FANUC AC SERVO MOTOR βi series

DESCRIPTIONS

B-65302EN/02

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Further, re-export to another country may be subject to the license of the government of the country from where the product is re-exported. Furthermore, the product may also be controlled by re-export regulations of the United States government.
Should you wish to export or re-export these products, please contact FANUC for advice.

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".

SAFETY PRECAUTIONS

This "Safety Precautions" section describes the precautions which must be observed to ensure safety when using FANUC AC Servo Motors.
Users of any servo motor model are requested to read this "Safety Precautions" carefully before using the servo motor.
The users are also requested to read this manual carefully and understand each function of the motor for correct use.
The users are basically forbidden to do any behavior or action not mentioned in the "Safety Precautions." They are invited to ask FANUC previously about what behavior or action is prohibited.

Contents

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.

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

WARNING

⚠ WARNING

- Be safely dressed when handling a motor.

Wear safety shoes or gloves when handling a motor as you may get hurt on any edge or protrusion on it or electric shocks.

- Use a crane or lift to move a motor from one place to another.

Motors are heavy. When moving them, use a crane or lift as required. (For the weight of motors, refer to Chapter 6, "SPECIFICATIONS")
When moving a motor using a crane or lift, use a hanging bolt if the motor has a corresponding tapped hole, or textile rope if it has no tapped hole. If a motor is attached with a machine or any other heavy stuff, do not use a hanging bolt to move the motor as the hanging bolt and/or motor may get broken.
When moving a motor, be careful not to apply excessive force to its windings as the windings may break and/or their insulation may deteriorate.

- Do not touch a motor with a wet hand.

A failure to observe this caution is vary dangerous because you may get electric shocks.

- Before starting to connect a motor to electric wires, make sure they are isolated from an electric power source.

A failure to observe this caution is vary dangerous because you may get electric shocks.

- Do not bring any dangerous stuff near a motor.

Motors are connected to a power line, and may get hot. If a flammable is placed near a motor, it may be ignited, catch fire, or explode.

- Be sure to ground a motor frame.

To avoid electric shocks, be sure to connect the grounding terminal in the terminal box to the grounding terminal of the machine.

- Do not ground a motor power wire terminal or short-circuit it to another power wire terminal.

A failure to observe this caution may cause electric shocks or a burned wiring.

* Some motors require a special connection such as a winding changeover. Refer to Chapter 7, "OUTLINE DRAWINGS" for details.

⚠ WARNING

- Connect power wires securely so that they will not get loose.

Securely connect power wires and short bars to the terminal block with the specified tightening torque according to the procedures described in this manual. If a motor runs with a wire loosely connected, the terminal block may get abnormally hot, resulting in a fire. The wire may also be disconnected, resulting in a ground fault, short circuit, or electric shock.

- Do not supply the power to the motor while any terminal is exposed.

A failure to observe this caution is very dangerous because you may get electric shocks if your body or any conductive stuff touches an exposed terminal.

- Do not get close to a rotary section of a motor when it is rotating.

A rotating part may catch your cloths or fingers. Before starting a motor, ensure that there is no stuff that can fly away (such as a key) on the motor.

- Before touching a motor, shut off the power to it.

Even if a motor is not rotating, there may be a voltage across the terminals of the motor.
Especially before touching a power supply connection, take sufficient precautions. Otherwise you may get electric shocks.

- Do not touch any terminal of a motor for a while (at least 5 minutes) after the power to the motor is shut off.

High voltage remains across power line terminals of a motor for a while after the power to the motor is shut off. So, do not touch any terminal or connect it to any other equipment. Otherwise, you may get electric shocks or the motor and/or equipment may get damaged.

- To drive a motor, use a specified amplifier and parameters.

An incorrect combination of a motor, amplifier, and parameters may cause the motor to behave unexpectedly. This is dangerous, and the motor may get damaged.

- Do not touch a regenerative discharge unit for a while (at least 30 minutes) after the power to the motor is shut off.

A regenerative discharge unit may get hot when the motor is running.
Do not touch the regenerative discharge unit before it gets cool enough. Otherwise, you may get burned.

- Do not touch a motor when it is running or immediately after it stops.

A motor may get hot when it is running. Do not touch the motor before it gets cool enough. Otherwise, you may get burned.

- Ensure that motors and related components are mounted securely.

If a motor or its component slips out of place or comes off when the motor is running, it is very dangerous.

CAUTION

⚠ CAUTION

- FANUC motors are designed for use with machines. Do not use them for any other purpose.

If a FANUC motor is used for an unintended purpose, it may cause an unexpected symptom or trouble. If you want to use a motor for an unintended purpose, previously consult with FANUC.

- Ensure that a base or frame on which a motor is mounted is strong enough.

Motors are heavy. If a base or frame on which a motor is mounted is not strong enough, it is impossible to achieve the required precision.

- Be sure to connect motor cables correctly.

An incorrect connection of a cable cause abnormal heat generation, equipment malfunction, or failure. Always use a cable with an appropriate current carrying capacity (or thickness). For how to connect cables to motors, refer to Chapter 7, “OUTLINE DRAWINGS”.

- When mounting a crimp terminal at the end of a power line to keep the insulation distance, always cover the crimping section of the crimp terminal with an insulating tube.

When an insulating cover is mounted on the terminal block, screw the power line, remount the cover in place, then use the motor.

- When attaching a component having inertia, such as a pulley, to a motor, ensure that any imbalance between the motor and component is minimized.

If there is a large imbalance, the motor may vibrates abnormally, resulting in the motor being broken.

- Be sure to attach a key to a motor with a keyed shaft.

If a motor with a keyed shaft runs with no key attached, it may impair torque transmission or cause imbalance, resulting in the motor being broken.

NOTE

NOTE

- Do not step or sit on a motor.

If you step or sit on a motor, it may get deformed or broken. Do not put a motor on another unless they are in packages.

- When storing a motor, put it in a dry (non-condensing) place at room temperature (0 to 40 °C).

If a motor is stored in a humid or hot place, its components may get damaged or deteriorated. In addition, keep a motor in such a position that its shaft is held horizontal and its terminal box is at the top.

- Do not remove a nameplate from a motor.

If a nameplate comes off, be careful not to lose it. If the nameplate is lost, the motor becomes unidentifiable, resulting in maintenance becoming impossible. For a nameplate for a built-in spindle motor, keep the nameplate with the spindle.

- Do not apply shocks to a motor or cause scratches to it.

If a motor is subjected to shocks or is scratched, its components may be adversely affected, resulting in normal operation being impaired. Be very careful when handling plastic portions, sensors, and windings, because they are very liable to break. Especially, avoid lifting a motor by pulling its plastic portion, winding, or power cable.

- Do not conduct dielectric strength or insulation test for a sensor.

Such a test can damage elements in the sensor.

- When testing the winding or insulation resistance of a motor, satisfy the conditions stipulated in IEC60034.

Testing a motor under a condition severer than those specified in IEC60034 may damage the motor.

- Do not disassemble a motor.

Disassembling a motor may cause a failure or trouble in it.
If disassembly is in need because of maintenance or repair, please contact a service representative of FANUC.

- Do not modify a motor.

Do not modify a motor unless directed by FANUC. Modifying a motor may cause a failure or trouble in it.

- Use a motor under an appropriate environmental condition.

Using a motor in an adverse environment may cause a failure or trouble in it. Refer to Chapter 3, “USAGE” for details of the operating and environmental conditions for motors.

NOTE

- Do not apply a commercial power source voltage directly to a motor.

Applying a commercial power source voltage directly to a motor may result in its windings being burned. Be sure to use a specified amplifier for supplying voltage to the motor.

- Before using a motor, measure its winding and insulation resistances, and make sure they are normal.

Especially for a motor that has been stored for a prolonged period of time, conduct these checks. A motor may deteriorate depending on the condition under which it is stored or the time during which it is stored. For the winding resistances of motors, refer to Chapter 6, "SPECIFICATIONS", or ask FANUC. For insulation resistances, see the following table.

- To use a motor as long as possible, perform periodic maintenance and inspection for it, and check its winding and insulation resistances.

Note that extremely severe inspections (such as dielectric strength tests) of a motor may damage its windings. For the winding resistances of motors, refer to Chapter 6, "SPECIFICATIONS", or ask FANUC. For insulation resistances, see the following table.

MOTOR INSULATION RESISTANCE MEASUREMENT

Measure an insulation resistance between each winding and motor frame using an insulation resistance meter (500 VDC). Judge the measurements according to the following table.

Insulation resistance	Judgment
100 MΩ or higher	Acceptable
10 to 100M Ω	The winding has begun deteriorating. There is no problem with the performance at present. Be sure to perform periodic inspection.
1 to 10 MΩ	The winding has considerably deteriorated. Special care is in need. Be sure to perform periodic inspection.
Lower than 1M Ω	Unacceptable. Replace the motor.

CAUTION LABEL

The following label is attached to the motor.
Attach this label to a prominent place on the motor to call attention to the user.

Heat caution label
(compliance with the IEC standard)

Heat caution label

Since the motor is heated to a high temperature during operation or immediately after a stop, touching the motor may cause a burn.
So, attach this label to a prominent place to call attention when the surface is exposed and may be touched.

Remark:
The mark of this label conforms to the IEC standard

PREFACE

This manual describes the specifications, outline drawings, detectors and other options, usage, and selection method of the FANUC AC Servo Motor β*i* series.

This manual describes the layout of power pins and the output of detector signals but does not provide information about connection to a servo amplifier and an NC. For a description of connection, refer to the FANUC SERVO AMPLIFIER α*i* series DESCRIPTION (B-65282EN), MAINTENANCE MANUAL (B-65285EN), FANUC SERVO AMPLIFIER β*i* series DESCRIPTION (B-65322EN), and MAINTENANCE MANUAL (B-65325EN).

In this manual, servo motor names are sometimes abbreviated as follows:
Example) β*i*S 22/2000 →β*i*S 22

Related manuals

The following five kinds of manuals are available for FANUC SERVO MOTOR β*i* series. In the table, this manual is marked with an asterisk (*).

Document name	Document number	Major contents	Major usage	
FANUC AC SERVO MOTOR β*i* series DESCRIPTIONS	B-65302EN	Specification Characteristics External dimensions Connections	Selection of motor Connection of motor	*
FANUC SERVO AMPLIFIER α*i* series DESCRIPTIONS	B-65282EN	Specifications and functions Installation External dimensions and maintenance area Connections	Selection of amplifier Connection of amplifier	
FANUC SERVO AMPLIFIER β*i* series DESCRIPTIONS	B-65322EN	Specifications and functions Installation External dimensions and maintenance area Connections	Selection of amplifier Connection of amplifier	
FANUC AC SERVO MOTOR α*i* series FANUC AC SPINDLE MOTOR α*i* series FANUC SERVO AMPLIFIER α*i* series MAINTENANCE MANUAL	B-65285EN	Start up procedure Troubleshooting Maintenance of motor	Start up the system (Hardware) Troubleshooting Maintenance of motor	
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	Start up procedure Troubleshooting Maintenance of motor	Start up the system (Hardware) Troubleshooting Maintenance of motor	
FANUC AC SERVO MOTOR α*i* series FANUC AC SERVO MOTOR β*i* series FANUC LINEAR MOTOR L*i*S series FANUC SYNCHRONOUS BUILT-IN SERVO MOTOR D*i*S series PARAMETER MANUAL	B-65270EN	Initial setting Setting parameters Description of parameters	Start up the system (Software) Tuning the system (Parameters)	

TABLE OF CONTENTS

1 GENERAL

Chapter 1, “GENERAL”, consists of:

1.1 LINEUP OF THE SERIES

The FANUC AC Servo Motor β*i* series consist of the following series, each of which has the listed characteristics.

<table>
<tr><th>Series</th><th>Voltage</th><th>Stall torque</th><th>Feature</th><th>Applications</th></tr>
<tr><td rowspan="2">βiS</td><td>200V</td><td>0.2 to 20 N·m</td><td>High cost-performance model driven by a small-capacity amplifier</td><td rowspan="2">Feed axes in machine tools
Peripherals of machine tools
Industrial machines</td></tr>
<tr><td>400V</td><td>2 to 20 N·m</td><td>βiS models applicable to 400VAC input</td></tr>
</table>

Lineup

<table>
<tr><td colspan="2">Stall torque
Nm</td><td>0.2</td><td>0.3</td><td>0.4</td><td>0.5</td><td>1</td><td>2</td><td>4</td><td>8</td><td>12</td><td>20</td></tr>
<tr><td colspan="2">Flange size
mm</td><td colspan="2">40</td><td colspan="3">60</td><td colspan="2">90</td><td colspan="2">130</td><td>174</td></tr>
<tr><td rowspan="3">βiS</td><td rowspan="2">200V</td><td rowspan="2">βiS 0.2
/5000</td><td rowspan="2">βiS 0.3
/5000</td><td rowspan="2">βiS 0.4
/5000</td><td rowspan="2">βiS 0.5
/6000</td><td rowspan="2">βiS 1
/6000</td><td rowspan="2">βiS 2
/4000</td><td rowspan="2">βiS 4
/4000</td><td rowspan="2">βiS 8
/3000</td><td>βiS 12
/2000</td><td>βiS 22
/1500</td></tr>
<tr><td>βiS 12
/3000</td><td>βiS 22
/2000</td></tr>
<tr><td>400V</td><td></td><td></td><td></td><td></td><td></td><td>βiS 2
/4000
HV</td><td>βiS 4
/4000
HV</td><td>βiS 8
/3000
HV</td><td>βiS 12
/3000
HV</td><td>βiS 22
/2000
HV</td></tr>
</table>

1.2 FEATURE

The FANUC AC Servo Motor β*i* series is an AC servo motor suitable for feed axes and peripherals of machine tools, and industrial machines. This servo motor realizes high cost-performance when combined with a small-capacity amplifier. This series has the following features:

Compact

The use of a latest magnet and the optimized mechanical design reduce the total length and weight, therefore realizing light, compact motors.

Smooth rotation

The optimized magnetic pole structure enables smooth rotation to give sufficient basic performance for feed axes in machine tools to this series. (β*i*S 2 to β*i*S 22)

Excellent acceleration

The use of a special rotor shape brings small and light motors, and a high level of torque. These motors, therefore, provide excellent acceleration characteristics.

Controllability

The use of the latest servo software maintains controllability even when a disturbance occurs.

High reliability

A totally-enclosed, friction-free brushless design is used. This allows the servo motors to be used in demanding environments with no need for special checks or maintenance.

Excellent drip-proofing

The adoption of water-proof connectors, combined with a unique stator seal structure, ensure high drip-proofing. (For the β*i*S 0.2 and the β*i*S 0.3, the connectors and the structure are options.)

Built-in, high-precision encoder

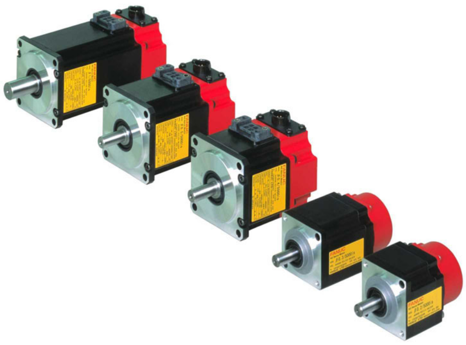
A low-indexing-error optical encoder (Pulsecoder) is built into the motors. This Pulsecoder enables precise positioning. (Resolution 65,536, 131,072/rev.)

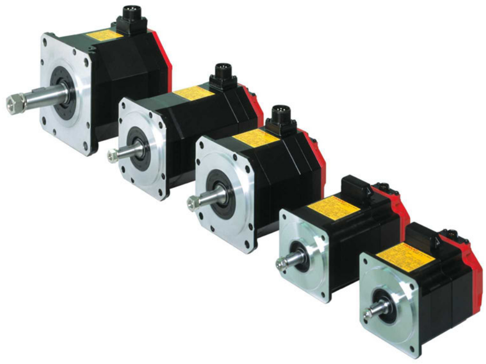
Powerful brake

A powerful brake with an increased holding torque is available as an option. The brake uses an asbestos-free design.

200-V and 400-V power supply specifications

A lineup of 400-V power supply specification motors is provided in addition to the 200-V power supply specification motors.
A suitable motor can be selected according to the local power supply specification.
(The β*i*S 2HV to the β*i*S 8HV, the β*i*S 12/3000HV, and the β*i*S 22/2000HV are 400-V power supply models.)





β*i*S series

2 ORDERING SPECIFICATION NUMBER

This chapter provides information about the ordering specification numbers and types of the FANUC AC Servo Motor β*i* series.

Chapter 2, "ORDERING SPECIFICATION NUMBER", consists of:

2.1 ORDERING SPECIFICATION NUMBER

The ordering specification numbers of the servo motors have the following format:

A06B-0□□□-B△0▽#◎◎◎◎

□□□

An ordering specification number are described on the tables after next page.

△

0 : Taper shaft
1 : Straight shaft
2 : Straight shaft with a key groove
3 : Taper shaft with a 24VDC brake
4 : Straight shaft with a 24VDC brake
5 : Straight shaft with a key way and a 24VDC brake

* When a large torque or sharp acceleration is required, the straight shaft with a key way should not be selected where possible.

▽

3 : Pulsecoder βA 64B(β*i*S 0.2, β*i*S 0.3)
Pulsecoder β*i*A 64(β*i*S 0.4 to β*i*S 1)
Pulsecoder β*i*A 128(β*i*S 2 to β*i*S 22)
6 : Pulsecoder β*i*A 128(for the FS0*i* only)

◎◎◎◎

0000 : Standard
0100 : IP67 specification
* Omitted in case of #0000.
* For the pulsecoder β*i*A 128 (for the FS0*i* only), #0100 cannot be selected.

⚠ **CAUTION**

When selecting the pulsecoder β*i*A 128 (for the FS0*i* only), note the following:

1 Do not use it as a combination with other than the FANUC Series 0*i* and 0*i* Mate.
2 Servo motors with the pulsecoder β*i*A 128 (for the FS0*i* only) have the following features:
   - The motor ID information (specification number, serial number, and other information) and the motor temperature information are omitted.
   - The servo parameters, the use of the servo motor (prohibition of the mounting of a rear fan unit, etc.), the conditions for certifying conformance with the IEC60034 Standard, and the overload duty characteristics differ from those of existing models.

The following table lists the allowable combinations of numbers represented by symbols in ordering specification numbers.

β*i*S series (200V)

A06B-0□□□-B△0▽#◎◎◎◎

Servo motor name \ Symbol in specification No.	□□□	△						▽		◎◎◎◎	
		0	1	2	3	4	5	3	6	0000	0100
β*i*S 0.2/5000	111		○	○		○	○	○		○	○
β*i*S 0.3/5000	112		○	○		○	○	○		○	○
β*i*S 0.4/5000	114		○	○		○	○	○		○	○
β*i*S 0.5/6000	115		○	○		○	○	○		○	○
β*i*S 1/6000	116		○	○		○	○	○		○	○
β*i*S 2/4000	061	○	○	○	○	○	○	○		○	○
β*i*S 2/4000 (for the FS0*i* only)	061	○	○	○	○	○	○		○	○	
β*i*S 4/4000	063	○	○	○	○	○	○	○		○	○
β*i*S 4/4000 (for the FS0*i* only)	063	○	○	○	○	○	○		○	○	
β*i*S 8/3000	075	○	○	○	○	○	○	○		○	○
β*i*S 8/3000 (for the FS0*i* only)	075	○	○	○	○	○	○		○	○	
β*i*S 12/2000	077	○	○	○	○	○	○	○		○	○
β*i*S 12/2000 (for the FS0*i* only)	077	○	○	○	○	○	○		○	○	
β*i*S 12/3000	078	○	○	○	○	○	○	○		○	○
β*i*S 22/1500 (for the FS0*i* only)	084	○	○	○	○	○	○		○	○	
β*i*S 22/2000	085	○	○	○	○	○	○	○		○	○

* The #0000 symbol is omitted.

β*i*S series (400V)

A06B-0□□□-B△0▽#◎◎◎◎

Servo motor name \ Symbol in specification No.	□□□	△						▽	◎◎◎◎	
		0	1	2	3	4	5	3	0000	0100
β*i*S 2/4000HV	062	○	○	○	○	○	○	○	○	○
β*i*S 4/4000HV	064	○	○	○	○	○	○	○	○	○
β*i*S 8/3000HV	076	○	○	○	○	○	○	○	○	○
β*i*S 12/3000HV	079	○	○	○	○	○	○	○	○	○
β*i*S 22/2000HV	086	○	○	○	○	○	○	○	○	○

* The #0000 symbol is omitted.

2.2 APPLICABLE AMPLIFIERS

The FANUC AC Servo Motor β*i* series can be driven using FANUC Servo Amplifier α*i*SV series or β*i*SV series.

Combinations of the β*i*S servo motors and the α*i*SV/β*i*SV servo amplifiers (200 V)

Stall torque		0.2	0.3	0.4	0.5	1	2	4	8	12		20	
Motor / Amplifier	β*i*S	β*i*S 0.2 /5000	β*i*S 0.3 /5000	β*i*S 0.4 /5000	β*i*S 0.5 /6000	β*i*S 1 /6000	β*i*S 2 /4000	β*i*S 4 /4000	β*i*S 8 /3000	β*i*S 12 /2000	β*i*S 12 /3000	β*i*S 22 /1500	β*i*S 22 /2000
α*i*SV 20	-			○	○	○	○	○	○	○		○	
α*i*SV 40	-										○		○
α*i*SV 4/4	L axis	○	○										
	M axis	○	○										
α*i*SV 20/20	L axis			○	○	○	○	○	○	○		○	
	M axis			○	○	○	○	○	○	○		○	
α*i*SV 20/40	L axis			○	○	○	○	○	○	○		○	
	M axis										○		○
α*i*SV 40/40	L axis										○		○
	M axis										○		○
α*i*SV 40/80	L axis										○		○
	M axis												
α*i*SV 4/4/4	L axis	○	○										
	M axis	○	○										
	N axis	○	○										
α*i*SV 20/20/20	L axis			○	○	○	○	○	○	○		○	
	M axis			○	○	○	○	○	○	○		○	
	N axis			○	○	○	○	○	○	○		○	
α*i*SV 20/20/40	L axis			○	○	○	○	○	○	○		○	
	M axis			○	○	○	○	○	○	○		○	
	N axis										○		○
β*i*SV 4	-	○	○										
β*i*SV 20	-			○	○	○	○	○	○	○		○	
β*i*SV 40	-										○		○
β*i*SV 20/20	L axis			○	○	○	○	○	○	○		○	
	M axis			○	○	○	○	○	○	○		○	
β*i*SVSP 20/20-5.5	L axis						○	○	○	○		○	
	M axis						○	○	○	○		○	
β*i*SVSP 20/20-11	L axis						○	○	○	○		○	
	M axis						○	○	○	○		○	
β*i*SVSP 40/40-15	L axis						*	*	*	*	○	*	○
	M axis						*	*	*	*	○	*	○
β*i*SVSP 20/20/40-5.5	L axis						○	○	○	○		○	
	M axis						○	○	○	○		○	
	N axis						*	*	*	*	○	*	○
β*i*SVSP 20/20/40-11	L axis						○	○	○	○		○	
	M axis						○	○	○	○		○	
	N axis						*	*	*	*	○	*	○
β*i*SVSP 40/40/40-15	L axis						*	*	*	*	○	*	○
	M axis						*	*	*	*	○	*	○
	N axis						*	*	*	*	○	*	○

(400 V)

Stall torque		2	4	8	12	20
Motor / Amplifier	β*i*S	β*i*S 2 /4000HV	β*i*S 4 /4000HV	β*i*S 8 /3000HV	β*i*S 12 /3000HV	β*i*S 22 /2000HV
α*i*SV 10HV	-	○	○	○		
α*i*SV 20HV	-				○	○
α*i*SV 10/10HV	L axis	○	○	○		
	M axis	○	○	○		
α*i*SV 20/20HV	L axis				○	○
	M axis				○	○
α*i*SV 20/40HV	L axis				○	○
	M axis					
β*i*SV 10HV	-	○	○	○		
β*i*SV 20HV	-				○	○

⚠ **CAUTION**

1. If a motor is used in a combination other than those listed above, it may become broken.
2. For details on the servo amplifier, refer to "FANUC SERVO AMPLIFIER α*i* series DESCRIPTIONS (B-65282EN)" and “FANUC SERVO AMPLIFIER β*i* series DESCRIPTIONS (B-65322EN)”.
3. If you want to use a motor in combination with the α/β series servo amplifier, consult with FANUC.
4. The β*i*SVSP series servo amplifier can drive a motor marked with an asterisk * by changing the appropriate servo parameter.

3 USAGE

This chapter explains how to connect the FANUC AC Servo Motor β*i* series to the CNC system and how to install it in the machine.

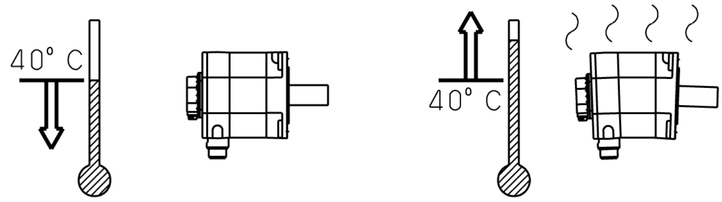
Chapter 3, "USAGE", consists of:

3.1 USE ENVIRONMENT FOR SERVO MOTORS

3.1.1 Ambient Temperature, Humidity, Installation Height, and Vibration

Ambient temperature

The ambient temperature should be 0°C to 40°C. If the ambient temperature exceeds this range, the operating conditions must be eased to prevent the motor and detector from overheating. (The values in the data sheet are determined for an ambient temperature of 20°C.)



Ambient humidity

The ambient humidity should be 80%RH or less and no condensation should not be caused.

Installation height

Up to 1,000 meters above the sea level requires, no particular provision for attitude. When operating the machine at a higher level, special care is unnecessary if the ambient temperature is lowered 1°C at every 100m higher than 1,000m. For example, when the machine is installed at a place of 1,500 meters above sea level, there is no problem if the ambient temperature is 35°C or less.

Vibration

When installed in a machine, the vibration applied to the motor must not exceed 5G.

If any one of the four environmental conditions specified above is not satisfied, the output must be restricted.

3.1.2 Usage Considering Environmental Resistance

Overview

The motor is an electric part, and if the lubricant or cutting fluid falls on the motor, it will enter the inside of the motor, possibly adversely affecting the motor. In particular, if the cutting fluid adheres to the motor, it will deteriorate the resin or rubber sealing members, causing a large amount of cutting fluid to enter the inside of the motor and possibly damaging the motor. When using the motor, note the points described below.

Level of motor protection

For the standard type, the level of motor protection is such that a single motor unit can satisfy IP65 of the IEC 60034-5 standard. As options, IP67 type motors are also available. For a description of the drip-proof and water-proof properties of each connector, see the section on that connector.

IP6□ : Fully dust-proof machine

Structure completely free from the entry of dust.

IP□5 : Machine protected from injected water

Water injected from a nozzle to the machine in any direction does not have a harmful impact on the machine.

IP□7 : Machine protected from the effect of seeping water

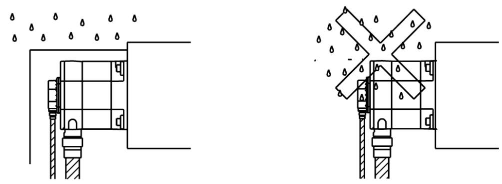
If the machine is immersed in water at a prescribed pressure for a prescribed duration, there is no possibility that an amount of water that has a harmful impact on the machine enters the machine.

If sufficient water-proof performance is required, as in the case in which a motor is used in a cutting fluid mist atmosphere, specify an IP67 type motor.
Note that both the standard and IP67 types satisfy the provisions for short-time water immersion, and do not guarantee their water-proof performance in an atmosphere in which the cutting fluid is applied directly to the motor. Before actual use, note the points described below.

Motor periphery

If the cutting fluid or lubricant falls on the motor, it will adversely affect the sealing properties of the motor surface, entering the inside of the motor and possibly damaging the motor. Note the following points on use.

Make sure that the motor surface is never wet with the cutting fluid or lubricant, and also make sure that no fluid builds up around the motor. If there is a possibility of the surface being wet, a cover is required. Be sure to mount a cover even when using an IP67 type motor.



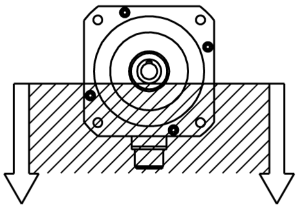
If the cutting fluid is misted, the cutting fluid may be condensed on the inside of the cover and fall on the motor. Make sure that no condensed droplets fall on the motor.

Completely separate the machining area from the motor area, using a telescopic cover, accordion curtain, and so on. Note that partitions such as accordion curtains are consumable and require periodic inspection for damage.

Output shaft seal (oil seal)

For all models, the shaft of the servo motor is provided with an oil seal to prevent entry of oil and other fluids into the motor. It does not, however, completely prevent the entry of lubricant and other fluids depending on the working conditions. Note the following points on use.

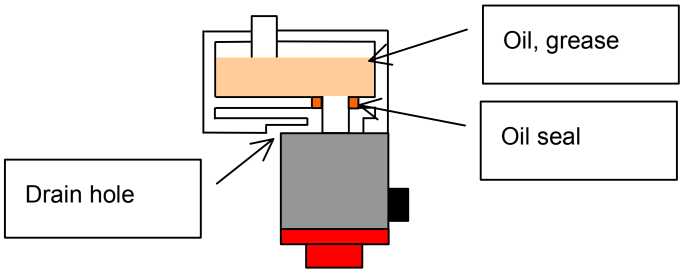
When the motor is rotating, the oil seal has an effect of discharging any oil that enters, but if it is pressurized for a long time when the motor is stopped, it may allow oil to enter through the lip. When lubrication with an oil bath is conducted for gear engagement, for example, the oil level must be below the lip of the oil seal of the shaft, and the oil level must be adjusted so that the oil does nothing but splash on the lip.



Diameters of the oil seal lips of motor shafts

Motor model	Oil seal diameter
β*i*S 0.2 β*i*S 0.3	ϕ8 [mm]
β*i*S 0.4 β*i*S 0.5 β*i*S 1	ϕ14.9[mm]
β*i*S 2, β*i*S 2HV β*i*S 4, β*i*S 4HV	ϕ15 [mm]
β*i*S 8, β*i*S 8HV β*i*S 12, β*i*S 12HV	ϕ24 [mm]
β*i*S 22, β*i*S 22HV	ϕ35 [mm]

If the shaft is directed upward so that it is constantly immersed in oil, the oil seal of the motor alone does not provide sufficient sealing. If grease is used for lubrication, the properties of the oil seal are generally impaired. In these cases, a special design is required. For example, another oil seal is mounted on the machine side and a drain is provided so that any oil passing through that seal can is discharged outside.



In such an environment in which the lip of the oil seal switches between dry and wet states repeatedly, if the cutting fluid flies about after the lip has worn in a dry state, the cutting fluid may easily enter the inside of the motor. In this case, provide a cover, etc. so that no cutting fluid is applied to the oil seal of the motor.

Ensure that no pressure is applied to the lip of the oil seal.

The cutting fluid does not provide lubrication for the oil seal lip, so that the fluid may easily enter the seal. Provide a cover so that no cutting fluid is applied to the oil seal.

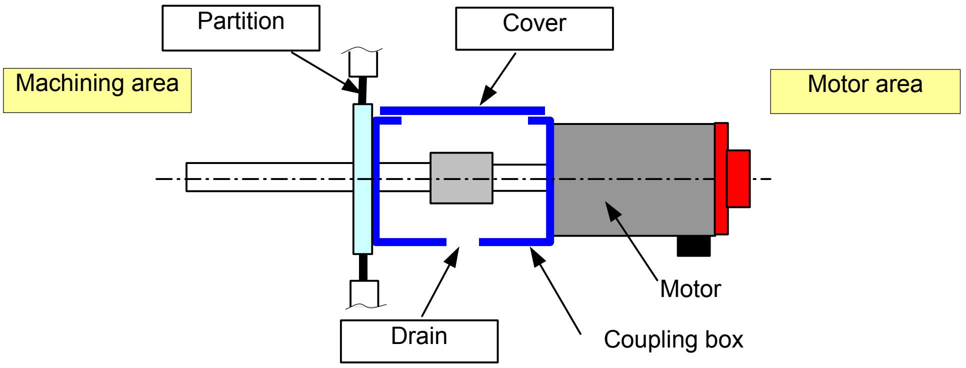
The oil seal lip is made of rubber, and if foreign matters such as cutting chips get in, it will be easily worn, losing its sealing properties. Provide a cover, etc. to prevent cutting chips from entering near the lip.

Motor coupling

If a coupling box exists between the motor and the machine, employ the structure described below so that no cutting fluid builds up in the box.

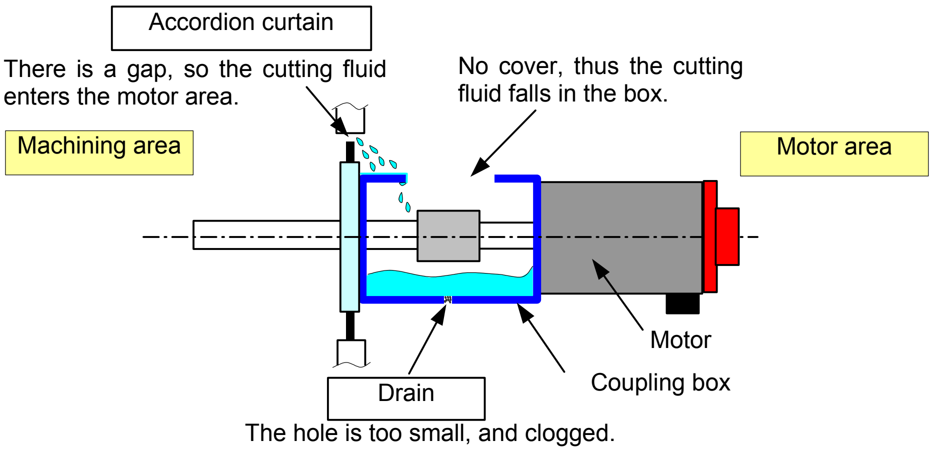
Provide a cover for the top and sides of the coupling box.

Provide a drain hole at the bottom of the coupling box. The hole must be large enough to avoid clogging. Make sure that any cutting fluid that bounces back is not applied from the drain hole to the motor.



<Fault example>

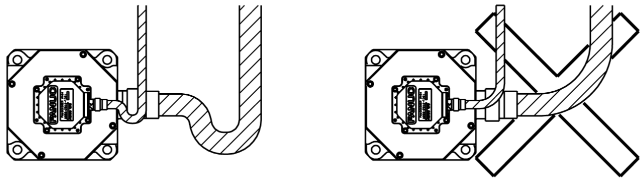
The cutting fluid leaks from a gap in the accordion curtain to the motor area, and builds up in the coupling box. While the motor is moving, the cutting fluid ripples, splashing on the oil seal of the motor. The cutting fluid enters the inside of the motor there in large quantities, deteriorating the insulation of the motor.



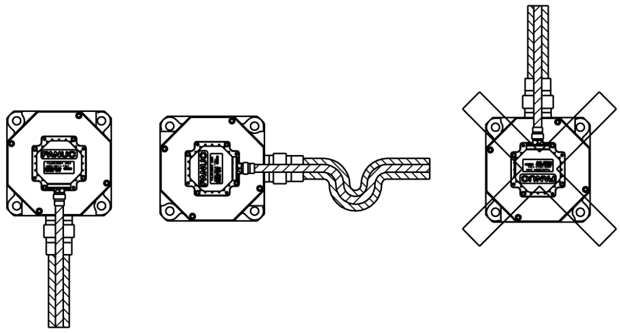
Connectors

Note the following points on use:

Make sure that no cutting fluid is introduced to the motor via cables. If the motor connector is used horizontally, this can be accomplished by forming a slack in the cable.



If the motor connector is directed upward, the cutting fluid collects into the cable connector. Whenever possible, direct the motor connector sideways or downward.



If there is a possibility of the power cable and the power connector being wet, it is recommended to use the water-proof connector plug recommended in this DESCRIPTIONS for the connector and a oil-proof cable as the power cable. (Oil-proof cable example: PUR (polyurethane) series made by LAPP)

If using a conduit hose for cable protection purposes, use the seal adapter recommended in this DESCRIPTIONS.

The feedback cable connector provides IP67 water-proof performance when it is engaged with the pulse coder connector. If the feedback cable connector is not fully engaged, the cutting fluid will enter the inside of the pulse coder from the connector, possibly causing a failure. Install the connector properly in accordance with the feedback cable engagement procedure described in this DESCRIPTIONS and check that it is engaged securely.

If the feedback cable connector cannot provide sufficient water resistance due to an assembly failure, the cutting fluid will enter the inside of the pulse coder from the connector, possibly causing a failure. When manufacturing a feedback cable connector, assemble it properly in accordance with the operator's manual issued by the connector manufacturer.

Notes on cutting fluid

Cutting fluid containing highly active sulfur, oil-free cutting fluid called synthetic cutting fluid, and highly alkaline, water-soluble cutting fluid in particular significantly affect the CNC, motor, or amplifier. Even when these components are protected from direct spraying of cutting fluid, problems as described below may arise. So special care should be taken.

- **Cutting fluid containing highly active sulfur**
  Some cutting fluids containing sulfur show extremely high activity of sulfur. Ingress of such cutting fluid into the CNC, motor, or amplifier can cause corrosion of copper, silver, and so on used as parts' materials, therefore resulting in parts' failures.

- **Synthetic cutting fluid with high permeability**
  Some synthetic type cutting fluids that use polyalkylene glycol (PAG) as a lubricant have extremely high permeability. Such cutting fluid can easily penetrate into the motor even if the motor is sealed well. Ingress of such cutting fluid into the CNC, motor, or amplifier can degrade insulation or lead to parts' failures.

- **Highly alkaline, water-soluble cutting fluid**
  Some cutting fluids that strengthen pH by alkanolamine show strong alkalinity of pH10 or higher when diluted to the standard level. Ingress of such cutting fluid into the CNC, motor, or amplifier can cause chemical reaction with plastic and so on and deteriorate them.

3.1.3 Checking a Delivered Servo Motor and Storing a Servo Motor

When the servo motor is delivered, check the following items.

- The motor meets the specifications.
  (Specifications of the model/shaft/sensor)
- Damage caused by the transportation.
- The shaft is normal when rotated by hand.
- The brake works.
- Looseness or play in screws.

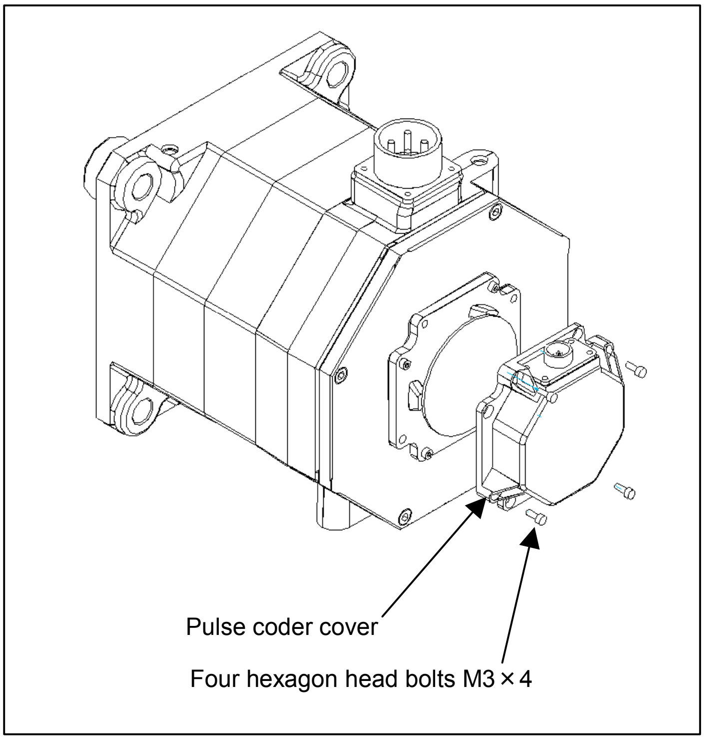
FANUC Servo Motors are completely checked before shipment, and the inspection at acceptance is normally unnecessary. When an inspection is required, check the specifications (wiring, current, voltage, etc.) of the motor and sensor. Store the motor indoors. The storage temperature is -20°C to +60°C. Avoid storing in the following places.

- Place with high humidity so condensation will form.
- Place with extreme temperature changes.
- Place always exposed to vibration.
  (The bearing may be damaged.)
- Place with much dust.

3.1.4 Separating and Disposing of a Servo Motor

For a servo motor, a plastic part is used.
Disassemble the motor as shown in the following figure, separate the plastic part (Pulsecoder cover), and dispose of the motor. The following plastic material is used:

Plastic material : > (PBT+PC)-GF(30)FR(17)<

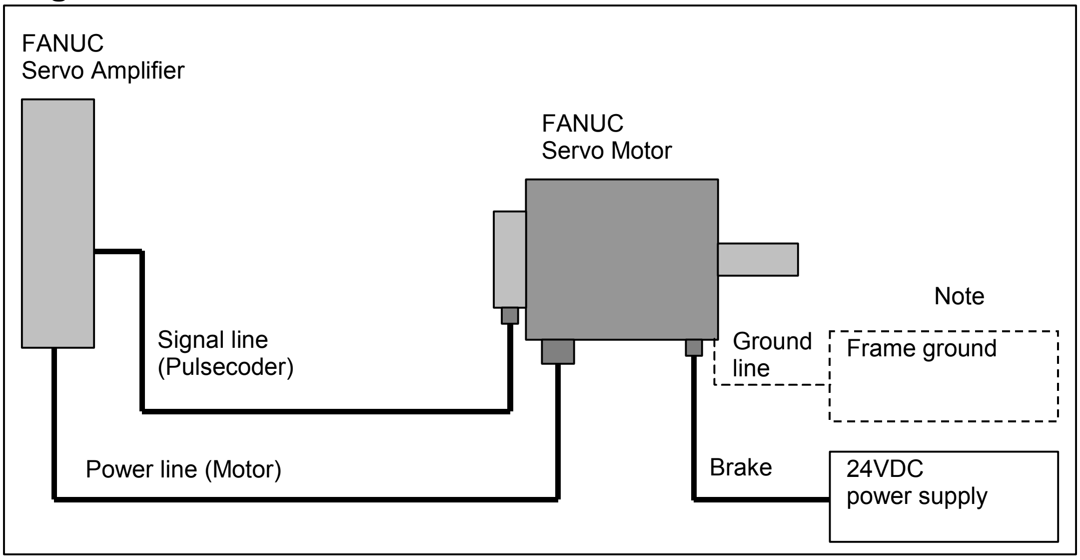


3.2 CONNECTING A SERVO MOTOR

3.2.1 Connections Related to a Servo Motor

For the FANUC AC Servo Motor β*i* series, connect the power line of the motor and the signal line of a Pulsecoder to an FANUC Servo Amplifier. When the motor has a built-in brake or cooling fan as an option, connect the built-in brake to the specified power supply.

Connection diagram



> ⚠ **CAUTION**
> If a motor is not connected to ground through the machine (cabinet) in which the motor is installed, connect the motor grounding point and the amplifier grounding point to absorb noise. In this case, use a wire with a thickness of at least 1.25 mm^2, other than the GND conductor in the power line. Keep the wire as far from the power line as possible.

Connecting the power line

For the pin layout of the power connector on the servo motor side or the layout of the power terminals, see Chapter 7, "OUTLINE DRAWINGS".
For details of the connector of a cable connected to the servo motor, see Chapter 10, "CONNECTORS ON THE CABLE SIDE."
For details of selection of a power line and the shapes of the connector and terminal connected to a servo amplifier, refer to "FANUC SERVO AMPLIFIER α*i* series Descriptions (B-65282EN)" or "FANUC SERVO AMPLIFIER β*i* series Descriptions (B-65322EN)."

Connecting the signal line

For details of the signal connector on a Pulsecoder, see Chapter 8, "FEEDBACK SENSOR".
For details of the connector of a cable connected to a Pulsecoder, see Chapter 10, "CONNECTORS ON THE CABLE SIDE."
For details of selection of a signal line and the connector connected to a servo amplifier, refer to "FANUC SERVO AMPLIFIER α*i* series Descriptions (B-65282EN)" or "FANUC SERVO AMPLIFIER β*i* series Descriptions (B-65322EN)."

Connecting a built-in brake

For details of how to connect the power connector on a built-in brake and the power supply, see Chapter 9, "BUILT-IN BRAKE."
For details of the connector of a cable connected to a built-in brake, see Chapter 10, "CONNECTORS ON THE CABLE SIDE."

