FANUC AC SERVO MOTOR αis series
FANUC AC SERVO MOTOR αi series
FANUC AC SERVO MOTOR βis series

SERVO TUNING PROCEDURE (BASIC)

B-65264EN/01

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".

TABLE OF CONTENTS

1 INTRODUCTION

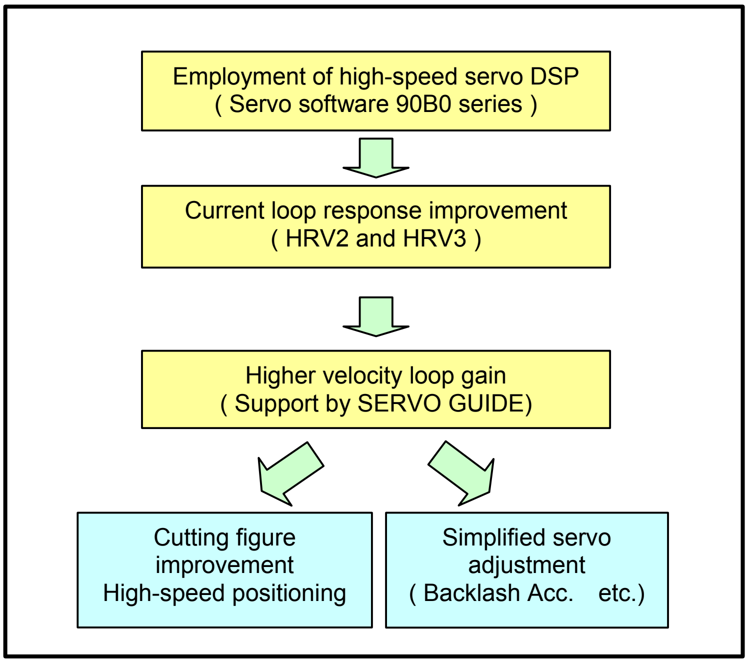
This manual explains the basis of servo tuning by using SERVO GUIDE. Please try to do servo tuning according to this manual. Then you will get easily good performance.

1.1 SERVO HRV CONTROL

Servo HRV2 and HRV3 improves current loop performance and it leads higher performance of servo system. It is important to understand the rough structure of servo control and how to realize high performance by using HRV2 and HRV3. Followings explain the basis of servo tuning procedure using SERVO GUIDE.

The *i* series CNC which is installed servo software 90B0 series can use SERVO HRV2 and HRV3. Using SERVO HRV2 and HRV3 improves current loop response. Therefore higher velocity loop gain and position loop gain can be set.
Higher velocity loop gain and position loop gain improve the response and rigidity of servo system. This reduces the error of cutting figure and higher-speed positioning with machine tools. In addition, higher gain makes servo adjustment easy.

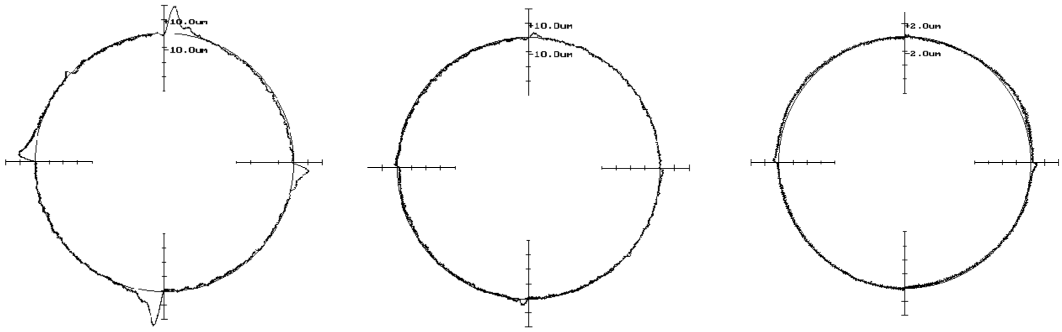
Thus it is necessary to use SERVO HRV2 and HRV3 control to realize high performance of servo system.



Achievements of SERVO HRV control

Even after the servo system is tuned with SERVO HRV2 control, higher-cycle current control can be easily realized by additional setting of SERVO HRV3 and this enables higher-level precision cutting. To use SERVO HRV2 and HRV3 with "Advanced Preview Control", "AI Contour Control", "AI Nano Contour Control" or "High-precision Contour Control" is effective and this much improves the performance of cutting machines.
For details, see section 3.4.3, "Servo Parameter Adjustment Procedure for Achieving High-Speed and High Precision" in Parameter Manual (B-65270).

Servo HRV1 control Servo HRV2 control Servo HRV3 control

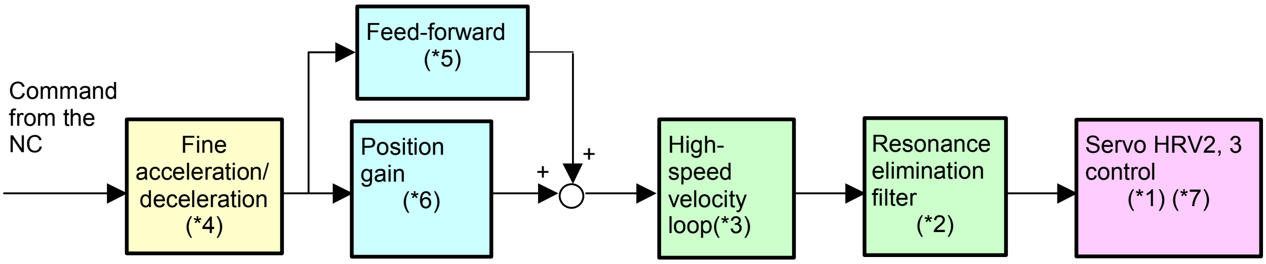


(R100 mm, 10000 mm/min, without quadrant protrusion compensation)

Example of effects of SERVO HRV control

1.2 ADJUSTMENT PROCEDURE OUTLINE

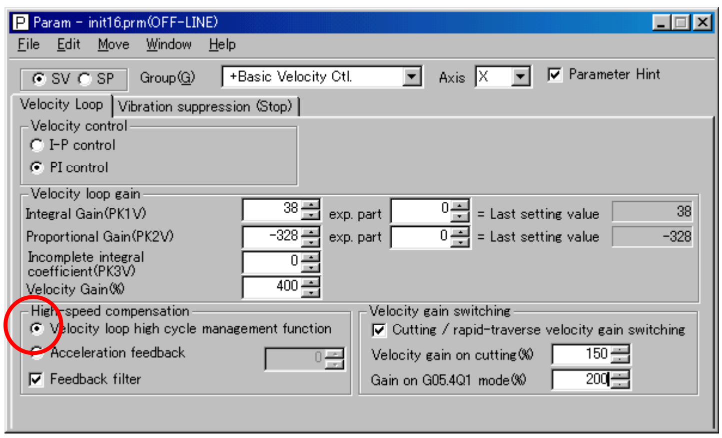
Use the procedure below for SERVO HRV2, 3 control setting.



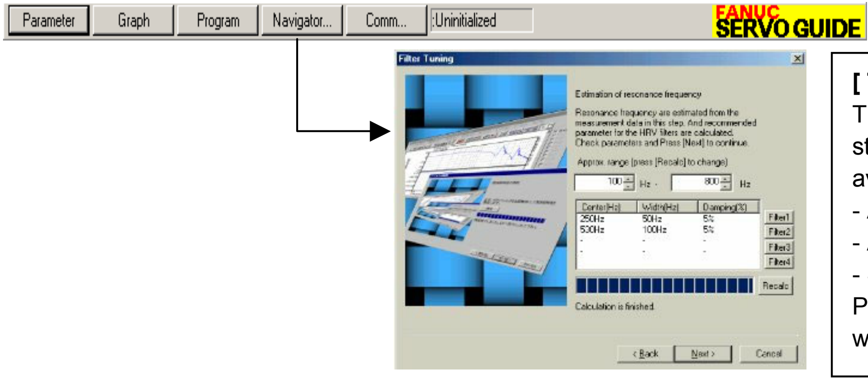
SERVO HRV control adjustment

- Setting of a current loop period and current loop gain (*1)
  The current control period is shortened from the conventional value 250 µs to 125 µs by setting HRV2 or HRV3. An improvement of current response makes the foundation of servo performance high.
  Please select Motor ID from 251 to 350 for α*i*s, α*i* and β*i*s motors in order to use HRV2 or HRV3 control.

- Velocity loop gain setting (*3)
  To use "high-speed loop proportional high-speed processing function" which processes a part of the velocity loop at high speed(No.2017#7=1) is effective for a velocity loop gain adjustment.



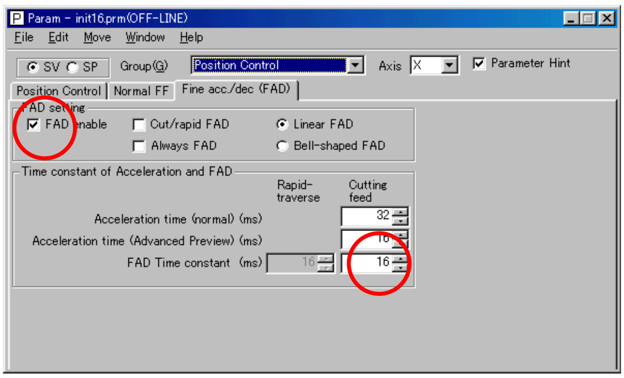
- Resonance elimination filter adjustment (*2)
  Some machines may resonate at a particular frequency. In such a case, the use of a resonance elimination filter (HRV Filter) for removing vibration of a particular frequency is effective.
  Tuning Navigator of SERVO GUIDE is useful to adjust HRV Filter.



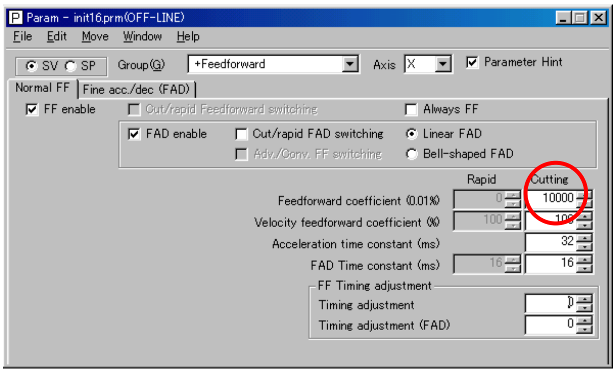
[Tuning Navigator]
Tuning navigator supports you by step-by-step Wizard. Following items are available.
- Automatic tuning of velocity gain setting
- Automatic tuning of HRV filters
- Support for setting of High Speed and High Precision functions. Please use this wizard with connecting to CNC.

- Velocity loop gain tuning
  Overall servo performance can be improved by setting a velocity loop gain as high as possible.
  Tuning Navigator of SERVO GUIDE is also useful to tune velocity loop gain.

