MITSUBISHI ELECTRIC

Changes for the Better

Numerical Control (CNC)

Guidebook

NC Analyzer2

MELSOFT
Integrated FA Software

IB-1501592(ENG)-A

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1. Introduction

(1) The operation procedure of this document applies to NC Analyzer2.

For details on functions or operations, refer to the NC Analyzer2 Instruction Manual (IB-1501326).

(2) Since settings described in this document are used for simplified adjustment and are performed in a stability-oriented manner, there are different settings from those described the Instruction Manual of the drive unit.

(3) Adjustment without having an enough running-in or a cover may result in an incorrect adjustment.

(4) For adjustment, it is essential to execute automatic operation (cycle start).

(5) Beforehand, set the standard parameters for the spindle motor using NC Configurator2.

(6) Make sure that #2013 (OT-), #2014 (OT+), etc. of the soft limit have been correctly set.

(7) Since the adjustment causes axis movement and axis vibration, be careful of confirming safe conditions, machine interference, etc.

(8) Complete the spindle assembly or bring it close to completion before adjusting the spindle.

Since the spindle is easily influenced by the machine system conditions, such as inertia and friction, attach beforehand at least a chuck, cylinder, jaws, etc. that should be attached to the spindle.

Especially for a lathe, without attaching items with large inertia, such as chuck, cylinder, jaws and maximum workpiece to be processed, adjustment results change heavily, and alarms may be triggered after installation.

Since the maximum permissible rotations and inertia are different between the milling cutter and the drill in the machining center or the tapping center, prepare the tools for checking "Maximum rotation" and "Maximum inertia" respectively.

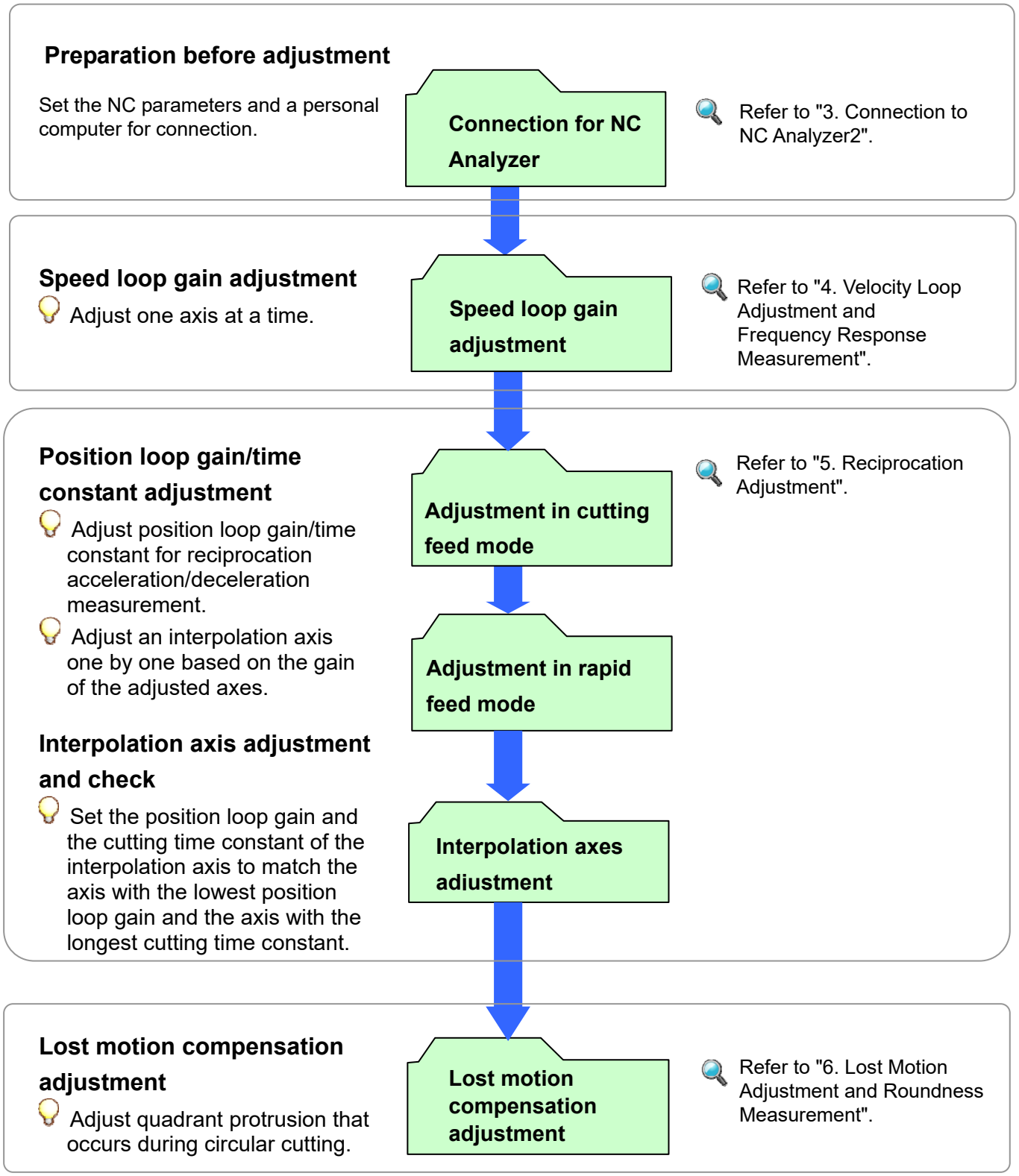
Carry out the initial operation (aging) so that the spindle can be rotated to the maximum speed before adjusting it.