3.3 MOUNTING A SERVO MOTOR

3.3.1 Methods for coupling the shaft

In many cases, the following four methods are used for coupling the motor shaft to the ball screw on a machine: Direct connection through a flexible coupling, direct connection through a rigid coupling, connection through gears, and connection through timing belts. It is important to understand the advantages and disadvantages of each method, and select one that is most suitable for the machine.

Direct connection using a flexible coupling

Direct connection by a flexible coupling has the following advantages over connection using gears:

- Even if the angle of the motor shaft to the ball screw changes, it can be compensated to a certain extent.
- Because a flexible coupling connects elements with less backlash, driving noise from joints can be significantly suppressed.

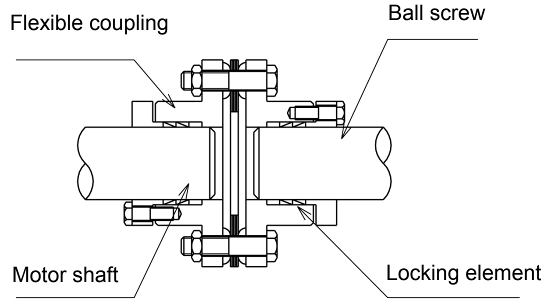
However, this method has the following disadvantages:

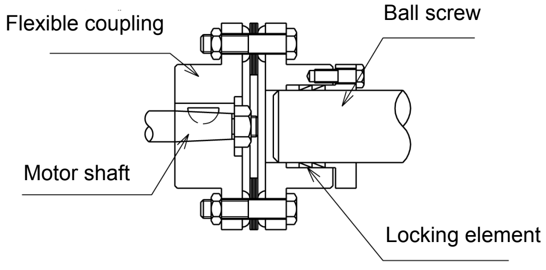
- The motor shaft and the ball screw must not slide from each other in the radial direction (for single coupling).
- Loose assembly may result in lower rigidity.

When the motor shaft needs to be connected directly to the ball screw, connecting them using a flexible coupling facilitates adjustment and installation of the motor.

To use a single coupling, the machine needs to be designed so that the centers of the motor shaft and the ball screw are aligned. (In the same way as with a rigid coupling, the use of a single coupling demands that there be almost no relative eccentricity between the axes.)

If it is difficult to align the centers, a double coupling needs to be employed.





Direct connection using a rigid coupling

Direct connection using a rigid coupling has the following advantages over direct connection using a flexible coupling:

- More economical
- The coupling rigidity can be increased.
- If the rigidity is the same as with a flexible coupling, the inertia can be reduced.

However, this method has the following disadvantages:

- The motor shaft and the ball screw must not slide from each other in the radial direction, and the angle of the motor shaft to the ball screw must be fixed.

For this reason, a rigid coupling needs to be mounted very carefully.
It is desirable that the run-out of the ball screw is 0.01 mm or less. When a rigid coupling is used on the motor shaft, the run-out of the hole for the ball screw must be set to 0.01 mm or less by adjusting the tightness of the locking element.
The run-out of the motor shaft and the ball screw in the radial direction can be adjusted or compensated to a certain extent by deflection. Note, however, that it is difficult to adjust or measure changes in the angle. Therefore, the structure of the machine should be such that precision can be fully guaranteed.

Gears

This method is used when the motor cannot be put in line with the ball screw because of the mechanical interference problem or when the reduction gear is required in order to obtain large torque. The following attention should be paid to the gear coupling method:

- Grinding finish should be given to the gear, and eccentricity, pitch error, tooth-shape deviations etc. should be reduced as much as possible. Please use the JIS, First Class as a reference of precision.
- Adjustment of backlash should be carefully performed. Generally, if there is too little backlash, a high-pitched noise will occur during high-speed operation, and if the backlash is too big, a drumming sound of the tooth surfaces will occur during acceleration/deceleration. Since these noises are sensitive to the amount of backlash, the structure should be so that adjustment of backlash is possible at construction time.

Timing belt

A timing belt is used in the same cases as gear connection, but in comparison, it has advantages such as low cost and reduced noise during operation, etc. However, it is necessary to correctly understand the characteristics of timing belts and use them appropriately to maintain high precision.
Generally, the rigidity of timing belt is sufficiently higher than that of other mechanical parts such as ball screw or bearing, so there is no danger of inferiority of performance of control caused by reduction of rigidity by using timing belt. When using a timing belt with a position sensor on the motor shaft, there are cases where poor precision caused by backlash of the belt tooth and pulley tooth, or elongation of belt after a long time becomes problem, so consideration should be given to whether these errors significantly affect precision. In case the position sensor is mounted behind the timing belt (for example, on the ball screw axis), a problem of precision does not occur.
Life of the timing belt largely varies according to mounting precision and tension adjustment. Please refer to the manufacturer's Instruction Manual for correct use.

3.3.2 Fastening the Shaft

Taper shaft

In case of taper shafts, the load must be exerted on the tapered surface. For this reason, at least 70% of gage fitting is required on the tapered surface.
In addition, the screw at the end of the taper shaft must be tightened with a proper torque to achieve sufficient axial force.

Straight shaft

To use a straight shaft that has no key way, connect the shaft with a coupling using a locking element. Because the locking element connects elements by the friction generated when the screw is tightened, it is free from backlash and the concentration of stress. For this reason, the locking element is highly reliable for connecting elements.
To assure sufficient transmission with the locking element, factors such as the tightening torque of the screw, the size of the screw, the number of screws, the clamping flange, and the rigidity of connecting elements are important. Refer to the manufacturer's specifications before using the locking element. When a coupling or gear is mounted using the locking element, tighten the screws to remove a run-out of the coupling or gear including the shaft.

Straight shaft with a key way

In a straight shaft with a key way, torque is transmitted at the key.
This means that if there is a looseness between the key and key way, the impact incurred at the time of inversion increases, which can result in shaft breakage, or a backlash occurs as a result of the looseness, which can lower positioning accuracy. Therefore, the key and key way should be designed so as to minimize the looseness between them.
When acceleration/deceleration is to be performed sharply or frequently, a taper shaft or a straight shaft with no key way should be selected.

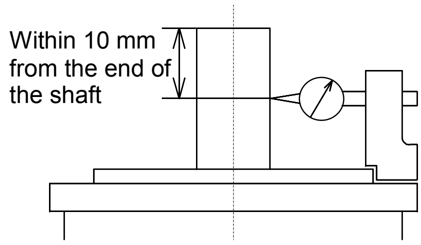
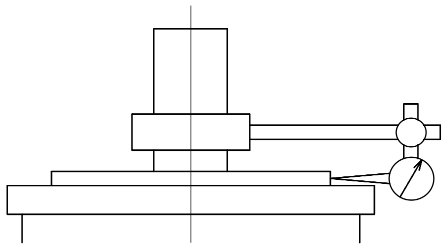
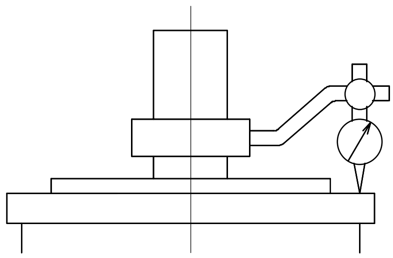
3.3.3 Allowable Axis Load for a Servo Motor

The allowable axis load for the shaft of each motor is indicated in Chapter 7, "OUTLINE DRAWINGS". Using a motor under a load higher than the allowable axial load may break the motor. When designing a machine and connecting a motor to the machine, fully consider the following points:

- The allowable radial load is determined, assuming that a radial load is applied to the end of the shaft.
- Applying a load higher than the allowable axis load may break the bearing. Applying a radial load higher than the allowable radial load may break the shaft due to a fatigue failure.
- A radial load indicates the constant force continuously applied to the shaft depending on the mounting method (such as belt tension) and the force by the load torque (such as dividing moment by pulley radius).
- When a timing belt is used, the belt tension is critical particularly. Too tight a belt causes a fault such as the broken shaft. Belt tension must be controlled so as not to exceed the limits calculated from the allowable radial load. Positioning the pulley as close to the bearing as possible in design can prevent possible faults such as the broken shaft.
- In some use conditions, the pulley diameter and gear size should be considered. For example, when the β*i*S 8 model is used with a gear and pulley with a radius of 2 cm or less, the radial load with a torque of 15 N·m (153 kgf·cm) exceeds 686 N (70 kgf). In this case, take measures such as supporting the end of the motor shaft mechanically.
- If a motor may be used under a load higher than the allowable axis load, the machine tool builder should examine the life by referencing the shaft diameter, bearing, and other factors. Since the standard single-row deep-groove ball bearing is used for the motor bearing, a too high axial load cannot be used. To use a worm or helical gear, in particular, use another bearing.
- The motor bearing is generally fixed with a C-snap ring, and there is a small play in the axial direction. If the axial play affects the positioning in the case of using a worm or helical gear, fit it with another bearing.

3.3.4 Shaft Run-out Precision of a Servo Motor

The shaft run-out precision of each motor is indicated in Chapter 7, "OUTLINE DRAWINGS". The methods of measuring the shaft run-out precision are specified below:

Item	Measuring method
Shaft diameter run-out	
Run-out of the faucet joint for mounting the flange against the center of the shaft (Only for flange type)	
Run-out of the flange mounting surface against the center of the shaft (Only for flange type)	

3.3.5 Other Notes on Axis Design

Machine movement per 1 revolution of motor shaft

The machine movement per 1 revolution of motor shaft must be determined at the first stage of machine design referring the load torque, load inertia, rapid traverse speed, and relation between minimum increment and resolution of the position sensor mounted on the motor shaft. To determine this amount, the following conditions should be taken into consideration.

- The machine movement per 1 revolution of motor shaft must be such that the desired rapid traverse speed can be obtained. For example, if the maximum motor speed is 1500 min^{-1} and the rapid traverse speed must be 12 m/min., the machine movement per 1 rev. must be 8 mm/rev. or higher.

- As the machine movement per 1 revolution of motor shaft is reduced, both the load torque and the load inertia reflected to motor shaft also decrease.
  Therefore, to obtain large thrust, the machine movement per 1 rev. should be the lowest value at which the desired rapid traverse speed can be obtained.

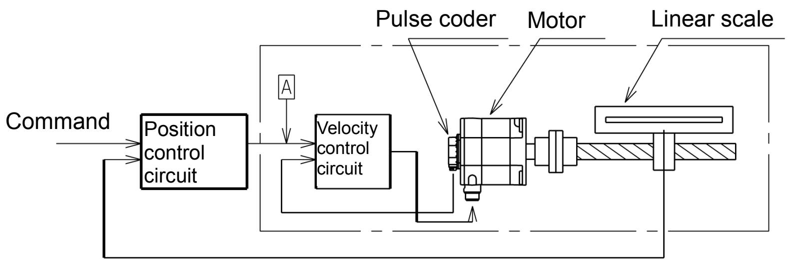
- Assuming that the accuracy of the reduction gear is ideal, it is advantageous to make the machine movement per 1 rev. of motor shaft as low as possible to obtain the highest accuracy in mechanical servo operations. In addition, minimizing the machine movement per 1 rev. of motor shaft can increase the servo rigidity as seen from the machine's side, which can contribute to system accuracy and minimize the influence of external load changes.

- When the machine is operation is characterized by repeated acceleration/deceleration cycles, a heating problem may occur due to the current flow caused by the acceleration and deceleration. Should this occur, the machine travel distance per motor shaft revolution should be modified. Given optimum conditions, the machine travel distance per motor shaft revolution is set such that the motor's rotor inertia equals the load inertia based on motor shaft conversion. For machines such as punch presses and PCB drilling machines, the machine's travel distance per motor shaft revolution should be set so as to satisfy this optimum condition as far as possible, while also considering the rapid traverse rate and increment system.

Precautions for using linear scale

In the case where the machine moves in a linear direction and movement is directly detected by linear scale such as inductosyn, magne-scale etc., special considerations are necessary in comparison with the method where feedback is produced by detecting the motor shaft rotation. This is because the machine movement now directly influences the characteristics of the control system.

The following block diagram shows feedback produced using a linear scale.



The response of this control system is determined by the adjustment value (position loop gain) of the position control circuit. In other words, the position loop gain is determined by the specified response time of the control system. In the diagram above, the section enclosed by the broken line is called the velocity loop.

Unless the response time of this section where position signal is detected is sufficiently shorter than the response time determined by the position loop gain, the system does not operate properly. In other words, when a command signal is put into point A, response time of the machine where position signals are detected must be sufficiently shorter than the response time defined by the position loop gain.

If the response of the sensor section is slow, the position loop gain should be reduced to have the system operate normally, and as a result, the response of the whole system becomes slow. The same problem is caused when inertia is great.

The main causes for slow response are the mass of the machine and the elastic deformation of the machine system. The larger the volume, and the greater the elastic deformation, the slower the response becomes.

As an index for estimating the response of this machine system, the natural frequency of the machine is used, and this is briefly calculated by the following equation.

$$W_m = \frac{1}{2\pi} \times \sqrt{\frac{K_m}{J_L}}$$

W_m : Natural frequency

J_L : Load inertia reflected to motor shaft

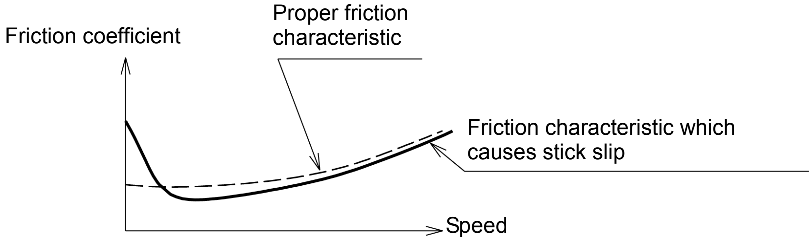
K_m : Rigidity of machine system

(=Torque necessary to elastically deform 1[rad] at the motor shaft when the machine table is clamped.)

The above values can be obtained by calculating the elastic deformation for each section of the driving system. The machine should be designed so that the value of this natural frequency [Hz] will be more than or equal to the value of the position loop gain [sec^{-1}]. For example, when setting 20 [sec^{-1}] as the value of position loop gain, natural frequency of machine system must be more than 20 [Hz].
In this case, the response of the control system becomes a problem for extremely small amounts of movement. Consequently, the natural frequency should be calculated from the rigidity at extremely small displacement such as 10 [μm] or less.

Stick slip

If machine movement causes a stick slip, the control system does not operate normally. That is, it does not stop where it is supposed to, but a phenomenon occurs where it goes beyond and then back within an extremely small range (hunting).
To avoid stick slip, the machine rigidity should be increased, or friction characteristics of the sliding surface should be improved. When the sliding surface friction characteristic is as in the figure below, stick slip occurs easily.



Value of machine overrun (Damping coefficient of machine system)

When the machine is floated by static pressure, etc., there are cases where the machine keeps on moving within the range of backlash although the motor shaft has stopped. If this amount is large, hunting will also occur. To avoid this, backlash should be reduced (especially the backlash of the last mass where position sensor is mounted) and the appropriate damping should be considered.

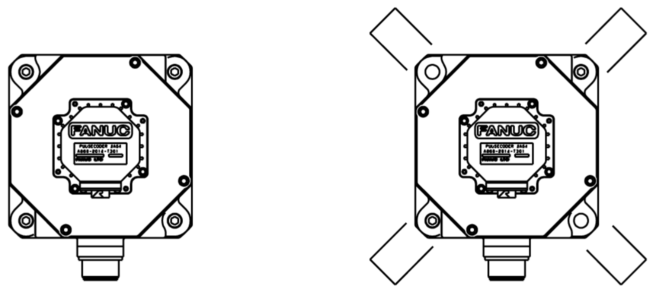
Reciprocating motion over a short distance

Continuing reciprocating motions over a short distance with a small number of revolutions causes the bearing to become short of lubricant, which can shorten the life of the bearing. When such motions are performed, special care should be taken by, for example, turning the motor at least one turn periodically.

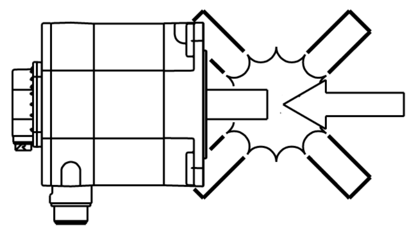
3.3.6 Cautions in Mounting a Servo Motor

The servo motor contains precision sensor, and is carefully machined and assembled to provide the required precision. Pay attention to the following items to maintain the precision and prevent damage to the sensor.

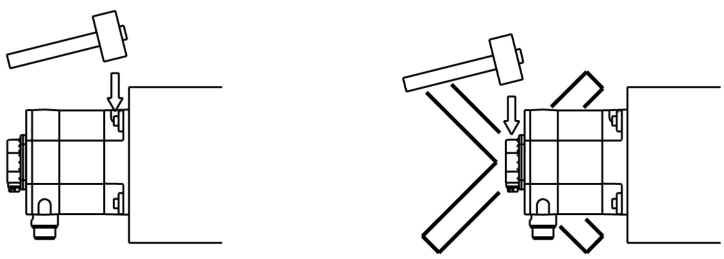
- Secure the servo motor uniformly using four bolt holes provided on the front flange.



- Ensure that the surface on which the machine is mounted is sufficiently flat.
  When mounting on the machine, take care not to apply a shock to the motor.

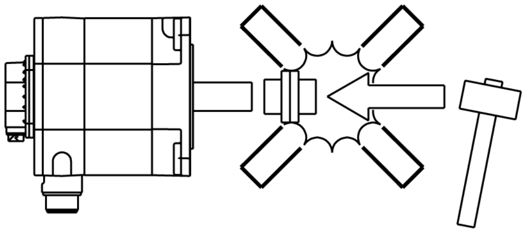


- When it is unavoidable to tap the motor for adjusting the position, etc., use a plastic hammer and tap only the front flange if possible.



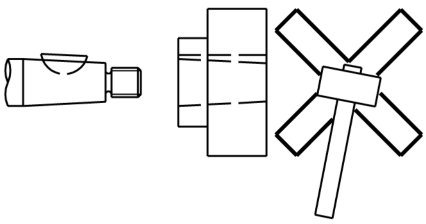
A precision sensor is directly connected to the servo motor shaft.
Pay attention to the following items to prevent damage to the sensor.

- When connecting the power transmission elements such as a gear, a pulley and a coupling to the shaft, take care not to apply a shock to the shaft.

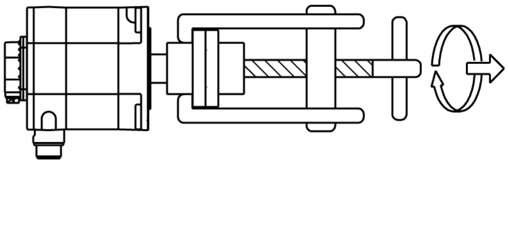


- Generally, in the case of straight shaft, use a locking element for connection with the shaft.

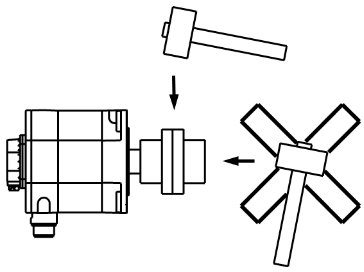
- In the case of tapered shaft, match the tapered surface with the power transmission element and fix by tightening the screw at the end. When the woodruff key is too tight, don't tap it with a hammer. Use the woodruff key mainly for positioning, and use the tapered surface for torque transmission. Machine the tapered surface of the power transmission element so that over 70% of the whole surface is contacted.



- To remove the connected power transmission element, be sure to use a jig such as a gear puller.



- When tapping slightly to remove the tightly contacted tapered surface, tap in the radial direction to prevent a shock in the axial direction.



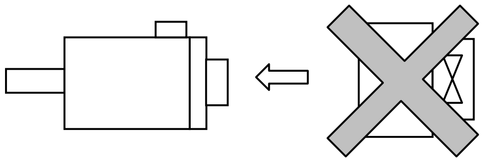
- Suppress the rotary unbalance of the connected power transmission element to the level as low as possible. It is usually believed that there is no problem in the symmetrical form. Be careful when rotating continuously the asymmetrical different form power transmission element. Even if the vibration caused by the unbalance is as small as 0.5G, it may damage the motor bearing or the sensor.

- An exclusive large oil seal is used in the front flange of the models β*i*S 8 to β*i*S 22.
  The oil seal surface is made of steel plate. Take care not to apply a force to the oil seal when installing the motor or connecting the power transmission elements.

3.3.7 Notes on Servo Motors with the Pulsecoder βiA 128 (for the FS0i only) Attached

- To use this model, it is important to set the soft thermal properly. Set it properly, referring to the Parameter Manual (B-65270JA).

- Never mount a rear fan unit to this motor. Otherwise, overheat protection may not be performed properly.



> ⚠ **WARNING**
> Failure to follow the notes above may result may cause the motor to be damaged.

- Do not use the pulsecoder in such a way that it is exposed to strong wind. Otherwise, overheat protection may not be performed properly. Do not use it in such a structure in which only the pulsecoder is cooled, either.

- If an OVC alarm is generated, wait for a couple of minutes and then restart it.

4 SELECTING A MOTOR

A servo motor should be selected based on the load on the servo motor, rapid traverse rate, unit, and other conditions. The load on the servo motor is the following types of torque: steady-state load torque (including gravity and friction), acceleration torque required for acceleration/deceleration, and, for a machine tool, cutting torque by cutting force.
When selecting a motor, calculate these loads accurately according to the instructions in this chapter and check that the calculated values satisfy the conditions for selecting a servo motor described in this chapter.
This chapter describes how to calculate the load and other conditions using a table with a horizontal axis as an example.

Chapter 4, “SELECTING A MOTOR”, consists of:

4.1 CONDITIONS FOR SELECTING A SERVO MOTOR

The conditions for selecting a servo motor are given below.

[Selection condition 1] Steady-state load torque

- **The steady-state load torque including mechanical friction and gravity must fall within approximately 70% of the stall torque of a motor.**
  If the steady-state load torque is close to the stall torque, the root-mean-square value of the total torque including the acceleration torque is more likely to exceed the stall torque.
  Along the vertical axis, the load may be increased during lifting and at stop due to a mechanical factor. In this case, the theoretically calculated gravity retaining torque must be 60% (less than 60% in some cases) of the stall torque of a motor.
  This figure of "within 70% of the steady-state load torque rating" is for reference only. Determine the appropriate torque based upon actual machine tool conditions.

[Selection condition 2] Motor speed

- **The motor speed must not exceed the maximum motor speed (rated speed during continuous operation).**
  Calculate the motor speed and check that the speed does not exceed the maximum motor speed. For continuous operation, check that the speed does not exceed the rated speed.

[Selection condition 3] Load inertia ratio

- **The load inertia ratio must be appropriate.**
  The ratio of motor inertia and load inertia (load inertia ratio) greatly affects the controllability of the motor as well as the acceleration/deceleration time in rapid traverse.
  When the load inertia does not exceed three times the motor inertia, an ordinary metal cutting machine can be used without problems, while the controllability may have to be lowered a little in some cases.
  For a machine for cutting a curve at a high speed, such as a router for woodworking, it is recommended that the load inertia be smaller than or equal to the motor inertia.
  If the load inertia is greater than the motor inertia by a factor of more than 3 to 5, the controllability of the motor may be adversely affected. If the load inertia is much larger than three times the motor inertia, adjustment within the normal range may be insufficient. It is desirable to avoid using a motor with such inertia.

[Selection condition 4] Acceleration torque

- **Acceleration can be made with a desired time constant.**
  Since the load torque generally helps deceleration, if acceleration can be executed with a desired time constant, deceleration can be made with the same time constant, through both acceleration and deceleration should be considered in principle. Calculate the acceleration torque and check that the torque required for acceleration is within the intermittent operating zone of the motor.

[Selection condition 5] Root-mean-square value of torque

- **The root-mean-square value of torque in a cycle must be sufficiently greater than the stall torque.**
  A motor gets hot in proportion to the square of the torque. For a servo motor for which the load condition always changes, the calculated root-mean-square value of torque in a cycle must be sufficiently greater than the stall torque.
  Pay attention, in particular, when the cutting load, acceleration/deceleration condition, and other load conditions variously change in a cycle.
  When the desired frequency of positioning in rapid traverse becomes greater, the ratio of the time during which the acceleration/deceleration torque is being applied to the entire operation time increases and the root-mean-square value of torque increases. In this case, increasing the acceleration/deceleration time constant is effective to decrease the root-mean-square value of torque.

[Selection condition 6] Percentage duty cycle and ON time with the maximum cutting torque

- **The time during which the table can be moved with the maximum cutting torque (percentage duty cycle and ON time) must be within a desired range.**
  The continuously applied torque such as the cutting load may exceed the stall torque. In this case, use overload duty curves to check how the ratio (percentage duty cycle) of the load applying time to the no-load applying time and the time during which the load is being applied (ON time) change.

[Selection condition 7] Dynamic brake stop distance

- **The stop distance when the dynamic brake is applied at an emergency stop must be within a desired range.**
  If the stop distance is not within the desired range, the machine may cause a collision at an emergency stop.

Along the vertical axis (for motors with a brake)
[Selection condition 8] Brake retaining torque

- **The load torque should be within the brake retaining torque.**
  If this cannot be satisfied, counter balance and so forth should be taken into consideration.

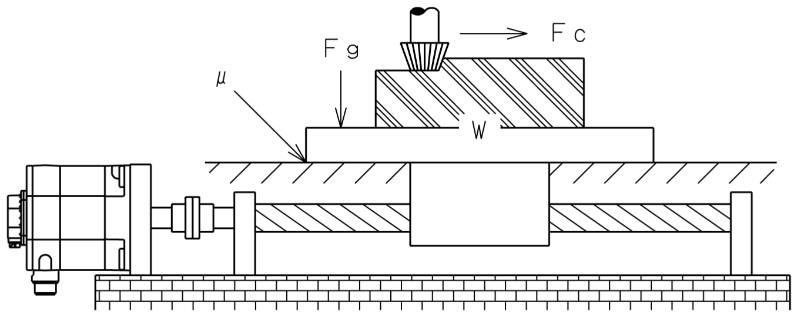
The following sections explain the procedure for selecting a motor sequentially for each selection condition. Determine whether each selection condition above is satisfied.

> **NOTE**
> When handling units, be extremely careful not to use different systems of units. For example, the weight of an object should be expressed in [kg] in the SI system of units because it is handled as "mass" or [kgf] in the gravitational system of units because it is handled as "force." Inertia is expressed in [kg·m^2] in the SI system of units or in [kgf·cm·sec^2] in the gravitational system of units.
> In this manual, both systems of units are written together to support them.
> ($1kg \cdot m^2 = \frac{100}{9.8} kgf \cdot cm \cdot s^2$)

4.2 SELECTING A MOTOR

Sample model for calculations for selecting a servo motor

The following subsections explain how to calculate conditions for selecting a servo motor best suited for a table with a horizontal axis with the following specifications.



Sample mechanical specifications of the table and workpiece

W : Weight of movable parts (table and workpiece) =2940[N]=300[kgf]
w : Mass of movable parts (table and workpiece) =300[kg]
μ : Friction coefficient of the sliding surface =0.05
η : Efficiency of the driving system (including a ball screw) =0.9
F_g : Gib fastening force (kgf) =490[N]=50[kgf]
F_c : Thrust counter force caused by the cutting force (kgf) =980[N]=100[kgf]
F_{cf}: Force by which the table is pressed against the sliding surface, caused by the moment of cutting force =294[N]=30[kgf]
Z_1/Z_2 : Gear reduction ratio = 1/1
T_f : Friction torque applied to the motor shaft =0.8[N·m]=8[kgf·cm]

Sample specifications of the feed screw (ball screw)

D_b : Shaft diameter $=25\times10^{-3}$[m]=25[mm]
L_b : Shaft length =1[m]=1000[mm]
P : Pitch $=20\times10^{-3}$[m/rev]=20[mm/rev]

Sample specifications of the operation of the motor shaft

T_a : Acceleration torque [N·m][kgf·cm]
V : Workpiece rapid traverse rate =60[m/min]
V_m : Motor speed in rapid traverse [min^{-1}]
t_a : Acceleration time =0.10[s]
J_M : Motor inertia [$kg\cdot m^2$][$kgf\cdot cm\cdot sec^2$]
J_L : Load inertia [$kg\cdot m^2$][$kgf\cdot cm\cdot sec^2$]
k_s : Position loop gain =30[s^{-1}]

4.2.1 Calculating the Load Torque

When a part moves along an axis at a constant speed, the torque obtained by multiplying the weight of the workpiece driving section by the friction coefficient is always applied. On a vertical or slanted axis, the motor keeps producing torque because it works against gravity. In addition, the motor also produces torque when the machine on the horizontal axis stops in proportion to the load friction. This continuously applied load torque is the steady-state load torque.
In cutting feed, the load torque is applied by cutting thrust. This is the cutting torque.
The above types of torque are generically called the load torque. The load torque applied to the motor shaft is generally given by the following equation:

$$T_m = \frac{F \times l}{2\pi\eta} + T_f$$

T_m : Load torque applied to the motor shaft [N·m]
F : Force required to move a movable part (table or tool post) along the axis [N]
l : Traveling distance of the machine tool per revolution of the motor = P × (Z_1/Z_2) [m/rev]
η : Efficiency of the driving system (including a ball screw)
T_f : Friction torque of the nut of the ball screw or bearing applied to the motor shaft (input if necessary) [N·m]

The force (F) is mainly given by the following equations:

<u>When cutting is not executed (vertical axis):</u>

$F=(w-w_c)g=W-W_c$

w_c : Mass of the counterbalance [kg]
Wc : Weight of the counterbalance [kgf]

<u>When cutting is not executed (horizontal axis):</u>

$F=\mu(W+F_g)$

<u>When cutting is in progress (horizontal axis) (constant load + cutting thrust):</u>

$F=F_c+\mu(W+F_g+F_{cf})$

[Example of calculation for condition 1] Steady-state load torque

For a table with a horizontal axis as given as a model, the steady-state load torque when cutting is not executed is calculated as follows:

Example $F=0.05\times(2940+490)=171.5[N]=17.5[kgf]$

$T_m=(171.5\times20\times10^{-3}\times1)\div(2\times\pi\times0.9)+0.8$
$=1.4[N\cdot m]=14.3[kgf\cdot cm]$

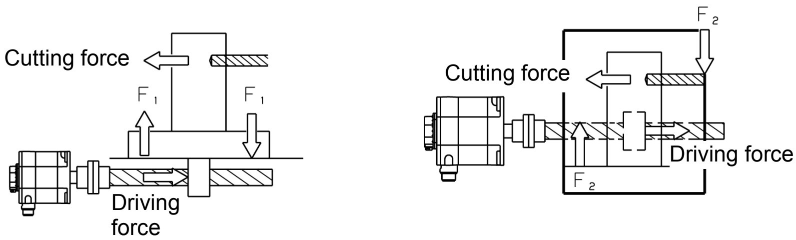
Cautions in calculating the load torque

When calculating the torque, take the following precautions:

- Allow for the friction torque caused by the gib fastening force (F_g).
  The torque calculated only from the weight of a movable part and the friction coefficient is generally quite small. The gib fastening force and precision of the sliding surface may have a great effect on the torque.

- The pre-load of the bearing or nut of the ball screw, pre-tension of the screw, and other factors may make T_c of the rolling contact considerable.
  In a small, lightweight machine tool, the friction torque will greatly affect the entire torque.

- Allow for an increase in friction on the sliding surface (F_{cf}) caused by the cutting resistance. The cutting resistance and the driving force generally do not act through a common point as illustrated below. When a large cutting resistance is applied, the moment increases the load on the sliding surface.
  When calculating the torque during cutting, allow for the friction torque caused by the load.



- The feedrate may cause the friction torque to vary greatly. Obtain an accurate value by closely examining variations in friction depending on variations in speed, the mechanism for supporting the table (sliding contact, rolling contact, static pressure, etc.), material of the sliding surface, lubricating system, and other factors.

- The friction torque of a single machine varies widely due to adjustment conditions, ambient temperature, and lubrication conditions. Collect a great amount of measurement data of identical models so that a correct load torque can be calculated. When adjusting the gib fastening force and backlash, monitor the friction torque. Avoid generating an unnecessarily great torque.

4.2.2 Calculating the Motor Speed

Calculate the motor speed using the movable part rapid traverse rate and traveling distance per revolution of the motor and check that the calculated motor speed does not exceed the maximum motor speed (rated speed for continuous operation).

$$V_m = \frac{V}{l}$$

V_m : Motor speed in rapid traverse [min^{-1}]
V : Workpiece rapid traverse rate [m/min]
l : Traveling distance per revolution of the motor [m/rev]= $P \times Z_1/Z_2$

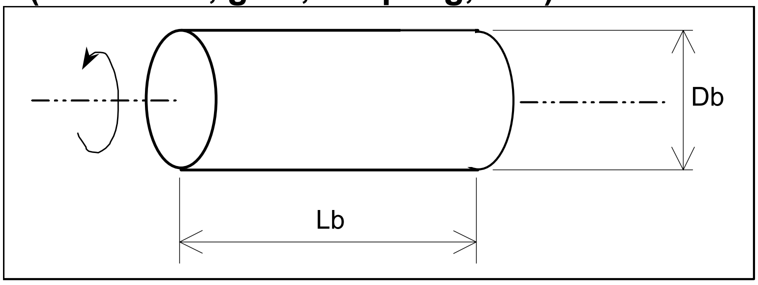
[Example of calculation for condition 2] Motor speed

When V is 60 [m/min] and l is $P \times Z_1/Z_2 = 0.020 \times 1/1 = 0.020$ [m/rev], V_m is 60/0.020 = 3000 min^{-1}.
Then, select a motor whose load torque when cutting is not executed (stall torque) is 1.4 [N·m] and whose maximum speed is at least 3000 [min^{-1}] from the data sheet. The β*i*S 8/3000 (with a stall torque of 7.0 [N·m]) is provisionally selected with considering the acceleration/deceleration condition described in the following subsection.

4.2.3 Calculating the Load Inertia

Unlike the load torque, an accurate load inertia can be obtained just by calculation.
The inertia of all objects moved by the revolution of a driving motor forms the load inertia of the motor. It does not matter whether the object is rotated or moved along a straight line. Calculate the inertia values of individual moving objects separately, then add the values together, according to a rule, to obtain the load inertia. The inertia of almost all objects can be calculated according to the following basic rules:

Inertia of a cylindrical object (ball screw, gear, coupling, etc.)



The inertia of a cylindrical object rotating about its central axis is calculated as follows:

SI units

$$Jb = \frac{\pi\gamma_b}{32} D_b^4 L_b \qquad [kg \cdot m^2]$$

J_b : Inertia [kg·m^2]
γ_b : Weight of the object per unit volume [kg/m^3]
D_b : Diameter of the object [m]
L_b : Length of the object [m]

Gravitational system of units

$$Jb = \frac{\pi\gamma_b}{32 \times 980} D_b^4 L_b \qquad [kgf \cdot cm \cdot s^2]$$

J_b : Inertia [kgf·cm·s^2]
γ_b : Weight of the object per unit volume [kg/cm^3]
D_b : Diameter of the object [cm]
L_b : Length of the object [cm]

[Example of calculation for condition 3-1] Load inertia

Example)

When the shaft of a ball screw is made of steel (γ=7.8×10^3[kg/m^3]), inertia Jb of the shaft is calculated as follows:
When D_b=0.025[m], L_b=1[m],
Jb=7.8×10^3×π÷32×0.025^4×1=0.00030[kg·m^2] (=0.0031[kgf·cm·s^2])

$$(1kg \cdot m^2 = \frac{100}{9.8} kgf \cdot cm \cdot s^2)$$

Inertia of a heavy object moving along a straight line (table, workpiece, etc.)

SI unit

$$J_b = W \times \left(\frac{l}{2\pi} \right)^2 \qquad [kg \cdot m^2]$$

W : Weight of the object moving along a straight line [kg]
l : Traveling distance along a straight line per revolution of the motor [m]

Gravitational system of units

$$J_b = \frac{W}{980} \times \left(\frac{l}{2\pi} \right)^2 \qquad [kgf \cdot cm \cdot s^2]$$

W : Weight of the object moving along a straight line [kgf]
l : Traveling distance along a straight line per revolution of the motor [cm]

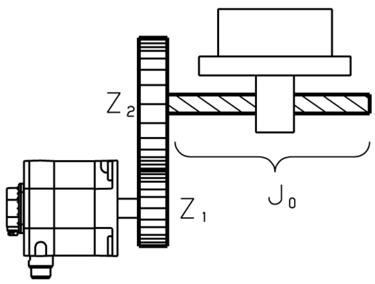
[Example of calculation for condition 3-2] Load inertia

Example)

When W is 300(kg) and l is 20(mm), J_w of a table and workpiece is calculated as follows:

$J_w=300\times(0.020\div2\div\pi)^2=0.00304$ [kg·m²] =0.0310 [kgf·cm·s²]

Inertia of an object whose speed is increased above or decreased below the speed of the motor shaft

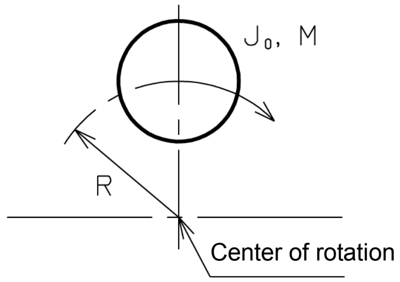


The inertia applied to the motor shaft by inertia J_0 is calculated as follows:

$$J = \left(\frac{Z_1}{Z_2} \right)^2 \times J_0 \quad or \quad \left(\frac{1}{Z} \right)^2 \times J_0$$

J_0 : Inertia before the speed is changed
Z_1,Z_2 : Number of teeth when the gear connection
1/Z : Deceleration ratio

Inertia of a cylindrical object in which the center of rotation is displaced



$$J = J_0 + MR^2$$

J_0 : Inertia around the center of the object
M : Weight of the object
R : Radius of rotation

The above equation is used to calculate the inertia of, for example, a large gear which is hollowed out in order to reduce the inertia and weight.
The sum of the inertia values calculated above is J (load inertia) for accelerating the motor.

Cautions as to the limitations on load inertia

The load inertia has a great effect on the controllability of the motor as well as the time for acceleration/deceleration in rapid traverse. When the load inertia is increased, the following two problems may occur: When a command is changed, it takes more time for the motor to reach the speed specified by the new command. When a machine tool is moved along two axes at a high speed to cut an arc or curve, a larger error occurs.
When the load inertia is smaller than or equal to the rotor inertia of the motor, those problems will not occur. When the load inertia is up to three times the rotor inertia, the controllability may have to be lowered a little. Actually, this will not adversely affect the operation of an ordinary metal cutting machine. If a router for woodworking or a machine to cut a curve at a high speed is used, it is recommended that the load inertia be smaller than or equal to the rotor inertia.
When the load inertia is greater than the rotor inertia by a factor of more than 3 to 5, the controllability of the motor will be adversely affected.
If the load inertia much larger than three times the rotor inertia, an adjustment in the normal range may be insufficient. Avoid using a machine with such a great load inertia.

[Example of calculation for condition 3-3] Load inertial ratio

The sum of J_b and J_w calculated in examples of calculation 3-1 and 2 is load inertia J_L, so the load inertia can be calculated as follows:

$J_L = 0.00030 + 0.00304 = 0.00334$ [kg·m^2]

The motor inertial of the β*i*S 8/3000 is 0.00117 [kg·m^2] and the load inertia ratio is 2.85 times the motor inertia. This value is within the allowable range.

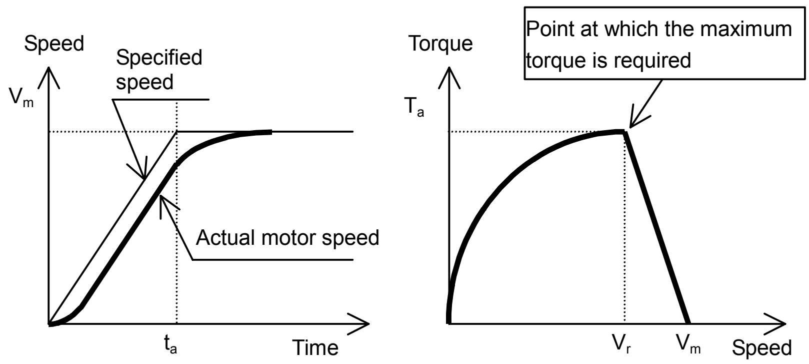
4.2.4 Calculating the Acceleration Torque

Calculate the acceleration torque required for the motor to accelerate and then obtain the torque required for acceleration by calculating the total torque including the steady-state load torque calculated before. Next, confirm the result is included in the intermittent operation area for the motor.

4.2.4.1 Calculating acceleration torque

Assuming that the motor shaft operates ideally in the acceleration/ deceleration mode determined by the NC, calculate the angular acceleration. Multiply the angular acceleration by the entire inertia (motor inertia + load inertia). The product is the acceleration torque.
In rapid traverse, there are linear acceleration/deceleration and feed-forward during rapid traverse + bell-shaped acceleration/ deceleration. The equations for calculating the acceleration torque in each mode are given below.

Acceleration torque in linear acceleration/deceleration



When the torque is T_a and the speed is V_r in the above figure, the maximum torque is required. The equations for calculating T_a and V_r are given below:

$$T_a = V_m \times \frac{2\pi}{60} \times \frac{1}{t_a} \times (J_M + J_L / \eta) \times (1 - e^{-k_s \cdot t_a})$$

$$V_r = V_m \times \{1 - \frac{1}{t_a \cdot k_s}(1 - e^{-k_s \cdot t_a})\}$$

- T_a : Acceleration torque [N·m]
- V_m : Motor speed in rapid traverse [min^{-1}]
- t_a : Acceleration time [sec]
- J_M : Motor inertia [$kg \cdot m^2$]
- J_L : Load inertia [$kg \cdot m^2$]
- V_r : Motor speed at which the acceleration torque starts to decrease [min^{-1}]
- k_s : Position loop gain [sec^{-1}]
- η : Machine tool efficiency
- e : base of a natural logarithm ($\fallingdotseq$ 2.71)

[Example of calculation for condition 4-1] Example of calculation

Try to perform linear acceleration/deceleration under the following condition.

V_m=3000 [min^{-1}]
t_a=0.1 [s]
k_s=30 [s^{-1}]
J_L=0.00334 [kg·m^2]

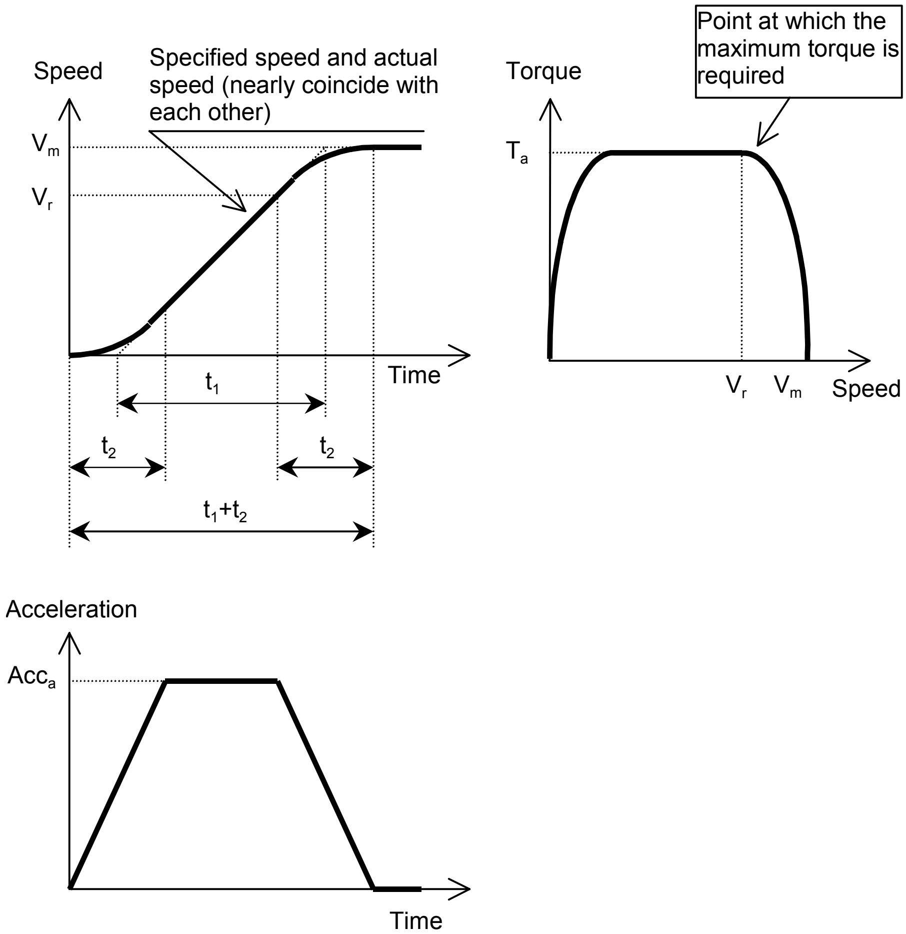
Select the β*i*S 8/3000 provisionally selected in example of calculation <1>.

