←	327	←
3150	4150	4150	23040	←	23040	←	0	←	20480	←
3151	4151	4151	100	←	100	←	100	←	100	←
3152	4152	4152	5268	←	5170	←	5660	←	4813	←
3153	4153	4153	90	←	90	←	90	←	90	←
3154	4154	4154	100	←	100	←	115	←	110	←
3155	4155	4155	0	←	0	←	0	←	0	←
3156	4156	4156	0	←	0	←	0	←	0	←
3158	4158	4158	110	←	105	←	0	←	90	←
3159	4159	4159	0	←	0	←	0	←	0	←
3161	4161	4161	25700	←	25700	←	25700	←	25700	←
3165	4165	4165	15	←	34	←	10	←	20	←
3166	4166	4166	70	←	70	←	77	←	75	←
3169	4169	4169	0	←	0	←	0	←	0	←
Maximum output during acceleration (for PS selection)			12.3kW	12.3kW	13.5kW	13.5kW	15.1kW	15.1kW	20.0kW	20.0kW
Motor model (old name)			α12/6000iP	α12/8000iP	α15/6000iP	α15/8000iP	α18/6000iP	α18/8000iP	α22/6000iP	α22/8000iP
Applicable amplifier (old name)			SPM-11i	SPM-11i	SPM-15i	SPM-15i	SPM-15i	SPM-15i	SPM-22i	SPM-22i

(*2) When using the SDT signal, manually change the parameters that were automatically set.

Motor model			αi IP 30/6000	αi IP 40/6000	αi IP 50/6000	αi IP 60/4500	αi IP 60/5000
Applicable amplifier			αi SP22	αi SP26	αi SP26	αi SP30	αi SP30
Model code			411	412	413	414	—
Applicable software series and edition			9D50/E	9D50/F	9D50/E	9D50/F	—
Low-speed winding characteristics			11/18.5kW 400/1500min^{-1}	13/22kW 400/1500min^{-1}	22/30kW 575/1500min^{-1}	18.5/30kW 400/1500min^{-1}	18.5/30kW 400/1500min^{-1}
High-speed winding characteristics			15/18.5kW 575/6000min^{-1}	18.5/22kW 575/6000min^{-1}	22/30kW 1200/6000min^{-1}	22/30kW 750/4500min^{-1}	22/30kW 750/5000min^{-1}
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D					
3007	4007	4007	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000000	00000000	00000000	00000000	00000000
3011	4011	4011	00011010	00011010	00011010	00011010	00011010
3012	4012	4012	10000010	10000000	10000010	10000000	10000000
3013	4013	4013	01010000	01010000	01010000	01010000	01010000
3019	4019	4019	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	6000	6000	6000	4500	5000
3023	4023	4023	96(*2)	96(*2)	200(*2)	167(*2)	167(*2)
3039	4039	4039	0	0	0	0	0
3040	4040	4040					
3041	4041	4041					
3048	4048	4048					
3049	4049	4049					
3080	4080	4080	19280	65	75	75	75
3083	4083	4083	30	30	30	30	30
3093	4093	4093	202	203	164	195	195
3100	4100	4100	590	590	1107	750	750
3101	4101	4101	100	100	100	84	84
3102	4102	4102	889	835	1107	861	861
3103	4103	4103	85	80	0	80	80
3104	4104	4104	10000	3500	8000	5000	5000
3105	4105	4105	0	0	0	0	0
3106	4106	4106	10000	6500	8000	9000	9000
3107	4107	4107	0	0	0	0	0
3108	4108	4108	0	0	0	0	0
3109	4109	4109	25	25	25	25	25
3110	4110	4110	750	1052	686	1018	1018
3111	4111	4111	267	312	175	280	280
3112	4112	4112	150	200	200	200	200
3113	4113	4113	198	170	180	196	196
3114	4114	4114	21760	0	25600	0	0
3115	4115	4115	100	100	100	100	100
3116	4116	4116	6050	4500	6150	5050	5050
3117	4117	4117	90	90	90	90	90
3118	4118	4118	100	100	100	100	100
3119	4119	4119	48	56	53	49	49
3120	4120	4120	0	0	0	0	0
3124	4124	4124	0	0	0	0	0
3127	4127	4127	148	143	164	164	164
3128	4128	4128	105	85	100	0	0
3129	4129	4129	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700
3134	4134	4134	130	130	130	130	130
3136	4136	4136	30	30	30	30	30
3138	4138	4138	400	430	608	420	420
3139	4139	4139	100	100	100	85	85
3140	4140	4140	684	713	608	497	497
3141	4141	4141	0	56	0	0	0
3142	4142	4142	13000	5000	21000	8000	8000
3143	4143	4143	13000	7000	21000	12000	12000
3144	4144	4144	0	0	0	0	0
3145	4145	4145	25	25	25	25	25
3146	4146	4146	2011	2155	1131	1764	1764
3147	4147	4147	733	655	317	510	510
3148	4148	4148	200	200	200	200	200
3149	4149	4149	165	200	195	195	195
3150	4150	4150	0	0	23040	0	0
3151	4151	4151	100	100	100	100	100
3152	4152	4152	6008	5200	6191	5045	5045
3153	4153	4153	28250	90	90	90	90
3154	4154	4154	100	100	100	100	100
3155	4155	4155	0	0	0	0	0
3156	4156	4156	0	0	0	0	0
3158	4158	4158	90	0	110	0	0
3159	4159	4159	0	0	0	0	0
3161	4161	4161	25700	25700	25700	25700	25700
3165	4165	4165	58	48	49	20	20
3166	4166	4166	50	17232	65	45	45
3169	4169	4169	0	0	0	0	0
Maximum output during acceleration (for PS selection)			25.0kW	29.0kW	35.4kW	36kW	36.0kW
Motor model (old name)			α30/6000*i* P	α40/6000*i* P	α50/6000*i* P	α60/4500*i* P	—
Applicable amplifier (old name)			SPM-22*i*	SPM-26*i*	SPM-26*i*	SPM-30*i*	—

(*2) When using the SDT signal, manually change the parameters that were automatically set.

C.3 SPINDLE MOTOR αiIT series

Motor model			αi IT 1.5/15000	αi IT 1.5/20000	αi IT 2/15000	αi IT 2/20000	αi IT 3/12000	αi IT 6/12000	αi IT 6/12000(*4)
Applicable amplifier			αi SP15	αi SP15	αi SP22	αi SP22	αi SP11	αi SP15	αi SP15
Model code			—	—	—	—	—	—	—
Applicable software series and edition			—	—	—	—	—	—	—
Low-speed winding characteristics			—	—	—	—	—	5.5/7.5kW 1500/12000min^{-1}	5.5/7.5kW 1500/12000min^{-1}
High-speed winding characteristics			1.5/2.2kW 3000/15000min^{-1}	1.5/2.2kW 3000/20000min^{-1}	2.2/3.7kW 3000/15000min^{-1}	2.2/3.7kW 3000/20000min^{-1}	3.7/5.5kW 1500/12000min^{-1}	5.5/7.5kW 4000/12000min^{-1}	—
FS15i-B	FS16i-B FS0i-C	FS30i-A FS30i-B FS0i-D							
3007	4007	4007	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000001	00000001	00000001	00000001	00000001	00000001	00000001
3011	4011	4011	00011001	00011001	00011001	00011001	00011001	00011010	00011010
3012	4012	4012	10000010	10000010	10000010	10000010	10000010	10000010	10000010
3013	4013	4013	00001100	00001100	01010000	01010000	00001100	00001100	00001100
3019	4019	4019	00000100	00000100	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	15000	20000	15000	20000	12000	12000	12000
3023	4023	4023						333(*2)	
3039	4039	4039	0	0	0	0	0	0	0
3040	4040	4040							
3041	4041	4041						6(*3)	
3048	4048	4048							
3049	4049	4049						6(*3)	
3080	4080	4080	14165	14165	12122	19290	16720	81	58
3083	4083	4083	10	10	10	10	30	30	30
3093	4093	4093	0	0	0	0	0	164	0
3100	4100	4100	3250	3250	3200	3200	1500	4200	1500
3101	4101	4101	33	33	45	45	87	50	71
3102	4102	4102	7145	7145	6432	6432	3015	4561	2630
3103	4103	4103	75	75	92	92	82	70	70
3104	4104	4104	2300	2300	3000	3000	3200	3000	5500
3105	4105	4105	0	0	0	0	0	0	0
3106	4106	4106	8700	8700	3000	3000	7500	3000	5500
3107	4107	4107	0	0	0	0	0	0	0
3108	4108	4108	0	0	0	0	0	0	0
3109	4109	4109	25	25	25	25	25	25	25
3110	4110	4110	629	629	588	588	559	646	1131
3111	4111	4111	180	180	175	175	190	185	353
3112	4112	4112	200	200	200	200	200	200	200
3113	4113	4113	2227	2227	1800	1800	900	650	620
3114	4114	4114	0	0	0	0	19200	20480	20480
3115	4115	4115	90	90	100	80	100	100	100
3116	4116	4116	10289	10289	16564	16564	7376	10783	8803
3117	4117	4117	90	90	90	90	90	90	90
3118	4118	4118	100	100	100	100	100	100	100
3119	4119	4119	5	5	2	2	9	15	527
3120	4120	4120	0	0	0	0	0	0	0
3124	4124	4124	0	0	0	0	0	0	0
3127	4127	4127	176	176	202	202	178	164	164
3128	4128	4128	73	73	85	85	0	95	105
3129	4129	4129	0	0	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700	25700	25700
3134	4134	4134	110	110	110	110	110	130	130
3136	4136	4136	0	0	0	0	0	30	0
3138	4138	4138	0	0	0	0	0	1500	0
3139	4139	4139	0	0	0	0	0	71	0
3140	4140	4140	0	0	0	0	0	2630	0
3141	4141	4141	0	0	0	0	0	70	0
3142	4142	4142	0	0	0	0	0	5500	0
3143	4143	4143	0	0	0	0	0	5500	0
3144	4144	4144	0	0	0	0	0	0	0
3145	4145	4145	0	0	0	0	0	25	0
3146	4146	4146	0	0	0	0	0	1131	0
3147	4147	4147	0	0	0	0	0	353	0
3148	4148	4148	0	0	0	0	0	200	0
3149	4149	4149	0	0	0	0	0	620	0
3150	4150	4150	0	0	0	0	0	20480	0
3151	4151	4151	0	0	0	0	0	100	0
3152	4152	4152	0	0	0	0	0	8803	0
3153	4153	4153	0	0	0	0	0	90	0
3154	4154	4154	0	0	0	0	0	100	0
3155	4155	4155	0	0	0	0	0	0	0
3156	4156	4156	0	0	0	0	0	0	0
3158	4158	4158	0	0	0	0	0	105	0
3159	4159	4159	0	0	0	0	0	0	0
3161	4161	4161	0	0	0	0	0	25700	0
3165	4165	4165	0	0	0	0	0	527	0
3166	4166	4166	0	0	0	0	0	58	0
3169	4169	4169	0	0	0	0	0	0	0
Maximum output during acceleration (for PS selection)			13.0kW	13kW	20kW	20kW	13kW	13kW	13kW
Motor model (old name)			α1.5/15000iT	—	α2/15000iT	—	α3/12000iT	α6/12000iT	α6/12000iT
Applicable amplifier (old name)			SPM-15i	—	SPM-22i	—	SPM-11i	SPM-15i	SPM-15i

(*2) When using the SDT signal, manually change the parameters that were automatically set.
(*3) Set this value as the initial value of the velocity loop gain for low-speed characteristics of speed range switching.
(*4) This setting is used when only a low-speed winding is connected without the output range being switched in the output range switching motor.

Motor model			αi IT 8/12000	αi IT 8/12000(*4)	αi IT 8/15000	αi IT 8/15000(*4)	αi IT 15/10000	αi IT 15/10000(*4)	αi IT 15/12000	αi IT 15/12000(*4)
Applicable amplifier			αi SP15	αi SP15	αi SP26	αi SP26	αi SP22	αi SP22	αi SP30	αi SP30
Model code			–	–	–	–	–	–	–	–
Applicable software series and edition			–	–	–	–	–	–	–	–
Low-speed winding characteristics			7.5/11kW 1500/12000min^{-1}	7.5/11kW 1500/12000min^{-1}	7.5/11/15kW 1500/4000min^{-1}	7.5/11/15kW 1500/4000min^{-1}	15/18.5kW 1500/10000min^{-1}	15/18.5kW 1500/10000min^{-1}	15/18.5/22kW 1400/4000min^{-1}	15/18.5/22kW 1400/4000min^{-1}
High-speed winding characteristics			7.5/11kW 4000/12000min^{-1}	–	7.5/11/15kW 4000/15000min^{-1}	–	15/18.5kW 4000/10000min^{-1}	–	15/18.5/22kW 5000/12000min^{-1}	–
FS15i-B	FS16i-B FS0i-C	FS30i-A FS30i-B FS0i-D								
3007	4007	4007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000001	00000001	00000001	00000001	00000001	00000001	00000001	00000001
3011	4011	4011	00011010	00011010	00011010	00011010	00011010	00011010	00011010	00011010
3012	4012	4012	10000010	10000010	10000010	10000010	10000010	10000010	10000010	10000010
3013	4013	4013	00001100	00001100	01010000	01010000	01010000	01010000	01010000	01010000
3019	4019	4019	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	12000	12000	15000	4000	10000	10000	12000	4000
3023	4023	4023	333(*2)		267(*2)		400(*2)		292(*2)	
3039	4039	4039	0	0	0	0	0	0	0	0
3040	4040	4040								
3041	4041	4041	6(*3)		4(*3)					
3048	4048	4048								
3049	4049	4049	6(*3)		4(*3)					
3080	4080	4080	70	49	18774	95	80	20555	85	65
3083	4083	4083	30	30	30	30	30	30	30	30
3093	4093	4093	176	0	240	0	148	0	176	0
3100	4100	4100	3580	1500	4040	1570	4000	1500	4500	1450
3101	4101	4101	100	89	84	90	62	95	65	70
3102	4102	4102	3580	1642	5161	2592	3482	1710	5392	1783
3103	4103	4103	0	77	0	0	75	70	82	93
3104	4104	4104	2300	5000	2700	5000	1700	5500	3500	7000
3105	4105	4105	0	0	0	0	0	0	0	0
3106	4106	4106	2300	5000	9200	16000	5500	5500	3500	7000
3107	4107	4107	0	0	0	0	0	0	0	0
3108	4108	4108	0	0	0	0	0	0	0	0
3109	4109	4109	25	25	25	25	25	25	25	25
3110	4110	4110	421	566	503	754	575	794	887	2155
3111	4111	4111	100	162	105	192	193	243	255	650
3112	4112	4112	200	200	200	200	200	200	200	200
3113	4113	4113	980	1090	1000	1050	275	304	380	380
3114	4114	4114	0	19200	28160	0	23040	23040	0	0
3115	4115	4115	100	100	100	100	100	100	100	100
3116	4116	4116	11031	8000	10984	11083	5126	5177	9314	2000
3117	4117	4117	90	90	90	90	90	90	90	90
3118	4118	4118	100	100	90	100	90	100	90	90
3119	4119	4119	522	521	10	15	35	31	25	25
3120	4120	4120	0	0	0	0	0	0	0	0
3124	4124	4124	0	0	0	0	0	0	0	0
3127	4127	4127	176	176	240	240	148	148	176	176
3128	4128	4128	0	0	0	110	0	105	0	0
3129	4129	4129	0	0	0	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700	25700	25700	25700
3134	4134	4134	130	130	130	130	130	130	130	130
3136	4136	4136	30	0	30	0	30	0	30	0
3138	4138	4138	1500	0	1570	0	1500	0	1450	0
3139	4139	4139	89	0	90	0	95	0	70	0
3140	4140	4140	1642	0	2592	0	1710	0	1783	0
3141	4141	4141	77	0	0	0	70	0	93	0
3142	4142	4142	5000	0	5000	0	5500	0	7000	0
3143	4143	4143	5000	0	16000	0	5500	0	7000	0
3144	4144	4144	0	0	0	0	0	0	0	0
3145	4145	4145	25	0	25	0	25	0	25	0
3146	4146	4146	566	0	754	0	794	0	2155	0
3147	4147	4147	162	0	192	0	243	0	650	0
3148	4148	4148	200	0	200	0	200	0	200	0
3149	4149	4149	1090	0	1050	0	304	0	380	0
3150	4150	4150	19200	0	0	0	23040	0	0	0
3151	4151	4151	100	0	100	0	100	0	100	0
3152	4152	4152	8000	0	11083	0	5177	0	2000	0
3153	4153	4153	90	0	90	0	90	0	90	0
3154	4154	4154	100	0	100	0	100	0	90	0
3155	4155	4155	0	0	0	0	0	0	0	0
3156	4156	4156	0	0	0	0	0	0	0	0
3158	4158	4158	0	0	110	0	105	0	0	0
3159	4159	4159	0	0	0	0	0	0	0	0
3161	4161	4161	25700	0	25700	0	25700	0	25700	0
3165	4165	4165	521	0	15	0	31	0	25	0
3166	4166	4166	49	0	95	0	20555	0	65	0
3169	4169	4169	0	0	0	0	0	0	0	0
Maximum output during acceleration (for PS selection)			13.2kW	13.2kW	28kW	28kW	22.2kW	22.2kW	38kW	38kW
Motor model (old name)			α8/12000iT	α8/12000iT	α8/15000iT	α8/15000iT	α15/10000iT	α15/10000iT	α15/12000iT	α15/12000iT
Applicable amplifier (old name)			SPM-15i	SPM-15i	SPM-26i	SPM-26i	SPM-22i	SPM-22i	SPM-30i	SPM-30i

(*2) When using the SDT signal, manually change the parameters that were automatically set.
(*3) Set this value as the initial value of the velocity loop gain for low-speed characteristics of speed range switching.
(*4) This setting is used when only a low-speed winding is connected without the output range being switched in the output range switching motor.

Motor model			αi IT 15/15000	αi IT 22/10000	αi IT 22/10000(*4)
Applicable amplifier			αi SP30	αi SP26	αi SP26
Model code			–	–	–
Applicable software series and edition			–	–	–
Low-speed winding characteristics			15/18.5/22kW 1400/4000min^{-1}	22/26kW 1500/10000min^{-1}	22/26kW 1500/10000min^{-1}
High-speed winding characteristics			15/18.5/22kW 5000/15000min^{-1}	22/26kW 4000/10000min^{-1}	–
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D			
3007	4007	4007	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000
3010	4010	4010	00000001	00000001	00000001
3011	4011	4011	00011010	00011010	00011010
3012	4012	4012	10000010	10000010	10000010
3013	4013	4013	01010000	01010000	01010000
3019	4019	4019	00000100	00000100	00000100
3020	4020	4020	15000	10000	10000
3023	4023	4023	233(*2)	400(*2)	
3039	4039	4039	0	0	0
3040	4040	4040			
3041	4041	4041	4(*3)		
3048	4048	4048			
3049	4049	4049	4(*3)		
3080	4080	4080	10583	75	56
3083	4083	4083	30	30	30
3093	4093	4093	176	142	0
3100	4100	4100	4500	4000	1440
3101	4101	4101	65	83	96
3102	4102	4102	5392	3504	1709
3103	4103	4103	82	0	96
3104	4104	4104	3500	2800	5000
3105	4105	4105	0	0	0
3106	4106	4106	3500	2800	5000
3107	4107	4107	0	0	0
3108	4108	4108	0	0	0
3109	4109	4109	25	25	25
3110	4110	4110	887	603	823
3111	4111	4111	255	143	213
3112	4112	4112	200	200	200
3113	4113	4113	380	265	300
3114	4114	4114	0	24320	19200
3115	4115	4115	100	100	100
3116	4116	4116	9314	5523	5593
3117	4117	4117	90	90	90
3118	4118	4118	90	100	100
3119	4119	4119	25	36	341
3120	4120	4120	0	0	0
3124	4124	4124	0	0	0
3127	4127	4127	176	142	142
3128	4128	4128	0	0	0
3129	4129	4129	0	0	0
3130	4130	4130	25700	25700	25700
3134	4134	4134	130	130	130
3136	4136	4136	30	30	0
3138	4138	4138	1450	1440	0
3139	4139	4139	70	96	0
3140	4140	4140	1783	1709	0
3141	4141	4141	93	96	0
3142	4142	4142	7000	5000	0
3143	4143	4143	7000	5000	0
3144	4144	4144	0	0	0
3145	4145	4145	25	25	0
3146	4146	4146	2155	823	0
3147	4147	4147	650	213	0
3148	4148	4148	200	200	0
3149	4149	4149	380	300	0
3150	4150	4150	0	19200	0
3151	4151	4151	100	100	0
3152	4152	4152	2000	5593	0
3153	4153	4153	90	90	0
3154	4154	4154	90	100	0
3155	4155	4155	0	0	0
3156	4156	4156	0	0	0
3158	4158	4158	0	0	0
3159	4159	4159	0	0	0
3161	4161	4161	25700	25700	0
3165	4165	4165	25	341	0
3166	4166	4166	65	56	0
3169	4169	4169	0	0	0
Maximum output during acceleration (for PS selection)			38kW	31.2kW	31.2kW
Motor model (old name)			α15/15000*i* T	α22/10000*i* T	α22/10000*i* T
Applicable amplifier (old name)			SPM-30*i*	SPM-26*i*	SPM-26*i*

(*2) When using the SDT signal, manually change the parameters that were automatically set.
(*3) Set this value as the initial value of the velocity loop gain for low-speed characteristics of speed range switching.
(*4) This setting is used when only a low-speed winding is connected without the output range being switched in the output range switching motor.

C.4 SPINDLE MOTOR αiIL series

Motor model			αi IL 8/20000	αi IL 15/15000	αi IL 26/15000
Applicable amplifier			αi SP30	αi SP30	αi SP30
Model code			–	–	–
Applicable software series and edition			–	–	–
Low-speed winding characteristics			11/15kW 1150/4000min^{-1}	18.5/22kW 1400/4000min^{-1}	15/22kW 600/2000min^{-1}
High-speed winding characteristics			15/18.5kW 5000/20000min^{-1}	18.5/22kW 6000/15000min^{-1}	26/30kW 2500/15000min^{-1}
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D			
3007	4007	4007	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000
3010	4010	4010	00000001	00000001	00000001
3011	4011	4011	00011001	00011001	00011001
3012	4012	4012	10000010	10000010	10000010
3013	4013	4013	01010000	01010000	01010000
3019	4019	4019	00000100	00000100	00000100
3020	4020	4020	20000	15000	15000
3023	4023	4023	200(*2)	267(*2)	120(*2)
3039	4039	4039	0	0	0
3040	4040	4040			
3041	4041	4041	3(*3)	4(*3)	5(*3)
3048	4048	4048			
3049	4049	4049	3(*3)	4(*3)	5(*3)
3080	4080	4080	11856	12115	12875
3083	4083	4083	20	30	30
3093	4093	4093	164	143	176
3100	4100	4100	5070	6000	2470
3101	4101	4101	69	52	70
3102	4102	4102	6960	6153	2580
3103	4103	4103	0	89	97
3104	4104	4104	2100	1800	2100
3105	4105	4105	0	0	0
3106	4106	4106	3900	2800	4600
3107	4107	4107	0	0	0
3108	4108	4108	0	0	0
3109	4109	4109	25	25	25
3110	4110	4110	805	1207	1207
3111	4111	4111	217	343	344
3112	4112	4112	200	200	200
3113	4113	4113	1005	300	320
3114	4114	4114	0	0	0
3115	4115	4115	100	100	100
3116	4116	4116	9613	7537	4716
3117	4117	4117	90	90	90
3118	4118	4118	100	90	100
3119	4119	4119	778	32	286
3120	4120	4120	0	0	0
3124	4124	4124	0	0	0
3127	4127	4127	148	143	138
3128	4128	4128	0	0	0
3129	4129	4129	0	0	0
3130	4130	4130	25700	25700	25700
3134	4134	4134	130	130	130
3136	4136	4136	30	30	30
3138	4138	4138	1350	1470	700
3139	4139	4139	75	79	67
3140	4140	4140	2605	2573	873
3141	4141	4141	0	0	0
3142	4142	4142	5600	4000	7000
3143	4143	4143	7000	6000	12000
3144	4144	4144	0	0	0
3145	4145	4145	25	25	25
3146	4146	4146	1724	2011	2321
3147	4147	4147	504	585	685
3148	4148	4148	200	200	200
3149	4149	4149	1145	300	420
3150	4150	4150	0	0	19200
3151	4151	4151	100	100	100
3152	4152	4152	10911	7536	4711
3153	4153	4153	90	90	90
3154	4154	4154	110	100	120
3155	4155	4155	0	0	0
3156	4156	4156	0	0	0
3158	4158	4158	110	107	105
3159	4159	4159	0	0	0
3161	4161	4161	25700	25700	25700
3165	4165	4165	8	32	23
3166	4166	4166	12893	75	60
3169	4169	4169	0	0	0
Maximum output during acceleration (for PS selection)			41kW	41kW	43kW
Motor model (old name)			α8/20000*i* L	α15/15000*i* L	α26/15000*i* L
Applicable amplifier (old name)			SPM-30*i*	SPM-30*i*	SPM-30*i*

(*2) When using the SDT signal, manually change the parameters that were automatically set.
(*3) Set this value as the initial value of the velocity loop gain for low-speed characteristics of speed range switching.

C.5 SPINDLE MOTOR αiI series (400V)

Motor model			αi I 0.5/10000HV	αi I 1/10000HV	αi I 1.5/10000HV	αi I 2/10000HV	αi I 3/10000HV	αi I 6/10000HV	αi I 8/8000HV	αi I 12/7000HV
Applicable amplifier			αi SP5.5HV	αi SP5.5HV	αi SP5.5HV	αi SP5.5HV	αi SP5.5HV	αi SP11HV	αi SP11HV	αi SP15HV
Model code			311	313	315	317	319	321	325	326
Applicable software series and edition			9D50/F	9D50/F	9D50/F	9D50/F	9D50/F	9D50/F	9D50/F	9D50/F
Low-speed winding characteristics			–	–	–	–	–	–	–	–
High-speed winding characteristics			0.55/1.1kW 3000/10000min^{-1}	1.5/2.2kW 3000/10000min^{-1}	1.1/3.7kW 1500/10000min^{-1}	2.2/3.7kW 1500/10000min^{-1}	3.7/5.5kW 1500/10000min^{-1}	5.5/7.5kW 1500/10000min^{-1}	7.5/11kW 1500/8000min^{-1}	11/15kW 1500/7000min^{-1}
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D								
3007	4007	4007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3011	4011	4011	00011000	00011001	00011001	00011001	00011001	00011010	00011010	00011010
3012	4012	4012	10000010	10000010	10000010	10000010	10000010	10000010	10000010	10000000
3013	4013	4013	00001100	00001100	00001100	00001100	00001100	00001100	00001100	00001100
3019	4019	4019	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	10000	10000	10000	10000	10000	10000	8000	7000
3023	4023	4023								
3039	4039	4039	0	0	0	0	0	0	0	0
3040	4040	4040								
3041	4041	4041								
3048	4048	4048								
3049	4049	4049								
3080	4080	4080	85	20565 20570(*1)	14173 14170(*1)	80 65(*1)	85 75(*1)	85 65(*1)	70	88 85(*1)
3083	4083	4083	30	30	30	30	30	30	30	30
3093	4093	4093	0	0	0	0	0	0	0	0
3100	4100	4100	3250	2600	1610	1500	1400	1500	1800	1550
3101	4101	4101	100	85	100	100	100	100	100	100
3102	4102	4102	6503	3600	2745	4421	2288	3000	2323	1754
3103	4103	4103	45 0 (*1)	83 0 (*1)	65 0 (*1)	50 0 (*1)	61 0 (*1)	58 0 (*1)	85 0(*1)	88 0(*1)
3104	4104	4104	4500	6000	5000	5000	7000	5000	7000	2000
3105	4105	4105	0	0	0	0	0	0	0	0
3106	4106	4106	4500	6000	12000	5000	7000	5000	7000	4500
3107	4107	4107	0	0	0	0	0	0	0	0
3108	4108	4108	0	0	0	0	0	0	0	0
3109	4109	4109	25	25	25	25	25	25	25	25
3110	4110	4110	3143	1423	1109	1397	1077	754	629	1077
3111	4111	4111	245	103	220	318	237	272	229	250
3112	4112	4112	200	200	200	200	200	200	200	200
3113	4113	4113	2058	2200	2400	935	873	878	723	275
3114	4114	4114	23040	14080	17920	110	20480	23040	23040	0
3115	4115	4115	100	100	100	100	100	100	100	100
3116	4116	4116	13641	17300	10218	10519	9908	9016	8734	5800
3117	4117	4117	90	90	90	90	90	90	90	90
3118	4118	4118	100	100	100	100	100	100	100	100
3119	4119	4119	5	4	4	10	11	11	13	35
3120	4120	4120	0	0	0	0	0	0	0	0
3124	4124	4124	0	0	0	0	0	0	0	0
3127	4127	4127	240	176	404	202	178	164	176	164
3128	4128	4128	120	75	107	90	90	0	0	108
3129	4129	4129	0	0	0	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700	25700	25700	25700
3134	4134	4134	110	110	110	110	110	130	130	130
3136	4136	4136	0	0	0	0	0	0	0	0
3138	4138	4138	0	0	0	0	0	0	0	0
3139	4139	4139	0	0	0	0	0	0	0	0
3140	4140	4140	0	0	0	0	0	0	0	0
3141	4141	4141	0	0	0	0	0	0	0	0
3142	4142	4142	0	0	0	0	0	0	0	0
3143	4143	4143	0	0	0	0	0	0	0	0
3144	4144	4144	0	0	0	0	0	0	0	0
3145	4145	4145	0	0	0	0	0	0	0	0
3146	4146	4146	0	0	0	0	0	0	0	0
3147	4147	4147	0	0	0	0	0	0	0	0
3148	4148	4148	0	0	0	0	0	0	0	0
3149	4149	4149	0	0	0	0	0	0	0	0
3150	4150	4150	0	0	0	0	0	0	0	0
3151	4151	4151	0	0	0	0	0	0	0	0
3152	4152	4152	0	0	0	0	0	0	0	0
3153	4153	4153	0	0	0	0	0	0	0	0
3154	4154	4154	0	0	0	0	0	0	0	0
3155	4155	4155	0	0	0	0	0	0	0	0
3156	4156	4156	0	0	0	0	0	0	0	0
3158	4158	4158	0	0	0	0	0	0	0	0
3159	4159	4159	0	0	0	0	0	0	0	0
3161	4161	4161	0	0	0	0	0	0	0	0
3165	4165	4165	0	0	0	0	0	0	0	0
3166	4166	4166	0	0	0	0	0	0	0	0
3169	4169	4169	0	0	0	0	0	0	0	0
Maximum output during acceleration (for PS selection)			1.32kW 2.59kW(*1)	2.64kW 3.0kW(*1)	4.44kW 6.3kW(*1)	4.44kW 7.5kW(*1)	6.6kW 8.9kW(*1)	9.0kW 15.4kW(*1)	13.2kW 15.8kW(*1)	18.0kW 20.3kW(*1)
Motor model (old name)			α0.5/10000HV*i*	α1/10000HV*i*	α1.5/10000HV*i*	α2/10000HV*i*	α3/10000HV*i*	α6/10000HV*i*	α8/8000HV*i*	α12/7000HV*i*
Applicable amplifier (old name)			SPM-5.5HV*i*	SPM-5.5HV*i*	SPM-5.5HV*i*	SPM-5.5HV*i*	SPM-5.5HV*i*	SPM-11HV*i*	SPM-11HV*i*	SPM-15HV*i*

(*1) This setting makes the maximum output during acceleration greater and the acceleration time reduced.

Motor model			αi I 15/7000HV	αi I 22/7000HV	αi I 30/6000HV	αi I 40/6000HV	αi I 50/5000HV	αi I 60/4500HV	αi I 60/5000HV	αi I 75/5000HV
Applicable amplifier			αi SP30HV	αi SP30HV	αi SP45HV	αi SP45HV	αi SP45HV(*5)	αi SP75HV	αi SP75HV	αi SP75HV(*5)
Model code			327	328	329	—	—	—	—	—
Applicable software series and edition			9D50/F	9D50/F	9D50/F	—	—	—	—	—
Low-speed winding characteristics			—	—	—	—	—	—	—	—
High-speed winding characteristics			15/18.5kW 1500/7000min^{-1}	22/26kW 1500/7000min^{-1}	30/37kW 1150/6000min^{-1}	37/45 kW 1500/6000 min^{-1}	45/55kW 1150/5000min^{-1}	60/75 kW 1150/4500 min^{-1}	60/75kW 1150/5000min^{-1}	75/90kW 1050/5000min^{-1}
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D								
3007	4007	4007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00010000	00010000	00000000	00000000	00010000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00010001
3011	4011	4011	00011010	00011010	00011010	00001010	00001010	00011010	00011010	00001010
3012	4012	4012	10000010	10000010	10000000	10000000	10000000	10000000	10000000	10000000
3013	4013	4013	01010000	01010000	01010000	01010000	00001100	00011000	00011000	00001100
3019	4019	4019	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	7000	7000	6000	6000	5000	4500	5000	5000
3023	4023	4023								
3039	4039	4039	0	0	0	0	0	0	0	0
3040	4040	4040								
3041	4041	4041								
3048	4048	4048								
3049	4049	4049								
3080	4080	4080	65	75	98	82	18000	90	90	20560
3083	4083	4083	30	30	30	30	30	30	30	30
3093	4093	4093	0	0	0	0	0	0	0	0
3100	4100	4100	1500	1595	1230	1600	1150	1130	1130	1100
3101	4101	4101	73	100	85	100	85	100	100	100
3102	4102	4102	1972	1595	1617	1940	1175	1491	1491	1254
3103	4103	4103	65	0	55	0	0	85	85	0
3104	4104	4104	4500	5000	2500	2500	4000	3500	3500	2500
3105	4105	4105	0	0	0	0	0	0	0	0
3106	4106	4106	4500	5000	4000	2800	6000	7000	7000	4000
3107	4107	4107	0	0	0	0	0	0	0	0
3108	4108	4108	0	0	0	0	0	0	0	0
3109	4109	4109	25	25	25	25	25	25	25	25
3110	4110	4110	1499	838	1257	718	678	1174	1174	887
3111	4111	4111	425	223	455	252	274	345	345	292
3112	4112	4112	200	200	200	200	200	200	200	200
3113	4113	4113	280	325	160	175	194	193	193	180
3114	4114	4114	23040	20480	0	0	0	0	0	0
3115	4115	4115	100	100	100	100	100	100	100	100
3116	4116	4116	5153	5572	5056	6212	5045	5042	5042	4794
3117	4117	4117	90	90	90	90	90	90	90	90
3118	4118	4118	100	100	100	100	100	100	100	100
3119	4119	4119	34	29	60	54	49	49	49	53
3120	4120	4120	0	0	0	0	0	0	0	0
3124	4124	4124	0	0	0	0	0	0	0	0
3127	4127	4127	148	142	148	146	147	150	150	144
3128	4128	4128	0	0	110	115	0	0	0	110
3129	4129	4129	0	0	0	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700	25700	25700	25700
3134	4134	4134	130	130	130	130	130	130	130	130
3136	4136	4136	0	0	0	0	0	0	0	0
3138	4138	4138	0	0	0	0	0	0	0	0
3139	4139	4139	0	0	0	0	0	0	0	0
3140	4140	4140	0	0	0	0	0	0	0	0
3141	4141	4141	0	0	0	0	0	0	0	0
3142	4142	4142	0	0	0	0	0	0	0	0
3143	4143	4143	0	0	0	0	0	0	0	0
3144	4144	4144	0	0	0	0	0	0	0	0
3145	4145	4145	0	0	0	0	0	0	0	0
3146	4146	4146	0	0	0	0	0	0	0	0
3147	4147	4147	0	0	0	0	0	0	0	0
3148	4148	4148	0	0	0	0	0	0	0	0
3149	4149	4149	0	0	0	0	0	0	0	0
3150	4150	4150	0	0	0	0	0	0	0	0
3151	4151	4151	0	0	0	0	0	0	0	0
3152	4152	4152	0	0	0	0	0	0	0	0
3153	4153	4153	0	0	0	0	0	0	0	0
3154	4154	4154	0	0	0	0	0	0	0	0
3155	4155	4155	0	0	0	0	0	0	0	0
3156	4156	4156	0	0	0	0	0	0	0	0
3158	4158	4158	0	0	0	0	0	0	0	0
3159	4159	4159	0	0	0	0	0	0	0	0
3161	4161	4161	0	0	0	0	0	0	0	0
3165	4165	4165	0	0	0	0	0	0	0	0
3166	4166	4166	0	0	0	0	0	0	0	0
3169	4169	4169	0	0	0	0	0	0	0	0
Maximum output during acceleration (for PS selection)			22.2kW	31.2kW	44.4kW	54kW	66kW	90kW	90kW	108kW
Motor model (old name)			α15/7000HV*i*	α22/7000HV*i*	α30/6000HV*i*	α40/6000HV*i*	–	α60/4500HV*i*	–	–
Applicable amplifier (old name)			SPM-30HV*i*	SPM-30HV*i*	SPM-45HV*i*	SPM-45HV*i*	–	SPM-75HV*i*	–	–

(*5) Spindle amplifiers indicated by A06B-612x-... are not applicable.

Motor model			αi I 100/4000HV	αi I 100/4000HV(*4)	αi I 100/5000HV
Applicable amplifier			αi SP75HV	αi SP75HV	αi SP100HV(*5)
Model code			415	—	—
Applicable software series and edition			9D50/F	—	—
Low-speed winding characteristics			100kW 1000/3000min^{-1}	100kW 1000/3000min^{-1}	100kW 1000/5000min^{-1}
High-speed winding characteristics			100kW 2000/4000min^{-1}	—	100kW 3000/5000min^{-1}
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D			
3007	4007	4007	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00010000
3009	4009	4009	00000000	00000000	00000000
3010	4010	4010	00000001	00000001	00010001
3011	4011	4011	00011010	00011010	00001010
3012	4012	4012	10000000	10000000	10000000
3013	4013	4013	00011000	00011000	00001100
3019	4019	4019	00000100	00000100	00000100
3020	4020	4020	4000	3000	5000
3023	4023	4023	500(*2)		600(*2)
3039	4039	4039	0	0	0
3040	4040	4040			
3041	4041	4041			
3048	4048	4048			
3049	4049	4049			
3080	4080	4080	80	72	85
3083	4083	4083	30	30	30
3093	4093	4093	120	0	0
3100	4100	4100	2007	835	3050
3101	4101	4101	100	100	90
3102	4102	4102	2007	835	3210
3103	4103	4103	0	0	0
3104	4104	4104	2500	6000	1400
3105	4105	4105	0	0	0
3106	4106	4106	3000	7500	2300
3107	4107	4107	0	0	0
3108	4108	4108	0	0	0
3109	4109	4109	25	25	25
3110	4110	4110	754	823	1131
3111	4111	4111	215	239	379
3112	4112	4112	200	200	200
3113	4113	4113	185	215	172
3114	4114	4114	0	0	0
3115	4115	4115	100	100	100
3116	4116	4116	6516	6532	4691
3117	4117	4117	105	105	90
3118	4118	4118	105	105	100
3119	4119	4119	39	20	55
3120	4120	4120	0	0	0
3124	4124	4124	0	0	0
3127	4127	4127	120	120	120
3128	4128	4128	0	0	0
3129	4129	4129	0	0	0
3130	4130	4130	25700	25700	25700
3134	4134	4134	140	140	130
3136	4136	4136	30	0	30
3138	4138	4138	835	0	1020
3139	4139	4139	100	0	79
3140	4140	4140	835	0	1042
3141	4141	4141	0	0	0
3142	4142	4142	6000	0	4000
3143	4143	4143	7500	0	7000
3144	4144	4144	0	0	0
3145	4145	4145	25	0	25
3146	4146	4146	823	0	993
3147	4147	4147	239	0	352
3148	4148	4148	200	0	200
3149	4149	4149	215	0	172
3150	4150	4150	0	0	0
3151	4151	4151	100	0	100
3152	4152	4152	6532	0	4691
3153	4153	4153	105	0	90
3154	4154	4154	105	0	100
3155	4155	4155	0	0	0
3156	4156	4156	0	0	0
3158	4158	4158	0	0	0
3159	4159	4159	0	0	0
3161	4161	4161	25700	0	25700
3165	4165	4165	20	0	55
3166	4166	4166	72	0	16730
3169	4169	4169	0	0	0
Maximum output during acceleration (for PS selection)			117kW	117kW	120kW
Motor model (old name)			α100/4000HV*i*	α100/4000HV*i*	-
Applicable amplifier (old name)			SPM-75HV*i*	SPM-75HV*i*	-

(*2) When using the SDT signal, manually change the parameters that were automatically set.
(*4) This setting is used when only a low-speed winding is connected without the output range being switched in the output range switching motor.
(*5) Spindle amplifiers indicated by A06B-612x-... are not applicable.