* During adjustment, the temperature of the spindle can reach approximately 80 [°C].

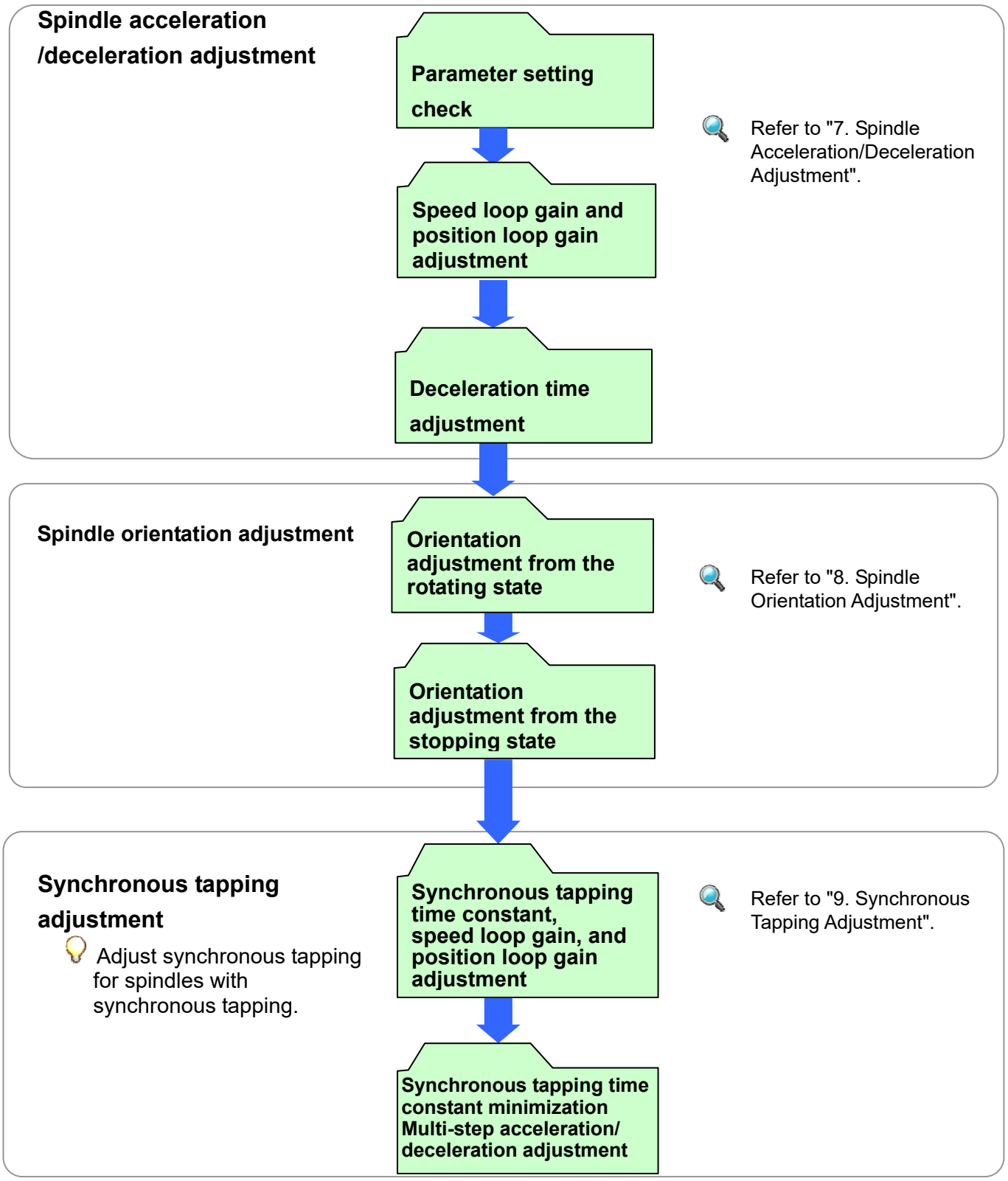
* To measure the waveforms, measure the temperature of the spindle in the low temperature condition (near the outside temperature) and the high temperature condition (not lower than 60 [°C]) (the condition in which the temperature of the spindle motor has been raised by repeating acceleration/deceleration) and make sure that the waveforms conform to the judgment criteria in both temperature conditions.