J_M motor inertia is 0.00117 [kg·m^2] when β*i*S 8/3000 is selected, so the load inertia is calculated as follows:

$T_a = 3000\times(2\pi/60)\times(1/0.1)\times(0.00117+0.00334\div0.9)\times(1-e^{-30\times0.1})$
$=14.6[N\cdot m]=149[kgf\cdot cm]$

$V_r = 3000\times\{1-1/(0.1\times30)\times(1-e^{-30\times0.1})\}=2050[min^{-1}]$

Acceleration torque in feed-forward during rapid traverse + bell-shaped acceleration/deceleration



When the feed-forward coefficient is large enough, the acceleration torque in feed-forward during rapid traverse + bell-shaped acceleration/deceleration can approximate to the value obtained with the feed-forward coefficient = 1. When the feed-forward coefficient is 1, the equations for calculating the acceleration torque (T_a), speed (V_r), and maximum workpiece acceleration (Acc_a) are given below:

$$T_a = V_m \times \frac{2\pi}{60} \times \frac{1}{t_1} \times (J_M + J_L/\eta)$$

$$V_r = V_m \times (1 - \frac{t_2}{2t_1})$$

$$Acc_a = V_m \times \frac{1}{60} \times \frac{1}{t_1} \times P$$

T_a : Acceleration torque [N·m]
V_m : Motor speed in rapid traverse [min^{-1}]
t_1 : Acceleration time constant T1 [sec]
t_2 : Acceleration time constant T2 [sec]
J_M : Motor inertia [$kg{\cdot}m^2$]
J_L : Load inertia [$kg{\cdot}m^2$]
η : Machine tool efficiency
V_r : Motor speed at which the acceleration torque starts to decrease [min^{-1}]
Acc_a : Maximum workpiece acceleration [m/sec^{-2}]=[G]
P : Pitch [m/rev]

(Reference)

Minimizing t_1 and increasing t_2 by the same amount allows the maximum workpiece acceleration (Acc_a) to be increased and the motor speed at which the acceleration torque starts to decrease (V_r) to be decreased. This allows the efficient use of the motor acceleration torque.

If t_2 is too large, the positioning completion time (t_1 + t_2) tends to increase.

Consequently, achieving a balance between t_1 and t_2 is effective in obtaining required specifications of the machine.

4.2.4.2 Calculating the torque required by the motor shaft in acceleration

To obtain the torque required by the motor shaft (T), add the steady-state load torque (T_m) to the acceleration torque (T_a). (Cutting torque T_{cf} is assumed not to be applied.)

$$T = T_a + T_m$$

T	:	Torque required by the motor axis
T_a	:	Acceleration torque
T_m	:	Steady-state load torque

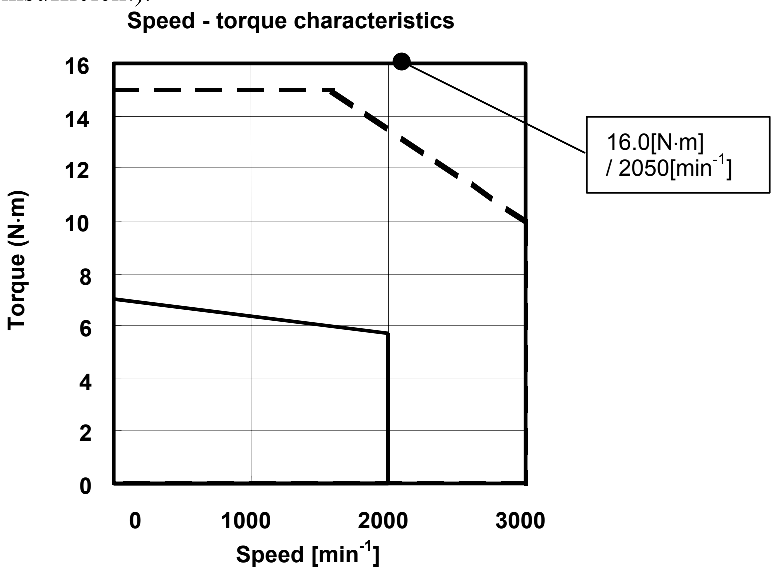
[Example of calculation for condition 4-2] Acceleration torque

When T_m is 1.4 [N·m] as calculated in example of calculation 1 and T_a is 14.6 [N·m] as calculated in example of calculation 4-1, the acceleration torque (T) is calculated as follows:

T = 14.6[N·m] + 1.4[N·m] = 16.0[N·m]

The speed when the maximum torque is required (V_r) is 2050 [min^{-1}].

The speed-torque characteristics of the β*i*S 8/3000, given below, show that the point of 16.0 [N·m]/2050 [min^{-1}] is beyond the intermittent operating zone of the β*i*S 8/3000 (the torque is insufficient).



Speed - torque characteristics for β*i*S 8/3000

If it is impossible to change the operation specifications of the shaft (such as to increase the acceleration time), a larger motor must be selected.

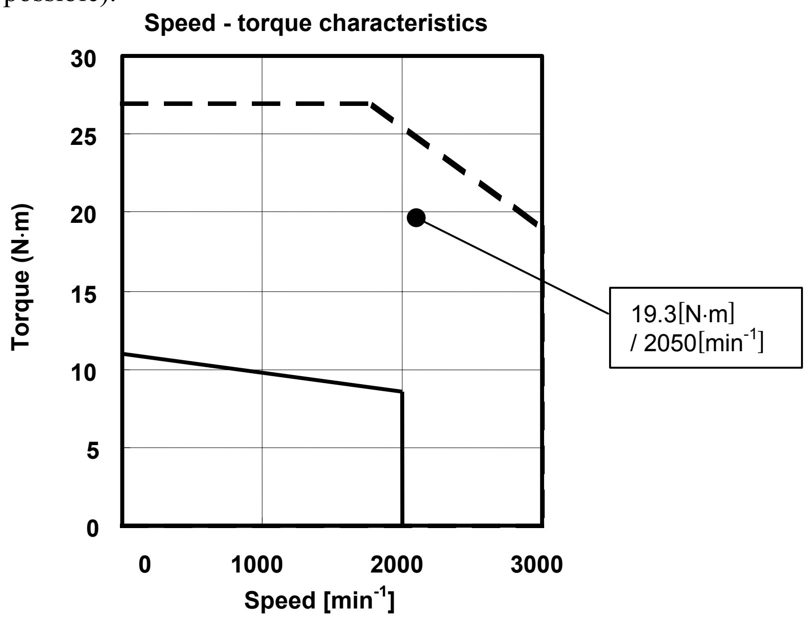
Select the β*i*S 12/3000 (motor inertia (J_M) = 0.00228 [kg·m^2], 1.5 times load inertia ratio) and calculate the acceleration torque again.

T_a=17.9[N·m]=182.5[kgf·cm]

V_r=2050[min^{-1}]

T=17.9[N·m]+1.4[N·m] = 19.3[N·m]

The speed-torque characteristics of the β*i*S 12/3000, given below, show that the point of 19.3 [N·m]/2050 [min^{-1}] is within the intermittent operating zone of the β*i*S 12/3000 (acceleration is possible).



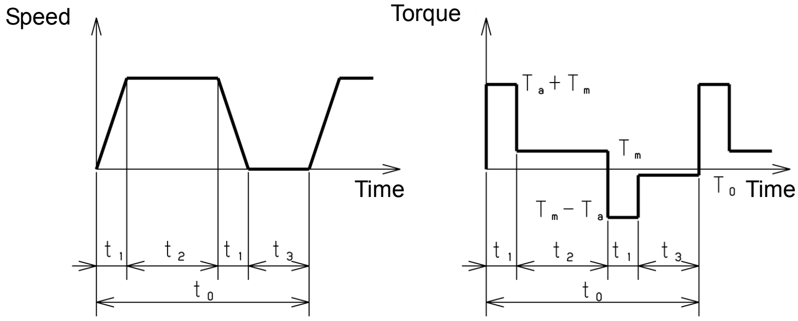
Speed - torque characteristics for β*i*S 12/3000

4.2.5 Calculating the Root-mean-square Value of the Torques

A motor gets hot in proportion to the square of the torque. For a servo motor for which the load condition always changes, the calculated root-mean-square value of torque in a cycle must be sufficiently greater than the stall torque.

Root-mean-square value of torque in acceleration/deceleration in rapid traverse

First, generate an operation cycle which performs acceleration/ deceleration in rapid traverse with a desired frequency of positioning in rapid traverse. Write the time-speed graph and time-torque graph as shown below.



From the time-torque graph, obtain the root-mean-square value of torques applied to the motor during the single operation cycle. Check whether the value is smaller than or equal to the torque at stall.

$$T_{rms} = \sqrt{\frac{(T_a + T_m)^2 t_1 + T_m{}^2 t_2 + (T_a - T_m)^2 t_1 + T_0{}^2 t_3}{t_0}}$$

T_a : Acceleration torque
T_m : Friction torque
T_o : Torque when stopped

When T_{rms} falls within 90% of the stall torque T_s, the servo motor can be used. (The entire thermal efficiency and other margins must be considered.)

NOTE

The motor actually rotates, but the determination must be based on the stall torque.
When the motor is being operated at high speed for a comparatively large proportion of the time, you must take the rotating speed of the motor into consideration and evaluate whether output can be specified in terms of a continuous operation torque.

[Example of calculation for condition 5]
Root-mean-square value of the torques

βis 12/3000 (T_s = 1.4[N·m] = 14.3[kgf·cm]), T_a = 17.9[N·m], T_m = T_o = 1.4[N·m], t_1 = 0.1[sec], t_2 = 2.0[sec], t_3 = 3.0[sec]

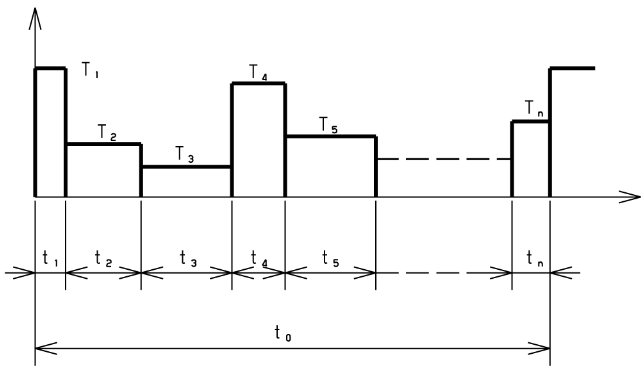
$$T_{rms} = \sqrt{\frac{(17.9 + 1.4)^2 \times 0.1 + 1.4^2 \times 2.0 + (17.9 - 1.4)^2 \times 0.1 + 1.4^2 \times 3.0}{0.1 \times 2 + 2.0 + 3.0}}$$

= 3.8[N·m] = 38.8[kgf·m] < T_s × 0.9 = 11 × 0.9 = 9.9[N·m]
= 101.0[kgf·cm]

The βis 12/3000 can be used for operation.

Root-mean-square value of torque in a cycle in which the load varies

If the load conditions (cutting load, acceleration/deceleration conditions, etc.) vary widely in a single cycle, write a time-torque graph according to the operation cycle, as in above item. Obtain the root-mean-square value of the torques and check that the value is smaller than or equal to the torque at stall.



$$T_{rms} = \sqrt{\frac{T_1{}^2 t_1 + T_2{}^2 t_2 + T_3{}^2 t_3 + \ldots + T_n{}^2 t_n}{t_0}}$$

$t_0 = t_1 + t_2 + t_3 + \ldots + t_n$

NOTE
The motor actually rotates, but the determination must be based on the stall torque.
When the motor is being operated at high speed for a comparatively large proportion of the time, you must take the rotating speed of the motor into consideration and evaluate whether output can be specified in terms of a continuous operation torque.

4.2.6 Calculating the Percentage Duty Cycle and ON Time with the Maximum Cutting Torque

Confirm that the time (duty percentage and ON time) during which the maximum cutting torque can be applied for cutting is shorter than the desired cutting time.
First, calculate the load torque applied when the cutting thrust (F_c) is applied to the motor shaft (T_{ms}). When this load torque is smaller than the product of the motor stall torque (T_s) and thermal efficiency (α), the motor can be used in continuous cutting. If the value is greater than the product, follow the procedure below to calculate the ON time during which the maximum cutting load torque (T_{ms}) can be applied to the motor (t_{ON}) and the percentage ratio (percentage duty cycle with the maximum cutting torque) of the ON time to the total time of a single cutting cycle (t).
α is assumed to be 0.9. Calculate the percentage considering the specifications of the machine.

Determining whether continuous operation can be performed with the maximum cutting torque

Calculate the percentage duty cycle, according to the following figure and expressions.

$T_{ms}<T_s\times\alpha$
Operation can be continued with the maximum cutting torque. (The percentage duty cycle with the maximum cutting torque is 100%.)

$T_{ms}>T_s\times\alpha$
Calculate the percentage duty cycle, according to the following figure and expressions.

[Example of calculation for condition 6-1]
Percentage duty cycle and ON time with the maximum cutting torque

The load torque in cutting is calculated as follows:

$F=F_c+\mu(W+F_g+F_{cf})$

$F=980+0.05\times(2940+490+294)=1166[N]=119[kgf]$

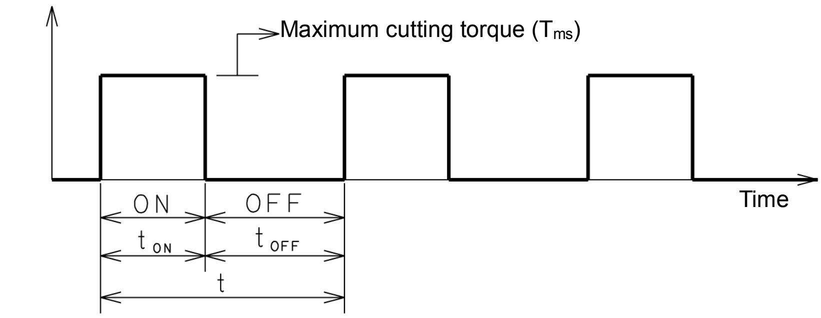
$T_m=(1166\times20\times10^{-3}\times1)\div(2\times\pi\times0.9)+0.8=4.9[N\cdot m]=50[kgf\cdot cm]$

The stall torque of the βiS 12/3000(T_s) is 11[N·m] = 112.2 [kgf·cm].

$T_s\times\alpha= 11\times0.9 = 9.9[N\cdot m]=101.0[kgf\cdot cm] > T_{ms} = 4.9[N\cdot m] = 50[kgf\cdot cm]$

No problems will occur in continuous cutting.

Calculating the percentage duty cycle with the maximum cutting torque



If the load torque (T_{ms}) is greater than the product of the motor stall torque (T_s) and thermal efficiency (α), calculate the root-mean-square value of torque applied in a single cutting cycle. Specify t_{ON} and t_{OFF} so that the value does not exceed the product of the motor stall torque (T_s) and thermal efficiency (α). Then, calculate the percentage duty cycle with the maximum cutting torque as shown below.

Percentage duty cycle with the maximum cutting torque (T_{ms})

$$= \frac{t_{on}}{t_{on} + t_{off}} \times 100[\%]$$

[Example of calculation for condition 6-2]
Percentage duty cycle and ON time with the maximum cutting force

Example)

Assume that Tms is 15[N·m] (Tm is 1.4 [N·m]).

$$\sqrt{\frac{15^2 t_{on} + 1.4^2 t_{off}}{t_{on} + t_{off}}} < 9.9[\text{N·m}]$$ (90% of the rated torque of the β*i*S 12/3000)

Therefore,

$$\frac{t_{on}}{t_{off}} < 0.76$$

The above ratio of the non-cutting time to the cutting time is required. The percentage duty cycle is calculated as follows:

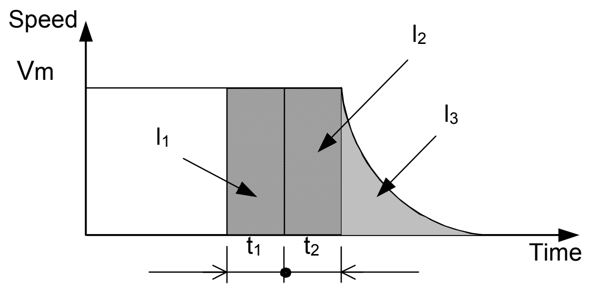
$$\frac{t_{on}}{t_{on} + t_{off}} \times 100 = 43.0\%$$

Limitations on ON time

The period during which continuous operation under an overload is allowed is also restricted by the OVC alarm level and overload duty cycle characteristics. Refer to Subsection 4.4.1, “Performance Curves” for details

4.2.7 Calculating the Dynamic Brake Stop Distance

The equation for calculating the coasting distance when an abnormality occurs and the machine tool is stopped by dynamic braking with both ends of the motor power line shorted (dynamic brake stop distance) is given below:



Vm : Rapid traverse rate, [mm/sec] or [deg /sec]
l_1 : Coasting distance due to delay time t_1 of receiver
l_2 : Coasting distance due to deceleration time t_2 of magnetic contactor
l_3 : Coasting distance by dynamic braking after magnetic contactor has been operated
(t_1+t_2) is usually about 0.05 [sec].

Coasting distance due $= V_m \times (t_2 + t_2) + (J_M + J_L) \times (A \times No + B \times No^3) \times L$ $[mm]\, or\, [\deg]$

- J_M : Motor inertia [kg·m^2] [kgf·cm·s^2]
- J_L : Load inertia [kg·m^2] [kgf·cm·s^2]
- N_O : Motor speed at rapid traverse [min^{-1}]
- L : Machine movement on one-rotation of motor [mm/rev] or [deg/rev] (N_O/60×L=V_m)
- A : Coefficient A for calculating the dynamic brake stop distance
- B : Coefficient B for calculating the dynamic brake stop distance

For details of A and B, see the table on the following page.
For J_M, see the data sheet of each motor in the Chapter 6, "SPECIFICATIONS."

There are two ways of shortening this dynamic brake stop distance: Emergency stop distance shortening function, and emergency stop distance shortening function effective also during power interruptions (additional hardware is required).

[Example of calculation for condition 7] Dynamic brake stop distance

Assume that the desired stop distance is 100 [mm].

Coasting distance =

$(3000/60\times20)[mm/sec]\times0.05[sec]+(0.00228[kg\cdot m^2]+$
$0.00334[kg\cdot m^2])\times(4.0\times10^{-2}\times3000[min^{-1}]+3.1\times10^{-9}\times3000^3[min^{-1}])$
$\times20[mm/rev]$
$=73[mm]$

It has been shown that the machine tool can be stopped within the desired stop distance.

Finally, the β*i*S 12/3000 which satisfies selection conditions 1 to 7 is selected.

Coefficients for dynamic brake calculation

(200-V system) when the servo amplifier αiSV or βiSV series is used

Model	SI units		Gravitational system of units	
	A	B	A	B
βiS 0.2/5000	8.3	5.8×10^{-7}	8.1×10^{-1}	5.7×10^{-8}
βiS 0.3/5000	3.4	4.6×10^{-7}	3.4×10^{-1}	4.5×10^{-8}
βiS 0.4/5000	2.3	4.6×10^{-7}	2.3×10^{-1}	4.5×10^{-8}
βiS 0.5/6000	9.0×10^{-1}	2.1×10^{-7}	8.8×10^{-2}	2.0×10^{-8}
βiS 1/6000	3.8×10^{-1}	8.8×10^{-8}	3.7×10^{-2}	8.7×10^{-9}
βiS 2/4000	2.1×10^{-1}	8.1×10^{-8}	2.1×10^{-2}	7.9×10^{-9}
βiS 4/4000	8.7×10^{-2}	4.1×10^{-8}	8.5×10^{-3}	4.0×10^{-9}
βiS 8/3000	3.9×10^{-2}	5.3×10^{-8}	3.8×10^{-3}	5.2×10^{-9}
βiS 12/2000	1.7×10^{-2}	2.7×10^{-8}	1.7×10^{-3}	2.6×10^{-9}
βiS 12/3000	1.0×10^{-1}	4.5×10^{-9}	1.0×10^{-2}	4.4×10^{-10}
βiS 22/1500	7.2×10^{-3}	3.0×10^{-8}	7.0×10^{-4}	3.0×10^{-9}
βiS 22/2000	4.0×10^{-2}	7.0×10^{-9}	3.9×10^{-3}	6.8×10^{-10}

The values of A and B are calculated by assuming that the resistance of the power line is 0.05Ω per phase. The values will vary slightly according to the resistance value of the power line.
The coefficient above values are applicable when the servo amplifier αiSV or βiSV series is being used. The coefficient may change, depending on the type of the servo amplifier.

(200-V system) when the servo amplifier βiSVSP series is used

Model	SI units		Gravitational system of units	
	A	B	A	B
βiS 12/3000	1.9×10^{-2}	2.5×10^{-8}	1.9×10^{-3}	2.4×10^{-9}
βiS 22/2000	7.8×10^{-3}	3.5×10^{-8}	7.6×10^{-4}	3.5×10^{-9}

(*) For the βiS 2/4000, the βiS 4/4000, the βiS 8/3000, the βiS 12/2000, and the βiS 22/1500, the same values as coefficients A and B assumed when the servo amplifier αiSV or βiSV series is used.

The values of A and B are calculated by assuming that the resistance of the power line is 0.05Ω per phase. The values will vary slightly according to the resistance value of the power line.
The coefficient above values are applicable when the servo amplifier βiSVSP series is being used. The coefficient may change, depending on the type of the servo amplifier.

(400-V system) when using the servo amplifier αiSV or βiSV series

Model	SI unit		Gravitational system of units	
	A	B	A	B
βiS 2/4000HV	4.2×10^{-1}	4.2×10^{-8}	4.1×10^{-2}	4.1×10^{-9}
βiS 4/4000HV	2.2×10^{-1}	1.6×10^{-8}	2.2×10^{-2}	1.6×10^{-9}
βiS 8/3000HV	9.3×10^{-2}	2.2×10^{-8}	9.1×10^{-3}	2.2×10^{-9}
βiS 12/3000HV	8.1×10^{-2}	5.8×10^{-9}	8.0×10^{-3}	5.7×10^{-10}
βiS 22/2000HV	3.1×10^{-2}	9.8×10^{-9}	3.0×10^{-3}	9.6×10^{-10}

The values of A and B are calculated by assuming that the resistance of the power line is 0.05Ω per phase. The values will vary slightly according to the resistance value of the power line.
The coefficient above values are applicable when the servo amplifier αiSV or βiSV series is being used. The coefficient may change, depending on the type of the servo amplifier.

If wishing to use amplifiers other than the above, contact FANUC.

4.3 HOW TO FILL IN THE SERVO MOTOR SELECTION DATA TABLE

Select a suitable motor according to load conditions, rapid traverse rate, increment system and other factors. To aid in selecting the correct motor, we recommend filling in the "Servo Motor Selection Data Table" on the following page.
This section describes the items to fill in the Servo Motor Selection Data Table.

4.3.1 Servo Motor Selection Data Table

The Servo Motor Selection Data Table for the SI system of units and that for the gravitational system of units are given on the following pages.

Servo Motor Selection Data Table

SI units

User name		Kind of machine tool	
CNC equipment		Type of machine tool	
Spindle motor			

Item		Axis				
Specifications of moving object						
* Weight of moving object (including workpiece, etc.)		kg				
* Axis movement direction (horizontal, vertical, rotation, slant)						
* Angle of the slant		deg				
* Counterbalance (forth)		N				
* Table support (sliding, rolling, static pressure)						
* Ball screw	Diameter	mm				
	Pitch	mm				
	Length	mm				
* Rack and pinion	Diameter of pinion	mm				
	Thickness of pinion	mm				
* Friction coefficient						
Machine tool efficiency						
* Total gear ratio						
Mechanical specifications						
Traveling distance of the machine tool per revolution of the motor		mm/rev				
Least input increment of NC		mm				
* Rapid traverse feedrate		mm/min				
Motor speed in rapid traverse		1/min				
* Total load inertia applied to the motor shaft (*1)		$kg{\cdot}m^2$				
Inertia of coupling, reduction gear and pulley		$kg{\cdot}m^2$				
* Steady-state load torque (*2)		N·m				
* Cutting thrust		N				
Maximum cutting torque		N·m				
Required percentage duty cycle/ON time with the maximum cutting torque		%				
Positioning distance		mm				
Required positioning time (*3)		sec				
In-position set value		mm				
Rapid traverse positioning frequency (continuous, intermittent)		times/min				
Dynamic brake stop distance		mm				
Motor specifications and characteristics						
Motor type						
Pulsecoder						
Shaft shape						
Brake (Yes/No)						
Feed-forward during rapid traverse (Yes/No)						
Acceleration/deceleration time constant in rapid traverse	T_1	msec				
	T_2	msec				
Position loop gain		1/sec				

CAUTION
Be sure to fill in units other than the above if used. (Sometimes "deg" is used instead of "mm" for the rotary axis.)
* Note required values for selecting the motor.
*1 If possible enter the total load inertia. If you enter the inertia of coupling, reduction gear and pulley (motor shaft conversion) in the next item, you can also calculate the total load inertia by adding the weight of the moving object and ball screw values by logical calculation in the case of a linear shaft.
*2 Steady-state load torque refers to the steady-state components such as friction (holding torque is included in the case of a gravity shaft) when the motor is rotating at a fixed speed. Enter the state-state load torque as far as possible. If details are unknown, use a value calculated logically from the weight and friction coefficient. Enter the steady-state load torque of the rotary axis in the same way as for load inertia as it cannot be calculated logically. You need not enter the torque required for acceleration/deceleration.
*3 Servo delay and setting times must also be taken into consideration in the positioning time.

(**) Comments

Servo Motor Selection Data Table

Gravitational system of units

User name		Kind of machine tool	
CNC equipment		Type of machine tool	
Spindle motor			

Item			Axis				
Specifications of moving object							
* Weight of moving object (including workpiece, etc.)			kgf				
* Axis movement direction (horizontal, vertical, rotation, slant)							
* Angle of the slant			deg				
* Counterbalance (forth)			kgf				
* Table support (sliding, rolling, static pressure)							
* Ball screw	Diameter		mm				
	Pitch		mm				
	Length		mm				
* Rack and pinion	Diameter of pinion		mm				
	Thickness of pinion		mm				
* Friction coefficient							
Machine tool efficiency							
* Total gear ratio							
Mechanical specifications							
Traveling distance of the machine tool per revolution of the motor			mm/rev				
Least input increment of NC			mm				
* Rapid traverse feedrate			mm/min				
Motor speed in rapid traverse			1/min				
* Total load inertia applied to the motor shaft (*1)			$kgf{\cdot}cm{\cdot}s^2$				
Inertia of coupling, reduction gear and pulley			$kgf{\cdot}cm{\cdot}s^2$				
* Steady-state load torque (*2)			kgf·cm				
* Cutting thrust			kgf				
Maximum cutting torque			kgf·cm				
Required percentage duty cycle/ON time with the maximum cutting torque			%				
Positioning distance			mm				
Required positioning time (*3)			sec				
In-position set value			mm				
Rapid traverse positioning frequency (continuous, intermittent)			times/min				
Dynamic brake stop distance			mm				
Motor specifications and characteristics							
Motor type							
Pulsecoder							
Shaft shape							
Brake (Yes/No)							
Feed-forward during rapid traverse (Yes/No)							
Acceleration/deceleration time constant in rapid traverse		T_1	msec				
		T_2	msec				
Position loop gain			1/sec				

CAUTION
Be sure to fill in units other than the above if used. (Sometimes "deg" is used instead of "mm" for the rotary axis.)
- * Note required values for selecting the motor.
- *1 If possible enter the total load inertia. If you enter the inertia of coupling, reduction gear and pulley (motor shaft conversion) in the next item, you can also calculate the total load inertia by adding the weight of the moving object and ball screw values by logical calculation in the case of a linear shaft.
- *2 Steady-state load torque refers to the steady-state components such as friction (holding torque is included in the case of a gravity shaft) when the motor is rotating at a fixed speed. Enter the state-state load torque as far as possible. If details are unknown, use a value calculated logically from the weight and friction coefficient. Enter the steady-state load torque of the rotary axis in the same way as for load inertia as it cannot be calculated logically. You need not enter the torque required for acceleration/deceleration.
- *3 Servo delay and setting times must also be taken into consideration in the positioning time.

(**) Comments

4.3.2 Explanation of Items

4.3.2.1 Title

User name

Fill in this blank with the name of the user.

Kind of machine tool

Fill in this blank with a general name of machine tools, such as lathe, milling machine, machining center, and others.

Type of machine tool

Fill in this blank with the type of machine tool decided by machine tool builder.

CNC equipment

Fill in this blank with the name of CNC (16*i*-MB, 21*i*-TB, PM*i*-D, etc.) employed.

Spindle motor

Enter the specifications and output of the spindle motor. (This item is needed when selecting PS.)

Axis

Fill in this blank with names of axes practically employed in CNC command.
If the number of axes exceeds 4 axes, enter them in the second sheet.

4.3.2.2 Specifications of moving object

Be sure to enter data in this row. Data entered here is needed for determining the approximate motor load conditions (inertia, load torque).

- Mass(weight) of driven parts

Enter the mass(weight) of driven parts, such as table, tool post, etc. by the maximum value including the weight of workpiece, jig, and so on. Do not include the weight of the counter balance in the next item in this item.

- Axis movement direction

Enter horizontal, vertical, slant, or rotation as the movement directions of driven parts such as the table and tool post.
Be sure to enter data because the axis movement direction is required for calculating the steady-state load torque and regenerative energy.

- Angle of the slant

Enter the angle which the movement direction forms with a horizontal surface only when the movement direction slants upward.
Be sure to enter data because the axis movement direction is required for calculating the steady-state load torque and regenerative energy.

- Counter balance

Enter the weight of the counter balance in the vertical axis, if provided.
Enter whether the counter balance is made by a weight or force as this influences inertia.

- Table support

Enter the type of table slide (e.g. rolling, sliding or static pressure).
Enter a special slide way material like Turcite, if used. Also enter the friction coefficient value. This item is significant in estimating the friction coefficient for calculating mainly the load torque.

- Ball screw

For a ball screw, enter the diameter, pitch, and length in order.
If a rack and pinion or other mechanism is used, also enter the traveling distance of the machine tool per revolution of the pinion.

- Rack and pinion

For a rack and pinion, enter the diameter and thickness of the pinion.

- Friction coefficient

Enter the friction coefficient of the table.

- Machine tool efficiency

This value is used for calculating the transfer efficiency of motor output on a machine tool. Standard value is 0.9.
Generally, a drop in transfer efficiency is expected if a reduction gear having a large deceleration rate is used.

- Total gear ratio

Enter the gear ratio between the ball screw and the servo motor, gear ratio between the final stage pinion and the servo motor in case of the rack pinion drive, or gear ratio between the table and the motor in case of rotary table.

4.3.2.3 Mechanical specifications

Enter basic data that is required for selecting the motor.
For details on how to calculate each of the items, see Section 4.2, "SELECTING A MOTOR."

- Movement per rotation of motor

Enter the movement of the machine tool when the motor rotates one turn.

Example

- When the pitch of ball screw is 12 [mm] and the gear ratio is 2/3,
  12 [mm] × 2/3 = 8 [mm]
- When the gear ratio is 1/72 in rotary table ;
  360 [deg.] × 1/72 = 5 [deg.]

- Least input increment CNC

Enter the least input increment of NC command. (The standard value is 0.001 [mm].)

- Rapid traverse rate

Enter the rapid traverse rate required for machine tool specifications.

- Motor speed in rapid traverse

Enter the motor speed during rapid traverse.

- Motor shaft converted load inertia

Enter a load inertia applied by the moving object reflected on the motor shaft.
Do not include the inertia of the motor proper in this value. For details on this calculation, see Subsection 4.2.3, "Calculating the Load Inertia."
In the case of a linear shaft, enter the load inertia calculated by logical calculation if you enter the next item. In the case of a rotary shaft, however, the load inertia cannot be calculated by logical calculation.
Enter values to two digits past the decimal point. (e.g. 0.2865 → 0.29)

- Inertia of coupling, reduction gear and pulley

Enter load inertia applied on transfer mechanisms other than couplings, moving objects and ball screw.
Enter values to two digits past the decimal point. (e.g. 0.2865 → 0.29)

- Steady-state load torque

Enter the torque obtained by calculating the force applied for moving the machine tool and state-state components such as friction (including holding torque in the case of a gravity shaft) reflected on the motor shaft when it is rotating at a fixed speed. (Do not include any torque required for acceleration/deceleration in this item.) If details are unknown, use a value calculated logically from the weight and friction coefficient. Enter the steady-state load torque of the rotary axis in the same way as for load inertia as it cannot be calculated logically.
If the load torque values differ during lifting and lowering in the vertical axis, enter both values. Also, if the load torque values differ during rapid traverse and cutting feed, enter a notice to that effect.
Since torque produced in low speed without cutting may be applied even when the motor has stopped, a sufficient allowance is necessary as compared with the continued rated torque of the motor. Suppress this load torque so that it is lower than 70% of the rated torque.

- Cutting thrust

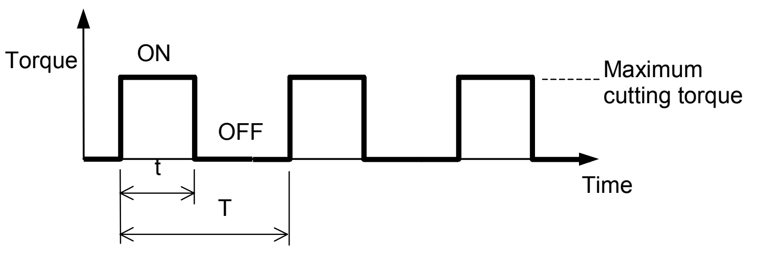
Enter the maximum value of the force applied during cutting by the force in the feed axis direction.

- Maximum cutting torque

Enter the torque value on the motor shaft corresponding to the maximum value of the above cutting thrust. When you enter this value, add the steady-state load to the motor shaft converted value for the cutting thrust.
Since the torque transfer efficiency may substantially deteriorate to a large extent due to the reaction from the slideway, etc. produced by the cutting thrust, obtain an accurate value by taking measured values in similar machine tools and other data into account.

- Maximum cutting duty / ON time

Enter the duty time and ON time with the maximum cutting torque in the above item applied.



ON : Time that the maximum cutting torque is applied
OFF : Time when cutting torque is not applied
Duty : (t/T) × 100 [%]
ON time = t [min]

- Positioning distance

Enter the distance as a condition required for calculating the rapid traverse positioning frequency.
When an exclusive positioning device is used, enter this value together with the desired positioning time below.

- Required positioning time

Enter the required positioning time when an exclusive positioning device is used.
When the device is actually attached on the machine tool, note that servo delay and setting times must also be taken into consideration in the positioning time.

- In-position set value

Enter the in-position set value as a condition required for calculating the above positioning times when an exclusive positioning device is used.
Note that the positioning time changes according to this value.

- Rapid traverse positioning frequency

Enter the rapid traverse positioning frequency by the number of times per minute.
Enter whether the value is for continuous positioning over a long period of time or for intermittent positioning within a fixed period of time. (This value is used to check the OVC alarm and whether the motor is overheated or not by a flowing current during acceleration/deceleration, or to check the regenerative capacity of the amplifier.)

4.3.2.4 Motor specifications and characteristics

- Motor type

Enter the motor type, if desired.

- Pulsecoder

Enter the specifications (absolute or increment, number of pulses: 65,536 or 131,072) of the feedback sensor (Pulsecoder) built into the motor.

- Shaft shape

Enter the shape of the motor shaft.

- Brake (Yes/No)

Enter whether or not the motor has a brake.

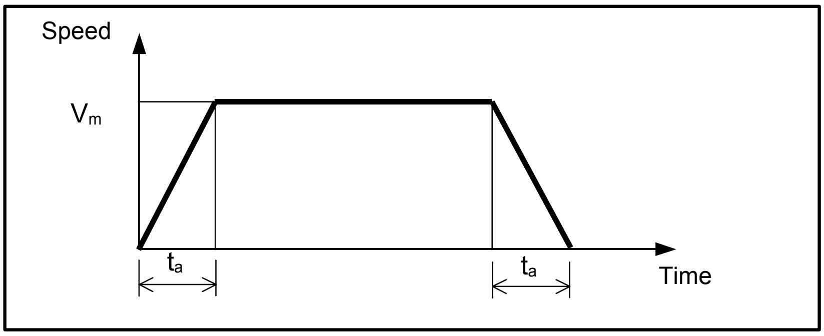
- Feed-forward during rapid traverse

Enter whether or not feed-forward control during rapid traverse is used.
Generally, feed-forward control can reduce the delay time in executing servo commands. However, overheating of the motor is more likely to occur as a higher torque is required for acceleration/deceleration.
Since mechanical shock increases in linear acceleration/deceleration, the bell-shaped acceleration/deceleration or fine acceleration/deceleration (FAD) function is generally used together with feed-forward control.

- Acceleration/deceleration time constant at rapid traverse

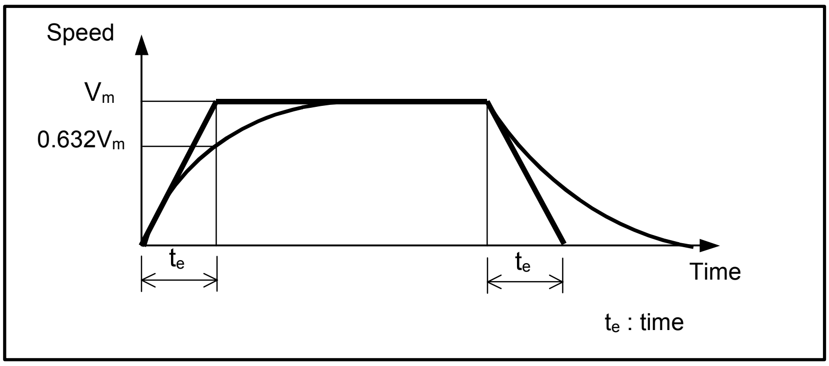
Enter the acceleration/deceleration time constant in rapid traverse.
The acceleration/deceleration time is determined according to the load inertia, load torque, motor output torque, and working speed.
The acceleration/deceleration mode in rapid traverse is linear acceleration/deceleration or feed-forward during rapid traverse + bell-shaped acceleration/deceleration. Enter T_1 only for linear acceleration/deceleration or T_1 and T_2 for feed-forward during rapid traverse + bell-shaped acceleration/deceleration.

Linear acceleration/deceleration



When cutting feed is important, enter the time constant in cutting feed. The acceleration/deceleration mode in cutting feed is linear acceleration/deceleration, exponential acceleration/deceleration, or bell-shaped acceleration/deceleration. Enter t_e only for the time constant in cutting feed.

Exponential acceleration/deceleration



- Position loop gain

Fill in this blank with a value which is considered to be settable judging it from the inertia value based on experiences.
Since this value is not always applicable due to rigidity, damping constant, and other factors of the machine tool, it is usually determined on the actual machine tool. If the position sensor is mounted outside the motor, this value is affected by the machine tool rigidity, backlash amount, and friction torque value. Enter these values without fail.

- Dynamic brake stop distance

Enter the coasting distance when an abnormality occurs and the machine tool is stopped by dynamic braking with both ends of the motor power line shorted.

4.4 CHARACTERISTIC CURVE AND DATA SHEET

The performance of each motor is described by the characteristic curves and data sheet given below.

4.4.1 Characteristic Curves

The characteristic curves representing the "speed-torque characteristics" and "overload duty characteristic" are given for each motor model.

Speed-torque characteristics

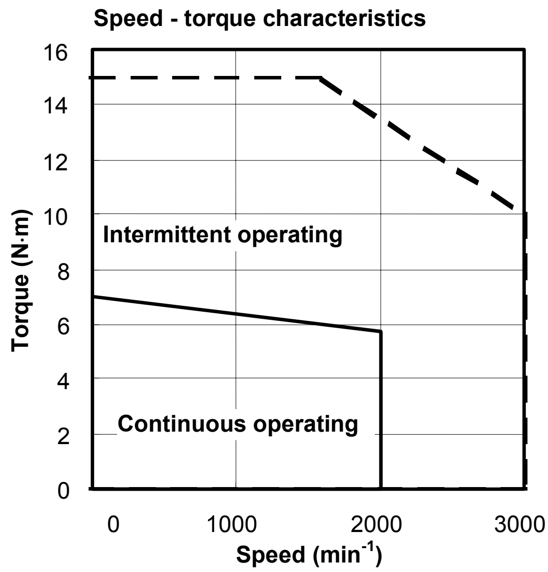
Speed-torque characteristics indicate the relationship between the output torque and speed of the motor.
In the continuous operating zone, the motor winding temperature and pulsecoder temperature are protected from exceeding the following overheat temperatures when the ambient temperature is 20°C, and an ideal sine wave is present.

- Motor winding: 140°C
- Pulsecoder: 100°C

In the continuous operating zone, the motor can be used continuously with any combination of a speed and a torque. In the intermittent operating zone outside the continuous operating zone, the motor is used intermittently using a duty cycle curve.

The torque decreases by 0.11% for the β*i*S series according to the negative temperature coefficient of magnetic materials every time the ambient temperature increases by 1°C after it exceeds 20°C.

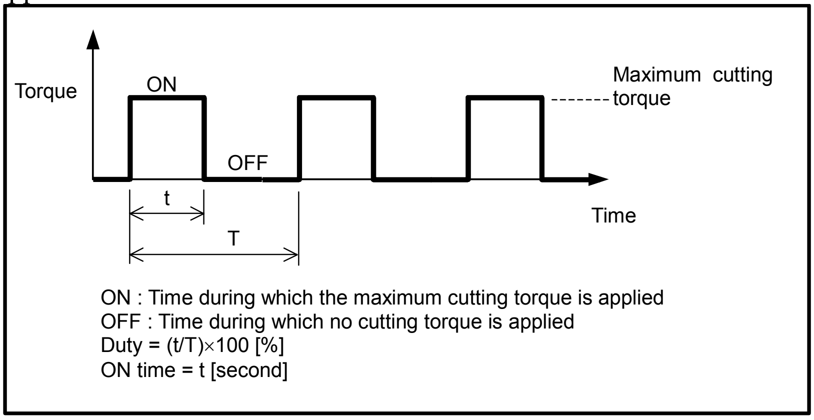
The intermittent operating zone may be limited by the motor input voltage. The values of the β*i*S series in the data sheets are observed when the input voltage is 200 V.



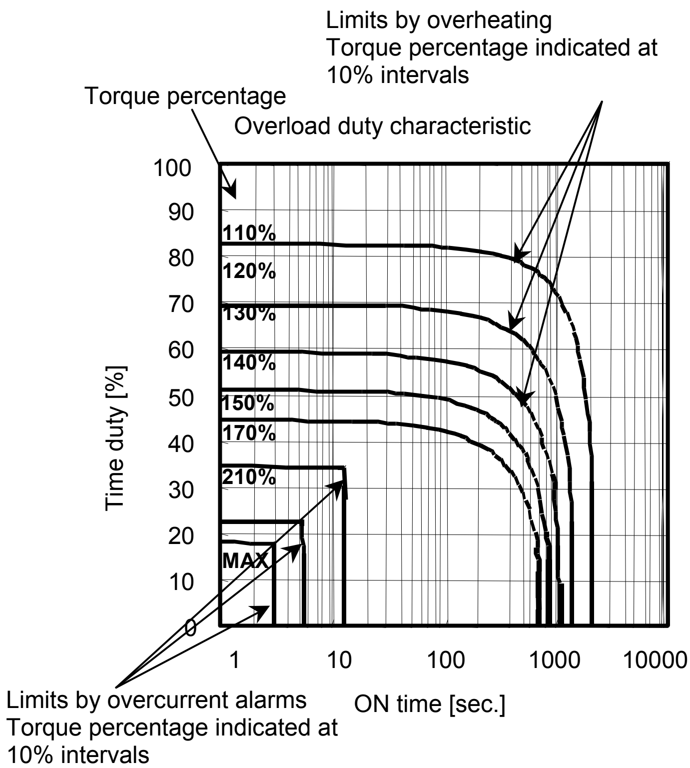
Example of β*i*S 8/3000

Overload duty characteristic

The percentage duty cycle indicates the ratio of the time during which torque can be applied to the total time of a single cycle.
The ON time indicates the time during which the torque is being applied.