C.6 SPINDLE MOTOR α*i*IP series (400V)

Motor model			α*i* IP 15/6000HV	α*i* IP 22/6000HV	α*i* IP 40/6000HV	α*i* IP 50/6000HV	α*i* IP 60/5000HV
Applicable amplifier			α*i* SP15HV	α*i* SP30HV	α*i* SP30HV	α*i* SP30HV	α*i* SP30HV
Model code			–	–	418	–	–
Applicable software series and edition			–	–	9D50/F,9D70/A	–	–
Low-speed winding characteristics			5/9kW 500/1500min^{-1}	7.5/15kW 500/1500min^{-1}	13/22kW 400/1500min^{-1}	22/30kW 575/1500min^{-1}	18.5/30kW 400/1500min^{-1}
High-speed winding characteristics			7.5/9kW 750/6000min^{-1}	11/15kW 750/6000min^{-1}	18.5/22kW 575/6000min^{-1}	22/30kW 1200/6000min^{-1}	22/30kW 750/5000min^{-1}
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D					
3007	4007	4007	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00010000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000000	00000000	00000000	00000000	00000000
3011	4011	4011	00011010	00001010	00011010	00011010	00001010
3012	4012	4012	10000010	10000010	10000000	10000010	10000000
3013	4013	4013	00001100	01010000	01010000	01010000	01010000
3019	4019	4019	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	6000	6000	6000	6000	5000
3023	4023	4023	125	125(*2)	96(*2)	167	150(*2)
3039	4039	4039	0	0	0	0	0
3040	4040	4040					
3041	4041	4041					
3048	4048	4048					
3049	4049	4049					
3080	4080	4080	95	75	73	80	80
3083	4083	4083	30	30	30	30	30
3093	4093	4093	216	240	203	164	195
3100	4100	4100	760	760	600	1120	863
3101	4101	4101	90	88	100	100	100
3102	4102	4102	1460	1240	889	1356	863
3103	4103	4103	60	0	75	85	0
3104	4104	4104	5000	5000	6400	6000	6000
3105	4105	4105	0	0	0	0	0
3106	4106	4106	12000	15000	6400	16000	14000
3107	4107	4107	0	0	0	0	0
3108	4108	4108	0	0	0	0	0
3109	4109	4109	25	25	25	25	25
3110	4110	4110	1384	1355	1098	838	764
3111	4111	4111	330	382	304	225	229
3112	4112	4112	200	200	200	200	200
3113	4113	4113	260	334	180	201	193
3114	4114	4114	0	20480	20480	0	0
3115	4115	4115	100	100	100	100	100
3116	4116	4116	4600	4500	6043	6202	5045
3117	4117	4117	90	90	90	90	90
3118	4118	4118	100	90	90	100	100
3119	4119	4119	37	29	53	48	49
3120	4120	4120	0	0	0	0	0
3124	4124	4124	0	0	0	0	0
3127	4127	4127	144	164	143	164	164
3128	4128	4128	103	105	115	104	0
3129	4129	4129	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700
3134	4134	4134	130	130	130	130	130
3136	4136	4136	30	30	30	30	30
3138	4138	4138	530	500	430	699	500
3139	4139	4139	75	60	100	95	100
3140	4140	4140	726	717	661	699	500
3141	4141	4141	75	0	60	95	0
3142	4142	4142	10000	8500	8600	10000	11000
3143	4143	4143	28000	19000	8600	24000	22000
3144	4144	4144	0	0	0	0	0
3145	4145	4145	25	25	25	25	25
3146	4146	4146	1934	2357	2514	1374	1331
3147	4147	4147	465	620	726	395	424
3148	4148	4148	200	200	200	200	200
3149	4149	4149	330	332	185	188	194
3150	4150	4150	0	23040	23040	0	0
3151	4151	4151	100	100	100	100	100
3152	4152	4152	5167	5542	6040	6203	5045
3153	4153	4153	90	90	90	90	90
3154	4154	4154	100	90	90	100	100
3155	4155	4155	0	0	0	0	0
3156	4156	4156	0	0	0	0	0
3158	4158	4158	0	0	0	120	0
3159	4159	4159	0	0	0	0	0
3161	4161	4161	25700	25700	25700	25700	25700
3165	4165	4165	29	29	52	51	49
3166	4166	4166	80	85	65	63	70
3169	4169	4169	0	0	0	0	0
Maximum output during acceleration (for PS selection)			13.5kW	20kW	29.0kW	35.4kW	36.0kW
Motor model (old name)			α15/6000HV*i* P	α22/6000HV*i* P	α40/6000HV*i* P	α50/6000HV*i* P	–
Applicable amplifier (old name)			SPM-15HV*i*	SPM-30HV*i*	SPM-30HV*i*	SPM-30HV*i*	–

(*2) When using the SDT signal, manually change the parameters that were automatically set.

C.7 SPINDLE MOTOR αiIT series (400V)

Motor model			αi IT 1.5/15000HV	αi IT 3/12000HV	αi IT 6/12000HV	αi IT 6/12000HV(*4)	αi IT 8/12000HV	αi IT 8/12000HV(*4)	αi IT 8/15000HV	αi IT 8/15000HV(*4)
Applicable amplifier			αi SP15HV	αi SP11HV	αi SP15HV	αi SP15HV	αi SP15HV	αi SP15HV	αi SP30HV	αi SP30HV
Model code			–	–	–	–	–	–	–	–
Applicable software series and edition			–	–	–	–	–	–	–	–
Low-speed winding characteristics			–	–	5.5/7.5kW 1500/12000min^{-1}	5.5/7.5kW 1500/12000min^{-1}	7.5/11kW 1500/12000min^{-1}	7.5/11kW 1500/12000min^{-1}	7.5/11/15kW 1500/4000min^{-1}	7.5/11/15kW 1500/4000min^{-1}
High-speed winding characteristics			1.5/2.2kW 3000/15000min^{-1}	3.7/5.5kW 1500/12000min^{-1}	5.5/7.5kW 4000/12000min^{-1}	–	7.5/11kW 4000/12000min^{-1}	–	7.5/11/15kW 4000/15000min^{-1}	–
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D								
3007	4007	4007	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000001	00000001	00000001	00000001	00000001	00000001	00000001	00000001
3011	4011	4011	00011001	00011001	00011010	00011010	00011010	00011010	00011010	00011010
3012	4012	4012	10000010	10000010	10000010	10000010	10000010	10000010	10000010	10000010
3013	4013	4013	00001100	00001100	00001100	00001100	00001100	00001100	01010000	01010000
3019	4019	4019	00000100	00000100	00000100	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	15000	12000	12000	12000	12000	12000	15000	4000
3023	4023	4023			333(*2)		333(*2)		267(*2)	
3039	4039	4039	0	0	0	0	0	0	0	0
3040	4040	4040						6(*3)		4(*3)
3041	4041	4041					6(*3)		4(*3)	
3048	4048	4048						6(*3)		4(*3)
3049	4049	4049					6(*3)		4(*3)	
3080	4080	4080	9045	90	96	19807	9050	14938	98	92
3083	4083	4083	10	30	30	30	30	30	30	30
3093	4093	4093	0	0	164	0	176	0	240	0
3100	4100	4100	3500	1550	4030	1570	3750	1550	4000	1630
3101	4101	4101	33	82	51	67	85	84	81	93
3102	4102	4102	7257	2864	4526	2475	3798	1957	5660	2913
3103	4103	4103	80	90	67	68	89	74	86	85
3104	4104	4104	3500	4000	2700	4600	3800	7000	3000	5500
3105	4105	4105	0	0	0	0	0	0	0	0
3106	4106	4106	3500	14000	7000	12000	10000	18000	3000	5500
3107	4107	4107	0	0	0	0	0	0	0	0
3108	4108	4108	0	0	0	0	0	0	0	0
3109	4109	4109	25	25	25	25	25	25	25	25
3110	4110	4110	1005	559	862	1508	569	838	646	984
3111	4111	4111	233	190	190	360	100	186	166	282
3112	4112	4112	200	200	200	200	200	200	200	200
3113	4113	4113	2000	850	750	730	950	1000	950	1100
3114	4114	4114	0	0	19200	19200	0	0	0	0
3115	4115	4115	100	100	100	100	100	100	100	100
3116	4116	4116	9815	7377	8202	8202	8736	8737	8703	8708
3117	4117	4117	90	90	90	90	90	90	90	90
3118	4118	4118	100	110	90	100	90	90	90	90
3119	4119	4119	5	11	13	13	10	266	266	9
3120	4120	4120	0	0	0	0	0	0	0	0
3124	4124	4124	0	0	0	0	0	0	0	0
3127	4127	4127	176	178	164	164	176	176	240	240
3128	4128	4128	90	0	105	113	0	0	105	106
3129	4129	4129	0	0	0	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700	25700	25700	25700
3134	4134	4134	110	110	130	130	130	130	130	130
3136	4136	4136	0	0	30	0	30	0	30	0
3138	4138	4138	0	0	1570	0	1550	0	1630	0
3139	4139	4139	0	0	67	0	84	0	93	0
3140	4140	4140	0	0	2475	0	1957	0	2913	0
3141	4141	4141	0	0	68	0	74	0	85	0
3142	4142	4142	0	0	4600	0	7000	0	5500	0
3143	4143	4143	0	0	12000	0	18000	0	5500	0
3144	4144	4144	0	0	0	0	0	0	0	0
3145	4145	4145	0	0	25	0	25	0	25	0
3146	4146	4146	0	0	1508	0	838	0	984	0
3147	4147	4147	0	0	360	0	186	0	282	0
3148	4148	4148	0	0	200	0	200	0	200	0
3149	4149	4149	0	0	730	0	1000	0	1100	0
3150	4150	4150	0	0	19200	0	0	0	0	0
3151	4151	4151	0	0	100	0	100	0	100	0
3152	4152	4152	0	0	8202	0	8737	0	8708	0
3153	4153	4153	0	0	90	0	90	0	90	0
3154	4154	4154	0	0	100	0	90	0	90	0
3155	4155	4155	0	0	0	0	0	0	0	0
3156	4156	4156	0	0	0	0	0	0	0	0
3158	4158	4158	0	0	113	0	0	0	106	0
3159	4159	4159	0	0	0	0	0	0	0	0
3161	4161	4161	0	0	25700	0	25700	0	25700	0
3165	4165	4165	0	0	13	0	266	0	9	0
3166	4166	4166	0	0	19807	0	14938	0	92	0
3169	4169	4169	0	0	0	0	0	0	0	0
Maximum output during acceleration (for PS selection)			13kW	13kW	13kW	13kW	13.2kW	13.2kW	28kW	28kW
Motor model (old name)			α1.5/15000HV*i*T	α3/12000HV*i*T	α6/12000HV*i*T	α6/12000HV*i*T	α8/12000HV*i*T	α8/12000HV*i*T	α8/15000HV*i*T	α8/15000HV*i*T
Applicable amplifier (old name)			SPM-15HV*i*	SPM-11HV*i*	SPM-15HV*i*	SPM-15HV*i*	SPM-15HV*i*	SPM-15HV*i*	SPM-30HV*i*	SPM-30HV*i*

(*2) When using the SDT signal, manually change the parameters that were automatically set.
(*3) Set this value as the initial value of the velocity loop gain for low-speed characteristics of speed range switching.
(*4) This setting is used when only a low-speed winding is connected without the output range being switched in the output range switching motor.

Motor model			αiIT 15/10000HV	αiIT 15/10000HV(*4)	αiIT 15/12000HV	αiIT 15/12000HV(*4)	αiIT 15/15000HV	αiIT 22/10000HV	αiIT 22/10000HV(*4)
Applicable amplifier			αiSP30HV	αiSP30HV	αiSP30HV	αiSP30HV	αiSP30HV	αiSP30HV	αiSP30HV
Model code			–	–	–	–	–	–	–
Applicable software series and edition			–	–	–	–	–	–	–
Low-speed winding characteristics			15/18.5kW 1500/10000min^{-1}	15/18.5kW 1500/10000min^{-1}	15/18.5/22kW 1400/4000min^{-1}	15/18.5/22kW 1400/4000min^{-1}	15/18.5/22kW 1400/4000min^{-1}	22/26kW 1500/10000min^{-1}	22/26kW 1500/10000min^{-1}
High-speed winding characteristics			15/18.5kW 4000/10000min^{-1}	–	15/18.5/22kW 5000/12000min^{-1}	–	15/18.5/22kW 5000/15000min^{-1}	22/26kW 4000/10000min^{-1}	–
FS15i-B	FS16i-B FS0i-C	FS30i-A FS30i-B FS0i-D							
3007	4007	4007	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3010	4010	4010	00000001	00000001	00000001	00000001	00000001	00000001	00000001
3011	4011	4011	00011010	00011010	00011010	00011010	00011010	00011010	00011010
3012	4012	4012	10000010	10000010	10000000	10000000	10000000	10000010	10000010
3013	4013	4013	01010000	01010000	01010000	01010000	01010000	01010000	01010000
3019	4019	4019	00000100	00000100	00000100	00000100	00000100	00000100	00000100
3020	4020	4020	10000	10000	12000	4000	15000	10000	10000
3023	4023	4023	400(*2)		292(*2)		233(*2)	400(*2)	
3039	4039	4039	0	0	0	0	0	0	0
3040	4040	4040							
3041	4041	4041					6(*3)		
3048	4048	4048							
3049	4049	4049					6(*3)		
3080	4080	4080	80	65	67	11354	19270	83	18517
3083	4083	4083	30	30	30	30	30	30	30
3093	4093	4093	148	0	176	0	176	142	0
3100	4100	4100	4000	1500	4600	1500	4600	3630	1500
3101	4101	4101	53	73	59	96	59	74	84
3102	4102	4102	3464	1972	4937	2494	4937	3318	1669
3103	4103	4103	70	65	94	0	94	93	82
3104	4104	4104	2800	4500	1800	3600	1800	2100	4000
3105	4105	4105	0	0	0	0	0	0	0
3106	4106	4106	2800	4500	3000	5500	3000	6300	12000
3107	4107	4107	0	0	0	0	0	0	0
3108	4108	4108	0	0	0	0	0	0	0
3109	4109	4109	25	25	25	25	25	25	25
3110	4110	4110	857	1499	870	1331	870	666	984
3111	4111	4111	229	425	295	470	295	160	270
3112	4112	4112	200	200	120	200	120	200	200
3113	4113	4113	280	280	400	440	400	265	275
3114	4114	4114	0	23040	0	0	0	0	0
3115	4115	4115	100	100	100	100	100	100	100
3116	4116	4116	5184	5153	9570	9567	9570	5000	4991
3117	4117	4117	90	90	90	90	90	90	90
3118	4118	4118	100	100	90	90	90	90	90
3119	4119	4119	34	34	1048	22	1048	50	70
3120	4120	4120	0	0	0	0	0	0	0
3124	4124	4124	0	0	0	0	0	0	0
3127	4127	4127	148	148	176	176	176	142	142
3128	4128	4128	0	0	0	0	0	98	103
3129	4129	4129	0	0	0	0	0	0	0
3130	4130	4130	25700	25700	25700	25700	25700	25700	25700
3134	4134	4134	130	130	130	130	130	130	130
3136	4136	4136	30	0	30	0	30	30	0
3138	4138	4138	1500	0	1500	0	1500	1500	0
3139	4139	4139	73	0	96	0	96	84	0
3140	4140	4140	1972	0	2494	0	2494	1669	0
3141	4141	4141	65	0	0	0	0	82	0
3142	4142	4142	4500	0	3600	0	3600	4000	0
3143	4143	4143	4500	0	5500	0	5500	12000	0
3144	4144	4144	0	0	0	0	0	0	0
3145	4145	4145	25	0	25	0	25	25	0
3146	4146	4146	1499	0	1331	0	1331	984	0
3147	4147	4147	425	0	470	0	470	270	0
3148	4148	4148	200	0	200	0	200	200	0
3149	4149	4149	280	0	440	0	440	275	0
3150	4150	4150	23040	0	0	0	0	0	0
3151	4151	4151	100	0	100	0	100	100	0
3152	4152	4152	5153	0	9567	0	9567	4991	0
3153	4153	4153	90	0	90	0	90	90	0
3154	4154	4154	100	0	90	0	90	90	0
3155	4155	4155	0	0	0	0	0	0	0
3156	4156	4156	0	0	0	0	0	0	0
3158	4158	4158	0	0	0	0	0	103	0
3159	4159	4159	0	0	0	0	0	0	0
3161	4161	4161	25700	0	25700	0	25700	25700	0
3165	4165	4165	34	0	22	0	22	70	0
3166	4166	4166	65	0	11354	0	11354	18517	0
3169	4169	4169	0	0	0	0	0	0	0
Maximum output during acceleration (for PS selection)			22.2kW	22.2kW	38kW	38kW	38kW	31.2kW	31.2kW
Motor model (old name)			α15/10000HViT	α15/10000HViT	α15/12000HViT	α15/12000HViT	α15/15000HViT	α22/10000HViT	α22/10000HViT
Applicable amplifier (old name)			SPM-30HVi	SPM-30HVi	SPM-30HVi	SPM-30HVi	SPM-30HVi	SPM-30HVi	SPM-30HVi

(*2) When using the SDT signal, manually change the parameters that were automatically set.

(*3) Set this value as the initial value of the velocity loop gain for low-speed characteristics of speed range switching.

(*4) This setting is used when only a low-speed winding is connected without the output range being switched in the output range switching motor.

C.8 SPINDLE MOTOR α*i*IL series (400V)

Motor model			α*i* IL 8/20000HV	α*i* IL 15/15000HV	α*i* IL 26/15000HV
Applicable amplifier			α*i* SP45HV	α*i* SP45HV	α*i* SP45HV
Model code			—	—	—
Applicable software series and edition			—	—	—
Low-speed winding characteristics			11/15kW 1150/4000min^{-1}	18.5/22kW 1400/4000min^{-1}	15/22kW 700/2000min^{-1}
High-speed winding characteristics			15/18.5kW 5000/20000min^{-1}	18.5/22kW 6000/15000min^{-1}	26/30kW 2000/15000min^{-1}
FS15*i*-B	FS16*i*-B FS0*i*-C	FS30*i*-A FS30*i*-B FS0*i*-D			
3007	4007	4007	00000000	00000000	00000000
3008	4008	4008	00000000	00000000	00000000
3009	4009	4009	00000000	00000000	00000000
3010	4010	4010	00000001	00000001	00000001
3011	4011	4011	00011001	00011001	00011001
3012	4012	4012	10000010	10000010	10000010
3013	4013	4013	01010000	01010000	01010000
3019	4019	4019	00000100	00000100	00000100
3020	4020	4020	20000	15000	15000
3023	4023	4023	200(*2)	267(*2)	100
3039	4039	4039	0	0	0
3040	4040	4040			
3041	4041	4041	3(*3)	5(*3)	7(*3)
3048	4048	4048			
3049	4049	4049	3(*3)	5(*3)	7(*3)
3080	4080	4080	95	19792	14165
3083	4083	4083	30	30	30
3093	4093	4093	164	143	176
3100	4100	4100	5050	5500	2030
3101	4101	4101	53	44	79
3102	4102	4102	6274	5335	2633
3103	4103	4103	0	94	95
3104	4104	4104	3400	2300	3500
3105	4105	4105	0	0	0
3106	4106	4106	5000	2600	5500
3107	4107	4107	0	0	0
3108	4108	4108	0	0	0
3109	4109	4109	25	25	25
3110	4110	4110	862	1437	1508
3111	4111	4111	255	456	475
3112	4112	4112	200	200	200
3113	4113	4113	907	320	390
3114	4114	4114	0	0	0
3115	4115	4115	100	90	100
3116	4116	4116	9345	8423	4525
3117	4117	4117	90	90	90
3118	4118	4118	90	90	90
3119	4119	4119	523	30	24
3120	4120	4120	0	0	0
3124	4124	4124	0	0	0
3127	4127	4127	148	143	138
3128	4128	4128	112	95	98
3129	4129	4129	0	0	0
3130	4130	4130	25700	25700	25700
3134	4134	4134	130	130	130
3136	4136	4136	30	30	30
3138	4138	4138	1320	1480	810
3139	4139	4139	88	92	77
3140	4140	4140	3163	2777	1248
3141	4141	4141	0	0	0
3142	4142	4142	7000	4800	6500
3143	4143	4143	10000	5200	12000
3144	4144	4144	0	0	0
3145	4145	4145	25	25	25
3146	4146	4146	1207	2011	2011
3147	4147	4147	375	632	639
3148	4148	4148	200	200	200
3149	4149	4149	1140	380	450
3150	4150	4150	0	0	0
3151	4151	4151	100	100	100
3152	4152	4152	12110	9785	4525
3153	4153	4153	90	90	85
3154	4154	4154	90	90	85
3155	4155	4155	0	0	0
3156	4156	4156	0	0	0
3158	4158	4158	123	0	0
3159	4159	4159	0	0	0
3161	4161	4161	25700	25700	25700
3165	4165	4165	8	10	21
3166	4166	4166	95	14180	60
3169	4169	4169	0	0	0
Maximum output during acceleration (for PS selection)			48kW	48kW	50kW
Motor model (old name)			α8/20000HV*i* L	α15/15000HV*i* L	—
Applicable amplifier (old name)			SPM-45HV*i*	SPM-45HV*i*	—

(*2) When using the SDT signal, manually change the parameters that were automatically set.
(*3) Set this value as the initial value of the velocity loop gain for low-speed characteristics of speed range switching.

C.9 SPINDLE MOTOR β*i*I series

Motor model		β*i* I 3/10000	β*i* I 3/10000	β*i* I 3/10000	β*i* I 3/10000	β*i* I 6/10000	β*i* I 6/10000	β*i* I 6/10000
Applicable amplifier		β*i* SVSPx-5.5 TYPE A	β*i* SVSPx-7.5 TYPE D	β*i* SVSPx-11 TYPE A,D	β*i* SVSPx-15 TYPE A,D	β*i* SVSPx-11 TYPE A,D	β*i* SVSPx-15 TYPE A,D	β*i* SVSPx-18
Model code		332	336	337	338	333	339	－
Applicable software series and edition		9D50/I	9D50/U	9D50/Q	9D50/Q	9D50/I	9D50/Q	－
Continuous rated characteristics		3.7kW 2000/10000min^{-1}	3.7kW 2000/10000min^{-1}	3.7kW 2000/10000min^{-1}	3.7kW 2000/10000min^{-1}	5.5kW 2000/10000min^{-1}	5.5kW 2000/10000min^{-1}	5.5kW 2000/10000min^{-1}
15-min. rated characteristics		5.5kW 1500/10000min^{-1}	5.5kW 1500/10000min^{-1}	5.5kW 1500/10000min^{-1}	5.5kW 1500/10000min^{-1}	7.5kW 1500/10000min^{-1}	7.5kW 1500/10000min^{-1}	7.5kW 1500/10000min^{-1}
FS0*i* -C	FS0*i* -D FS0*i* Mate-D							
4007	4007	00000000	←	←	←	00000000	←	←
4008	4008	00000000	←	←	←	00000000	←	←
4009	4009	00000000	←	←	←	00000000	←	←
4010	4010	00010000	←	←	←	00010000	←	←
4011	4011	00011001	←	←	←	00011001	←	←
4012	4012	10000000	←	←	←	10000000	←	←
4013	4013	00001100	←	←	←	00001100	←	←
4019	4019	00000100	←	←	←	00000100	←	←
4020	4020	10000	←	←	←	10000	←	←
4023	4023							
4039	4039	0	←	←	←	0	←	←
4040	4040							
4041	4041							
4048	4048							
4049	4049							
4080	4080	13412	←	←	←	14170	←	←
4083	4083	30	←	←	←	30	←	←
4093	4093	0	←	←	←	0	←	←
4100	4100	1700	←	←	←	1550	←	←
4101	4101	90	←	←	←	90	←	←
4102	4102	2154	←	←	←	2621	←	←
4103	4103	72	←	←	←	58	←	←
4104	4104	2500	←	←	←	2000	←	←
4105	4105	0	←	←	←	0	←	←
4106	4106	6600	←	←	←	5500	←	←
4107	4107	0	←	←	←	0	←	←
4108	4108	0	←	←	←	0	←	←
4109	4109	25	←	←	←	25	←	←
4110	4110	718	1149	1436	2154	520	780	1040
4111	4111	318	←	←	←	208	←	←
4112	4112	200	←	←	←	200	←	←
4113	4113	850	←	←	←	800	←	←
4114	4114	21760	←	←	←	0	←	←
4115	4115	100	←	←	←	100	←	←
4116	4116	7978	←	←	←	7395	←	←
4117	4117	90	←	←	←	90	←	←
4118	4118	100	←	←	←	100	←	←
4119	4119	11	←	←	←	12	←	←
4120	4120	0	←	←	←	0	←	←
4124	4124	0	←	←	←	0	←	←
4127	4127	164	←	←	←	150	←	←
4128	4128	120	←	←	←	115	←	←
4129	4129	0	←	←	←	0	←	←
4130	4130	25700	←	←	←	25700	←	←
4134	4134	110	←	←	←	110	←	←
4136	4136	0	←	←	←	0	←	←
4138	4138	0	←	←	←	0	←	←
4139	4139	0	←	←	←	0	←	←
4140	4140	0	←	←	←	0	←	←
4141	4141	0	←	←	←	0	←	←
4142	4142	0	←	←	←	0	←	←
4143	4143	0	←	←	←	0	←	←
4144	4144	0	←	←	←	0	←	←
4145	4145	0	←	←	←	0	←	←
4146	4146	0	←	←	←	0	←	←
4147	4147	0	←	←	←	0	←	←
4148	4148	0	←	←	←	0	←	←
4149	4149	0	←	←	←	0	←	←
4150	4150	0	←	←	←	0	←	←
4151	4151	0	←	←	←	0	←	←
4152	4152	0	←	←	←	0	←	←
4153	4153	0	←	←	←	0	←	←
4154	4154	0	←	←	←	0	←	←
4155	4155	0	←	←	←	0	←	←
4156	4156	0	←	←	←	0	←	←
4158	4158	0	←	←	←	0	←	←
4159	4159	0	←	←	←	0	←	←
4161	4161	0	←	←	←	0	←	←
4165	4165	0	←	←	←	0	←	←
4166	4166	0	←	←	←	0	←	←
4169	4169	0	←	←	←	0	←	←
Maximum output during		6.1kW	6.1kW	6.1kW	6.1kW	8.3kW	8.3kW	8.3kW
Motor model (old name)		β3/10000*i*	β3/10000*i*	β3/10000*i*	β3/10000*i*	β6/10000*i*	β6/10000*i*	β6/10000*i*
Applicable amplifier (old name)		SVPMx-5.5*i*	-	SVPMx-11*i*	SVPMx-15*i*	SVPMx-11*i*	SVPMx-15*i*	－

Motor model		β*i* I 8/8000	β*i* I 8/8000	β*i* I 8/8000	β*i* I 8/10000	β*i* I 8/10000	β*i* I 8/10000	β*i* I 12/7000	β*i* I 12/7000
Applicable amplifier		β*i* SVSPx-11 TYPE A,D	β*i* SVSPx-15 TYPE A,D	β*i* SVSPx-18	β*i* SVSPx-11 TYPE A,D	β*i* SVSPx-15 TYPE A,D	β*i* SVSPx-18	β*i* SVSPx-15 TYPE A,D	β*i* SVSPx-18
Model code		334	340	−	341	342	−	335	−
Applicable software series and edition		9D50/I	9D50/Q	−	9D50/Q	9D50/Q	−	9D50/I	−
Continuous rated characteristics		7.5kW 2000/8000min^{-1}	7.5kW 2000/8000min^{-1}	7.5kW 2000/8000min^{-1}	7.5kW 2000/10000min^{-1}	7.5kW 2000/10000min^{-1}	7.5kW 2000/10000min^{-1}	11kW 2000/7000min^{-1}	11kW 2000/7000min^{-1}
15-min. rated characteristics		11kW 1500/8000min^{-1}	11kW 1500/8000min^{-1}	11kW 1500/8000min^{-1}	11kW 1500/10000min^{-1}	11kW 1500/10000min^{-1}	11kW 1500/10000min^{-1}	15kW 1500/7000min^{-1}	15kW 1500/7000min^{-1}
FS0*i*-C	FS0*i*-D FS0*i* Mate-D								
4007	4007	00000000	←	←	←	←	←	00000000	←
4008	4008	00000000	←	←	←	←	←	00000000	←
4009	4009	00000000	←	←	←	←	←	00000000	←
4010	4010	00010000	←	←	←	←	←	00010000	←
4011	4011	00011010	←	←	←	←	←	00011010	←
4012	4012	10000000	←	←	←	←	←	10000000	←
4013	4013	00001100	←	←	←	←	←	00001100	←
4019	4019	00000100	←	←	←	←	←	00000100	←
4020	4020	8000	←	←	10000	←	←	7000	←
4023	4023								
4039	4039	0	←	←	←	←	←	0	←
4040	4040								
4041	4041								
4048	4048								
4049	4049								
4080	4080	75	←	←	←	←	←	60	←
4083	4083	30	←	←	←	←	←	30	←
4093	4093	0	←	←	←	←	←	0	←
4100	4100	1500	←	←	←	←	←	1550	←
4101	4101	95	←	←	←	←	←	82	←
4102	4102	2602	←	←	←	←	←	1844	←
4103	4103	64	←	←	←	←	←	80	←
4104	4104	2000	←	←	←	←	←	3000	←
4105	4105	0	←	←	←	←	←	0	←
4106	4106	6000	←	←	←	←	←	8000	←
4107	4107	0	←	←	←	←	←	0	←
4108	4108	0	←	←	←	←	←	0	←
4109	4109	25	←	←	←	←	←	25	←
4110	4110	887	1331	1774	887	1331	1774	1031	1375
4111	4111	381	←	←	←	←	←	355	←
4112	4112	200	←	←	←	←	←	200	←
4113	4113	500	←	←	←	←	←	705	←
4114	4114	0	←	←	←	←	←	23040	←
4115	4115	100	←	←	←	←	←	100	←
4116	4116	8000	←	←	←	←	←	6300	←
4117	4117	90	←	←	←	←	←	90	←
4118	4118	100	←	←	←	←	←	100	←
4119	4119	19	←	←	←	←	←	14	←
4120	4120	0	←	←	←	←	←	0	←
4124	4124	0	←	←	←	←	←	0	←
4127	4127	161	←	←	←	←	←	150	←
4128	4128	78	←	←	←	←	←	95	←
4129	4129	0	←	←	←	←	←	0	←
4130	4130	25700	←	←	←	←	←	25700	←
4134	4134	110	←	←	←	←	←	110	←
4136	4136	0	←	←	←	←	←	0	←
4138	4138	0	←	←	←	←	←	0	←
4139	4139	0	←	←	←	←	←	0	←
4140	4140	0	←	←	←	←	←	0	←
4141	4141	0	←	←	←	←	←	0	←
4142	4142	0	←	←	←	←	←	0	←
4143	4143	0	←	←	←	←	←	0	←
4144	4144	0	←	←	←	←	←	0	←
4145	4145	0	←	←	←	←	←	0	←
4146	4146	0	←	←	←	←	←	0	←
4147	4147	0	←	←	←	←	←	0	←
4148	4148	0	←	←	←	←	←	0	←
4149	4149	0	←	←	←	←	←	0	←
4150	4150	0	←	←	←	←	←	0	←
4151	4151	0	←	←	←	←	←	0	←
4152	4152	0	←	←	←	←	←	0	←
4153	4153	0	←	←	←	←	←	0	←
4154	4154	0	←	←	←	←	←	0	←
4155	4155	0	←	←	←	←	←	0	←
4156	4156	0	←	←	←	←	←	0	←
4158	4158	0	←	←	←	←	←	0	←
4159	4159	0	←	←	←	←	←	0	←
4161	4161	0	←	←	←	←	←	0	←
4165	4165	0	←	←	←	←	←	0	←
4166	4166	0	←	←	←	←	←	0	←
4169	4169	0	←	←	←	←	←	0	←
Maximum output during		12.1kW	12.1kW	12.1kW	12.1kW	12.1kW	12.1kW	16.5kW	16.5kW
Motor model (old name)		β8/8000*i*	β8/8000*i*	β8/8000*i*	β8/10000*i*	β8/10000*i*	β8/10000*i*	β12/7000*i*	β12/7000*i*
Applicable amplifier (old name)		SVPMx-11*i*	SVPMx-15*i*	−	SVPMx-11*i*	SVPMx-15*i*	SVPMx-15*i*	SVPMx-15*i*	−

Motor model		βiI 12/8000	βiI 12/8000	βiI 15/7000
Applicable amplifier		βi SVSPx-15 TYPE A,D	βi SVSPx-18	βi SVSPx-18
Model code		343	–	–
Applicable software series and edition		9D50/Q	–	–
Continuous rated characteristics		11kW 2000/8000min^{-1}	11kW 2000/8000min^{-1}	15kW 2000/7000min^{-1}
15-min. rated characteristics		15kW 1500/8000min^{-1}	15kW 1500/8000min^{-1}	18.5kW 1500/7000min^{-1}
FS0i-C	FS0i-D FS0i Mate-D			
4007	4007	00000000	←	00000000
4008	4008	00000000	←	00000000
4009	4009	00000000	←	00000000
4010	4010	00010000	←	00010000
4011	4011	00011010	←	00011010
4012	4012	10000000	←	10000000
4013	4013	00001100	←	00001100
4019	4019	00000100	←	00000100
4020	4020	8000	←	7000
4023	4023			
4039	4039	0	←	0
4040	4040			
4041	4041			
4048	4048			
4049	4049			
4080	4080	60	←	15445
4083	4083	30	←	30
4093	4093	0	←	0
4100	4100	1550	←	1550
4101	4101	82	←	81
4102	4102	1844	←	1610
4103	4103	80	←	0
4104	4104	3000	←	2500
4105	4105	0	←	0
4106	4106	8000	←	5000
4107	4107	0	←	0
4108	4108	0	←	0
4109	4109	25	←	25
4110	4110	1031	1375	1426
4111	4111	355	←	389
4112	4112	200	←	200
4113	4113	705	←	298
4114	4114	23040	←	0
4115	4115	100	←	100
4116	4116	6300	←	4344
4117	4117	90	←	90
4118	4118	100	←	100
4119	4119	14	←	32
4120	4120	0	←	0
4124	4124	0	←	0
4127	4127	150	←	148
4128	4128	95	←	0
4129	4129	0	←	0
4130	4130	25700	←	25700
4134	4134	110	←	130
4136	4136	0	←	0
4138	4138	0	←	0
4139	4139	0	←	0
4140	4140	0	←	0
4141	4141	0	←	0
4142	4142	0	←	0
4143	4143	0	←	0
4144	4144	0	←	0
4145	4145	0	←	0
4146	4146	0	←	0
4147	4147	0	←	0
4148	4148	0	←	0
4149	4149	0	←	0
4150	4150	0	←	0
4151	4151	0	←	0
4152	4152	0	←	0
4153	4153	0	←	0
4154	4154	0	←	0
4155	4155	0	←	0
4156	4156	0	←	0
4158	4158	0	←	0
4159	4159	0	←	0
4161	4161	0	←	0
4165	4165	0	←	0
4166	4166	0	←	0
4169	4169	0	←	0
Maximum output during		16.5kW	16.5kW	
Motor model (old name)		β12/8000i	β12/8000i	–
Applicable amplifier (old name)		SVPMx-15i	–	–

C.10 SPINDLE MOTOR β*i*IP series

Motor model		β*i* IP 8/6000	β*i* IP 15/6000	β*i* IP 15/6000	β*i* IP 15/6000	β*i* IP 18/6000	β*i* IP 18/6000	β*i* IP 18/6000
Applicable amplifier		β*i* SVSPx-7.5 TYPE D	β*i* SVSPx-11 TYPE D	β*i* SVSPx-15 TYPE A,D	β*i* SVSPx-18	β*i* SVSPx-11 TYPE D	β*i* SVSPx-15 TYPE A,D	β*i* SVSPx-18
Model code		—	350	351	–	353	352	–
Applicable software series and edition		—	9D50/U	9D50/Q	–	9D50/U	9D50/Q	–
Continuous rated characteristics		3.7kW 1000/6000min^{-1}	7.5kW 1200/6000min^{-1}	7.5kW 1200/6000min^{-1}	7.5kW 1200/6000min^{-1}	9kW 1000/6000min^{-1}	9kW 1000/6000min^{-1}	9kW 1000/6000min^{-1}
15-min. rated characteristics		5.5kW 750/6000min^{-1}	9kW 750/6000min^{-1}	9kW 750/6000min^{-1}	9kW 750/6000min^{-1}	11kW 750/6000min^{-1}	11kW 750/6000min^{-1}	11kW 750/6000min^{-1}
FS0*i*-C	FS0*i*-D FS0*i* Mate-D							
4007	4007	00000000	00000000	←	←	00000000	←	←
4008	4008	00010000	00010000	←	←	00010000	←	←
4009	4009	00000000	00000000	←	←	00000000	←	←
4010	4010	00010000	00010000	←	←	00010000	←	←
4011	4011	00001010	00001010	←	←	00001010	←	←
4012	4012	10000000	10000000	←	←	10000000	←	←
4013	4013	00001100	00001100	←	←	00001100	←	←
4019	4019	00000100	00000100	←	←	00000100	←	←
4020	4020	6000	6000	←	←	6000	←	←
4023	4023							
4039	4039	0	0	←	←	0	←	←
4040	4040							
4041	4041							
4048	4048							
4049	4049							
4080	4080	16474	20575	←	←	21845	←	←
4083	4083	30	30	←	←	30	←	←
4093	4093	0	0	←	←	0	←	←
4100	4100	800	750	←	←	750	←	←
4101	4101	65	79	←	←	79	←	←
4102	4102	1345	1566	←	←	1191	←	←
4103	4103	0	0	←	←	0	←	←
4104	4104	4500	2000	←	←	3000	←	←
4105	4105	0	0	←	←	0	←	←
4106	4106	7500	7000	←	←	7000	←	←
4107	4107	0	0	←	←	0	←	←
4108	4108	0	0	←	←	0	←	←
4109	4109	25	25	←	←	25	←	←
4110	4110	1106	943	1414	1886	793	1190	1586
4111	4111	503	503	←	←	410	←	←
4112	4112	200	200	←	←	200	←	←
4113	4113	730	228	←	←	268	←	←
4114	4114	23552	0	←	←	0	←	←
4115	4115	100	100	←	←	100	←	←
4116	4116	6255	5307	←	←	4194	←	←
4117	4117	90	90	←	←	90	←	←
4118	4118	100	100	←	←	100	←	←
4119	4119	13	42	←	←	36	←	←
4120	4120	0	0	←	←	0	←	←
4124	4124	0	0	←	←	0	←	←
4127	4127	164	132	←	←	134	←	←
4128	4128	110	90	←	←	105	←	←
4129	4129	0	0	←	←	0	←	←
4130	4130	25700	25700	←	←	25700	←	←
4134	4134	110	130	←	←	130	←	←
4136	4136	0	0	←	←	0	←	←
4138	4138	0	0	←	←	0	←	←
4139	4139	0	0	←	←	0	←	←
4140	4140	0	0	←	←	0	←	←
4141	4141	0	0	←	←	0	←	←
4142	4142	0	0	←	←	0	←	←
4143	4143	0	0	←	←	0	←	←
4144	4144	0	0	←	←	0	←	←
4145	4145	0	0	←	←	0	←	←
4146	4146	0	0	←	←	0	←	←
4147	4147	0	0	←	←	0	←	←
4148	4148	0	0	←	←	0	←	←
4149	4149	0	0	←	←	0	←	←
4150	4150	0	0	←	←	0	←	←
4151	4151	0	0	←	←	0	←	←
4152	4152	0	0	←	←	0	←	←
4153	4153	0	0	←	←	0	←	←
4154	4154	0	0	←	←	0	←	←
4155	4155	0	0	←	←	0	←	←
4156	4156	0	0	←	←	0	←	←
4158	4158	0	0	←	←	0	←	←
4159	4159	0	0	←	←	0	←	←
4161	4161	0	0	←	←	0	←	←
4165	4165	0	0	←	←	0	←	←
4166	4166	0	0	←	←	0	←	←
4169	4169	0	0	←	←	0	←	←
Maximum output during		6.1kW	9.9kW	9.9kW	9.9kW	12.1kW	12.1kW	12.1kW
Motor model (old name)		–	–	–	–	–	–	–
Applicable amplifier (old name)		–	–	–	–	–	–	–

Motor model		β*i* IP 22/6000	β*i* IP 22/6000	β*i* IP 30/6000
Applicable amplifier		β*i* SVSPx-15 TYPE A,D	β*i* SVSPx-18	β*i* SVSPx-18
Model code		–	–	–
Applicable software series and edition		–	–	–
Continuous rated characteristics		11kW 1000/6000min^{-1}	11kW 1000/6000min^{-1}	15kW 1000/6000min^{-1}
15-min. rated characteristics		15kW 750/6000min^{-1}	15kW 750/6000min^{-1}	18.5kW 750/6000min^{-1}
FS0*i*-C	FS0*i*-D FS0*i* Mate-D			
4007	4007	00000000	←	00000000
4008	4008	00010000	←	00010000
4009	4009	00000000	←	00000000
4010	4010	00010000	←	00010000
4011	4011	00001010	←	00001010
4012	4012	10000000	←	10000000
4013	4013	00001100	←	00001100
4019	4019	00000100	←	00000100
4020	4020	6000	←	6000
4023	4023			
4039	4039	0	←	0
4040	4040			
4041	4041			
4048	4048			
4049	4049			
4080	4080	19275	←	16730
4083	4083	30	←	30
4093	4093	0	←	0
4100	4100	770	←	750
4101	4101	100	←	100
4102	4102	953	←	1007
4103	4103	0	←	0
4104	4104	4000	←	3500
4105	4105	0	←	0
4106	4106	9000	←	8000
4107	4107	0	←	0
4108	4108	0	←	0
4109	4109	25	←	25
4110	4110	1077	1436	1143
4111	4111	333	←	334
4112	4112	200	←	200
4113	4113	300	←	300
4114	4114	20480	←	0
4115	4115	100	←	100
4116	4116	4408	←	4298
4117	4117	90	←	90
4118	4118	100	←	100
4119	4119	32	←	32
4120	4120	0	←	0
4124	4124	0	←	0
4127	4127	150	←	136
4128	4128	103	←	0
4129	4129	0	←	0
4130	4130	25700	←	25700
4134	4134	130	←	130
4136	4136	0	←	0
4138	4138	0	←	0
4139	4139	0	←	0
4140	4140	0	←	0
4141	4141	0	←	0
4142	4142	0	←	0
4143	4143	0	←	0
4144	4144	0	←	0
4145	4145	0	←	0
4146	4146	0	←	0
4147	4147	0	←	0
4148	4148	0	←	0
4149	4149	0	←	0
4150	4150	0	←	0
4151	4151	0	←	0
4152	4152	0	←	0
4153	4153	0	←	0
4154	4154	0	←	0
4155	4155	0	←	0
4156	4156	0	←	0
4158	4158	0	←	0
4159	4159	0	←	0
4161	4161	0	←	0
4165	4165	0	←	0
4166	4166	0	←	0
4169	4169	0	←	0
Maximum output during		16.5kW	9.9kW	–
Motor model (old name)		–	–	–
Applicable amplifier (old name)		–	–	–

C.11 SPINDLE MOTOR β*i*Ic series

Motor model	β*i* Ic3/6000	β*i* Ic6/6000	β*i* Ic8/6000
Applicable amplifier	β*i* SVSPc*-7.5	β*i* SVSPc*-7.5L	β*i* SVSPc*-11
Model code	271	272	273
Applicable software series and edition	9D60/F	9D60/F	9D60/F
Continuous rated characteristics	3.7kW 2000/6000min^{-1}	5.5kW 2000/6000min^{-1}	7.5kW 2000/6000min^{-1}
15-min. rated characteristics	5.5kW 1500/6000min^{-1}	7.5kW 1500/6000min^{-1}	11kW 1500/6000min^{-1}
FS0*i* Mate-TD			
4000	00000000	00000000	00000000
4001	00000001	00000001	00000001
4002	00000010(*1)	00000010(*1)	00000010(*1)
4003	00000000	00000000	00000000
4005	00000001	00000001	00000001
4006	00000000	00000000	00000000
4007	00000000	00000000	00000000
4008	00001000	00001000	00001000
4011	00001000	00001000	00001000
4012	00000000	00000000	00000000
4013	00001100	00001100	00001100
4019	00000000	00000000	00000000
4020	6000	6000	6000
4040~4045	24(*2)	34(*2)	28(*2)
4048~4053	607(*2)	844(*2)	696(*2)
4080	75	75	80
4083	60	60	60
4084	60	60	60
4085	60	60	60
4100	1600	1607	1450
4101	90	65	90
4102	1800	1607	1799
4103	53	53	36
4104	400	300	400
4105	25	25	25
4106	100	100	100
4107	0	0	0
4108	200	200	200
4109	25	25	25
4110	929	623	580
4111	250	276	250
4112	200	200	200
4113	1000	897	680
4114	0	0	0
4115	100	100	100
4116	8500	7393	8001
4117	29530	120	32090
4118	120	120	100
4119	10	21	12
4120	15	15	15
4124	0	0	0
4127	164	150	161
4128	0	90	90
4129	0	0	0
4130	100	100	100
4131	12900	12900	12900
4134	110	110	110
4138	1500	1700	4350
4139	150	150	450
4140	5600	6000	5800
4141	680	650	600
4142	0	0	0
4143	0	0	0
4362	-28572	-30645	-32693
4363	-30495	30820	-26424
4364	28972	31020	26924

(*1) This setting is applied to when the position coder is attached to the spindle.
When using the αiBZ sensor, set bits 3, 2, 1, 0 of parameter No. 4002 to 0, 0, 1, 1, respectively, and set bits 7, 6, 5, 4 of parameter No. 4003 or parameter No. 4361 depending on the number of sensor teeth.
(*2) Since these values are the standard values for the motor alone, they need to be changed as shown below depending on the load state of an actual machine.
Setting = (machine load inertia/motor inertia + 1) * standard value of motor alone

C.12 SPINDLE MOTOR αC*i* series

Motor model		αC1/6000*i*	αC2/6000*i*	αC3/6000*i*	αC6/6000*i*	αC8/6000*i*	αC12/6000*i*	αC15/6000*i*
Applicable amplifier		SPMC-2.2*i*	SPMC-5.5*i*	SPMC-5.5*i*	SPMC-11*i*	SPMC-11*i*	SPMC-15*i*	SPMC-22*i*
Model code (Applicable software series and edition)		240	241	242	243	244	245	246
Output specification / Parameter number		1.5/2.2 kW 3000/6000 min^{-1}	2.2/3.7 kW 1500/6000 min^{-1}	3.7/5.5 kW 1500/6000 min^{-1}	5.5/7.5 kW 1500/6000 min^{-1}	7.5/11 kW 1500/6000 min^{-1}	11/15 kW 1500/6000 min^{-1}	15/18.5 kW 1500/6000 min^{-1}
FS15*i*	FS16*i*							
3001	4001	00000001	00000001	00000001	00000001	00000001	00000001	00000001
3002	4002	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3010	4010	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3011	4011	00011000	00011000	00011000	00011000	00011000	00011000	00011000
3012	4012	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3013	4013	00001100	00001100	00001100	00001100	00001100	01010000	01010000
3019	4019	00000000	00000000	00000000	00000000	00000000	00000000	00000000
3020	4020	6000	6000	6000	6000	6000	6000	6000
3040,3041	4040,4041	50	60	90	50	60	150	120
3042~3045	4042~4045	100	100	150	100	100	250	200
3048,3049	4048,4049	360	240	360	200	240	600	480
3050~3053	4050~4053	600	400	600	400	400	1000	800
3080	4080	90	75	100	80	100	100	100
3083	4083	60	60	60	60	60	60	60
3100	4100	3300	1700	1800	1700	1900	1700	1500
3101	4101	100	100	100	100	100	100	100
3102	4102	4000	2600	1800	2500	1900	1700	1750
3103	4103	91	87	86	73	96	89	53
3104	4104	1300	500	800	400	600	600	500
3105	4105	100	30	30	20	20	15	10
3106	4106	200	200	200	400	200	100	200
3107	4107	1000	800	800	800	800	1000	600
3108	4108	200	200	200	200	200	200	500
3109	4109	25	25	25	25	25	25	25
3110	4110	629	503	419	686	539	808	862
3111	4111	75	188	147	244	202	252	262
3112	4112	200	200	200	200	200	200	200
3113	4113	2439	1192	1077	690	819	311	304
3114	4114	0	0	0	0	0	0	0
3115	4115	100	100	100	100	100	100	100
3116	4116	10494	10580	9938	8803	8118	5000	5177
3117	4117	90	90	32090	90	32090	32090	32090
3118	4118	100	100	110	100	110	110	110
3119	4119	4	8	9	14	12	31	31
3120	4120	15	15	15	15	15	50	50
3124	4124	0	0	0	0	0	0	0
3127	4127	176	202	178	164	176	164	148
3128	4128	0	0	0	0	0	0	0
3129	4129	0	0	0	0	0	0	0
3130	4130	100	100	100	100	100	100	100
3131	4131	5220	12900	12900	12900	10355	5235	5235
3134	4134	110	110	110	130	130	130	130
Maximum output during acceleration (for PS selection)		2.64kW	4.44kW	6.6kW	9.0kW	13.2kW	18.0kW	22.2kW

D LISTS OF ALARMS/STATE ERRORS

D.1 LIST OF SPINDLE ALARMS

This section provides a list of spindle alarms. For details of the alarms and actions to be taken, refer to Part II, “TROUBLESHOOTING”, in “FANUC SERVO MOTOR αi series MAINTENANCE MANUAL (B-65285EN)”.
When two rows are present in the [LED display] field, the upper row indicates SP, PS, and SVSP for specification drawing numbers A06B-61xx-... and the lower row indicates SP, PS, and SVSP for specification drawing numbers A06B-62xx-...