2. Flow of Adjustment Operation

2.1 Flow of Servo Adjustment Operation



2.2 Flow of Spindle Adjustment Operation

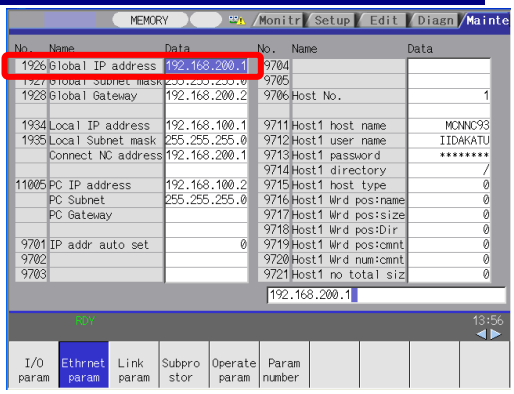


Adjust spindle C-axis and spindle synchronization according to their specifications.
Refer to "10. Spindle C-Axis Adjustment" and "11. Spindle Synchronization Adjustment".

3. Connection to NC Analyzer2

[1] Confirm NC IP address

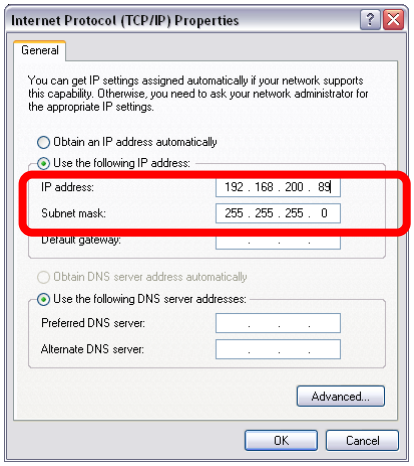
(1) Turn the NC power ON with the emergency stop button pressed. Check the NC's IP address set by "Ethernet parameter".



[2] Change the PC's (Windows) IP address

(1) Make a note of the original IP address and subnet mask. After adjustment, set the PC's IP address back to the original setting.

(2) Set the IP address to "192.168.200.89", and set the subnet mask to "255.255.255.0".



[3] Set the NC parameters

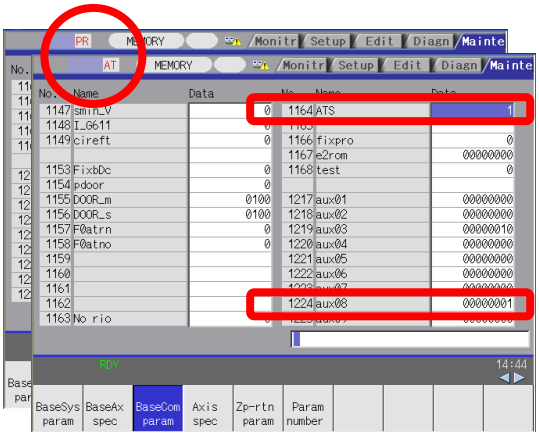
(1) Set #1224 aux08 bit 0 to "1".