Overload duty characteristics indicate the relationship between the percentage duty cycle (%) and ON time (load time) in which the motor can intermittently be operated with no temperature limit in the range exceeding the continuous rated torque.



Overload duty characteristic for β*i*S 8/3000

The duty calculation procedure is shown below:

<1> Calculate Torque percent by formula (b) below.
<2> Motor can be operated at any point on and inside the curve (according to the limits by overheating or overcurrent alarms) corresponding to the given over load conditions obtained form <1>.
<3> Calculate t_F by formula (a)

$$t_F = t_R \times \left(\frac{100}{Dutypercent} - 1 \right) --- (a)$$

$$TMD = \frac{Load\ torque}{Continuous\ rated\ torque} --- (b)$$

t_F : "OFF" time
t_R : "ON" time

The values of t_R and t_F obtained form the above mentioned procedure shows the ones limited by motor thermal conditions.

The motor temperature limits for determining overload duty curves are determined according to the motor temperature limit (overheat alarm) and according to the soft thermal function of monitoring the current by servo soft for a rapid increase in temperature (overcurrent alarm).
The overload duty characteristic determined according to the overheat alarm is represented with a curve within a relatively long time range of at least about 100 seconds of the load time. That determined according to the overcurrent alarm is represented with a curve within a relatively short time range of up to about 100 seconds. The final overload duty characteristic is represented with the curve described using either characteristic value, whichever is shorter. For the soft function of monitoring overcurrent, the settings differ depending on the motor. If the motor is in the overload status at a motor speed of about 0, an overcurrent (OVC) alarm may be issued for a time shorter than described. Note that another restriction may be imposed depending on the use condition since driving device (such as an amplifier), Pulsecoder, and other devices contain a thermal protection device.

4.4.2 Data Sheet

The data sheet gives the values of motor parameters relating to the performance.
The values of parameters are those under the following conditions.

- The ambient temperature for the motor is 20°C.
- The error is ±10%.
- The drive current of the motor is pure sine wave.

The following parameters are given on the data sheet:

Stall torque : T_s [N·m]

Torque that allows the motor to operate continuously at 0 [min^{-1}].

Stall current : I_s [Arms]

Maximum effective current value that allows the motor to operate continuously at 0 [min^{-1}].

Rated output : P_r [kW]

Maximum speed at which the motor can continuously operate.

Rating rotation speed : N_r [min^{-1}]

Maximum speed at which the motor can continuously operate.

Maximum rotation speed : N_{max} [min^{-1}]

Maximum speed at which the motor can operate.

Maximum torque : T_{max} [min^{-1}]

Maximum motor torque
More specifically, torque with which the motor can intermittently be operated within the current restricted range (from 0 [min^{-1}] to the beginning of dropping of the shoulder)
The maximum torque value is generally the product of the torque constant of each motor and the current limit of the amplifier. This value varies according to fluctuations in the power supply, motor parameters, and limits of the amplifier. For some models, when the maximum current flows through the motor, the maximum torque may be lower than the calculated value (the product of the motor torque constant and the current limit of the amplifier) due to magnetic saturation and other factors.

Motor inertia : J_m [kg·m^2] [kgf·cm·sec^2]

Motor rotor inertia
The values for the standard specification with no brake and for the specification with a brake are given.

Torque constant : K_t [N·m/Arms] [kgf·cm/Arms]

This is known as torque sensitivity and represents the torque developed per ampere of phase current. This value is a motor-specific constant, and is calculated by the flux distribution and location of coils in the armature, and the dimensions of the motor.

The torque constant decreases by 0.11% for the β*i*S series according to the temperature coefficient of the magnet every time the temperature of the magnet increases by 1°C after it exceeds 20°C.

Back EMF (electromotive force) constant: Kv [Vrms·sec] ([Vrms·sec/rad])

This indicates the strength of a permanent magnet and is a motor-specific constant. This is the voltage generated when the rotor is externally and mechanically rotated.
Back EMF is a motor-specific constant, and is also calculated by the flux distribution and location of coils in the armature, and the dimensions of the motor. Expressed in [min^{-1}] units, back EMF has the dimensions of [$Vrms/min^{-1}$]. The relationship can be given as:
[Vrms·sec/rad] = [9.55×$Vrms/min^{-1}$] (9.55=60/(2π))
The back EMF constant is indicated as the RMS voltage per phase, so multiple by $\sqrt{3}$ to obtain the actual terminal voltage.
The relationship between the torque constant (K_t) and back EMF constant (K_v) can also be given as:

SI units

$$K_t \quad [N \cdot m / Arms] = 3K_v \quad [Vrms \cdot \sec / rad]$$

Gravitational system of units

$$K_t \quad [kgf \cdot cm / Arms] = 30.6K_v \quad [Vrms \cdot \sec / rad]$$

For this reason, when back EMF constant (K_v) drops lower than the demagnetization of the magnet, the torque constant (K_t) also drops by the same ratio.

Example)

For the β*i*S 2/4000
The torque constant is $K_t = 6.3[kgf \cdot cm / Arms] = 0.62[N \cdot m / Arms]$, and the back electromotive force is $K_v = 0.21[Vrms \cdot \sec / rad]$, therefore, the above equation can be satisfied.

Winding resistance : R [Ω]

Resistance per phase of the motor

Mechanical time constant : t_m [sec]

This is a function of the initial rate of rise in velocity when a step voltage is applied. It is calculated from the following relationship.

$$tm = \frac{Jm \cdot Ra}{Kt \cdot Kv}$$

Jm : Rotor inertia [kg·m^2]
Ra : Resistance of the armature [Ω]

Thermal time constant : t_t [min]

This is a function of the initial rate of rise of winding temperature at rated current. It is defined as the time required to attain 63.2 percent of the final temperature rise.

Axis friction torque : T_f [N·m] [kgf·cm]

This is the no-load torque required just to rotate the rotor.

Mass : w [kg]

This is the mass of the motor.
The masses of the motor with brakes and that without brakes are indicated.

Maximum current of applicable servo amplifiers

Applicable servo amplifiers are briefly described.
For more specific servo amplifiers, see Section 2.2, "APPLICABLE AMPLIFIERS."

5 CONDITIONS FOR APPROVAL RELATED TO THE IEC60034 STANDARD

This chapter describes the conditions the following FANUC AC Servo Motor βi series must clear before they can be approved for the IEC60034 standard. For details on EMC compliance authorization, refer to the separate manual "Compliance with EMC Directives."

Chapter 5, “CONDITIONS FOR APPROVAL RELATED TO THE IEC60034 STANDARD”, consists of:

5.1 TYPES OF MOTORS TO BE APPROVED

The following FANUC AC Servo Motor β*i* series can comply with the IEC60034 standard if you follow the descriptions in this chapter.
The TUV mark is printed on the nameplates of the following motors.
The FANUC AC Servo Motor β*i* series has two types of motors: one type is driven by FANUC servo amplifiers (for 200 to 240 VAC) and the other type is driven by FANUC servo amplifiers (400 to 480 VAC).

β*i*S series (200V)

Model name	Motor specification number
β*i*S 0.2/5000	A06B-0111-Bx03
β*i*S 0.3/5000	A06B-0112-Bx03
β*i*S 0.4/5000	A06B-0114-Bx03
β*i*S 0.5/6000	A06B-0115-Bx03
β*i*S 1/6000	A06B-0116-Bx03
β*i*S 2/4000	A06B-0061-Bx0x
β*i*S 4/4000	A06B-0063-Bx0x
β*i*S 8/3000	A06B-0075-Bx0x
β*i*S 12/2000	A06B-0077-Bx0x
β*i*S 12/3000	A06B-0078-Bx03
β*i*S 22/1500	A06B-0084-Bx06
β*i*S 22/2000	A06B-0085-Bx03

β*i*S series (400V)

Model name	Motor specification number
β*i*S 2/4000HV	A06B-0062-Bx03
β*i*S 4/4000HV	A06B-0064-Bx03
β*i*S 8/3000HV	A06B-0076-Bx03
β*i*S 12/3000HV	A06B-0079-Bx03
β*i*S 22/2000HV	A06B-0086-Bx03

5.2 APPROVED SPECIFICATIONS

The following specifications are approved for the IEC60034 standard.

5.2.1 Motor Speed (IEC60034-1)

The "rated-output speed" and "allowable maximum speed" are given on the data sheet in Chapter 6, “SPECIFICATIONS.”
The rated-output speed is the speed which specifies the rated output.
The allowable maximum speeds are specified in such a way that the approval conditions of the IEC60034-1 standard, as they relate to rotational speed, are satisfied.
When the allowable maximum speeds are used, the characteristics are not guaranteed.

5.2.2 Output (IEC60034-1)

The "rated output" available with a motor is given on the data sheet in Chapter 6, “SPECIFICATIONS.”The rated output is guaranteed as continuous output for the rated-output speed under Insulation Class F.

The output in an intermittent operation range is not specified.

5.2.3 Protection Type (IEC60034-5)

Motor protection confirms to IP65. (Connectors of the pulsecoders other than those for the β*i*S 0.2 and the β*i*S 0.3 are water-proof when engaged. The power connectors of the β*i*S 0.2 and the β*i*S 0.3 and the connectors of the pulsecoders are not drip-proof even when engaged.)

IP6x: Completely dust-proof machine
This structure completely prevents dust from entering the machine.

IPx5: Sprinkle-proof machines
A sprinkle-proof machine shall not suffer inadvertent influence when they are exposed to water sprinkled from nozzles at any angle to the machine.

The conditions of the IPx5 type test are as follows:
Nozzle inside diameter .... 6.3 [mm]
Amount of sprinkled water .... 12.5 [liters/minute]
Water pressure at the nozzle .... 30 [kPa]
Test time for a 1-m^2 surface area of the machine to be tested .... 1 [minute]
Minimum test time... 3 [minutes]
Distance between the nozzle and machine ... Approximately 3 [m]

> ⚠ **CAUTION**
> IPx5 evaluates machines for waterproofness in a short-term test as described above, allowing chances that the machines may get dry after the test. If a machine is exposed to liquids other than water or so continuously to water that it cannot get dry, it may suffer inadvertent influence even if the degree of exposure is low.

5.2.4 Cooling Method (IEC60034-6)

The cooling method is fully-closed, natural air cooling for all models. The IC code is IC410.

5.2.5 Mounting Method (IEC60034-7)

All motors can be mounted as follows:

IMB5: Flange mounting with the shaft facing sideways(from the rear)
IMV1: Flange mounting with the shaft facing upward(from the rear)
IMV3: Flange mounting with the shaft facing downward(from the rear)

5.2.6 Heat Protection (IEC60034-11)

Each FANUC AC Servo Motor conforms to the standard for heat protection (IEC60034-11), using an overheat protection circuit (overheat alarm) with temperature detection or an overheat protection circuit (soft thermal alarm) with current detection.

5.2.7 Grounding (IEC60204-1)

For each FANUC AC Servo Motor, continuity between the ground terminal and housing of the power connector has been checked based on the IEC60204-1 safety standard and it has been ensured that it satisfies the standard.
The ground wire to be connected to the motor must have a diameter not smaller than the diameter of each phase wire.

5.2.8 Remarks

For details on EMC compliance authorization, refer to the separate manual "Compliance with EMC Directives"
Mechanical and electrical safety of each motor should be evaluated after the motor is mounted on the machine.

5.3 CONNECTORS REQUIRED FOR APPROVAL

Power connector

The power and cooling fan must be connected to the motor with a TUV-approved connector and a cable clamp. For details, see Section 3.2, "CONNECTING A SERVO MOTOR".

- The TUV-approved plug connectors and cable clamps in Chapter 10, "CONNECTORS ON THE CABLE SIDE", are approved by TUV that they conform to the safety standard VDE0627 when combined with the FANUC AC Servo Motor β*i* series. Plug connectors other than the above are prepared by each manufacturer. For information on the conformance to the safety standard when these are combined with the FANUC AC Servo Motor β*i* series, contact the connector manufacturer.

Manufacturer	Product series name
Tyco Electronics AMP	Dynamic Series
MOLEX JAPAN Co., Ltd.	500381 Series
	5.08 pitch motor connector series
Hirose Electric (HRS)	H/MS310 TUV-conforming series
Japan Aviation Electronics Industry (JAE)	JL04V series
DDK Ltd. (DDK)	CE05 series

- If a cable or conduit hose seal adapter is used, consult an appropriate connector maker.

6 SPECIFICATIONS

The specifications and characteristics of each motor of the FANUC AC Servo Motor α*i* series are described separately with characteristic curves and a data sheet.
For information about the characteristic curves and data sheet, see Section 4.4, "CHARACTERISTIC CURVE AND DATA SHEET".

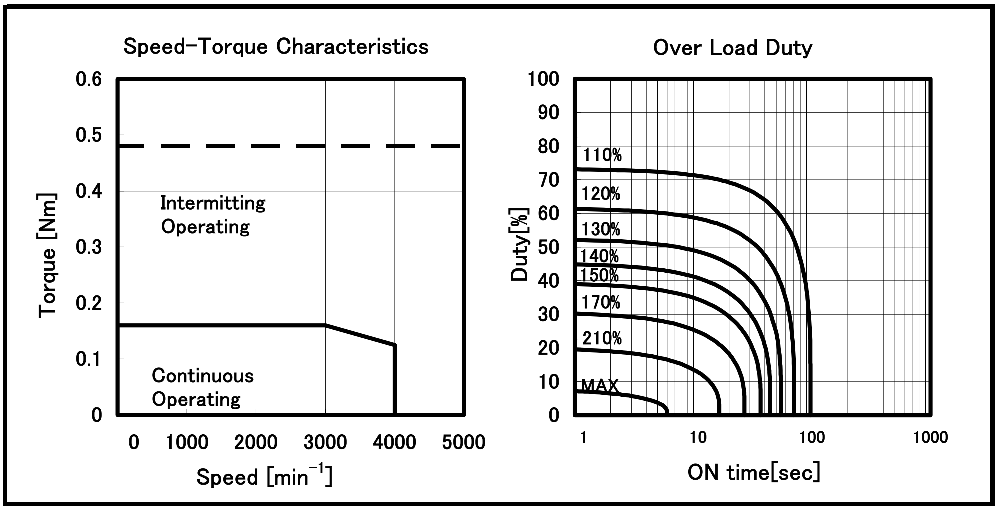
For the models β*i*S 2/4000, β*i*S 4/4000, β*i*S 8/3000, and β*i*S 12/2000, the overload duty characteristics are reduced if the pulsecoder β*i*A128 (for the FS0*i* only) is selected.
Also, for the model β*i*S 4/4000, the speed-torque characteristics and motor output are reduced if the pulsecoder β*i*A128 (for the FS0*i* only) is selected.
The changes to be made in the cases above are summarized in "Changes to be made if selecting the β*i*A128 (for the FS0*i* only). Refer to it, if required.
. The β*i*S 22/1500 is available with β*i*A128 (for the FS0*i* only) attached to it.)

Chapter 6, "SPECIFICATIONS", consists of:

6.1 CHARACTERISTIC CURVE AND DATA SHEET

6.1.1 β*i*S Series (200V)

Model β*i* S 0. 2/5000 Specification A06B-0111-B□03

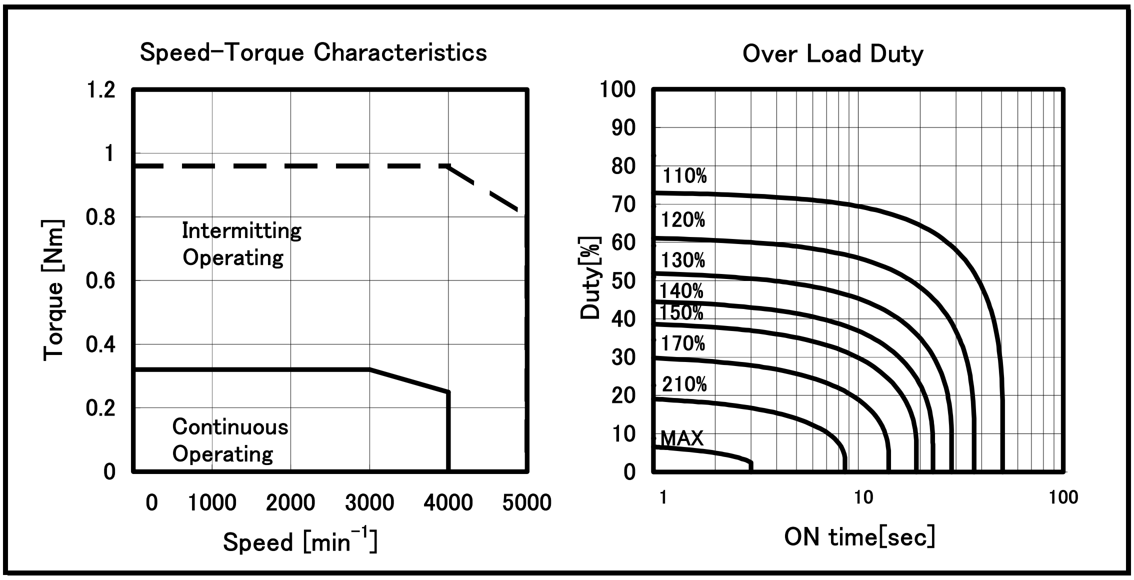


Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	0.16			Nm
		1.6			kgfcm
Stall Current (*)	Is	0.84			A (rms)
Rated Output (*)	Pr	0.05			kW
		0.07			HP
Rating Speed	Nr	4000			min^{-1}
Maximum Speed	Nmax	5000			min^{-1}
Maximum Torque (*)	Tmax	0.48			Nm
		4.9			kgfcm
Rotor Inertia	Jm	0.0000019			kgm^2
		0.0000194			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.0000039			kgm^2
		0.0000398			$kgfcms^2$
Torque constant (*)	Kt	0.191			Nm/A (rms)
		1.95			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	6.7			V (rms)/1000 min^{-1}
	Kv	0.064			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	6			Ω
Mechanical time constant	tm	0.0009			s
Thermal time constant	tt	5			min
Static friction	Tf	0.02			Nm
		0.2			kgfcm
Weight	w	0.33			kg
Weight (with Brake)	w	0.55			kg
Max. Current of Servo Amp.	Imax	4			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)
(note)This motor can not be driven by Servo HRV1 Control.

Model βiS 0.3/5000 Specification A06B-0112-B□03

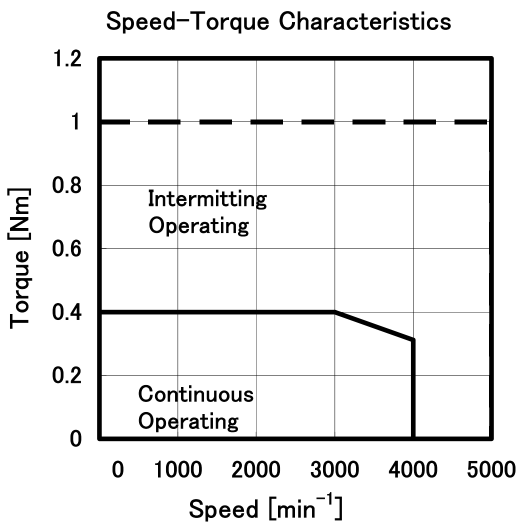


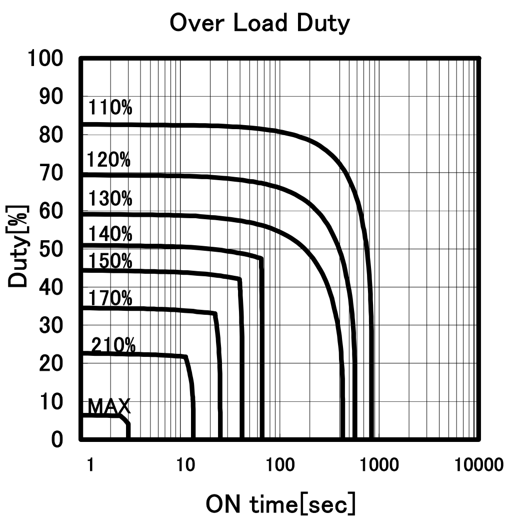
Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	0.32			Nm
		3.3			kgfcm
Stall Current (*)	Is	0.84			A (rms)
Rated Output (*)	Pr	0.1			kW
		0.13			HP
Rating Speed	Nr	4000			min^{-1}
Maximum Speed	Nmax	5000			min^{-1}
Maximum Torque (*)	Tmax	0.96			Nm
		9.8			kgfcm
Rotor Inertia	Jm	0.0000034			kgm^2
		0.0000347			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.0000054			kgm^2
		0.0000551			$kgfcms^2$
Torque constant (*)	Kt	0.38			Nm/A (rms)
		3.9			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	13			V (rms)/1000 min^{-1}
	Kv	0.13			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	10			Ω
Mechanical time constant	tm	0.0007			s
Thermal time constant	tt	8			min
Static friction	Tf	0.02			Nm
		0.2			kgfcm
Weight	w	0.44			kg
Weight (with Brake)	w	0.66			kg
Max. Current of Servo Amp.	Imax	4			A (peak)

(*) The values are the standard values at 20°C and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)
(note)This motor can not be driven by Servo HRV1 Control.

Model βi S 0. 4/5000 Specification A06B-0114-B□03



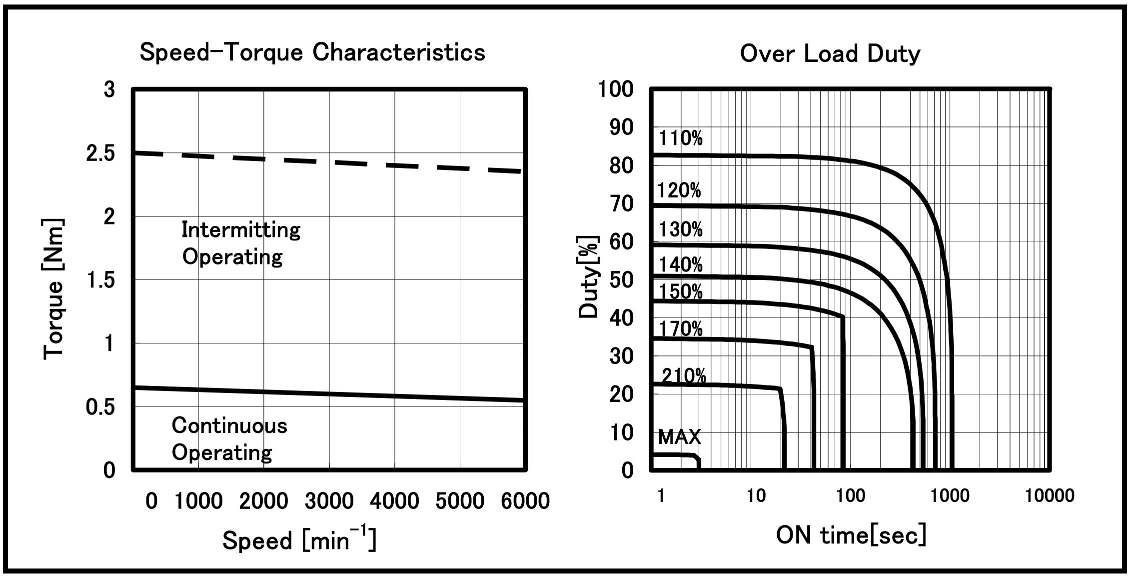


Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	0.4			Nm
		4.1			kgfcm
Stall Current (*)	Is	3.6			A (rms)
Rated Output (*)	Pr	0.13			kW
		0.17			HP
Rating Speed	Nr	4000			min^{-1}
Maximum Speed	Nmax	5000			min^{-1}
Maximum Torque (*)	Tmax	1			Nm
		10			kgfcm
Rotor Inertia	Jm	0.00001			kgm^2
		0.000102			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.000019			kgm^2
		0.000194			$kgfcms^2$
Torque constant (*)	Kt	0.112			Nm/A (rms)
		1.14			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	4			V (rms)/1000 min^{-1}
	Kv	0.038			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	0.55			Ω
Mechanical time constant	tm	0.001			s
Thermal time constant	tt	8			min
Static friction	Tf	0.04			Nm
		0.4			kgfcm
Weight	w	0.8			kg
Weight (with Brake)	w	1.2			kg
Max. Current of Servo Amp.	Imax	20			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)
(note)This motor can not be driven by Servo HRV1 Control.

Model βi S 0．5/6000 Specification A06B-0115-B□03

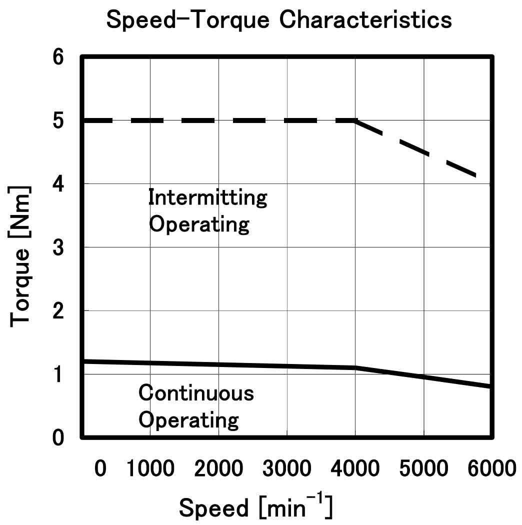


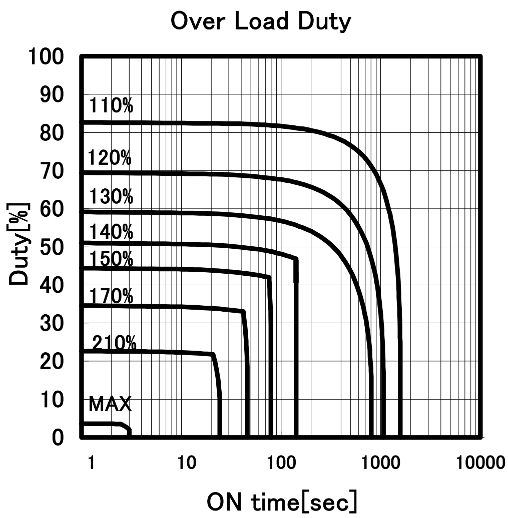
Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	0.65			Nm
		6.6			kgfcm
Stall Current (*)	Is	2.9			A (rms)
Rated Output (*)	Pr	0.35			kW
		0.47			HP
Rating Speed	Nr	6000			min^{-1}
Maximum Speed	Nmax	6000			min^{-1}
Maximum Torque (*)	Tmax	2.5			Nm
		26			kgfcm
Rotor Inertia	Jm	0.000018			kgm^2
		0.000184			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.000027			kgm^2
		0.000276			$kgfcms^2$
Torque constant (*)	Kt	0.223			Nm/A (rms)
		2.28			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	7.7			V (rms)/1000 min^{-1}
	Kv	0.074			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	0.85			Ω
Mechanical time constant	tm	0.0009			s
Thermal time constant	tt	10			min
Static friction	Tf	0.04			Nm
		0.4			kgfcm
Weight	w	1			kg
Weight (with Brake)	w	1.4			kg
Max. Current of Servo Amp.	Imax	20			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

Model βi S 1/6000 Specification A06B-0116-B□03



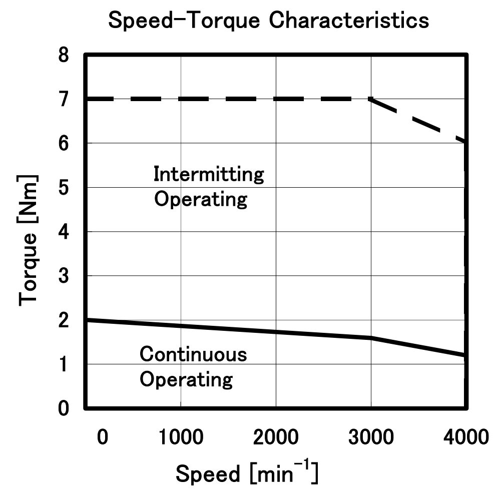


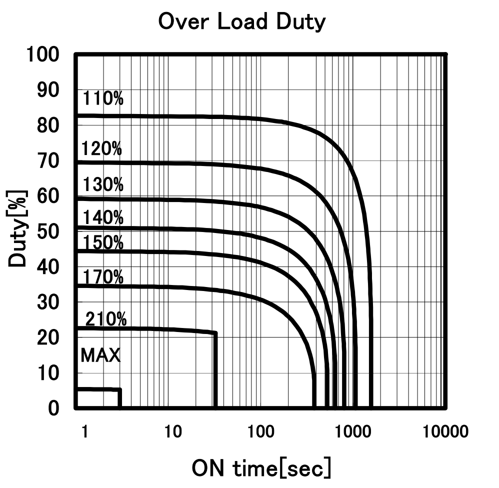
Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	1.2 12			Nm kgfcm
Stall Current (*)	Is	2.7			A (rms)
Rated Output (*)	Pr	0.5 0.67			kW HP
Rating Speed	Nr	6000			min^{-1}
Maximum Speed	Nmax	6000			min^{-1}
Maximum Torque (*)	Tmax	5 51			Nm kgfcm
Rotor Inertia	Jm	0.000034 0.000347			kgm^2 $kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.000043 0.000439			kgm^2 $kgfcms^2$
Torque constant (*)	Kt	0.45 4.6			Nm/A (rms) kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke Kv	15.4 0.14			V (rms)/1000 min^{-1} V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	1.5			Ω
Mechanical time constant	tm	0.0007			s
Thermal time constant	tt	15			min
Static friction	Tf	0.04 0.4			Nm kgfcm
Weight	w	1.5			kg
Weight (with Brake)	w	1.9			kg
Max. Current of Servo Amp.	Imax	20			A (peak)

(*) The values are the standard values at 20°C and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

Model βi S 2/4000 Specification A06B-0061-B□0□



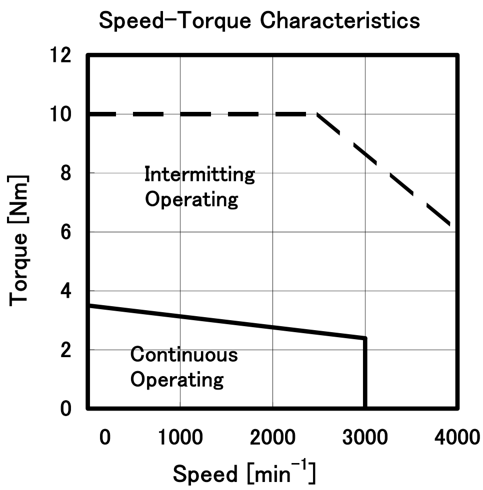


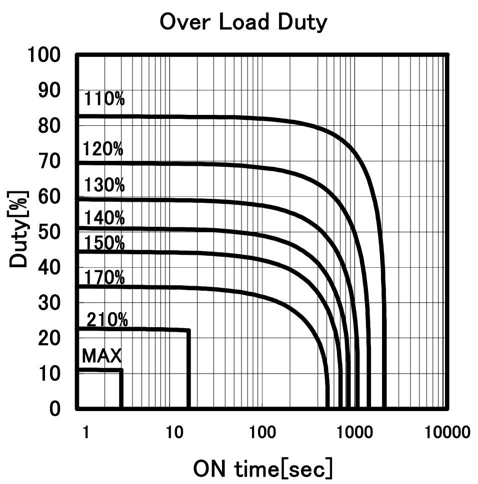
Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	2			Nm
		20			kgfcm
Stall Current (*)	Is	3.3			A (rms)
Rated Output (*)	Pr	0.5			kW
		0.67			HP
Rating Speed	Nr	4000			min^{-1}
Maximum Speed	Nmax	4000			min^{-1}
Maximum Torque (*)	Tmax	7			Nm
		71			kgfcm
Rotor Inertia	Jm	0.000291			kgm^2
		0.00297			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.000311			kgm^2
		0.00317			$kgfcms^2$
Torque constant (*)	Kt	0.62			Nm/A (rms)
		6.3			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	21			V (rms)/1000 min^{-1}
	Kv	0.21			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	1.6			Ω
Mechanical time constant	tm	0.004			s
Thermal time constant	tt	15			min
Static friction	Tf	0.1			Nm
		1			kgfcm
Weight	w	2.8			kg
Weight (with Brake)	w	3.8			kg
Max. Current of Servo Amp.	Imax	20			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)
(note)In case of the model with the Pulse corder βi A128(for FS0i),Speed - Torque Characteristics, Over Load Duty,and Rated output go down.Please refer to the page of "Change when the Pulse corder βi A128(for FS0i) is included".

Model βi S 4/4000 Specification A06B-0063-B□0□



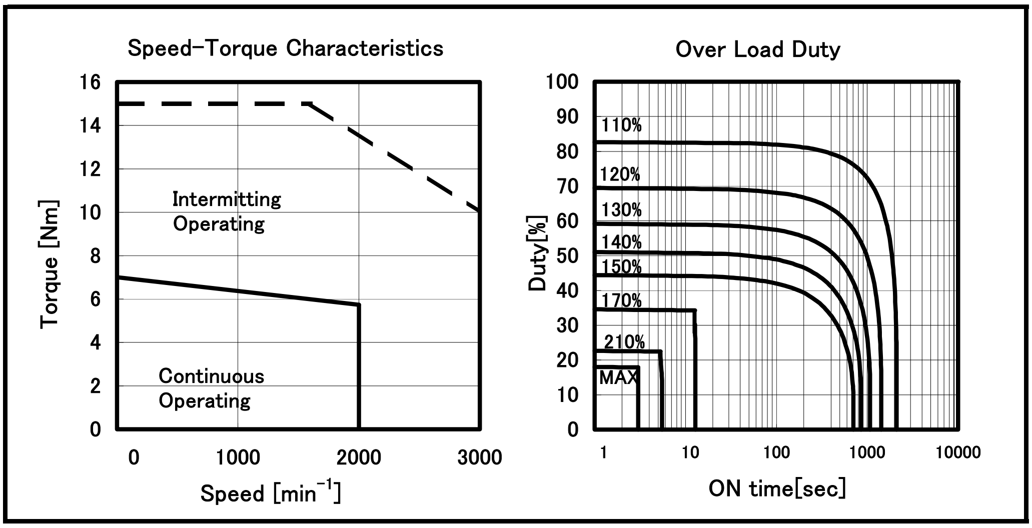


Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	3.5			Nm
		36			kgfcm
Stall Current (*)	Is	4.7			A (rms)
Rated Output (*)	Pr	0.75			kW
		1			HP
Rating Speed	Nr	3000			min^{-1}
Maximum Speed	Nmax	4000			min^{-1}
Maximum Torque (*)	Tmax	10			Nm
		102			kgfcm
Rotor Inertia	Jm	0.000515			kgm^2
		0.00526			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.000535			kgm^2
		0.00546			$kgfcms^2$
Torque constant (*)	Kt	0.75			Nm/A (rms)
		7.7			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	26			V (rms)/1000 min^{-1}
	Kv	0.25			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	0.94			Ω
Mechanical time constant	tm	0.003			s
Thermal time constant	tt	20			min
Static friction	Tf	0.2			Nm
		2			kgfcm
Weight	w	4.3			kg
Weight (with Brake)	w	5.3			kg
Max. Current of Servo Amp.	Imax	20			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)
(note)In case of the model with the Pulse corder βi A128(for FS0i),Speed - Torque Characteristics, Over Load Duty,and Rated output go down.Please refer to the page of "Change when the Pulse corder βi A128(for FS0i) is included".

Model βi S 8/3000 Specification A06B-0075-B□0□



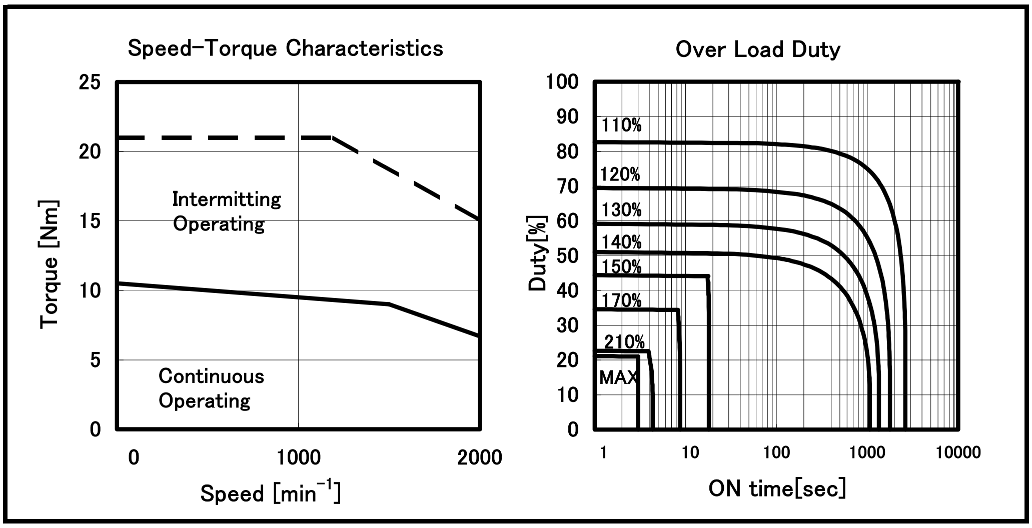
Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	7			Nm
		71			kgfcm
Stall Current (*)	Is	6			A (rms)
Rated Output (*)	Pr	1.2			kW
		1.6			HP
Rating Speed	Nr	2000			min^{-1}
Maximum Speed	Nmax	3000			min^{-1}
Maximum Torque (*)	Tmax	15			Nm
		153			kgfcm
Rotor Inertia	Jm	0.00117			kgm^2
		0.0119			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.00124			kgm^2
		0.0127			$kgfcms^2$
Torque constant (*)	Kt	1.16			Nm/A (rms)
		11.8			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	41			V (rms)/1000 min^{-1}
	Kv	0.39			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	1			Ω
Mechanical time constant	tm	0.003			s
Thermal time constant	tt	20			min
Static friction	Tf	0.3			Nm
		3			kgfcm
Weight	w	7.4			kg
Weight (with Brake)	w	9.6			kg
Max. Current of Servo Amp.	Imax	20			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

(note)In case of the model with the Pulse corder βi A128(for FS0i),Speed - Torque Characteristics, Over Load Duty,and Rated output go down.Please refer to the page of "Change when the Pulse corder βi A128(for FS0i) is included".

Model βi S 12/2000 Specification A06B-0077-B□0□



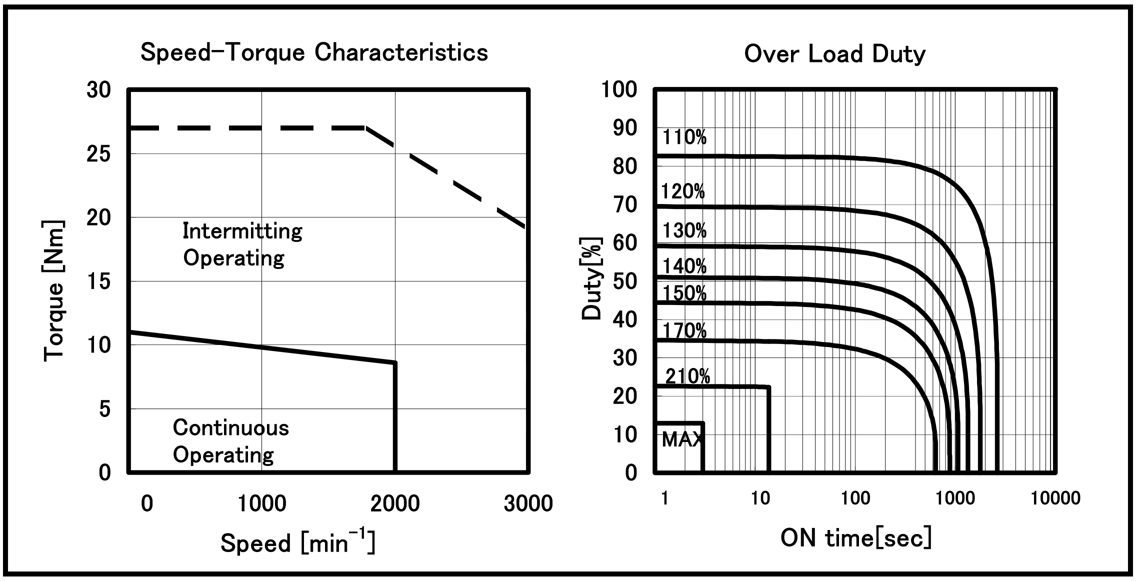
Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	10.5			Nm
		107			kgfcm
Stall Current (*)	Is	6.5			A (rms)
Rated Output (*)	Pr	1.4			kW
		1.9			HP
Rating Speed	Nr	2000			min^{-1}
Maximum Speed	Nmax	2000			min^{-1}
Maximum Torque (*)	Tmax	21			Nm
		214			kgfcm
Rotor Inertia	Jm	0.00228			kgm^2
		0.0233			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.00235			kgm^2
		0.024			$kgfcms^2$
Torque constant (*)	Kt	1.62			Nm/A (rms)
		16.5			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	57			V (rms)/1000 min^{-1}
	Kv	0.54			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	0.87			Ω
Mechanical time constant	tm	0.002			s
Thermal time constant	tt	25			min
Static friction	Tf	0.3			Nm
		3			kgfcm
Weight	w	11.9			kg
Weight (with Brake)	w	14.1			kg
Max. Current of Servo Amp.	Imax	20			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

(note)In case of the model with the Pulse corder βi A128(for FS0i),Speed - Torque Characteristics, Over Load Duty,and Rated output go down.Please refer to the page of "Change when the Pulse corder βi A128(for FS0i) is included".