Alarm No.			LED display		Description
15*i*	16*i*	30*i*	SP	PS	
SP097x	749	SP12xx	A		Program ROM error
SP097x	749	SP12xx	A1		Program ROM error
SP097x	749	SP12xx	A2		Program ROM error
SP0001	9001	SP9001	01		Motor overheat
SP0002	9002	SP9002	02		Excessive velocity error
SP0003	9003	SP9003	03		DC link fuse blown
SP0004	9004	SP9004	04	E	Open phase in the converter main power supply
				14	
SP0006	9006	SP9006	06		Temperature sensor disconnected
SP0007	9007	SP9007	07		Overspeed
SP0009	9009	SP9009	09		Main circuit overload/IPM overheat
SP0010	9010	SP9010	10		Low power supply input voltage
SP0011	9011	SP9011	11	7	Converter: DC link overvoltage
				07	
SP0012	9012	SP9012	12		DC link overcurrent/IPM alarm
SP0014	9014	SP9014	14		Amplifier ID not registered
SP098x	750	SP12xx	13		CPU internal data memory error
SP0015	9015	SP9015	15		Speed range switching/spindle switching alarm
	9016	SP9016	16		RAM error
SP0017	9017	SP9017	17		Amplifier ID data error
SP098x	750	SP12xx	18		Program sum check error
SP098x	750	SP12xx	19		Excessive offset of the phase U current detection circuit
SP098x	750	SP12xx	20		Excessive offset of the phase V current detection circuit
SP0021	9021	SP9021	21		Position sensor polarity setting incorrect
SP0022	9022	SP9022	22		Spindle amplifier current overload
SP022x	749	SP12xx	24		Serial communication error
SP0027	9027	SP9027	27		Position coder disconnected
SP0029	9029	SP9029	29		Short-time overload
SP0030	9030	SP9030	30	1	Overcurrent in the converter input circuit
				01	
SP0031	9031	SP9031	31		Motor lock alarm
SP0032	9032	SP9032	32		Serial communication LSI RAM error
SP0033	9033	SP9033	33	5	Converter: DC link precharge failure
				05	
SP0034	9034	SP9034	34		Parameter data out of the specifiable range
SP0035	9035	SP9035	35		Gear ratio parameter error
SP0036	9036	SP9036	36		Error counter overflow
SP0037	9037	SP9037	37		Speed detector parameter error
SP0041	9041	SP9041	41		Position coder one-rotation signal detection error

Alarm No.			LED display		Description
15*i*	16*i*	30*i*	SP	PS	
SP0042	9042	SP9042	42		Position coder one-rotation signal not detected
SP0043	9043	SP9043	43		Position coder signal for differential speed mode disconnected
SP0046	9046	SP9046	46		Position sensor one-rotation signal detection error during thread cutting
SP0047	9047	SP9047	47		Position coder signal error
SP0049	9049	SP9049	49		Overflow of converted motor speed for differential spindle speed control
SP0050	9050	SP9050	50		Excessive speed command calculation value during spindle synchronous control
SP0051	9051	SP9051	51	4	Converter: DC link low voltage
				04	
SP0052	9052	SP9052	52		ITP signal error I
SP0053	9053	SP9053	53		ITP signal error II
SP0054	9054	SP9054	54		Current overload alarm
SP0055	9055	SP9055	55		Abnormal switching status of power leads
SP0056	9056	SP9056	56		Internal cooling fan stopped
SP0057	9057	SP9057	57	H	Converter: excessive deceleration power
				16	
SP0058	9058	SP9058	58	3	Converter: main circuit overload
				03	
SP0059	9059	SP9059	59	2	Converter: cooling fan stopped
				02	
SP0061	9061	SP9061	61		Excessive semi-closed loop/closed loop position error alarm
SP0065	9065	SP9065	65		Abnormal travel distance in magnetic pole determination operation
SP0066	9066	SP9066	66		Communication alarm between SPM's
SP0067	9067	SP9067	67		Reference position return command in the EGB mode
	9069	SP9069	69		Safety speed exceeded
	9070	SP9070	70		Abnormal axis data
	9071	SP9071	71		Abnormal safety parameter
	9072	SP9072	72		Motor speed mismatch
SP0073	9073	SP9073	73		Motor sensor disconnected
	9074	SP9074	74		CPU test alarm
	9075	SP9075	75		CRC test alarm
	9076	SP9076	76		Safety function not executed
	9077	SP9077	77		Axis number mismatch
	9078	SP9078	78		Safety parameter mismatch
	9079	SP9079	79		Abnormal initial test operation
SP0080	9080	SP9080	80		Destination amplifier error in inter-spindle amplifier communication
SP0081	9081	SP9081	81		Motor sensor one-rotation signal detection error
SP0082	9082	SP9082	82		Motor sensor one-rotation signal not detected
SP0083	9083	SP9083	83		Motor sensor signal error
SP0084	9084	SP9084	84		Spindle sensor disconnected
SP0085	9085	SP9085	85		Spindle sensor one-rotation signal detection error
SP0086	9086	SP9086	86		Spindle sensor one-rotation signal not detected
SP0087	9087	SP9087	87		Spindle sensor signal error
SP0088	9088	SP9088	88		Cooling fan stopped of the radiator
SP0089	9089	SP9089	89		Sub module SM (SSM) error
SP0090	9090	SP9090	90		Unexpected rotation alarm
SP0091	9091	SP9091	91		Pole position count miss alarm

Alarm No.			LED display		Description
15*i*	**16*i***	**30*i***	**SP**	**PS**	
SP0092	9092	SP9092	92		Velocity command-dependent *overspeed alarm*
SP0110	9110	SP9110	b0		Communication error between amplifier modules
SP0111	9111	SP9111	b1	6	Converter: control power supply low voltage
				06	
SP0112	9112	SP9112	b2	8	Converter: excessive regenerative power
				08	
SP0113	9113	SP9113	b3	A	Converter: cooling fan stopped of the radiator
				10	
		SP9114	b4		Invalid specification of PS management axis 1
		SP9115	b5		Invalid specification of PS management axis 2
SP0120	9120	SP9120	C0		Communication data alarm
SP0121	9121	SP9121	C1		Communication data alarm
SP0122	9122	SP9122	C2		Communication data alarm
SP0123	9123	SP9123	C3		Spindle switch circuit error
		SP9124	C4		Invalid speed specification during learning control
		SP9125	C5		Invalid dynamic characteristics compensation order during learning control
SP0126	9126	SP9126	C6		Spindle speed exceeded
SP0128	9128	SP9128	C8		Excessive speed deviation alarm on spindle synchronous control
SP0129	9129	SP9129	C9		Excessive positional deviation alarm on spindle synchronous control
SP0130	9130	SP9130	d0		Speed polarity error in torque tandem operation
SP0131	9131	SP9131	d1		Spindle Tuning function alarm
SP0132	9132	SP9132	d2		Serial data error
SP0133	9133	SP9133	d3		Data transfer error
SP0134	9134	SP9134	d4		Soft phase alarm
		SP9135	d5		Safety speed zero monitoring error
		SP9136	d6		Safety speed zero monitoring mismatch
SP0137	9137	SP9137	d7		Device communication error
SP0139	9139	SP9139	d9		Pulse error alarm
SP0140	9140	SP9140	E0		Count error alarm
		SP9141	E1		Serial sensor one-rotation signal not detected
		SP9142	E2		Serial sensor abnormal
		SP9143	E3		Cs axis high-speed switching function command abnormal
		SP9144	E4		Current detection circuit abnormal
		SP9145	E5		Driver voltage low
		SP9146	E6		SP inside overheat
		SP9147	E7		SP ground fault
		SP9148	E8		Axis number not set
		SP9153	F3		SP normal
		SP9154	F4		Phase-to-phase open
		SP9155	F5		SP abnormal（OPEN）
		SP9156	F6		Current control bad
		SP9157	F7		SP abnormal (SHORT)
		SP9160	G0		SP thermistor wire break
		SP9161	G1		Motor power line short-circuited
		SP9200		09	PS ground fault
		SP9201		11	PS input overcurrent 2
		SP9202		12	PS input overcurrent 3
		SP9203		13	PS input overcurrent 4
		SP9204		15	PS soft thermal
		SP9205		17	PS DC link unit overcurrent 2

Alarm No.			LED display		Description
15*i*	16*i*	30*i*	SP	PS	
		SP9206		18	PS DC link unit overcurrent 3
		SP9207		19	PS DC link unit overcurrent 4
		SP9208		20	PS DC link unit low voltage 2
		SP9209		21	PS DC link unit low voltage 3
		SP9210		22	PS DC link unit low voltage 4
		SP9211		23	Invalid PS parameter
		SP9212		24	PS hardware error
			UU		FSSB master port wire break
			LL		FSSB slave port wire break

D.2 LIST OF SPINDLE STATE ERRORS

When a parameter is set incorrectly or a sequence is incorrect, the error LED (yellow) on the indicator of the spindle amplifier (SP) is turned on, and an error code is displayed. The error is also displayed on the diagnosis screen of the CNC.

Diagnostic number			Content
FS15*i*	FS16*i*	FS30*i*	
1561	710 (1st spindle) 711 (2nd spindle) 730 (3rd spindle) 731 (4th spindle)	710	State error number

When the spindle motor malfunctions, check the error code and take action according to the table below.

Indication	Description of error state	Action
01	Although neither *ESP (emergency stop signal; there are two types of signals including the input signal and common power supply (PS) contact signal) nor MRDY (machine ready signal) is input, SFR (forward rotation signal)/SRV (reverse rotation signal)/ORCM (orientation command) is input.	Check the *ESP and MRDY sequence. For MRDY, pay attention to the parameter setting regarding the use of the MRDY signal (bit 0 of parameter No. 4001).
03	Although a parameter setting (bits 3,2,1,0 of No. 4002 = 0,0,0,0) is made to use no position sensor (to exercise no position control), the Cs contouring control command is input. In this case, the motor is not excited.	Check the parameter setting.
04	Although a parameter setting (bits 3,2,1,0 of No. 4002 = 0,0,0,0) is made to use no position sensor (to exercise no position control), a command for servo mode (such as rigid tapping and spindle positioning) or spindle synchronous control is input. In this case, the motor is not excited.	Check the parameter setting.
05	Although the option parameter of the orientation function is not set, the ORCM (orientation command) is input.	Check the parameter setting of the orientation function.
06	Although the option parameter of the speed range switching control function is not set, the low-speed characteristics winding is selected. (RCH=1)	Check the parameter setting of the speed range switching control function and also check the power line state check signal (RCH).

Indication	Description of error state	Action
07	Although the Cs contour control command is specified, SFR(clockwise command) / SRV(counterclockwise command) is not input.	Check the sequence.
08	Although the servo mode (rigid tapping, spindle positioning, etc.) is specified, SFR(clockwise command) / SRV(counterclockwise command) is not input.	Check the sequence.
09	Although spindle synchronous control mode is specified, SFR(clockwise command) / SRV(counterclockwise command) is not input.	Check the sequence.
10	Although Cs contour control mode is set, another mode (servo mode, spindle synchronous control, or orientation) is specified.	During execution of the C-axis control command, do not specify another mode. Before entering another mode, cancel the Cs contour control command.
11	Although servo mode (rigid tapping, or spindle positioning, etc.) is set, another mode (Cs contour control, spindle synchronous control, or orientation) is specified.	During execution of the servo mode command, do not specify another mode. Before entering another mode, cancel the servo mode.
12	Although spindle synchronous control is being performed, another mode (Cs contour control, servo mode, or orientation) is specified.	During execution of the spindle synchronous control command, do not specify another mode. Before entering another mode, cancel the spindle synchronous control command.
13	Although the orientation command is being executed, another mode (Cs contour control, servo mode, or spindle synchronous control) is specified.	During execution of the orientation command, do not specify another mode. Before entering another mode, cancel the orientation command.
14	The SFR(clockwise command) and SRV(counterclockwise command) signals are both input at the same time.	Input the SFR(clockwise command) or SRV(counterclockwise command)signal.
16	Although a parameter setting (bit 5 of parameter No. 4000 = 0) is made to use no differential spindle speed control function, DEFMD (differential speed mode command) is input.	Check the parameter setting and differential speed mode command.
17	Setting of the speed detector parameter (bits 2, 1, and 0 of parameter No. 4011) is invalid. The corresponding speed detector is not present.	Check the parameter setting.
18	Although a parameter setting (bits 3,2,1,0 of No. 4002 = 0,0,0,0) is made to use no position sensor (to exercise no position control), position coder method orientation is specified.	Check the parameter setting and input signal.
19	Although the magnetic sensor method orientation command is specified, another mode (Cs contouring control, servo mode, or spindle synchronous control) is specified.	During the execution of the orientation command, do not specify another mode. Before changing the mode to another mode, cancel the orientation command.
21	A tandem operation command was input when spindle synchronous control is enabled.	Input a tandem operation command after canceling spindle synchronous control.
22	Spindle synchronous control was specified when tandem operation is enabled.	Specify spindle synchronous control after canceling torque tandem operation.
23	A tandem operation command is input even if the option is not specified.	Torque tandem control requires the CNC software option. Check the option.
24	For successive indexing in position coder method orientation, an incremental operation (INCMD = 1) is first performed, then an absolute position command (INCMD = 0) is input.	Check INCMD (incremental command). When specifying the absolute position command successively, be sure to perform absolute position command orientation first.
26	Parameter settings are made to use both spindle switching and three stage speed range switching control.	Check the parameter settings and input signals.

Indication	Description of error state	Action
29	Parameter settings for using the shortest time orientation function (bit 6 of No. 4018 = 0, No. 4320 to No. 4323 ≠ 0) are made.	The shortest time orientation function is unusable with the αi series spindle amplifier. Using optimum orientation function is recommended.
30	The magnetic pole undetected state is set, but a command is input.	In the magnetic pole undetected state (EPFIXA = 0), the motor cannot be driven even if a command is input. Input a command in the magnetic pole detection completed state (EPFIXA = 1). While EPFSTR = 1 is set, a command is ignored even in the magnetic pole detection completed state, and this error is indicated. Upon completion of magnetic pole detection, set EPFSTR = 0.
31	The hardware configuration disables the use of the spindle FAD function. In this case, the motor is not excited.	Check the model of the CNC.
32	Although S0 is not specified for the speed mode, the parameter setting is made to enable the disturbance input function (bit 7 of parameter No. 4395 = 1).	Specify S0 for the speed mode before enabling the disturbance input function (setting bit 7 of parameter No. 4395 to 1).
33	The hardware configuration disables the use of the spindle EGB function. In this case, the motor is not excited.	Check the model of the CNC.
34	Both the spindle FAD function and spindle EGB function are enabled. In this case, the motor is not excited.	The two functions cannot be used at the same time. Enable one of the two functions at a time.
35	ID information of the spindle amplifier cannot be obtained.	Replace the spindle amplifier with one for which correct ID information is written.
36	The sub module SM (SSM) is abnormal. *1) Disconnection of the interface signal between the spindle amplifier and SSM *2) SSM failure	For action to be taken for this error, see Section 1.4, “SUB MODULE SM”, in Part IV.
37	The current loop setting (parameter No. 4012) is changed.	Check the setting of parameter No. 4012, and turn the power off, then on again.
38	Parameters related to inter-spindle amplifier communication are not set correctly, or functions that cannot be used together with the torque tandem function are set.	Check the parameters.
39	DSCN (disconnection detection disable signal) is input in the state where SFR (forward rotation command), SRV (reverse rotation command), or ORCM (orientation command) is input.	Check the sequence. Do not input DSCN (disconnection detection disable signal) while a command for motor activation is input.
43	A setting unavailable with the αiCZ sensor (serial) is made. (*1)	Check the parameters.
44	The spindle amplifier does not support the control frequency setting.	Check the setting of parameter No. 4012.

NOTE

1 If state error 43 is displayed, check the following items. The items to be checked differ depending on the spindle software series and edition.

Series 9D80/E(05), F(06): Items <1> to <12>
Series 9D80/G(07): Items <1> to <9>, <12>, and <13>
Series 9D80/H(08): Items <1> to <9>, <13>, and <14>
Series 9D90/A(01): Items <1> to <9>, <13>, and <14>
Series 9DA0/A(01): Items <1> to <9>, <13>, and <14>

<1> The setting is made so that the αiCZ sensor (serial) is used as both of the motor and spindle sensors. (No.4010#2,1,0=0,1,0 and No.4002#3,2,1,0=0,1,1,0)
<2> Spindle HRV control is not set. (No.4012#7=0)
<3> The use of the differential spindle speed control function is set. (No.4000#5=1)
<4> The use of the spindle switching control function is set. (No.4014#0=1)
<5> The setting is made so that alarms related to position feedback are not detected. (No.4007#6=1 or No.4016#5=0)
<6> The setting is made so that feedback signal disconnection is not detected. (No.4007#5=1)
<7> The setting is made so that alarms related to threading position detection signal feedback are not detected. (No.4016#5=0)
<8> The use of an external one-rotation signal is set. (No.4004#2=1)
<9> The use of a position coder is set. (No.4002#3,2,1,0=0,0,1,0)
<10> The setting is made so that the synchronous built-in spindle motor is driven. (No.4012#6=1)
<11> The use of inter-spindle amplifier communication is set. (No.4352#7=1 or No.4352#6=1)
<12> The use of the dual check safety function is set.
<13> The use of the spindle tandem function is set. (No.4015#3=1)
<14> The use of the αiCZ sensor (serial) as the motor sensor is set and the dual check safety function is enabled.

E TABLE OF I/O SIGNALS RELATED TO SPINDLE CONTROL

E.1 αi SERIES SPINDLE

E.1.1 Input Signals (PMC→CNC)

(1) Series 16*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027	CON			*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
Common to all axes	G038					SPPHS	SPSYC		
Common to all axes	G061								RGTAP
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(2) Series 30*i*

		#7	#6	#5	#4	#3	#2	#1	#0
	G021	SVR08I	SVR07I	SVR06I	SVR05I	SVR04I	SVR03I	SVR02I	SVR01I
	G022	SVSP		SVGN	DFSYC	SVR12I	SVR11I	SVR10I	SVR09I
	G026		*SSTP4 (*1)			SWS4 (*1)		PC4SLC	PC3SLC
	G027	CON		*SSTP3 (*1)	*SSTP2 (*1)	*SSTP1 (*1)	SWS3 (*1)	SWS2 (*1)	SWS1 (*1)
	G028	PC2SLC	SPSTPA	*SCPFA	*SUCPFA		GR12	GR11	
	G029		*SSTP	SOR	SAR	GR32	GR31	GR22	GR21
	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
	G031	PKESS2	PKESS1	GR42	GR41				
Common to all axes	G038					SPPHS	SPSYC	SBRT	
	G061	RGTSP4 (*1)	RGTSP3 (*1)	RGTSP2 (*1)	RGTSP1 (*1)		SYSS		RGTAP
Common to all axes	G064		ESRSYC						
	G122	PKESS2	PKESS1						
	G264					ESSYC4	ESSYC3	ESSYC2	ESSYC1
	G265					PKESE4	PKESE3	PKESE2	PKESE1
	G274	CSFI4	CSFI3	CSFI2	CSFI1	CONS4	CONS3	CONS2	CONS1
	G288					SPSYC4	SPSYC3	SPSYC2	SPSYC1
	G289					SPPHS4	SPPHS3	SPPHS2	SPPHS1
	G351					SSEGB4	SSEGB3	SSEGB2	SSEGB1
	G400					*SUCPFD	*SUCPFC	*SUCPFB	

	G401					*SCPFD	*SCPFC	*SCPFB	
	G402					SPSTPD	SPSTPC	SPSTPB	
	G521	SRVON8	SRVON7	SRVON6	SRVON5	SRVON4	SRVON3	SRVON2	SRVON1
	G523	SVRVS8	SVRVS7	SVRVS6	SVRVS5	SVRVS4	SVRVS3	SVRVS2	SVRVS1
	G533				SSRS	SSR4	SSR3	SSR2	SSR1
	G536	SPSP							

1st-	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
2nd-	G376	SOV27	SOV26	SOV25	SOV24	SOV23	SOV22	SOV21	SOV20
3rd-	G377	SOV37	SOV36	SOV35	SOV34	SOV33	SOV32	SOV31	SOV30
4th-	G378	SOV47	SOV46	SOV45	SOV44	SOV43	SOV42	SOV41	SOV40

1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
3rd-	G036	R08I3	R07I3	R06I3	R05I3	R04I3	R03I3	R02I3	R01I3
4th-	G272	R08I4	R07I4	R06I4	R05I4	R04I4	R03I4	R02I4	R01I4

1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2
3rd-	G037	SIND3	SSIN3	SGN3		R12I3	R11I3	R10I3	R09I3
4th-	G273	SIND4	SSIN4	SGN4		R12I4	R11I4	R10I4	R09I4

1st-	G078	SH07A	SH06A	SH05A	SH04A	SH03A	SH02A	SH01A	SH00A
1st-	G079					SH11A	SH10A	SH09A	SH08A
2nd-	G080	SH07B	SH06B	SH05B	SH04B	SH03B	SH02B	SH01B	SH00B
2nd-	G081					SH11B	SH10B	SH09B	SH08B
3rd-	G208	SH07C	SH06C	SH05C	SH04C	SH03C	SH02C	SH01C	SH00C
3rd-	G209					SH11C	SH10C	SH09C	SH08C
4th-	G270	SH07D	SH06D	SH05D	SH04D	SH03D	SH02D	SH01D	SH00D
4th-	G271					SH11D	SH10D	SH09D	SH08D

NOTE
1 These signals are valid in multi-spindle control.

(3) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G005							FIN	
	G067	SCNTR1							
	G071	SCNTR2							
	:	:							

1st-	G024	RI7A	RI6A	RI5A	RI4A	RI3A	RI2A	RI1A	RI0A
2nd-	G232	RI7B	RI6B	RI5B	RI4B	RI3B	RI2B	RI1B	RI0B

1st-	G025	RISGNA			RI12A	RI11A	RI10A	RI9A	RI8A
2nd-	G233	RISGNB			RI12B	RI11B	RI10B	RI9B	RI8B

1st-	G026		GS4A	GS2A	GS1A				SPSTPA
2nd-	G272		GS4B	GS2B	GS1B				SPSTPA

(4) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA	ORCMA	SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA

2nd-	G235	G074	G074	MRDYB	ORCMB	SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB
3rd-			G204	MRDYC	ORCMC	SFRC	SRVC	CTH1C	CTH2C	TLMHC	TLMLC
4th-			G266	MRDYD	ORCMD	SFRD	SRVD	CTH1D	CTH2D	TLMHD	TLMLD
1st-	G226	G071	G071	RCHA	RSLA	INTGA	SOCNA	MCFNA	SPSLA	*ESPA	ARSTA
2nd-	G234	G075	G075	RCHB	RSLB	INTGB	SOCNB	MCFNB	SPSLB	*ESPB	ARSTB
3rd-			G205	RCHC	RSLC	INTGC	SOCNC	MCFNC	SPSLC	*ESPC	ARSTC
4th-			G267	RCHD	RSLD	INTGD	SOCND	MCFND	SPSLD	*ESPD	ARSTD
1st-	G229	G072	G072	RCHHGA	MFNHGA	INCMDA	OVRA	DEFMDA	NRROA	ROTAA	INDXA
2nd-	G237	G076	G076	RCHHGB	MFNHGB	INCMDB	OVRB	DEFMDB	NRROB	ROTAB	INDXB
3rd-			G206	RCHHGC	MFNHGC	INCMDC	OVRC	DEFMDC	NRROC	ROTAC	INDXC
4th-			G268	RCHHGD	MFNHGD	INCMDD	OVRD	DEFMDD	NRROD	ROTAD	INDXD
1st-	G228	G073	G073				DSCNA	SORSLA	MPOFA	SLVA	
2nd-	G236	G077	G077				DSCNB	SORSLB	MPOFB	SLVB	
3rd-			G207				DSCNC	SORSLC	MPOFC	SLVC	
4th-			G269				DSCND	SORSLD	MPOFD	SLVD	

E.1.2 Output Signals (CNC→PMC)

(1) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O
F044				SYCAL	FSPPH	FSPSY	FSCSL	
F065							RGSPM (*1)	RGSPP (*1)
F076					RTAP			
F094	ZP8	ZP7	ZP6	ZP5	ZP4	ZP3	ZP2	ZP1

NOTE
1 These signals are valid with the M series only.

(2) Series 30*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F001				ENB				
Common to all axes	F002						CSS		
Common to all axes	F007						SF		
Common to all axes	F022	S07	S06	S05	S04	S03	S02	S01	S00
Common to all axes	F023	S15	S14	S13	S12	S11	S10	S09	S08
Common to all axes	F024	S23	S22	S21	S20	S19	S18	S17	S16
Common to all axes	F025	S31	S30	S29	S28	S27	S26	S25	S24

	F034	SRSRDY	SRSP1R	SRSP2R	SRSP3R	SRSP4R	GR3O (*1)	GR2O (*1)	GR1O (*1)
	F038					ENB3	ENB2	SUCLPA	SCLPA
	F035								SPAL
	F039							ENB4	MSPOSA
	F043					SYCAL4	SYCAL3	SYCAL2	SYCAL1
Common to all axes	F044				SYCAL	FSPPH	FSPSY	FSCSL	
Common to all axes	F065						RSMAX	RGSPM (*1)	RGSPP (*1)
Common to all axes	F076					RTAP			
	F090	SVSPM	SVAR	SYSSM	SYAR				
Common to all axes	F094	ZP8	ZP7	ZP6	ZP5	ZP4	ZP3	ZP2	ZP1
Common to all axes	F160	MSP07	MSP06	MSP05	MSP04	MSP03	MSP02	MSP01	MSP00
Common to all axes	F161	MSP15	MSP14	MSP13	MSP12	MSP11	MSP10	MSP09	MSP08
Common to all axes	F264	SPWRN8	SPWRN7	SPWRN6	SPWRN5	SPWRN4	SPWRN3	SPWRN2	SPWRN1
Common to all axes	F265								SPWRN9
	F274	CSFO4	CSFO3	CSFO2	CSFO1	FCSS4	FCSS3	FCSS2	FCSS1
	F288					FSPSY4	FSPSY3	FSPSY2	FSPSY1
	F289					FSPPH4	FSPPH3	FSPPH2	FSPPH1
	F351					SSEGBM 4	SSEGBM 3	SSEGBM 2	SSEGBM 1
	F376	SVSST8	SVSST7	SVSST6	SVSST5	SVSST4	SVSST3	SVSST2	SVSST1
	F377	SVSAR8	SVSAR7	SVSAR6	SVSAR5	SVSAR4	SVSAR3	SVSAR2	SVSAR1
	F400					SUCLPD	SUCLPC	SUCLPB	
	F401					SCLPD	SCLPC	SCLPB	
	F402					MSPOSD	MSPOSC	MSPOSB	
	F521	SVREV8	SVREV7	SVREV6	SVREV5	SVREV4	SVREV3	SVREV2	SVREV1
	F522	SPP8	SPP7	SPP6	SPP5	SPP4	SPP3	SPP2	SPP1

1st-	F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
1st-	F037					R12O	R11O	R10O	R09O
2nd-	F200	R08O2	R07O2	R06O2	R05O2	R04O2	R03O2	R02O2	R01O2
2nd-	F201					R12O2	R11O2	R10O2	R09O2
3rd-	F204	R08O3	R07O3	R06O3	R05O3	R04O3	R03O3	R02O3	R01O3
3rd-	F205					R12O3	R11O3	R10O3	R09O3
4th-	F270	R08O4	R07O4	R06O4	R05O4	R04O4	R03O4	R02O4	R01O4
4th-	F271					R12O4	R11O4	R10O4	R09O4

1st-	F040	AR07	AR06	AR05	AR04	AR03	AR02	AR01	AR00
1st-	F041	AR15	AR14	AR13	AR12	AR11	AR10	AR09	AR08
2nd-	F202	AR072	AR062	AR052	AR042	AR032	AR022	AR012	AR002
2nd-	F203	AR152	AR142	AR132	AR122	AR112	AR102	AR092	AR082
3rd-	F206	AR073	AR063	AR053	AR043	AR033	AR023	AR013	AR003
3rd-	F207	AR153	AR143	AR133	AR123	AR113	AR103	AR093	AR083
4th-	F272	AR074	AR064	AR054	AR044	AR034	AR024	AR014	AR004
4th-	F273	AR154	AR144	AR134	AR124	AR114	AR104	AR094	AR084

1st-	F045		TLMA	LDT2A	LDT1A				
2nd-	F049		TLMB	LDT2B	LDT1B				
3rd-	F168		TLMC	LDT2C	LDT1C				
4th-	F266		TLMC	LDT2D	LDT1D				

1st-	F048				CSPENA				
2nd-	F052				CSPENB				

		#7	#6	#5	#4	#3	#2	#1	#0
3rd-	F171				CSPENC				
4th-	F269				CSPEND				

NOTE
1 These signals are valid with the M series only.

(3) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F008							SF	
Common to all axes	F020	S7	S6	S5	S4	S3	S2	S1	S0
Common to all axes	F021	S15	S14	S13	S12	S11	S10	S09	S08
Common to all axes	F022	S23	S22	S21	S20	S19	S18	S17	S16
Common to all axes	F023	S31	S30	S29	S28	S27	S26	S25	S24
Common to all axes	F040				RTAP				
Common to all axes	F045			SRSRDY					
	F064								ZP1
	F068								ZP2
	:								:
	F067	MSCNTR1							
	F071	MSCNTR2							
	:	:							
Common to all axes	F155						RSPC	RSPM	RSPP
1st-	F010	RO7A	RO6A	RO5A	RO4A	RO3A	RO2A	RO1A	RO0A
2nd-	F320	RO7B	RO6B	RO5B	RO4B	RO3B	RO2B	RO1B	RO0B
1st-	F011	RO15A	RO14A	RO13A	RO12A	RO11A	RO11A	RO10A	RO9A
2nd-	F321	RO15B	RO14B	RO13B	RO12B	RO11B	RO11B	RO10B	RO9B
1st-	F014	MR7A	MR6A	MR5A	MR4A	MR3A	MR2A	MR1A	MR0A
2nd-	F324	MR7B	MR6B	MR5B	MR4B	MR3B	MR2B	MR1B	MR0B
1st-	F015	MR15A	MR14A	MR13A	MR12A	MR11A	MR10A	MR9A	MR8A
2nd-	F325	MR15B	MR14B	MR13B	MR12B	MR11B	MR10B	MR9B	MR8B
1st-	F234	SSPD7A	SSPD6A	SSPD5A	SSPD4A	SSPD3A	SSPD2A	SSPD1A	SSPD0A
2nd-	F250	SSPD7B	SSPD6B	SSPD5B	SSPD4B	SSPD3B	SSPD2B	SSPD1B	SSPD0B
1st-	F235	SSPD15A	SSPD14A	SSPD13A	SSPD12A	SSPD11A	SSPD10A	SSPD9A	SSPD8A
2nd-	F251	SSPD15B	SSPD14B	SSPD13B	SSPD12B	SSPD11B	SSPD10B	SSPD9B	SSPD8B
1st-	F341								SRRDYA
2nd-	F342								SRRDYB

(4) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA	TLMA	LDT2A	LDT1A	SARA	SDTA	SSTA	ALMA
2nd-	F245	F049	F049	ORARB	TLMB	LDT2B	LDT1B	SARB	SDTB	SSTB	ALMB
3rd-			F168	ORARC	TLMC	LDT2C	LDT1C	SARC	SDTC	SSTC	ALMC
4th-			F266	ORARD	TLMD	LDT2D	LDT1D	SARD	SDTD	SSTD	ALMD
1st-	F228	F046	F046				SLVSA	RCFNA	RCHPA	CFINA	CHPA
2nd-	F244	F050	F050				SLVSB	RCFNB	RCHPB	CFINB	CHPB

				#7	#6	#5	#4	#3	#2	#1	#0
3rd-			F169				SLVSC	RCFNC	RCHPC	CFINC	CHPC
4th-			F267				SLVSD	RCFND	RCHPD	CFIND	CHPD

				#7	#6	#5	#4	#3	#2	#1	#0
1st-	F231	F047	F047				EXOFA	SORENA		INCSTA	PC1DTA
2nd-	F247	F051	F051				EXOFB	SORENB		INCSTB	PC1DTB
3rd-			F170				EXOFC	SORENC		INCSTC	PC1DTC
4th-			F268				EXOFD	SOREND		INCSTD	PC1DTD

				#7	#6	#5	#4	#3	#2	#1	#0
1st-	F230	F048	F048				CSPENA				
2nd-	F246	F052	F052				CSPENB				
3rd-			F171				CSPENC				
4th-			F269				CSPEND				

E.2 αC*i* SERIES SPINDLE

E.2.1 Input Signals (PMC→CNC)

(1) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
G028						GR2	GR1	
G029		*SSTP	SOR	SAR				
G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
G038					SPPHS	SPSYC		
G061								RGTAP

NOTE
1 These signals are valid in multi-spindle control.

(2) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
G027				*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
G028						GR2	GR1	
G029		*SSTP	SOR	SAR				
G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
G038					SPPHS	SPSYC		
G061								RGTAP

NOTE
1 These signals are valid in multi-spindle control.

(3) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G005							FIN	

	G067	SCNTR1							
	G071	SCNTR2							
	:	:							
1st-	G024	RI7A	RI6A	RI5A	RI4A	RI3A	RI2A	RI1A	RI0A
2nd-	G232	RI7B	RI6B	RI5B	RI4B	RI3B	RI2B	RI1B	RI0B
1st-	G025	RISGNA			RI12A	RI11A	RI10A	RI9A	RI8A
2nd-	G233	RISGNB			RI12B	RI11B	RI10B	RI9B	RI8B
1st-	G026		GS4A	GS2A	GS1A				SPSTPA
2nd-	G272		GS4B	GS2B	GS1B				SPSTPA

(4) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA	ORCMA	SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA (*1)
2nd-	G235	G074	G074	MRDYB	ORCMB	SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB (*1)
1st-	G226	G071	G071			INTGA				*ESPA	ARSTA
2nd-	G234	G075	G075			INTGB				*ESPB	ARSTB
1st-	G229	G072	G072			INCMDA	OVRA		NRROA	ROTAA	INDXA
2nd-	G237	G076	G076			INCMDB	OVRB		NRROB	ROTAB	INDXB
1st-	G228	G073	G073						MPOFA		
2nd-	G236	G077	G077						MPOFB		

NOTE

1 The signal functions of the αC*i* series differ from those of the α*i* series. For details, see Chapter 3, "I/O SIGNALS (CNC↔PMC)", in Part III.

E.2.2 Output Signals (CNC→PMC)

(1) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O
F044				SYCAL	FSPPH	FSPSY	FSCSL	
F065							RGSPM (*1)	RGSPP (*1)
F076					RTAP			
F094	ZP8	ZP7	ZP6	ZP5	ZP4	ZP3	ZP2	ZP1

NOTE
1 These signals are valid with the M series only.

(2) Series 30*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O
F044				SYCAL	FSPPH	FSPSY	FSCSL	
F065							RGSPM (*1)	RGSPP (*1)
F076					RTAP			
F094	ZP8	ZP7	ZP6	ZP5	ZP4	ZP3	ZP2	ZP1

NOTE
1 These signals are valid with the M series only.

(3) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F008							SF	
Common to all axes	F020	S7	S6	S5	S4	S3	S2	S1	S0
Common to all axes	F021	S15	S14	S13	S12	S11	S10	S09	S08
Common to all axes	F022	S23	S22	S21	S20	S19	S18	S17	S16
Common to all axes	F023	S31	S30	S29	S28	S27	S26	S25	S24
Common to all axes	F040				RTAP				
Common to all axes	F045			SRSRDY					
	F064								ZP1
	F068								ZP2
	:								:
	F067	MSCNTR1							
	F071	MSCNTR2							
	:	:							
Common to all axes	F155						RSPC	RSPM	RSPP

1st-	F010	RO7A	RO6A	RO5A	RO4A	RO3A	RO2A	RO1A	RO0A
2nd-	F320	RO7B	RO6B	RO5B	RO4B	RO3B	RO2B	RO1B	RO0B

1st-	F011	RO15A	RO14A	RO13A	RO12A	RO11A	RO11A	RO10A	RO9A
2nd-	F321	RO15B	RO14B	RO13B	RO12B	RO11B	RO11B	RO10B	RO9B

1st-	F014	MR7A	MR6A	MR5A	MR4A	MR3A	MR2A	MR1A	MR0A
2nd-	F324	MR7B	MR6B	MR5B	MR4B	MR3B	MR2B	MR1B	MR0B

1st-	F015	MR15A	MR14A	MR13A	MR12A	MR11A	MR10A	MR9A	MR8A
2nd-	F325	MR15B	MR14B	MR13B	MR12B	MR11B	MR10B	MR9B	MR8B

		#7	#6	#5	#4	#3	#2	#1	#0
1st-	F234	SSPD7A	SSPD6A	SSPD5A	SSPD4A	SSPD3A	SSPD2A	SSPD1A	SSPD0A
2nd-	F250	SSPD7B	SSPD6B	SSPD5B	SSPD4B	SSPD3B	SSPD2B	SSPD1B	SSPD0B
1st-	F235	SSPD15A	SSPD14A	SSPD13A	SSPD12A	SSPD11A	SSPD10A	SSPD9A	SSPD8A
2nd-	F251	SSPD15B	SSPD14B	SSPD13B	SSPD12B	SSPD11B	SSPD10B	SSPD9B	SSPD8B
1st-	F341								SRRDYA
2nd-	F342								SRRDYB

(4) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA	TLMA		LDT1A	SARA	SDTA	SSTA	ALMA
2nd-	F245	F049	F049	ORARB	TLMB		LDT1B	SARB	SDTB	SSTB	ALMB
1st-	F231	F047	F047							INCSTA	PC1DTA
2nd-	F247	F051	F051							INCSTB	PC1DTB

E.3 B*i*S SERIES SPINDLE

E.3.1 Input Signals (PMC→CNC)

(1) Series 16*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G027	CON			*SSTP2 (*1)	*SSTP1 (*1)		SWS2 (*1)	SWS1 (*1)
Common to all axes	G028						GR2	GR1	
Common to all axes	G029		*SSTP	SOR	SAR				
Common to all axes	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
Common to all axes	G038					SPPHS	SPSYC		
Common to all axes	G061								RGTAP
1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2

NOTE
1 These signals are valid in multi-spindle control.