Input "00000001" as in the screenshot right.

(2) Set #1164 ATS to "1".

"PR" appears and flashes at the upper left corner of the screen.

(3) "AT" appears and flashes at the top left corner of the screen. The NC's setup is complete.



[4] Connect the PC and NC using an Ethernet cable

Connect the NC and PC using a cross cable.

Straight cables are also available with a hub.

NC Analyzer2

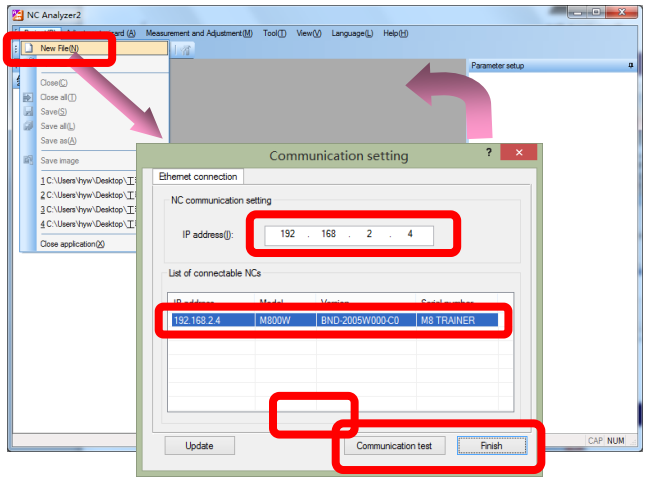
[5] Connection setting of NC Analyzer2

(1) Select “New File” from “Project” menu.

If connected NCs exist, information of the NC is displayed in the “List of connectable NCs” part.

When the part is clicked, IP address of the NC is displayed on the IP address section

(2) Check if the confirmed NC’s address “192.168.200.1” is set in the “IP address” section.



Execute the following ways when NC to connect does not exist in the List of connectable NCs, even if the IP address setting is appropriate.

(1) Check if PC’s IP address and NC’s IP address are set on the same network.

(2) Check if the network cable is connected properly.

(3) Press “Update” for reconfirmation.

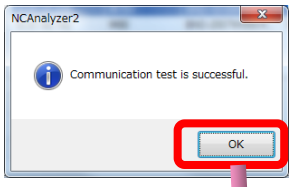
(4) Press “Manual entry” to specify NC’s IP address for the IP address.

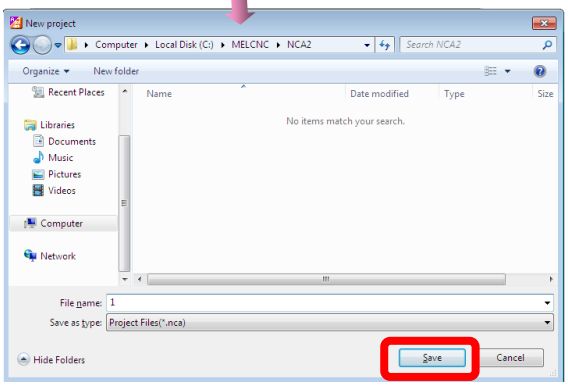
[6] Perform a communication test

(1) Click “Communication test”.

(2) When “Communication test is successful.” is displayed, click “OK”.

(3) When Project saving window is displayed, set the project name and click “Save” to save the project.





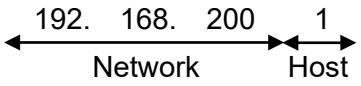
When “Communication has failed.” is displayed.

NC Analyzer2 may not connect to CNC when Windows firewall function is enabled. Disable the firewall function or register NC Analyzer2 as an exception. (Carry out with the authority of the administrator.)