Model βi S 12/3000 Specification A06B-0078-B□03

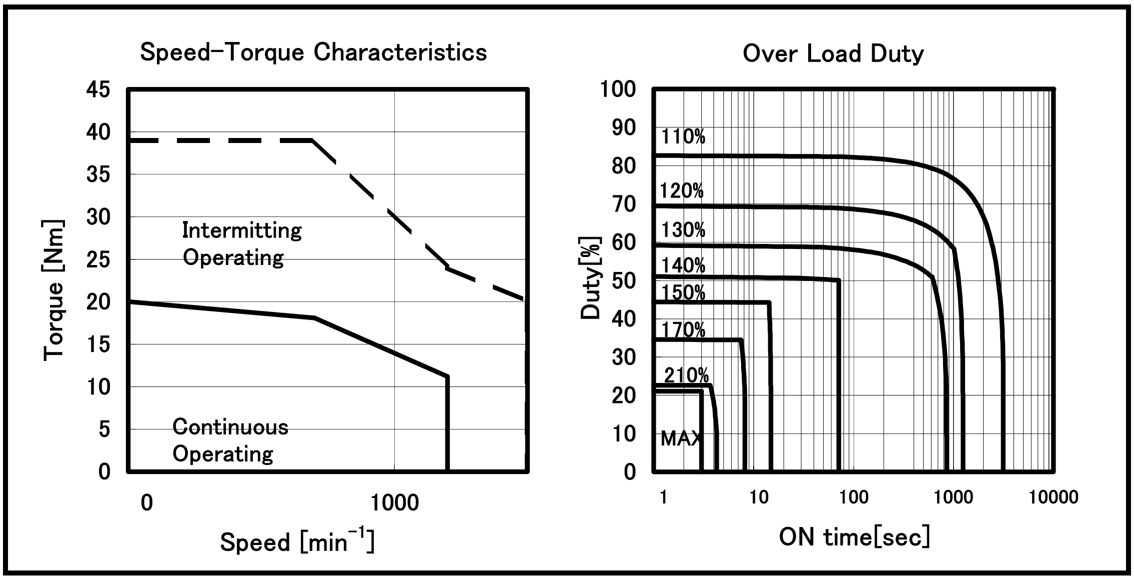


Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	11			Nm
		112			kgfcm
Stall Current (*)	Is	10.2			A (rms)
Rated Output (*)	Pr	1.8			kW
		2.4			HP
Rating Speed	Nr	2000			min^{-1}
Maximum Speed	Nmax	3000			min^{-1}
Maximum Torque (*)	Tmax	27			Nm
		276			kgfcm
Rotor Inertia	Jm	0.00228			kgm^2
		0.0233			kgfcms^2
Rotor Inertia (with Brake)	Jm	0.00235			kgm^2
		0.024			kgfcms^2
Torque constant (*)	Kt	1.08			Nm/A (rms)
		11			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	38			V (rms)/1000 min^{-1}
	Kv	0.36			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	0.39			Ω
Mechanical time constant	tm	0.002			s
Thermal time constant	tt	25			min
Static friction	Tf	0.4			Nm
		4			kgfcm
Weight	w	11.9			kg
Weight (with Brake)	w	14.1			kg
Max. Current of Servo Amp.	Imax	40			A (peak)

(*) The values are the standard values at 20°C and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

Model βi S 22/1500 Specification A06B-0084-B□06

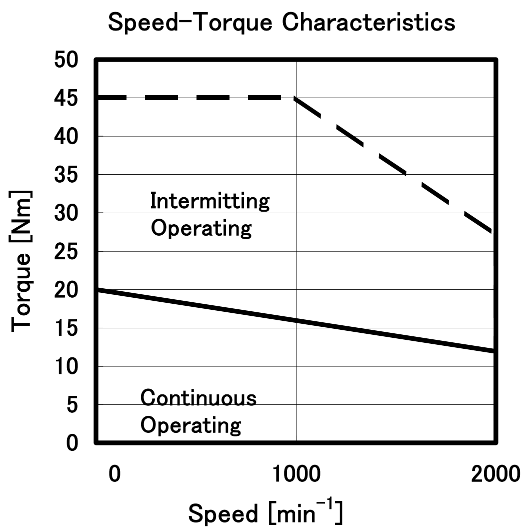


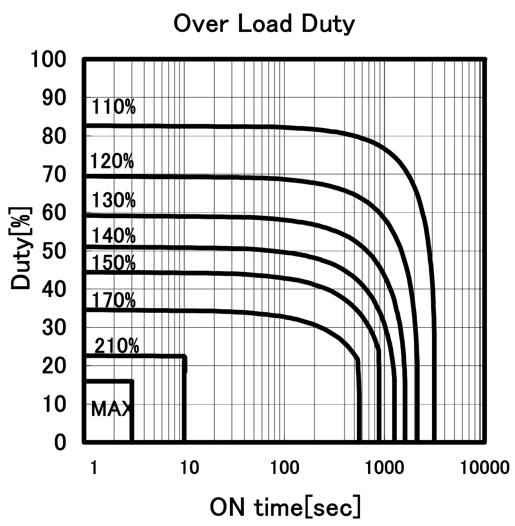
Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	20 204			Nm kgfcm
Stall Current (*)	Is	6.5			A (rms)
Rated Output (*)	Pr	1.4 1.9			kW HP
Rating Speed	Nr	1200			min^{-1}
Maximum Speed	Nmax	1500			min^{-1}
Maximum Torque (*)	Tmax	39 398			Nm kgfcm
Rotor Inertia	Jm	0.00527 0.0538			kgm^2 $kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.00587 0.0599			kgm^2 $kgfcms^2$
Torque constant (*)	Kt	3.1 32			Nm/A (rms) kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke Kv	110 1			V (rms)/1000 min^{-1} V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	1.3			Ω
Mechanical time constant	tm	0.002			s
Thermal time constant	tt	30			min
Static friction	Tf	0.8 8			Nm kgfcm
Weight	w	17			kg
Weight (with Brake)	w	23			kg
Max. Current of Servo Amp.	Imax	20			A (peak)

(*) The values are the standard values at 20°C and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

Model βi S 22/2000 Specification A06B-0085-B□03





Data sheet

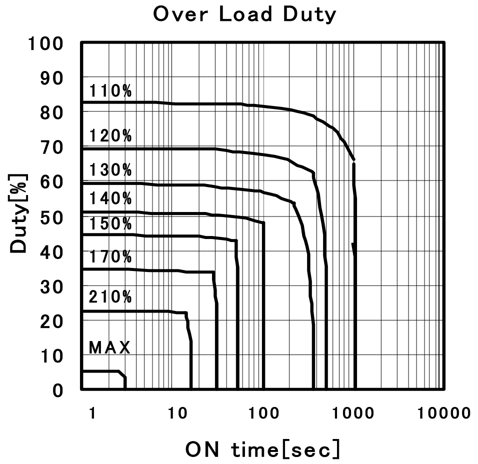
Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	20 204			Nm kgfcm
Stall Current (*)	Is	11.3			A (rms)
Rated Output (*)	Pr	2.5 3.4			kW HP
Rating Speed	Nr	2000			min^{-1}
Maximum Speed	Nmax	2000			min^{-1}
Maximum Torque (*)	Tmax	45 459			Nm kgfcm
Rotor Inertia	Jm	0.00527 0.0538			kgm^2 $kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.00587 0.0599			kgm^2 $kgfcms^2$
Torque constant (*)	Kt	1.77 18.1			Nm/A (rms) kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke Kv	62 0.59			V (rms)/1000 min^{-1} V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	0.44			Ω
Mechanical time constant	tm	0.002			s
Thermal time constant	tt	30			min
Static friction	Tf	0.8 8			Nm kgfcm
Weight	w	17			kg
Weight (with Brake)	w	23			kg
Max. Current of Servo Amp.	Imax	40			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

Changes when the pulse coder β*i*A128 (for the FS0*i* only) is included

Described below are changes applied when the pulse coder β*i*A 128 (for the FS0*i* only) is selectively included.

Model: β*i*S 2/4000
Specification: A06B-0061-B□06

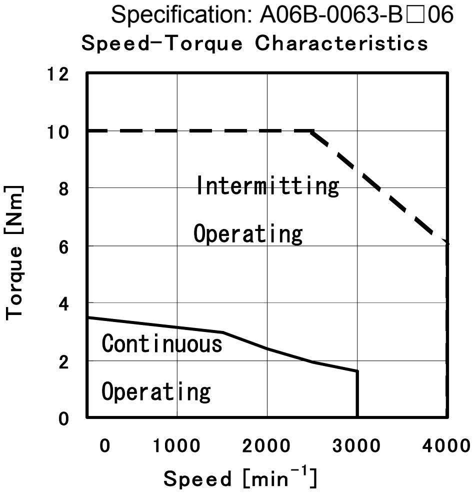


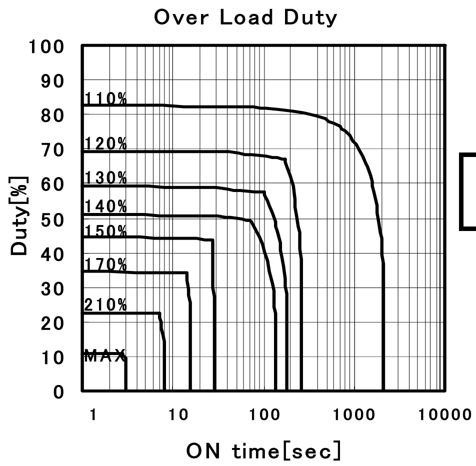
⚠ **CAUTION**

When the β*i*S 2/4000, β*i*S 8/3000, or β*i*S 12/2000 equipped with the pulse coder β*i*A 128 (specific to the FS0*i*) is selected, the overload duty ratio characteristics is lowered.

With the β*i*S 4/4000, the speed-torque characteristics, overload duty ratio characteristics, and output characteristics are lowered.

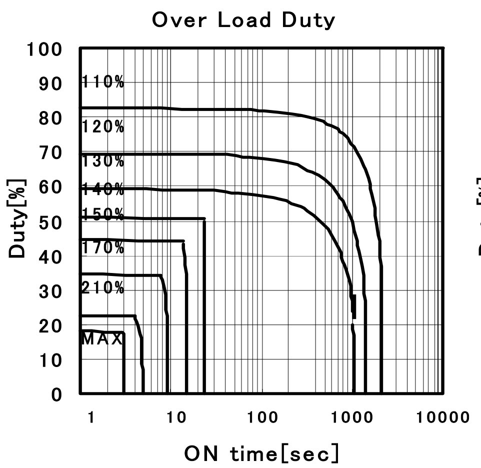
Model: β*i*S 4/4000
Specification: A06B-0063-B□06



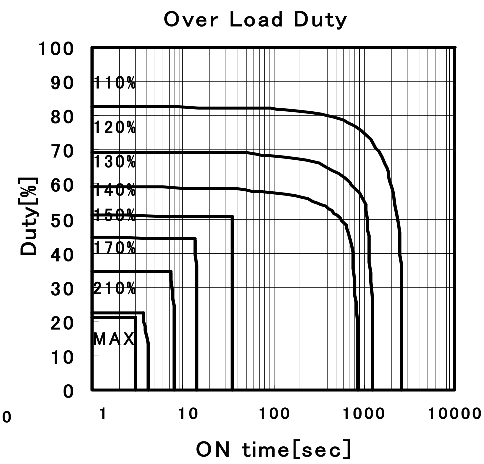


Rated output	Pr	0.5	kW
		0.67	HP

Model: β*i*S 8/3000
Specification: A06B-0075-B□06

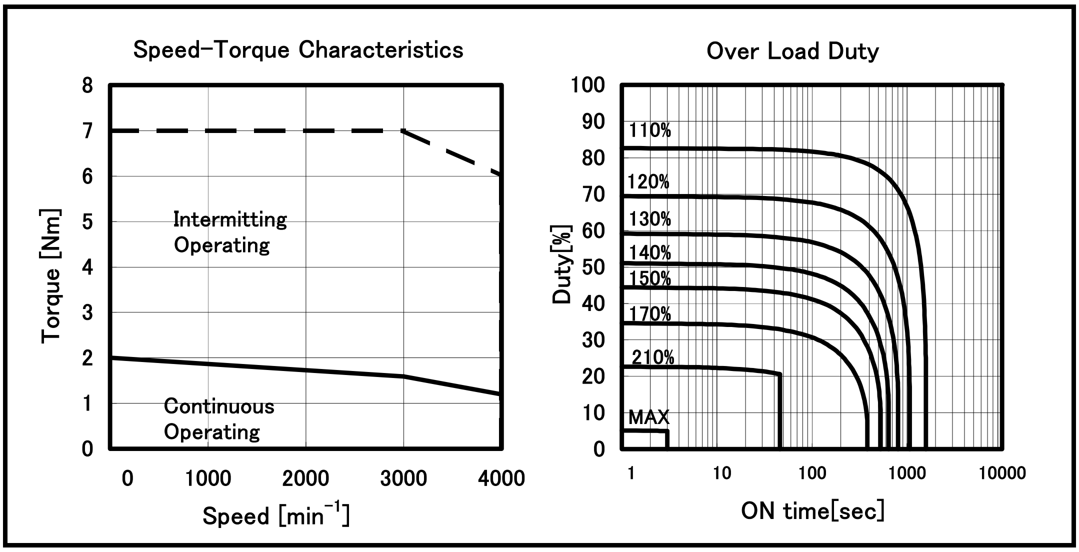


Model: β*i*S 12/2000
Specification: A06B-0077-B□06



6.1.2 βiS Series (400V)

Model βi S 2/4000 HV Specification A06B-0062-B□03

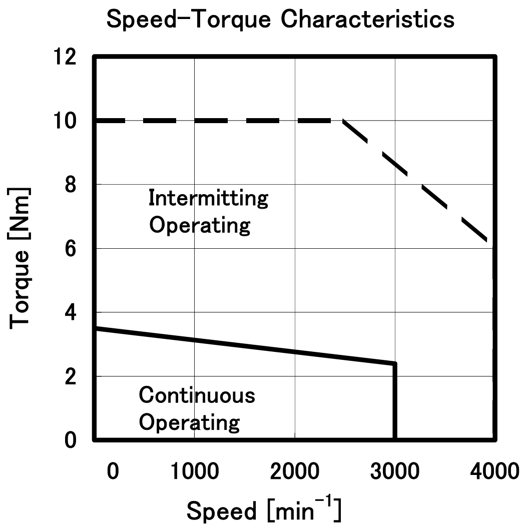


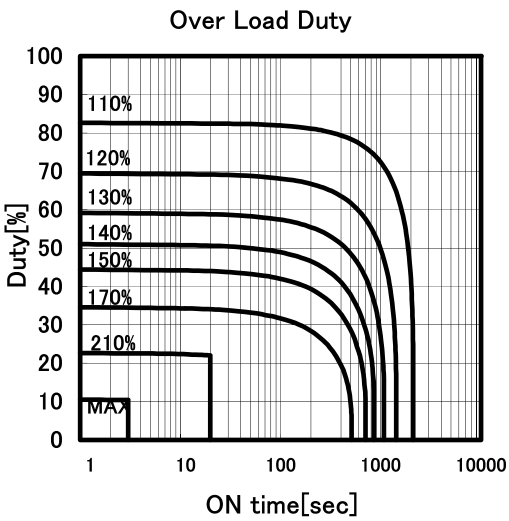
Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	2			Nm
		20			kgfcm
Stall Current (*)	Is	1.6			A (rms)
Rated Output (*)	Pr	0.5			kW
		0.67			HP
Rating Speed	Nr	4000			min^{-1}
Maximum Speed	Nmax	4000			min^{-1}
Maximum Torque (*)	Tmax	7			Nm
		71			kgfcm
Rotor Inertia	Jm	0.000291			kgm^2
		0.00297			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.000311			kgm^2
		0.00317			$kgfcms^2$
Torque constant (*)	Kt	1.23			Nm/A (rms)
		12.6			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	43			V (rms)/1000 min^{-1}
	Kv	0.41			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	6.6			Ω
Mechanical time constant	tm	0.004			s
Thermal time constant	tt	15			min
Static friction	Tf	0.1			Nm
		1			kgfcm
Weight	w	2.8			kg
Weight (with Brake)	w	3.8			kg
Max. Current of Servo Amp.	Imax	10			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

Model βi **S 4/4000 HV** Specification A06B-0064-B□03



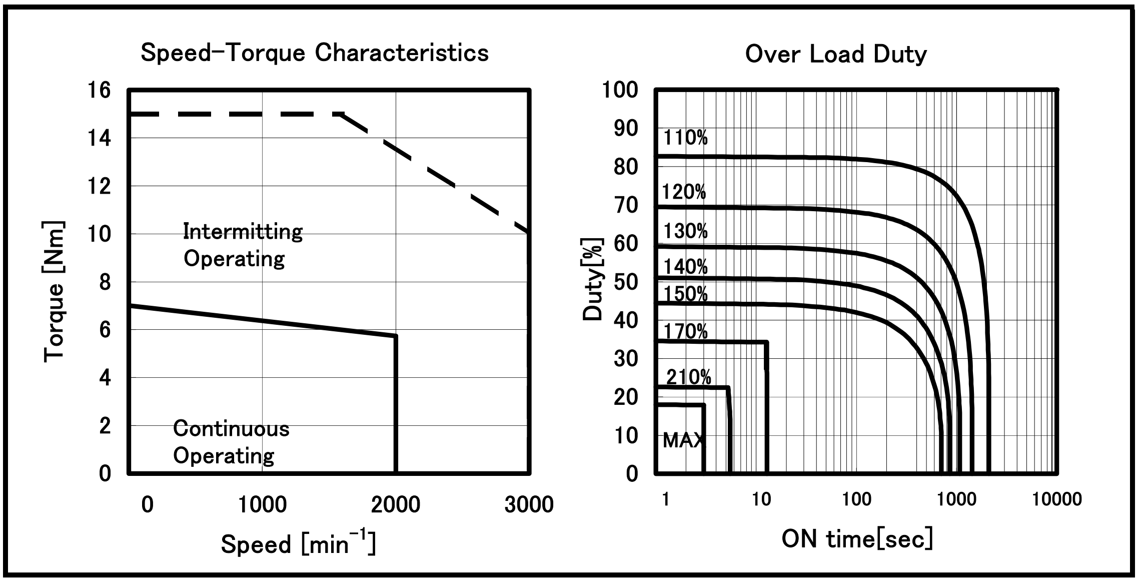


Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	3.5			Nm
		36			kgfcm
Stall Current (*)	Is	2.3			A (rms)
Rated Output (*)	Pr	0.75			kW
		1			HP
Rating Speed	Nr	3000			min^{-1}
Maximum Speed	Nmax	4000			min^{-1}
Maximum Torque (*)	Tmax	10			Nm
		102			kgfcm
Rotor Inertia	Jm	0.000515			kgm^2
		0.00526			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.000535			kgm^2
		0.00546			$kgfcms^2$
Torque constant (*)	Kt	1.5			Nm/A (rms)
		15.3			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	53			V (rms)/1000 min^{-1}
	Kv	0.5			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	4			Ω
Mechanical time constant	tm	0.003			s
Thermal time constant	tt	20			min
Static friction	Tf	0.2			Nm
		2			kgfcm
Weight	w	4.3			kg
Weight (with Brake)	w	5.3			kg
Max. Current of Servo Amp.	Imax	10			A (peak)

(*) The values are the standard values at 20°C and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

Model βi S 8/3000 HV Specification A06B-0076-B□03

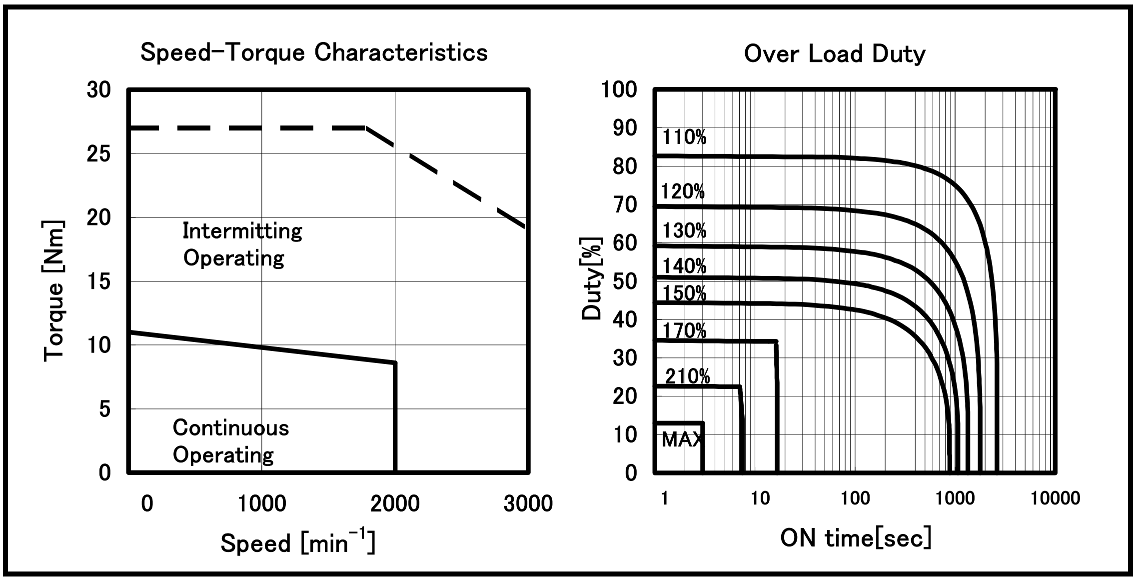


Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	7			Nm
		71			kgfcm
Stall Current (*)	Is	3			A (rms)
Rated Output (*)	Pr	1.2			kW
		1.6			HP
Rating Speed	Nr	2000			min^{-1}
Maximum Speed	Nmax	3000			min^{-1}
Maximum Torque (*)	Tmax	15			Nm
		153			kgfcm
Rotor Inertia	Jm	0.00117			kgm^2
		0.0119			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.00124			kgm^2
		0.0127			$kgfcms^2$
Torque constant (*)	Kt	2.32			Nm/A (rms)
		23.7			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	81			V (rms)/1000 min^{-1}
	Kv	0.77			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	3.9			Ω
Mechanical time constant	tm	0.003			s
Thermal time constant	tt	20			min
Static friction	Tf	0.3			Nm
		3			kgfcm
Weight	w	7.4			kg
Weight (with Brake)	w	9.6			kg
Max. Current of Servo Amp.	Imax	10			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

Model βi S 12/3000 HV Specification A06B-0079-B□03

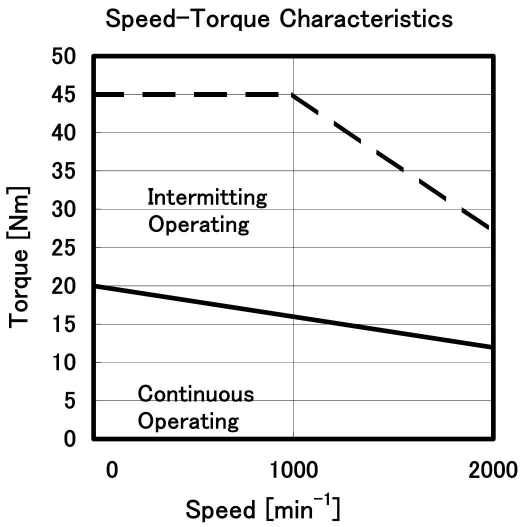


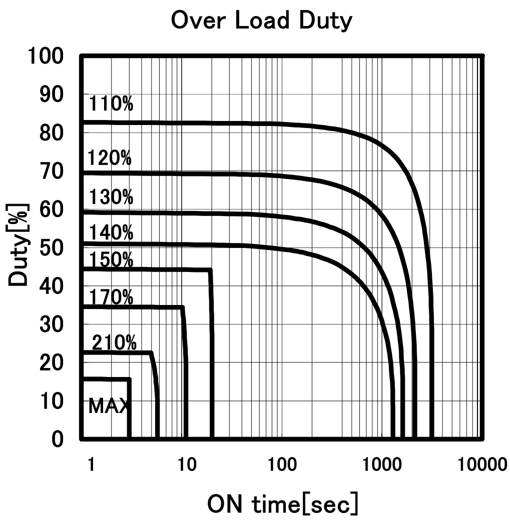
Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	11 112			Nm kgfcm
Stall Current (*)	Is	5.1			A (rms)
Rated Output (*)	Pr	1.8 2.4			kW HP
Rating Speed	Nr	2000			min^{-1}
Maximum Speed	Nmax	3000			min^{-1}
Maximum Torque (*)	Tmax	27 276			Nm kgfcm
Rotor Inertia	Jm	0.00228 0.0233			kgm^2 $kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.00235 0.024			kgm^2 $kgfcms^2$
Torque constant (*)	Kt	2.16 22			Nm/A (rms) kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke Kv	76 0.72			V (rms)/1000 min^{-1} V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	1.6			Ω
Mechanical time constant	tm	0.002			s
Thermal time constant	tt	25			min
Static friction	Tf	0.4 4			Nm kgfcm
Weight	w	11.9			kg
Weight (with Brake)	w	14.1			kg
Max. Current of Servo Amp.	Imax	20			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

Model βi **S 22/2000 HV** Specification A06B-0086-B□03





Data sheet

Parameter	Symbol	Value			Unit
Stall Torque (*)	Ts	20			Nm
		204			kgfcm
Stall Current (*)	Is	5.6			A (rms)
Rated Output (*)	Pr	2.5			kW
		3.4			HP
Rating Speed	Nr	2000			min^{-1}
Maximum Speed	Nmax	2000			min^{-1}
Maximum Torque (*)	Tmax	45			Nm
		459			kgfcm
Rotor Inertia	Jm	0.00527			kgm^2
		0.0538			$kgfcms^2$
Rotor Inertia (with Brake)	Jm	0.00587			kgm^2
		0.0599			$kgfcms^2$
Torque constant (*)	Kt	3.5			Nm/A (rms)
		36			kgfcm/A (rms)
Back EMF constant (1phase) (*)	Ke	120			V (rms)/1000 min^{-1}
	Kv	1.2			V (rms)sec/rad
Armature Resistance (1 phase) (*)	Ra	1.8			Ω
Mechanical time constant	tm	0.002			s
Thermal time constant	tt	30			min
Static friction	Tf	0.8			Nm
		8			kgfcm
Weight	w	17			kg
Weight (with Brake)	w	23			kg
Max. Current of Servo Amp.	Imax	20			A (peak)

(*) The values are the standard values at 20℃ and the tolerance is ±10%.
The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo software. (The above figures show average values.)

7 OUTLINE DRAWINGS

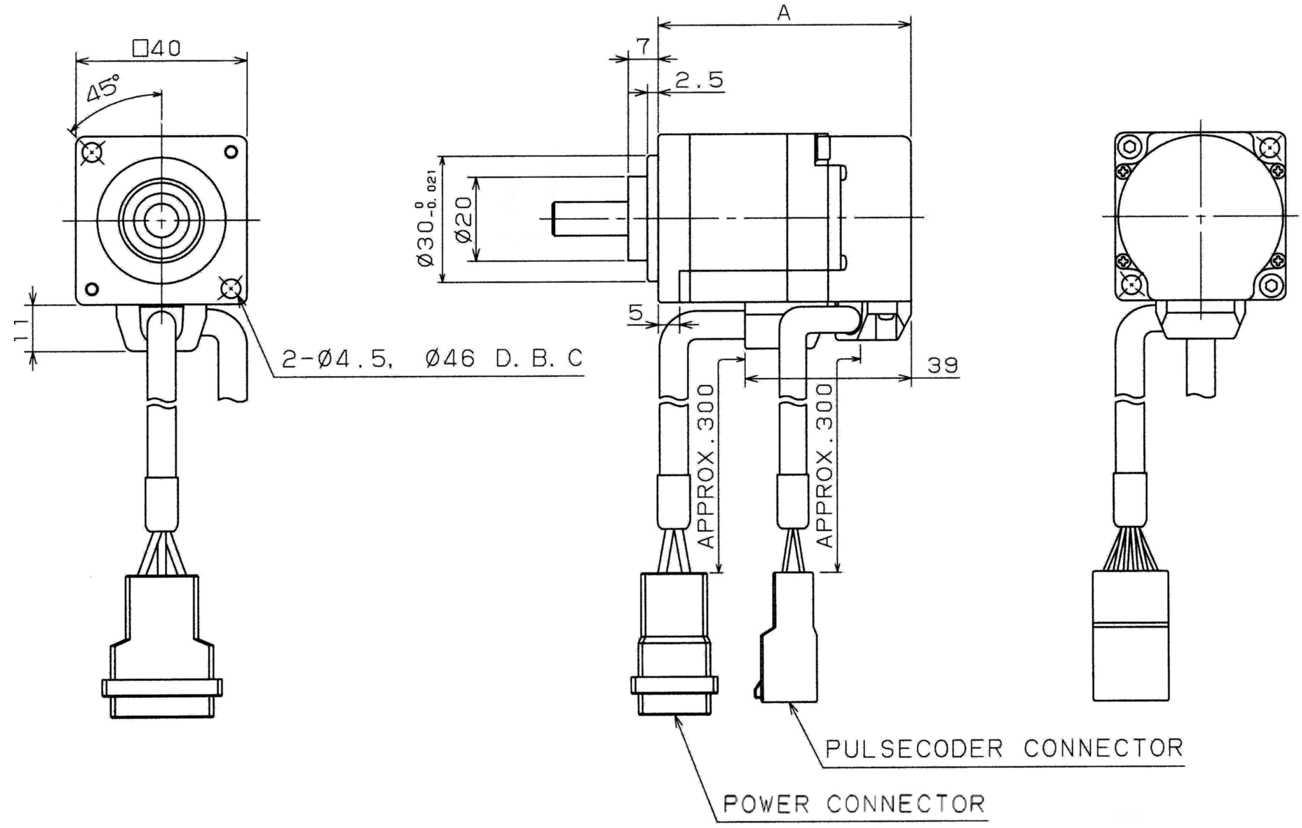
This chapter presents outline drawings of the FANUC AC Servo Motors (motor body, shaft details, allowable axis load, shaft run-out precision, and power pin layout).

Chapter 7, “OUTLINE DRAWINGS”, consists of:

7.1 MODELS βiS 0.2 AND βiS 0.3

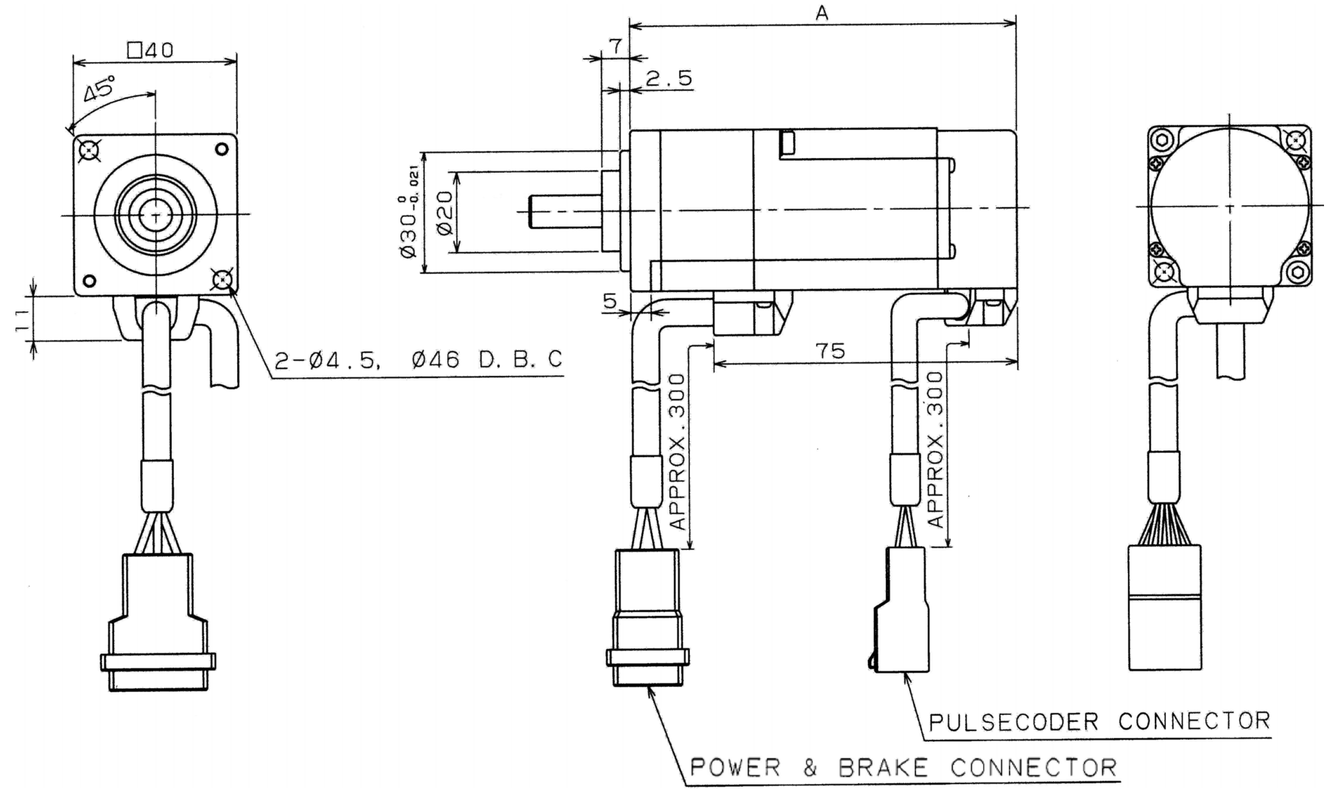
7.1.1 Outline Drawing of the Motors

Outline drawing of the motors (standard)



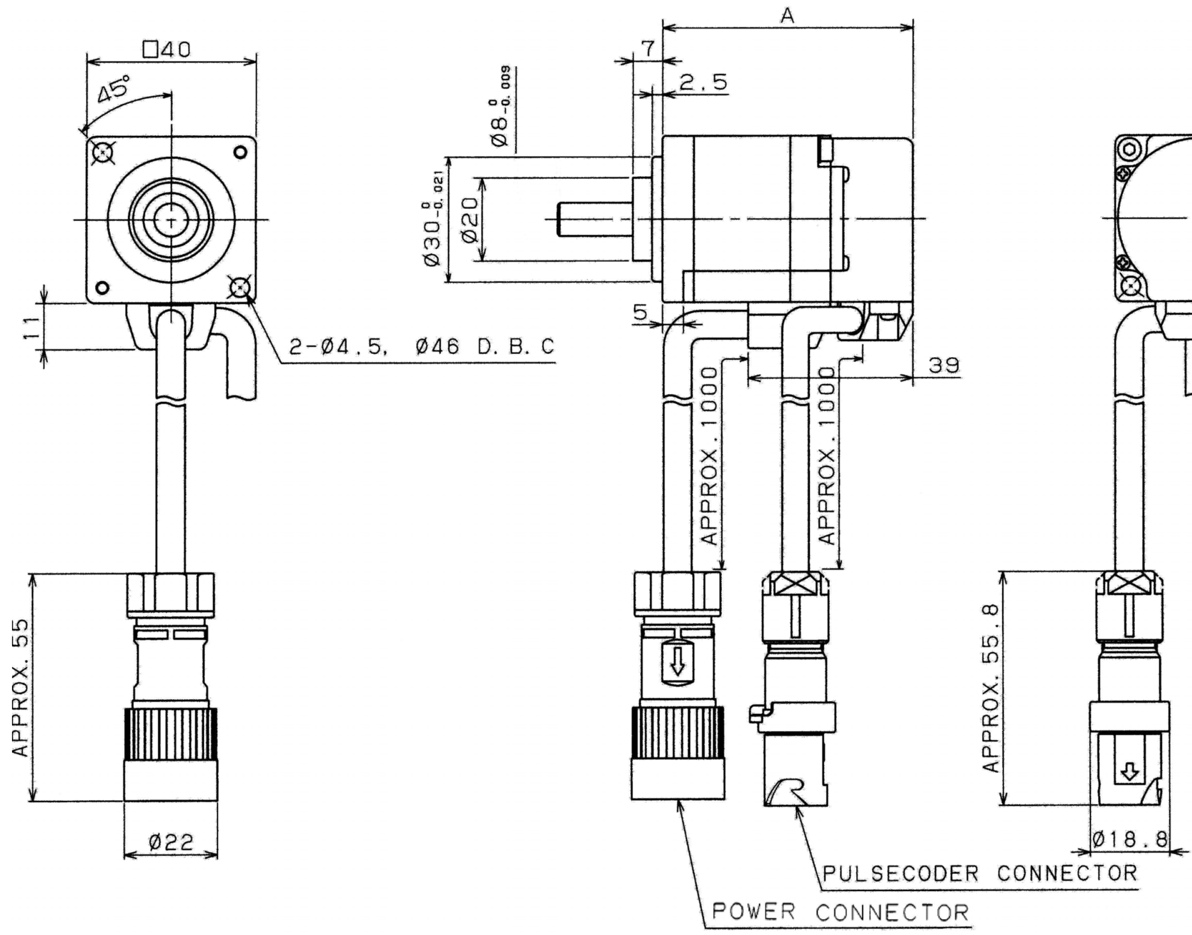
MODEL	A
βiS 0.2	59.5
βiS 0.3	73.5

Outline drawing of the motors (standard, with a brake)



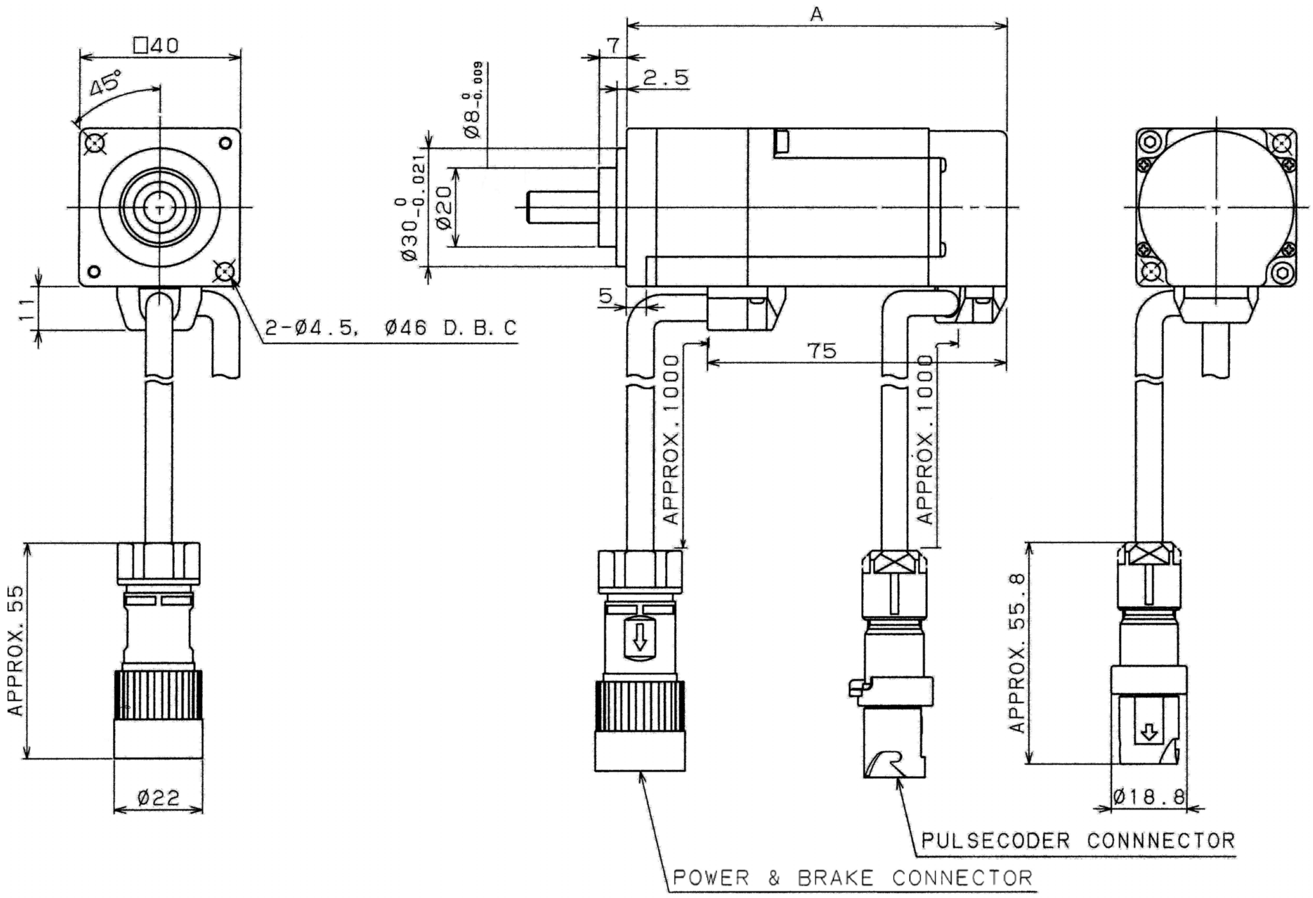
MODEL	A
β*i*S 0.2	95
β*i*S 0.3	109

Outline drawing of the motors (IP67 specification)



MODEL	A
βiS 0.2	59.5
βiS 0.3	73.5

Outline drawing of the motors (IP67 specification, with a brake)



MODEL	A
β*i*S 0.2	95
β*i*S 0.3	109

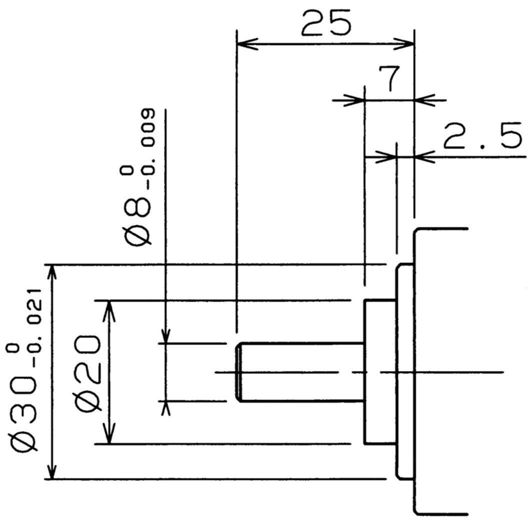
7.1.2 Shaft Shape

Shaft shape types

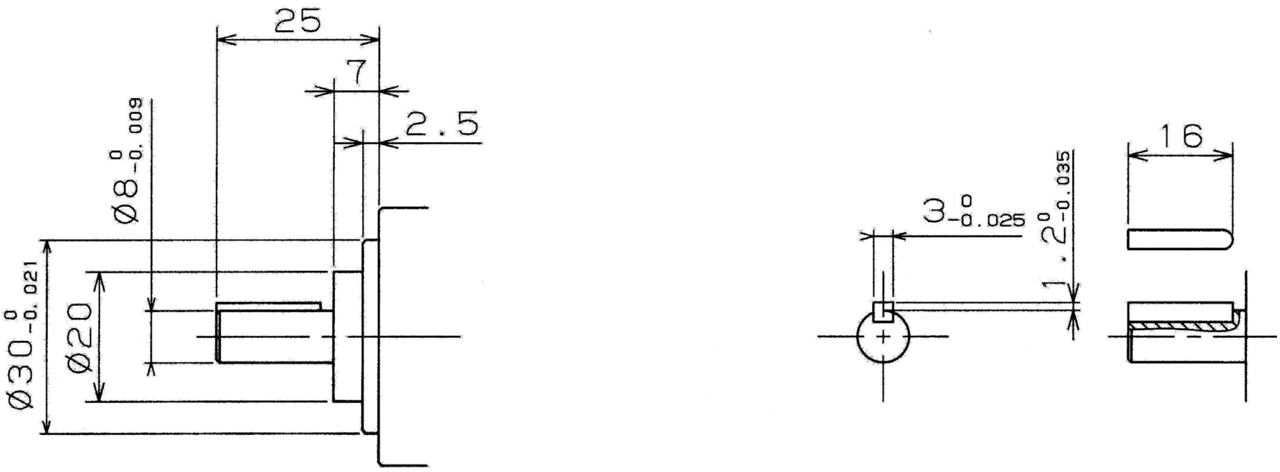
The shafts of the motors have the following shapes:。

	Straight shaft	Straight shaft with key way
β*i*S 0.2	ϕ8	ϕ8
β*i*S 0.3	ϕ8	ϕ8

ϕ8 straight shaft



ϕ8 straight shaft with key way



7.1.3 Allowable Axis Load

The allowable axis load is indicated below.
For details of the allowable axis load, see Chapter 3, “USAGE”.

Radial load	Axial load	(Reference) Front bearing specification
63[N] (6.4 [kgf])	39[N] (4 [kgf])	699

7.1.4 Shaft Run-out Precision

The shaft run-out precision is indicated below.
For details of the shaft run-out precision, see Chapter 3, “USAGE”.

Shaft dia. run-out	Faucet joint run-out	Mounting face run-out
0.02mm or less	0.04mm or less	0.06mm or less

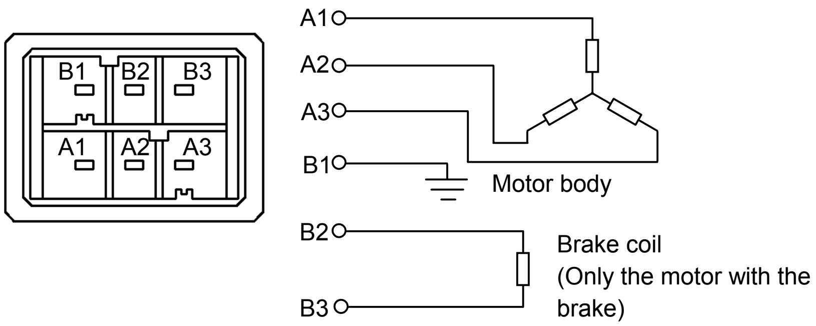
7.1.5 Power and Brake Connector

Standard

Manufacture: Tyco Electronics AMP
Manufacturer specification: 3-179554-3

The power and brake connector does not have a dripproof property when engaged with the connector on the cable side.

The following shows the shape and pin layout of the power connector.



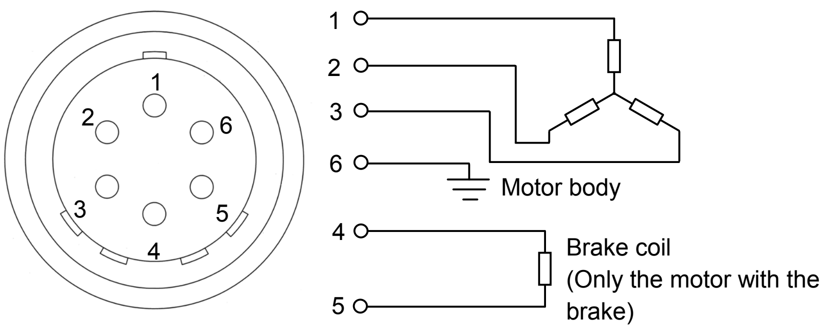
> **NOTE**
> No surge absorber for brake is contained in the motor. Prepare a surge absorber in the power magnetics cabinet.

IP67 specification

Manufacture: MOLEX JAPAN Co., Ltd.
Manufacturer specification: 500381-0000

The power and brake connector has a dripproof property when engaged with the connector on the cable side.

The following shows the shape and pin layout of the power connector.