(2) Series 30*i*

		#7	#6	#5	#4	#3	#2	#1	#0
	G021	SVR08I	SVR07I	SVR06I	SVR05I	SVR04I	SVR03I	SVR02I	SVR01I
	G022	SVSP		SVGN	DFSYC	SVR12I	SVR11I	SVR10I	SVR09I
Common to all axes	G026		*SSTP4 (*1)			SWS4 (*1)		PC4SLC	PC3SLC

	G027	CON		*SSTP3 (*1)	*SSTP2 (*1)	*SSTP1 (*1)	SWS3 (*1)	SWS2 (*1)	SWS1 (*1)
	G028	PC2SLC	SPSTPA	*SCPFA	*SUCPFA		GR12	GR11	
	G029		*SSTP	SOR	SAR	GR32	GR31	GR22	GR21
	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
	G031	PKESS2	PKESS1	GR42	GR41				
Common to all axes	G038					SPPHS	SPSYC	SBRT	
	G061	RGTSP4 (*1)	RGTSP3 (*1)	RGTSP2 (*1)	RGTSP1 (*1)		SYSS		RGTAP
Common to all axes	G064		ESRSYC						
	G122	PKESS2	PKESS1						
	G264					ESSYC4	ESSYC3	ESSYC2	ESSYC1
	G265					PKESE4	PKESE3	PKESE2	PKESE1
	G274	CSFI4	CSFI3	CSFI2	CSFI1	CONS4	CONS3	CONS2	CONS1
	G288					SPSYC4	SPSYC3	SPSYC2	SPSYC1
	G289					SPPHS4	SPPHS3	SPPHS2	SPPHS1
	G351					SSEGB4	SSEGB3	SSEGB2	SSEGB1
	G400					*SUCPFD	*SUCPFC	*SUCPFB	
	G401					*SCPFD	*SCPFC	*SCPFB	
	G402					SPSTPD	SPSTPC	SPSTPB	
	G521	SRVON8	SRVON7	SRVON6	SRVON5	SRVON4	SRVON3	SRVON2	SRVON1
	G523	SVRVS8	SVRVS7	SVRVS6	SVRVS5	SVRVS4	SVRVS3	SVRVS2	SVRVS1
	G533				SSRS	SSR4	SSR3	SSR2	SSR1
	G536	SPSP							

1st-	G030	SOV7	SOV6	SOV5	SOV4	SOV3	SOV2	SOV1	SOV0
2nd-	G376	SOV27	SOV26	SOV25	SOV24	SOV23	SOV22	SOV21	SOV20
3rd-	G377	SOV37	SOV36	SOV35	SOV34	SOV33	SOV32	SOV31	SOV30
4th-	G378	SOV47	SOV46	SOV45	SOV44	SOV43	SOV42	SOV41	SOV40

1st-	G032	R08I	R07I	R06I	R05I	R04I	R03I	R02I	R01I
2nd-	G034	R08I2	R07I2	R06I2	R05I2	R04I2	R03I2	R02I2	R01I2
3rd-	G036	R08I3	R07I3	R06I3	R05I3	R04I3	R03I3	R02I3	R01I3
4th-	G272	R08I4	R07I4	R06I4	R05I4	R04I4	R03I4	R02I4	R01I4

1st-	G033	SIND	SSIN	SGN		R12I	R11I	R10I	R09I
2nd-	G035	SIND2	SSIN2	SGN2		R12I2	R11I2	R10I2	R09I2
3rd-	G037	SIND3	SSIN3	SGN3		R12I3	R11I3	R10I3	R09I3
4th-	G273	SIND4	SSIN4	SGN4		R12I4	R11I4	R10I4	R09I4

1st-	G078	SH07A	SH06A	SH05A	SH04A	SH03A	SH02A	SH01A	SH00A
1st-	G079					SH11A	SH10A	SH09A	SH08A
2nd-	G080	SH07B	SH06B	SH05B	SH04B	SH03B	SH02B	SH01B	SH00B
2nd-	G081					SH11B	SH10B	SH09B	SH08B
3rd-	G208	SH07C	SH06C	SH05C	SH04C	SH03C	SH02C	SH01C	SH00C
3rd-	G209					SH11C	SH10C	SH09C	SH08C
4th-	G270	SH07D	SH06D	SH05D	SH04D	SH03D	SH02D	SH01D	SH00D
4th-	G271					SH11D	SH10D	SH09D	SH08D

NOTE

1 These signals are valid in multi-spindle control.

(3) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	G005							FIN	
	G067	SCNTR1							
	G071	SCNTR2							
	:	:							
1st-	G024	RI7A	RI6A	RI5A	RI4A	RI3A	RI2A	RI1A	RI0A
2nd-	G232	RI7B	RI6B	RI5B	RI4B	RI3B	RI2B	RI1B	RI0B
1st-	G025	RISGNA			RI12A	RI11A	RI10A	RI9A	RI8A
2nd-	G233	RISGNB			RI12B	RI11B	RI10B	RI9B	RI8B
1st-	G026		GS4A	GS2A	GS1A				SPSTPA
2nd-	G272		GS4B	GS2B	GS1B				SPSTPA

(4) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	G227	G070	G070	MRDYA	ORCMA	SFRA	SRVA	CTH1A	CTH2A	TLMHA	TLMLA
2nd-	G235	G074	G074	MRDYB	ORCMB	SFRB	SRVB	CTH1B	CTH2B	TLMHB	TLMLB
3rd-			G204	MRDYC	ORCMC	SFRC	SRVC	CTH1C	CTH2C	TLMHC	TLMLC
4th-			G266	MRDYD	ORCMD	SFRD	SRVD	CTH1D	CTH2D	TLMHD	TLMLD
1st-	G226	G071	G071			INTGA	SOCNA			*ESPA	ARSTA
2nd-	G234	G075	G075			INTGB	SOCNB			*ESPB	ARSTB
3rd-			G205			INTGC	SOCNC			*ESPC	ARSTC
4th-			G267			INTGD	SOCND			*ESPD	ARSTD
1st-	G229	G072	G072			INCMDA	OVRA	DEFMDA	NRROA	ROTAA	INDXA
2nd-	G237	G076	G076			INCMDB	OVRB	DEFMDB	NRROB	ROTAB	INDXB
3rd-			G206			INCMDC	OVRC	DEFMDC	NRROC	ROTAC	INDXC
4th-			G268			INCMDD	OVRD	DEFMDD	NRROD	ROTAD	INDXD
1st-	G228	G073	G073	EPFSTRA			DSCNA	SORSLA	MPOFA		
2nd-	G236	G077	G077	EPFSTRB			DSCNB	SORSLB	MPOFB		
3rd-			G207	EPFSTRC			DSCNC	SORSLC	MPOFC		
4th-			G269	EPFSTRD			DSCND	SORSLD	MPOFD		

E.3.2 Output Signals (CNC→PMC)

(1) Series 16*i*

	#7	#6	#5	#4	#3	#2	#1	#0
F001				ENB				
F007						SF		
F022	S07	S06	S05	S04	S03	S02	S01	S00
F023	S15	S14	S13	S12	S11	S10	S09	S08
F024	S23	S22	S21	S20	S19	S18	S17	S16
F025	S31	S30	S29	S28	S27	S26	S25	S24
F034						GR3O (*1)	GR2O (*1)	GR1O (*1)
F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
F037					R12O	R11O	R10O	R09O
F044				SYCAL	FSPPH	FSPSY	FSCSL	

F065							RGSPM (*1)	RGSPP (*1)
F076					RTAP			
F094	ZP8	ZP7	ZP6	ZP5	ZP4	ZP3	ZP2	ZP1

NOTE
1 These signals are valid with the M series only.

(2) Series 30*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F001				ENB				
Common to all axes	F002						CSS		
Common to all axes	F007						SF		
Common to all axes	F022	S07	S06	S05	S04	S03	S02	S01	S00
Common to all axes	F023	S15	S14	S13	S12	S11	S10	S09	S08
Common to all axes	F024	S23	S22	S21	S20	S19	S18	S17	S16
Common to all axes	F025	S31	S30	S29	S28	S27	S26	S25	S24
	F034	SRSRDY	SRSP1R	SRSP2R	SRSP3R	SRSP4R	GR3O (*1)	GR2O (*1)	GR1O (*1)
	F038					ENB3	ENB2	SUCLPA	SCLPA
	F035								SPAL
	F039							ENB4	MSPOSA
	F043					SYCAL4	SYCAL3	SYCAL2	SYCAL1
Common to all axes	F044				SYCAL	FSPPH	FSPSY	FSCSL	
Common to all axes	F065						RSMAX	RGSPM (*1)	RGSPP (*1)
Common to all axes	F076					RTAP			
Common to all axes	F090	SVSPM	SVAR	SYSSM	SYAR				
Common to all axes	F094	ZP8	ZP7	ZP6	ZP5	ZP4	ZP3	ZP2	ZP1
Common to all axes	F160	MSP07	MSP06	MSP05	MSP04	MSP03	MSP02	MSP01	MSP00
Common to all axes	F161	MSP15	MSP14	MSP13	MSP12	MSP11	MSP10	MSP09	MSP08
Common to all axes	F264	SPWRN8	SPWRN7	SPWRN6	SPWRN5	SPWRN4	SPWRN3	SPWRN2	SPWRN1
Common to all axes	F265								SPWRN9
	F274	CSFO4	CSFO3	CSFO2	CSFO1	FCSS4	FCSS3	FCSS2	FCSS1
	F288					FSPSY4	FSPSY3	FSPSY2	FSPSY1
	F289					FSPPH4	FSPPH3	FSPPH2	FSPPH1
	F351					SSEGBM 4	SSEGBM 3	SSEGBM 2	SSEGBM 1
	F376	SVSST8	SVSST7	SVSST6	SVSST5	SVSST4	SVSST3	SVSST2	SVSST1
	F377	SVSAR8	SVSAR7	SVSAR6	SVSAR5	SVSAR4	SVSAR3	SVSAR2	SVSAR1
	F400					SUCLPD	SUCLPC	SUCLPB	
	F401					SCLPD	SCLPC	SCLPB	
	F402					MSPOSD	MSPOSC	MSPOSB	
	F521	SVREV8	SVREV7	SVREV6	SVREV5	SVREV4	SVREV3	SVREV2	SVREV1
	F522	SPP8	SPP7	SPP6	SPP5	SPP4	SPP3	SPP2	SPP1

1st-	F036	R08O	R07O	R06O	R05O	R04O	R03O	R02O	R01O
1st-	F037					R12O	R11O	R10O	R09O
2nd-	F200	R08O2	R07O2	R06O2	R05O2	R04O2	R03O2	R02O2	R01O2
2nd-	F201					R12O2	R11O2	R10O2	R09O2
3rd-	F204	R08O3	R07O3	R06O3	R05O3	R04O3	R03O3	R02O3	R01O3
3rd-	F205					R12O3	R11O3	R10O3	R09O3
4th-	F270	R08O4	R07O4	R06O4	R05O4	R04O4	R03O4	R02O4	R01O4
4th-	F271					R12O4	R11O4	R10O4	R09O4

1st-	F040	AR07	AR06	AR05	AR04	AR03	AR02	AR01	AR00
1st-	F041	AR15	AR14	AR13	AR12	AR11	AR10	AR09	AR08
2nd-	F202	AR072	AR062	AR052	AR042	AR032	AR022	AR012	AR002
2nd-	F203	AR152	AR142	AR132	AR122	AR112	AR102	AR092	AR082
3rd-	F206	AR073	AR063	AR053	AR043	AR033	AR023	AR013	AR003
3rd-	F207	AR153	AR143	AR133	AR123	AR113	AR103	AR093	AR083
4th-	F272	AR074	AR064	AR054	AR044	AR034	AR024	AR014	AR004
4th-	F273	AR154	AR144	AR134	AR124	AR114	AR104	AR094	AR084

1st-	F045		TLMA	LDT2A	LDT1A				
2nd-	F049		TLMB	LDT2B	LDT1B				
3rd-	F168		TLMC	LDT2C	LDT1C				
4th-	F266		TLMC	LDT2D	LDT1D				

1st-	F048				CSPENA				
2nd-	F052				CSPENB				
3rd-	F171				CSPENC				
4th-	F269				CSPEND				

NOTE
1 These signals are valid with the M series only.

(3) Series 15*i*

		#7	#6	#5	#4	#3	#2	#1	#0
Common to all axes	F008							SF	
Common to all axes	F020	S7	S6	S5	S4	S3	S2	S1	S0
Common to all axes	F021	S15	S14	S13	S12	S11	S10	S09	S08
Common to all axes	F022	S23	S22	S21	S20	S19	S18	S17	S16
Common to all axes	F023	S31	S30	S29	S28	S27	S26	S25	S24
Common to all axes	F040				RTAP				
Common to all axes	F045			SRSRDY					
	F064								ZP1
	F068								ZP2
	:								:
	F067	MSCNTR1							
	F071	MSCNTR2							
	:	:							
Common to all axes	F155						RSPC	RSPM	RSPP

1st-	F010	RO7A	RO6A	RO5A	RO4A	RO3A	RO2A	RO1A	RO0A
2nd-	F320	RO7B	RO6B	RO5B	RO4B	RO3B	RO2B	RO1B	RO0B
1st-	F11	RO15A	RO14A	RO13A	RO12A	RO11A	RO11A	RO10A	RO9A
2nd-	F321	RO15B	RO14B	RO13B	RO12B	RO11B	RO11B	RO10B	RO9B

1st-	F014	MR7A	MR6A	MR5A	MR4A	MR3A	MR2A	MR1A	MR0A
2nd-	F324	MR7B	MR6B	MR5B	MR4B	MR3B	MR2B	MR1B	MR0B

1st-	F015	MR15A	MR14A	MR13A	MR12A	MR11A	MR10A	MR9A	MR8A
2nd-	F325	MR15B	MR14B	MR13B	MR12B	MR11B	MR10B	MR9B	MR8B

1st-	F234	SSPD7A	SSPD6A	SSPD5A	SSPD4A	SSPD3A	SSPD2A	SSPD1A	SSPD0A
2nd-	F250	SSPD7B	SSPD6B	SSPD5B	SSPD4B	SSPD3B	SSPD2B	SSPD1B	SSPD0B

		#7	#6	#5	#4	#3	#2	#1	#0
1st-	F235	SSPD15A	SSPD14A	SSPD13A	SSPD12A	SSPD11A	SSPD10A	SSPD9A	SSPD8A
2nd-	F251	SSPD15B	SSPD14B	SSPD13B	SSPD12B	SSPD11B	SSPD10B	SSPD9B	SSPD8B

		#7	#6	#5	#4	#3	#2	#1	#0
1st-	F341								SRRDYA
2nd-	F342								SRRDYB

(4) Common to CNCs

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F229	F045	F045	ORARA	TLMA	LDT2A	LDT1A	SARA	SDTA	SSTA	ALMA
2nd-	F245	F049	F049	ORARB	TLMB	LDT2B	LDT1B	SARB	SDTB	SSTB	ALMB
3rd-			F168	ORARC	TLMC	LDT2C	LDT1C	SARC	SDTC	SSTC	ALMC
4th-			F266	ORARD	TLMD	LDT2D	LDT1D	SARD	SDTD	SSTD	ALMD

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F231	F047	F047				EXOFA	SORENA		INCSTA	PC1DTA
2nd-	F247	F051	F051				EXOFB	SORENB		INCSTB	PC1DTB
3rd-			F170				EXOFC	SORENC		INCSTC	PC1DTC
4th-			F268				EXOFD	SOREND		INCSTD	PC1DTD

	15*i*	16*i*	30*i*	#7	#6	#5	#4	#3	#2	#1	#0
1st-	F230	F048	F048	EPFIXA			CSPENA	SSMBRKA			
2nd-	F246	F052	F052	EPFIXB			CSPENB	SSMBRKB			
3rd-			F171	EPFIXC			CSPENC	SSMBRKC			
4th-			F269	EPFIXD			CSPEND	SSMBRKD			

F OBSERVING DATA USING THE SERVO GUIDE

Using the servo adjustment tool, SERVO GUIDE, enables you to observe internal data for the spindle.
This Appendix F describes the spindle data that can be observed using the SERVO GUIDE. It also presents examples of observed data. Refer to FANUC SERVO GUIDE OPERATOR'S MANUAL (B-65404EN) online help for detailed explanations about how to use the SERVO GUIDE.

F.1 SERIES AND EDITIONS OF APPLICABLE SPINDLE SOFTWARE

9D50 series B (02) edition or later
9D53 series A (01) edition or later
9D70 series A (01) edition or later
9D80 series A (01) edition or later
9D90 series A (01) edition or later
9DA0 series A (01) edition or later

F.2 SPINDLE DATA THAT CAN BE OBSERVED USING THE SERVO GUIDE

F.2.1 Data List

The following table lists the spindle data that can be observed using the SERVO GUIDE.

Data type	Description	Description
SPEED	Motor speed	
INORM	Motor current amplitude	
TCMD	Torque command	
VCMD	Motor speed command	
VERR	Speed deviation	
MCMD	Move command for an individual communication cycle	
ERR	Position error	9D50 series 11 edition or later *1
ERRC	Position error (CNC)	
SYNC	Synchronous error	9D50 series 11 edition or later *1
ORERR	Position error at orientation	
ORSEQ	Orientation sequence data	
PCPOS	Cumulative position feedback value	
CSPOS	Cumulative position feedback value	
WMDAT	Move command for an individual position loop	
ERR2	Position error 2	
ERR2C	Position error 2 (CNC)	9D50 series 11 edition or later *1
SPCMD	Speed command data from the CNC	
SPSPD	Spindle speed	9D50 series 11 edition or later *1
SPCT1	Spindle control signal 1	
SPCT2	Spindle control signal 2	
SPCT3	Spindle control signal 3	9D50 series 11 edition or later *1

Data type	Description	Description
SPST1	Spindle status signal 1	
SPST2	Spindle status signal 2	
SFLG1	Spindle flag 1	9D50 series 11 edition or later *1
SPPOS	Spindle position data	9D50 series 12 edition or later *2
LMDAT	Load meter data	9D50 series 11 edition or later *1
DTRQ	Spindle load torque (unexpected disturbance torque detection function)	9D50 series 11 edition or later *1
FREQ	Frequency of a disturbance torque command (disturbance input function)	9D50 series 11 edition or later *1
GAIN	Gain (disturbance input function)	9D50 series 11 edition or later *1
MTTMP	Motor winding temperature	9D50 series 11 edition or later *1
MFBDF	Feedback differential data on the motor side (for amplitude ratio/phase difference compensation adjustment)	9D50 series 11 edition or later *1
SFBDF	Feedback differential data on the spindle side (for amplitude ratio/phase difference compensation adjustment)	9D50 series 11 edition or later *1
PA1	A/D value of motor sensor phase A	9D50 series 11 edition or later *1
PB1	A/D value of motor sensor phase B	9D50 series 11 edition or later *1
PA2	A/D value of spindle sensor phase A	9D50 series 11 edition or later *1
PB2	A/D value of spindle sensor phase B	9D50 series 11 edition or later *1
VDC	DC link voltage	9D50 series 11 edition or later *1
SFERR	Semi-closed loop/closed loop difference (Dual position feedback function)	9D50 series 11 edition or later *1
SMERR	Positional deviation on the semi-closed loop side (Dual position feedback function)	9D50 series 11 edition or later *1
SPACC	Spindle acceleration data	9D50 series 20 edition or later *4

NOTE

1. Valid with 9D53 series 03 edition or later, valid with 9D70 series 02 edition or later, valid with 9D80 series 01 edition or later, valid with 9D90 series 01 edition or later, and valid with 9DA0 series 01 edition or later
2. Valid with 9D53 series 04 edition or later, valid with 9D70 series 03 edition or later, valid with 9D80 series 01 edition or later, valid with 9D90 series 01 edition or later, and valid with 9DA0 series 01 edition or later
3. To observe data marked with *1 and *2, Servo Guide Ver. 3.0 or later is needed.
4. Valid with 9D70 series 10 edition or later, valid with 9D80 series 04 edition or later, valid with 9D90 series 01 edition or later, and valid with 9DA0 series 01 edition or later. To observe data, Servo Guide Ver. 4.10 or later is needed.

F.2.2 About the Spindle Speed Control and Spindle Status Signals

As stated in the previous item, the SERVO GUIDE can be used to observe the PMC signals (spindle speed control signals 1 and 2 and spindle status signals 1 and 2) used by the spindle.
Listed below is the data configuration for spindle speed control signals 1 and 2 and spindle status signals 1 and 2. Refer to Chapter 3, “I/O SIGNALS (CNC↔PMC)”, in each part for explanations about each signal.

(a) Spindle speed control signal 1 (SPCT1)

#15	#14	#13	#12	#11	#10	#9	#8
RCH	RSL	INTG	SOCN	MCFN	SPSL	*ESP	ARST
#7	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**
MRDY	ORCM	SFR	SRV	CTH1	CTH2	TLMH	TLML

(b) Spindle speed control signal 2 (SPCT2)

#15	#14	#13	#12	#11	#10	#9	#8
			DSCN	SORSL	MPOF	SLV	
#7	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**
RCHHG	MFNHG	INCMD	OVR	DEFMD	NRRO	ROTA	INDX

(c) Spindle speed control signal 3 (SPCT3)

#15	#14	#13	#12	#11	#10	#9	#8
#7	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**

(d) Spindle status signal 1 (SPST1)

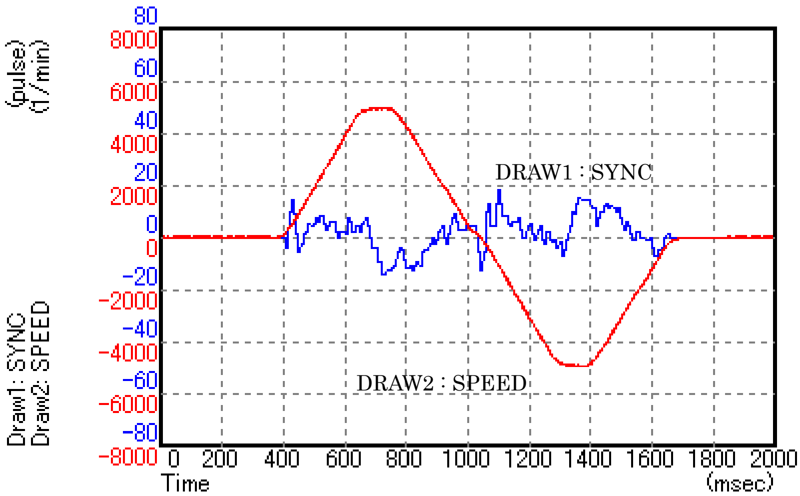
#15	#14	#13	#12	#11	#10	#9	#8
			SLVS	RCFN	RCHP	CFIN	CHP
#7	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**
ORAR	TLM	LDT2	LDT1	SAR	SDT	SST	ALM

(e) Spindle status signal 2 (SPST2)

#15	#14	#13	#12	#11	#10	#9	#8
			CSPEN				
#7	**#6**	**#5**	**#4**	**#3**	**#2**	**#1**	**#0**
			EXOF	SOREN		INCST	PC1DT

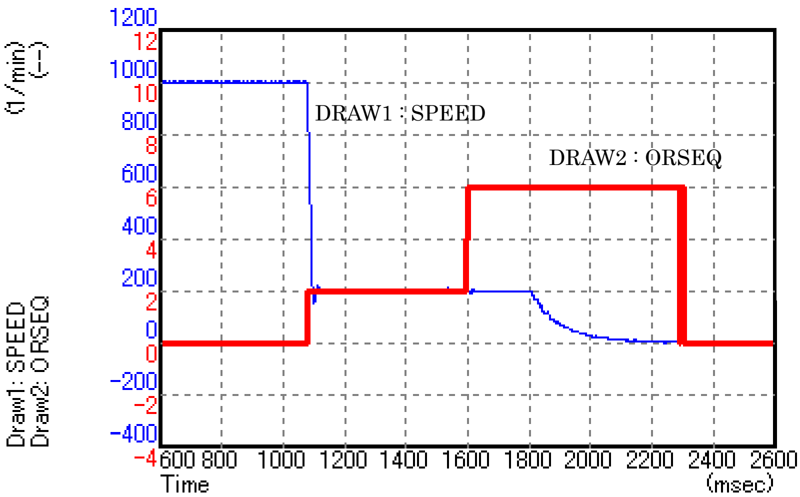
F.3 EXAMPLE OF OBSERVING DATA

(1) Synchronous error and motor speed in rigid tapping



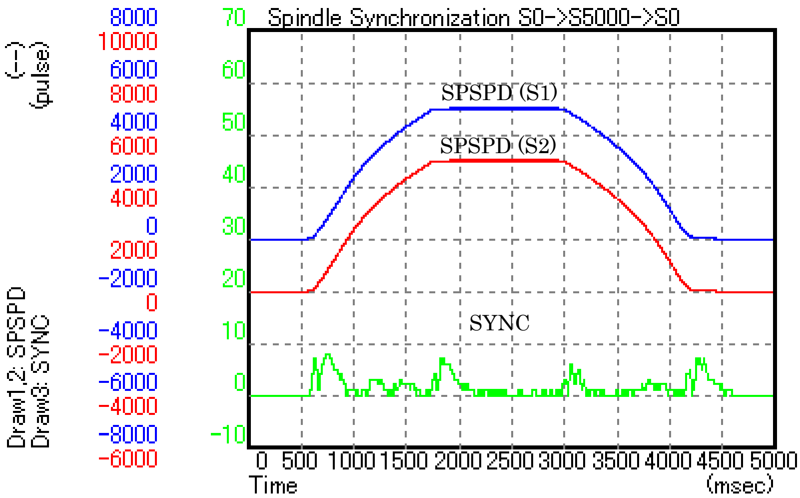
DRAW1: SYNC (Synchronous error)
DRAW2: SPEED (Motor speed)

(2) Motor speed and orientation sequence in orientation



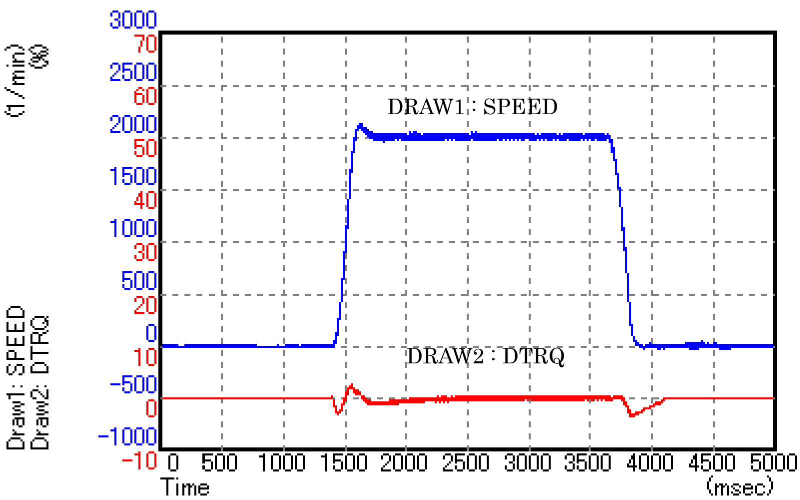
DRAW1: SPEED (Motor speed)
DRAW2: ORSEQ (Orientation sequence)

(3) Spindle speeds and synchronous error in spindle synchronous control



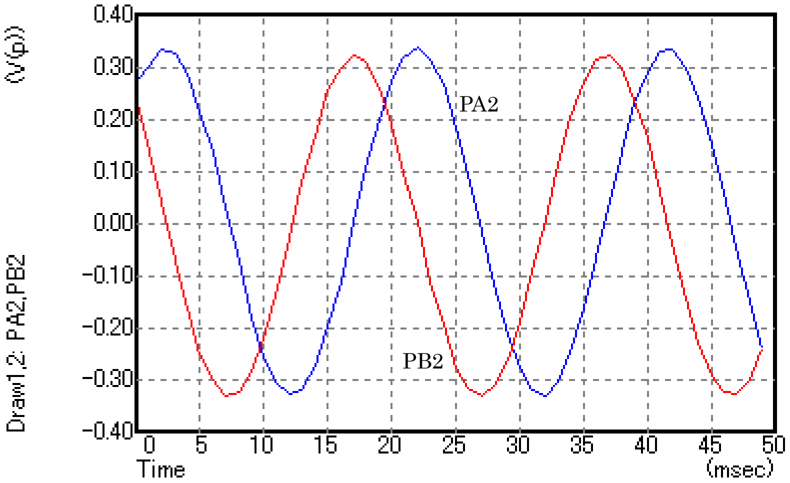
DRAW1, 2: SPSPD (Spindle speed S1 and S2)
DRAW3: SYNC (Synchronous error)

(4) Motor speed and estimated load torque data



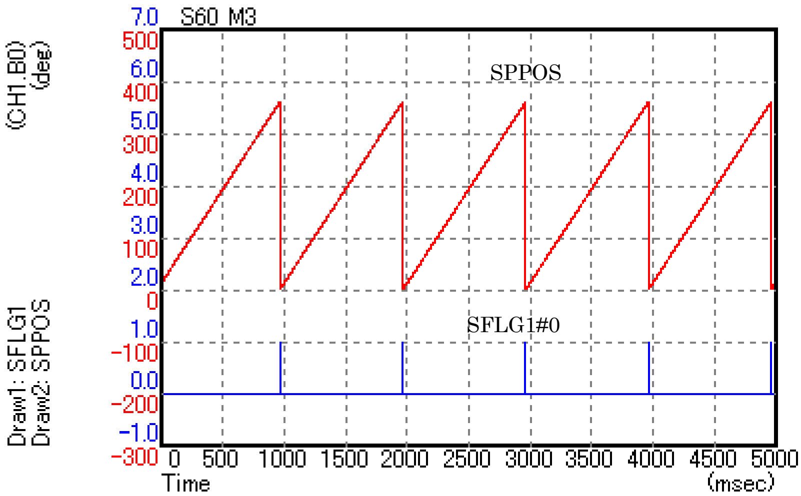
DRAW1: SPEED (Motor speed)
DRAW2: DTRQ (Estimated load torque)

(5) Phase A/B feedback signal of α*i*BZ sensor



DRAW1: PA2 (Phase A signal of a separate α*i*BZ sensor)
DRAW2: PB2 (Phase B signal of a separate α*i*BZ sensor)

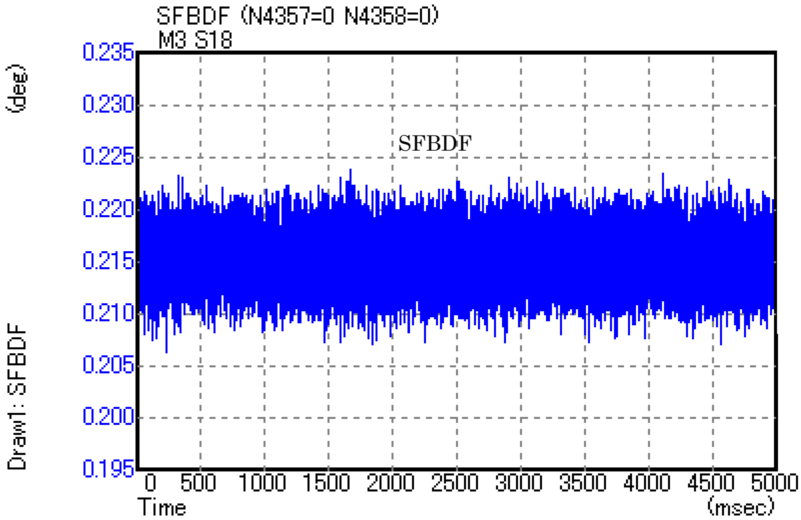
(6) Spindle position data and one-rotation signal



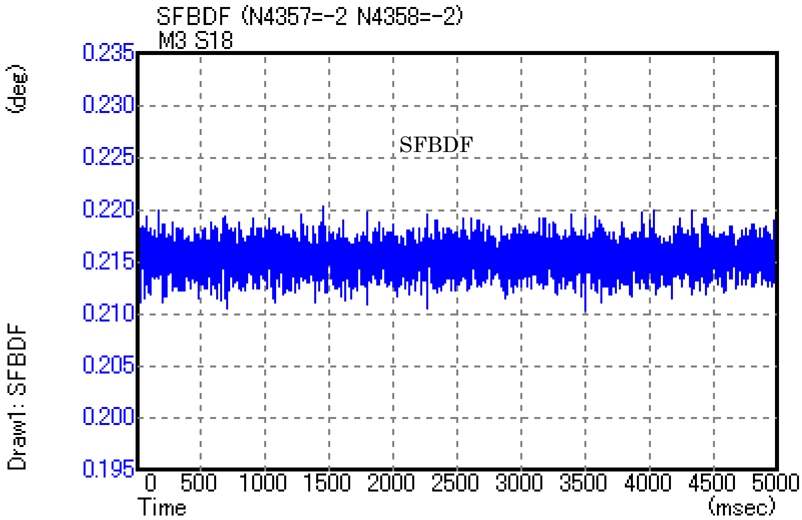
DRAW1, 2: SPPOS (Spindle position data)
DRAW3: SFLG#0 (FGRD: One-rotation signal detection flag)

(7) Adjustment of amplitude ratio/phase difference compensation data

(a) Before adjustment (No.4357=0, No.4358=0)

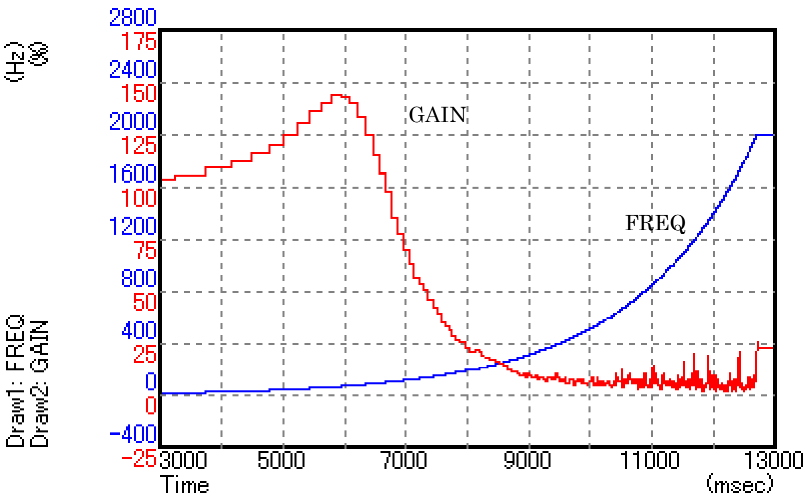


(b) After adjustment (No.4357=-2, No.4358=-2)

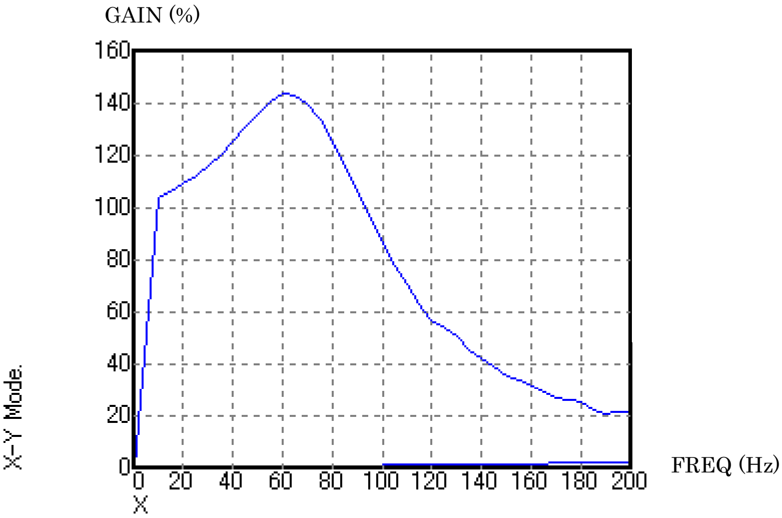


DRAW1: SFBDF (Spindle feedback difference data)

(8) Measurement of frequency characteristics using the disturbance input function
(a) XTYT display

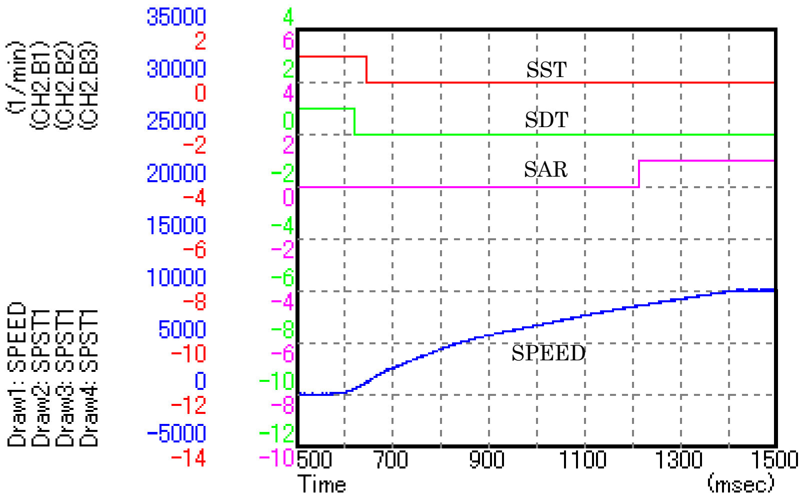


(b) X-Y display



DRAW1: FREQ (Frequency in the disturbance torque command)
DRAW2: GAIN (Gain)

(9) Observation of spindle status signals



DRAW1: SPEED (Motor speed)
DRAW2: SPST1#1 (SST: Speed zero detection signal)
DRAW3: SPST1#2 (SDT: Speed detection signal)
DRAW4: SPST1#3 (SAR: Speed arrival signal)

G PARAMETER SPECIFICATION DIFFERENCES BETWEEN THE αi SERIES AND αCi SERIES

This appendix describes the parameter specification differences between the α*i* series and αC*i* series.
The specifications of some parameters differ between the α*i* series and αC*i* series. For example, some identical parameter numbers do not specify the same functions. Take care at the time of the parameter setting.

G.1 PARAMETERS WITH DIFFERENT MEANINGS

15*i*	16*i*	30*i*	Contents	
			α*i* series	αC*i* series
3000#1	4000#1	4000#1	Spindle rotation direction when a positive (+) move command is specified on Cs contouring control	Unused (Set to 0.)
3000#3	4000#3	4000#3	Return direction for the reference position on Cs contouring control mode	Unused (Set to 0.)
3002#4	4002#4	4002#4	Whether to use the rotation direction signal (SFR/SRV) function on Cs contouring control	SM pin output data selection
3002#7	4002#7	4002#7	Whether to use the CMR (servo mode Cs contouring) function on servo mode	Unused (Set to 0.)
3003#3	4003#3	4003#3	Rotation direction during spindle orientation	Unused (Set to 0.)
3004#2	4004#2	4004#2	Setting of external one-rotation signal	Unused (Set to 0.)
3004#3	4004#3	4004#3	Setting of external one-rotation signal	Unused (Set to 0.)
3005#0	4005#0	4005#0	Unused (Set to 0.)	Setting of the velocity feedback method
3009#0	4009#0	4009#0	Increment system of velocity loop gain	Unused (Set to 0.)
3010#0	4010#0	4010#0	Motor sensor type	Unused (Set to 0.)
3010#1	4010#1	4010#1	Motor sensor type	Unused (Set to 0.)
3010#2	4010#2	4010#2	Motor sensor type	Unused (Set to 0.)
3011#0	4011#0	4011#0	Teeth number setting of motor sensor	Unused (Set to 0.)
3011#1	4011#1	4011#1	Teeth number setting of motor sensor	Unused (Set to 0.)
3011#2	4011#2	4011#2	Teeth number setting of motor sensor	Unused (Set to 0.)
3012#7	4012#7	4012#7	Setting of spindle HRV function	Unused (Set to 0.)
3013#7	4013#7	4013#7	Setting of a PWM carrier for low-speed characteristics area	Unused (Set to 0.)
3014#0	4014#0	4014#0	Whether to use the spindle switch function	Unused (Set to 0.)
3014#2	4014#2	4014#2	Whether to check both spindle switch main and sub magnetic contactor contacts	Unused (Set to 0.)
3014#3	4014#3	4014#3	Whether to check both magnetic contactor contacts for high-speed characteristics/low-speed characteristics in speed range switching	Unused (Set to 0.)
3014#6	4014#6	4014#6	Whether to use the orientation function on spindle synchronous control	Unused (Set to 0.)
3016#4	4016#4	4016#4	Setting related to control characteristics on Cs contouring control/servo mode	Unused (Set to 0.)
3016#5	4016#5	4016#5	Whether to detect the alarms (SPM alarms 82, 83, 85, 86) related to position feedback (in Cs contouring control mode)	Unused (Set to 0.)
3018#5	4018#5	4018#5	Whether to use the velocity command compensation function during high-speed orientation	Unused (Set to 0.)
3018#6	4018#6	4018#6	High-speed orientation function	Unused (Set to 0.)
3019#4	4019#4	4019#4	Setting of the function for switching from high-speed characteristics to low-speed characteristics with the speed detection signal SDT = 1 at speed range switching	Unused (Set to 0.)
3021	4021	4021	Maximum speed on Cs contouring control mode	Unused (Set to 0.)

15*i*	16*i*	30*i*	Contents	
			α*i* series	**αC*i* series**
3027	4027	4027	Load detection level 2	Unused (Set to 0.)
3028	4028	4028	Limited output pattern	Unused (Set to 0.)
3029	4029	4029	Output limit	Unused (Set to 0.)
3030	4030	4030	Soft start/stop time	Unused (Set to 0.)
3038	4038	4038	Spindle orientation speed (*1)	Spindle orientation speed (*1)
3039	4039	4039	Slip compensation gain	Unused (Set to 0.)
3046	4046	4046	Velocity loop proportional gain on Cs contouring control (High)	Unused (Set to 0.)
3047	4047	4047	Velocity loop proportional gain on Cs contouring control (Low)	Unused (Set to 0.)
3054	4054	4054	Velocity loop integral gain on Cs contouring control (High)	Unused (Set to 0.)
3055	4055	4055	Velocity loop integral gain on Cs contouring control (Low)	Unused (Set to 0.)
3064	4064	4064	Rate of change in position gain upon completion of orientation / Acceleration limitation ratio at deceleration time	Acceleration limitation ratio at deceleration time
3069	4069	4069	Position gain on Cs contouring control (High)	Acceleration/deceleration constant (High)
3070	4070	4070	Position gain on Cs contouring control (Medium High)	Acceleration/deceleration constant (Medium High)
3071	4071	4071	Position gain on Cs contouring control (Medium Low)	Acceleration/deceleration constant (Medium Low)
3072	4072	4072	Position gain on Cs contouring control (Low)	Acceleration/deceleration constant (Low)
3076	4076	4076	Motor speed limit value on orientation	Unused (Set to 0.)
3078	4078	4078	Reserved (Set to 200.)	Gear switch timer
3086	4086	4086	Motor voltage on Cs contouring control	Gear ratio parameter setting error alarm (SPM alarm 35) detection level
3087	4087	4087	Overspeed level	Unused (Set to 0.)
3092	4092	4092	Rate of change in position gain during reference position return on Cs contouring control	Unused (Set to 0.)
3093	4093	4093	Value displayed on load meter at maximum output	Unused (Set to 0.)
3094	4094	4094	Disturbance torque compensation constant (acceleration feedback gain)	Unused (Set to 0.)
3096	4096	4096	Adjusted output voltage of load meter	Unused (Set to 0.)
3097	4097	4097	Feedback gain of spindle speed	Unused (Set to 0.)
3103	4103	4103	Base speed limit ratio	Compensation data for resistance
3104	4104	4104	Current loop proportional gain (*1)	Current loop proportional gain (*1)
3105	4105	4105	Unused (Set to 0.)	Current loop integral gain
3106	4106	4106	Current loop integral gain	D-axis current loop gain
3107	4107	4107	Unused (Set to 0.)	Q-axis current loop gain
3108	4108	4108	Velocity at which the current loop integral gain is zero	Q-axis current deviation limitation coefficient
3114	4114	4114	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration	Unused (Set to 0.)
3120	4120	4120	Dead-band rectangular wave component zero voltage/dead-band data	Dead-band compensation data
3129	4129	4129	Secondary current coefficient for rigid tapping	Unused (Set to 0.)
3131	4131	4131	Time constant for velocity detecting filter (on Cs contouring control)	Dead-band compensation hysteresis
3135	4135	4135	Grid shift during Cs contouring control mode I (2-word)	Unused (Set to 0.)
3320	4320	4320	Motor acceleration at deceleration time (High)	Acceleration at orientation deceleration time (High)
3321	4321	4321	Motor acceleration at deceleration time (Medium High)	Acceleration at orientation deceleration time (Medium High)
3322	4322	4322	Motor acceleration at deceleration time (Medium Low)	Acceleration at orientation deceleration time (Medium Low)
3323	4323	4323	Motor acceleration at deceleration time (Low)	Acceleration at orientation deceleration time (Low)

NOTE

1 The name is identical, but the specification differs partly.

H PARAMETER SPECIFICATION DIFFERENCES BETWEEN THE α*i* SERIES AND B*i*S SERIES

This appendix describes the parameter specification differences between the α*i* series and B*i*S series.
The specifications of some parameters differ between the α*i* series and B*i*S series. For example, some identical parameter numbers do not specify the same functions. Take care at the time of the parameter setting.