[Appendix 1] [TCP/IP setting] (Example using Windows7)

IP address setting

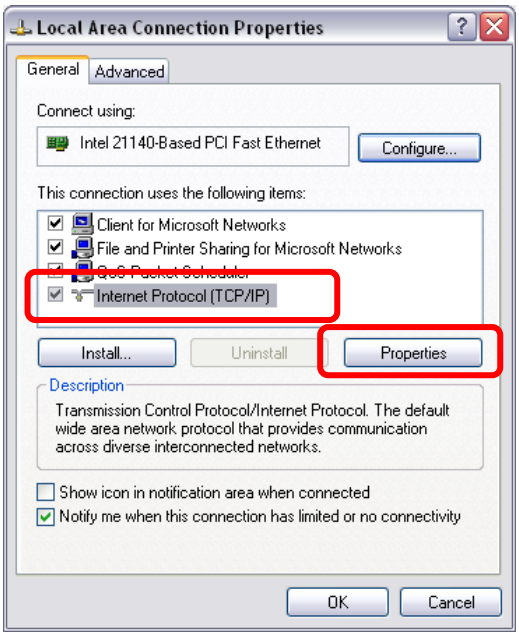
An IP address is an address and destination used in TCP/IP communications.



Network: Equivalent meaning as an address of a building (apartment)

Host: Equivalent meaning as a room number of the building (apartment)

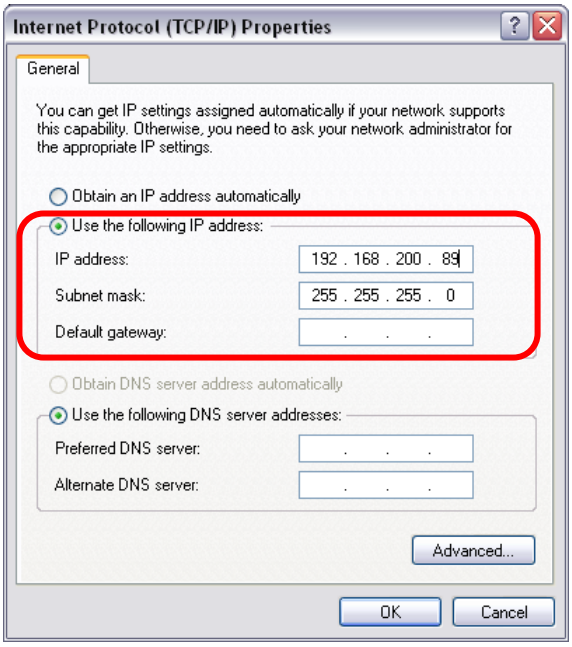
In this guidebook, PC's IP address is set to "192.168.200.89". However, instead of "89", it can be a value from 1 to 254 that has not been used as an address on the network.



(1) "Start"→ "Control Panel"→ "Network Connection" → "Change adapter settings"→ "Local Area Connection"→ "Properties"→ "Local Area Connection Properties"

(2) Select "Internet Protocol (TCP/IP)" and click "Properties".

(3) Under "Use the following IP address", set "IP address" And "Subnet mask".



<IP Address>

Two or more same addresses cannot exist on one network.

<Subnet mask>

In the case of a small LAN, normally "255.255.255.0" is used.

<Default gateway>

It is not necessary to fill in if there is no Internet connection.

🔍 Settings may differ in the case of a large scale LAN. Consult with your network administrator or refer to a technical book.

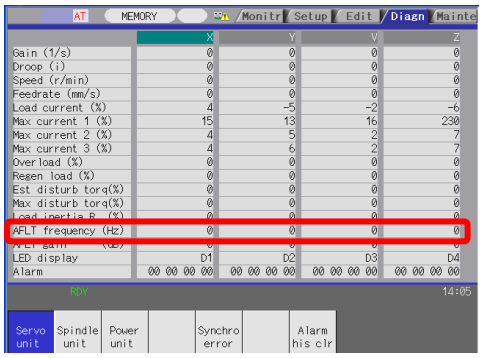
(4) Once the setting is changed, press "OK" to reflect the adjustment.

🔍 If you are using the PC that requires the IP address setting, you will not be able to get back to the original network after you change settings. Before making any change, take notes of your original settings then after the operation, change back to the original settings.

4. Velocity Loop Adjustment and Frequency Response Measurement

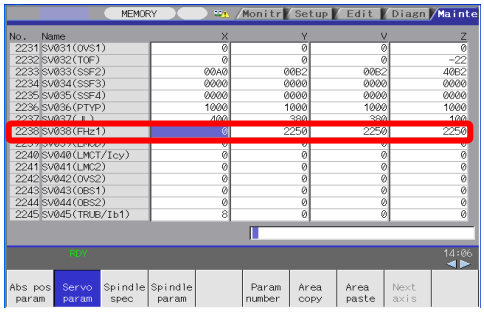
[1] Resonance frequency confirmation and temporary resonance filter setting

(1) Cancel the emergency stop and move the axis in mode such as JOG. If a resonance occurs while the axis stops or moves, check the resonance frequency using the drive monitor. If no noise occurs, jump to [2].