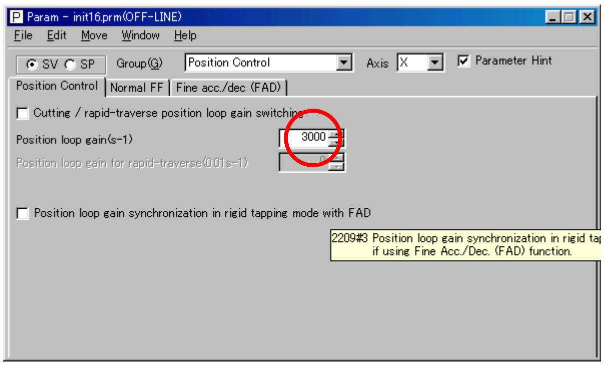
- Fine acceleration/deceleration setting (*4)
  When the response of the servo system becomes high, a figure error dependent on the command distribution cycle of the CNC may occur. This effect is eliminated by fine acceleration/ deceleration.



- Feed-forward coefficient adjustment (*5)
  By advanced preview feed-forward, a servo delay is eliminated, and a figure error is minimized. Usually, a feed-forward coefficient of 97% to 100% is used.



- Position gain adjustment (*6)
  As the response of the velocity loop increases, a higher position gain can be set. A higher position gain is also useful for error reduction.



- Setting and adjusting SERVO HRV3 control
  When a further improvement in performance is needed, SERVO HRV3 control may be able to set a much higher velocity loop gain.

2 INITIAL SERVO PARAMETERS FOR HIGH-SPEED AND HIGH PRECISION OPERATIONS

Described below are the servo parameters that need setting and tuning for high-speed and high precision operations. These parameters are assumed that HRV2 control

2.1 RECOMMENDATION OF INITIAL SERVO PARAMETERS FOR HIGH SPEED AND HIGH PRECISION (Series 16*i*/18*i*/21*i*/0*i*)

Following table shows recommendation of servo parameters that are to be set before starting servo tuning. These values will be enough to get good performance. If you want to get higher performance, you have to tune the values in gray boxes

[Fundamental Parameters]

Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
2004	0X000011 (Note 1) (Note 2)	Current control cycle 125 μs
2040	Standard parameter (Note 1)	Current integral gain
2041	Standard parameter (Note 1)	Current proportional gain
2003 #3	1	Enables PI function
2017 #7	1	Enables velocity loop high cycle management function
2006 #4	1	Uses the latest feedback data for velocity feedback.
2016 #3	1	Enables variable proportional gain in the stop state
2119	2 (detection unit of 1 μm) 20 (detection unit of 0.1μm)	For variable proportional gain function in the stop state : judgment level for stop state (specified in detection units)
1825	3000	Position gain
2021	300	Load Inertia ratio (Velocity Loop Gain)
2202 #1	1	Cutting/rapid traverse velocity loop gain variable
2107	150	Velocity loop gain override at cutting traverse

NOTE

1 For αi series motors, using standard parameters for HRV2 and HRV3 automatically sets up optimum values.
For α series motors, please change current loop gain according to following equation.
No.2040 = Standard parameter × 0.8
No.2041 = Standard parameter × 1.6

2 Keep the bit indicated with X (bit 6) at the standard setting.

3 There is the following relationship between the load inertia ratio and velocity loop gain (%).
Velocity loop gain (%) =
(1 + load inertia ratio/256) × 100

[Feed forward and FAD(Fine Acc./Dec.)]

Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
2007 #6	1	Enables FAD (Fine Acc./Dec.)
2209 #2	1	Enables FAD of linear type.
2109	16	FAD time constant
2005 #1	1	Enables feed-forward
1800 #3	0	Feed forward at rapid traverse
2017#5	1	RISC feed-forward is improved
2200#5	1	RISC feed-forward is improved
2092	10000	Advanced preview (position) feed-forward coefficient
2069	50	Velocity feed-forward coefficient

[Backlash Acceleration]

Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
1851	more than 1	Backlash compensation
2003 #5	1	Enables backlash acceleration
2006 #0	0/1	0 : Semi-close system 1 : Full-close system
2009 #7	1	Backlash acceleration stop
2009 #6	1	Backlash acceleration only at cutting feed (FF)
2223 #7	1	Backlash acceleration only at cutting feed (G01)
2015 #6	0	two-stage backlash acceleration
2146	50	Stage-2 backlash acceleration end timer
2048	50	Backlash acceleration amount
2082	5 (1um detection) 50(0.1umdetection)	Stop distance (detection unit)
2071	20	Backlash acceleration time

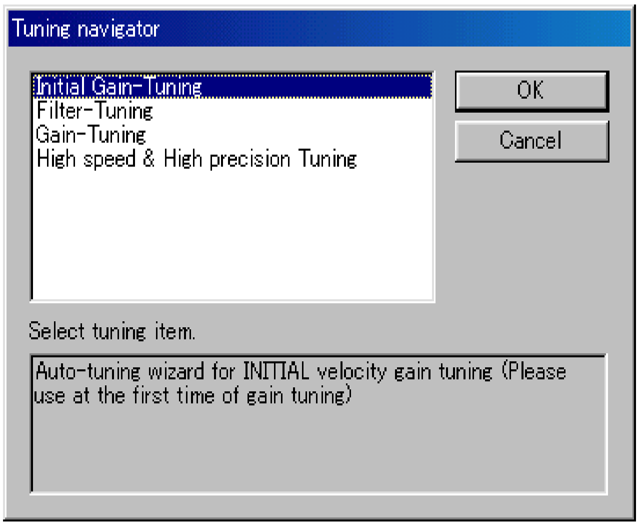
[Time Constant]

Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
1620	200	Time constant(ms) for linear-shaped Acc./Dec.
1621	200	Time constant(ms) for bell-shaped Acc./Dec.
1770	10000	Maximum Cutting Speed
1771	240	Time(ms) → 0.2G (AI, AI Nano)
1772	64	Time constant for bell-shape
8400	10000	Maximum Cutting Speed
19510	240	Time(ms) → 0.2G (AI HPCC, AI Nano HPCC)
8416	64	Time constant for bell-shape
1768	24	Time constant for after interpolation

3 GAIN TUNING BY TUNING NAVIGATOR

3.1 OUTLINE OF GAIN TUNING BY TUNING NAVIGATOR

If you press the [Navigator] button in main bar , you see the following dialog . Please select "Initial Gain-Tuning" at first and tune servo loop gain according to following procedure.



- In "Initial Gain-Tuning", the velocity gain is determined with large margin against the limit of vibration level. When you use this tuning, the gain become a little larger than initial state, and the resonance of the machine becomes more clear.
- Next, please select "Filter-Tuning" in order to suppress the resonance vibration.
- "Gain-Tuning" is used for final determination without any resonance. This function realizes the higher velocity loop gain by reducing the gain margin.

The following table shows the items and contents to tune.

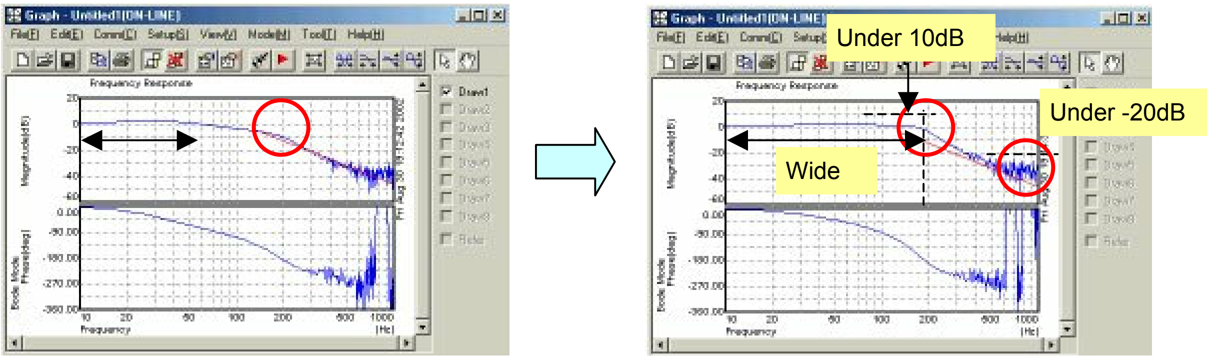
Initial Gain-Tuning	This is the automatic tuning of velocity gain. It determines the gain, moving the target axis and measuring frequency response. When you've not tune the gain yet, please select this menu first.
Filter-Tuning	This is the automatic tuning of HRV filters(Resonance elimination filters). It determines the optimum filter setting by detecting resonance frequency with the gain which is determined Initial Gain-Tuning.
Gain-Tuning	After application of above filters, this wizard raise the gain more by automatic tuning.
High speed & High precision Tuning	The wizard, which makes the tuning for High speed & High precision easy, will start. The plural parameters, which are related High speed & High precision function, can be determined easily by only one slider. The square with 1/4 arc program is used for the evaluation.

3.2 GAIN AND FILTER TUNING BY TUNING NAVIGATOR

By using Tuning Navigator you can easily tune velocity loop gain. As the tuning of velocity loop gain is most important for all of servo performance, please execute Tuning Navigator before following servo tuning.

[Initial Gain Tuning]

At first, please select "Initial Gain-Tuning".



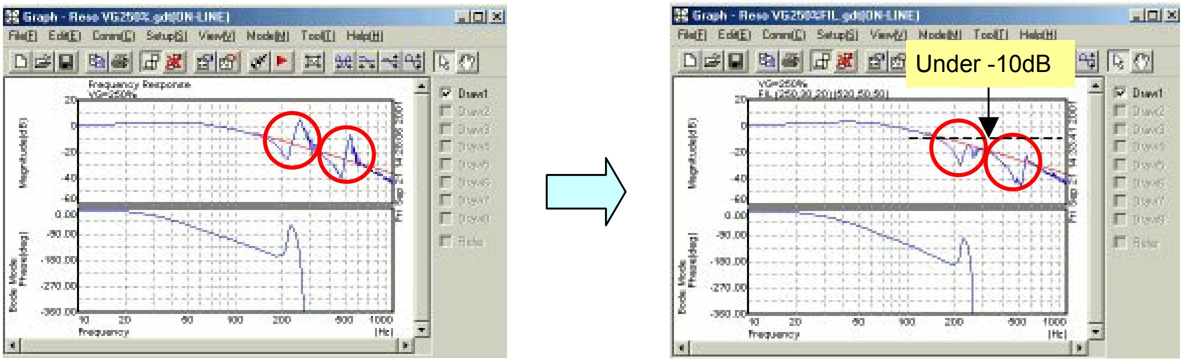
Tuning Navigator shows bode-plot of velocity loop and you can understand the performance of velocity loop.
Upper line in bode-plot shows gain characteristic and lower line shows phase characteristic. Important points of this figure that you should note are as follows. (About the details of bode-plot, please refer to several books of basic control method)

- The width of 0dB level of gain line is important. By setting higher velocity loop gain, it becomes wide.
- Gain level of resonance frequency has to be suppressed at least under -10dB.
- Gain level around cut-off frequency is less than 10dB.
- Gain level near 1000Hz has to be lower than -20dB.