H.1 PARAMETERS WITH DIFFERENT MEANINGS

NOTE
The parameters marked with (*1) have the same name but their specifications partly differ from each other.

15*i*	16*i*	30*i*	Contents	
			α*i* series	B*i*S series
3006#2	4006#2	4006#2	Increment system of spindle speed	Unused (Set to 0.)
3006#4	4006#4	4006#4	Reserved	Sets the d-phase current command.
3007#5	4007#5	4007#5	Whether to detect a feedback signal disconnection (*1)	Whether to detect a feedback signal disconnection (*1)
3007#7	4007#7	4007#7	Reserved	Magnetic pole detection start signal selection
3008#3	4008#3	4008#3	Reserved	Sets the current command.
3008#5	4008#5	4008#5	Reserved	Setting for using the sub module SM
3008#6	4008#6	4008#6	Reserved	Reference magnetic pole position selection
3009#5	4009#5	4009#5	Reserved	Setting related to magnetic flux reduction speed
3012#6	4012#6	4012#6	Unused (Set to 0.)	Setting of whether to drive the synchronous built-in spindle motor
3012#7	4012#7	4012#7	Setting of spindle HRV function	Setting of spindle HRV function
3013#7	4013#7	4013#7	Setting of a PWM carrier frequency for low-speed characteristics area	Unused (Set to 0.)
3014#0	4014#0	4014#0	Whether to use the spindle switch function	Unused (Set to 0.)
3014#2	4014#2	4014#2	Whether to check both spindle switch main and sub magnetic contactor contacts	Unused (Set to 0.)
3014#3	4014#3	4014#3	Whether to check both magnetic contactor contacts for high-speed /low-speed characteristics in speed range switching	Unused (Set to 0.)
3015#2	4015#2	4015#2	Whether to use the speed range switching function	Unused (Set to 0.)
3015#3	4015#3	4015#3	Whether to use the spindle tandem function	Unused (Set to 0.)
3016#4	4016#4	4016#4	Setting related to control characteristics on Cs contouring control/servo mode	Unused (Set to 0.)
3017#0	4017#0	4017#0	This parameter sets speed integration operation when differential spindle speed control is exercised.	Unused (Set to 0.)
3019#4	4019#4	4019#4	Setting of the function for switching from high-speed characteristics to low-speed characteristics with the speed detection signal SDT = 1 at speed range switching	Unused (Set to 0.)
3024	4024	4024	Zero speed detection level (SST) (*1)	Zero speed detection level (SST) (*1)
3039	4039	4039	Slip compensation gain	Unused (Set to 0.)
3080	4080	4080	Regenerative power limit for high-speed zone/regenerative power limit	Regenerative power limit
3083	4083	4083	Motor voltage on velocity control mode	Current ratio/motor stop confirmation time in magnetic pole detection operation
3084	4084	4084	Motor voltage on orientation	AMR offset
3085	4085	4085	Motor voltage on servo mode/spindle synchronous control mode	AMR offset fine adjustment
3086	4086	4086	Motor voltage on Cs contouring control	Inductance ratio
3097	4097	4097	Feedback gain of spindle speed	Unused (Set to 0.)

15*i*	16*i*	30*i*	Contents	
			α*i* series	B*i*S series
3102	4102	4102	Excitation voltage saturation speed at no-load	Base speed
3103	4103	4103	Base speed limit ratio	Magnetic flux reduction speed at maximum load
3109	4109	4109	Filter time constant for processing saturation related to the voltage command	Unused (Set to 0.)
3111	4111	4111	Secondary current coefficient	Maximum current constant
3113	4113	4113	Slip constant	Current constant for magnetic flux reduction
3114	4114	4114	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration	Unused (Set to 0.)
3116	4116	4116	Motor leakage constant	Counter electromotive voltage compensation constant for magnetic flux reduction speed at maximum load
3117	4117	4117	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient	Interference voltage compensation constant for magnetic flux reduction speed at maximum load
3118	4118	4118	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient	Unused (Set to 0.)
3119	4119	4119	Deceleration-time excitation current change time constant/excitation current change time constant	Interference voltage compensation
3128	4128	4128	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient	Unused (Set to 0.)
3129	4129	4129	Secondary current coefficient for rigid tapping	Unused (Set to 0.)
3130	4130	4130	Current loop proportional gain speed coefficient/current phase delay compensation coefficient	Current phase delay compensation coefficient
3136	4136	4136	Motor voltage on velocity control mode	Unused (Set to 0.)
3137	4137	4137	Motor voltage on servo mode/spindle synchronous control mode	Unused (Set to 0.)
3138	4138	4138	Base speed of motor output specifications	Unused (Set to 0.)
3139	4139	4139	Output limit for motor output specifications	Unused (Set to 0.)
3140	4140	4140	Excitation voltage saturation speed at no-load	Unused (Set to 0.)
3141	4141	4141	Base speed limit ratio	Unused (Set to 0.)
3142	4142	4142	Current loop proportional gain	Unused (Set to 0.)
3143	4143	4143	Current loop integral gain	Unused (Set to 0.)
3144	4144	4144	Velocity at which the current loop integral gain is zero	Unused (Set to 0.)
3145	4145	4145	Filter time constant for processing saturation related to the voltage command	Unused (Set to 0.)
3146	4146	4146	Current conversion constant	Unused (Set to 0.)
3147	4147	4147	Secondary current coefficient	Unused (Set to 0.)
3148	4148	4148	Criterion level for saturation related to the voltage command/PWM command clamp value	Unused (Set to 0.)
3149	4149	4149	Slip constant	Unused (Set to 0.)
3150	4150	4150	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration	Unused (Set to 0.)
3151	4151	4151	PWM command clamp value at deceleration	Unused (Set to 0.)
3152	4152	4152	Motor leakage constant	Unused (Set to 0.)
3153	4153	4153	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient	Unused (Set to 0.)
3154	4154	4154	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient	Unused (Set to 0.)
3156	4156	4156	Slip compensation gain	Unused (Set to 0.)
3157	4157	4157	Time constant for changing the torque (TCMD filter time constant)	Unused (Set to 0.)
3158	4158	4158	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient	Unused (Set to 0.)
3159	4159	4159	Secondary current coefficient for rigid tapping	Unused (Set to 0.)
3161	4161	4161	Current loop proportional gain speed coefficient/current phase delay compensation coefficient	Unused (Set to 0.)
3163	4163	4163	Integral gain of velocity loop during cutting feed on Cs contouring control mode (Low)	Unused (Set to 0.)
3165	4165	4165	Deceleration-time excitation current change time constant/excitation current change time constant	Unused (Set to 0.)
3166	4166	4166	Regenerative power limit for high-speed zone/regenerative power limit	Unused (Set to 0.)
3168	4168	4168	Current overload alarm detection level	Unused (Set to 0.)

15*i*	16*i*	30*i*	Contents	
			α*i* series	B*i*S series
3176#0	4176#0	4176#0	Rotation direction relationship between the spindle and motor	Unused (Set to 0.)
3176#4	4176#4	4176#4	Return direction for the reference position on servo mode	Unused (Set to 0.)
3177#0	4177#0	4177#0	Whether to use MRDY (machine ready) signal	Unused (Set to 0.)
3177#3	4177#3	4177#3	Mounting direction of the magnetic sensor	Unused (Set to 0.)
3177#4	4177#4	4177#4	Mounting direction of the spindle sensor	Unused (Set to 0.)
3178#0	4178#0	4178#0	Spindle sensor type	Unused (Set to 0.)
3178#1	4178#1	4178#1	Spindle sensor type	Unused (Set to 0.)
3178#2	4178#2	4178#2	Spindle sensor type	Unused (Set to 0.)
3178#3	4178#3	4178#3	Spindle sensor type	Unused (Set to 0.)
3178#5	4178#5	4178#5	Whether to use the rotation direction signal (SFR/SRV) function on servo mode	Unused (Set to 0.)
3179#0	4179#0	4179#0	Spindle orientation method	Unused (Set to 0.)
3179#2	4179#2	4179#2	Rotation direction during spindle orientation	Unused (Set to 0.)
3179#3	4179#3	4179#3	Rotation direction during spindle orientation	Unused (Set to 0.)
3179#4	4179#4	4179#4	Teeth number setting of spindle sensor	Unused (Set to 0.)
3179#5	4179#5	4179#5	Teeth number setting of spindle sensor	Unused (Set to 0.)
3179#6	4179#6	4179#6	Teeth number setting of spindle sensor	Unused (Set to 0.)
3179#7	4179#7	4179#7	Teeth number setting of spindle sensor	Unused (Set to 0.)
3180#2	4180#2	4180#2	Setting of external one-rotation signal	Unused (Set to 0.)
3180#3	4180#3	4180#3	Setting of external one-rotation signal	Unused (Set to 0.)
3182#1	4182#1	4182#1	Increment system of gear ratio	Unused (Set to 0.)
3182#2	4182#2	4182#2	Increment system of spindle speed	Unused (Set to 0.)
3182#5	4182#5	4182#5	Setting of analog override range	Unused (Set to 0.)
3182#7	4182#7	4182#7	Whether to use the command arbitrary gear ratio (CMR) function on rigid tapping	Unused (Set to 0.)
3183#5	4183#5	4183#5	Whether to detect a feedback signal disconnection	Unused (Set to 0.)
3183#6	4183#6	4183#6	Whether to detect the alarms (spindle alarms 41, 42, 47, 81, 82, 83, 85, 86, and 87) related to the position feedback signal (when Cs contouring control mode is not set)	Unused (Set to 0.)
3184#4	4184#4	4184#4	Setting of output limitation method	Unused (Set to 0.)
3185#0	4185#0	4185#0	Increment system of velocity loop gain	Unused (Set to 0.)
3185#2	4185#2	4185#2	Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued	Unused (Set to 0.)
3185#4	4185#4	4185#4	Whether to output the load detection signals (LDT1, LDT2) during acceleration/deceleration	Unused (Set to 0.)
3185#6	4185#6	4185#6	Analog override type	Unused (Set to 0.)
3186#0	4186#0	4186#0	Motor sensor type	Unused (Set to 0.)
3186#1	4186#1	4186#1	Motor sensor type	Unused (Set to 0.)
3186#2	4186#2	4186#2	Motor sensor type	Unused (Set to 0.)
3187#0	4187#0	4187#0	Teeth number setting of motor sensor	Unused (Set to 0.)
3187#1	4187#1	4187#1	Teeth number setting of motor sensor	Unused (Set to 0.)
3187#2	4187#2	4187#2	Teeth number setting of motor sensor	Unused (Set to 0.)
3187#3	4187#3	4187#3	Number of motor poles	Unused (Set to 0.)
3187#4	4187#4	4187#4	Setting of maximum output during acceleration/deceleration	Unused (Set to 0.)
3187#7	4187#7	4187#7	Number of motor poles	Unused (Set to 0.)
3188#0	4188#0	4188#0	Setting of PWM carrier frequency	Unused (Set to 0.)
3188#1	4188#1	4188#1	Setting of PWM carrier frequency	Unused (Set to 0.)
3188#2	4188#2	4188#2	Setting of PWM carrier frequency	Unused (Set to 0.)
3189#2	4189#2	4189#2	Current dead-band data	Unused (Set to 0.)
3189#3	4189#3	4189#3	Current dead-band data	Unused (Set to 0.)
3189#4	4189#4	4189#4	Current dead-band data	Unused (Set to 0.)
3189#5	4189#5	4189#5	Current dead-band data	Unused (Set to 0.)
3189#6	4189#6	4189#6	Current dead-band data	Unused (Set to 0.)
3189#7	4189#7	4189#7	Setting of a PWM carrier frequency for low-speed characteristics area	Unused (Set to 0.)
3192#3	4192#3	4192#3	Setting of the smoothing function in feed-forward control	Unused (Set to 0.)
3192#4	4192#4	4192#4	Setting related to control characteristics on servo mode	Unused (Set to 0.)
3192#6	4192#6	4192#6	Whether to detect the alarm (spindle alarms 46) related to feedback of the position detection signal for threading	Unused (Set to 0.)

15*i*	16*i*	30*i*	Contents	
			α*i* series	**B*i*S series**
3192#7	4192#7	4192#7	Function for newly detecting the one-rotation signal before entering position control mode	Unused (Set to 0.)
3193#0	4193#0	4193#0	This parameter sets speed integration operation when differential spindle speed control is exercised.	Unused (Set to 0.)
3193#7	4193#7	4193#7	Setting of shortcut orientation from stop state in position coder method spindle orientation	Unused (Set to 0.)
3194#5	4194#5	4194#5	Whether to use the velocity command compensation function during high-speed orientation	Unused (Set to 0.)
3194#6	4194#6	4194#6	High-speed orientation function	Unused (Set to 0.)
3195#2	4195#2	4195#2	Whether to use torque clamp at zero speed	Unused (Set to 0.)
3195#4	4195#4	4195#4	Setting of the function for switching from high-speed characteristics to low-speed characteristics with the speed detection signal SDT = 1 at speed range switching	Unused (Set to 0.)
3195#7	4195#7	4195#7	Automatic parameter setting function (16*i* /30*i*)	Unused (Set to 0.)
3196	4196	4196	Maximum motor speed	Unused (Set to 0.)
3197	4197	4197	Speed arrival detection level (SAR)	Unused (Set to 0.)
3198	4198	4198	Speed detection level (SDT)	Unused (Set to 0.)
3199	4199	4199	Zero speed detection level (SST)	Unused (Set to 0.)
3200	4200	4200	Limited torque (TLMH, TLML)	Unused (Set to 0.)
3201	4201	4201	Load detection level 1 (LDT1)	Unused (Set to 0.)
3202	4202	4202	Limited output pattern	Unused (Set to 0.)
3203	4203	4203	Output limit	Unused (Set to 0.)
3204	4204	4204	Stop position of position coder method orientation	Unused (Set to 0.)
3205	4205	4205	Spindle orientation speed	Unused (Set to 0.)
3206	4206	4206	Velocity loop proportional gain on velocity control mode (High)	Unused (Set to 0.)
3207	4207	4207	Velocity loop proportional gain on velocity control mode (Low)	Unused (Set to 0.)
3208	4208	4208	Velocity loop proportional gain on orientation (High)	Unused (Set to 0.)
3209	4209	4209	Velocity loop proportional gain on orientation (Low)	Unused (Set to 0.)
3210	4210	4210	Velocity loop proportional gain on servo mode (High)	Unused (Set to 0.)
3211	4211	4211	Velocity loop proportional gain on servo mode (Low)	Unused (Set to 0.)
3212	4212	4212	Velocity loop integral gain on velocity control mode (common to High and Low)	Unused (Set to 0.)
3213	4213	4213	Velocity loop integral gain on orientation (common to High and Low)	Unused (Set to 0.)
3214	4214	4214	Velocity loop integral gain on servo mode (common to High and Low)	Unused (Set to 0.)
3216	4216	4216	Gear ratio (High)	Unused (Set to 0.)
3217	4217	4217	Gear ratio (Low)	Unused (Set to 0.)
3218	4218	4218	Position gain on orientation (High)	Unused (Set to 0.)
3219	4219	4219	Position gain on orientation (Low)	Unused (Set to 0.)
3220	4220	4220	Ordinary orientation: Rate of change in position gain upon completion of orientation High-speed orientation: Rate of change in position gain upon completion of orientation	Unused (Set to 0.)
3221	4221	4221	Position gain on servo mode (High)	Unused (Set to 0.)
3222	4222	4222	Position gain on servo mode (Low)	Unused (Set to 0.)
3223	4223	4223	Grid shift on servo mode	Unused (Set to 0.)
3226	4226	4226	Detection level for orientation completion signal (ORAR)	Unused (Set to 0.)
3227	4227	4227	Ordinary orientation: Motor speed limit value on orientation High-speed orientation: Reserved	Unused (Set to 0.)
3228	4228	4228	Orientation stop position shift	Unused (Set to 0.)
3229	4229	4229	MS signal constant	Unused (Set to 0.)
3230	4230	4230	MS signal gain adjustment	Unused (Set to 0.)
3231	4231	4231	Regenerative power limit for high-speed zone/regenerative power limit	Unused (Set to 0.)
3232	4232	4232	Delay time until motor power is cut off	Unused (Set to 0.)
3233	4233	4233	Setting of acceleration/deceleration time	Unused (Set to 0.)
3234	4234	4234	Spindle load monitor observer gain 1	Unused (Set to 0.)
3235	4235	4235	Spindle load monitor observer gain 2	Unused (Set to 0.)
3236	4236	4236	Motor voltage on velocity control mode	Unused (Set to 0.)

15*i*	16*i*	30*i*	Contents	
			α*i* series	B*i*S series
3237	4237	4237	Motor voltage on orientation	Unused (Set to 0.)
3238	4238	4238	Motor voltage on servo mode	Unused (Set to 0.)
3239	4239	4239	Rate of change in position gain during reference position return on servo mode	Unused (Set to 0.)
3240	4240	4240	Feed-forward coefficient	Unused (Set to 0.)
3241	4241	4241	Feed-forward coefficient of velocity loop	Unused (Set to 0.)
3243	4243	4243	Denominator of arbitrary gear ratio between motor sensor and spindle (High)	Unused (Set to 0.)
3244	4244	4244	Numerator of arbitrary gear ratio between motor sensor and spindle (High)	Unused (Set to 0.)
3245	4245	4245	Denominator of arbitrary gear ratio between motor sensor and spindle (Low)	Unused (Set to 0.)
3246	4246	4246	Numerator of arbitrary gear ratio between motor sensor and spindle (Low)	Unused (Set to 0.)
3254	4254	4254	Slip compensation gain	Unused (Set to 0.)
3255	4255	4255	Slip compensation gain	Unused (Set to 0.)
3256	4256	4256	Base speed of motor output specifications	Unused (Set to 0.)
3257	4257	4257	Output limit for motor output specifications	Unused (Set to 0.)
3258	4258	4258	Excitation voltage saturation speed at no-load	Unused (Set to 0.)
3259	4259	4259	Base speed limit ratio	Unused (Set to 0.)
3260	4260	4260	Current loop proportional gain	Unused (Set to 0.)
3261	4261	4261	Current loop integral gain	Unused (Set to 0.)
3262	4262	4262	Velocity at which the current loop integral gain is zero	Unused (Set to 0.)
3263	4263	4263	Filter time constant for processing saturation related to the voltage command	Unused (Set to 0.)
3264	4264	4264	Current conversion constant	Unused (Set to 0.)
3265	4265	4265	Secondary current coefficient	Unused (Set to 0.)
3266	4266	4266	Criterion level for saturation related to the voltage command/PWM command clamp value	Unused (Set to 0.)
3267	4267	4267	Slip constant	Unused (Set to 0.)
3268	4268	4268	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration	Unused (Set to 0.)
3269	4269	4269	PWM command clamp value at deceleration	Unused (Set to 0.)
3270	4270	4270	Motor leakage constant	Unused (Set to 0.)
3271	4271	4271	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient	Unused (Set to 0.)
3272	4272	4272	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient	Unused (Set to 0.)
3273	4273	4273	Time constant for changing the torque (TCMD filter time constant)	Unused (Set to 0.)
3274	4274	4274	Value displayed on load meter at maximum output	Unused (Set to 0.)
3275	4275	4275	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient	Unused (Set to 0.)
3276	4276	4276	Secondary current coefficient for rigid tapping	Unused (Set to 0.)
3277	4277	4277	Current loop proportional gain speed coefficient/current phase delay compensation coefficient	Unused (Set to 0.)
3278	4278	4278	Time constant for velocity detecting filter	Unused (Set to 0.)
3279	4279	4279	Value displayed on load meter at maximum output	Unused (Set to 0.)
3280	4280	4280	Deceleration-time excitation current change time constant/excitation current change time constant	Unused (Set to 0.)
3281	4281	4281	Spindle load monitor torque constant	Unused (Set to 0.)
3282	4282	4282	Spindle load monitor torque constant	Unused (Set to 0.)
3283	4283	4283	Spindle load monitor torque constant	Unused (Set to 0.)
3284	4284	4284	Motor voltage on velocity control mode	Unused (Set to 0.)
3285	4285	4285	Motor voltage on servo mode	Unused (Set to 0.)
3286	4286	4286	Base speed of motor output specifications	Unused (Set to 0.)
3287	4287	4287	Output limit for motor output specifications	Unused (Set to 0.)
3288	4288	4288	Excitation voltage saturation speed at no-load	Unused (Set to 0.)
3289	4289	4289	Base speed limit ratio	Unused (Set to 0.)
3290	4290	4290	Current loop proportional gain	Unused (Set to 0.)
3291	4291	4291	Current loop integral gain	Unused (Set to 0.)
3292	4292	4292	Velocity at which the current loop integral gain is zero	Unused (Set to 0.)

15*i*	16*i*	30*i*	Contents	
			α*i* series	B*i*S series
3293	4293	4293	Filter time constant for processing saturation related to the voltage command	Unused (Set to 0.)
3294	4294	4294	Current conversion constant	Unused (Set to 0.)
3295	4295	4295	Secondary current coefficient	Unused (Set to 0.)
3296	4296	4296	Criterion level for saturation related to the voltage command/PWM command clamp value	Unused (Set to 0.)
3297	4297	4297	Slip constant	Unused (Set to 0.)
3298	4298	4298	Slip compensation coefficient for a high-speed zone/slip compensation coefficient at deceleration	Unused (Set to 0.)
3299	4299	4299	PWM command clamp value at deceleration	Unused (Set to 0.)
3300	4300	4300	Motor leakage constant	Unused (Set to 0.)
3301	4301	4301	Regular-time voltage compensation coefficient for high-speed zone/regular-time motor voltage coefficient	Unused (Set to 0.)
3302	4302	4302	Acceleration-time voltage compensation coefficient for high-speed zone/acceleration-time motor voltage coefficient	Unused (Set to 0.)
3303	4303	4303	Time constant for changing the torque (TCMD filter time constant)	Unused (Set to 0.)
3304	4304	4304	Compensation coefficient between the specification and true base/maximum torque curve compensation coefficient	Unused (Set to 0.)
3305	4305	4305	Secondary current coefficient for rigid tapping	Unused (Set to 0.)
3306	4306	4306	Current loop proportional gain speed coefficient/current phase delay compensation coefficient	Unused (Set to 0.)
3307	4307	4307	Regenerative power limit for high-speed zone/regenerative power limit	Unused (Set to 0.)
3308	4308	4308	Deceleration-time excitation current change time constant/excitation current change time constant	Unused (Set to 0.)
3309	4309	4309	Motor model code	Unused (Set to 0.)
3310	4310	4310	Motor overheat detect level (2-word)	Unused (Set to 0.)
3324	4324	4324	Motor acceleration at deceleration time (High)	Unused (Set to 0.)
3325	4325	4325	Motor acceleration at deceleration time (Low)	Unused (Set to 0.)
3327	4327	4327	Acceleration limitation start speed at deceleration time (High)	Unused (Set to 0.)
3329	4329	4329	Command multiplication for spindle orientation by position coder	Unused (Set to 0.)
3331	4331	4331	Acceleration limitation start speed at deceleration time (Low)	Unused (Set to 0.)
3335	4335	4335	Number of motor sensor arbitrary teeth	Unused (Set to 0.)
3347	4347	4347	Master-slave speed difference state signal output setting	Unused (Set to 0.)
3348	4348	4348	Current overload alarm detection level	Unused (Set to 0.)
3349	4349	4349	Temperature monitoring time constant	Unused (Set to 0.)
3350	4350	4350	Current overload alarm detection level	Unused (Set to 0.)
3353#1	4353#1	4353#1	Velocity feedback signal setting in torque tandem operation	Unused (Set to 0.)
3353#2	4353#2	4353#2	Relationship of master/slave motor rotation directions in torque tandem operation	Unused (Set to 0.)
3360	4360	4360	Preload value	Unused (Set to 0.)
3365	4365	4365	Load meter compensation 1	Unused (Set to 0.)
3366	4366	4366	Load meter compensation 2	Unused (Set to 0.)
3367	4367	4367	Load meter compensation 3	Unused (Set to 0.)
3373#1	4373#1	4373#1	Setting of the peak hold function for load meter output	Unused (Set to 0.)
3376	4376	4376	Load meter compensation 1	Unused (Set to 0.)
3377	4377	4377	Load meter compensation 2	Unused (Set to 0.)
3378	4378	4378	Load meter compensation 3	Unused (Set to 0.)
3379	4379	4379	Load meter compensation 1	Unused (Set to 0.)
3380	4380	4380	Load meter compensation 2	Unused (Set to 0.)
3381	4381	4381	Load meter compensation 3	Unused (Set to 0.)
3398#2	4398#2	4398#2	Unused (Set to 0.)	Magnetic pole detection mode selection 1
3398#3	4398#3	4398#3	Whether to use the twin drive function	Unused (Set to 0.)
3398#6	4398#6	4398#6	Whether to detect a speed polarity error (spindle alarm d0) in torque tandem operation	Unused (Set to 0.)
3399#5	4399#5	4399#5	Unused (Set to 0.)	Neglect "Pole position count miss alarm (spindle alarm 91)"

15*i*	16*i*	30*i*	Contents	
			α*i* series	B*i*S series
3399#6	4399#6	4399#6	Unused (Set to 0.)	Magnetic pole detection mode selection 2
3443	4443	4443	Feed-forward coefficient of velocity loop	Unused (Set to 0.)
3463	4463	4463	Unused (Set to 0.)	Unexpected rotation detection level (spindle alarm 90)
3467#2	4467#2	4467#2	Setting of the detection lower limit of the one-rotation signal	Unused (Set to 0.)
3467#3	4467#3	4467#3	Setting of the fine acceleration/deceleration (FAD) function	Unused (Set to 0.)
3467#4	4467#4	4467#4	Acceleration/deceleration type of fine acceleration/deceleration (FAD)	Unused (Set to 0.)
3467#5	4467#5	4467#5	Whether to detect the alarm related to spindle sensor polarity erroneous setting	Unused (Set to 0.)
3468#6	4468#6	4468#6	Triggering of the disturbance input function (vibration application function)	Unused (Set to 0.)
3468#7	4468#7	4468#7	Setting of the disturbance input function (vibration application function)	Unused (Set to 0.)
3481	4481	4481	Feed-forward timing adjustment coefficient	Unused (Set to 0.)
3486	4486	4486	Feed-forward coefficient of velocity loop	Unused (Set to 0.)
3520	4520	4520	Primary delay time constant in dual position feedback [in servo mode]	Unused (Set to 0.)
3521	4521	4521	Maximum amplitude in dual position feedback [in servo mode]	Unused (Set to 0.)
3522	4522	4522	Dual position feedback zero width [in servo mode]	Unused (Set to 0.)
3523	4523	4523	Excessive semi-closed loop/closed loop position error alarm detection level [in servo mode]	Unused (Set to 0.)

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REVISION RECORD

Edition	Date	Contents
08	Jun., 2011	- Applied to Series 30*i*-B - Addition of SPINDLE MOTOR β*i*Ic series - Addition of speed tandem control
07	Jul., 2008	- Addition of optimum orientation - Addition of α*i*CZ sensor (serial)
06	Jul., 2006	- Change of the motor model name - Addition of spindle backlash acceleration function
05	Apr., 2005	- Applied to Series 30*i* - Addition of BUILT-IN SPINDLE MOTOR B*i*s series
04	Oct., 2003	- Addition of AC SPINDLE MOTOR β*i* series
03	Apr., 2003	- Change of the motor model name - Addition of the spindle speed differential control function
02	Oct., 2002	Total revision - Addition of AC SPINDLE MOTOR αC*i* series - Addition of Appendixes C, D, F, and G
01	Jun., 2001	

B-65280EN/08

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Tuning way for FSSB High Speed Rigid Tap

1. Type of applied documents

Name	FANUC AC SPINDLE MOTOR αi series, FANUC AC SPINDLE MOTOR βi series, FANUC BUILT-IN SPINDLE MOTOR Bi series PARAMETER MANUAL
Spec. No./Ver.	B-65280EN/08

2. Summary of Change

Group	Name / Outline	New, Add Correct, Del	Applicable Date
Basic Function			
Optional Function			
Unit			
Maintenance Parts			
Notice			
Correction			
Another	Addition of tuning way for FSSB high speed rigid tap	Add	2011.04

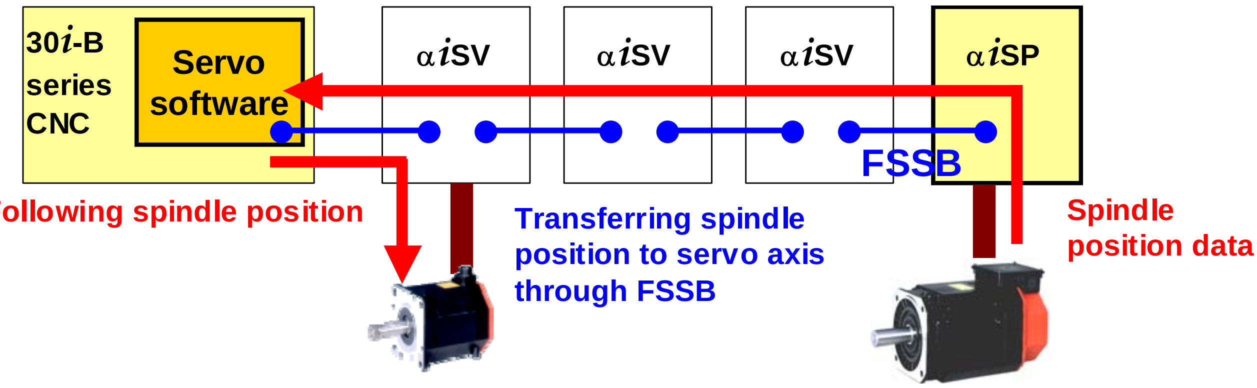
Tuning way for FSSB High Speed Rigid Tap

1. Outline

The connection between CNC and spindle amplifier is changed to FSSB in 30i-B series CNC. It becomes possible to transfer the spindle position data to servo software directly by using FSSB communication. In FSSB high speed rigid tap function, servo axis follows spindle axis in rigid tap by this high speed communication.

As the servo axis always follows the spindle axis, the synchronous error will not become large even if the torque command of spindle motor becomes a little bit saturated. Therefore it’s possible to use the large torque near the limitation and to reduce cycle time with keeping the accuracy.

This document shows the tuning way for FSSB high speed rigid tap function.



2. Tuning procedure of FSSB high speed rigid tap

2.1. Initial parameter settings

First of all, please set some parameters for rigid tap as before even in case of using FSSB high speed rigid tap. And after that, please set some parameters for FSSB high speed rigid tap additionally. (* mark in the following table)

Parameter number (FS30i-B)	Contents
2005#1	Feed-forward function bit (Servo) Initial setting : 1 Note) The feed-forward coefficient for servo axis always becomes 100% regardless of parameter setting of feed-forward coefficient, when FSSB high speed rigid tap is used.
5203#2	Feed-forward function bit (Spindle) Initial setting : 0 Note) If you use feed-forward function in spindle axis, please use “Rigid tapping bell-shaped acc./dec.” function together. In case of FSSB high speed rigid tap, you don’t have to set same feed-forward coefficient for spindle as the one for servo.
5241~5244	Maximum speed of spindle in rigid tap
5261~5264	Time constant for acc./dec. in rigid tap Initial setting : 500
4065~4068	Position gain for spindle in servo mode Initial setting : 3000
4044~4045	Proportional gain of velocity loop for spindle in servo mode Initial setting : see following formula Proportional gain of velocity loop = 30159/Tmax*(Jm+Jl) Assume that Tmax : Short time rated torque at constant torque range * 1.2 [Nm] Jm : Motor rotor inertia [kgm^2] Jl : Load inertia converted to motor side [kgm^2]
4052~4053	Integral gain of velocity loop for spindle in servo mode Initial setting : see following formula

	Integral gain of velocity loop = 280735/Tmax*(Jm+Jl) Assume that Tmax : Short time rated torque at constant torque range * 1.2 [Nm] Jm : Motor rotor inertia [kgm^2] Jl : Load inertia converted to motor side [kgm^2]
4085	Motor voltage in rigid tap (for high speed characteristics) Initial setting : 100 When the maximum motor speed in rigid tap is higher than the base speed of the spindle motor (No. 4100 for high speed characteristics), set the value calculated from the following formula. $\text{Motor voltage (\%)} = 100 * \frac{\text{Spindle motor base speed(No.4100)}}{\text{Maximum motor speed in rigid tap}}$
4137	Motor voltage in rigid tap (for low speed characteristics) Initial setting : 100 When the maximum motor speed in rigid tap is higher than the base speed of the spindle motor (No. 4138 for low speed characteristics), set the value calculated from the following formula. $\text{Motor voltage (\%)} = 100 * \frac{\text{Spindle motor base speed(No.4138)}}{\text{Maximum motor speed in rigid tap}}$
4016#4	Motor voltage control characteristic setting in rigid tap Initial setting : 0 If you set less value than 100 in No.4085 or No.4137, please set 1.
4099	Delay time for motor excitation Initial setting : 300 However when you use Magnetic flux boost function, please change it. (Refer to chapter 4)
24203#0 (*NEW)	FSSB high speed rigid tap function bit (CNC) Initial setting : 1
2429#1 (*NEW)	FSSB high speed rigid tap function bit (Servo) Initial setting : 1
4549#1 (*NEW)	FSSB high speed rigid tap function bit (Spindle) Initial setting : 1
24204 (*NEW)	Spindle axis number which synchronizes with servo axis
2610 (*NEW)	Position gain for servo axis during FSSB high speed rigid tap Initial setting : 3000

2.2. Tuning parameters

The parameters to tune are basically same as before. But the tuning way is different in the following points when you use FSSB high speed rigid tap.

- It's possible to set less value in time constant for acc./dec. generally.
- It's not necessary to set the same value in position gain both for servo axis and spindle axis. The new position gain parameter, which is effective only in FSSB high speed rigid tap, is prepared.

Parameter number (FS30i-B)	Contents
5261~5264	Time constant for acc./dec. in rigid tap
5280~5284	Position gain of servo axis for rigid tap (These parameters are used when No.2610=0.)
2610 (*NEW)	Position gain for servo axis during FSSB high speed rigid tap
4065~4068	Position gain for spindle in servo mode
4044~4045	Proportional gain of velocity loop for spindle in servo mode
4052~4053	Integral gain of velocity loop for spindle in servo mode

2.3. Tuning with using SERVO GUIDE

Please use SERVO GUIDE for parameter tuning with observing following data (Synchronous error, Spindle speed, Torque command, and etc.)

Axis	Data kind	Data unit at observing
Servo axis	SYNC (Synchronous error)	[pulse]
	TCMD (Torque command)	[%]
Spindle axis	SPSPD (Spindle speed)	[min^{-1}]
	TCMD (Torque command)	[%]
	ERRC (Position error)	[pulse]

Note) Synchronous error is calculated by the following formula.

$$SYNC[pulse] = PERsp[pulse] - PERsv[pulse]$$

$SYNC[pulse]$: Synchronous error (4096 pulse per spindle 1 revolution)

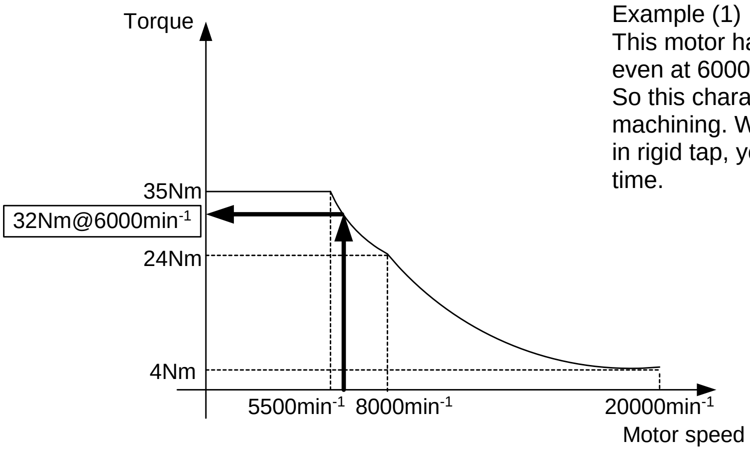
$PERsp[pulse]$: Position error of spindle

$PERsv[pulse]$: Position error of servo converted to the weight of spindle

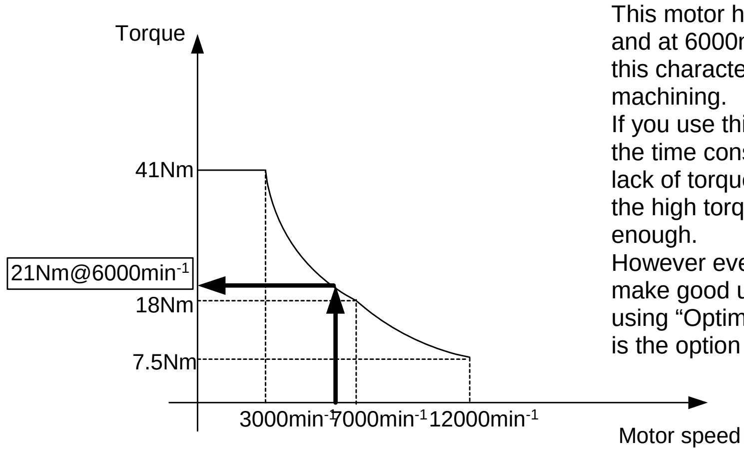
2.3.1. Setting of maximum spindle speed in rigid tap

Please set maximum spindle speed in rigid tap according to the specification of the machine. When you use higher speed domain where the spindle motor output enough torque, you might be able to reduce the cycle time of the machining.

[Example of the character of Spindle motor speed-Torque]



Example (1)
This motor has wide torque constant range and even at 6000min^{-1} enough torque can be used. So this character is suited to high speed machining. When you use high speed domain in rigid tap, you will be able to reduce cycle time.



Example (2)
This motor has narrow torque constant range and at 6000min^{-1} the torque is very small. So this character is not suited to high speed machining.
If you use this motor for high speed rigid tap, the time constant is limited by the reason of lack of torque at high speed. It also means that the high torque at low speed will not be used enough.
However even in such motor, it's possible to make good use of torque in all speed range by using "Optimum acc./dec. for rigid tap", which is the option function. (Refer to chapter 3)

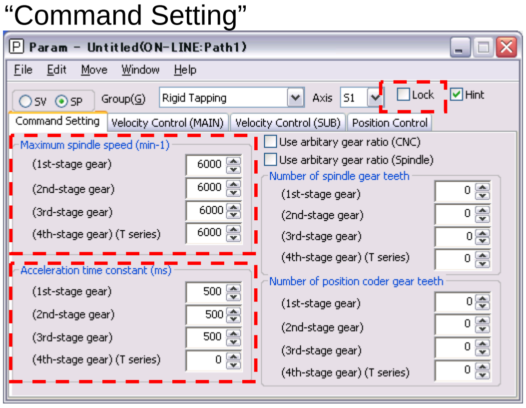
2.3.2. Preparation before start tuning

(1) Initial parameter setting

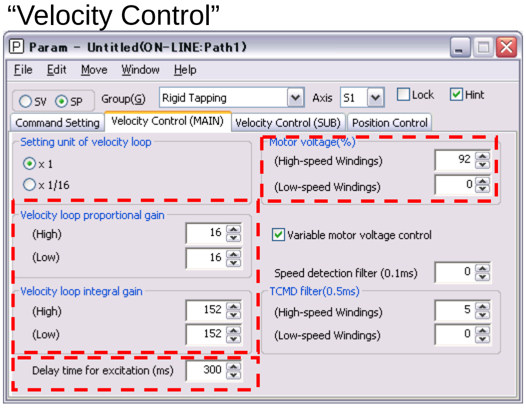
Please set some parameters for rigid tap from Parameter Window in SERVO GUIDE. Please open Parameter Window in "Online" and select "SP" in radio button and select "Rigid tapping" in Group.

"Rigid tapping" group has 4 types of tabs "Command Setting", "Velocity Control", and "Position Control". Please input the initial parameters in each tab. When you change parameters, please make sure to release the "Lock" check-box.
Please try to input 500-600ms in time constant for acc./dec. in rigid tap as initial value. (It depends on the maximum spindle speed, though.)
Regarding position gain of servo axis for FSSB high speed rigid tap, please set them in No.2610 after selecting "Parameter Table" in Group.