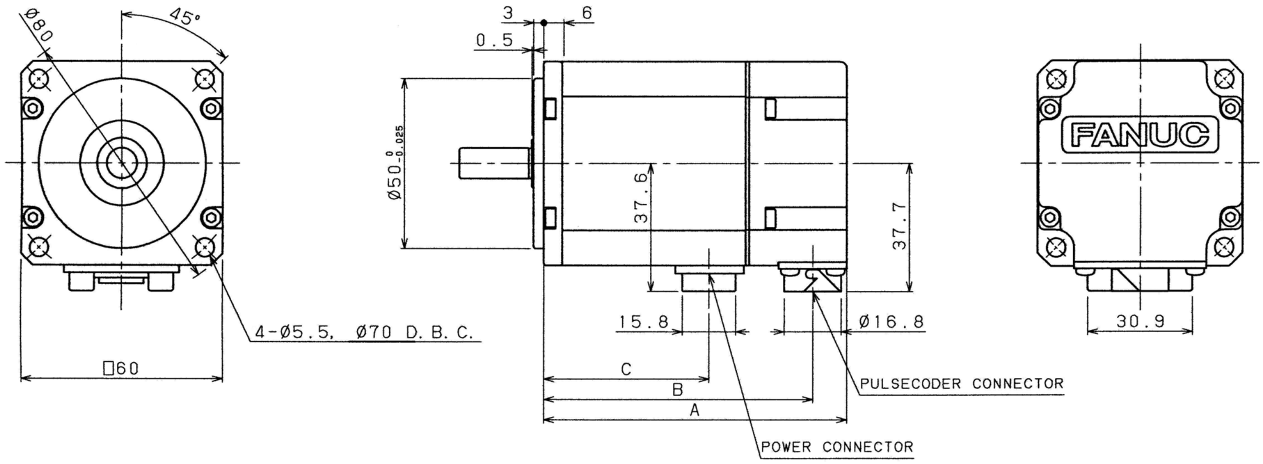


> **NOTE**
> No surge absorber for brake is contained in the motor. Prepare a surge absorber in the power magnetics cabinet.

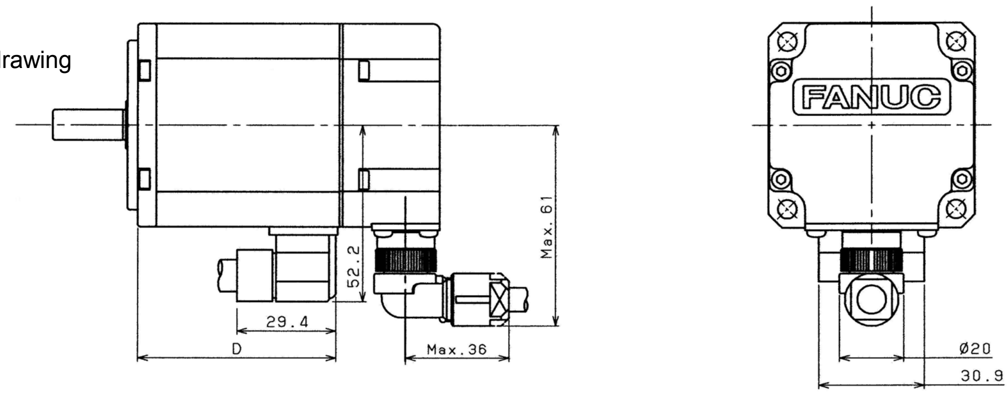
7.2 MODELS β*i*S 0.4 TO β*i*S 1

7.2.1 Outline Drawing of the Motors

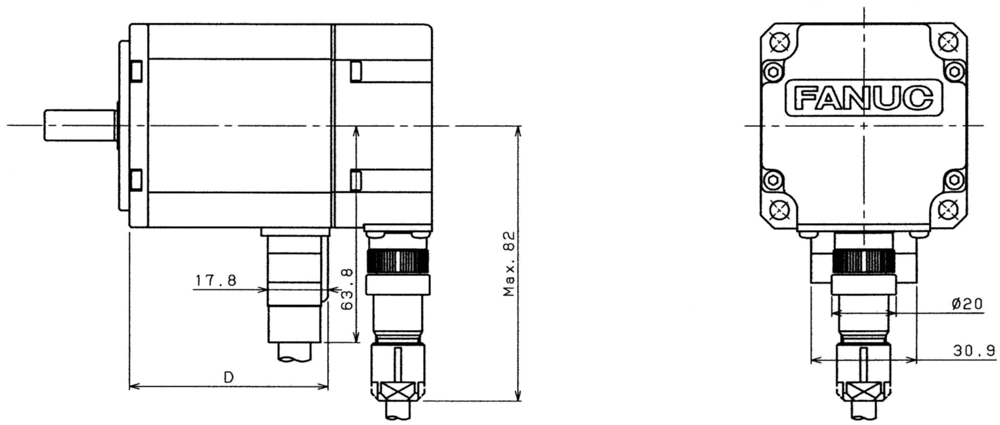
Outline drawing of the motors (standard)



Connector engagement drawing (right angle)

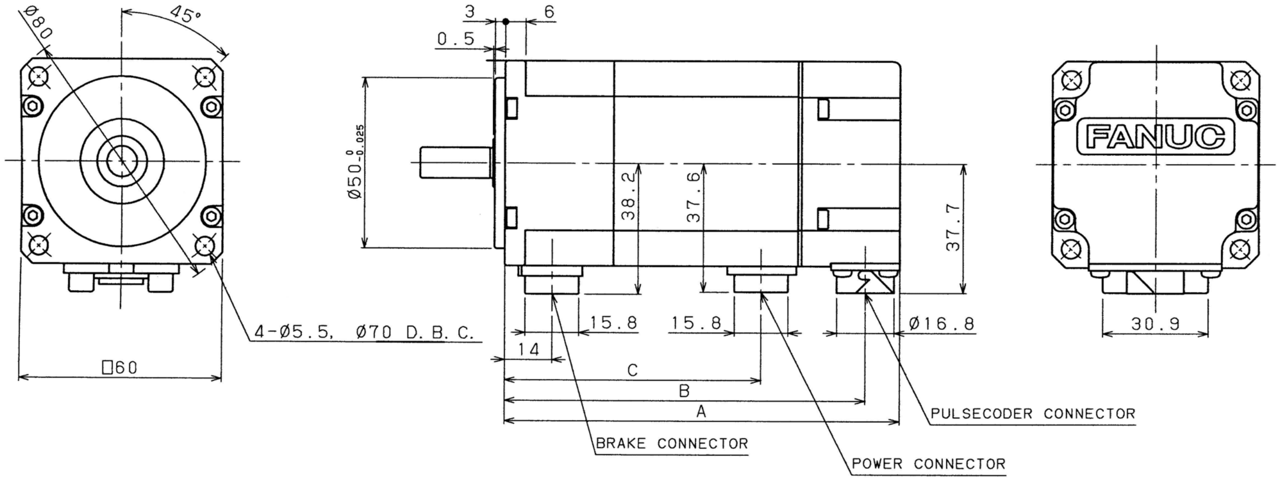


Connector engagement drawing (straight)

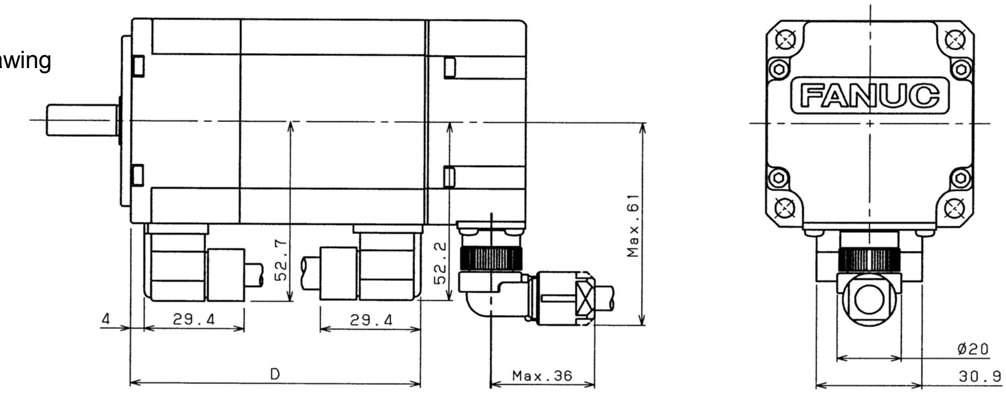


MODEL	A	B	C	D
β*i*S 0.4	75	65	34.5	44.3
β*i*S 0.5	89.5	79.5	49	58.8
β*i*S 1	118.5	108.5	78	87.8

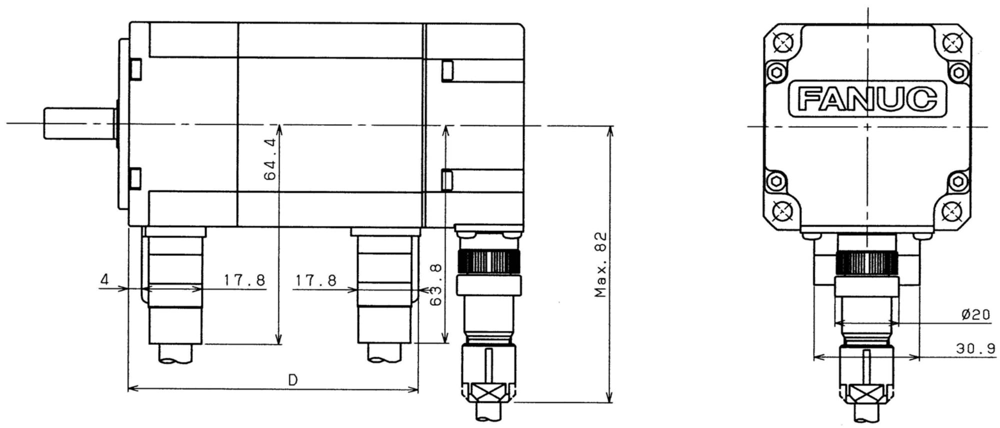
Outline drawing of the motors (with a brake)



Connector engagement drawing (right angle)



Connector engagement drawing (straight)



MODEL	A	B	C	D
βiS 0.4	101.5	91.5	61	70.8
βiS 0.5	116	106	75.5	85.3
βiS 1	145	135	104.5	114.3

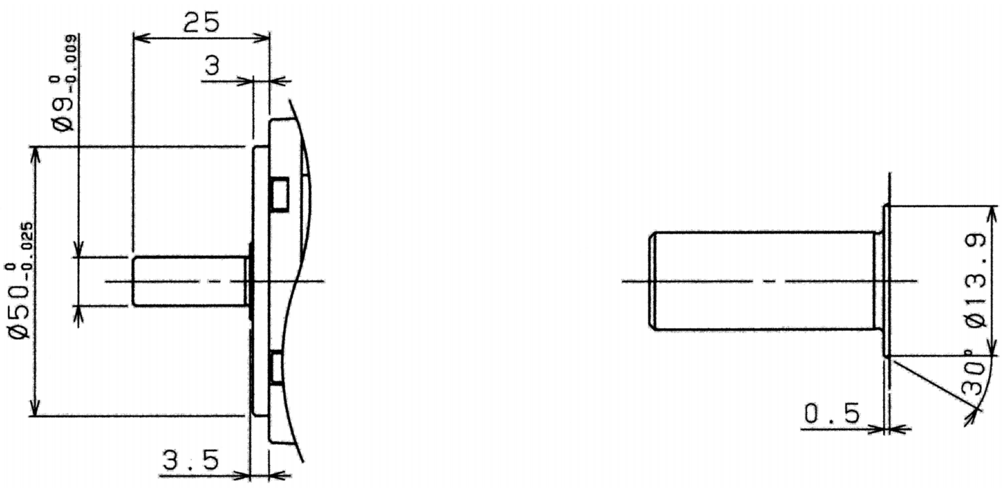
7.2.2 Shaft Shape

Shaft shape types

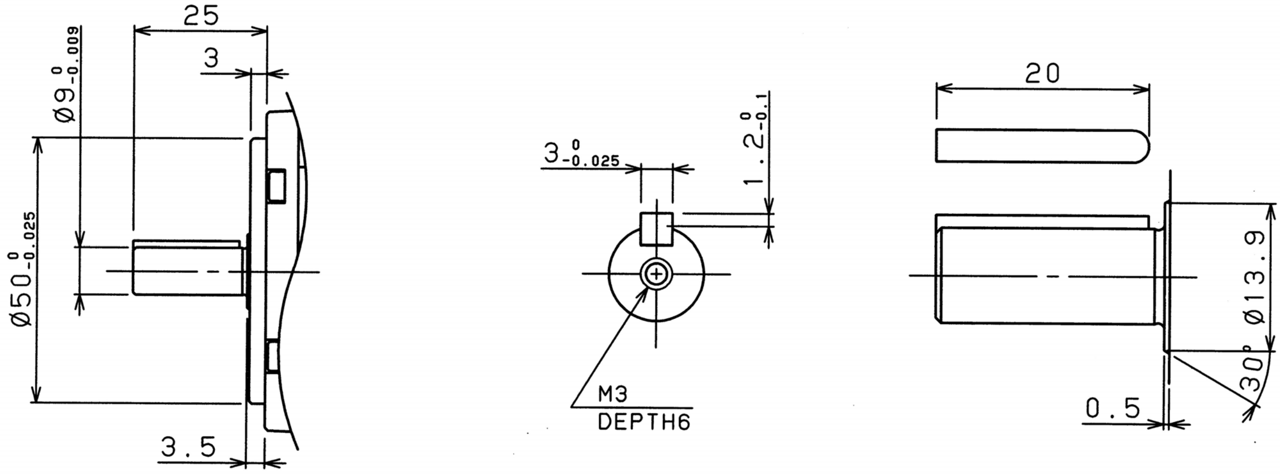
The shafts of the motors have the following shapes:。

	Straight shaft	Straight shaft with key way
β*i*S 0.4	ϕ9	ϕ9
β*i*S 0.5	ϕ9	ϕ9
β*i*S 1	ϕ14	ϕ14

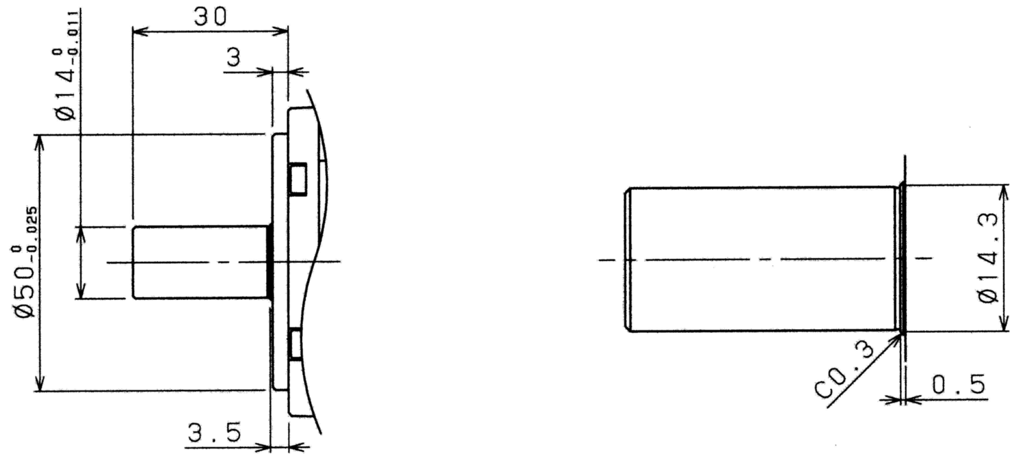
ϕ9 straight shaft



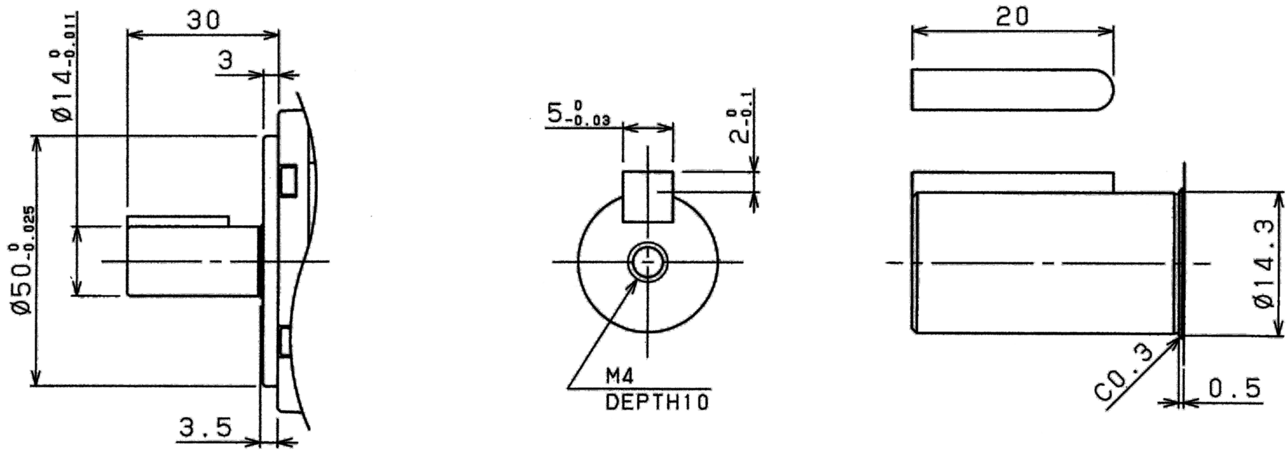
ϕ9 straight shaft with key way



ϕ14 straight shaft



ϕ14 straight shaft with key way



7.2.3 Allowable Axis Load

The allowable axis load is indicated below.
For details of the allowable axis load, see Chapter 3, “USAGE”.

Radial load	Axial load	(Reference) Front bearing specification
196[N] (20 [kgf])	49[N] (5 [kgf])	6902

7.2.4 Shaft Run-out Precision

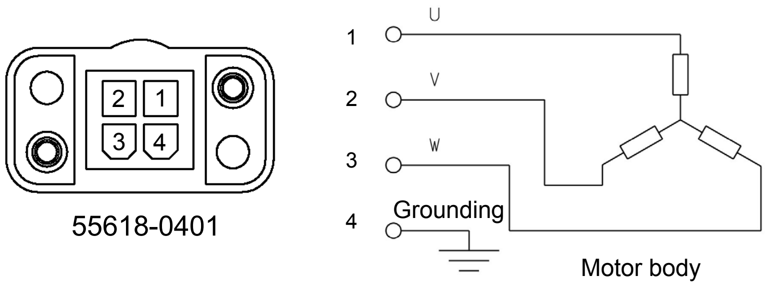
The shaft run-out precision is indicated below.
For details of the shaft run-out precision, see Chapter 3, “USAGE”.

Shaft dia. run-out	Faucet joint run-out	Mounting face run-out
0.02mm or less	0.04mm or less	0.06mm or less

7.2.5 Power Connector

Manufacture: MOLEX JAPAN Co., Ltd.
Manufacturer specification: 55618-0401

The power connector has a dripproof property when engaged with the connector on the cable side.
The following shows the shape and pin layout of the power connector.

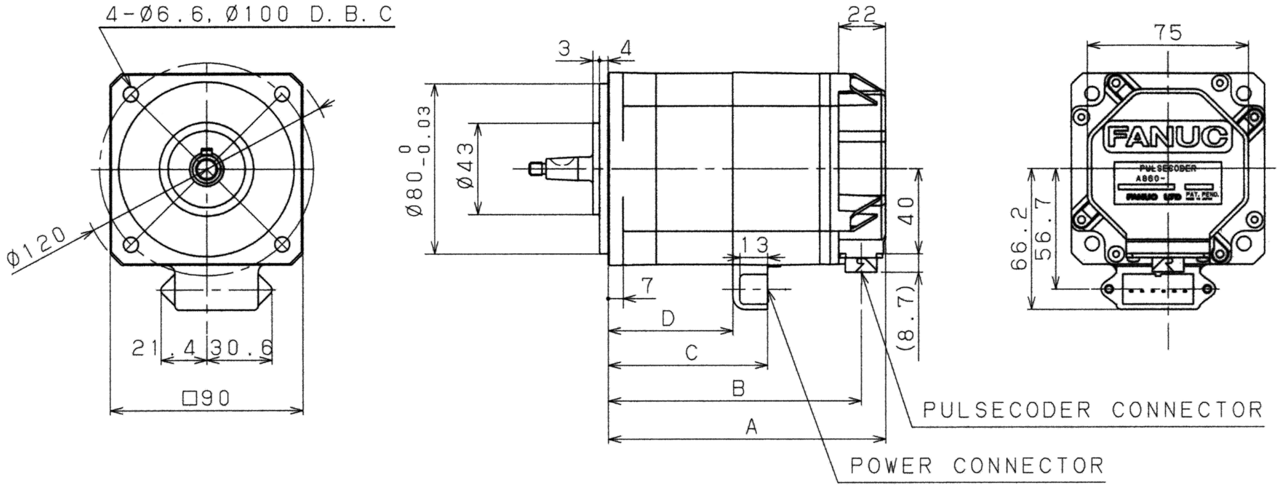


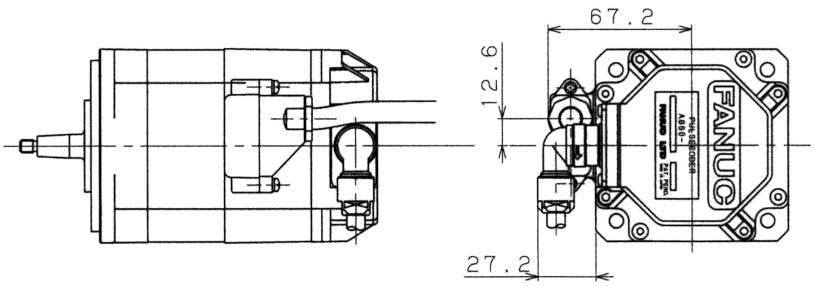
For the specifications, shapes, and pin layouts of the connectors of the pulsecoder, see Section 8.1, “PULSECODER”.

7.3 MODELS β*i*S 2, β*i*S 4, β*i*S 2 HV, AND β*i*S 4 HV

7.3.1 Outline Drawing of the Motors

Outline drawing of the motors (standard)

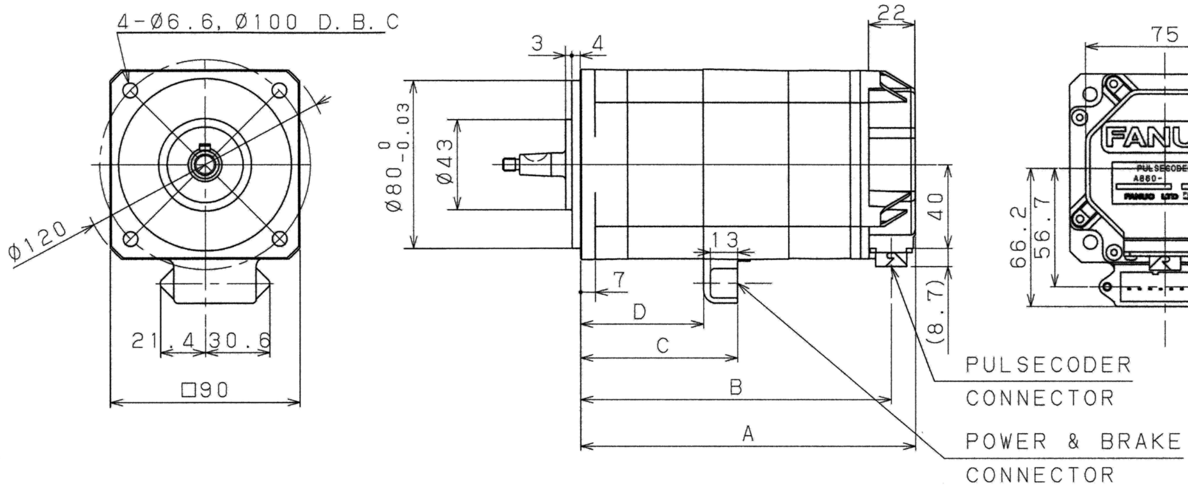


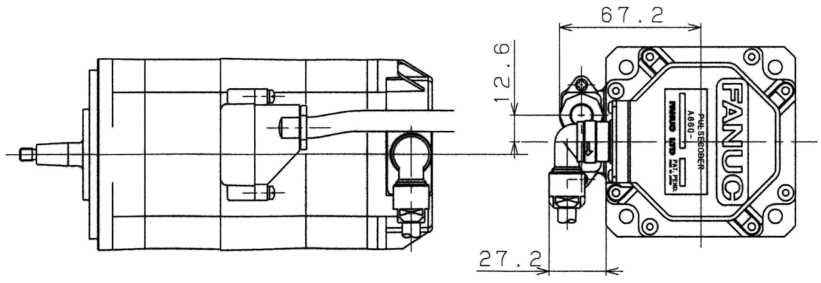


DIMENSION WITH CONNECTOR

MODEL	A	B	C	D
β*i*S 2, β*i*S 2HV	130	119	75	59
β*i*S 4, β*i*S 4HV	166	155	111	95

Outline drawing of the motors (with a brake)





DIMENSION WITH CONNECTOR

MODEL	A	B	C	D
β*i*S 2, β*i*S 2HV	159	148	75	59
β*i*S 4, β*i*S 4HV	195	184	111	95

7.3.2 Shaft Shape

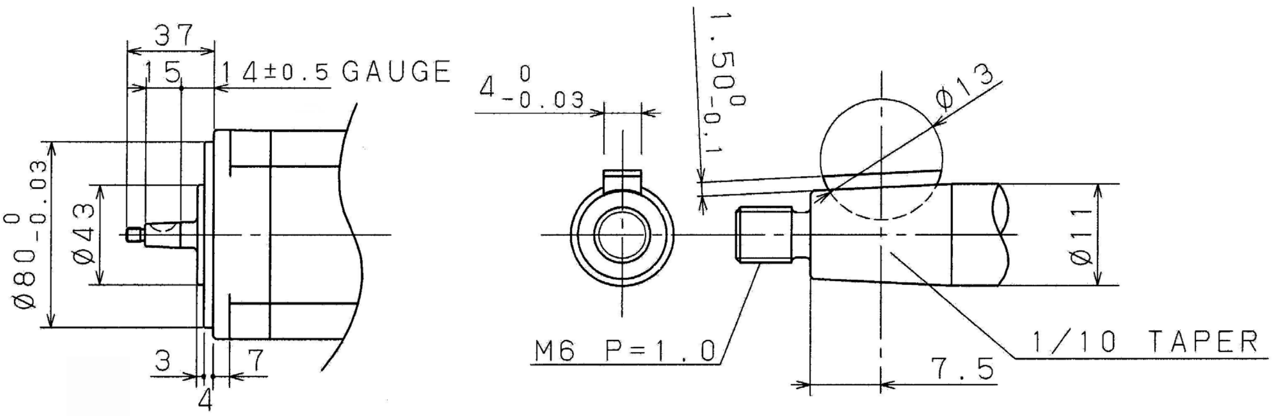
Shaft shape types

The shafts of the motors have the following shapes:

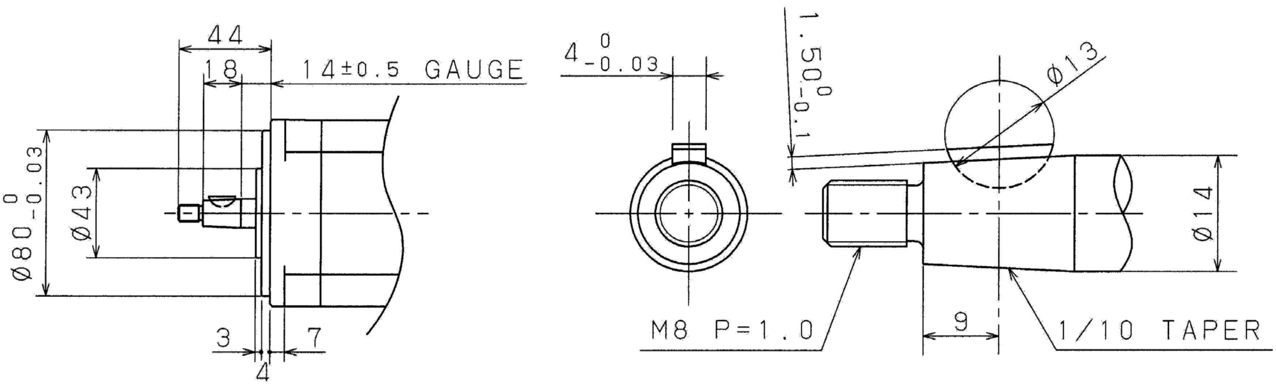
	Taper shaft	Straight shaft	Straight shaft with key way
β*i*S 2, β*i*S 2HV	φ11	φ10	φ10
β*i*S 4,β*i*S 4HV	φ14	φ14	φ14

Shaft details

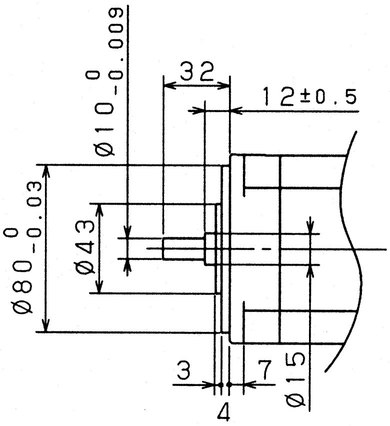
・φ11 taper shaft



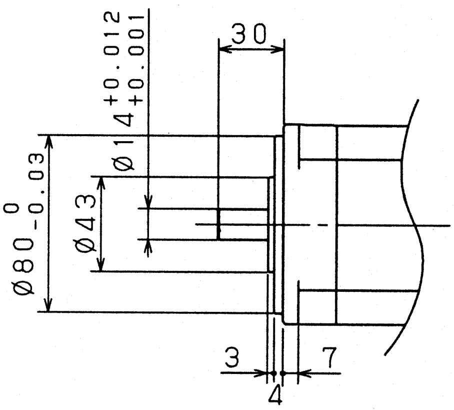
・φ14 taper shaft



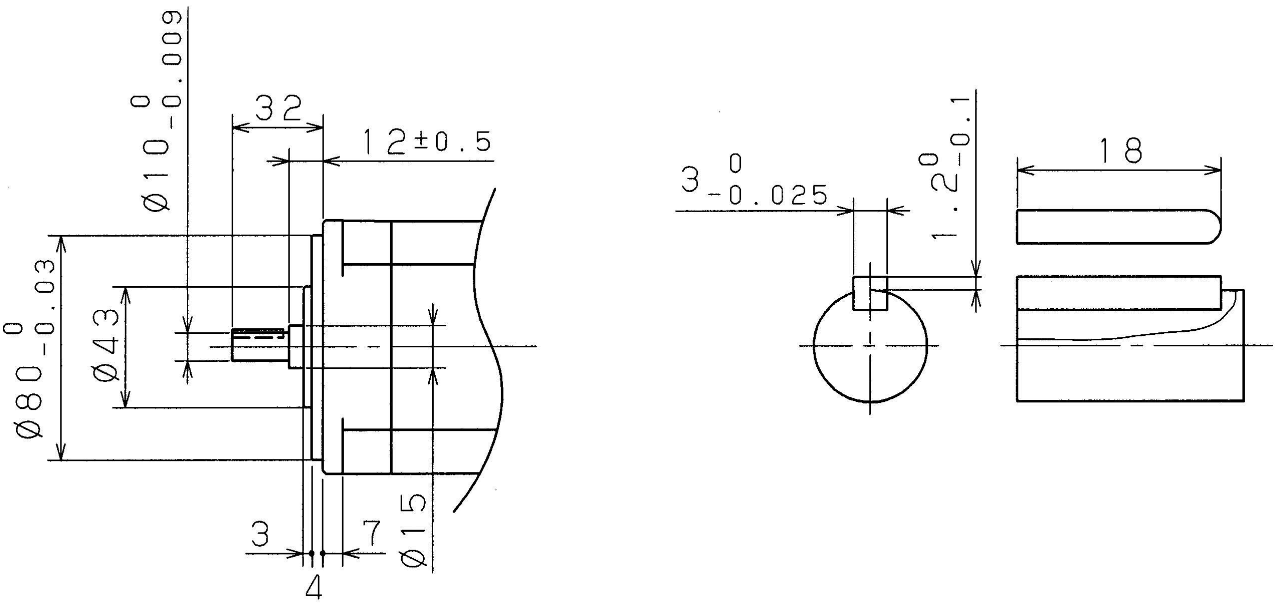
- **ϕ10 straight shaft**



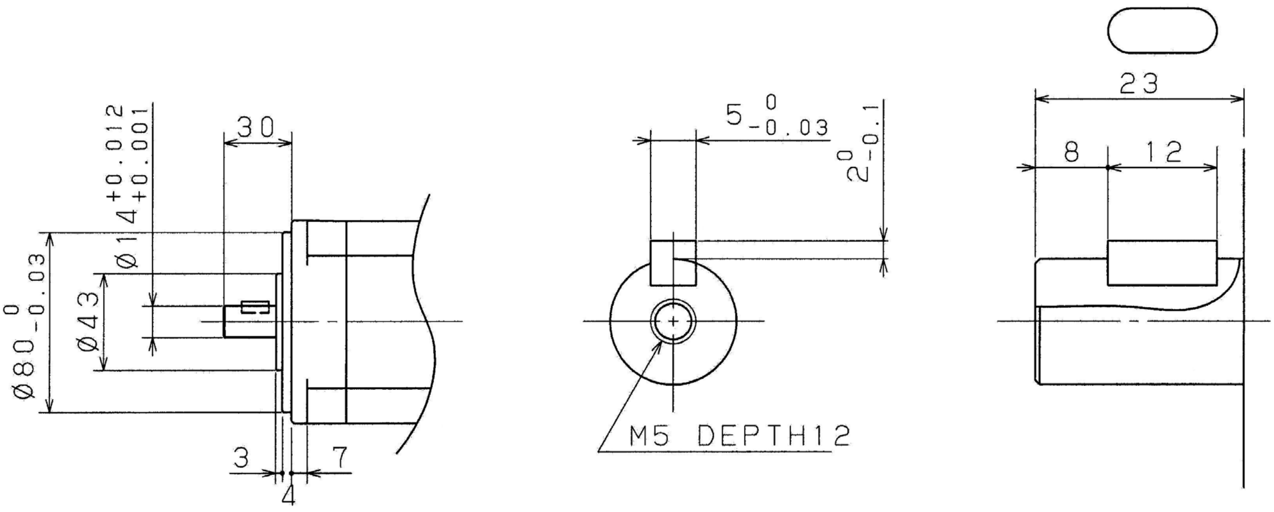
- **ϕ14 straight shaft**



- **ϕ10 straight shaft with key way**



· ϕ14 straight shaft with key way



7.3.3 Allowable Axis Load

The allowable axis load is indicated below.
For details of the allowable axis load, see Chapter 3, "USAGE".

Radial load	Axial load	(Reference) Front bearing specification
245[N] (25 [kgf])	78[N] (8 [kgf])	6003

7.3.4 Shaft Run-out Precision

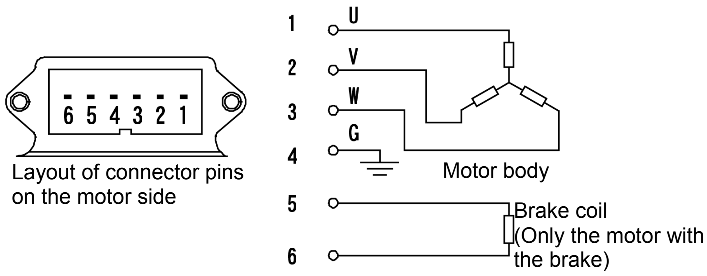
The shaft run-out precision is indicated below.
For details of the shaft run-out precision, see Chapter 3, "USAGE".

Shaft dia. run-out	Faucet joint run-out	Mounting face run-out
0.02mm or less	0.04mm or less	0.06mm or less

7.3.5 Power and Brake Connector

Manufacture: Tyco Electronics AMP
Manufacturer specification: 1473060-2

The power and brake connector does not have a dripproof property when engaged with the connector on the cable side.
The following shows the shape and pin layout of the power connector.



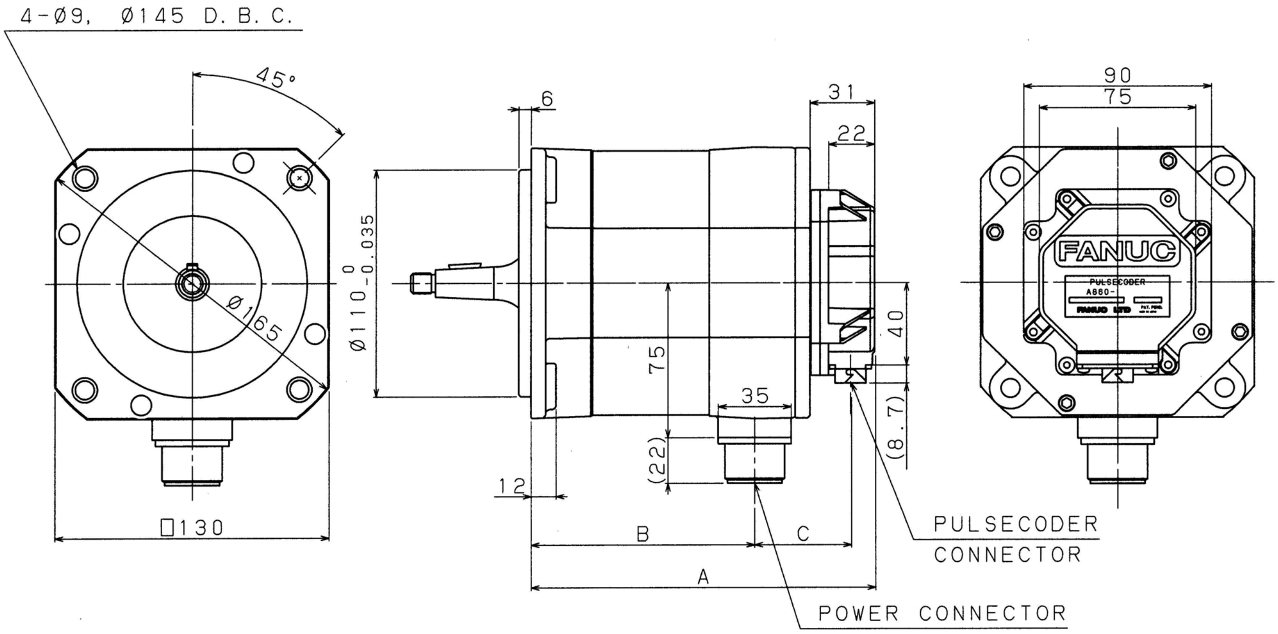
> **NOTE**
> No surge absorber for brake is contained in the motor. Prepare a surge absorber in the power magnetics cabinet.

For the specifications, shapes, and pin layouts of the connectors of the pulsecoder, see Section 8.1, "PULSECODER".