This bode-plot shows that 0 level of gain line becomes wider and performance of velocity loop rises.

[Filter Tuning]

Next, Please select "Filter Tuning". Following example shows that gain line at two resonance frequencies (250Hz and 530Hz) are suppressed by Filter Tuning.



[Gain Tuning]

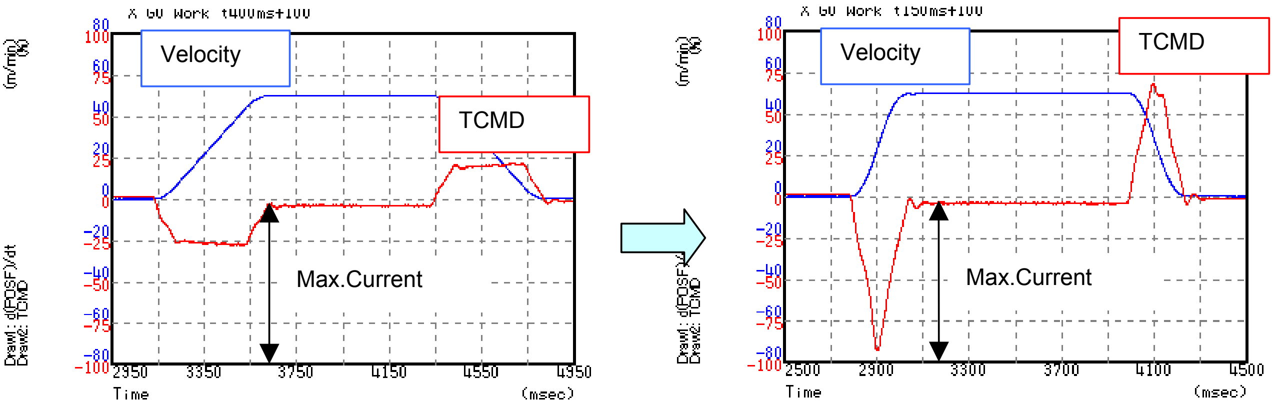
Finally, Please select "Gain Tuning". Tuning Navigator decides the final result of gain tuning.

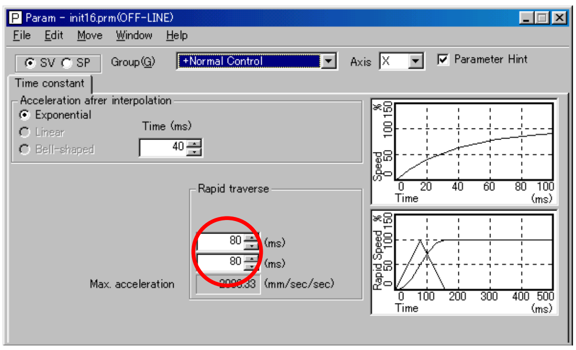
4 TUNING OF ACCELERATION AND DECELERATION

4.1 TUNING OF TIME CONSTANT FOR RAPID TRAVERSE

Please rise time constant for rapid traverse by observing TCMD. Bell shape acceleration/deceleration is effective in order to avoid the mechanical shock and to avoid TCMD limitation at high speed.
Please set this time constant as small as possible. Normally TCMD has to be smaller than 100% when maximum weight is put on your machine.

Following figure shows the effect of this tuning. Tuning of rapid traverse contributes to reduce cutting time .





[Time Constant for Rapid Traverse]

Parameter No. 16*i*/18*i*/21*i*/0*i*	Description
1620	Time constant(ms) for linear-shaped Acc./Dec.
1620	Time constant(ms) for bell-shaped Acc./Dec.

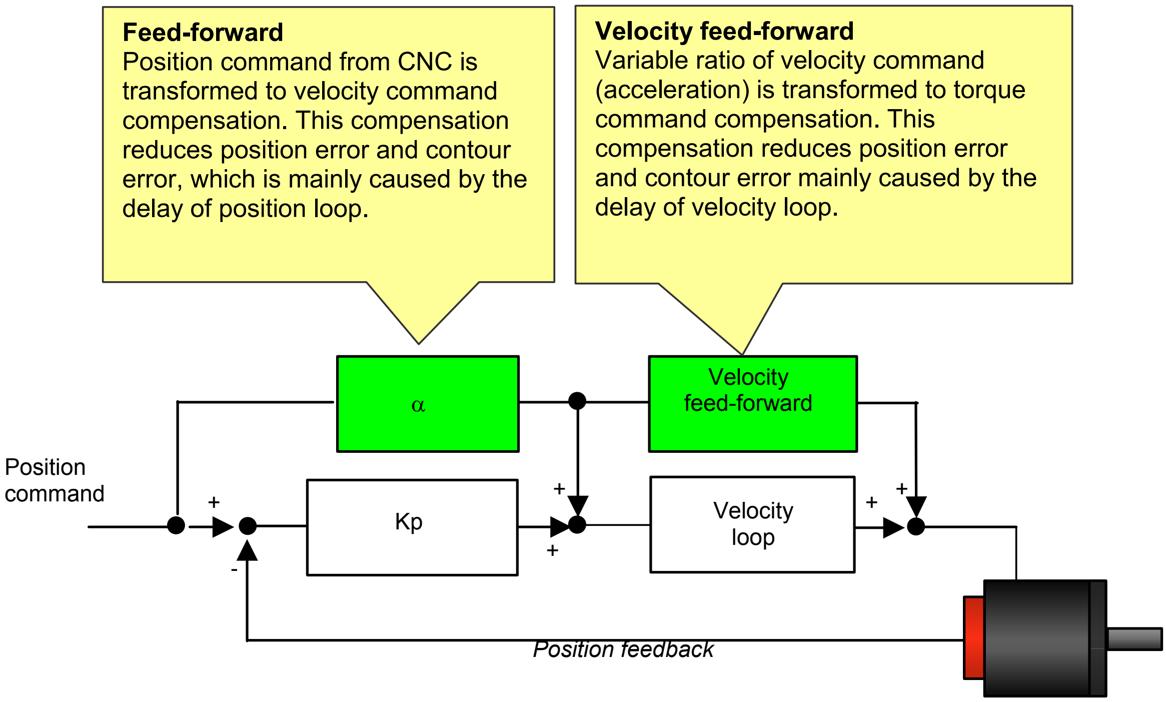
4.2 POSITION GAIN CHECK

Please set position gain 5000 and check TCMD and velocity at rapid traverse. If there is no vibration please change position gain to 5000.

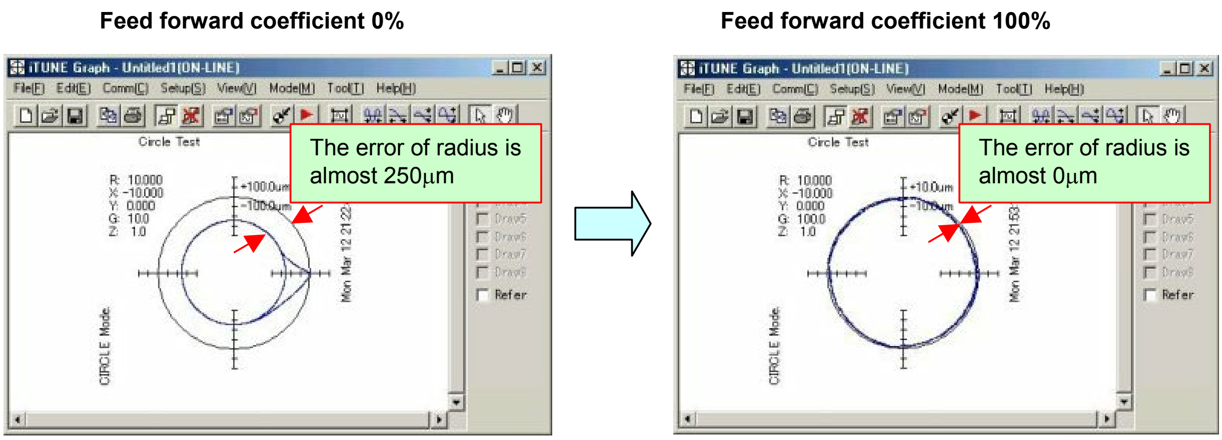
5 TUNING OF CIRCLE

5.1 TUNING OF FEED FORWARD COEFFICIENT

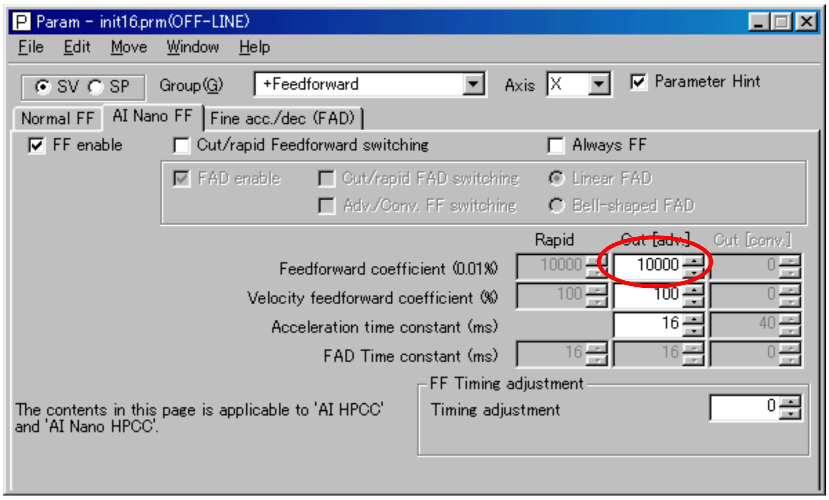
To set feed forward function is necessary to realize higher performance. Feed forward function reduces position error and makes it 0 by setting 100% coefficient.



Following figure shows the effect of feed forward function. Feed forward function reduces 250um error to 0um.



If you want to adjust more, please adjust feed forward coefficient. But you have to note that we don't recommend to set feed forward coefficient over 100% because it indicates that the actual machine moves ahead of its motion command.