"Command Setting"



"Velocity Control"



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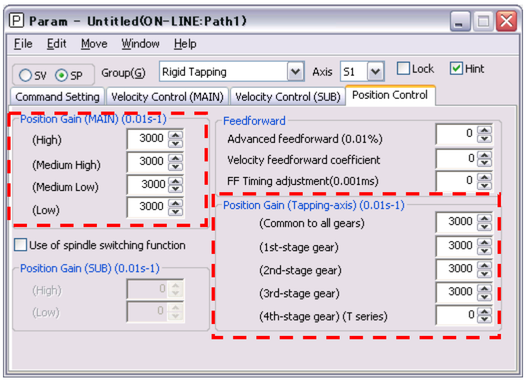
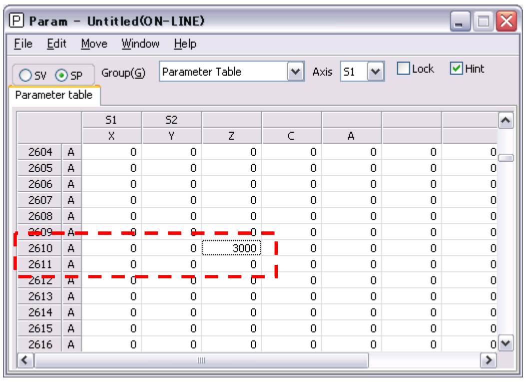
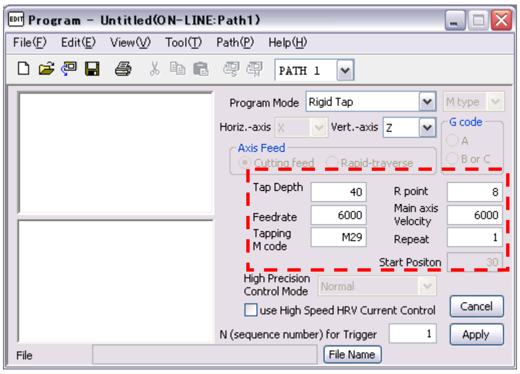
"Position Control" "Parameter Table"

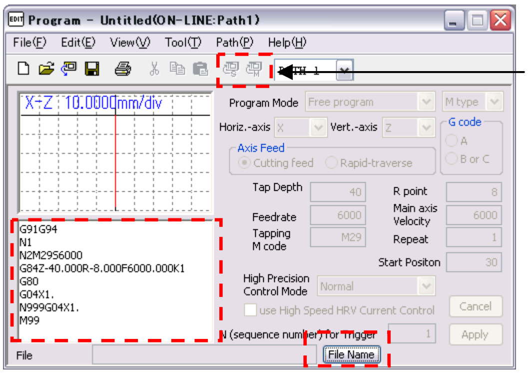




(2) Making test program

You can make the test program by Program Window in SERVO GUIDE. Please select "Rigid tap" in program mode combo-box and set some conditions. After finishing the settings and click "Apply" button, SERVO GUIDE will make the test program.



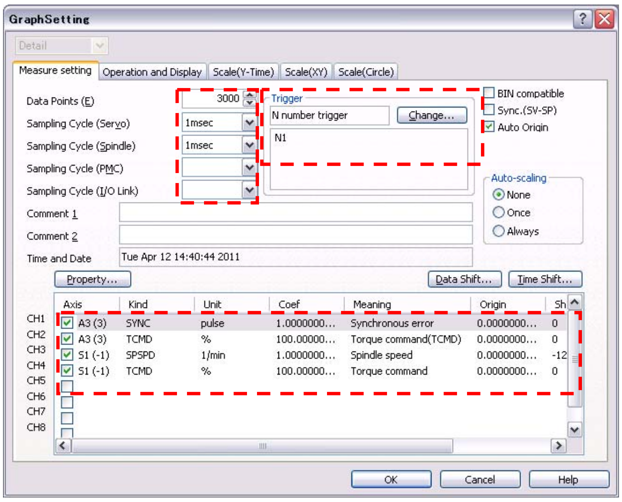


"Send" button

After confirming the program, please input the file name by click "File name" button. And send it to CNC by click "Send sub" and "Send main" button in order.

(3) Channel settings for Graph Window

Please open Graph Window and make the channel settings to measure data. The trigger condition should be the "N number" which was specified in Program Window.



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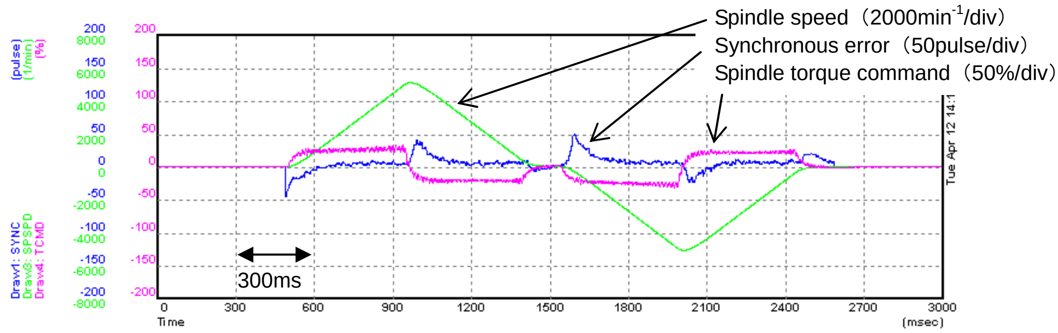
(4) Confirmation of movement in test program

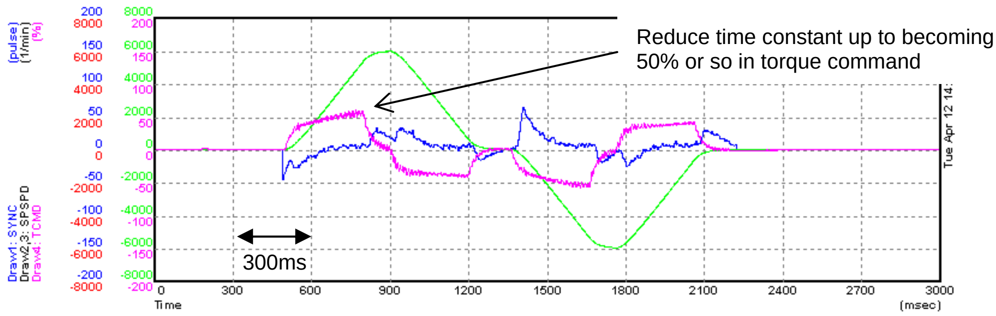
Before starting data measurement, please click “Origin” button in Graph Window. After click “Measure” button, Graph Window will be the trigger waiting state. Please press cycle start button in the operation panel on the machine. The test program, which was sent before, will be executed and the data will be measured.

Example of measurement result in rigid tap with initial parameter settings (Time constant = 500ms)



As nest step, please reduce the time constant for acc./dec. up to becoming 50% or so in spindle torque command. Based on this setting, please continue the velocity gain tuning and position gain tuning.

Example of measurement result in rigid tap after first tuning of time constant for acc./dec. (Time constant = 300ms)



In this stage, please make sure that the spindle speed reaches the maximum speed for rigid tap. If it doesn’t, please change the movement distance of Z axis in test program.

After that, to confirm whether spindle movement is proper or not, please check the position error at maximum rigid tap speed. The ideal position error can be calculated by following formula.

$$Perr[pulse] = \frac{Nr[\min^{-1}]}{60} \times 4096[pulse/rev] \times \frac{1}{PG[\sec^{-1}]} \times \left(1 - \frac{RFF[\%]}{100}\right)$$

$Perr[pulse]$: Position error at speed Nr

$Nr[\min^{-1}]$: Maximum speed for rigid tap

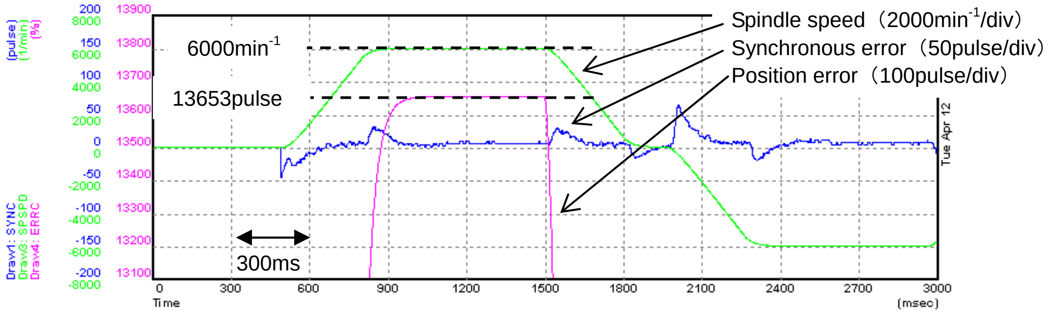
$PG[\sec^{-1}]$: Position gain for rigid tap

$RFF[\%]$: Feed-forward coefficient (in case of No.5203#2=1)

Ex.) The position error with initial setting in this document becomes

$$Perr[pulse] = \frac{6000}{60} \times 4096 \times \frac{1}{30} \times (1 - \frac{0}{100}) = 13653[pulse]$$

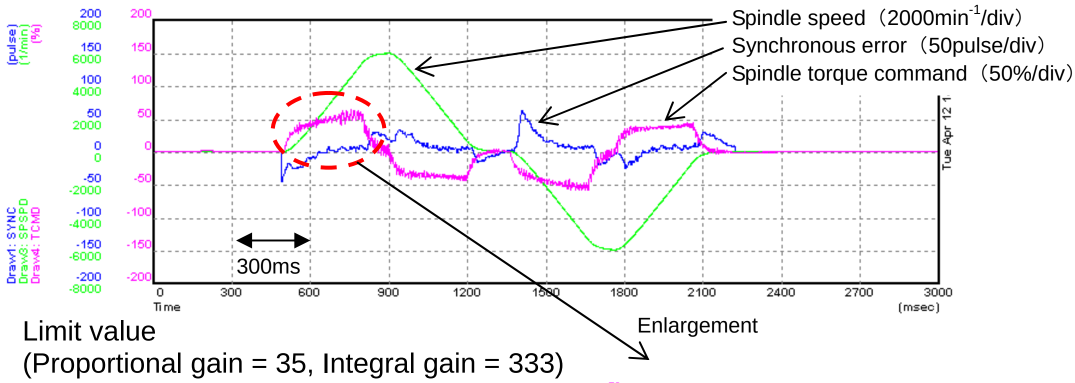
Example of measurement result in rigid tap to confirm the position error
(Ideal position error = 13653[pulse])



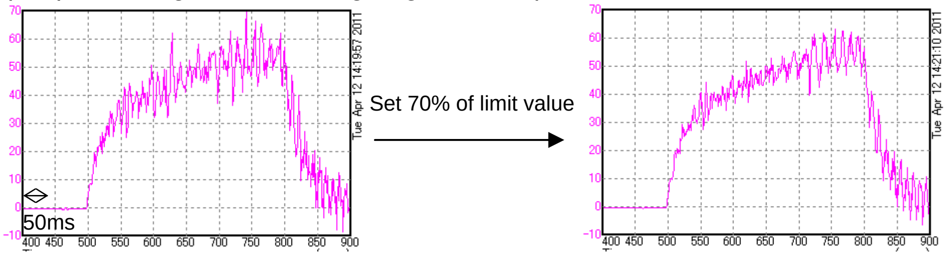
2.3.3. Velocity gain tuning

Please tune velocity loop gain. Please try to raise the proportional gain and integral gain in “Velocity Control” tab in Parameter Window with the same proportion. The limit value can be known from the torque command waveform, vibration, or motor sound. The final setting value should be the 70% of the limit value.

Example of measurement result after tuning of velocity gain
(Proportional gain = 25, Integral gain = 238)



Limit value
(Proportional gain = 35, Integral gain = 333)



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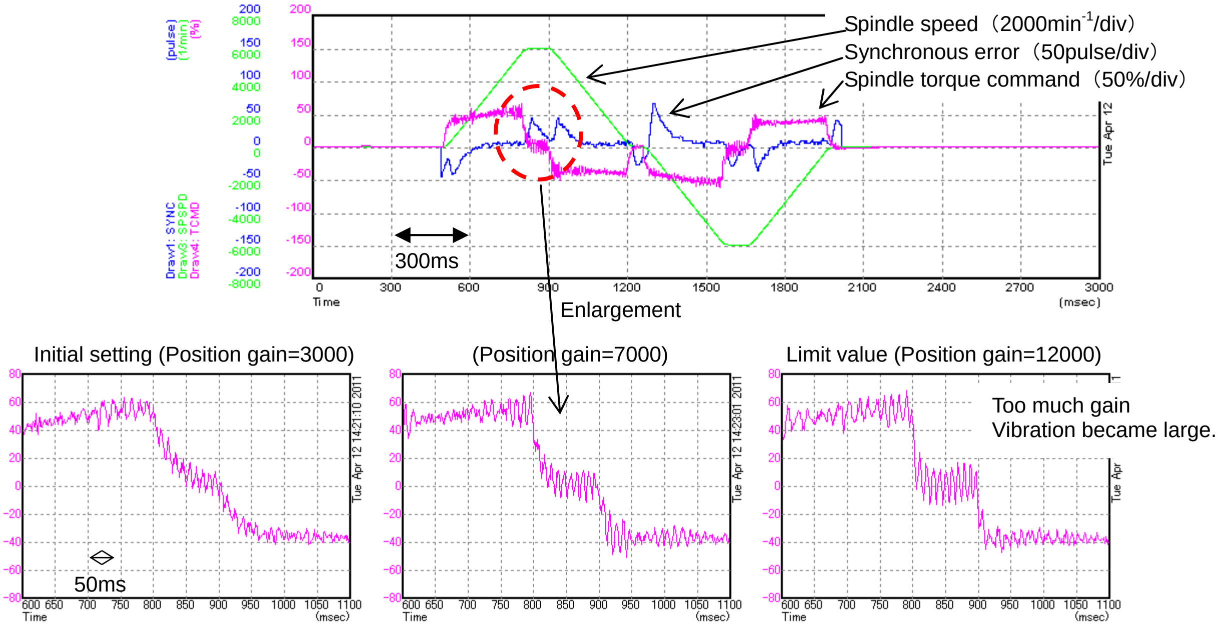
2.3.4. Position gain tuning

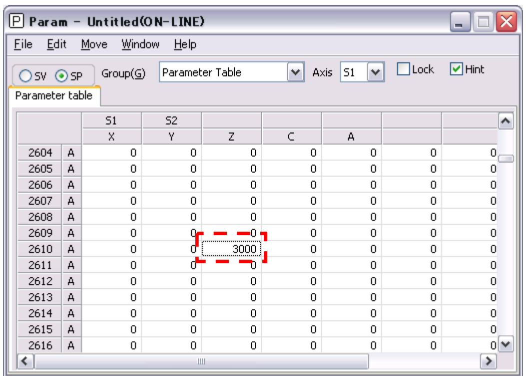
Please tune position loop gain. Please try to raise the position loop gain 2000 by 2000 in “Position Control” tab in Parameter Window. The limit value can be known from the torque command waveform, vibration, or motor sound. Please determine the final setting value from those factors.

Example of measurement result after tuning of spindle position gain (Spindle position gain = 7000)

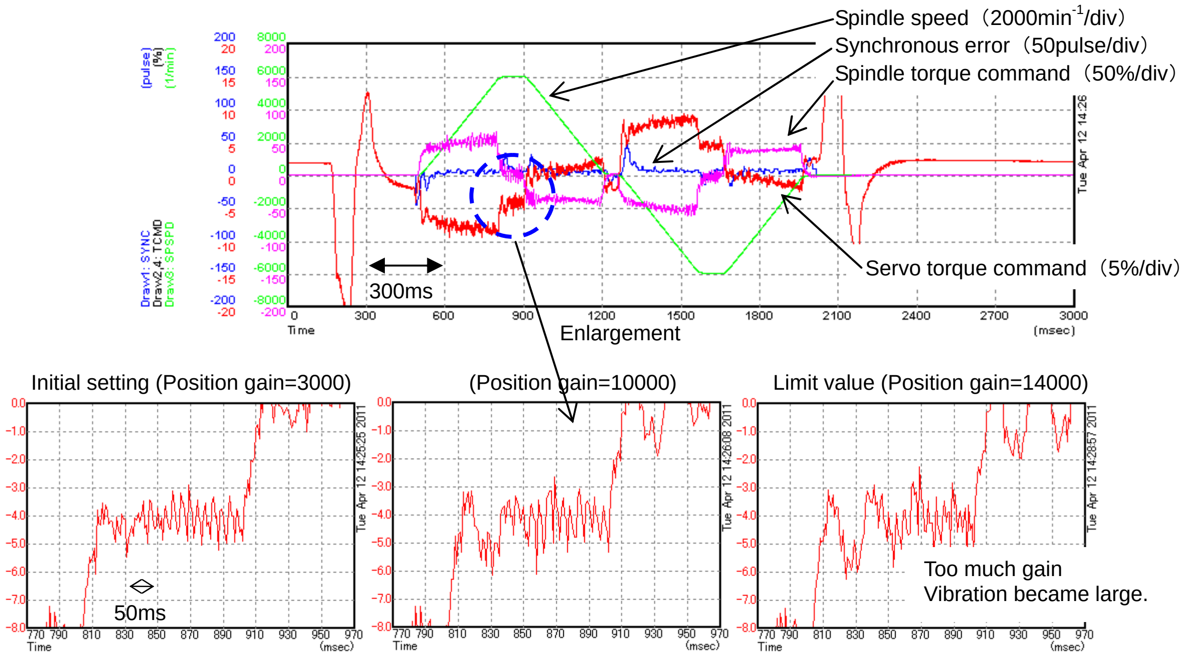


As next step, we’ll proceed to position gain of servo axis for FSSB high speed rigid tap. But before it, please tune the velocity loop gain of servo axis well in the ordinary servo tuning.

In former rigid tap, the synchronization between servo axis and spindle axis is realized by giving same position command to both axes. Therefore position gains for both servo axis and spindle axis should be same value. But in FSSB high speed rigid tap, the synchronization is realized by the way that servo axis follows spindle axis movement. So the position gains for both axes can be set independently.
The position gains for servo axis for former rigid tap are prepared in No.5280-5284. These parameters can be used also for FSSB high speed rigid tap. But new parameter No.2610, which is effective only for FSSB high speed rigid tap, is prepared.
As this parameter has not been included yet in “Rigid Tapping” group in Parameter Window of SERVO GUIDE, please change it in “Parameter Table”. The tuning way is same as the one for spindle axis.



Example of measurement result after tuning of servo position gain (Position gain = 10000)



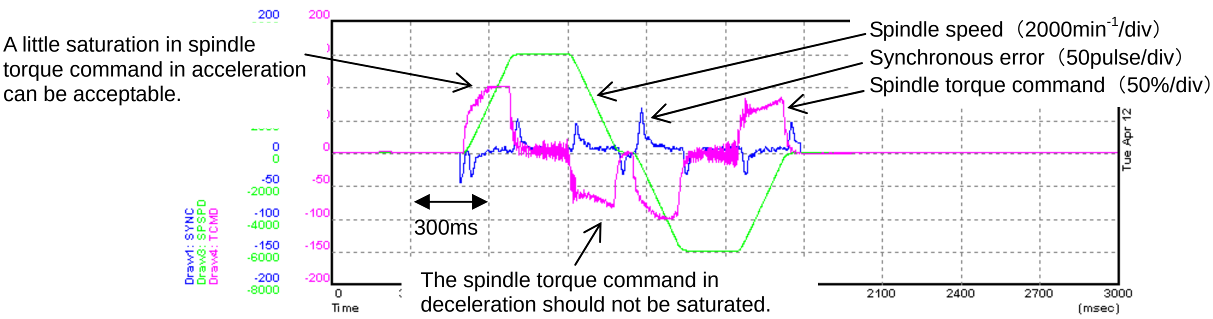
2.3.5. Tuning of time constant for acc./dec.

In former rigid tap, we’ve tuned the time constant for acc./dec. so that the peak torque command of spindle axis becomes 80% or so of maximum value. As the servo axis follows the spindle axis In FSSB high speed rigid tap, it’s possible to use the spindle torque up to the maximum level. And there is a possibility to be able to reduce time constant for acc./dec. at using FSSB high speed rigid tap. Please tune the time constant for acc./dec. so that the peak torque command of spindle axis becomes nearly 100%. However if you reduce it up to the situation that the torque command in deceleration becomes too much saturated, the spindle motor might make a overshoot in the bottom of the hole. Please tune it so that the overshoot doesn’t occur in the bottom of the hole.

Note) Assuming high speed and light load cutting, as the load torque of cutting is not so large, the time constant, which is determined in air-cut, can be used without any change. Considering low speed and heavy load cutting, the necessary torque for acc./dec. becomes small, because the speed is low. So the torque will be sufficient generally even in the heavy load cutting. Therefore the time constant, which is determined in air-cut at high speed, is usable in low speed and heavy load cutting also.

Please confirm the actual torque command in actual cutting as the final test.

Example of measurement result in rigid tap after second tuning of time constant for acc./dec.
(Time constant = 175ms)



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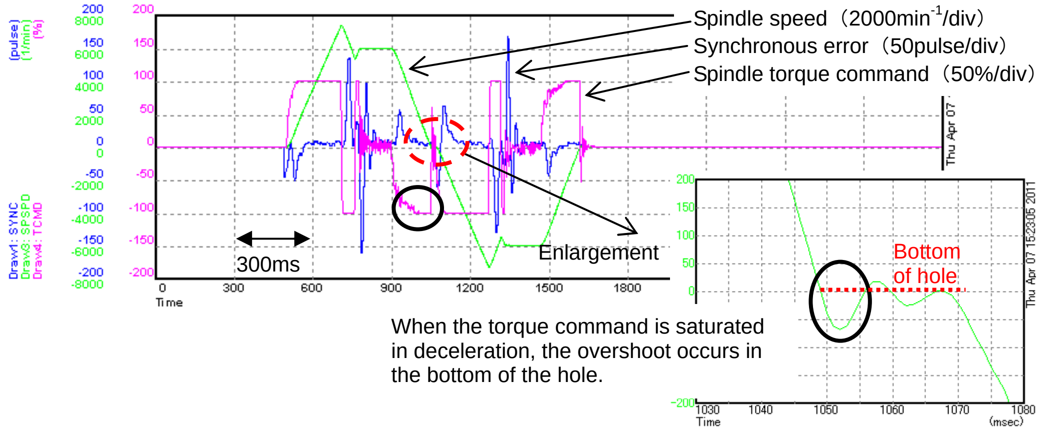
Example of measurement result in rigid tap with using too short constant for acc./dec.
(Time constant = 135ms)



2.3.6. Confirmation of synchronous error

Basically that’s all for the tuning for FSSB high speed rigid tap. After finishing the tuning of time constant for acc./dec., please check the synchronous error between servo axis and spindle axis. Please make sure that the synchronous error is less than 100 or so.

2.4. Tuning of former type rigid tap (for reference)

The tuning way of former type rigid tap is shown as follows for your reference.

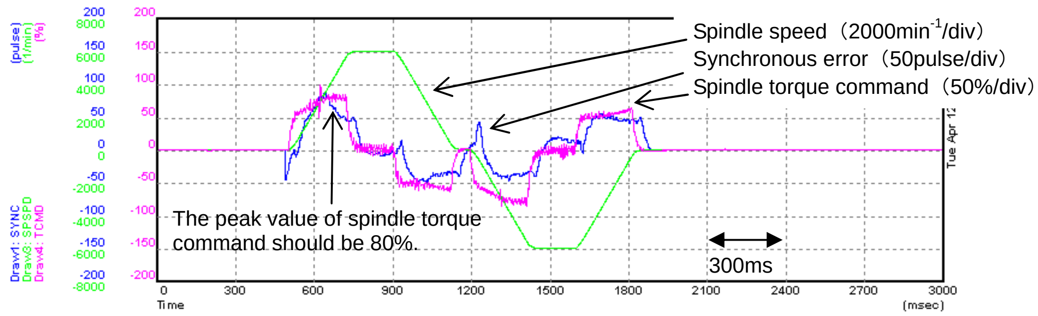
2.4.1. Initial settings and gain tuning of velocity loop and position loop

The initial settings for former rigid tap are same as the ones for FSSB high speed rigid tap.
And the tuning ways of velocity loop gain and position loop gain are almost same. There is only one difference in position gain setting. The position gains both for servo and spindle should be just same.

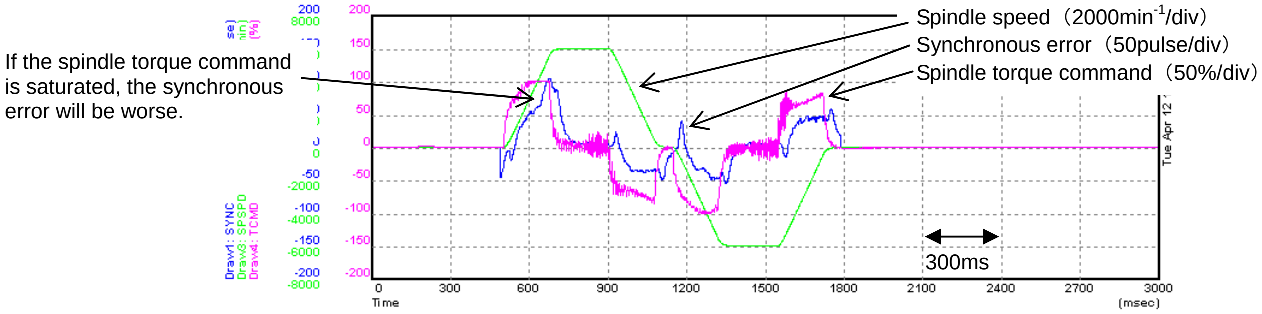
2.4.2. Tuning of time constant for acc./dec.

In the former type rigid tap, if the torque command is saturated, the synchronous error will be larger. So in this case, please tune the time constant for acc./dec. so that the peak value of spindle torque command becomes 80% of maximum torque, which includes a margin.

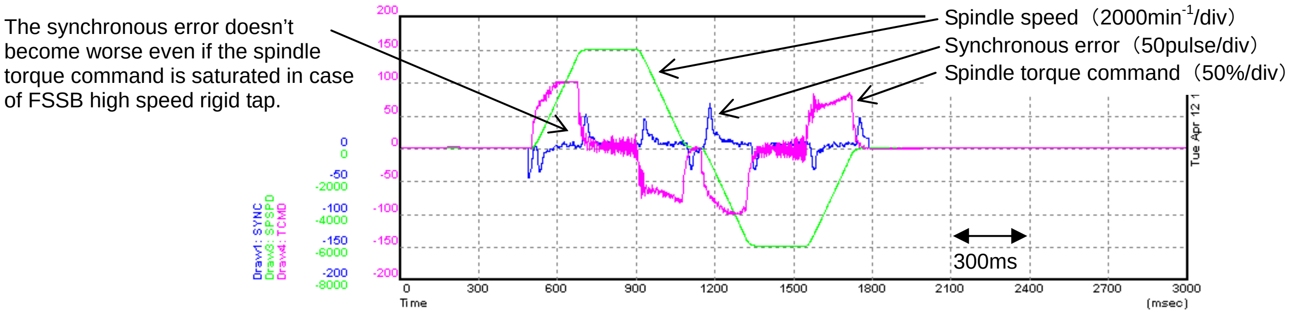
Example 1 of measurement result in former type rigid tap (Time constant = 220ms)



Example 2 of measurement result in former type rigid tap (Time constant = 175ms)



Ref.) Example of measurement result in FSSB high speed rigid tap (Time constant = 175ms)



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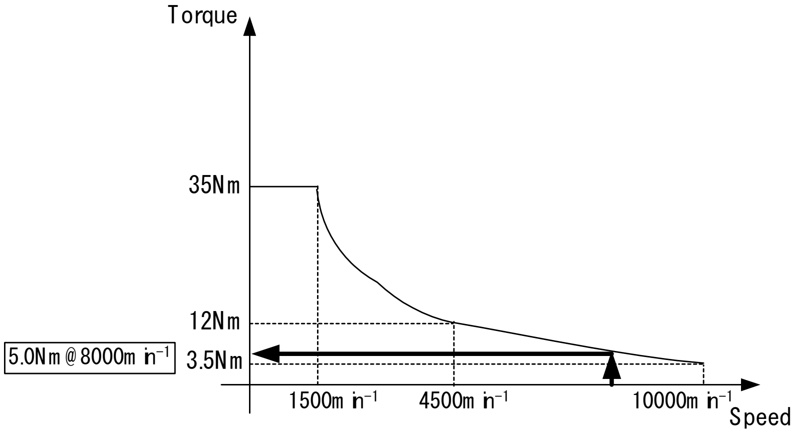
3. Using “Optimum Acc./Dec. for Rigid Tap” together

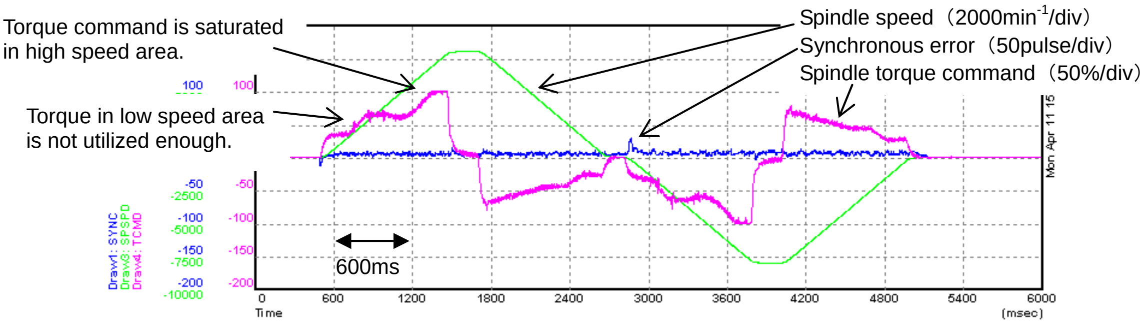
“Optimum acc./dec. for rigid tap” is the function that enables to change the acceleration in rigid tap according to the character of the spindle motor. By using this function together, the motor torque is derived at maximum in all speed range and it becomes possible to reduce the time for acc./dec.
Note) “Optimum acc./dec. for rigid tap” is an option function.

(Example) Assuming that we use the spindle motor, which has following character, at 8000min^{-1} for rigid tap,



This motor has small torque at 8000min^{-1}. When the acceleration is constant value in all speed, the torque in low speed area is not utilized enough, because the tolerable acceleration is limited by the torque in high speed area.

Example of measurement result without Optimum acc./dec. for rigid tap



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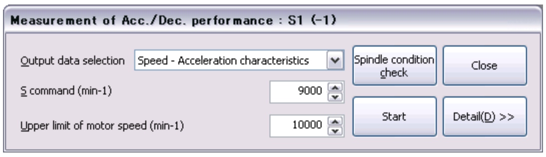
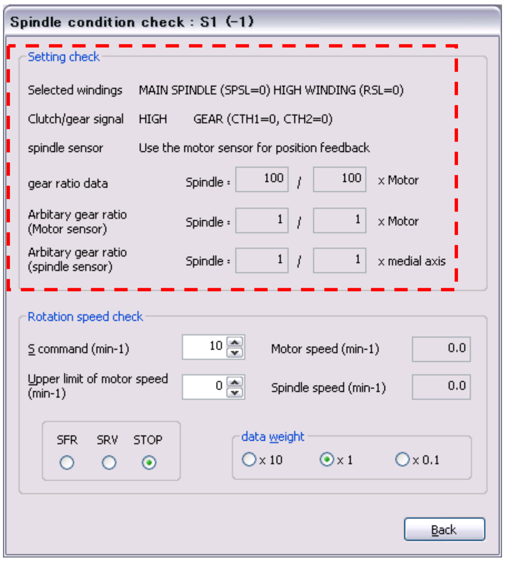
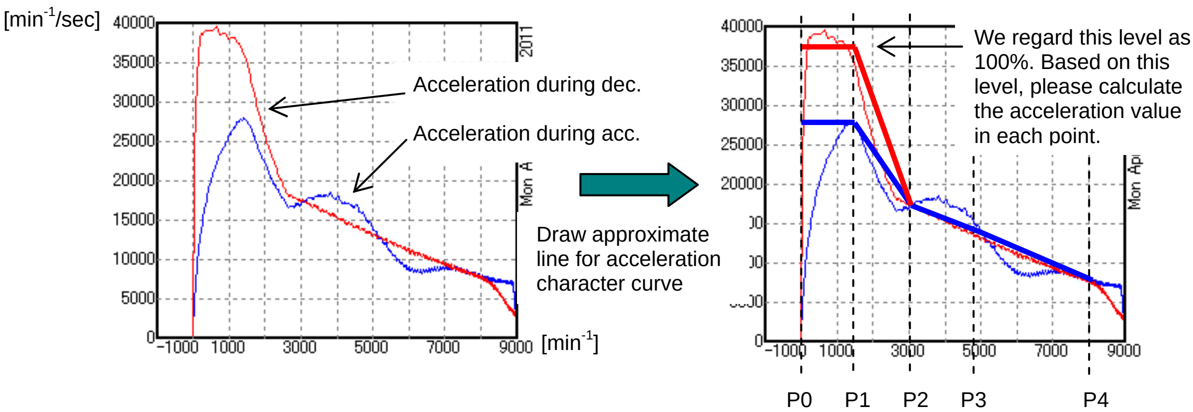
Please use “Acc./Dec performance measurement” for spindle tuning in SERVO GUIDE to determine the initial settings for Optimum acc./dec. for rigid tap.
Please open Graph Window and select [Tool] -> [Spindle Tuning] -> [Acc./Dec performance measurement]. The following window will be shown after getting spindle information.



Click [Spindle condition check] and confirm whether spindle conditions are proper or not.



Go back to the measurement window and after setting S command and upper limit of motor speed, click “Start”. Please set higher value than the maximum rigid tap speed in S command box, if you can.



Please estimate the initial setting values from the measurement result. Please draw approximate line through each setting point (P0-P4) to determine the acceleration character during acc./dec.. The above data shows the character in acc./dec. with maximum torque. So available torque in rigid tap will be less than this character. Please set the initial value for Optimum acc./dec. for rigid tap as 70% or so of approximate line.

(Setting example from the figure in former page)

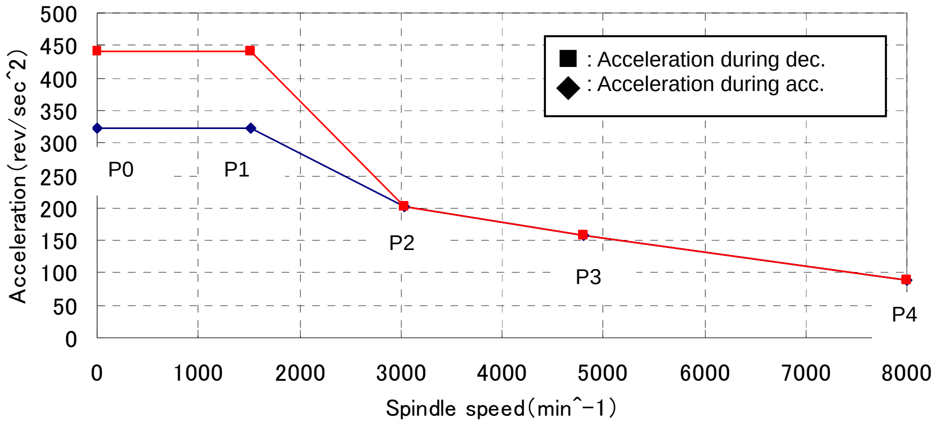
The maximum acceleration can be seen at 0-1500min^{-1} in deceleration. It's value is

$$37800(0 \sim 1500\,\mathrm{min}^{-1})[\mathrm{min}^{-1}/\mathrm{sec}] \div 60[\mathrm{sec}] \times 0.7 = 441[rev/\mathrm{sec}^2]$$

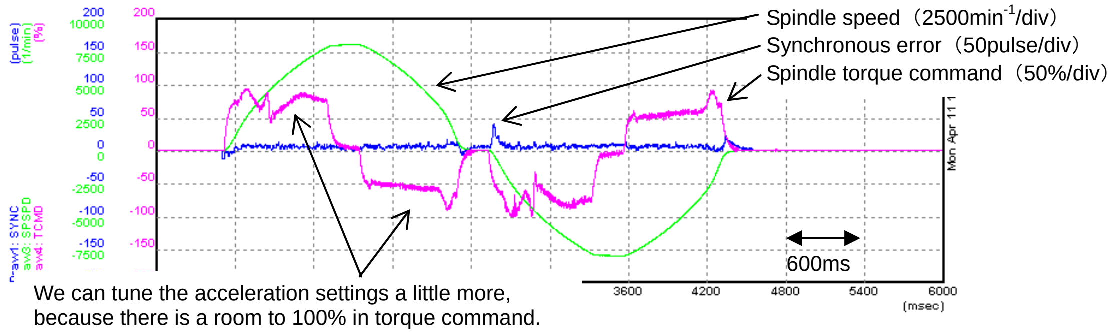
The rest of acceleration settings should be set as the proportion of this value.

Initial settings for Optimum acc./dec. for rigid tap

Gear	Maximum acceleration [rev/sec^2]	Maximum spindle speed [min^{-1}]	Acc. setting point	Spindle speed (Ratio to max. speed [%])	Acc. setting (Ration to max. acc. [%]) Forward / Reverse During acc.	During dec.
Gear 1	No.11421=441	No.5241=8000	P0	None（0%）	No.11441=73	No.11461=100
			P1	No.11429=19	No.11442=73	No.11462=100
			P2	No.11430=38	No.11443=46	No.11463=46
			P3	No.11431=60	No.11444=36	No.11464=36
			P4	None（100%）	No.11445=20	No.11465=40



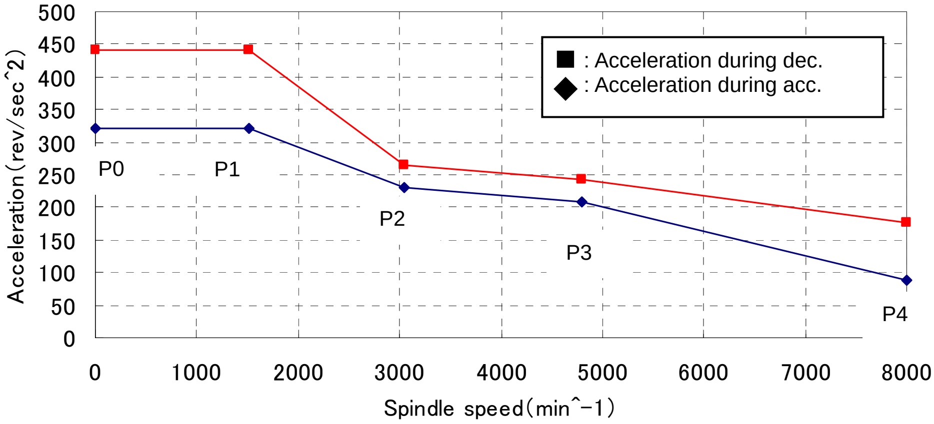
Example of **measurement result after initial setting** of Optimum acc./dec. for rigid tap



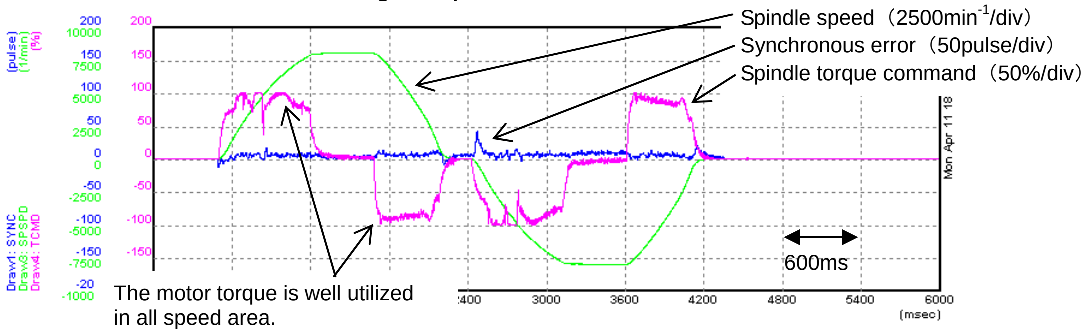
After confirming the measurement result with initial setting, please tune the acceleration parameters so that the spindle torque command reaches near 100% in all speed area.
When you tune them, please use the test program, which has the maximum rigid tap speed, and start tuning from the high speed point (P4) first, and continue to the low speed points in order.

After tuning settings for Optimum acc./dec. for rigid tap

Gear	Maximum acceleration [rev/sec^2]	Maximum spindle speed [min^{-1}]	Acc. setting point	Spindle speed (Ratio to max. speed [%])	Acc. setting (Ration to max. acc. [%]) Forward / Reverse	
					No.11441=73	No.11461=100
Gear 1	No.11421=441	No.5241=8000	P0	None（0%）	No.11442=73	No.11462=100
			P1	No.11429=19	No.11443=52	No.11463=60
			P2	No.11430=38	No.11444=47	No.11464=55
			P3	No.11431=60	No.11445=20	No.11465=40
			P4	None（100%）	No.11441=73	No.11461=100



Example of **measurement result after tuning** of Optimum acc./dec. for rigid tap



In the above example, the acceleration time and deceleration time are reduced as follows by applying Optimum acc./dec. for rigid tap.

	Function OFF		Function ON
Acceleration time :	976ms	->	720ms
Deceleration time :	976ms	->	588ms

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4. Using “Magnetic Flux Boost Function” together

Asynchronous spindle motors need some time to raise the magnetic flux at the excitation increasing. Therefore we recommend generally to set some waiting time at the changing from velocity control mode to servo mode including rigid tap. (No.4099: Delay time for stable motor excitation)
To reduce the waiting time, we are providing the function that gives large excitation current in an instance at the changing from velocity control mode to servo mode. It helps to quicken the increasing of magnetic flux. And as this function judges the status of preparation of magnetic flux, the rigid tap will start faster without waiting time set in No.4099.
There is a possibility to reduce the cycle time by using this function together.

Parameter settings for Flux boost function

Parameter number（FS30i-B）	Contents
4353#6	Magnetic flux boost function bit　Setting value : 1
4124(for high speed winding, or without speed range switching) 4155(for low speed winding)	Magnetic flux boost setting level / Magnetic flux boost coefficient Setting value : See below
4099	Delay time for stable motor excitation (ms)　Setting value : 300 Note) Even when you use magnetic flux boost function, please set something value (300 or so) in this parameter.

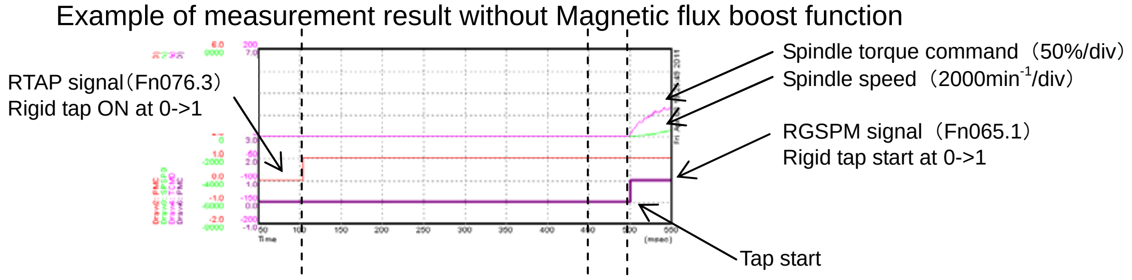
Spindle parameter manual (B-65280/08 edition or subsequent editions) shows the setting value for No.4124 and 4155. Please set them according to the description. If you can’t find the description for your motors, please calculate it according to the following formulas.

$$No.4124 = 24320 + \left\{Minimum\_value\_between(\sqrt{(No.4111/100)^2+1} \times 0.9 \times 100)\_and\_255\right\}$$

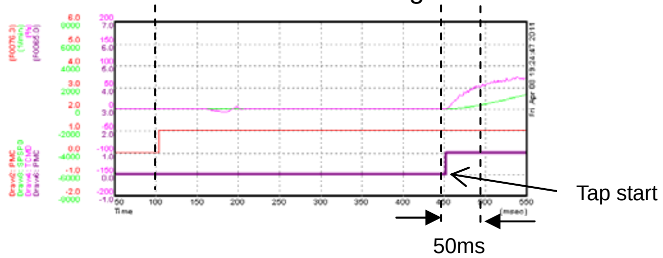
$$No.4155 = 24320 + \left\{Minimum\_value\_between(\sqrt{(No.4147/100)^2+1} \times 0.9 \times 100)\_and\_255\right\}$$

Note) If you don’t use Speed range switching function, it’s not necessary to set No.4155.