7.4 MODELS βiS 8, βiS 12, βiS 8HV, AND βiS 12HV

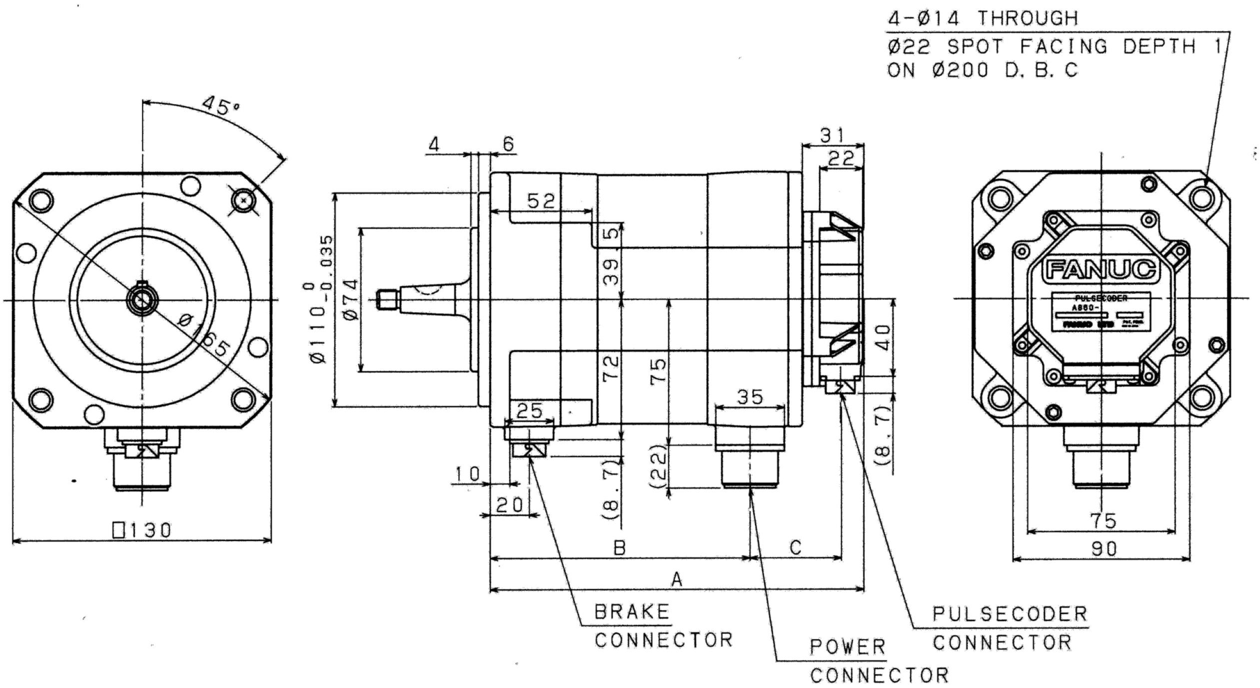
7.4.1 Outline Drawing of the Motors

Outline drawing of the motors (standard)



MODEL	A	B	C
βiS 8, βiS 8HV	166	108	47
βiS 12, βiS 12HV	222	164	

Outline drawing of the motors (with a brake)



MODEL	A	B	C
β*i*S 8, β*i*S 8HV	191	133	47
β*i*S 12, β*i*S 12HV	247	189	

7.4.2 Shaft Shape

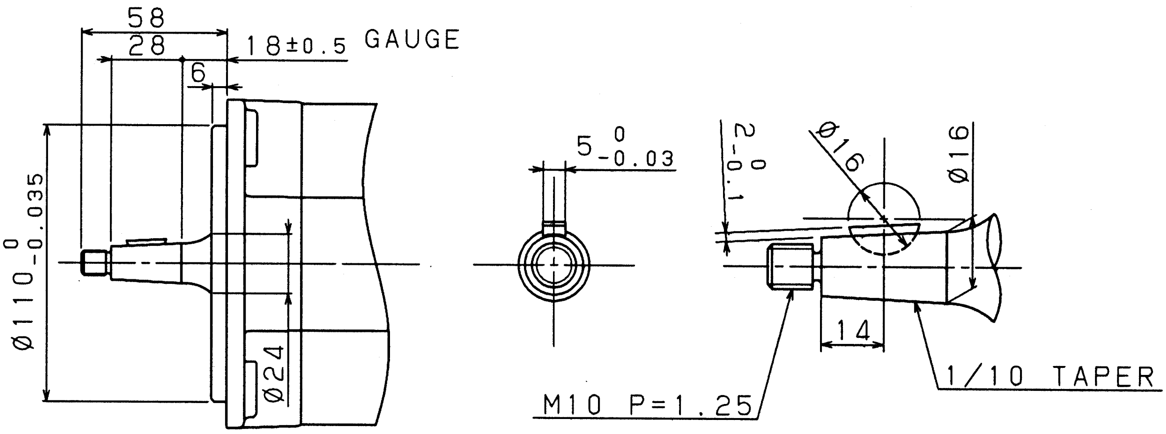
Shaft shape types

The shafts of the motors have the following shapes:

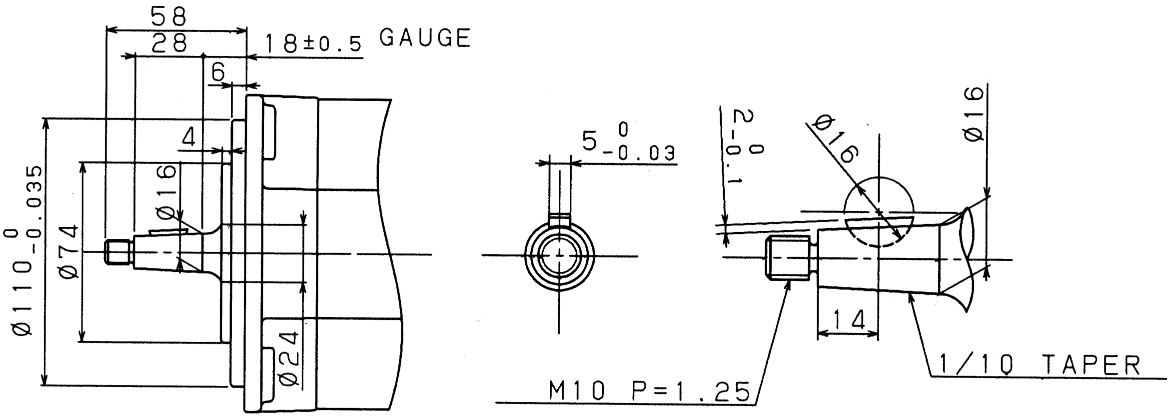
	Taper shaft	Straight shaft	Straight shaft with key way
β*i*S 8,β*i*S 8HV	ϕ16	ϕ19	ϕ19
β*i*S 12,β*i*S 12HV	ϕ16	ϕ24	ϕ24

Shaft details

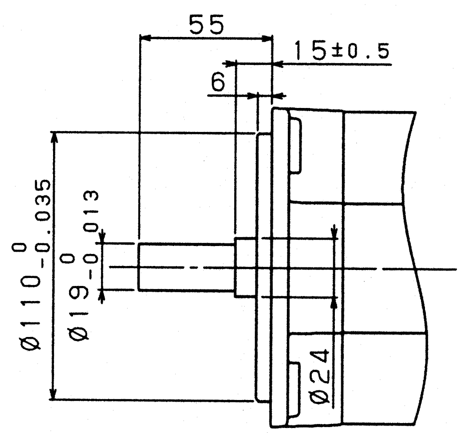
- ϕ16 taper shaft (standard)



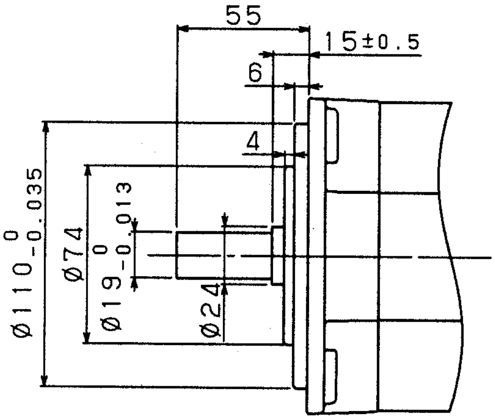
- **ϕ16 taper shaft (with a brake)**



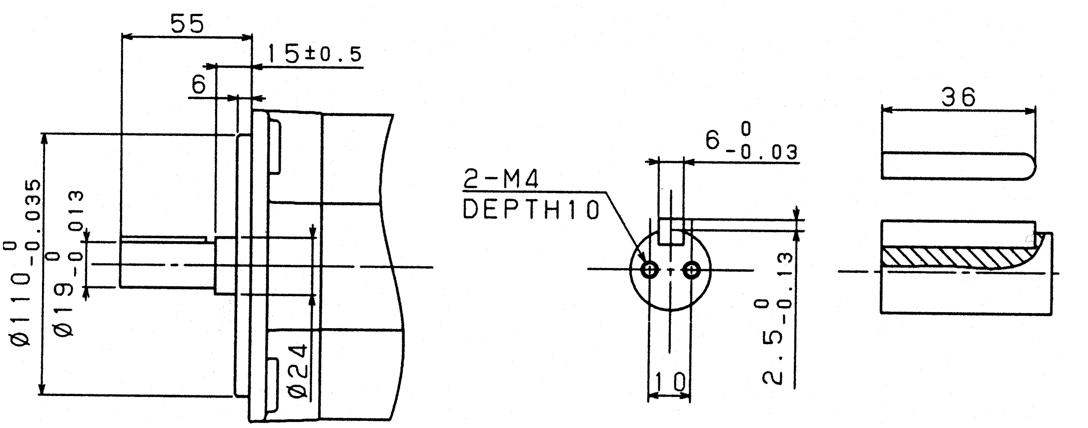
- **ϕ19 straight shaft (standard)**



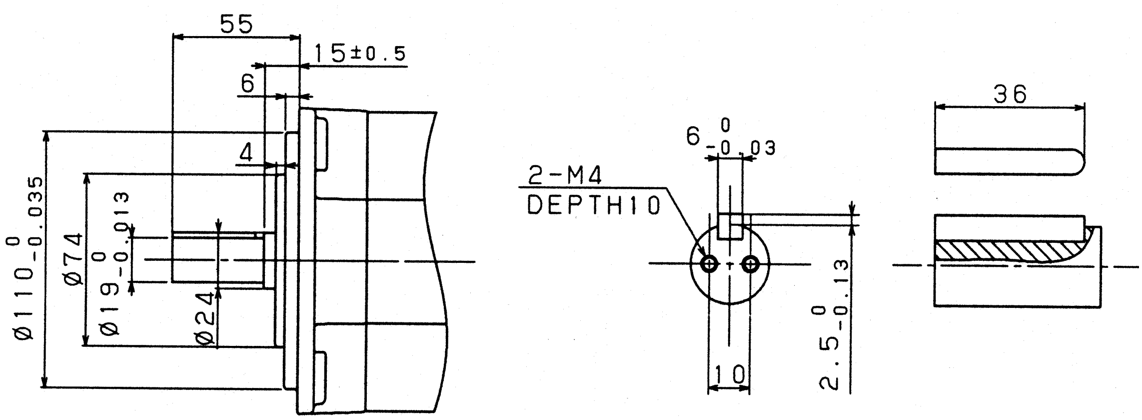
- **ϕ19 straight shaft (with a brake)**



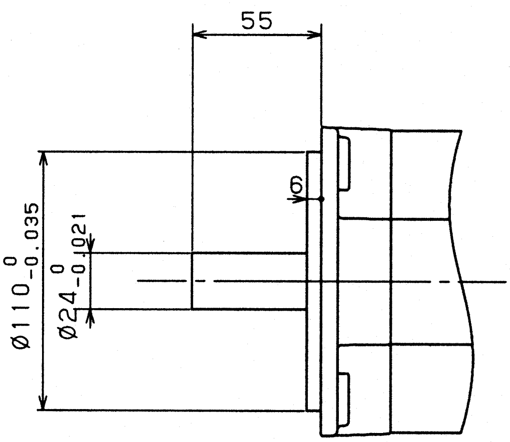
- **ϕ19 straight shaft with key way (standard)**



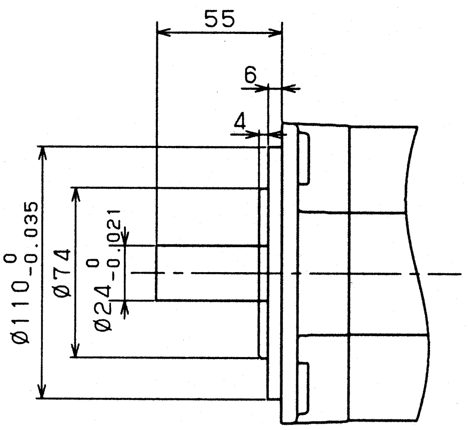
- **ϕ19 straight shaft with key way (with a brake)**



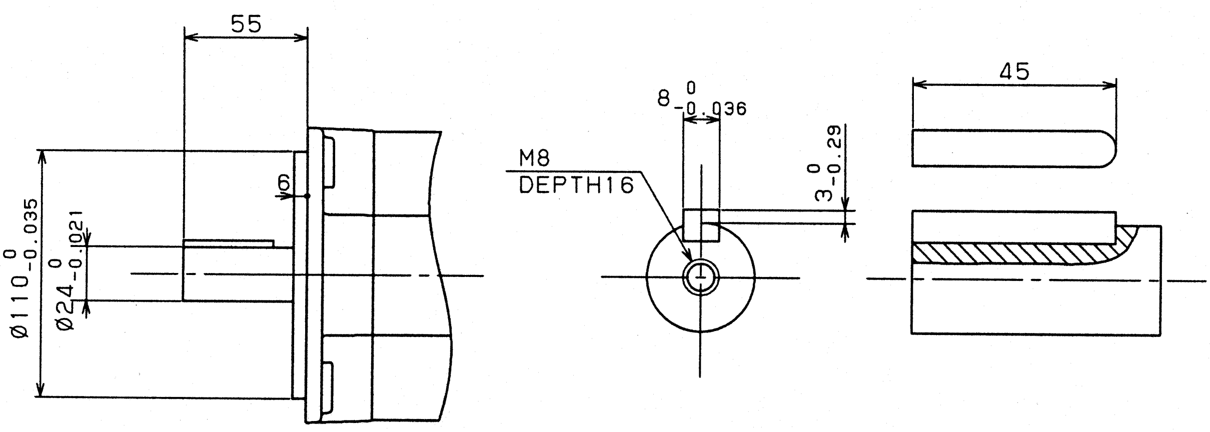
- **ϕ24 straight shaft (standard)**



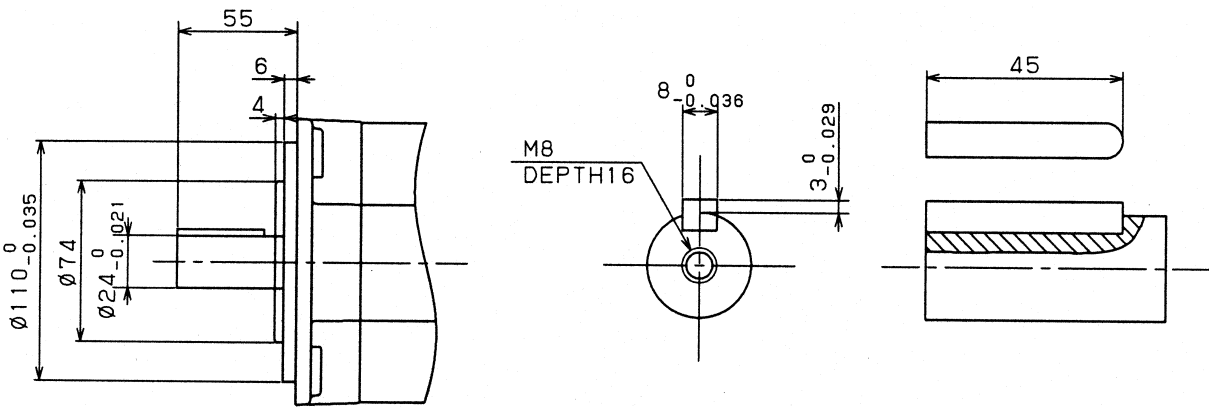
・ϕ24 straight shaft (with a brake)



・ϕ24 straight shaft with key way (standard)



・ϕ24 straight shaft with key way (with a brake)



7.4.3 Allowable Axis Load

The allowable axis load is indicated below.
For details of the allowable axis load, see Chapter 3, “USAGE”.

Radial load	Axial load	(Reference) Front bearing specification
686[N] (70 [kgf])	196[N] (20 [kgf])	6205

7.4.4 Shaft Run-out Precision

The shaft run-out precision is indicated below.
For details of the shaft run-out precision, see Chapter 3, “USAGE”.

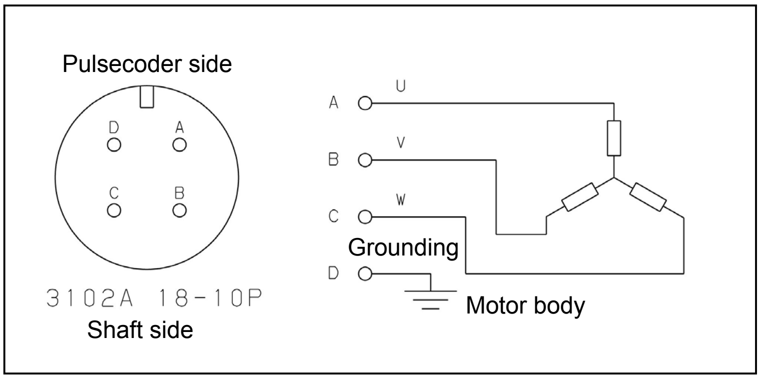
Shaft dia. run-out	Faucet joint run-out	Mounting face run-out
0.02mm or less	0.04mm or less	0.06mm or less

7.4.5 Power Connector

Manufacture: Hirose Electric
Manufacturer specification: H/MS3102A18-10P-D-T(10)

As the power connector a receptacle connector having a dripproof property by itself (when it is not engaged) is used as standard. Strictly speaking, this power connector does not meet the MS standard, but it can be used as a connector compatible with the MS-standard round connector.

The following shows the shape and pin layout of the power connector.

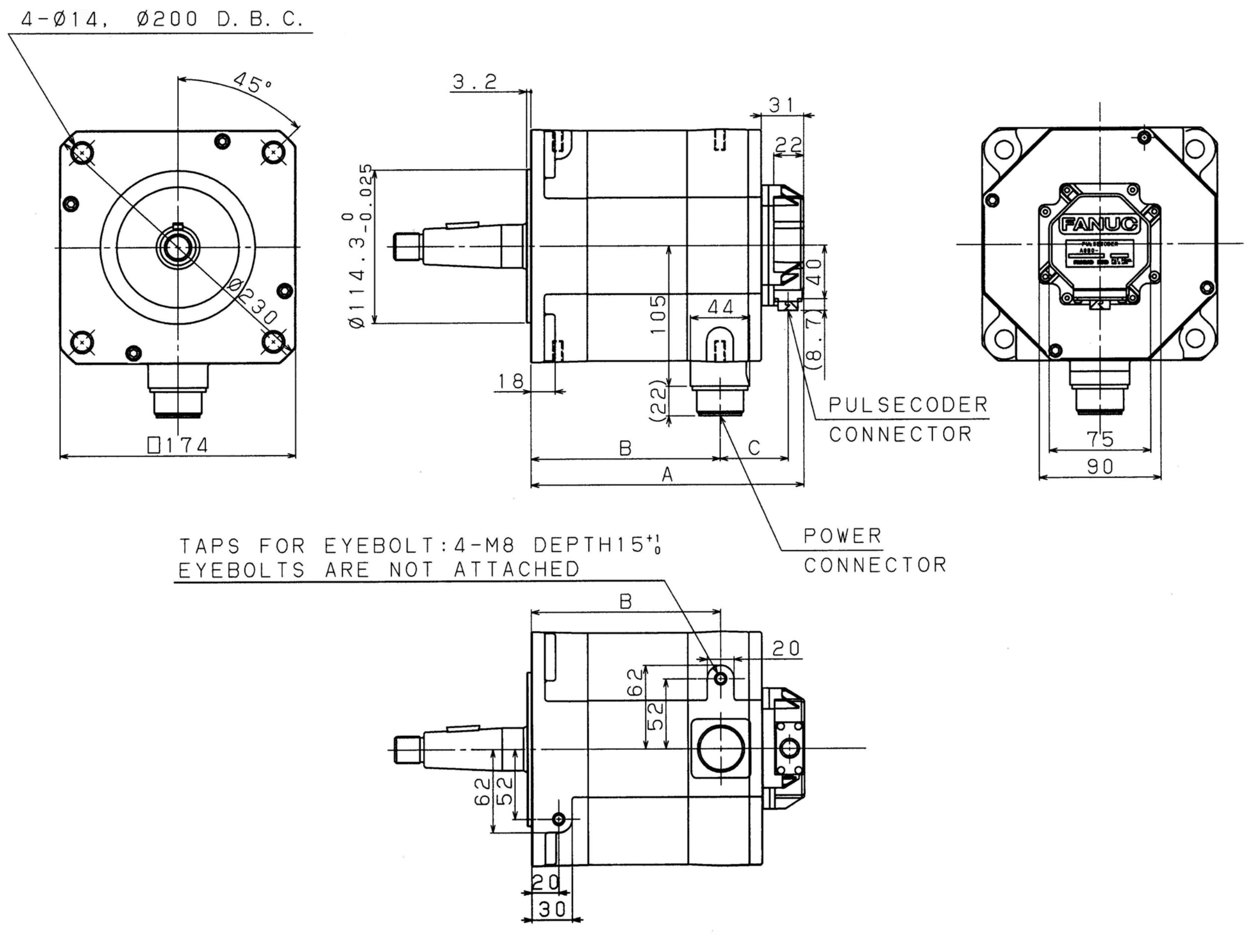


For the specifications, shapes, and pin layouts of the connectors of the pulsecoder, see Section 8.1, "PULSECODER".

7.5 MODELS βiS 22 AND βiS 22HV

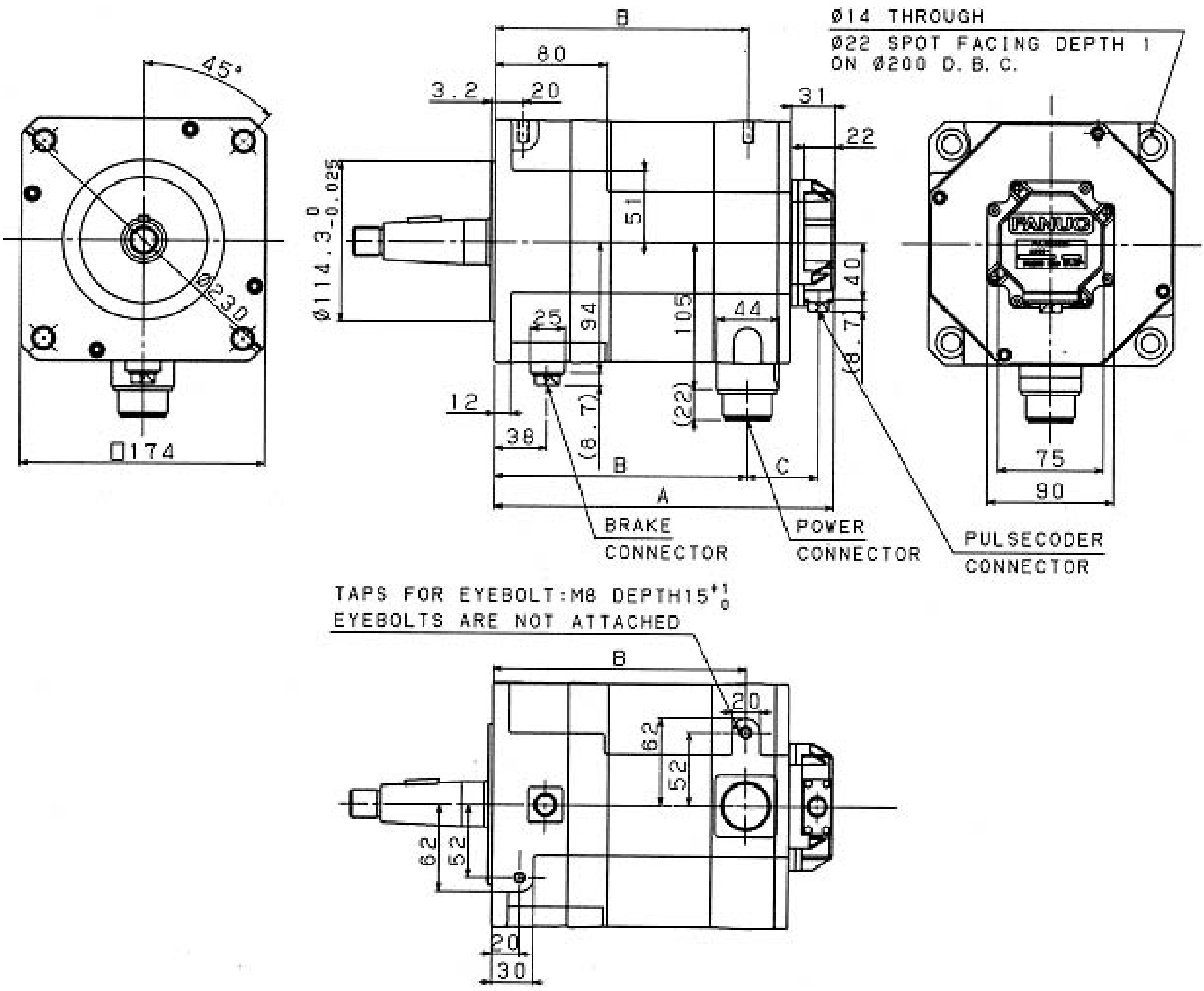
7.5.1 Outline Drawing of the Motors

Outline drawing of the motors (standard)



MODEL	A	B	C
βiS 22, βiS 22HV	202	141	50

Outline drawing of the motors (with a brake)



MODEL	A	B	C
β*i*S 22, β*i*S 22HV	243	182	50

7.5.2 Shaft Shape

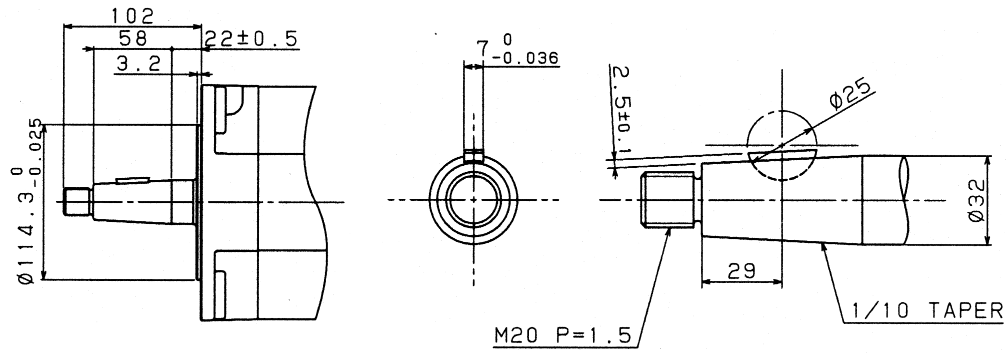
Shaft shape types

The shafts of the motors have the following shapes:

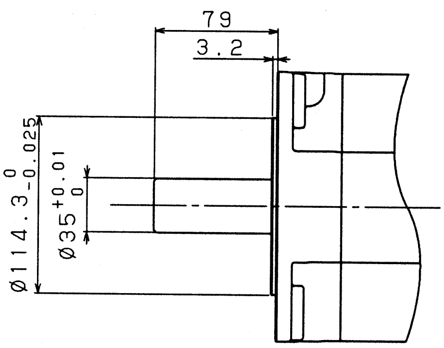
	Taper shaft	Straight shaft	Straight shaft with key way
β*i*S 22,β*i*S 22HV	φ32	φ35	φ35

Shaft details

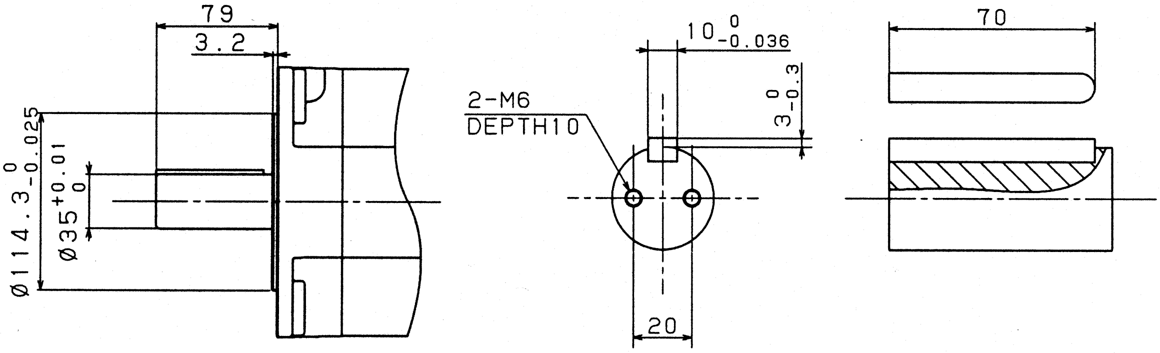
- **φ32 taper shaft**



- **φ35 straight shaft**



- **φ35 straight shaft with key way**



7.5.3 Allowable Axis Load

The allowable axis load is indicated below.
For details of the allowable axis load, see Chapter 3, “USAGE”.

Radial load	Axial load	(Reference) Front bearing specification
1960[N] (200 [kgf])	588[N] (60 [kgf])	6208

7.5.4 Shaft Run-out Precision

The shaft run-out precision is indicated below.
For details of the shaft run-out precision, see Chapter 3, “USAGE”.

Shaft dia. run-out	Faucet joint run-out	Mounting face run-out
0.03mm or less	0.05mm or less	0.07mm or less

7.5.5 Connector

Types of power connectors

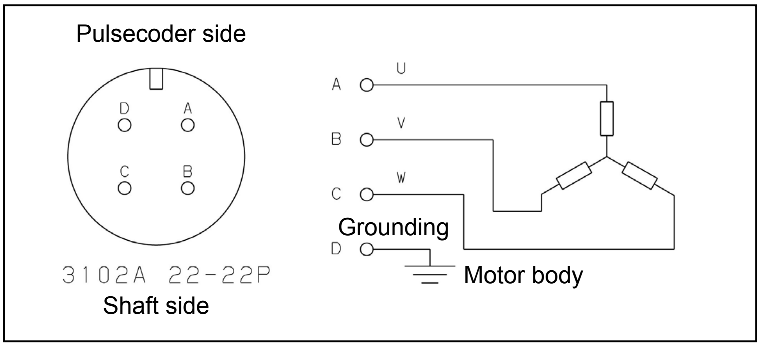
The following power connectors are used for the motors:

· MS22-22P compatible connector

Manufacture: Japan Aviation Electronics Industry
Manufacturer specification: JL04 HV-2E22-22PE-BT-R

As the power connector a receptacle connector having a dripproof property by itself (when it is not engaged) is used as standard. Strictly speaking, this power connector does not meet the MS standard, but it can be used as a connector compatible with the MS-standard round connector.

The following shows the specification, shape, and pin layout of the power connector.



8 FEEDBACK SENSOR

All β*i* series AC Servo Motors contain Pulsecoder (optical encoder) as a feedback sensor which detects position and velocity.
Separate type position sensors are also available for detecting a position by attaching directly to a ball screw or machine.

Chapter 8, "FEEDBACK SENSOR", consists of:

8.1 PULSECODER

All AC Servo Motors β*i* series feature Pulsecoder (optical encoder).
The Pulsecoder outputs position information and an alarm signal.
The outline drawing of Pulsecoder is not given in this section because it is contained in a motor. See the outline drawing (Chapter 7, "OUTLINE DRAWINGS") of each motor model.

8.1.1 Types of Pulsecoders and Designation

The following table lists the types of Pulsecoders.

Pulsecoder type	Resolution [Division/rev]	Absolute/ incremental	Applicable motor
βA 64B	65,536	Absolute	β*i*S 0.2 and β*i*S 0.3
β*i*A 64	65,536	Absolute	β*i*S 0.4 to β*i*S 1
β*i*A 128	131,072	Absolute	β*i*S 2 to β*i*S 22 (including HV)
β*i*A 128 (for the FS0*i* only)	131,072	Absolute	β*i*S 2 to β*i*S 22

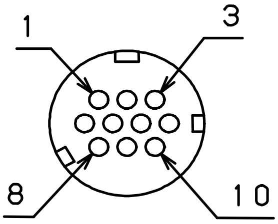
For how to specify Pulsecoder, see the Chapter 2, "ORDERING SPECIFICATION NUMBER" because Pulsecoder is specified together with a motor.

8.1.2 Connecting Pulsecoder

Connector

The connectors of the β*i* series pulsecoders are dripproof when engaged with connectors on the cable side other than the βA 64B. (When the motor is left singly, the connector is dripproof when the cap mounted at shipment is fit in the connector.)
The signals of the β*i* series Pulsecoder are arranged as follows:

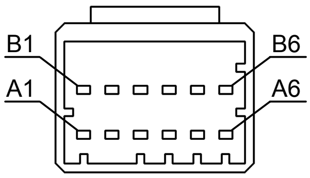
βA 64B(IP67 specification),β*i*A 64,β*i*A 128,β*i*A 128(for the FS0*i* only)



Manufacturer specification:
JN2AS10UL1-R(Japan Aviation Electronics Industry)
HR34B-12WR-10PD(Hirose Electric)
(β*i*A 64, β*i*A 128,β*i*A 128 for the FS0*i* only)

JN1HS10PL1(Japan Aviation Electronics Industry)
(β*i*A 64B(IP67 specification))

βA 64B



Manufacturer specification: 1-1318115-6(Tyco Electronics AMP)

Signal name	Pin No.				
	βA 64B	βA 64B (IP67 specification)	β*i*A 64	β*i*A 128	β*i*A 128 (for the FS0*i* only)
SD	A4	2	-	-	-
*SD	B4	1	-	-	-
REQ	A3	6	-	-	-
*REQ	B3	5	-	-	-
RD	-	-	6	6	6
*RD	-	-	5	5	5
+5V	A2,B2	8,9	8,9	8,9	8,9
0V	A1,B1,A6	7,10	7,10	7,10	7,10
FG	B6	3	3	3	3
+6V	A5	4	4	4	4

Connector kits

For information on connectors and crimping jigs required for creating a feedback cable, see Section 10.1, “CONNECTORS FOR SIGNALS.”

> **NOTE**
> If the motor is mounted on a movable part, or a conduit hose is used for the connector, excessive force may be applied to the connector. In this case, fix the feedback cable to prevent the connector from being broken.

Connecting Pulsecoder to an amplifier

For cables connecting Pulsecoder and amplifier, refer to "FANUC SERVO AMPLIFIER α*i* series Descriptions (B-65282EN)" or FANUC SERVO AMPLIFIER β*i* series Descriptions (B-65322EN)."
In particular, special care should be taken when the Pulsecoder is connected to an I/O link amplifier. For details, refer to the description of the I/O link amplifier in "FANUC SERVO AMPLIFIER β*i* series Descriptions (B-65322EN)".

8.1.3 Absolute-type Pulsecoder

When the CNC is turned off, the Pulsecoder position detection function is backed up by battery. So, when the CNC is next turned on, the operator does not have to perform reference position return.
For backup, a battery unit must be installed in the CNC or servo amplifier.
If a low-battery indication appears on the CNC, replace the new battery as soon as possible.
For this Pulsecoder, the function is backed up for about 10 minutes by a backup capacitor when the battery is removed. In the backup status, the battery can be replaced when the power to the servo amplifier is off.
The operator does not also have to perform reference position return after replacing the feedback cable or servo amplifier. Note that the βA 64B pulsecoder does not contain a backup capacitor.

8.2 SEPARATE PULSECODER

For detecting a position by attaching directly to a ball screw or a machine, use a separate Pulsecoder.

8.2.1 Separate Pulsecoder Type and Designation

Separate Pulsecoder are available.

Separate Pulsecoder name	Resolution	Allowanble maximum speed	Absolute/ incremental	Ordering number
αA1000S	1,000,000 /rev	4000min^{-1}	Absolute	**A860-0372-T001**

8.2.2 Separate Pulsecoder Specifications

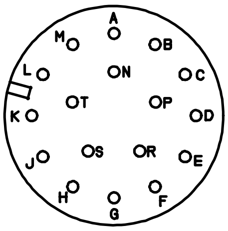
Pulsecoder αA1000S

Item		Specification
Power voltage		5 [V]±5%
Current consumption		Up to 0.3 [A]
Working temperature range		0 to +60 [°C]
Resolution		1,000,000 [/rev.]
Maximum speed of rotation		4000 [min^{-1}]
Input shaft inertia		Up to 1×10^{-4} [kg·m^2]
Input shaft startup torque		Up to 0.1 [N·m]
Input shaft allowable load	Radial	100 [N]
	Axial	50 [N]
Shaft diameter run-out		0.02×10^{-3}[m]
Structure		Dust-proof, drip-proof (IP55 or equivalent: when water-proof connector is fitted)
Vibration resistance acceleration		5 [G] (50 to 2,000[Hz])
Weight		Approx. 0.75 [kg]

8.2.3 Connecting a Separate Type Pulsecoder

The layout of connector pins is shown below.
For the connection diagram for separate type Pulsecoders, refer to the relevant CNC connection manual.

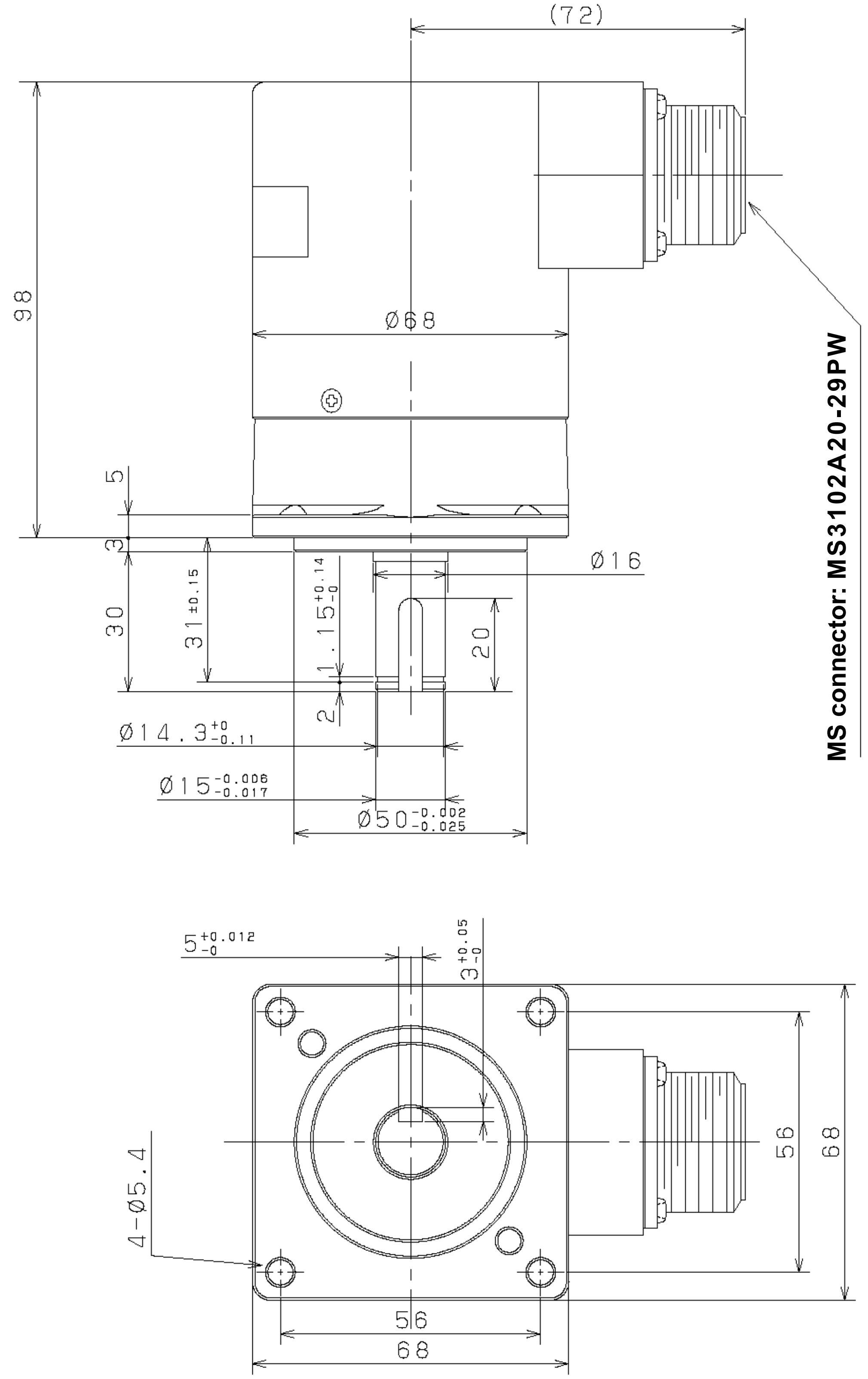
Layout of Connector Pins of Pulsecoder αA1000S



MS3102A20-29PW

Signal name	Pin No. αA1000S MS3102A20-29PW
SD	A
*SD	D
REQ	F
*REQ	G
+5V	J,K
0V	N,T
Shield	H
+6VA	R
0VA	S

8.2.4 Outline Drawings of Separate Pulsecoder



Pulsecoder αA1000S

8.2.5 Cautions when Using a Separate Type Pulsecoder

Pay attention to the following items when using the separate Pulsecoder.

- Increase the machine rigidity between the servo motor and the Pulsecoder to minimize mechanical vibration. If the machine rigidity is low or the structure vibrates, poor performance, over shoot is likely to occur.

- When the separate Pulsecoder is used, the influence of gear, ball screw pitch error or table inclination is decreased and the positioning accuracy and geometrical accuracy (roundness, etc.) are increased, but the smoothness may deteriorate due to the elasticity in the machine between the servo motor and the separate Pulsecoder.

- It is necessary to use the built-in Pulsecoder with a resolution equal to or finer than that of the separate Pulsecoder.

To connect the separate Pulsecoder to the CNC, connect only the signals described in the CNC Connection Manual.
When the other signal is connected, the unit may occur malfunction.

9 BUILT-IN BRAKE

Some models of the FANUC AC Servo Motor β*i* series use motors that contain a holding brake to prevent falling along a vertical axis.
This chapter explains the specifications of built-in brakes and gives cautions.
The motor with a built-in brake differs from that with no brake in outside dimensions. For the outside dimensions, see the Chapter 7, "OUTLINE DRAWINGS."

Chapter 9, "BUILT-IN BRAKE", consists of:

9.1 BRAKE SPECIFICATIONS

The specifications of built-in brakes are listed below.

Motor model		Unit	βis 0.2 βis 0.3	βis 0.4 βis 0.5	βis 1	βis 2 βis 4 (Including HV)	βis 8 βis 12 (Including HV)	βis 22 (Including HV)
Brake torque		Nm	0.32	0.65	1.2	3	8	35
		kgf·cm	3.3	6.6	12	31	82	357
Response time	Release	msec	40	40	40	60	160	160
	Brake	msec	20	20	20	20	30	30
Power supply	Voltage	V	24VDC (±10%)					
	Current	A	0.3	0.5	0.5	0.9	1.1	1.2
	Wattage	W	7	12	12	22	26	29
Weight increase		kg	Approx. 0.2	Approx. 0.4	Approx. 0.4	Approx. 1.0	Approx. 2.2	Approx. 6.0
Inertia increase		$kg \cdot m^2$	0.000002	0.000009	0.000009	0.00002	0.00007	0.0006
		$kgf \cdot cm \cdot s^2$	0.00002	0.00009	0.00009	0.0002	0.0007	0.006

The values shown above are standard values at 20°C.

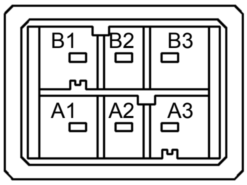
9.2 CONNECTING A BRAKE

9.2.1 Brake Connectors

The following shows the shape and pin arrangement of the brake connectors.
For the connected cables and the connectors on the cable side, see Chapter 10, "CONNECTORS ON THE CABLE SIDE"..

Connector for models β*i*S 0.2 and β*i*S 0.3 (standard)

The brake connector for models β*i*S 0.2 and β*i*S 0.3 also serves as the power connector.
For the connector specifications, see Chapter 7, "OUTLINE DRAWINGS".

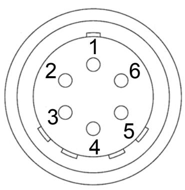


Connections: B2=BK, B3=BK
(Connect to inside of power connector.)
(A1=U, A2=V, A3=W, B1=GND)

* BK indicates a power supply (24 VDC, 0 VDC) for the brake. The brake is nonpolarized.

Connector for models β*i*S 0.2 and β*i*S 0.3 (IP67 specifications)

The brake connector for models β*i*S 0.2 and β*i*S 0.3 (IP67 specifications) also serves as the power connector.
For the connector specifications, see Chapter 7, "OUTLINE DRAWINGS".

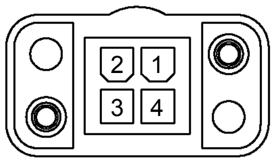


Connections: 4=BK, 5=BK
(Connect to inside of power connector.)
(1=U, 2=V, 3=W, 6=GND)

* BK indicates a power supply (24 VDC, 0 VDC) for the brake. The brake is nonpolarized.

Connector for models β*i*S 0.4 to β*i*S 1

Manufacture: MOLEX JAPAN Co., Ltd.
Manufacturer specification: 55619-0401

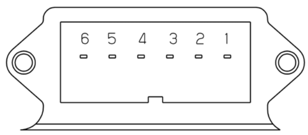


Connections: 1=BK, 2=BK, 4=GND

* BK indicates a power supply (24 VDC, 0 VDC) for the brake. The brake is nonpolarized.

Connector for models β*i*S 2 and β*i*S 4 (including HV)

The brake connector for models β*i*S 2 and β*i*S 4 also serves as the power connector.
For the connector specifications, see Chapter 7, "OUTLINE DRAWINGS".



Connections: 5=BK, 6=BK
(Connect to inside of power connector.)
(1=U, 2=V, 3=W, 4=GND)

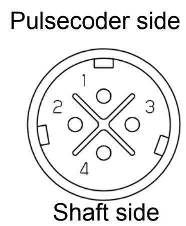
* BK indicates a power supply (24 VDC, 0 VDC) for the brake. The brake is nonpolarized.

Connector for models β*i*S 8 to β*i*S 22 (including HV)

Manufacture: Japan Aviation Electronics Industry
Manufacturer specification: JN2AS04MK2-R

This connector alone is dripproof.

The shape and pin layout of the connector are shown below.



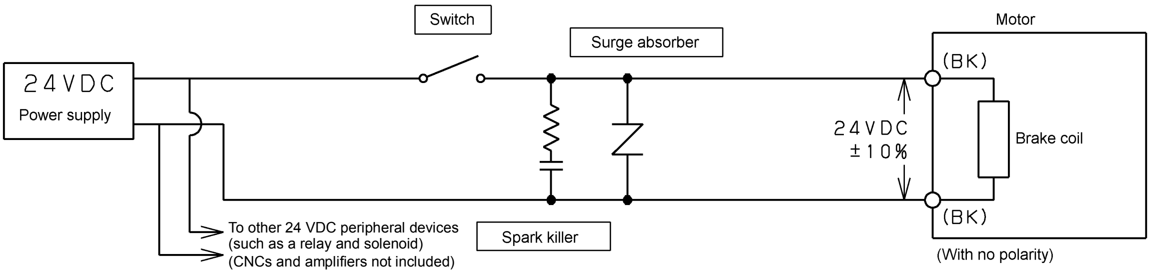
Connections:
1=BK, 2=BK,
3=NC (Not Connected)
4=GND (Note)

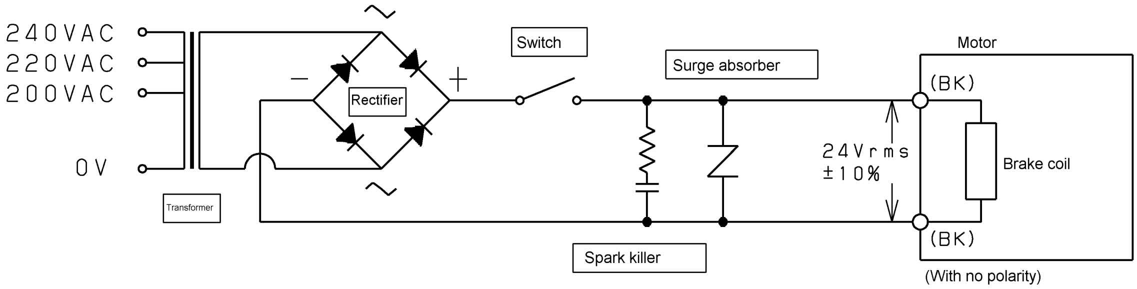
* BK indicates a power supply (24 VDC, 0 VDC) for the brake. The brake is nonpolarized.

NOTE
Since pin 4 is connected to the brake cabinet, it can be used when the shield wire of a brake cable needs to be connected.

9.2.2 Connection of the Brakes

Configure a brake circuit by referencing the following brake connection diagrams and the recommended parts shown in the following section.





1 Use a 24 VDC power supply as the power supply for the FANUC AC Servo Motor β*i* series brake. Power (equivalent to 24 Vrms) produced by full-wave rectification after transforming commercial power (50 Hz/60 Hz) is also available.
2 Use a power supply separate from the 24-V power supply for the CNC and amplifier as the power supply for the brake. If the control power supply is also used for the brake, an CNC or amplifier malfunction or another danger may occur. The power supply for a relay, solenoid, or another peripheral device can be used for the brake. Be careful of the power capacity and changes in voltage due to changes in load.
3 For full-wave rectification, transform the secondary side voltage obtained during energization of the brake into approximately 29 VAC by taking voltage drop in the rectifier or cable into account. In this case, check the power capacity and power voltage fluctuations sufficiently and then make sure the fluctuations of the voltage applied to the brake during energization falls within 24 Vrms ±10%. Switch the transformer's primary side input to a desired position such as 100-110-120 VAC or 200-220-240 VAC.
4 If the contact is installed on the DC side (at the position shown in the figure), the life of the contact is generally shortened due to the surge voltage at brake off. Provide an adequate contact capacity and always use a surge absorber and spark killer for protecting the contact.
5 You can use either positive or negative power pin to connect the brake because the brake coil is nonpolarized.
6 Use a shielded cable as required.