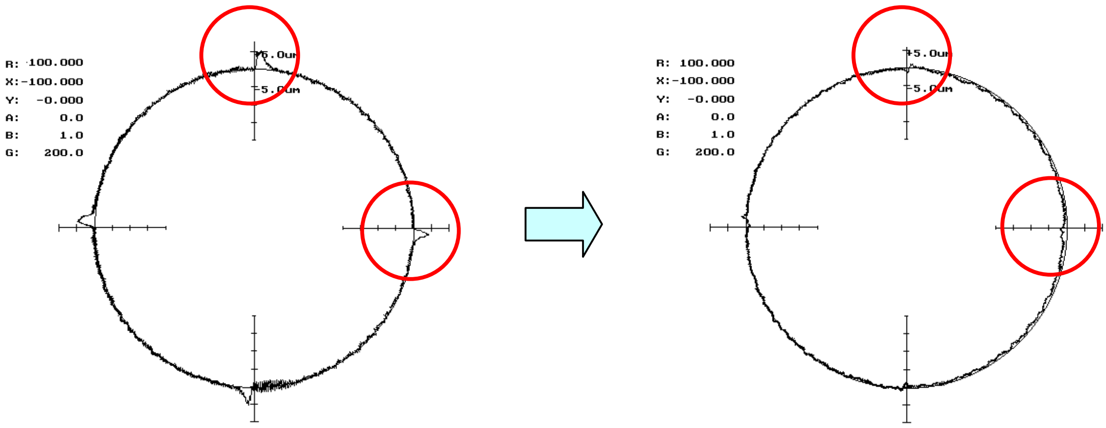


5.2 TUNING OF BACKLASH ACCELERATION

If there is position error at the point that the axis turns, please adjust backlash acceleration amount.
Please rise or reduce backlash acceleration amount step by step. The step value of this is about 10. If under cut occurs just after position tuning, please stop adjusting. Big protrusion and under cut make the result of cutting worse. Please try to tune this value so as to make protrusion under 5um.

[Backlash Acceleration]

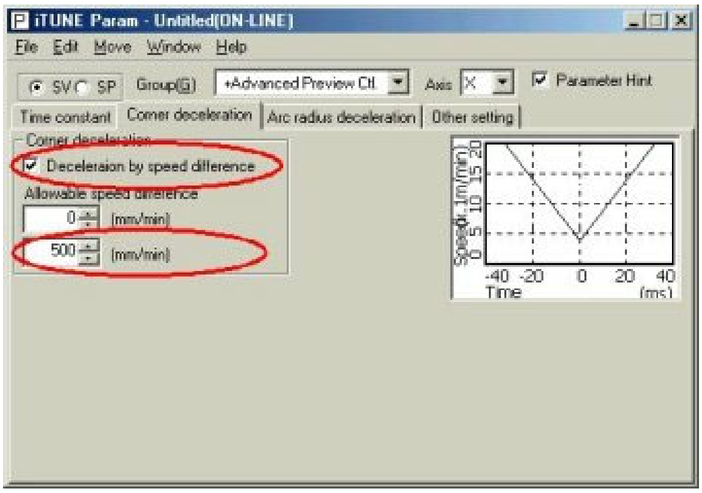
Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
2048	50	Backlash acceleration amount



6 TUNING OF SQUARE

6.1 SETTING OF CORNER DECELERATION

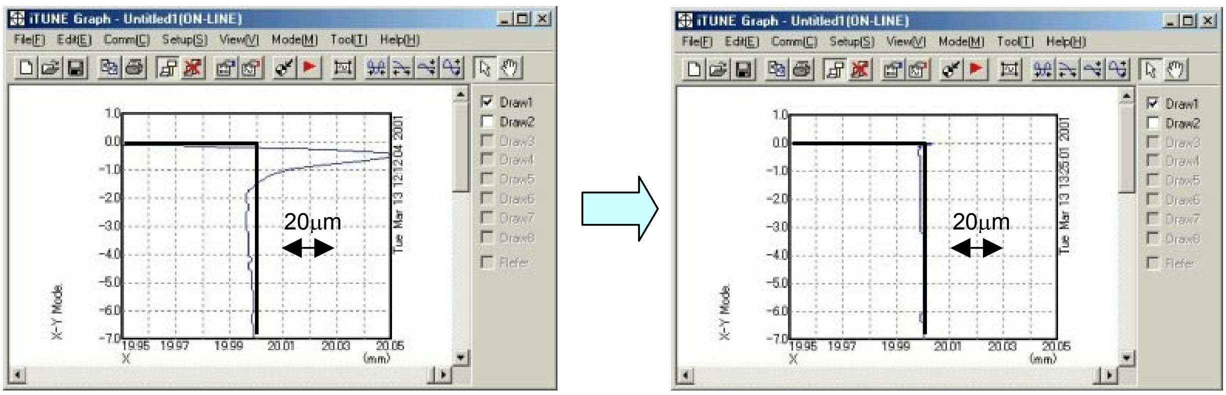
Corner deceleration is necessary to reduce position error at corner. Please set about 500mm/min at first.



[Corner Deceleration (Allowable Speed Difference)]

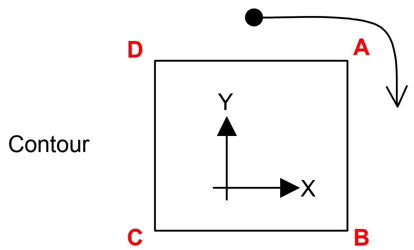
AI CONTOUR AI NANO CONTOUR	AI High Precision Contour AI Nano High Precision Contour	Standard setting value
Parameter No. 16*i*/18*i*/21*i*/0*i*	**Parameter No. 16*i*/18*i*/21*i*/0*i***	
1783	8410	500

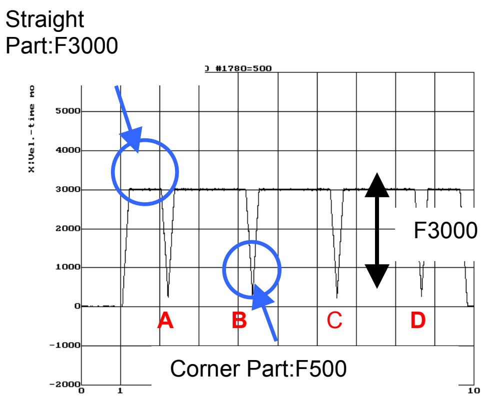
Following figure shows the effect of corner deceleration. You can see the position error becomes small.



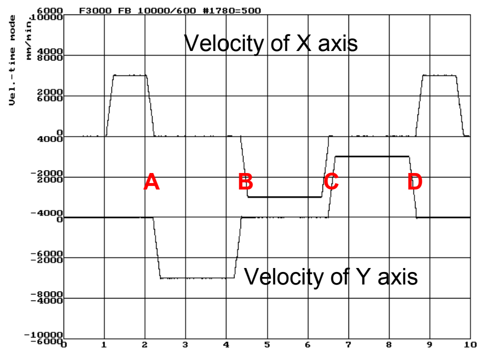
6.2 TUNING OF TIME CONSTANT FOR CUTTING FEED

You also have to note the value of time constant of corner deceleration and its shape when you tune the position error at the corner. Time constant before interpolation is applied to this deceleration. If you don't use bell time constant the shape of tangent velocity at the corner becomes "V" as you can see in following figure. As the changing rate of its deceleration is decided by time constant before interpolation, to set large value to this time constant (to set small acceleration) leads better result at the corner.



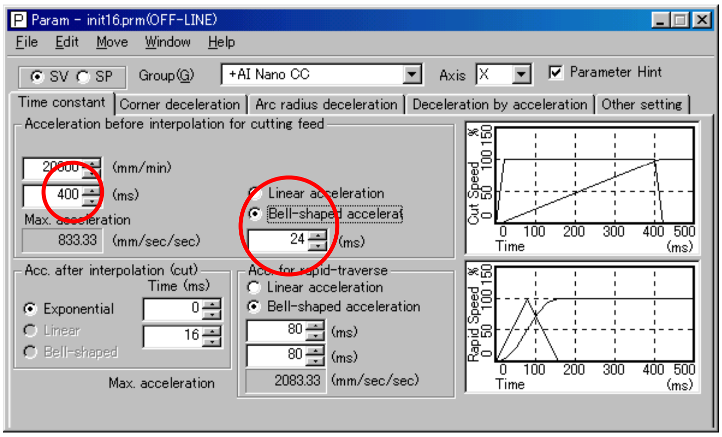


Tangent velocity



Velocity of each axis

If you couldn't get good result by setting corner deceleration, please adjust time constant. And to set bell-shape time constant is also effective not only to corner performance but also arc corner performance. But you have to note that to set bigger time constant makes cutting time longer.

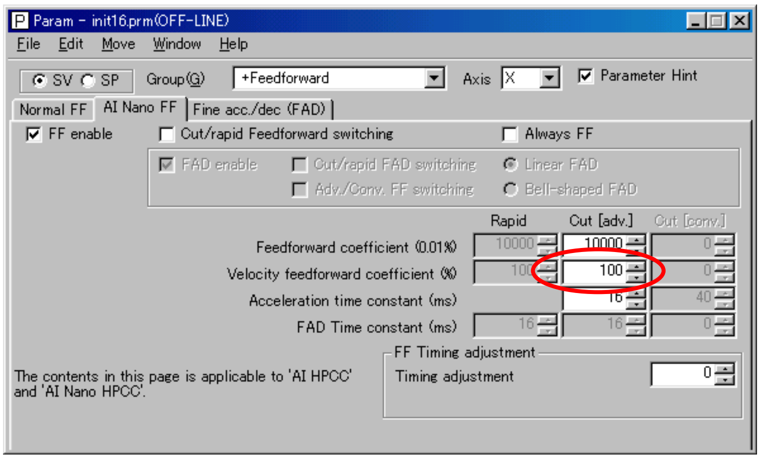


[Time Constant Before Interpolation]

AI CONTOUR AI NANO CONTOUR	AI High Precision Contour AI Nano High Precision Contour	Description
Parameter No. 16*i*/18*i*/21*i*/0*i*	**Parameter No. 16*i*/18*i*/21*i*/0*i***	
1770	-	Maximum Cutting Feedrate
1771	-	Time
-	8400	Maximum Cutting Feedrate
-	19510	Time

6.3 TUNING OF VELOCITY FEED FORWARD

Velocity feed forward can improve the shape at corner. Because it outputs ideal TCMD for acceleration and deceleration and helps the movement of integration in velocity control. Please adjust this coefficient.
If you don't use Nano-Interpolation, please set this coefficient under 400.