Example of measurement result without Magnetic flux boost function



Example of measurement result with Magnetic flux boost function



In the above example, the start timing of rigid tap became 50ms faster, and the total cycle time also reduced 50ms.

Revision of αi series Spindle Software
(9D90/H(08), 9DA0/K(11))

1. Type of applied documents

Name	FANUC AC SPINDLE MOTOR αi series, FANUC AC SPINDLE MOTOR βi series, FANUC BUILT-IN SPINDLE MOTOR Bi series PARAMETER MANUAL
Spec. No./Ver.	B-65280EN/08

2. Summary of Change

Group	Name / Outline	New, Add Correct, Del	Applicable Date
Basic Function			
Optional Function			
Unit			
Maintenance Parts			
Notice			
Correction			
Another	Revision of spindle software 9D90/H(08), 9DA0/K(11)	Add	2011.06

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Revision of αi series Spindle Software (9D90/H(08),9DA0/K(11))

1. General

   αi series spindle software was revised as follows.

2. Software series, edition and applied spindle amplifier

Software edition	Spindle amplifier specification		Notes
9D90 edition H(08)	αiSP	A06B-6144-Hxxx#H590 A06B-6154-Hxxx#H590	30*i*/31*i*/32*i*-A, 16*i*/18*i*/21*i*-B, 0*i* -B/C, 0*i* -D,15*i*-MB,PM*i*-D Induction/ synchronous spindle motor
9DA0 edition K(11)	αiSP	A06B-6220-Hxxx#H600 A06B-6270-Hxxx#H600	30 *i*//31 *i*//32 *i*/-B, 35 *i*/-B Induction/ synchronous spindle motor
	αiSVP	A06B-6230-Hxxx#H600	

3. Contents of modification

	Contents	9D90/H	9DA0/K
(1)	It has become possible to connect spindle amplifier for FS30*i*-B to FS0*i*-D controller. Note) It's necessary to update system software to use this feature. It will be delivered from August.	-	◎
(2)	The number of the measurable spindle channel per one spindle axis has been expanded from "2" to "4". Note) It's necessary to update system software and SERVO GUIDE to use this feature. It will be delivered from September.	-	◎
(3)	It has become possible to drive αiI150/5000HV with FS0*i*-D.	◎	◎

◎ : Revised item - : Not supported

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Revision of αi series Spindle Software
(9D5A/L, 9D53/Y, 9D7A/A, 9D80/X)

1. Type of applied documents

Name	FANUC AC SPINDLE MOTOR αi series, FANUC AC SPINDLE MOTOR βi series, FANUC BUILT-IN SPINDLE MOTOR Bi series PARAMETER MANUAL
Spec. No./Ver.	B-65280EN/08

2. Summary of Change

Group	Name / Outline	New, Add Correct, Del	Applicable Date
Basic Function			
Optional Function			
Unit			
Maintenance Parts			
Notice			
Correction			
Another	Revision of spindle software 9D5A/L Revision of spindle software 9D53/Y Revision of spindle software 9D7A/A Revision of spindle software 9D80/X	Add	2011.06

				TITLE	Revision of αi series Spindle software (9D5A/L, 9D53/Y, 9D7A/A, 9D80/X)	
01	11.06.22	Tsutsumi	Newly designed	DRAW. No.	B-65280EN/08-03	CUST.
Ed.	Date	Design.		FANUC CORPORATION	SHEET	1/2

Revision of αi series Spindle Software (9D5A/L, 9D53/Y, 9D7A/A, 9D80/X)

1. General

   αi series spindle software was revised as follows.

2. Software series, edition and applied spindle amplifier

Software edition	Spindle amplifier specification		Notes
9D5A edition L(12)	αiSP	A06B-6111-Hxxx#H550 A06B-6112-Hxxx#H550 A06B-6121-Hxxx#H550 A06B-6122-Hxxx#H550	16*i*/18*i*/21*i*-B, 0*i*-B/C, 15*i*-MB, PM*i*-D Induction spindle motor
	βiSVSP	A06B-6134-Hxxx#A A06B-6134-Hxxx#D	0*i*-B/C Induction spindle motor
9D53 edition Y(25)	αiSP	A06B-6111-Hxxx#H553 A06B-6112-Hxxx#H553 A06B-6121-Hxxx#H553 A06B-6122-Hxxx#H553	16*i*/18*i*/21*i*-B, 0*i*-B/C, 15*i*-MB, PM*i*-D Synchronous spindle motor
9D7A *) edition A(01)	αiSP	A06B-6111-Hxxx#H570 A06B-6112-Hxxx#H570 A06B-6121-Hxxx#H570 A06B-6122-Hxxx#H570	30*i*/31*i*/32*i*-A, Induction/ synchronous spindle motor
9D80 edition X(24)	αiSP	A06B-6141-Hxxx#H580 A06B-6142-Hxxx#H580 A06B-6151-Hxxx#H580 A06B-6152-Hxxx#H580	30*i*/31*i*/32*i*-A, 16*i*/18*i*/21*i*-B, 0*i*-D, 0*i*-B/C, 15*i*-MB , PM*i*-D Induction/ synchronous spindle motor
	βiSVSP	A06B-6164-Hxxx#H580	0*i*-D Induction spindle motor

*) 9D7A series is a successor of 9D70 series. 9D70/Y was revised to 9D7A/A.

- Only the name of the spindle software is changed.
- The specification No. of the amplifier is not changed.
- 9D7A series is revised from 9D70 series, and has an upper compatibility with 9D70 series.

3. Contents of modification

Contents of modification	9D5A/L	9D53/Y	9D7A/A	9D80/X
1) It has become possible to drive αiI150/5000HV with FS0*i*-D.	-	-	-	○
2) The protect operation was added to the torque command calculation not to output over the tolerable current limit of the amplifier for improvement of reliability.	○	○	○	○

○ : Revised item - : Not supported

				TITLE Revision of αi series Spindle software (9D5A/L, 9D53/Y, 9D7A/A, 9D80/X)
01	11.06.22	Tsutsumi	Newly designed	DRAW. No. B-65280EN/08-03 CUST.
Ed.	Date	Design.		FANUC CORPORATION SHEET 2/2

Notes for using Optimum Orientation and
Corrections of Spindle Parameter Manual

1. Type of applied documents

Name	FANUC AC SPINDLE MOTOR αi series, FANUC AC SPINDLE MOTOR βi series, FANUC BUILT-IN SPINDLE MOTOR Bi series PARAMETER MANUAL
Spec. No./Ver.	B-65280EN/08

2. Summary of Change

Group	Name / Outline	New, Add Correct, Del	Applicable Date
Basic Function			
Optional Function			
Unit			
Maintenance Parts			
Notice	Notes for using Optimum Orientation	Add	2011.07
Correction	Corrections of spindle parameter manual	Add	2011.07
Another			

				TITLE Notice of using Optimum Orientation and Correction of Spindle Parameter Manual
01	11.07.29	Tomiyama	Newly designed	DRAW. No. B-65280EN/08-04 CUST.
Ed.	Date	Design.		FANUC CORPORATION SHEET 1/3

Notes for using Optimum Orientation and Corrections of Spindle Parameter Manual

1. General

This document describes the notes for using the Optimum Orientation and corrections of FANUC AC SPINDLE MOTOR αi series Parameter Manual B-65280EN/08.

2. Notes for using Optimum Orientation

In case of using the optimum orientation (30*i*: No.4018#6,#3=0,1) and the following function (1) or (2) together, please set the parameter for the reference position return speed without fail.

(1) Reference position return at the start of rigid tapping (30*i*: No.5202#0=1)

(2) Reference position return for the spindle positioning

The reference position return speed for (1)and (2) is specified by the parameter below.

Please set a value other than 0 in the parameter below in case of using the optimum orientation function. It's impossible to do the reference position return if the parameter below is set to 0.

15*i*	16*i*	30*i*	
3074	4074	4074	**Speed of reference position return for Cs contouring control mode/servo mode**

Unit of data : $1 min^{-1}$
Valid data range : 0 to 32767
Standard setting : 0

- When 0 is set
  The orientation speed is equal to the reference position return speed in servo mode (rigid tapping/spindle positioning) in case of using conventional type orientation function.

- When a value other than 0 is set
  The value set in this parameter is used as a reference position return speed for servo mode (rigid tapping/spindle positioning).
  Set a value other than 0 in case of using the optimum orientation function.

  Please set this parameter No.4074 according to the following guideline.
  Generally this parameter is set to between 100 and 300. In case of tuning this parameter, please follow the procedure below.
  1) Set 100 as an initial value for No.4074.
  2) If an overshoot does not occur at positioning of the reference position return, please increase the value in No.4074 as far as the overshoot does not occur. The higher speed of the reference position return, the shorter the time to complete becomes.
  3) If an overshoot occurs even when No.4074 is 100, please decrease the value in No.4074 so as to eliminate the overshoot.

3. Corrections of Spindle Parameter Manual B-65280EN/08

<table>
<tr><th>Page</th><th>Error</th><th>Correction</th></tr>
<tr>
<td>305</td>
<td>(1) Input signals (PMC→CNC)
<table>
<tr><td>__</td><td>__</td><td>#7</td><td>#6</td><td>#5</td><td>#4</td></tr>
<tr><td>__</td><td>G066</td><td></td><td></td><td></td><td>RTRCT</td></tr>
</table>
(2) Output signals (CNC→PMC)
<table>
<tr><td>__</td><td>30i</td><td>#7</td><td>#6</td><td>#5</td><td>#4</td></tr>
<tr><td>__</td><td>F065</td><td></td><td>SYNMOD</td><td></td><td>RTRCT</td></tr>
</table>
</td>
<td>(1) Input signals (PMC→CNC)
<table>
<tr><td><u>16i</u></td><td><u>30i</u></td><td>#7</td><td>#6</td><td>#5</td><td>#4</td></tr>
<tr><td><u>G066</u></td><td>G066</td><td></td><td></td><td></td><td>RTRCT</td></tr>
</table>
(2) Output signals (CNC→PMC)
<table>
<tr><td><u>16i</u></td><td><u>30i</u></td><td>#7</td><td>#6</td><td>#5</td><td>#4</td></tr>
<tr><td><u>F065</u></td><td>F065</td><td></td><td>SYNMOD</td><td></td><td>RTRCT</td></tr>
</table>
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<tr>
<td>408</td>
<td>
<table>
<tr><td>15i</td><td>16i</td><td>30i</td><td></td></tr>
<tr><td>3124</td><td>4124</td><td>4124</td><td>Magnetic flux boost completion level / magnetic flux boost coefficient</td></tr>
</table>
Set the parameters for using the magnetic flux boost function.
For information about the values to be set, see Subsection <u>5.15.7.</u> “Adjustment Procedure.”
</td>
<td>
<table>
<tr><td>15i</td><td>16i</td><td>30i</td><td></td></tr>
<tr><td>3124</td><td>4124</td><td>4124</td><td>Magnetic flux boost completion level / magnetic flux boost coefficient</td></tr>
</table>
Set the parameters for using the magnetic flux boost function.
For information about the values to be set, see Subsection <u>5.17.5</u> “Adjustment Procedure”.
</td>
</tr>
</table>

Twin Drive for Spindle Motor

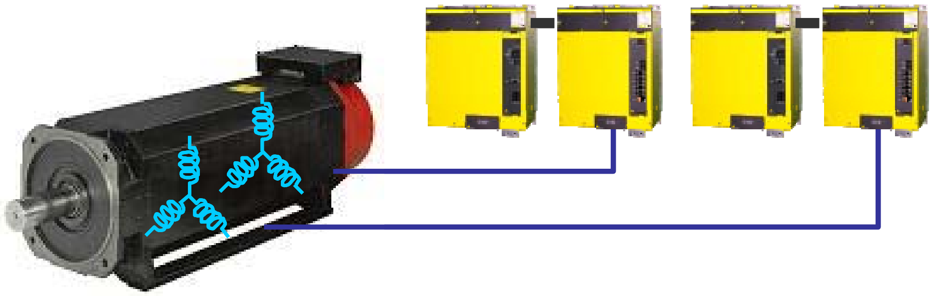
Specifications

				TITLE	Twin Drive for Spindle Motor Specifications	
01	11.07.29	Tomiyama	Newly designed	DRAW. No.	B-65280EN/08-05	CUST.
Ed.	Date	Design.		FANUC CORPORATION	SHEET	1/16

1. Outline

This document describes the Twin Drive to drive a spindle motor with two windings.

Regarding the specifications of motors driven by the Twin Drive, refer to manuals for each spindle motor.



2. Application

2.1. Combination of spindle amplifier and CNC

Spindle amplifier		CNC				
Amplifier spec. No. A06B-xxxx-･･･	Software series	15*i*-MB	16*i*-B 18*i*-B	30*i*-A 31*i*-A	0*i*-D	30*i*-B 31*i*-B 32*i*-B
6112 6122	9D50 9D5A	○ *1	○*1	–	–	–
	9D70 9D7A	–	–	○*2	–	–
6142 6152	9D80	○ *3	○*3	○*3	◎*4	–
6144 6154	9D90	○ *5	○*5	○*5	◎*6	–
6220 6270	9DA0	–	–	–	◎*7	◎*7

◎: Available without option

○: CNC software option of Spindle tandem control is necessary.

* The Twin Drive uses the Spindle tandem control inside CNC system to control a motor. So the option of Spindle tandem control has been necessary for the Twin Drive. From 30*i*-B series CNC and 0*i*-D series CNC, the Twin Drive is available without option of Spindle tandem control.

Applicable spindle software

*1: 9D50/O(15) or later, 9D5A/A(01) or later
*2: 9D70/F(06) or later, 9D7A/A(01) or later
*3: 9D80/A(01) or later
*4: 9D80/X(24) or later
*5: 9D90/A(01) or later
*6: 9D90/H(08) or later
*7: 9DA0/K(11) or later

2.2. Note

- The Twin Drive needs two αiSP amplifiers (TYPE B) (as for master SP, slave SP) per one motor. αiSP of 6220 or 6270 has no distinction between TYPE A and TYPE B. All of the amplifiers support Twin Drive.

- The same spindle software series and edition should be used both for the master SP and the slave SP.

- The specification of an applied spindle amplifier depends on the specification of the spindle motor. The specification and the number of power supply (PS) also depend on the specification of the spindle motor.

- For designation of spindle axes, 2 spindles are necessary per one twin drive spindle motor (master SP, slave SP). For designation of control axes, 1 axis is necessary per one twin drive spindle motor (master SP) in case of Cs contouring control.

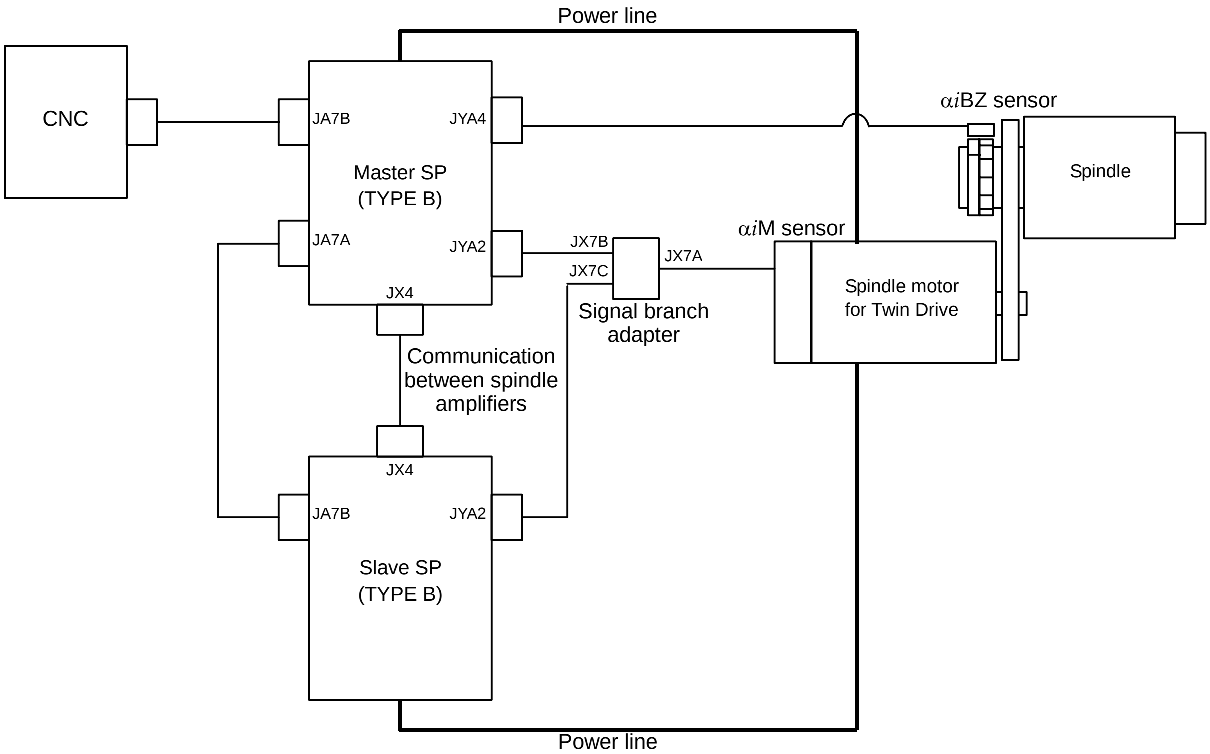
- It is not possible to use Twin Drive and the following functions together:
  - Spindle switching control
  - Position coder signal output (Connector JX4)
  - Spindle EGB
  - Spindle learning control
  - Spindle tandem control (Velocity tandem, Torque tandem)
  - Integrator copy function
  - Synchronous spindle motor driving

- There is no restriction to assign spindle axes for a master spindle and a slave spindle. In this document, the following assignment is applied for explanation.

  Master SP: 1st spindle
  Slave SP: 2nd spindle

3. System configuration

3.1. In case of a separate sensor



Note

*1 The motor sensor feedback should be connected to both the master SP and the slave SP by using a signal branch adapter.

*2 The separate sensor should be connected to the master SP.

*3 Regarding detailed specifications of each cable, refer to FANUC SERVO AMPLIFIER αi series DESCRIPTIONS (B-65282EN).

*4 The number of power supply (PS) depends on the specification of the spindle motor.

*5 The emergency stop signal for power supply (PS) (connector CX4) should be connected to each PS.

				TITLE Twin Drive for Spindle Motor Specifications
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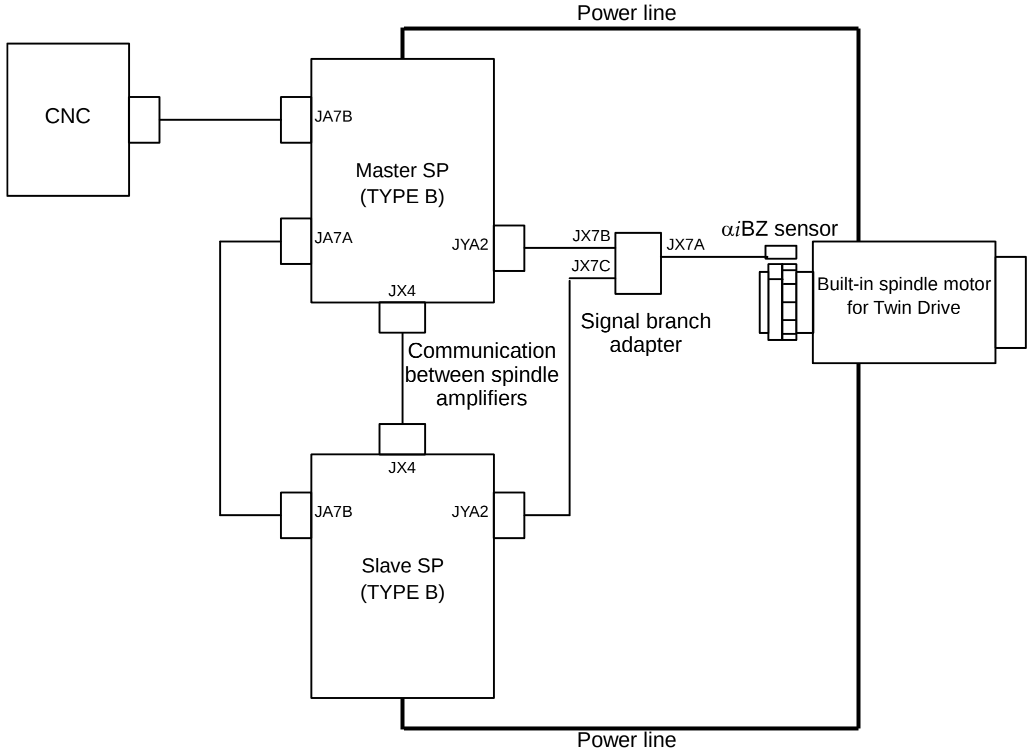
3.2. In case of a built-in motor



Note

*1 The motor sensor feedback should be connected to both the master SP and the slave by using a signal branch adapter.

*2 αiCZ sensor (serial) is not applicable for the motor sensor.

*3 Regarding detailed specification of each cable, refer to FANUC SERVO AMPLIFIER αi series DESCRIPTIONS (B-65282EN).

*4 The number of power supply (PS) depends on the specification of the spindle motor.

*5 The emergency stop signal (connector CX4) for power supply (PS) should be connected to each PS.

4. Input/output Signals (CNC↔PMC)

> Note
> *1 The command to the spindle should be given to the master during Twin driving.
> The specification of the input signals is the same as that of a normal spindle (without Twin Drive).
> For details of signals for each control mode, refer to FANUC AC SPINDLE MOTOR αi series parameter manual (B-65280JA).
> *2 When Twin Drive is active, it is not necessary to input signals from PMC to slave SP.
> Input signals for slave SP are transmitted from master SP through communication between spindle amplifiers.
> *3 When Twin Drive is active, output signals for master SP should be used for judgments of sequence (speed arrival, alarm, etc.).

4.1. Input signals (PMC→CNC)

	15*i*	16*i*	30*i*, 0*i*-D	#7	#6	#5	#4	#3	#2	#1	#0
1st	G228	G073	G073							**SLVA**	
2nd	G236	G077	G077							**SLVB**	

SLVA : Tandem mode command (1st spindle)
SLVB : Tandem mode command (2nd spindle)
0 : Tandem mode OFF
1 : Tandem mode ON.
This signal specifies whether Tandem control is active or not.
In case Twin Drive is used, set this signal to 1 for both master SP and slave SP.

> Note
> *1 This signal should be changed during spindle stop status. The change of this signal is not accepted during rotation.
> *2 This signal should be changed in the velocity mode. The change of this signal is not accepted except in the velocity mode.

4.2. Output signals (CNC→PMC)

	15*i*	16*i*	30*i*, 0*i*-D	#7	#6	#5	#4	#3	#2	#1	#0
1st	F228	F046	F046				**SLVSA**				
2nd	F244	F050	F050				**SLVSB**				

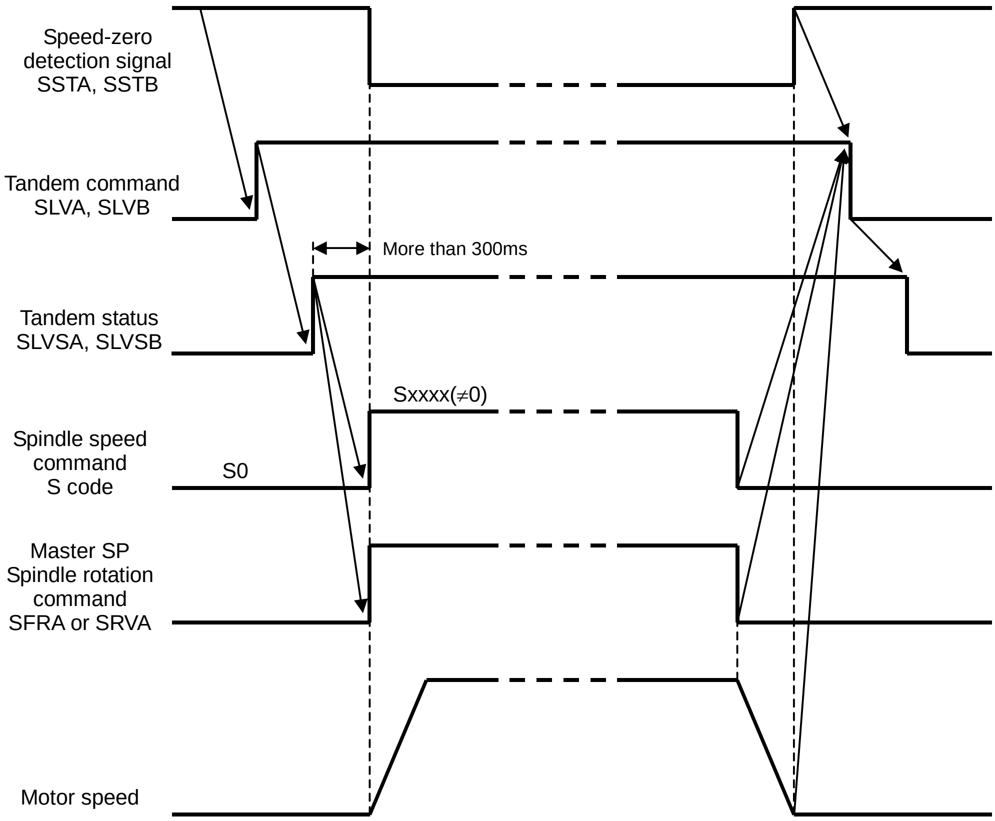
SLVSA : Tandem mode status signal (1st spindle)
SLVSB : Tandem mode status signal (2nd spindle)
0 : Tandem mode OFF
1 : Tandem mode ON
After both the signals for the master spindle and the slave spindle become 1, the command should be given to the master spindle.

5. Sequence examples

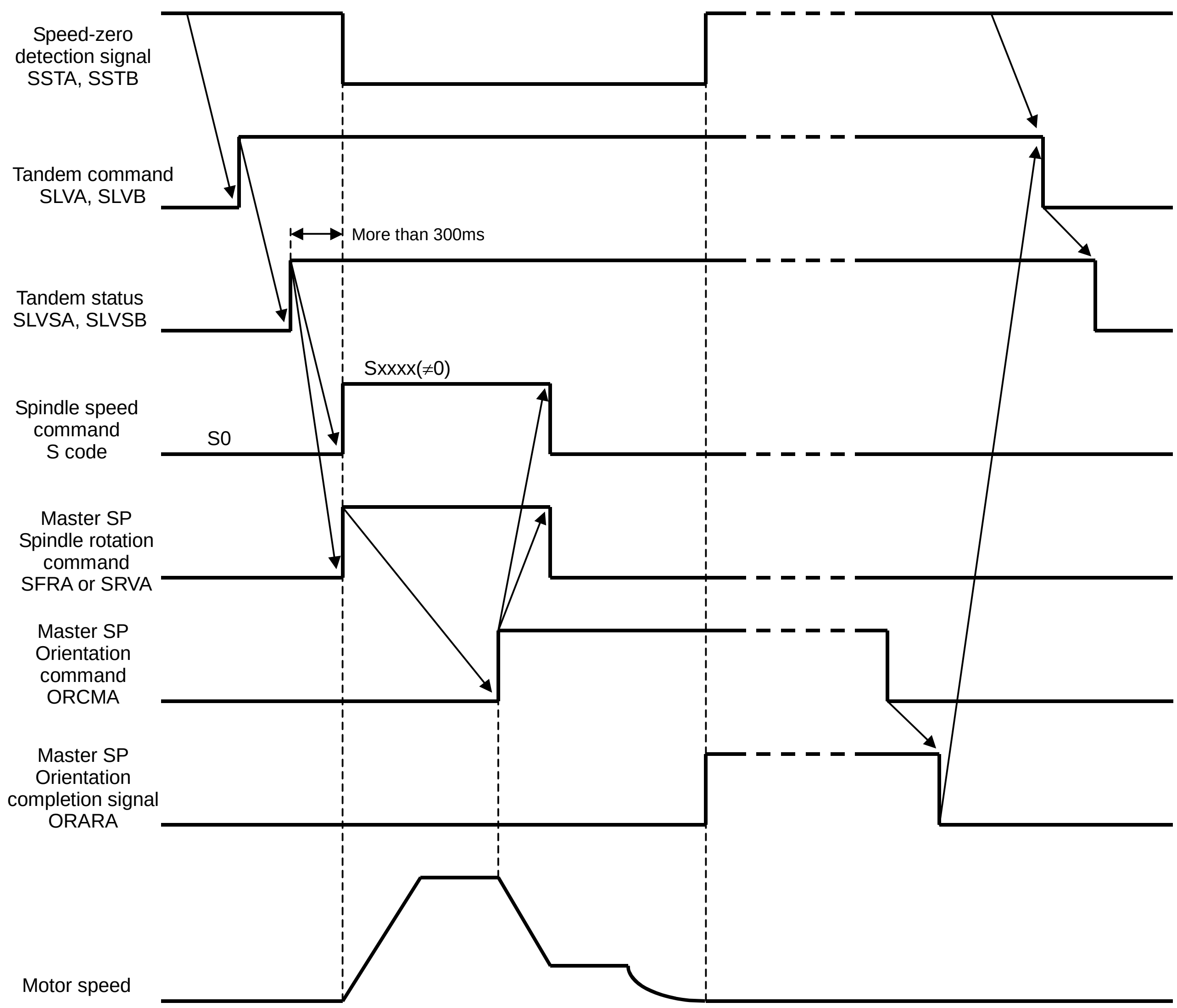
Sequence examples for the following assignment are described as follows.

1st spindle: Master SP
2nd spindle: Slave SP

5.1.1. Velocity mode

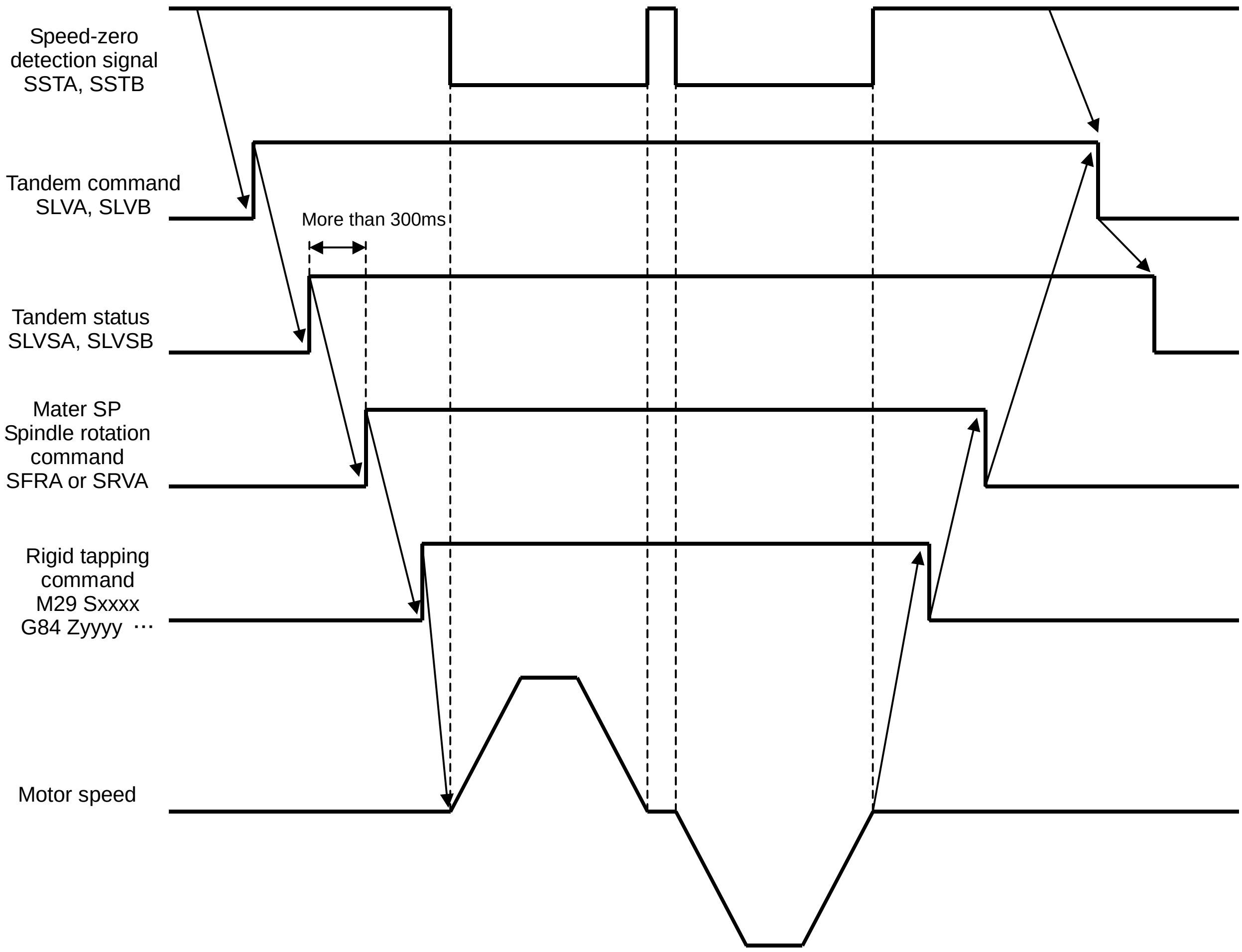


5.1.2. Spindle orientation

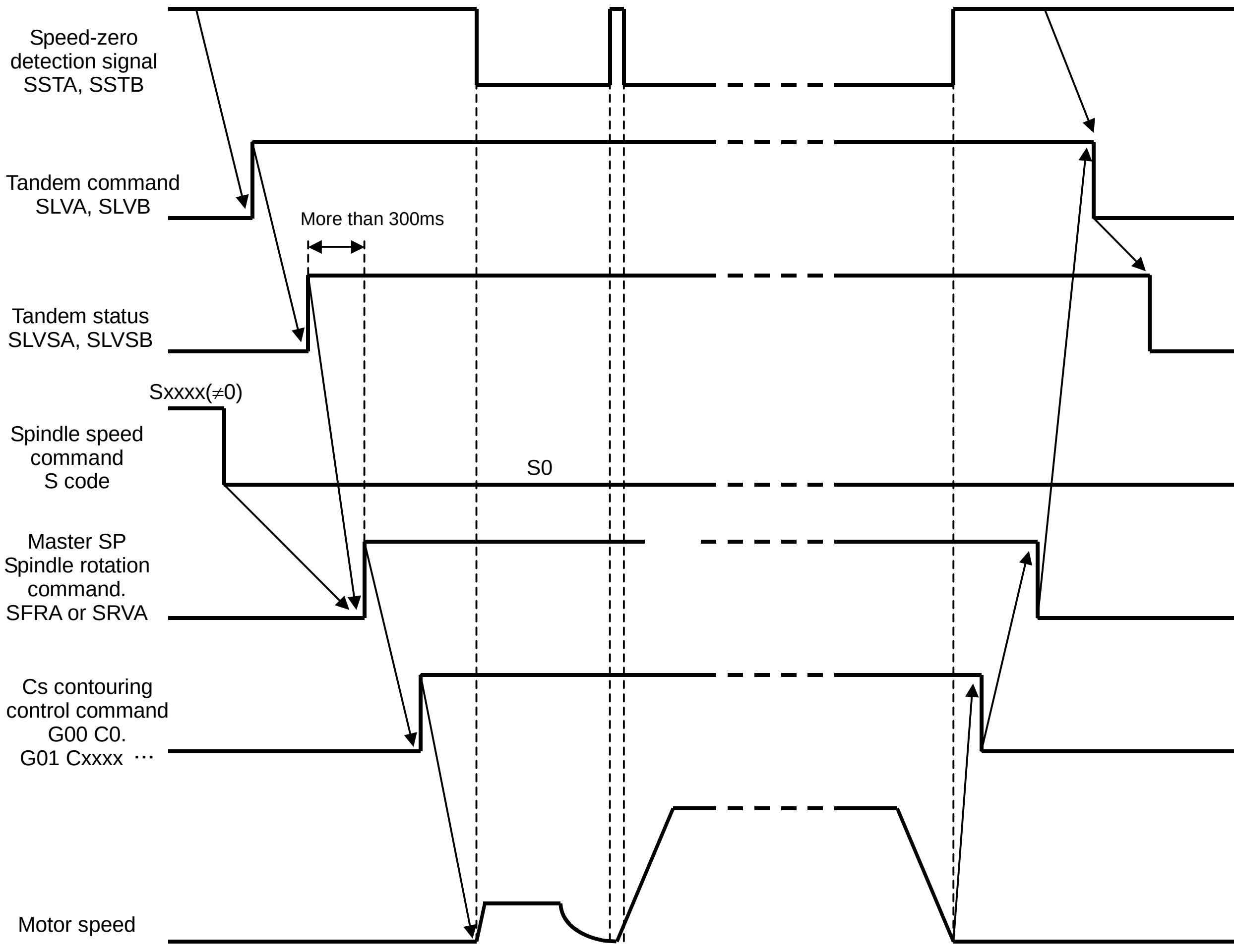


				TITLE Twin Drive for Spindle Motor Specifications		
01	11.07.29	Tomiyama	Newly designed	DRAW. No. B-65280EN/08-05		CUST.
Ed.	Date	Design.		FANUC CORPORATION	SHEET 8/16	

5.1.3. Rigid tapping



5.1.4. Cs contouring control



6. List of related parameters

Parameter No.			Contents
15*i*	16*i*	30*i*, 0*i*-D	
3015#3	4015#3	4015#3	Spindle tandem control function
3352#6	4352#6	4352#6	Slave axis for communication between spindle amplifiers
3352#7	4352#7	4352#7	Master axis for communication between spindle amplifiers
3398#3	4398#3	4398#3	Using Twin Drive

Note

*1 The spindle parameters for the master spindle and the slave spindle should be the same setting except the below parameters.

Parameter No.			Master SP	Slave SP	Contents
15*i*	16*i*	30*i*, 0*i*-D			
3352 #7,6	4352 #7,6	4352 #7,6	1, 0	0, 1	Communication between spindle amplifiers
3002 #3,2,1,0	4002 #3,2,1,0	4002 #3,2,1,0	Depending on sensor	0,0,0,0	Kind of spindle sensor
3134	4134	4134	Depending on motor	0	Motor overheat level

7. Details of related parameters

15*i*	16*i*	30*i*, 0*i* -D	#7	#6	#5	#4	#3	#2	#1	#0
3009	4009	4009						**ALSP**		

ALSP Motor power turn-off method when spindle alarm 24 (serial data transfer error) is issued
- 0 : Turns off the power after the motor is decelerated to stop.
- 1 : Turns off the power immediately (Set 1)

15*i*	16*i*	30*i*, 0*i* -D	#7	#6	#5	#4	#3	#2	#1	#0
3015	4015	4015					**SPDTDM**			

SPDTDM Spindle tandem control function (CNC software option is necessary)
- 0 : Spindle tandem function is not available
- 1 : Spindle tandem function is available

Note

1 When the Twin drive is used with 30*i*-B or 0*i*-D, CNC software option is not necessary. Regardless of setting status of this, Twin Drive is available.

2 When the Twin Drive is used with 15*i*-MB, 16*i*-B or 30*i*-A, CNC software option of Spindle tandem control is necessary. Please confirm this bit is 1.

15*i*	16*i*	30*i*, 0*i* -D	#7	#6	#5	#4	#3	#2	#1	#0
3352	4352	4352	**MASTER**	**SLAVE**						

SLAVE Slave axis for communication between spindle amplifies
0 : Not slave axis
1 : Slave axis (Set 1 in case of slave SP)

MASTER Master axis for communication between spindle amplifies
0 : Not master axis
1 : Master axis (Set 1 in case of master SP)

15*i*	16*i*	30*i*, 0*i* -D	#7	#6	#5	#4	#3	#2	#1	#0
3398	4398	4398					**WNDTDM**			

WNDTDM Using Twin Drive
0 : Twin Drive is not available
1 : Twin Drive is available (Set 1)
This parameter specifies whether Twin Drive to drive one motor by two amplifiers is available or not.

> Note
> If this bit is 0, Twin Drive does not work. Please confirm this bit is set to1.

8. Alarm and status error

8.1. Spindle alarm

Alarm No.				Contents	Measure
15*i*-MB	16*i*	30*i* 0*i*-D	SP		
SP0066	9066	SP9066	66	Error in communication between spindle amplifiers	Check the connection of cable (connector JX4).
SP0080	9080	SP9080	80	Alarm occurring on destination amplifier of communication between spindle amplifiers	Remove alarm factor of the amplifier.

8.2. Spindle status error

Error No.	Contents	Measure
38	・Wrong settings in parameters for communication between spindle amplifiers ・Wrong settings for function which can not used together with Twin Drive at the same time	Check parameter settings

9. Parameters for each motor model

Parameter No.			αiI 150/5000HV
			αiSP75HV x2 (*1) αiPS100HV x2
FS15*i*	FS16*i*	FS30*i* FS0*i*-D	150/ 180 kW 1500 / 5000 min^{-1}
3007	4007	4007	00000000
3008	4008	4008	00000000
3009	4009	4009	00000000
3010	4010	4010	00010001
3011	4011	4011	00001010
3012	4012	4012	10000000
3013	4013	4013	00001100
3019	4019	4019	00000100
3020	4020	4020	5000
3039	4039	4039	0
3080	4080	4080	10591
3083	4083	4083	30
3100	4100	4100	1520
3101	4101	4101	100
3102	4102	4102	1551
3103	4103	4103	0
3104	4104	4104	2500
3105	4105	4105	0
3106	4106	4106	4000
3107	4107	4107	0
3108	4108	4108	0
3109	4109	4109	25
3110	4110	4110	973
3111	4111	4111	324
3112	4112	4112	200
3113	4113	4113	172
3114	4114	4114	0
3115	4115	4115	100
3116	4116	4116	4691
3117	4117	4117	90
3118	4118	4118	100
3119	4119	4119	55
3120	4120	4120	0
3124	4124	4124	0
3127	4127	4127	144
3128	4128	4128	120
3129	4129	4129	0
3130	4130	4130	25700
3134	4134	4134	130
3169	4169	4169	0
Maximum power at acceleration: 216 kW			

[Procedure for setting spindle parameters]

(1) For both master spindle and slave spindle, load parameters automatically with model code 300.

(2) For both master spindle and slave spindle, set parameters manually according to the parameter table, except No.4134 for slave spindle. Set 0 in No.4134 for slave spindle.

(3) Set parameter for Twin drive. (Refer to item 5.)

(4) Turn off and on again to activate spindle parameters surely.