9.2.3 Recommended Parts in Brake Circuits

The following table lists the recommended parts to be used as components of a brake circuit and their specifications.

All models of the β*i*S series

Name	Model No.	Name of Manufacturer	Specifications	FANUC Procurement Dwg. No.
Rectifier	D3SB60 (Note 1)	SHINDENGEN ELECTRIC MFG. CO., LTD.	Withstand voltage 400 V min. Maximum output current: 2.3 A (with no fin)	A06B-6050-K112
Switch	-	-	Rated load capacity (resistance load) 250VAC 10A / 30VDC 10A or more	-
Spark killer	XEB0471	OKAYA ELECTRIC IND. CO., LTD.	47Ω / 0.1μF Withstand voltage 400 V min.	-
Surge absorber	ERZV10D820	Matsusihita Electric Industrial Co., Ltd.	Varistor voltage 82V Max. allowable voltage 50VAC	-

NOTE

At an ambient temperature of 20°C, the temperature of the rectifier rises to about 60°C when one brake axis is used or to about 90°C when two brake axes are used. Use a radiator fin as required.

9.3 CAUTIONS

⚠ CAUTION

Pay attention to the following points when motors with built-in brakes are used.

1. A built-in brake is used as a holding brake to prevent falling along an axis at servo off. This brake functions as a brake at an emergency stop or power failure, but cannot be used to decrease the stop distance during ordinary deceleration.

2. The brake cannot be used as assistance to stop the motor in the stopped state with energization of the motor. This causes an abnormal heat of the motor.

3. Match the timing of brake release (axis release) to the timing of servo on (motor energization) as much as possible.
   Similarly, match the timing of brake start (axis fix) to the timing of servo off as much as possible.

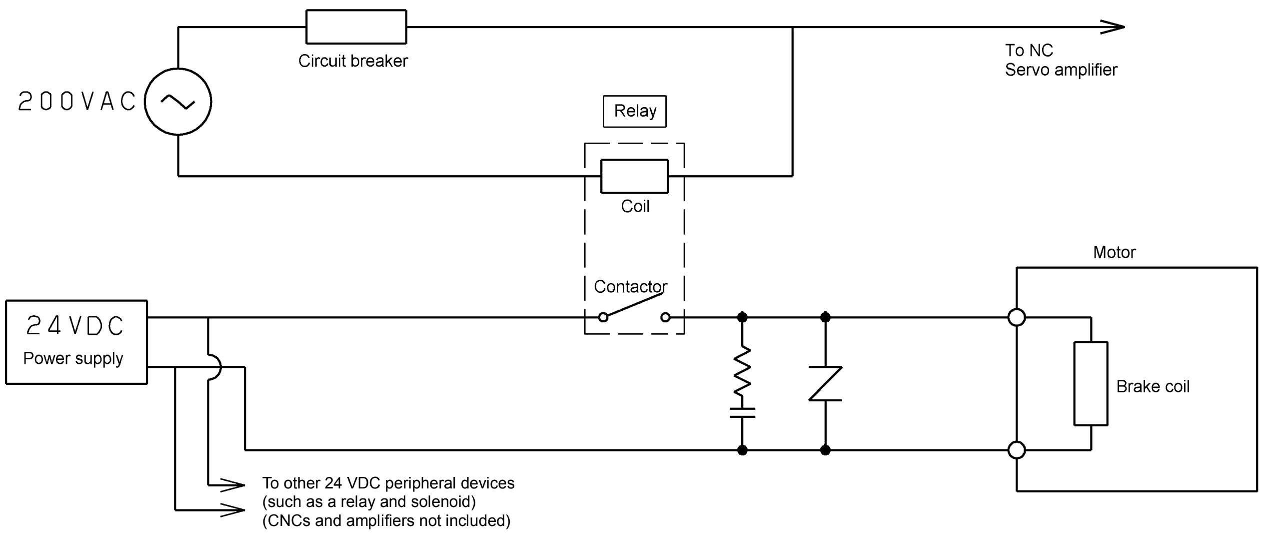
9.4 REDUCING THE BRAKE SHAFT FALL AMOUNT

During use of a motor with a brake, the amount of falling along an axis at a power failure or emergency stop, or when the CNC power supply is turned off during excitation of the motor may become an issue. To operate the brake immediately and reduce the amount of falling along an axis to a minimum, note the following points:

(1) To operate the brake immediately, the switch and relay for controlling on and off must be installed on the DC side (at the position shown in the following figure) of the break circuit.
If the contact is installed on the AC side (between the transformer's secondary side and rectifier), it takes time until braking starts because of the current returned to the rectifier diodes.

(2) To reduce the amount of falling along a vertical axis, the switch or relay must be turned off at a power failure as soon as possible.
To turn the relay off immediately at a power failure, it is effective to supply the relay driving power from the main power supply whenever possible as shown in the following figure.

(3) To prevent the shaft from falling during an emergency stop, it is sometimes effective to use the "brake control function" in the servo software. This function enables continuous excitation of the motor until the motor built-in brake operates.
For details, see Parameter Manual (B-65270EN).



10 CONNECTORS ON THE CABLE SIDE

This chapter describes the specifications of the connectors on the cable side that are to be connected to a motor. For the specifications and pin layout of the connector mounted on a motor, see Chapter 7, "OUTLINE DRAWINGS".

This chapter classifies connectors by the following groups:

Group	Servo motor name
Group A	β*i*S 0.2/5000, β*i*S 0.3/5000
Group B	β*i*S 0.2/5000(IP67 specification), β*i*S 0.3/5000(IP67 specification)
Group C	β*i*S 0.4/5000, β*i*S 0.5/6000, β*i*S 1/6000
Group D	β*i*S 2/4000, β*i*S 4/4000 β*i*S 2/4000HV, β*i*S 4/4000HV
Group E	β*i*S 8/3000, β*i*S 12/2000, β*i*S 12/3000 β*i*S 8/3000HV, β*i*S 12/3000HV
Group F	β*i*S 22/1500, β*i*S 22/2000 β*i*S 22/2000HV

Chapter 10, "CONNECTORS ON THE CABLE SIDE", consists of:

10.1 CONNECTORS FOR SIGNALS

10.1.1 Connectors for Signals (Group A)

Connectors for signals in Group A are not dripproof.
To connect the cable, a dedicated crimping tool must be used.
Consider crimping, cable clamp, and voltage drop. Also note that there are restrictions.

	For signal		
Housing specification (Tyco Electronics AMP)	1-1318118-6 (D-2100D 12-position receptacle housing)		
Contact specifications (Tyco Electronics AMP)	1318107-1 (D-2 receptacle contact M)		1318108-1 (D-2 receptacle contact S)
Applicable wire size	0.18 to 0.5 mm^2	0.3 to 0.85 mm^2	0.08 to 0.2 mm^2
Insulation external diameter	ϕ0.88 to 1.5 mm	ϕ1.1 to 1.87 mm	ϕ0.88 to 1.5 mm
Applicable crimping tool	1463475-1 (Dedicated crimping tool)	1276654-1 (D-2 M standard tool)	1276653-1 (D-2 S standard tool)

The following signal connector kit is available:

	For signal
Connector kit specification (FANUC specification)	A06B-6114-K241
Contents of the connector kit	Receptacle housing (1-1318118-6)×1 Receptacle contact D-2 M (1318107-1)×12

The following dedicated tools are required for this connector.

	Applicable contact	Tyco Electronics AMP specification	FANUC specification
Crimping tool	D-2 contact size M (Dedicated crimping tool for which the applicable wire size is 0.18 to 0.5 mm^2.)	1463475-1	A06B-6114-K242
	D-2 contact size M	1276654-1	A06B-6110-K220#D2M
	D-2 contact size S	1276653-1	-
Extractor	D-2 contact	1276716-1	A06B-6110-K220#D2R

NOTE

1. When you use the recommended wire (cable diameter of 0.18 to 0.5 mm^2) only with one D-2 size M contact, the above dedicated crimping tool is required.
   Use a standard crimping tool for a D-2 contact within the applicable range, with checking the size of the wire to be used, contact type, and crimping tool specification.
2. The contacts are of the type which crimps the covering in addition to the wire. Follow the dimension of the insulation part listed above. An insulation of a diameter outside the above range may be able to be connected depending on the wire or tool, however. For details, contact the connector manufacturer.

10.1.2 Connectors for Signals (Group B)

Connectors for signals in Group B (on the cable side) are dripproof when engaged with the connectors on the motor side.
To connect the cable, a dedicated crimping tool must be used.
Consider crimping, cable clamp, and voltage drop. Also note that there are restrictions.

Crimp type connector

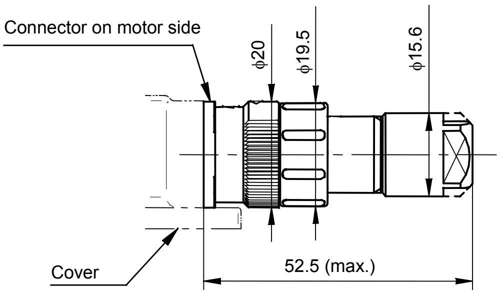
<table>
<tr><th colspan="2"></th><th colspan="2">For signal</th></tr>
<tr><td rowspan="2">Connector specifications</td><td>Straight type</td><td colspan="2">JN2DS10SL1-R or JN2DS10SL2-R: Connector,
JN1-22-22S: Contact (Japan Aviation Electronics Industry)
A06B-6114-K204#S (FANUC specification) * Including the contact</td></tr>
<tr><td>Right angle type</td><td colspan="2">JN2FS10SL1-R or JN2FS10SL2-R: Connector,
JN1-22-22S: Contact (Japan Aviation Electronics Industry)
A06B-6114-K204#E (FANUC specification) * Including the contact</td></tr>
<tr><td colspan="2">Insulation external diameter</td><td colspan="2">ϕ1.5 or less</td></tr>
<tr><td colspan="2">Compatible cable O.D.</td><td colspan="2">ϕ5.7 to ϕ7.3: JN2DS10SL1-R or JN2FS10SL1-R
ϕ6.5 to ϕ8.0: JN2DS10SL2-R or JN2FS10SL2-R
* With the FANUC specifications, two types of bushings: for ϕ5.7 to ϕ7.3 and for ϕ6.5 to ϕ8.0 are included.</td></tr>
<tr><td rowspan="4">Used wire</td><td></td><td>Cable length: 28 m or less</td><td>Cable length: 50 m or less</td></tr>
<tr><td>5V,0V</td><td>0.3 $mm^2 \times 2$</td><td>0.5$mm^2 \times 2$
(Strand configuration: 20/0.18 or 104/0.08)</td></tr>
<tr><td>6V</td><td>0.3 mm^2</td><td>0.5mm^2
(Strand configuration: 20/0.18 or 104/0.08)</td></tr>
<tr><td>SD,*SD
REQ ,*REQ</td><td colspan="2">Twisted pair of at least 0.18 mm^2</td></tr>
<tr><td colspan="2" rowspan="2">Tool for crimping terminal</td><td>AWG#21 (0.5mm^2:20/0.18),
AWG#23 (0.3mm^2),
AWG#25 (0.18mm^2)</td><td>CT150-2-JN1-E (Japan Aviation Electronics Industry)
A06B-6114-K201#JN1E (FANUC specification)</td></tr>
<tr><td>AWG#20 (0.5mm^2:104/0.08),
AWG#21 (0.5mm^2:20/0.18),
AWG#25 (0.18mm^2)</td><td>CT150-2-JN1-D (Japan Aviation Electronics Industry)
A06B-6114-K201#JN1D (FANUC specification)</td></tr>
<tr><td colspan="2">Tool for pulling terminal out</td><td colspan="2">ET-JN1(Japan Aviation Electronics Industry)
A06B-6114-K201#JN1R (FANUC specification)</td></tr>
</table>

10.1.3 Connectors for Signals (Groups C to F)

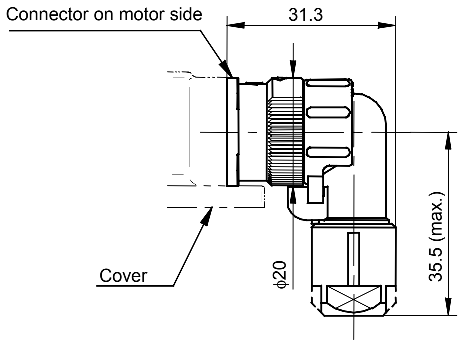
Connectors for signals in Groups C to F (on the cable side) are dripproof when engaged with the connectors on the motor side.
To connect the cable, a dedicated crimping tool must be used.
Consider crimping, cable clamp, and voltage drop. Also note that there are restrictions.

<table>
<tr><th colspan="2"></th><th colspan="2">For signal</th></tr>
<tr><td rowspan="2">Connector specifications</td><td>Straight type</td><td colspan="2">JN2DS10SL1-R or JN2DS10SL2-R: Connector,
JN1-22-22S: Contact (Japan Aviation Electronics Industry)
A06B-6114-K204#S (FANUC specification) * Including the contact</td></tr>
<tr><td>Right angle type</td><td colspan="2">JN2FS10SL1-R or JN2FS10SL2-R: Connector,
JN1-22-22S: Contact (Japan Aviation Electronics Industry)
A06B-6114-K204#E (FANUC specification) * Including the contact</td></tr>
<tr><td colspan="2">Insulation external diameter</td><td colspan="2">ϕ1.5 or less</td></tr>
<tr><td colspan="2">Compatible cable O.D.</td><td colspan="2">ϕ5.7 to ϕ7.3: JN2DS10SL1-R or JN2FS10SL1-R
ϕ6.5 to ϕ8.0: JN2DS10SL2-R or JN2FS10SL2-R
* With the FANUC specifications, two types of bushings: for ϕ5.7 to ϕ7.3 and for ϕ6.5 to ϕ8.0 are included.</td></tr>
<tr><td rowspan="4">Used wire</td><td></td><td>Cable length: 28 m or less</td><td>Cable length: 50 m or less</td></tr>
<tr><td>5V,0V</td><td>0.3 $mm^2 \times 2$</td><td>0.5$mm^2 \times 2$
(Strand configuration: 20/0.18 or 104/0.08)</td></tr>
<tr><td>6V</td><td>0.3 mm^2</td><td>0.5mm^2
(Strand configuration: 20/0.18 or 104/0.08)</td></tr>
<tr><td>RD,*RD</td><td colspan="2">Twisted pair of at least 0.18 mm^2</td></tr>
<tr><td colspan="2" rowspan="2">Tool for crimping terminal</td><td>AWG#21 (0.5mm^2:20/0.18),
AWG#23 (0.3mm^2),
AWG#25 (0.18mm^2)</td><td>CT150-2-JN1-E (Japan Aviation Electronics Industry)
A06B-6114-K201#JN1E (FANUC specification)</td></tr>
<tr><td>AWG#20 (0.5mm^2:104/0.08),
AWG#21 (0.5mm^2:20/0.18),
AWG#25 (0.18mm^2)</td><td>CT150-2-JN1-D (Japan Aviation Electronics Industry)
A06B-6114-K201#JN1D (FANUC specification)</td></tr>
<tr><td colspan="2">Tool for pulling terminal out</td><td colspan="2">ET-JN1(Japan Aviation Electronics Industry)
A06B-6114-K201#JN1R (FANUC specification)</td></tr>
</table>

The outside dimensions of each type of connector when engaged are shown below:



Straight type

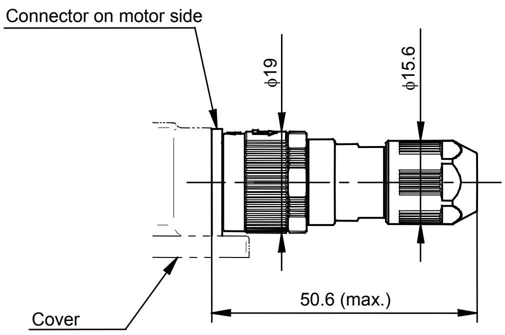


Right angle type

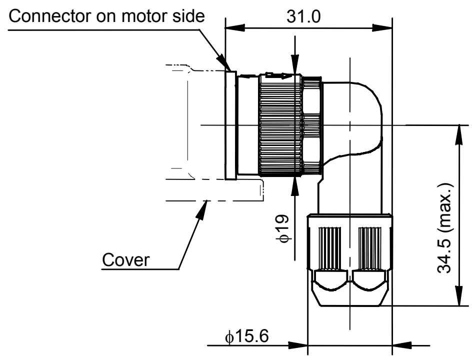
Solder type connector

		For signal	
Connector specifications	Straight type	HR34B-12WPA-10S or HR34B-12WPB-10S (Hirose Electric) A06B-6114-K205#S (FANUC specification)	
	Right angle type	HR34B-12WLPA-10S or HR34B-12WLPB-10S (Hirose Electric) A06B-6114-K205#E (FANUC specification)	
Applicable wire size		AWG#20 or less (φ0.8mm or less)	
Compatible cable O.D.		φ5.7 to φ7.3: HR34B-12WPA-10S or HR34B-12WLPA-10S φ6.5 to φ8.0: HR34B-12WPB-10S or HR34B-12WLPB-10S * FANUC specification includes two types of bushings and end nuts for φ5.7 to φ7.3 and for φ6.5 to φ8.0.	
Used wire		Cable length: 28 m or less	Cable length: 50 m or less
	5V,0V	0.3 $mm^2 \times 2$	0.5 $mm^2 \times 2$
	6V	0.3 mm^2	0.5mm^2
	RD,*RD	Twisted pair of at least 0.18 mm^2	

The outside dimensions of each type of connector when engaged are shown below:



Straight type



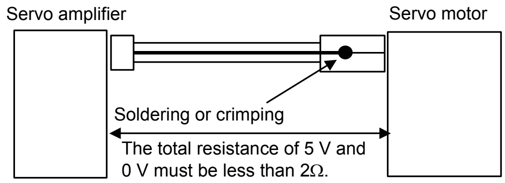
Right angle type

⚠ CAUTION

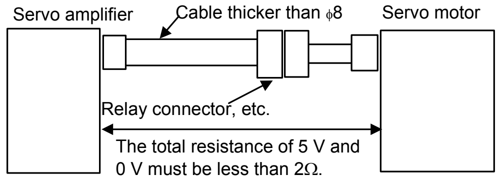
1 In case that the cable is prepared by MTB, total resistance of 5V and 0V must be less than 2Ω.

2 Pulsecoder side connector can accept maximum $0.5mm^2$ (wire construction 20/0.18 or 104/0.08, diameter φ1.5 or less) wire and sheath diameter is φ5.7 to φ8.0. In case of using thicker wire or cable, take measures described below.

Case 1] Cable conductor exceeds $0.5mm^2$.



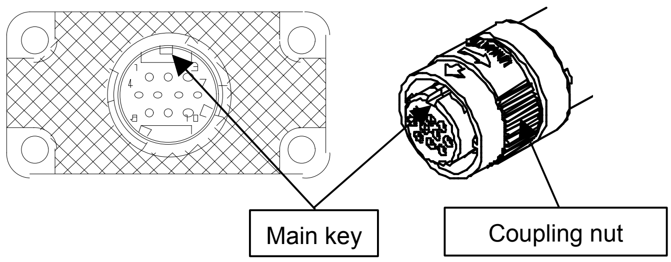
[Case 2] Sheath diameter of exceeds φ8.



Procedure for engaging feedback cable connectors

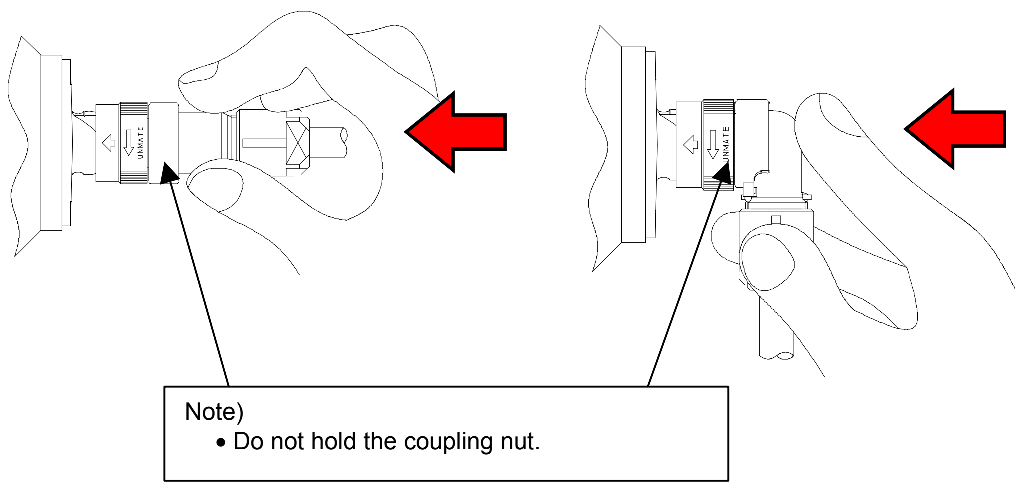
Engage the feedback cable connectors according to the procedure described below, and check that they are engaged securely.

1 Checking the mating surfaces and the key direction
Check that the mating surfaces are free from any substance such as foreign particles or oil.



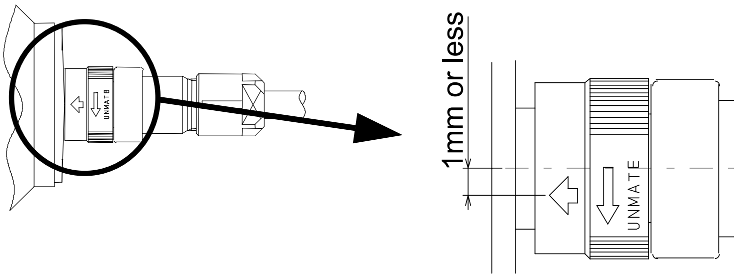
2 Engaging the connectors
Hold the connector at the position shown in the figure, insert it straightforward until it snaps into place.

Straight type Right angle type



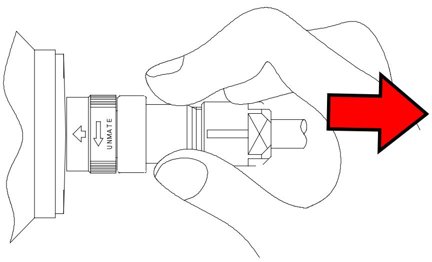
3 Checking the engaged status

<1> Check that the arrow on the connector is positioned at the center as shown in the figure below.
If the arrow is not at the center, turn the coupling nut by hand so that the arrow is at the correct position.

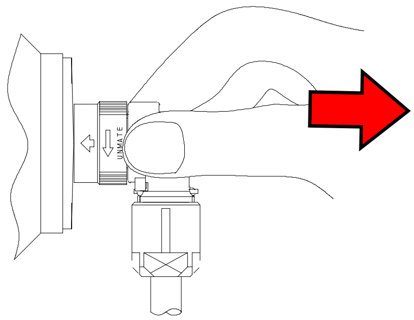


<2> Hold the connector at the position shown in the following figure, and check that the connector does not come off when it is pulled lightly.

Straight type



Right angle type



Note)
- Do not pull the cable.
- Pull the connector straightforward.

10.2 CONNECTORS FOR POWER

10.2.1 Connectors for Power (for Group A)

Dedicated connectors which are TUV approved are available as the connector for power for group A.
The following subsection describes the specifications as a connector kit. These connectors are not dripproof when engaged.
To connect the cable, a dedicated crimping tool must be used.
Consider crimping and cable clamp. Also note that there are restrictions.

		For power and brake
Housing specification (Tyco Electronics AMP)		3-178129-6 (D-3200M 6-position receptacle housing XY)
Contact specifications (Tyco Electronics AMP)		1-175218-2 (D-3 receptacle contact L)
	Applicable wire size	0.5 to 1.25 mm^2
	Insulation external diameter	ϕ1.8 to 2.8 mm

The following power and brake connector kit is available:

	For power and brake
Connector kit specifications (FANUC specification)	A06B-6114-K240
Contents of the connector kit	Receptacle housing(3-178129-6) × 1 Receptacle contact D-3 L (1-175218-2) × 6

The following dedicated tools are required for this connector.

	Applicable contact	Tyco Electronics AMP specification	FANUC specification
Crimping tool	D-3 contact size L	914596-3	A06B-6110-K220#D3L
Extractor	D-3 contact	234168-1	A06B-6110-K220#D3R

> ⚠ **CAUTION**
> The contacts are of the type which crimps the covering in addition to the wire. Follow the dimension of the insulation part listed above. An insulation of a diameter outside the above range may be able to be connected depending on the wire or tool, however. For details, contact the connector manufacturer.

10.2.2 Connectors for Power (for Group B)

Dedicated connectors which are TUV approved are available as the connector for power for group B.
The following subsection describes the specifications as a connector kit. These connectors are dripproof when engaged.
When the cables are to be connected, no special tools are required because they only need to be soldered.

		For power
Connector kit specifications (MOLEX JAPAN Co., Ltd.)	**Straight type (standard)**	500376-000* (MOLEX JAPAN Co., Ltd.) A06B-6114-K250#* (FANUC specification)
Applicable wire size		0.75 mm^2 (AWG#18)
Insulation external diameter		ϕ1.8 or less
Compatible cable O.D.		*: Specify the cable diameter. 0: ϕ6.5 to 7.2 1: ϕ7.3 to 8.0 2: ϕ8.1 to 8.8 3: ϕ8.9 to 9.6 4: ϕ9.7 to 10.4 5: ϕ10.5 to 11.0

10.2.3 Connectors for Power (for Group C)

Dedicated connectors which are TUV approved are available as the connector for power for group C.
The following subsection describes the specifications as a connector kit. These connectors are dripproof when engaged.
To connect the cable, a dedicated crimping tool must be used.
Consider crimping and cable clamp. Also note that there are restrictions.

		For power	For brake
Connector body specifications (MOLEX JAPAN Co., Ltd.)	**Straight type**	54983-0000	54982-0000
	Right angle type	55765-0000	55766-0000
Contact specifications (MOLEX JAPAN Co., Ltd.)		56052-8100	
	Applicable wire size	0.75 to 1.05 mm^2 (AWG18 to AWG17)	
	Insulation external diameter	φ2.5 mm or less	
	Compatible cable O.D.	φ9.1 to φ9.8 mm	φ6.2 to φ6.7 mm

The following power and brake connector kit is available:

		For power	For brake
Connector kit specification (FANUC specification)	**Straight type**	A06B-6114-K230#S	A06B-6114-K232#S
	Right angle type	A06B-6114-K230#E	A06B-6114-K232#E
Contents of the connector kit		Connector body × 1 Contact × 4	Connector body × 1 Contact × 3

The following dedicated tools are required for this connector.

	MOLEX JAPAN Co., Ltd.	FANUC specification
Crimping tool	57406-5000	A06B-6114-K234#C
Extractor	57406-6000	A06B-6114-K234#R

> ⚠ **CAUTION**
> The contacts are of the type which crimps the covering in addition to the wire. Follow the dimension of the insulation part listed above. An insulation of a diameter outside the above range may be able to be connected depending on the wire or tool, however. For details, contact the connector manufacturer.

10.2.4 Connectors for Power (for Group D)

Dedicated connectors which are TUV approved are available as the connector for power for group D.
The following subsection describes the specifications as a connector kit. These connectors are dripproof when engaged.
For the connector of the motor with a brake, perform cabling for the power and cabling for the brake at the same time.
The following subsection describes the specifications as a connector kit. These connectors are dripproof when engaged.
To connect the cable, a dedicated crimping tool must be used.
Consider crimping and cable clamp. Also note that there are restrictions.

		For power
Connector kit specifications (Including the contact)	Straight type (standard)	1473063-2 (Tyco Electronics AMP) A06B-6114-K220#S (FANUC specification)
	Right angle type (CAUTION 1)	1473393-2 (Tyco Electronics AMP) A06B-6114-K220#E (FANUC specification)
Applicable wire size (CAUTION 2)		AWG#18 to 16
Insulation external diameter (CAUTION 3)		ϕ1.8 to 2.8
Compatible cable O.D. (CAUTION 4)		ϕ9.2 to ϕ9.9, ϕ9.9 to ϕ11.4
Tool for crimping terminal (CAUTION 5)		1463328-1 (Tyco Electronics AMP) A06B-6114-K221#C (FANUC specification)
Tool for pulling terminal out (CAUTION 5)		1463329-1 (Tyco Electronics AMP) A06B-6114-K221#R (FANUC specification)

⚠ **CAUTION**

1. For the right angle type, a cable juts from the motor in a vertical direction. To connect a conduit hose to the connector, use the right angle type. (The straight type cannot be used due to dimensional restrictions.)
2. The contact is of the crimp type. Be careful of the applicable wire.
3. The crimping contact crimps the covering in addition to the wire. Follow the dimensions listed above.
   An insulation of a smaller diameter may be able to be connected by a wire or tool, however. For details, contact Tyco Electronics AMP.
4. To satisfy the TUV-approved and waterproof performance, a cable of an outside diameter within the applicable cable clamp range must be used.
   The connector kit includes two types of rubber bushings (cable clamps): one for ϕ9.2 to ϕ9.9 (blue) and the other for ϕ9.9 to ϕ11.4 (black).
5. Dedicated tools are required for crimping and extracting the contact. Keep them on hand when required.

10.2.5 Connectors for Power (for Groups E and F)

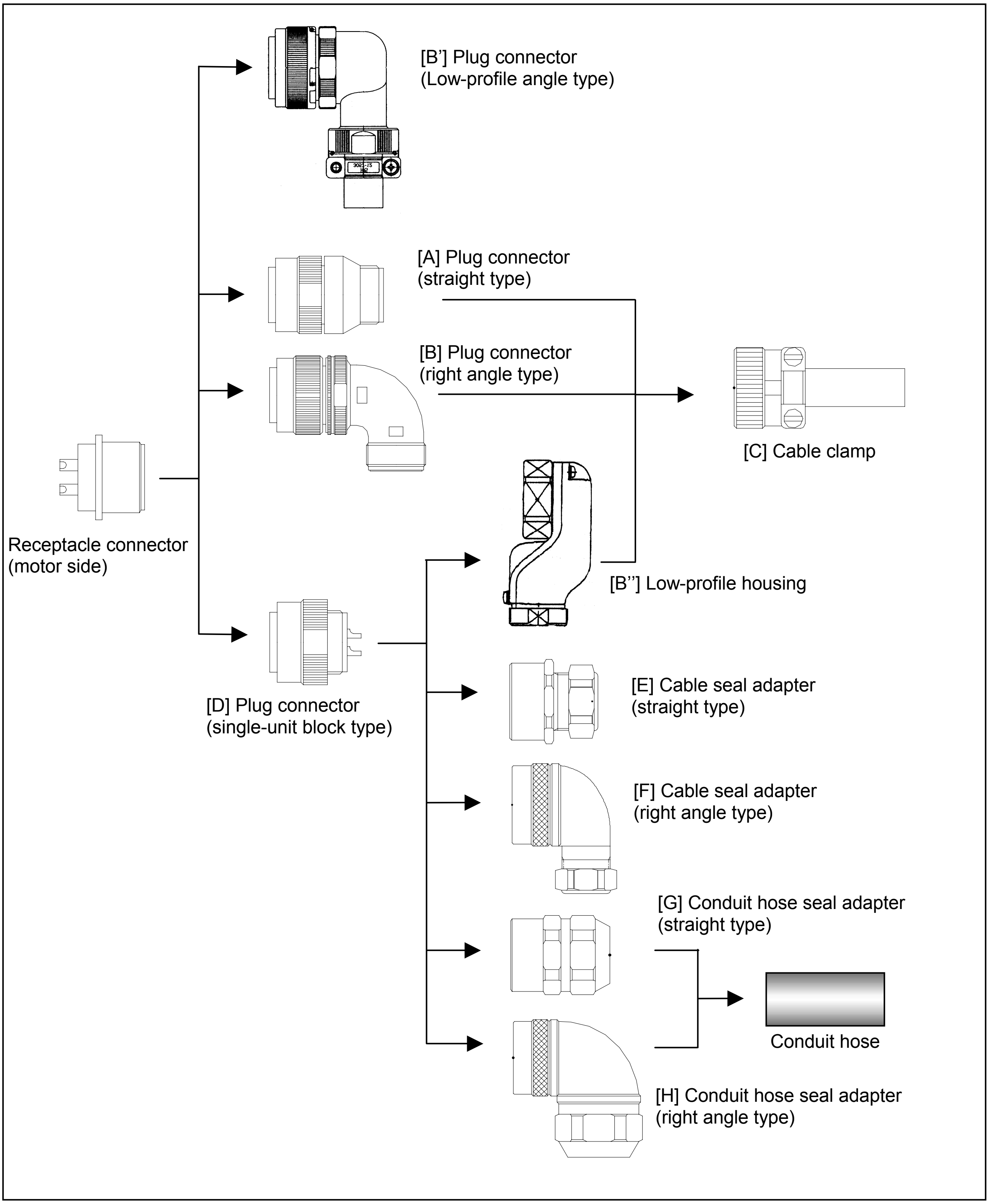
To meet the IEC60034 standard, TUV-approved plug connectors and cable clamps should be used in connecting the power cable. To meet the IEC60034 standard by using a cable or conduit hose seal adapter, contact the manufacturer for details. FANUC can provide TUV-approved types (waterproof) and waterproof types as plug connectors on the cable side for the FANUC AC Servo Motor β*i* series ; all these connectors are black. Of course, conventional plug connectors may be used, because they are MS-compatible. The specifications of each connector are explained based on the examples shown below.

Ordering specification number of the power connector kit

The specification numbers used for ordering a power connector kit from FANUC are listed below. The power connector kit contains a plug connector on the cable side (waterproof conforming to IP67, TUV approved type) described subsequently.

Group	Power connector kit specification	Content
Group E	A06B-6079-K810	Single block type connector
	A06B-6079-K811	Straight type connector + cable clamp
	A06B-6079-K812	Right angle type connector + cable clamp
Group F	A06B-6079-K813	Single block type connector
	A06B-6079-K814	Straight type connector + cable clamp
	A06B-6079-K815	Right angle type connector + cable clamp

Example of connector connection



Specifications of plug connectors on the cable side (support for waterproof IP67, TUV-approved type)

Listed below are the specifications of waterproof (conforming to IP67), TUV-approved plug connectors on the cable side, supplied by some manufacturers. For details of the connectors, contact each manufacturer.

Model Name	[D] **Single Block Type Plug Connector**	**[A] Straight Type Plug Connector**	[B] **Right angle Type Plug Connector**	**[B'] Low-profile angle type plug connector (with clamp)**	**[B''] Low-profile housing**	**[C] Cable Clamp**
Group E	(Hirose Electric)					
	H/MS3106A 18-10S-D-T(13)	H/MS3106A 18-10S-D-T(10)	H/MS3108A 18-10S-D-T(10)	(1) H/MS3108A 18-10S-DT10D(10) (2) H/MS3108A 18-10S-DT10D1(10)		H/MS3057-10A (10)
	Solder pot diameter ϕ2.6			Solder pot diameter ϕ2.5 Compatible cable O.D. (1) ϕ12 to ϕ14.3 (2) ϕ10 to ϕ12.5		Compatible cable O.D. ϕ10.3 - ϕ14.3
Group F	(Japan Aviation Electronics Industry)					
	JL04V-6A22-22SE-R (Both (1) and (2))	(1) JL04V-6A22-22SE-EB-R (2) JL04V-6A22-22SE-EB1-R	(1) JL04V-8A22-22SE-EB-R (2) JL04V-8A22-22SE-EB1-R		(1) JL04-22 EBA (2) -Not supported.	(1)JL04-2022CK (14)-R (2)JL04-2428CK (20)-R
	Solder pot diameter ϕ5.3				Compatible cable O.D. (1) ϕ12.9 to ϕ16, (2) ϕ18 to ϕ20	

* For the connectors of size 22-22, the part number of the plug connector differs depending on the type of cable clamp.

* The items preceded by the same number in ( ) correspond to each other.

⚠ CAUTION

1 TUV have certified that the plug connectors and cable clamps listed above, when combined with the FANUC AC Servo Motor β*i* series, satisfy the VDE0627 safety standard.
Several manufacturers offer other plug connectors. For information about whether the plug connectors satisfy the safety standard when combined with the FANUC β*i* series, contact the corresponding manufacturer.
- Hirose Electric (HRS) : H/MS310 TUV-conforming series
- Japan Aviation Electronics Industry (JAE) : JL04V series
- DDK Ltd. (DDK) : CE05 series

Specifications of plug connectors on the cable side (support for waterproof IP67)

Listed below are the specifications of waterproof (conforming to IP67) plug connectors on the cable side, supplied by some manufacturers. For details of the connectors, contact each manufacturer.

Model Name	[D] Single Block Type Plug Connector	[A] Straight Type Plug Connector	[B] Right Angle Type Plug Connector	[B] Low-profile angle type plug connector	[B''] Low-profile housing	[C] Cable Clamp
Group E	(Japan Aviation Electronics Industry)					
	JA06A-18-10S -J1-R	JA06A-18-10S -J1-EB-R	JA08A-18-10S -J1-EB-R		JL04V-18EBA	JL04-18CK (13)-R
	(Hirose Electric)					
	H/MS3106A 18-10S(13)	H/MS3106A 18-10S(10)	H/MS3108B 18-10S(10)	H/MS08A18-1 0S-DT10D(10)		H/MS3057 -10A(10)
	(DDK Ltd.)					
	D/MS3106A 18-10S-B(D190)	D/MS3106A 18-10S-B-BSS	D/MS3108A 18-10S-B-BAS			CE3057 -10A-1-D
Group F	(Japan Aviation Electronics Industry)					
	JA06A-22-22S -J1-R	JA06A-22-22S -J1-EB-R	JA08A-22-22S -J1-EB-R		JL04V-22EBA	JL04-2022 CK (14)-R
	(Hirose Electric)					
	H/MS3106A 22-22S(13)	H/MS3106A 22-22S(10)	H/MS3108B 22-22S(10)	H/MS08A22-2 2S-DT12D(10)		H/MS3057 -12A(10)
	(DDK Ltd.)					
	D/MS3106A 22-22S-B(D190)	D/MS3106A 22-22S-B-BSS	D/MS3108A 22-22S-B-BAS			CE3057 -12A-1-D

10.3 CONNECTORS FOR THE BRAKE

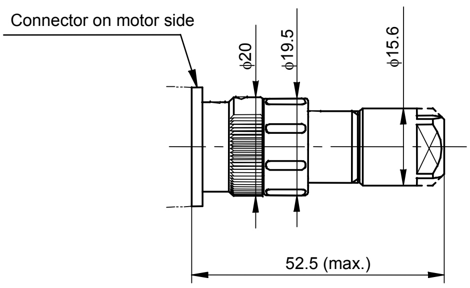
The connector for the brake for groups A, B, and D is the same as the power connector. See Section 10.2, "CONNECTORS FOR POWER". For the connector for the brake for group C, see CONNECTORS FOR POWER". The following subsections describe the connectors for the brake for groups D and E.

10.3.1 Connectors for the Brake (for Groups D and E)

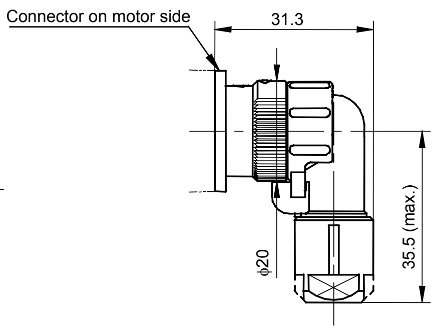
The models β*i*S 8 to β*i*S 22 (including HV) use a dedicated connector to connect the built-in brake cable.
This connector is dripproof. It is connected by soldering, so no special tool is required.
This connector differs from conventional connectors used for the α series. The following subsection explains this connector.
Consider soldering, cable clamp, and voltage drop. Also note that there are restrictions. The connector for the 24-V brake does not conform to the IEC60034 standard.

Specifications of connectors for brake

Connector specifications	Straight type	JN2DS04FK2-R (Japan Aviation Electronics Industry) A06B-6114-K213#S (FANUC specification)
	Right angle	JN2FS04FK2-R (Japan Aviation Electronics Industry) A06B-6114-K213#E (FANUC specification)
Applicable wire size		AWG#16 or less (1.25mm^2 or less) * Solder pot diameter ϕ1.9
Insulation external diameter		ϕ2.7 or less
Compatible cable O.D.		ϕ6.5 to 8.0
Example of applicable wire		300-V two-conductor vinyl heavy-duty power cord cable VCTF (JIS C 3306) or equivalent
Applicable wire size and cable length		0.75mm^2 (AWG#18) when cable length 30 m or less 1.25mm^2 (AWG#16) when cable length 50 m or less



Straight type



Right angle type

⚠ **CAUTION**

1 The same body is used for the brake and fan connectors. They differ in the key position to prevent an improper insertion.
2 If the cable length is longer than or equal to 50 m, take measures such as installation of repeaters so that the sum of wire resistance (for both ways) becomes 1.5Ω or less.
3 For details of brakes, see Chapter 9, "BUILT-IN BRAKE."

10.4 CONNECTION TO A CONDUIT HOSE

This section gives information on the specifications of several adapters to be connected that are made by conduit hose manufacturers for reference purposes.
Before using an adapter, contact the corresponding conduit hose manufacturer.

Specifications of plug connectors on the cable side (Waterproof type/seal adapter specifications)

Model Name	[E] Cable Seal adapter Straight type	[F] Cable Seal adapter Right angle type	[G] Conduit hose Seal adapter Straight type	[H] Conduit hose Seal adapter Right angle type
For power				
β*i*S 2 β*i*S 4			N2BM20-FN4 (SANKEI) MAS-SG16-M20 (NEOFLEX)	
β*i*S 8 β*i*S 12	CKD12-18 (SANKEI) YSO 18-12-14 (DAIWA DENGYOU) ACS-12RL-MS18F (NIPPON FLEX) CG12S-JL18 (NEOFLEX)	C90° KD12-18 (SANKEI) YLO 18-12-14 (DAIWA DENGYOU) ACA-12RL-MS18F (NIPPON FLEX) CG12A-JL18 (NEOFLEX)	KKD16-18 (SANKEI) MSA 16-18 (DAIWA DENGYOU) RCC-104RL-MS18F (NIPPON FLEX) MAS16S-JL18 (NEOFLEX)	K90° KD16-18 (SANKEI) MAA 16-18 (DAIWA DENGYOU) RCC-304RL-MS18F (NIPPON FLEX) MAS16A-JL18 (NEOFLEX)
β*i*S 22	CKD16-22 (SANKEI) YSO 22-12-14 (DAIWA DENGYOU) ACS-16RL-MS22F (NIPPON FLEX) CG16S-JL22 (NEOFLEX)	C90° KD16-22 (SANKEI) YLO 22-12-14 (DAIWA DENGYOU) ACA-16RL-MS22F (NIPPON FLEX) CG16A-JL22 (NEOFLEX)	KKD22-22 (SANKEI) MSA 22-22 (DAIWA DENGYOU) RCC-106RL-MS22F (NIPPON FLEX) MAS22S-JL22 (NEOFLEX)	K90° KD22-22 (SANKEI) MAA 22-22 (DAIWA DENGYOU) RCC-306RL-MS22F (NIPPON FLEX) MAS22A-JL22 (NEOFLEX)

Specifications of plug connectors on the cable side (Waterproof type/seal adapter specifications)

Model Name	[E] Cable Seal adapter Straight type	[F] Cable Seal adapter Right angle type	[G] Conduit hose Seal adapter Straight type	[H] Conduit hose Seal adapter Right angle type
For signal				
Common to all models (other than β*i*S 0.2 and β*i*S 0.3)			N2KY16-FN3 (SANKEI) PCJN-12-M13F (DAIWA DENGYOU) RQJN-M13-9 RQJN-M13-16 (NEOFLEX)	
For brake				
Common to all models (other than β*i*S 0.2 and β*i*S 0.3)			N2KY16-FN3 (SANKEI) PCJN-12-M13F (DAIWA DENGYOU) RQJN-M13-9 RQJN-M13-16 (NEOFLEX)	

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Revision Record

FANUC AC SERVO MOTOR β*i* series DESCRIPTIONS (B-65302EN)

Edition	Date	Contents	Edition	Date	Contents
02	Oct., 2007	• Addition of models β*i*S 0.5/6000, β*i*S 1/6000, and β*i*S 12/2000 • Deletion of models β*i*S 0.5/5000 and β*i*S 1/5000 • Addition of servo motor only for FANUC Series 0*i* • Addition of descriptions of "Usage considering environmental resistance" • Addition of descriptions of "Notes on cutting fluid" • Addition of descriptions of "Heat caution label" • Correction of errors			
01	May., 2003	――――――――――			