(2) Check "AFLT frequency" on the drive monitor. "AFLTfrequency" shows the current resonance frequency in real-time.

(3) Set the temporary resonance filter.
#In #2238 SV038(FHz1), input the value of "AFLT frequency" having been checked above.



If the resonance persists, refer to the drive unit's instruction manual.

[2] Set up the machine

(1) Establish the zero point in zero position return mode when the drive is not absolute position detector specification.

(2) Move the axis near the center of the stroke with manual operation (handle or JOG mode).

(3) Change to the memory mode on the machine operation board.

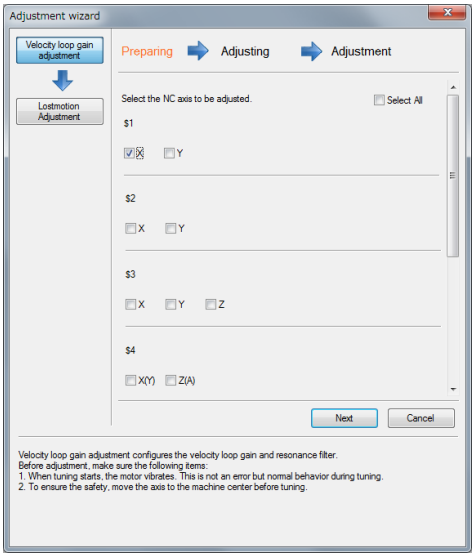
(4) When adjusting velocity loop gain, go to [3]. When measuring frequency response, jump to [7].

[3] Velocity loop gain adjustment Axes selection

(1) Select "Velocity loop gain adjustment" of "Adjustment wizard" in the menu.

(2) Check the boxes of axes to adjust.

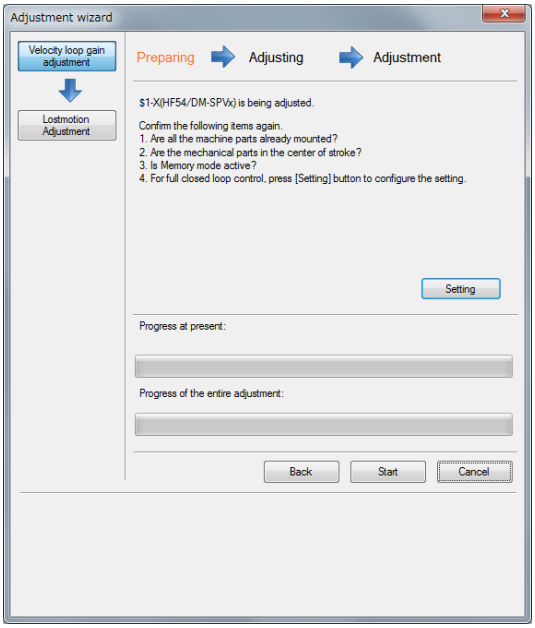
(3) Press "Next".



[4] Velocity loop gain adjustment Setup

(1) When Full closed loop axis or synchronized control axis exists, press "Setting" to open the tab of "Encoder/Sync axis", and check Full closed loop/Sync control axis.

(2) Check the precautions, and press "Start" if there is nothing wrong.