(*1) Please note that the following αiSP75HV amplifier is not applicable for this motor.
A06B-6122-H075#Hxxx

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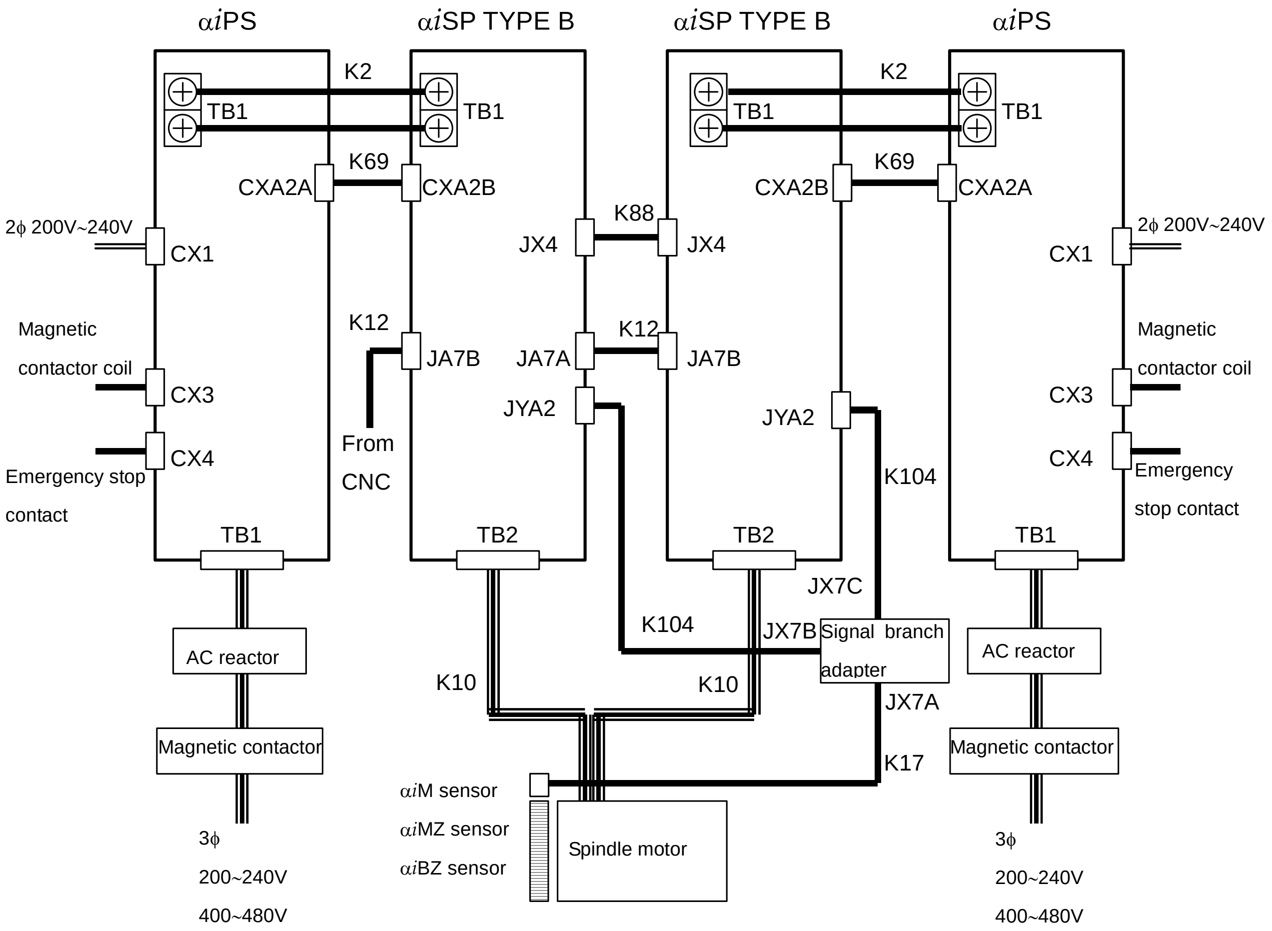
01	11.07.29	Tomiyama	Newly designed	DRAW. No. B-65280EN/08-05	CUST.
Ed.	Date	Design.		FANUC CORPORATION	SHEET 13/16

10. Connection example

10.1. In case of configuration with two αiPSs and two αiSPs

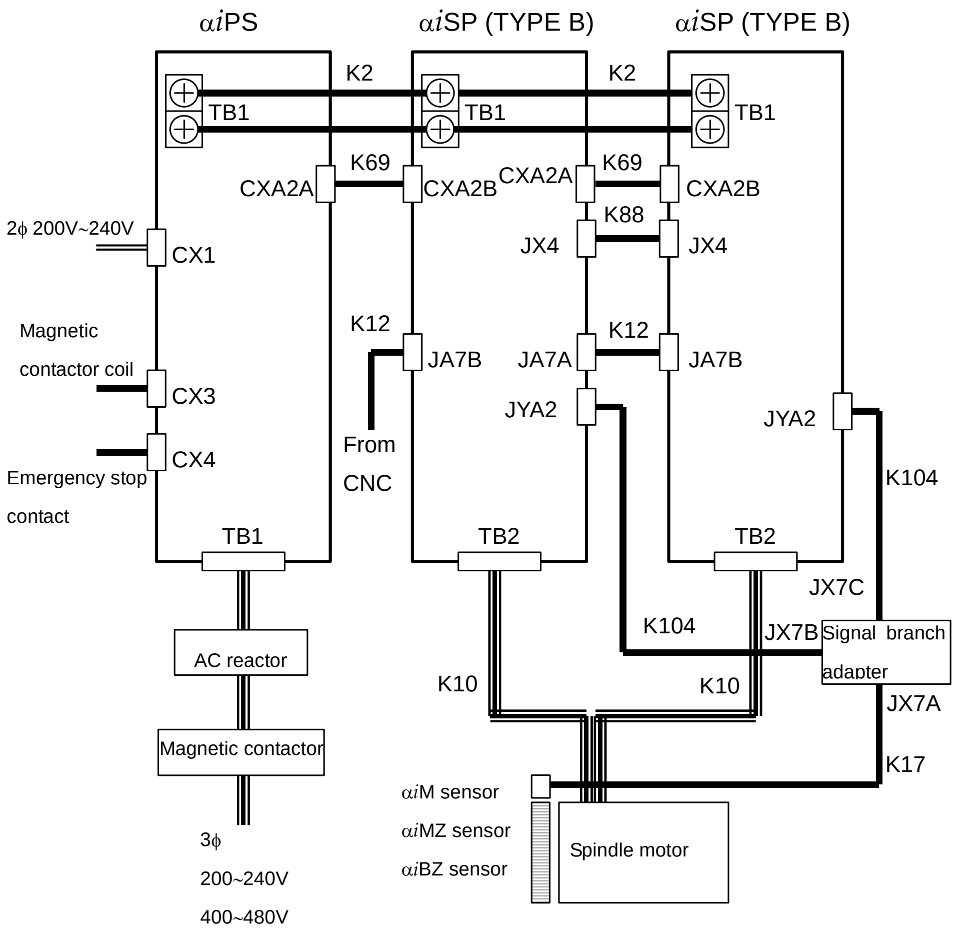


Note

*1 For detailed specification of each cable, refer to FANUC SERVO AMPLIFIER αi series DESCRIPTIONS (B-65282EN).

*2 The emergency stop signal (connector CX4) for power supply (PS) should be input to each PS.

10.2. In case of configuration with one αiPS and two αiSPs



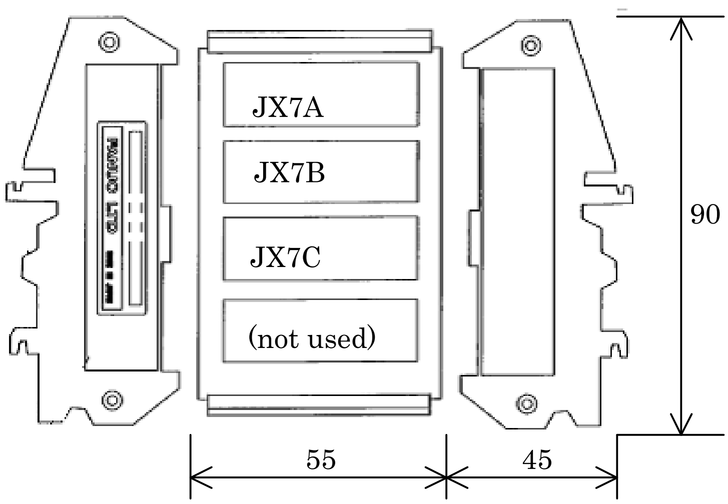
> Note
> For detailed specification of each cable, refer to FANUC SERVO AMPLIFIER αi series DESCRIPTIONS (B-65282EN).

11. Signal Branch Adapter

11.1. Order information

Name	Specification No.	Note
Signal Branch Adapter	A06B-6111-H405	Cable is not attached. Please make it in the user side.

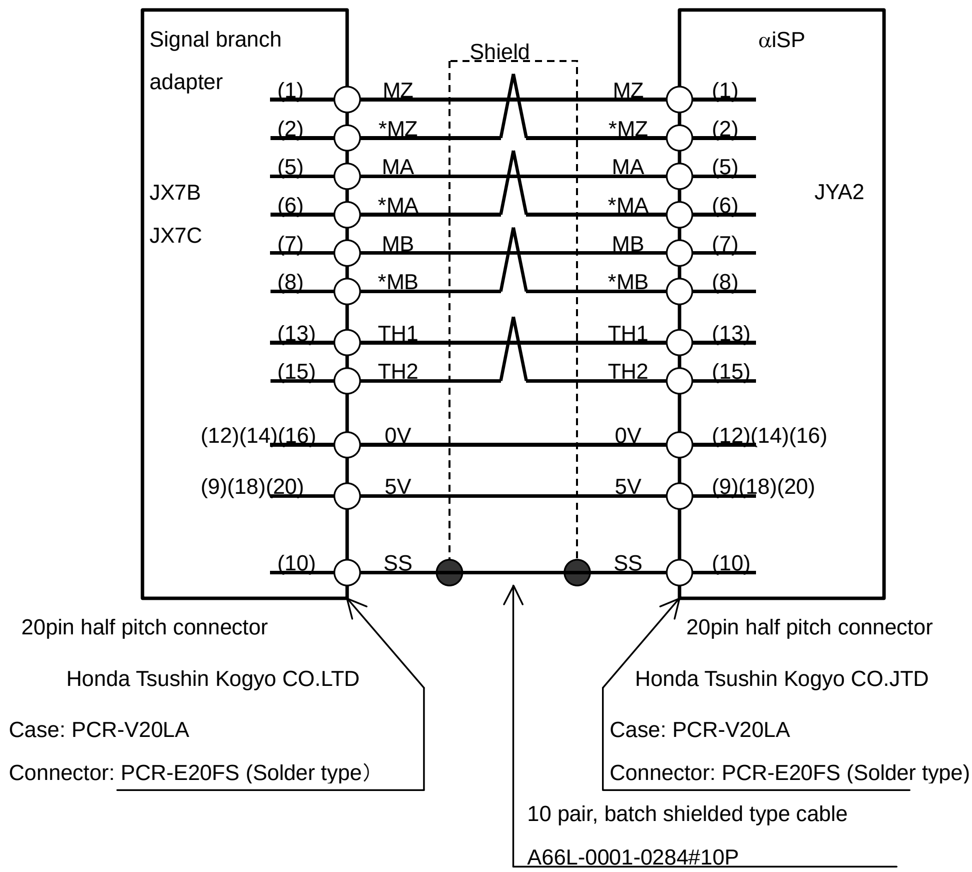
11.2. External dimension



Unit (mm)

> Note
> Attach this adapter to DIN rail.

11.3. Detail of cable K104



				TITLE Twin Drive for Spindle Motor Specifications
01	11.07.29	Tomiyama	Newly designed	DRAW. No. B-65280EN/08-05	CUST.
Ed.	Date	Design.		FANUC CORPORATION	SHEET 16/16

Revision of αi series Spindle Software
(9D90/I(09), 9DA0/L(12))

1. Type of applied documents

Name	FANUC AC SPINDLE MOTOR αi series, FANUC AC SPINDLE MOTOR βi series, FANUC BUILT-IN SPINDLE MOTOR Bi series PARAMETER MANUAL
Spec. No./Ver.	B-65280EN/08

2. Summary of Change

Group	Name / Outline	New, Add Correct, Del	Applicable Date
Basic Function			
Optional Function			
Unit			
Maintenance Parts			
Notice			
Correction			
Another	Revision of spindle software 9D90/I(09), 9DA0/L(12)	Add	2011.08

				TITLE	Revision of αi series Spindle software (9D90/I(09),9DA0/L(12))	
01	11.08.17	K.Tomiyama	Newly designed	DRAW. No.	B-65280EN/08-06	CUST.
Ed.	Date	Design.		FANUC CORPORATION	SHEET	1/3

Revision of αi series Spindle Software (9D90/I(09),9DA0/L(12))

1. Outline

   αi series spindle software was revised as follows.

2. Software series, edition and applied spindle amplifier

Software edition	Spindle amplifier specification		Notes
9D90 edition I(09)	αiSP	A06B-6144-Hxxx#H590 A06B-6154-Hxxx#H590	30*i*/31*i*/32*i*-A, 16*i*/18*i*/21*i*-B, 0*i* -B/C, 0*i* -D,15*i*-MB,PM*i*-D Induction/ synchronous spindle motor
9DA0 edition L(12)	αiSP	A06B-6220-Hxxx#H600 A06B-6270-Hxxx#H600	30 *i*//31 *i*//32 *i*/-B, 35 *i*/-B Induction/ synchronous spindle motor
	αiSVP	A06B-6230-Hxxx#H600	

3. Contents of modification

	Contents	9D90/I	9DA0/L
(1)	It has become possible to connect spindle amplifier for FS30*i*-B to FS0*i*-D controller. In the former report for 9DA0/K, we informed that it became possible, but we found that an alarm occurs when you connect the spindle amplifier next to αiPS. We improved it. Please use 9DA0/L or subsequent editions when you connect the spindle amplifier for FS30*i*-B to FS0*i*-D controller from now on.	-	◎
(2)	We added the function “Spindle DC link stabilizer during power failure”, which keeps DC link voltage and supports the controlled stop of other axes at power failure by using kinetic energy of spindle. Regarding detail of the function, please refer to the technical report (B-65280EN/08-07).	◎	◎
(3)	We corrected the problem that the position error always becomes 0 during Cs contouring control or rigid tapping when we use Dual position feedback function. Please refer to the item 4 in detail.	◎	◎
(4)	We corrected the problem that the Safety parameter error (SP9071) is mis-detected. Please refer to the item 5 in detail.	◎	-
(5)	“U-axis control” using two spindle motors has been supported in this revision. It’s necessary to update the CNC system software also to use the function. But the development of CNC system software has not been completed yet. After the completion, we’ll issue the technical report for the function.	-	◎
(6)	“Energy saving level selecting function” has been supported in this revision. The function enables the smart selection for trade-off between "shorter cycle time" and "energy saving". It’s necessary to update the CNC system software also to use the function. But the development of CNC system software has not been completed yet. After the completion, we’ll issue the technical report for the function.	-	◎

◎ : Revised item - : Not supported

4. The problem of Dual position feedback function

We found the problem that the position error always becomes 0 during Cs contouring control or rigid tapping when we use Dual position feedback function in the following spindle software. We corrected it.

[The software editions having the problem]
- 9D90 series / edition G(07) or H(08)
- 9DA0 series / edition H(08) to K(11)

[Countermeasure]
When you use Dual position feedback function, please use the software which is not listed above or use the revised software in this time.
If you use the software having the problem and execute Cs contouring control or rigid tapping, the position error becomes always 0. And the detection of excess error and in-position check aren't executed. As it might cause something trouble, please use the software which doesn't have the problem.

5. The problem of mis-detection of Safety parameter error (SP9071)

We found the problem that Safety parameter error (SP9071) occurs when we use the following spindle software and Dual check safety function. We corrected it.

[The software editions having the problem]
- 9D90 series / edition G(07), H(08)

[Countermeasure]
Please use the revised software (9D90/I) in this time or subsequent edition.
As temporary countermeasure, it's possible to avoid the alarm by setting No.4544=11111111, No.4545=00000000.

Additional information)
Dual check safety function doesn't support "Spindle switching control". If set Dual check safety ON in the axis which uses "Spindle switching control", Safety parameter alarm (SP9071) occurs. Please don't use these two functions together.

Spindle DC-link stabilizer during power failure

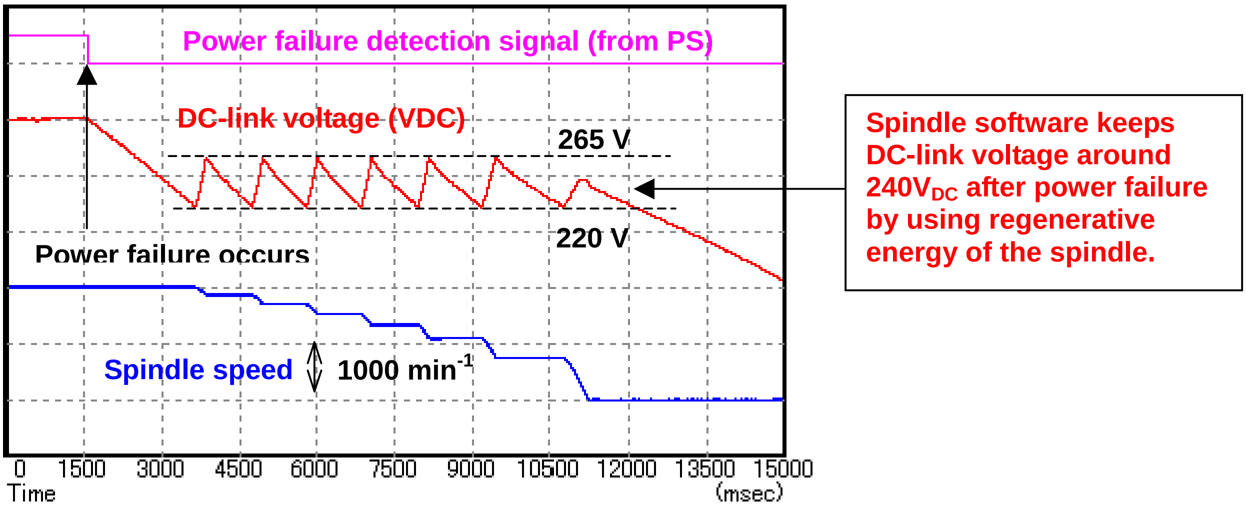
Specifications

1. Outline

This document describes specification of Spindle DC-link stabilizer during power failure.
This function monitors power failure detection signal and DC-link voltage, and keeps DC-link voltage within specific range after power failure until spindle stops by using spindle regenerative energy.
If the following conditions are fully satisfied, you can use spindle regenerative energy for the retraction at power failure.

(1) Retraction axes are driven by servo amplifiers connected to the same power supply (PS) which spindle amplifier is also connected.
(2) Spindle always rotates with sufficient kinetic energy when the retraction at power failure is required.

Example of application



2. Application

2.1. Combination of spindle software, amplifier and CNC

Spindle software		Spindle amplifier	CNC
Series	Version		
9D90	I (09)	A06B-6144-Hxxx#H590 A06B-6154-Hxxx#H590	FS30*i*-A/FS31*i*-A/FS32*i*-A, FS0*i*-D
9DA0	L(12)	A06B-6220-Hxxx#H600 A06B-6270-Hxxx#H600 A06B-6230-H001#H600 (SVP) A06B-6280-H001#H600 (SVP)	FS30*i*-B/FS31*i*-B/FS32*i*-B/FS35*i*-B, FS0*i*-D (SVP can't be used with FS0*i*-D.)

2.2. Notes for application

- When you apply this function, you should use UPS(Uninterruptible Power Supply) or Power Failure Backup Module(PFBM) to keep the control power source for CNC (24VDC) or for servo amplifiers (Single phase 200VAC for FS30i-A, 24VDC for FS30i-B) during power failure.

  If the backup system of control power source is broken, this function dose not work properly.

- You can use this function with Spindle HRV control (induction motor/ synchronous motor).

- When you use this function with speed range switching control, you should keep the power source of magnetic contactor (MCC) to suppress switching of MCC during power failure.
  And you have to make the ladder program to keep the state of MCC and signals for speed range switching control (RSLx/ RCFNx/ RCHPx) during power failure.

- When you use this function with spindle switching control, you should keep the power source of MCC to suppress switching of MCC during power failure.
  And you have to make the ladder program to keep the state of MCC and signals for spindle switching control (SPSLx/ MCFNx/ MFNHGx) during power failure.

- When the system drives plural spindle motors connected mechanically with synchronous control (Spindle synchronous control/ Spindle tandem control), you should apply this function to 1 spindle only, and you should set MPOFx signals to “1” for other spindles when the power failure is detected.

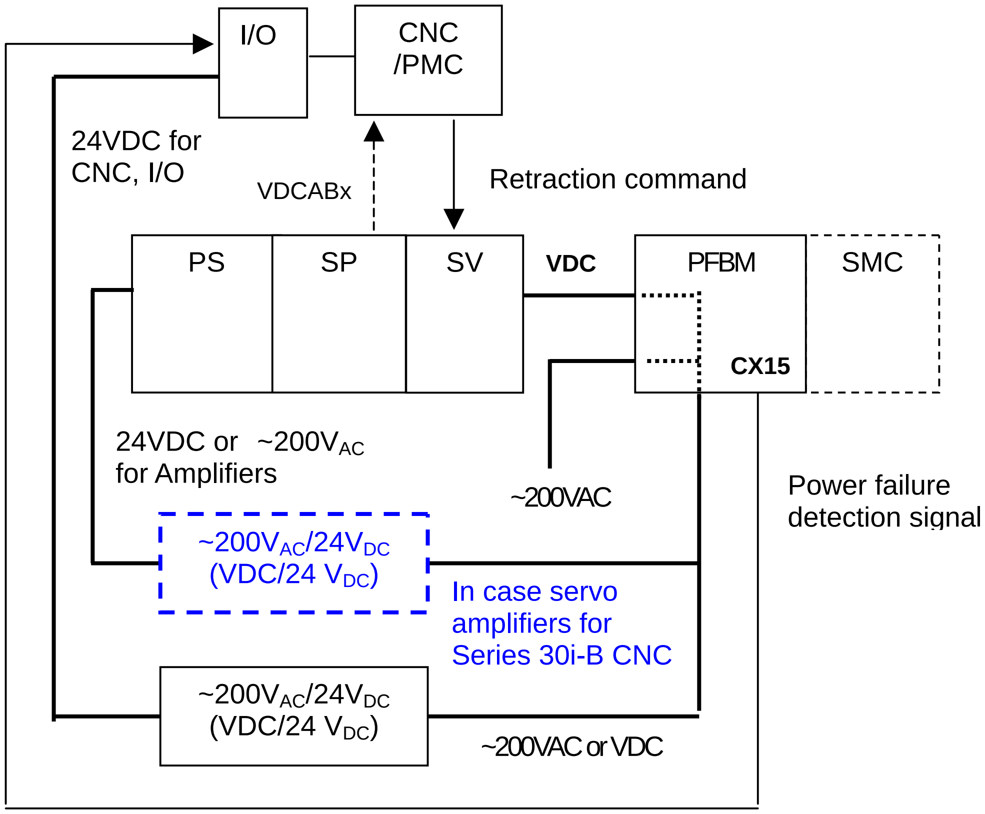
- When you use this function with spindle software 9DA0 series, you should use “Servo Amplifiers for series 30i-B CNC (A06B-62xx-Hxxx)” for all of the Servo Amplifiers (PS/SP/SV).

- When you use this function with spindle software 9D90 series, you should use “Servo Amplifiers for series 30i-A CNC (A06B-61xx-Hxxx)” for all of the Servo Amplifiers (PS/SP/SV).

- When you use this function with spindle software 9D90 series, you should complete the retraction within 1 minute, because PS alarm (SP9004/SV0607) may occur in 1 minute after power failure. Please consult FANUC if you need retraction time over 1 minute.

3. System configuration example

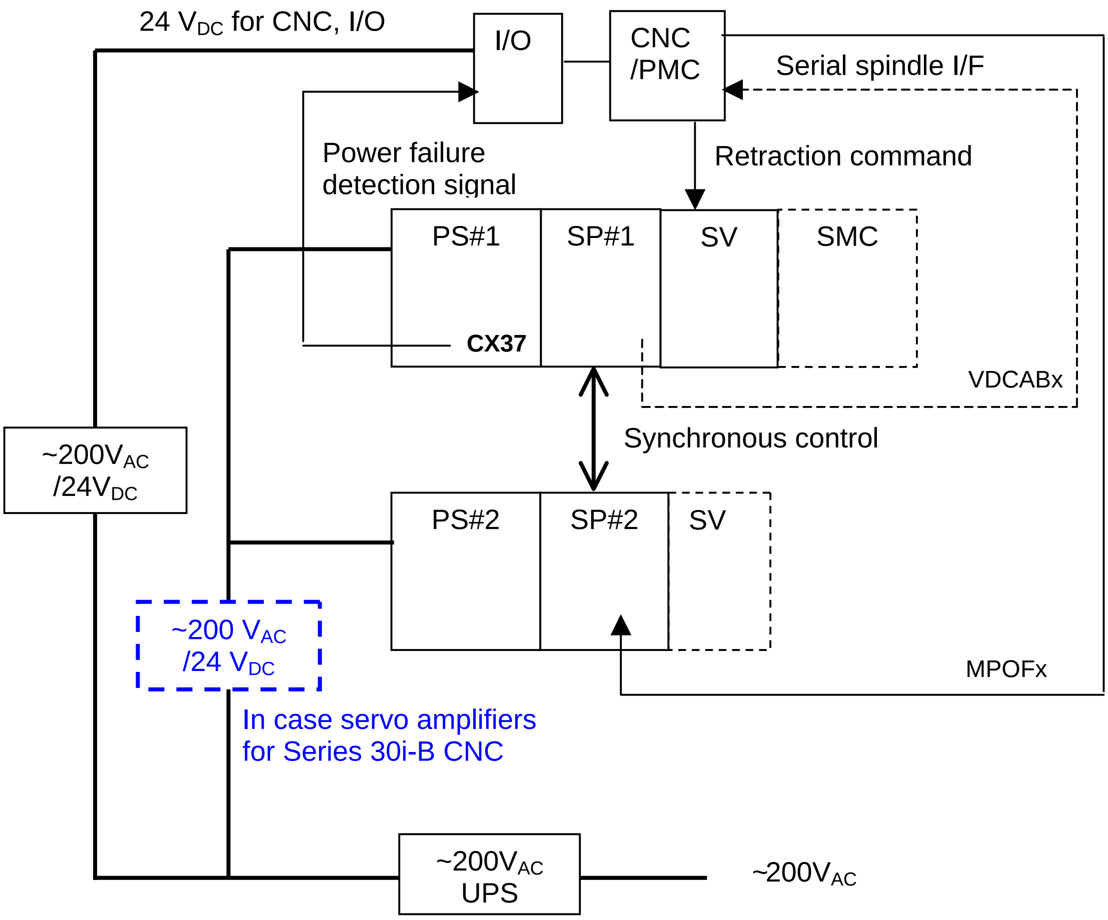
3.1. In case of using power failure backup module (PFBM)



Please refer to “FANUC SERVO AMPLIFIER α i series DESCRIPTION (B-65282EN)” for details of connection.

3.2. In case of driving 2 spindles synchronously and using UPS for control power back-up

The system drives 2 spindle motors connected mechanically
with synchronous control (Spindle synchronous control/ spindle tandem control).



Please refer to “FANUC SERVO AMPLIFIER α i series DESCRIPTION (B-65282EN)”
for details of connection.

4. Input/output signals (CNC↔PMC)

4.1. Input signals (PMC→CNC)

	30*i*, 0*i* -D	#7	#6	#5	#4	#3	#2	#1	#0
1st SP	G073						**MPOFA**		
2nd SP	G077						**MPOFB**		

MPOFx : Motor power turn off signal (1st spindle)
0 : Disabled
1 : Enabled (Turn off the motor power).

When the system drives plural spindle motors connected mechanically with synchronous control (Spindle synchronous control/ Spindle tandem control), you should apply this function to 1 spindle only, and you should set MPOFx signals to “1” for other spindles when the power failure is detected. For power failure detection, please use the signal of PS(CX37) or PFBM(CX15) or unexpected DC-link voltage detection signal (VDCABx).

4.2. Output signals (CNC→PMC)

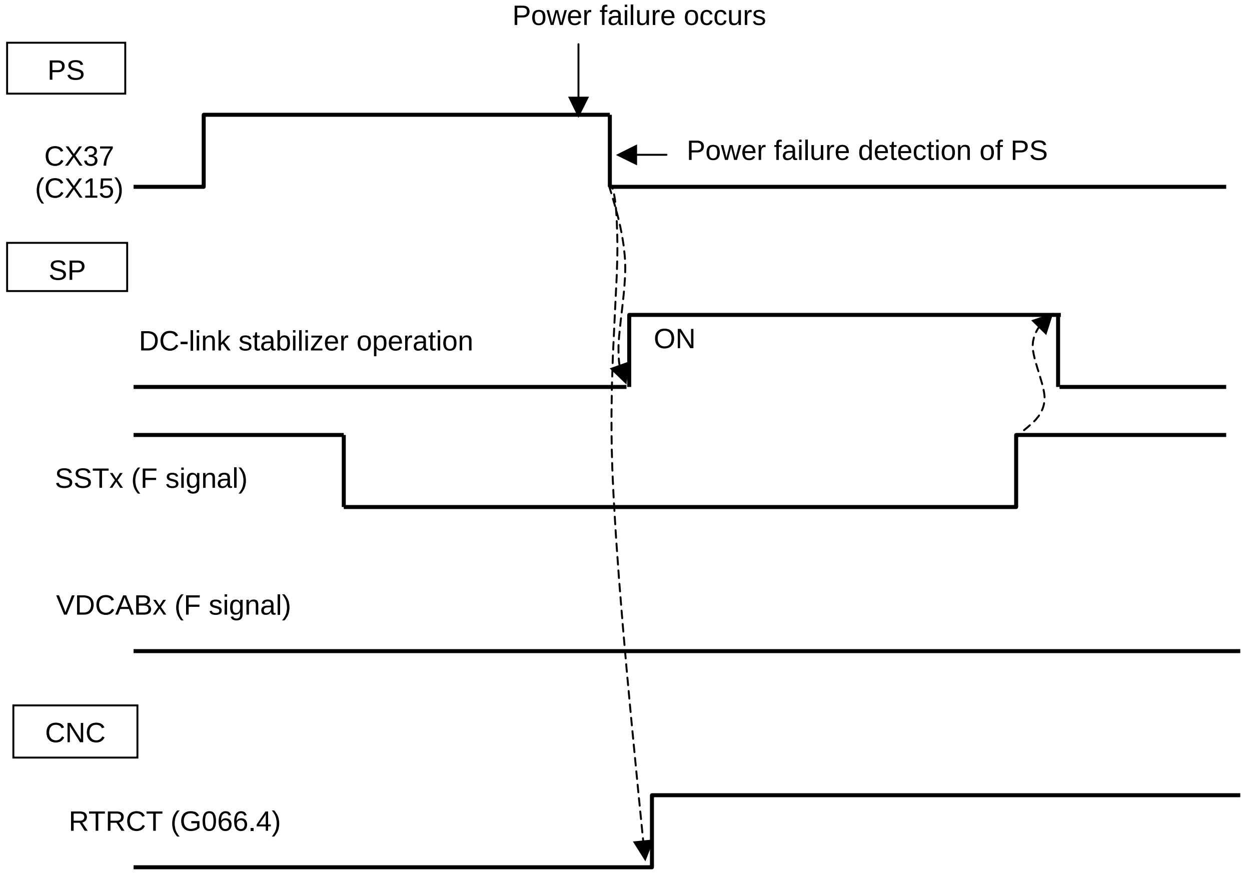
	30*i*, 0*i* –D	#7	#6	#5	#4	#3	#2	#1	#0
1st SP	F306				**VDCABA**				
2nd SP	F308				**VDCABB**				

VDCABx : Unexpected DC-link voltage detection signal
0 : Normal state.
1 : Unexpected state

When you use Spindle DC-link stabilizer during power failure, this signal turns to “1” and the DC-link stabilizer operation starts if an unexpected state of DC-link voltage is detected.
When the parameter “VDCPFD(No.4548#5)” is set to”1”, the detection of unexpected DC-link voltage (Power failure detection with DC-link voltage) is disabled.

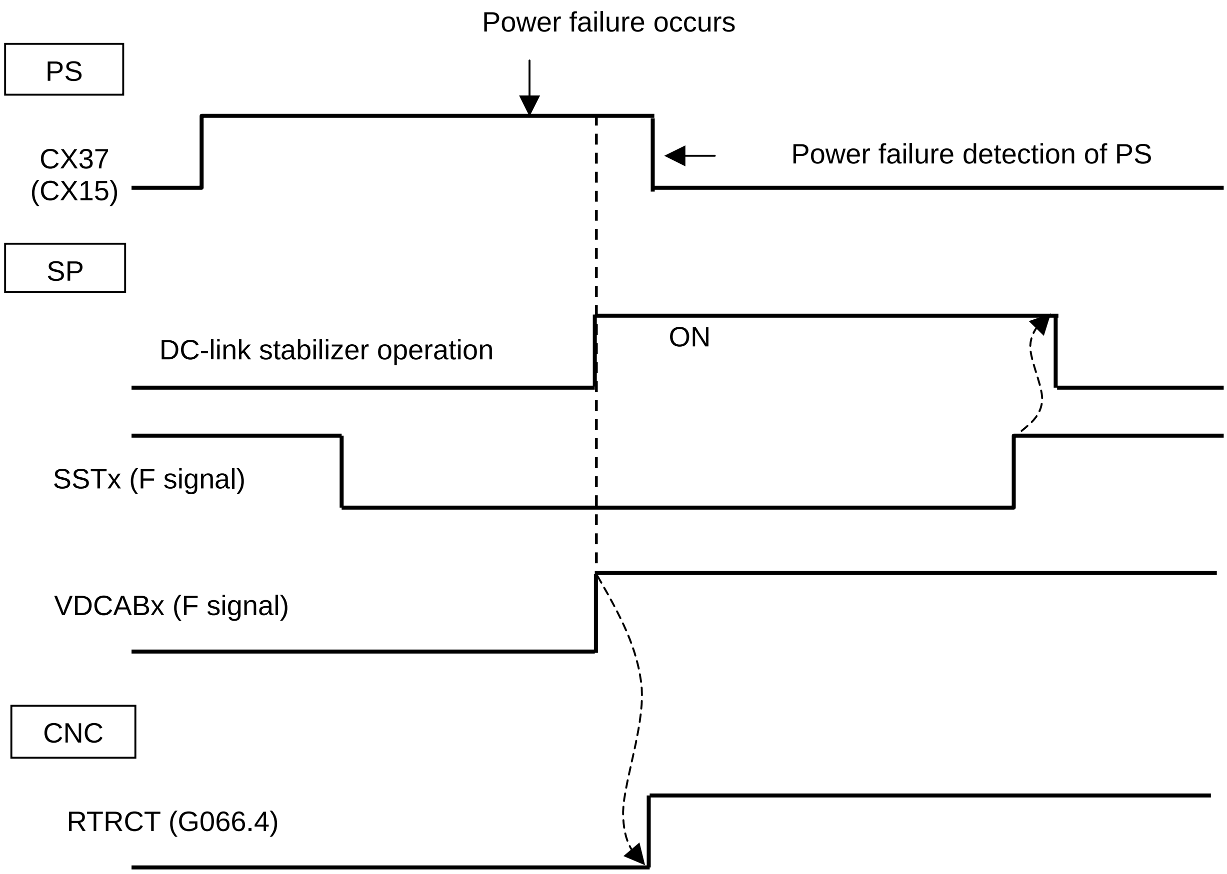
5. Sequence examples

5.1. In case of normal power failure



				TITLE Spindle DC-link stabilizer during power failure Specifications
01	11.08.22	Morita	Newly designed	DRAW. No. B-65280EN/08-07 CUST.
Ed.	Date	Design.		FANUC CORPORATION SHEET 7/11

5.2. In case unexpected DC-link voltage is detected



				TITLE Spindle DC-link stabilizer during power failure Specifications
01	11.08.22	Morita	Newly designed	DRAW. No. B-65280EN/08-07 CUST.
Ed.	Date	Design.		**FANUC CORPORATION** SHEET 8/11

6. List of related parameters

Parameter No. 30*i*, 0*i* –D	Contents
4540#7 4670#7	Setting of spindle DC-link stabilizer during power failure
4540#2	Setting of preload during power failure
4548#5 4678 #5	Setting of unexpected state of DC-link voltage detection
4352#4 4678#4	Setting of torque limit during DC-link keeping operation
4510	Spindle DC-link stabilizer/ Upper limit of DC-link voltage
4511	Spindle DC-link stabilizer/ Lower limit of DC-link voltage

7. Details of related parameters

	30*i*, 0*i* -D	#7	#6	#5	#4	#3	#2	#1	#0
Main	4540	**GOPF**					**PLDPWF**		
Sub	4670								

GOPF Spindle DC-link stabilizer during power failure is
0 : Disabled
1 : Enabled

When you set this parameter to “1”, the spindle software keeps DC-link voltage within specific range by using spindle regenerative energy in case of a power failure or an unexpected state of DC-link voltage is detected.
When you use this function with Twin drive spindle motor, please set this parameter to ”1” to master SP and “0” to slave SP.

PLDPWF Setting of preload during power failure
0 : Preload is enabled during power failure
1 : Preload is disabled during power failure

When you use Spindle DC-link stabilizer during power failure with spindle tandem control and preload, set this parameter to “1” to both spindles.

30*i*, 0*i* –D		#7	#6	#5	#4	#3	#2	#1	#0
Main	4548			**VDCPFD**	**PFTLD**				
Sub	4678								

VDCPFD Unexpected state of DC-link voltage detection
(Power failure detection for DC-link voltage) is
0 : enabled (Standard setting)
1 : disabled

If an unexpected state of DC-link voltage is detected, spindle software starts DC-link stabilizer operation and sets VDCABx to ”1”.
When this parameter is set to”1”, the detection of Unexpected DC-link voltage is disabled.
In case there are some misdetections of unexpected state of DC-link voltage during acceleration/ deceleration of spindle, set this parameter to”1”.

PFTLD Torque limit during power failure is
0 : enabled (Standard setting)
1 : disabled

During the DC-link stabilizer operation is performing, maximum torque is limited the value specified by No.4025.
When this parameter is set to”1”, torque limit during DC-link stabilizer operation is disabled.

> Note:
> Torque limit signal (TLMH,L) is always available regardless of this parameter setting.

30*i*, 0*i* -D
4510 — Spindle DC-link stabilizer/ Upper limit of DC-link voltage

Setting Unit : 1 VDC
Setting range : 0, 550~700(400V Amp.), 250~325(200V Amp.)
Standard setting: 0 = 650VDC(400V Amp.), 265VDC(200V Amp.)

30*i*, 0*i* -D
4511 — Spindle DC-link stabilizer/ Lower limit of DC-link voltage

Setting Unit : 1 VDC
Setting range : 0, 450~650(400V Amp.), 200~300(200V Amp.)
Standard setting: 0 = 550VDC(400V Amp.), 220VDC(200V Amp.)

During the DC-link stabilizer operation is performing, spindle software keeps DC-link voltage between upper limit (No4510) and lower limit (No4511) by repeating deceleration mode and velocity keeping mode.
Normally please set 0 to both parameters.
When you adjust these parameters, refer to the setting range of both parameters.

8. Alarm

After the spindle is stopped by DC link stabilizer operation, DC-link voltage will go down gradually. And following alarms will occur, if the control power source is kept at that time.

<u>In case of 9D90 series (Series 30i-A CNC)</u>

CNC alarm message	: None. If a SV is connected, SV alarm (SV0433/ SV0607) will occur.
PS alarm display(LED)	: 4 (DC-link low voltage), E (Open phase)
SP alarm display(LED)	: None

<u>In case of 9DA0 series (Series 30i-B CNC)</u>

CNC alarm message	: SP9004 If SV is connected with PS, SV alarm (SV0607) will occur.
PS alarm display(LED)	: 14 (Improper input power)
SP alarm display(LED)	: None

Correction of a parameter for spindle motor βiI15/7000

1. Type of applied documents

Name	FANUC AC SPINDLE MOTOR αi series, FANUC AC SPINDLE MOTOR βi series, FANUC BUILT-IN SPINDLE MOTOR Bi series PARAMETER MANUAL
Spec. No./Ver.	B-65280EN/08

2. Summary of Change

Group	Name / Outline	New, Add Correct, Del	Applicable Date
Basic Function			
Optional Function			
Unit			
Maintenance Parts			
Notice			
Correction	Correction of a parameter for spindle motor βiI15/7000	Add	2011.08
Another			

				TITLE Correction of a parameter for spindle motor βiI15/7000
01	11.08.22	G.Li	Newly designed	DRAW. No. B-65280EN/08-08 CUST.
Ed.	Date	Design.		FANUC CORPORATION SHEET 1/2

Correction of a parameter for spindle motor β*i*I15/7000

1. General

This document describes correction of parameter No.4127 (Load meter indication value at maximum output) for spindle motor β*i*I15/7000.

Incorrect value: No.4127=148
Correct value: No.4127=136

The value of No.4127 is used for calculating the load value on the spindle monitor screen and the diagnosis screen (No.410).
So in case of setting 148 to No.4127, the load meter value is 8% larger than the value in case of setting 136 to No.4127.
But, even though 148 is set to No.4127, the spindle motor output characteristic and the alarm detection don't receive the influence.

2. Detail of correction

Motor model		β*i* I 15/7000
Applicable amplifier		β*i* SVSPx-18
Model code		−
Applicable software series and edition		−
Continuous rated characteristics		15kW 2000/7000min^{-1}
15-min,rated characteristics		18.5kW 1500/7000min^{-1}
FS0*i* -C	FS0*i* -D FS0*i* Mate-D	
4007	4007	00000000
4008	4008	00000000
4009	4009	00000000
4010	4010	00010000
4011	4011	00011010
4012	4012	10000000
4013	4013	00001100
4019	4019	00000100
4020	4020	7000
4023	4023	
4039	4039	0
4040	4040	
4041	4041	
4048	4048	
4049	4049	
4080	4080	15445
4083	4083	30
4093	4093	0
4100	4100	1550
4101	4101	81
4102	4102	1610
4103	4103	0
4104	4104	2500
4105	4105	0
4106	4106	5000
4107	4107	0
4108	4108	0
4109	4109	25
4110	4110	1426
4111	4111	389
4112	4112	200
4113	4113	298
4114	4114	0
4115	4115	100
4116	4116	4344
4117	4117	90
4118	4118	100
4119	4119	32
4120	4120	0
4124	4124	0
4127	4127	136*
4128	4128	0
4129	4129	0
4130	4130	25700
4134	4134	130
4136	4136	0
4138	4138	0
4139	4139	0
4140	4140	0
4141	4141	0
4142	4142	0
4143	4143	0
4144	4144	0
4145	4145	0
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4154	4154	0
4155	4155	0
4156	4156	0
4158	4158	0
4159	4159	0
4161	4161	0
4165	4165	0
4166	4166	0
4169	4169	0

* Modified parameter