[Velocity Feed Forward]

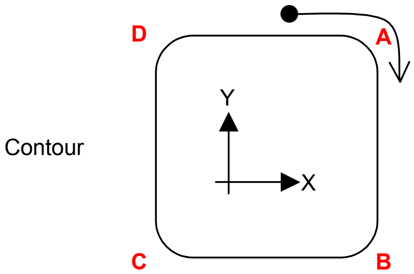
Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
2069	50	Velocity feed-forward coefficient

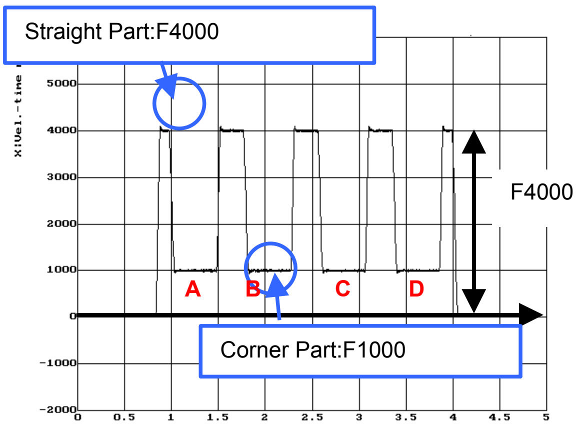
7 TUNING OF ARC SQUARE

7.1 SETTING OF ACCELERATION AT ARC

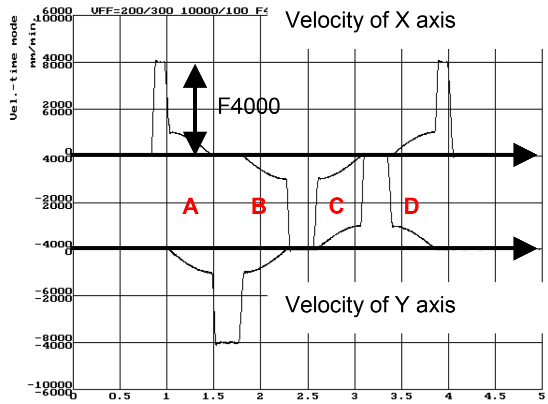
At the arc part the acceleration quickly changes and it makes position error. In order to avoid this problem, please set the limitation of acceleration at the arc.

Following figure shows how velocity changes by using this function. In this example feed rate at the arc is reduced till F1000 and becomes F4000 again after the arc. Deceleration rate before and after the arc is decided by time constant before interpolation.



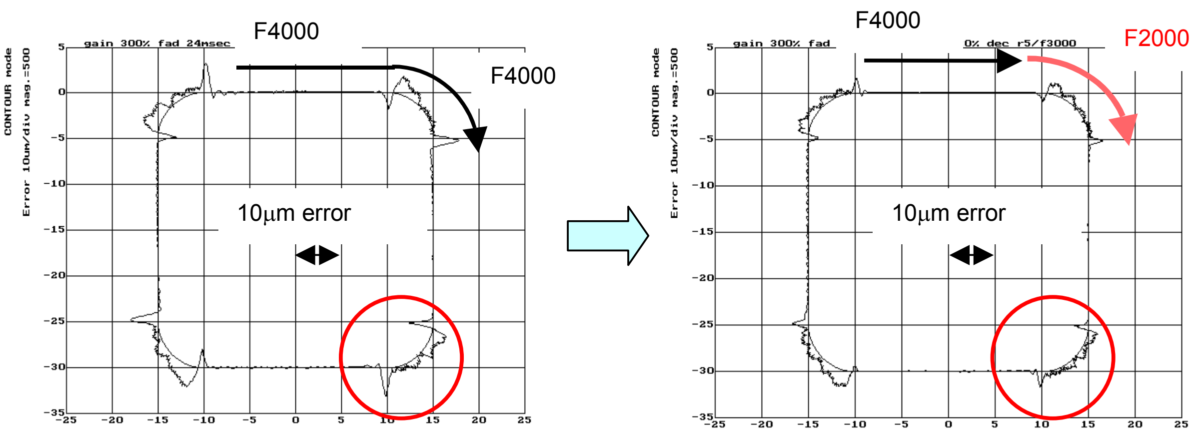


Tangent Velocity

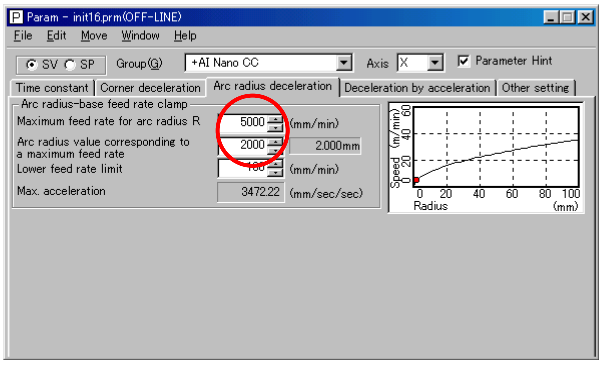


Velocity of each axis

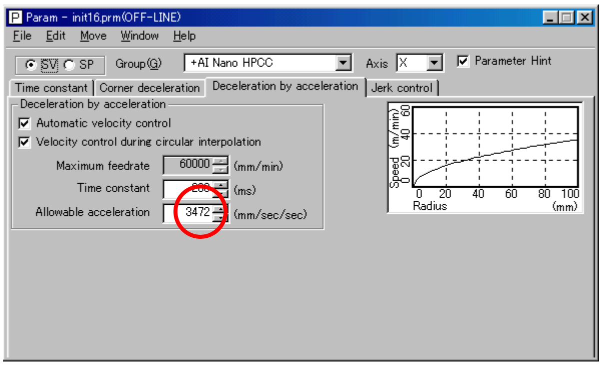
Following figure shows the effect of applying this function. Position error at the arc is reduced.



If you are using AI Contour Control or AI Nano Contour Control, you can select radius and feed rate. As this example radius=5mm and feed rate at the arc is F2000, you only have to set R=5000um and feed rate =F2000.



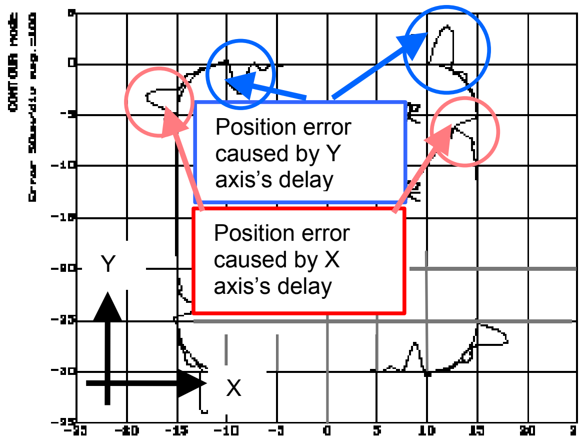
If you are using AI High Precision Contour Control or AI Nano High Precision Contour Control, you have to set by time constant or acceleration value.



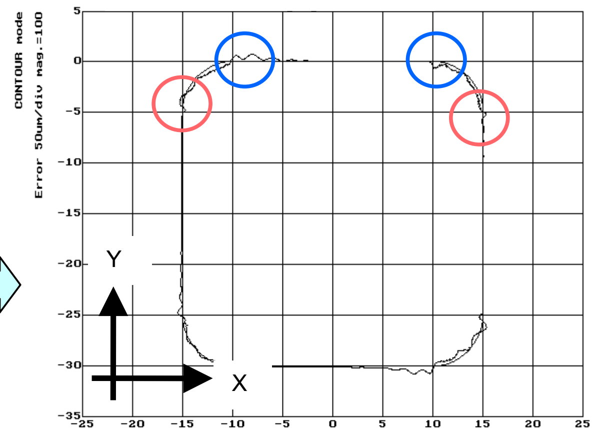
[Allowable Acceleration]

AI CONTOUR AI NANO CONTOUR Parameter No. 16*i*/18*i*/21*i*/0*i*	AI High Precision Contour AI Nano High Precision Contour Parameter No. 16*i*/18*i*/21*i*/0*i*	Description
1730	-	Feedrate (mm/min)
1731	-	Radius (um)
-	8470	Allowable Acceleration

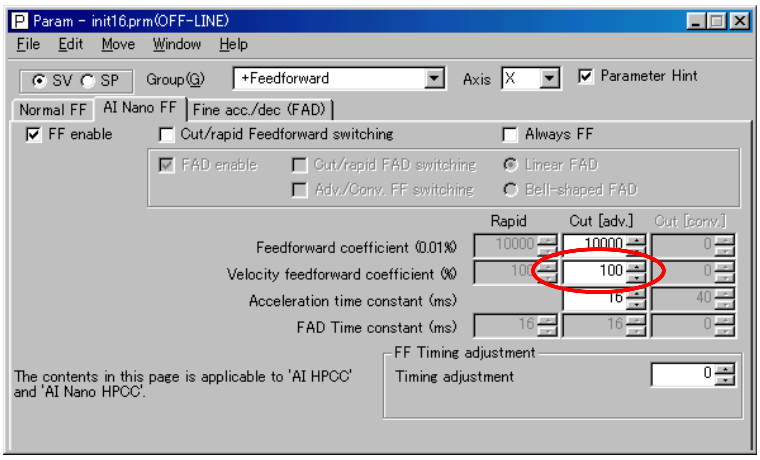
Adjusting velocity feed forward coefficient is also effective to this part. Position error is caused by a delay of velocity loop just after entering the arc and just after the end of the arc. Velocity feed forward compensates this delay and position error is reduced.



Without Velocity Feed Forward



With Velocity Feed Forward



[Velocity Feed forward]

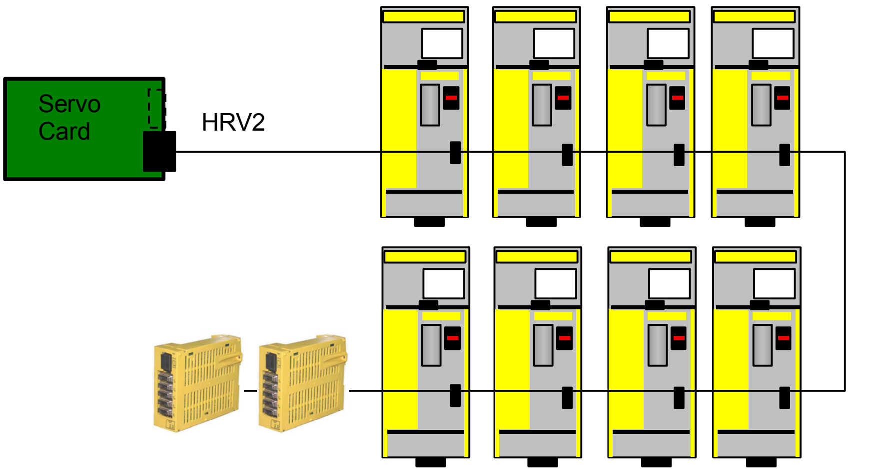
Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
2069	50	Velocity feed-forward coefficient

8 HRV3 CONTROL

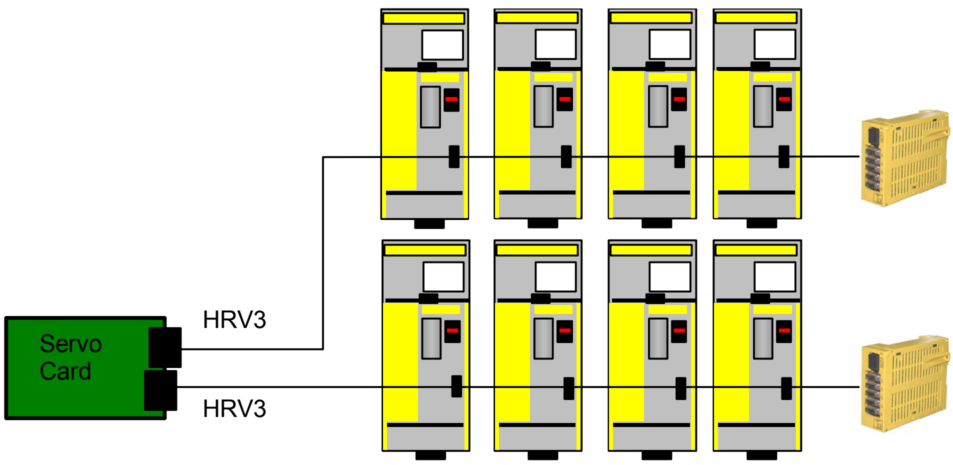
HRV3 Control is effective to get higher performance at high-speed and high-precision machining center. HRV3 Control manages current control twice faster than HRV2 Control. This contributes to make motor current smooth and to make current response faster. If your machine's precision is over your target by HRV2 Control, HRV3 Control will help you.
HRV3 Control has a current control mode. When "High Speed HRV Current Control Mode" is on, cycle of current control becomes twice faster than HRV2 Control. When it is off and rapid traverse, cycle of current control equals to HRV2 Control. By program code G5.4Q1 and G5.4Q0 you can select "High Speed HRV Current Control Mode".