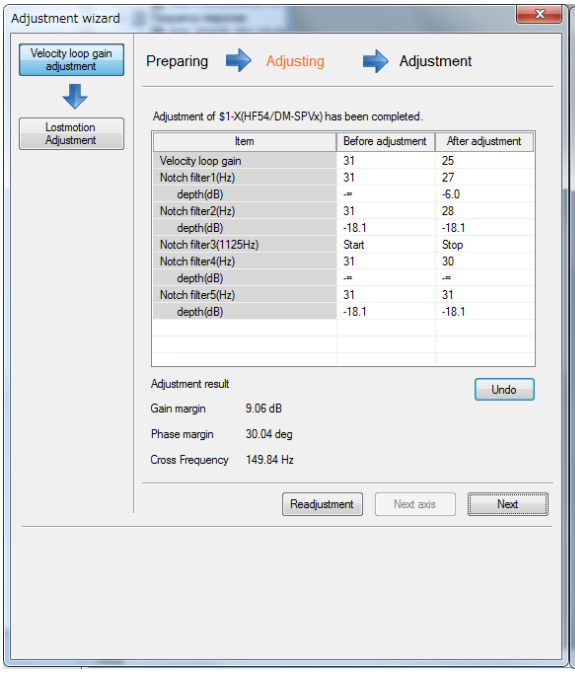
If vibration or abnormal sound lasts 7 seconds or longer, press the emergency stop button to stop the adjustment and adjust again.
In that case, reduce the SV005 VGN1 (velocity loop gain) to a half of the existing setting and retry adjustment.

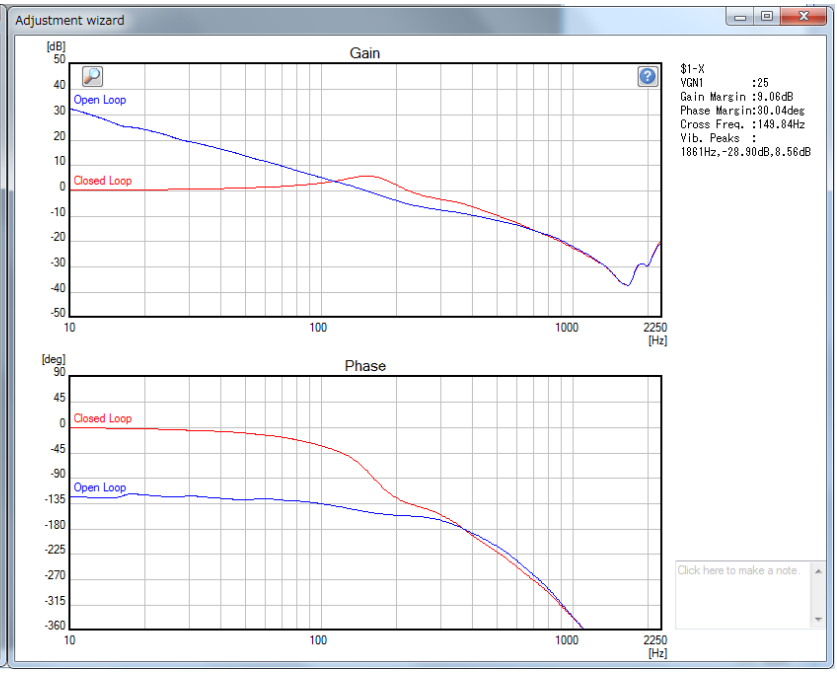
If an error occurred when output signal is small by strong friction etc., raise the vibration level.

[5] Check the velocity loop gain adjustment result.

(1) After automatic adjustment is completed, changed parameters are displayed in the left window, Bode diagrams are displayed in the right window.

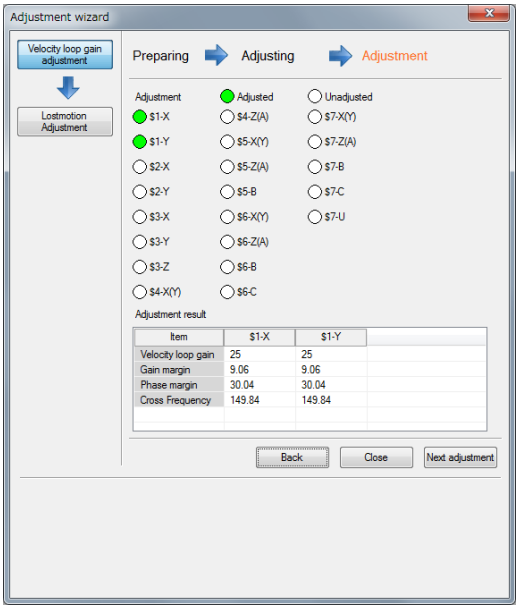
(2) Press "Restore the previous state before adjustment" to restore the parameter before adjustment. Press "Next axis" if there is nothing wrong.