8.1 BEFORE YOU SET HRV3 CONTROL

Before you set HRV3 Control you have to notice the number of amplifiers. When HRV3 is set the maximum number of amplifier per one FSSB line is 4. So if the number of amplifier of your machine is over 4, you have to use two FSSB line.



8 amplifiers and 1 module are available per one FSSB line



4 amplifiers and 1 module are available per one FSSB line

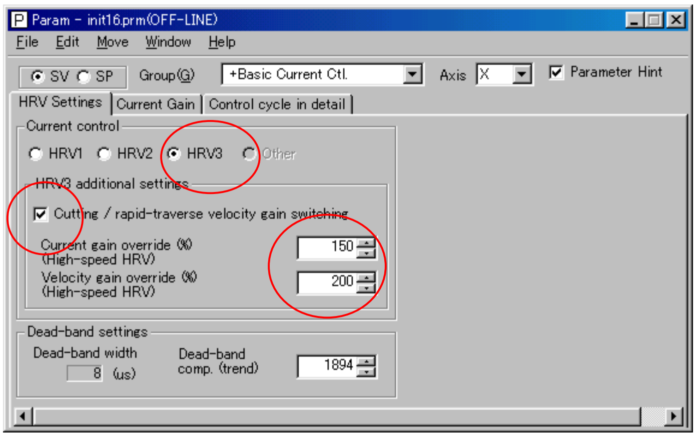
8.2 PARAMETERS FOR HRV3 CONTROL

To set HRV3 Control from fundamental parameters which we recommends you have to set only three parameters. No.2013#0 is a function bit of HRV3 Control. No.2334 and No.2335 are magnification of current gain and velocity gain in HRV3 mode.

[HRV3 Parameters]

Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
2013 #0	1	HRV3 (Current control cycle 62.5 μs)
2334	150	Current loop gain override in HRV3 mode
2335 *1)	200	Velocity loop gain override in HRV3 mode

(*1) No.2202#1 is needed to valid this parameter.



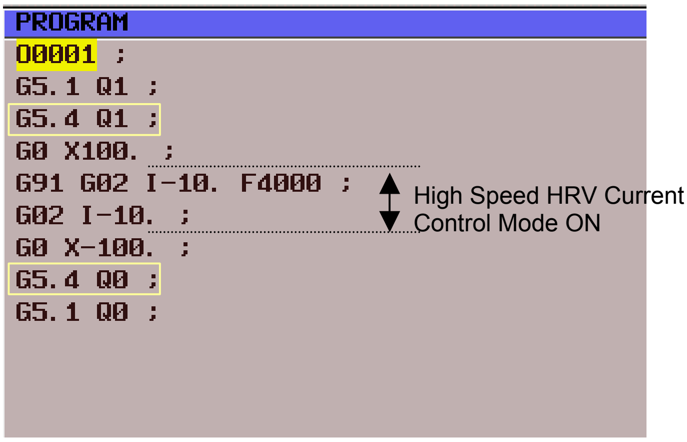
Following table shows fundamental parameters for HRV2 Control. HRV3 Control also needs these parameters. Please confirm these parameters too.

[Fundamental Parameters]

Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
2004	0X000011	Current control cycle 125 μs
2040	Standard parameter	Current integral gain
2041	Standard parameter	Current proportional gain
2003 #3	1	Enables PI function
2017 #7	1	Enables velocity loop high cycle management function
2006 #4	1	Uses the latest feedback data for velocity feedback.
2202 #1	1	Cutting/rapid traverse velocity loop gain variable
2107	150	Velocity loop gain override at cutting traverse

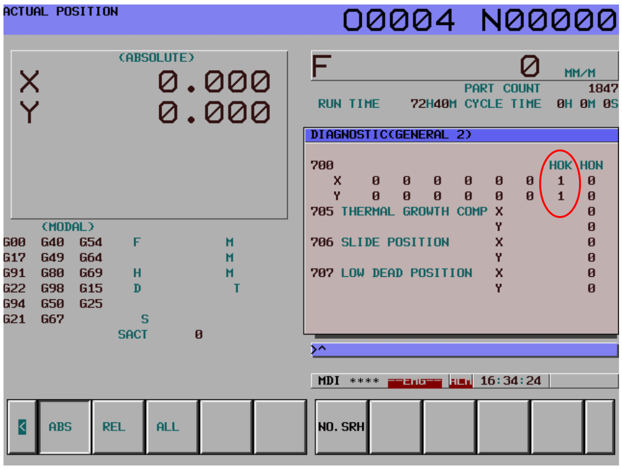
8.3 HIGH SPEED HRV CURRENT CONTROL MODE IN HRV3 CONTROL

G5.4Q1 and G5.4Q0 are program codes to specify "High Speed HRV Current Control Mode". Program codes for cutting traverse between G5.4Q1 and G5.4Q0 is in "High Speed HRV Current Control Mode" and cycle of current loop becomes faster and magnification for control gain is applied.

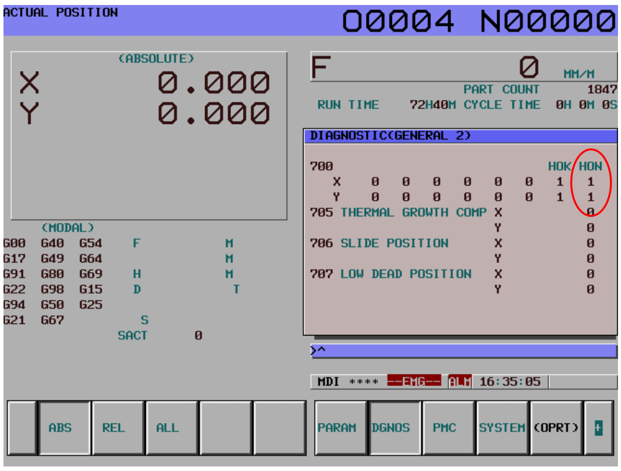


8.4 HOW TO CHECK THE STATE OF HRV3 CONTROL

Diagnose No.700 is available to check the state of HRV3. After you set HRV3 Control(No.2013#0) and power off/on, please check Bit1 of DGN700(HOK). When HRV3 Control is accepted to CNC, HOK becomes 1.



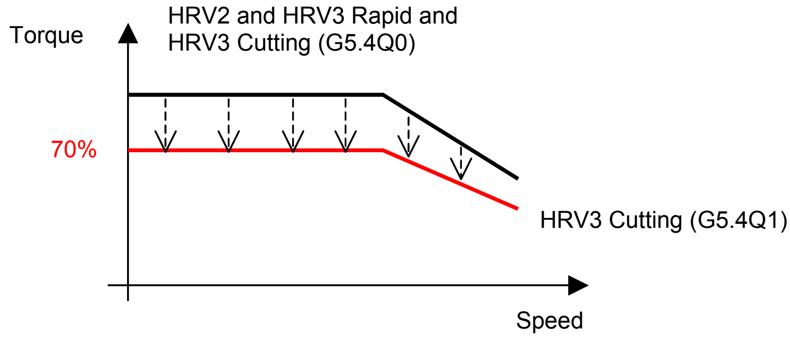
After you commands G5.4Q1 when HOK=1, Bit0 of DGN700(HON) becomes 1 in cutting traverse. This means cycle of current loop becomes faster and magnification for control gain is applied.



8.5 TORQUE COMMAND LIMITATION IN HIGH SPEED HRV CURRENT CONTROL MODE

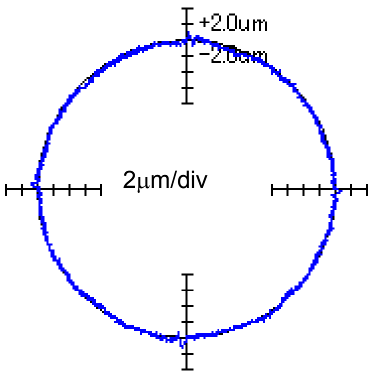
In "High Speed HRV Current Control Mode" torque command is automatically limited less than 70% of the maximum torque to protect transistor in amplifier. So torque command is easy to be saturated by torque limit. Please don't command high speed and high acceleration in "High Speed HRV Current Control Mode". Normally this mode in HRV3 Control is used for final cutting and 70% limit doesn't become the reason of trouble.

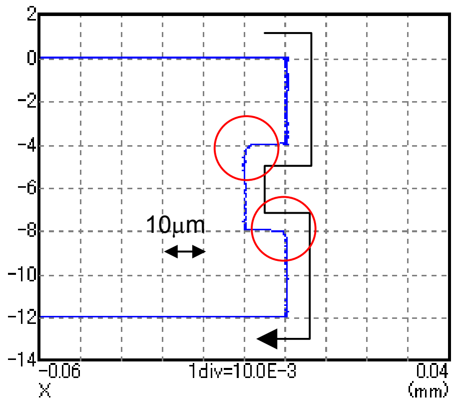
Torque Curve in G5.4Q1



8.6 ABOUT THE EFFECT IN HIGH SPEED HRV CURRENT CONTROL MODE

Following result of circular shape and 10μm step are an actual result of a machining center which uses HRV3 Control. You can see the path error of circle is less than 2μm and smoothness is less than 1μm. There is no overshoot at the point of 10μm step.



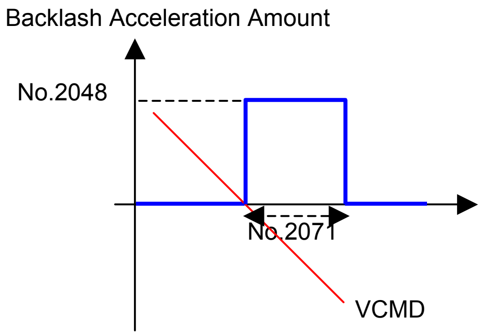


9 BACKLASH ACCELERATION

9.1 ABOUT BACKLASH ACCELERATIONS

The shape of backlash acceleration is simple as following figure. This acceleration value is added to VCMD for velocity loop integration and it helps the movement of the integration at its reverse point. By this effect, position error at the reverse point is reduced.

(Standard Backlash Acceleration)



Basically you only have to think two parameters. No.2071 means time width and its default value is 20. Normally you don't have to change this value. No.2048 means amount of backlash acceleration. Please set 100 at the start of tuning and change this value by watching circular shape.

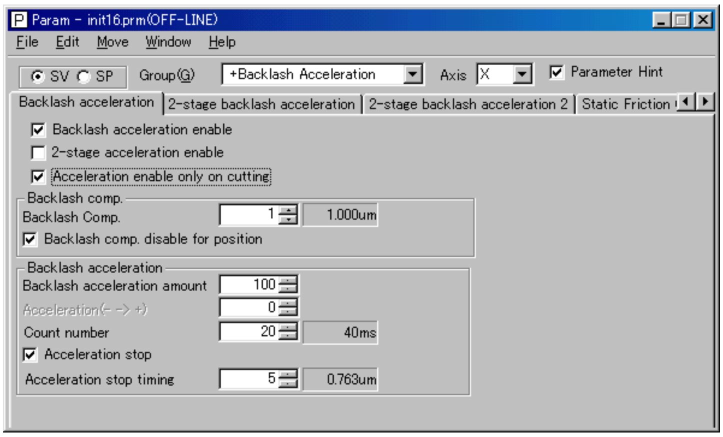
9.2 INITIAL PARAMETERS FOR BACKLASH ACCELERATION

Before you start to tune backlash acceleration, please set the initial parameters as follows.

[Fundamental Parameters for Backlash Acceleration]

Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
1851	more than 1	Backlash compensation
2003 #5	1	Enables backlash acceleration
2006 #0	0/1	0 : Semi-close system 1 : Full-close system
2009 #7	1	Backlash acceleration stop
2009 #6	1	Backlash acceleration only at cutting feed (FF)
2223 #7	1	Backlash acceleration only at cutting feed (G01)
2015 #6	0	two-stage backlash acceleration
2146	50	Stage-2 backlash acceleration end timer
2048	100	Backlash acceleration amount
2082	5 (1μm detection) 50 (0.1μm detection)	Stop distance (detection unit)
2071	20	Backlash acceleration time

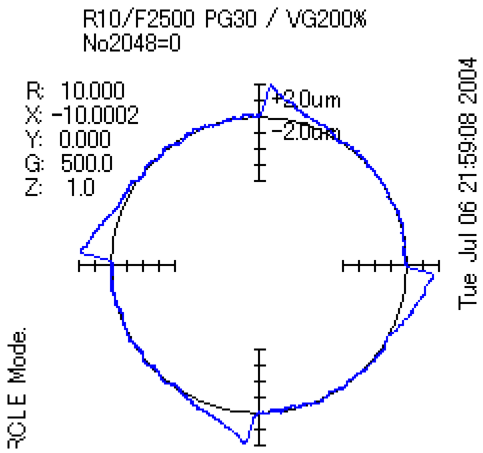
You can set almost all of these parameters from parameter window.



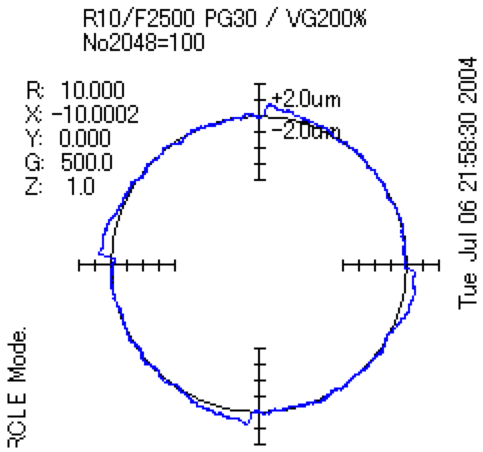
9.3 TUNING OF BACKLASH ACCELERATION

9.3.1 Initial State

Following figure shows initial state of circular shape with no servo tuning. You can see about 2μm quadrant protrusion at the reverse point of X axis and Y axis.

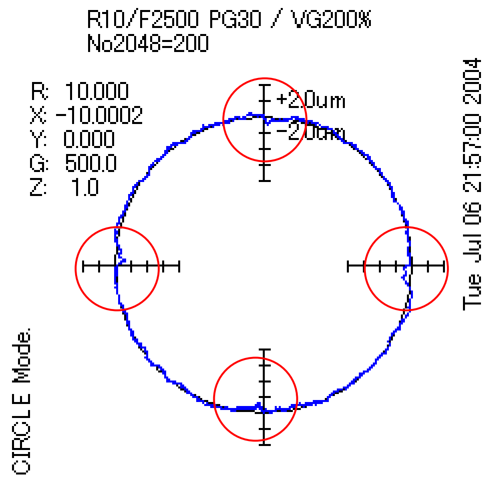


Following figure shows the result after setting the initial parameters for backlash acceleration in Section 9.2. By setting the initial parameters quadrant protrusion is suppressed well.



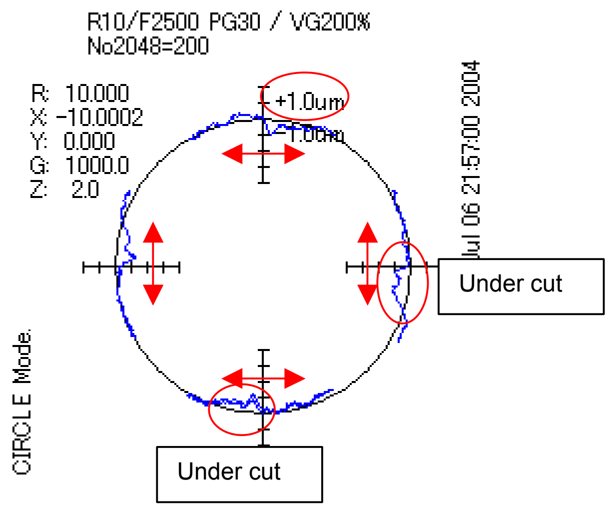
9.3.2 When to Stop Tuning

At first we have to know when to stop tuning of backlash acceleration amount.
Following figure shows the result of No.2048=200. This figure shows "under cut" is occurred at reverse points. We have to avoid "under cut" because this citrainly makes scratch on a surface of cutting work. So we have to stop tuning No.2048 just before "under cut" appears.



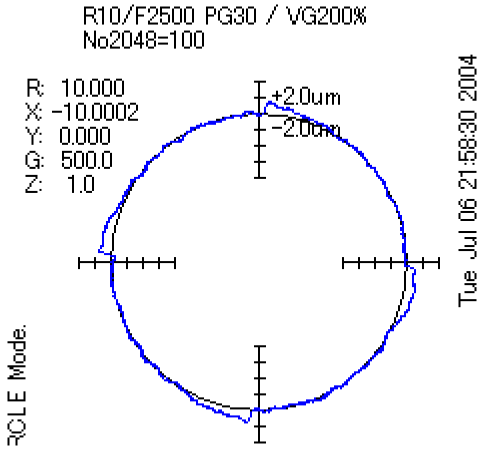
By enlarging the error at the reverse point it becomes easier to judge if "under cut" occurs or not.
By pushing "z" the error becomes wide and by pushing "Z" it becomes narrow.
By pushing "u" the grid of the error becomes small and by pushing "d" it becomes big.

Following figure is the result after pushing "z" and "u".



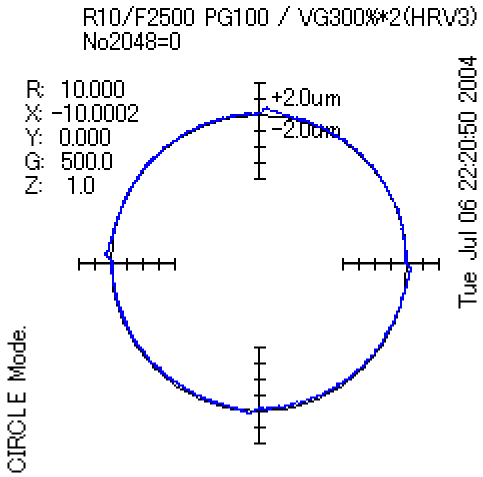
9.3.3 The Effect of Gain Tuning

From Section 9.2 we have to judge No.2048=100 is final value. But a little protrusion is still at the reverse point. In this example the reason of this is insufficient gain tuning. The power of suppressing protrusion by position gain and velocity loop gain is strong and stable. We have to do sufficient gain tuning before all tuning items.

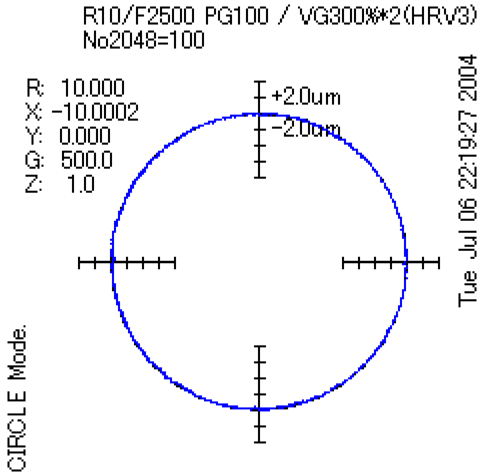


Following figure is the result after gain tuning with no backlash acceleration. Protrusion is almost dissapired without backlash acceleration and you can recognize how important gain tuning is.
(Tuning Item)

- "High Speed HRV Current Control" is applied
- Velocity loop gain is 600% (In upper result velocity loop gain is 200%)
- Position loop gain is 100/s (In upper result position gain is 30/s)



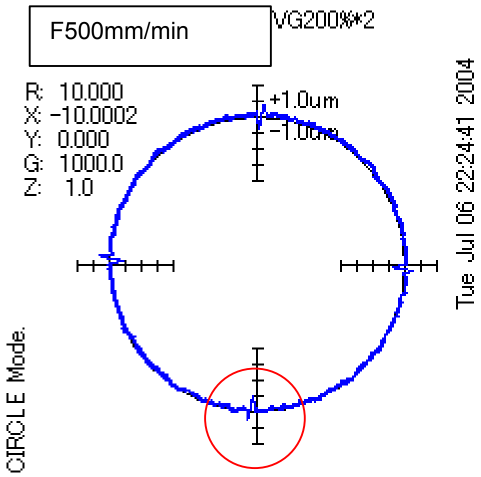
The tuning of backlash acceleration becomes easier after sufficient gain tuning. Following figure is the result after applying the initial parameters for backlash acceleration in Section 9.2. There is no protrusion by the effect of high gain and a little support by backlash acceleration.



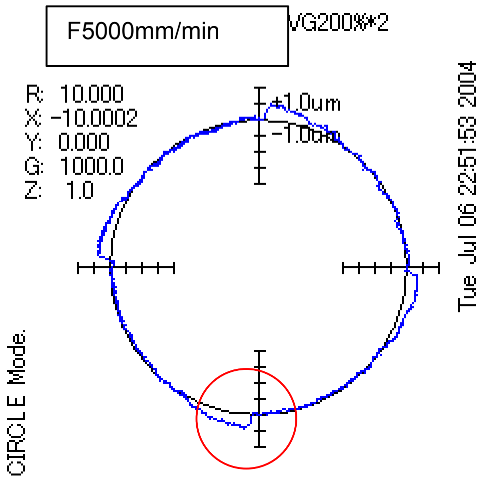
As this figure shows the most important thing to remove quadrant protrusion is to do gain tuning. After you success to do gain tuning, the tuning of backlash acceleration becomes easy. So please consider backlash acceleration is not the main function to suppress quadrant protrusion.

9.3.4 Override Function

Following two figure shows the difference by feed rate. In these results same acceleration amount (No.2048=100) is used, but the result is opposite. As this figures show, small backlash acceleration amount is needed at low speed and big amount is needed at high speed. So we have to change backlash acceleration amount by feed rate.
Actually optimum acceleration amount is almost proportional to acceleration. Therefore "Override Function" which changes the acceleration value according to the acceleration is needed.



No.2048=100 is big for F500mm/min



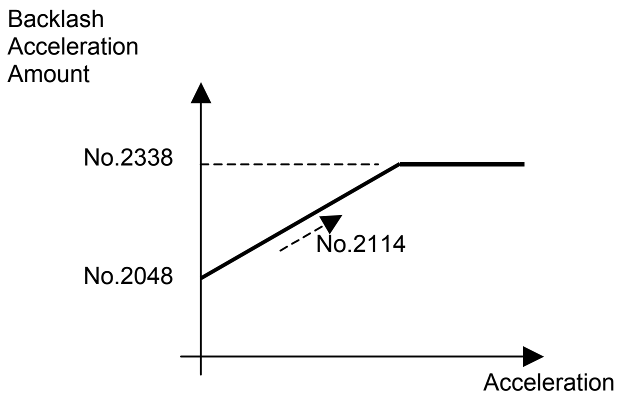
No.2048=100 is small for F5000mm/min

(*) In this chapter we use Position Gain=50, Velocity Gain=400%

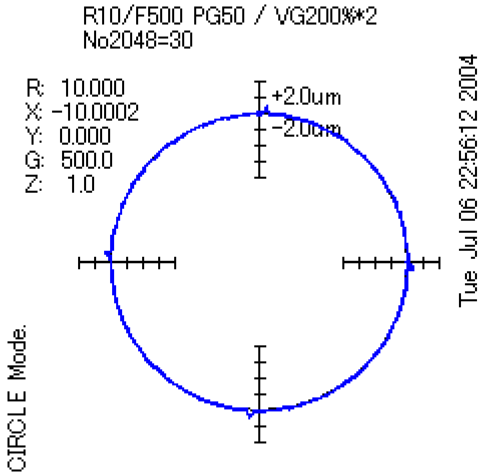
Override function has two parameters. No.2114 is a coefficient of override and No.2339 is a limit value. Tuning process of these parameters is not difficult if you do it by following method from (1) to (3).

[Parameters for Override Function]

Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
2048	100	Backlash acceleration amount
2114	0	Backlash acceleration override coefficient
2338	0	Backlash acceleration limit



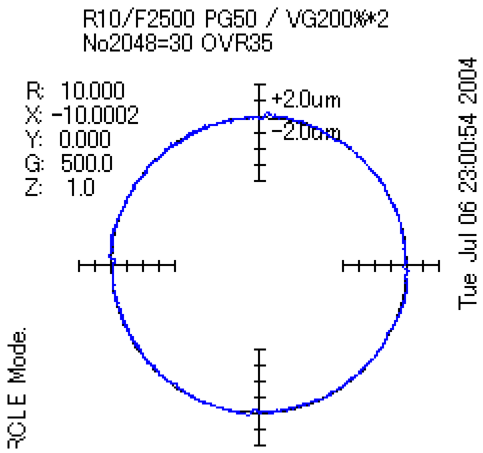
(1) Decision of No.2048
In order to decide No.2048 you have to tune No.2048 at low speed. In this example we used F500mm/min and Radius 10mm. Please deside optimum value of No.2048 at low speed and set the result in No.2048. Following figure is the result of No.2048=30 and we set 30 in No.2048 here.



(2) Decision of No.2114

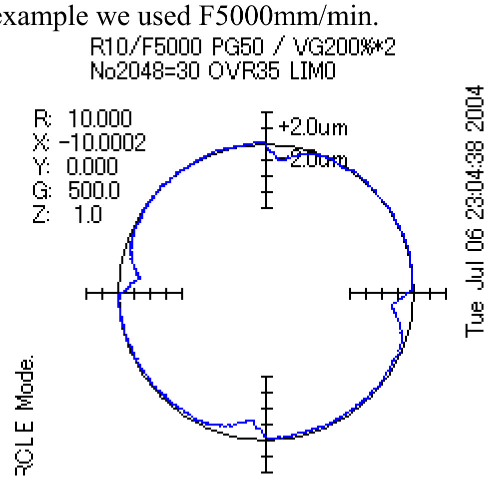
No.2114 has to set after tuning No.2048. No.2114 is decided at middle of maximum cutting feed rate. In this example we used F2500mm/min. Please increase No.2114 and decide optimum value of it not to occur "under cut". If you increase No.2114, actual amount of backlash acceleration increases.

Following figure shows the result of tuning No.2114. Quadrant protrusion is well suppressed.

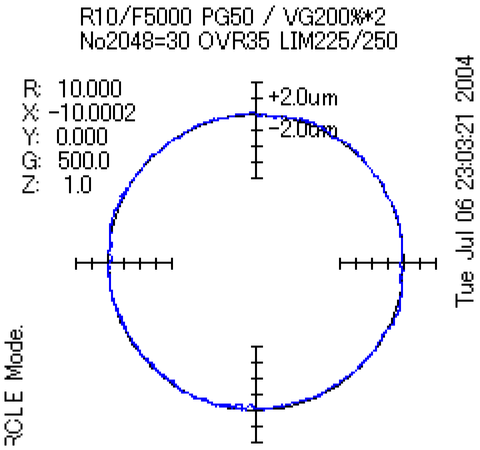


(3) Decision of No.2338

Finally you have to set No.2338. Override coefficient decided at middle speed outputs big acceleration amount for high speed as following figure. So we have to decide limit value at high speed. In this example we used F5000mm/min.



Following figure shows the result of tuning No.2338 at high speed. Quadrant protrusion is well suppressed.

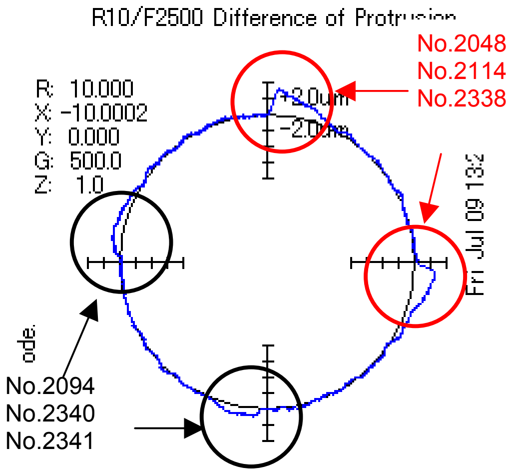


9.4 ACCELERATION AMOUNT BY EACH DIRECTION

Sometimes we meet a circular shape that protrusion of top and bottom, or protrusion of left and right are different. In this case we have to set acceleration amount separately.
If No.2094 is not 0 No.2094 is applied to the reverse point of left and bottom. And No.2340 is a coefficient of override function and No.2341 is a limit value for No.2094.

[Parameters for Separate Backlash Acceleration]

Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
2048	50	Backlash acceleration amount
2114	0	Backlash acceleration override coefficient
2338	0	Backlash acceleration limit
2094	0	Backlash acceleration amount (- to +)
2340	0	Backlash acceleration override coefficient (- to +)
2341	0	Backlash acceleration limit (- to +)



9.5 BACKLASH ACCELERATION OFF AFTER STOP

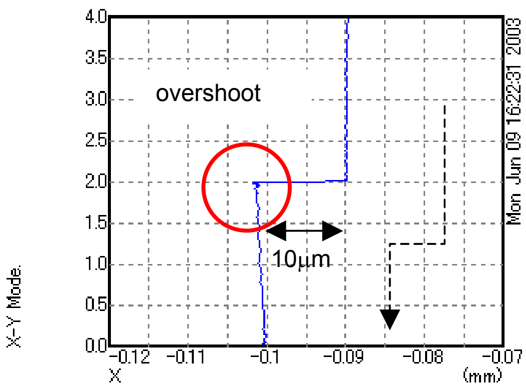
Sometimes the optimum value of acceleration for long time stop is a little different from the value which is decided by circular shape. The phenomenon is caused by the difference of friction, backlash or mechanical torsion at stop. Following figure shows the bad influence from backlash acceleration at the case of 10μm step movement. You can see about 3μm overshoot occurs.
As a countermeasure for this problem, the function of "Backlash Acceleration Off after Stop" is available.

[Parameters for Backlash Acceleration Off after Stop]

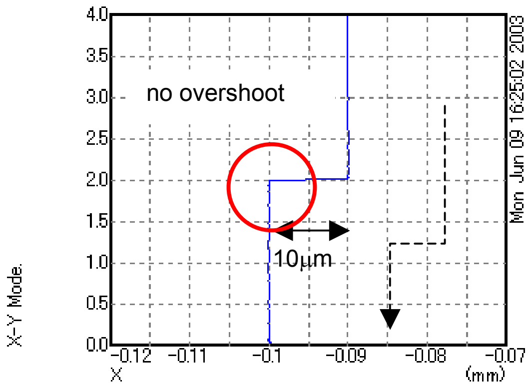
Parameter No. 16*i*/18*i*/21*i*/0*i*	Standard setting value	Description
2005#7	1	The static friction compensation
2283#7	1	Backlash acceleration off after stop
2073	5	Stop state judgement (ITP)
2071	0	Static friction compensation count
2072	0	Static friction compensation

(*) This function uses same parameter for "static friction compensation".

This function is OFF



This function is ON



INDEX

<V>

<W>

Revision Record

FANUC AC SERVO MOTOR α*i*s/α*i*/β*i*s series SERVO TUNING PROCEDURE (BASIC) (B-65264EN)

Edition	Date	Contents	Edition	Date	Contents
01	Mar., 2005	———			