[6] Completion of velocity loop gain adjustment

The following window is displayed after completing the adjustment for all the axes. That is all for the adjustment of velocity loop gain.

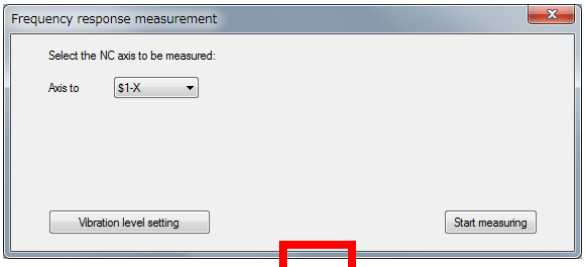


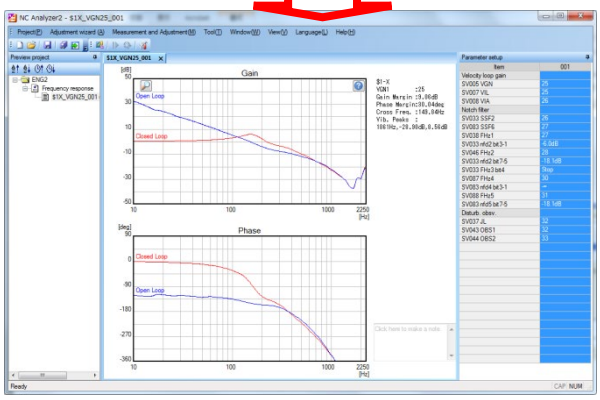
[7] Frequency response measurement

(1) Select "Frequency response measurement" from the menu "Measurement and Adjustment".

(2) Select the axis to measure in "Axis to measure".

(3) Click "Start measuring" after completing the setting.





If vibration or abnormal sound lasts 7 seconds or longer, press the emergency stop button to stop the adjustment and adjust again. In that case, reduce the SV005 VGN1 (velocity loop gain) to a half of the existing setting and retry adjustment.

If an error occurred when output signal is small by strong friction etc., raise the vibration level.

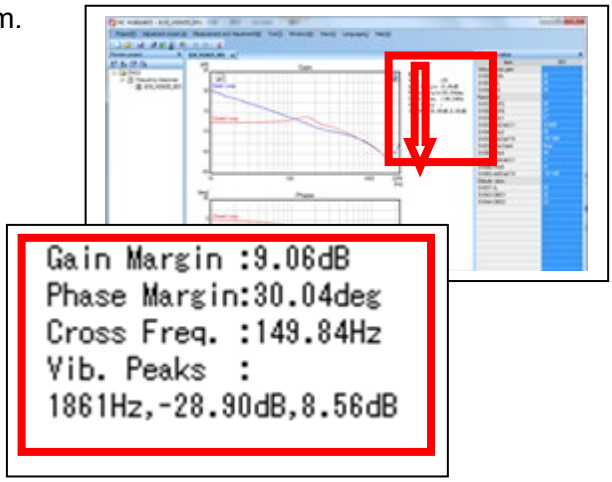
[8] Standard of the velocity loop gain value

(1) Check the right side area of the Bode diagram.

- Normally, if the value of "Gain Margin" is 8dB or more (*), and also if the value of "Phase Margin" is 30deg or more, it is thought to be stable.

*The case of Full closed loop/ Sync control axis, 10dB or more is thought to be stable.

In "Automatic velocity loop gain adjustment", automatic adjustment is carried out so that these target values are achieved.



- Velocity loop gain values and resonance frequency values do not have to be the same among all the axes.
- During a performance check after having set "Automatic velocity loop gain adjustment", if a noise/vibration occurs under a specific condition, lower the speed gain down to the half of the setting. If no change occurs, a factor other than resonance (such as a friction noise of the cover, oil seal, etc.) can be the cause. If the noise/vibration is reduced, it is difficult to detect it with this tool. Set the resonance frequency according to the tone.

5. Reciprocation Adjustment

[1] Parameter setting for position loop gain

(1) Press the emergency stop button.

(2) Set the entire axis to the following value.

Parameter	Setting value
[#2203] SV003 PGN1	33
[#2204] SV004 PGN2	88
[#2208] SV008 VIA	1900
[#2215] SV015 FFC	50
[#2257] SV057 SHGC	198
[#2001] rapid	Max. speed at rapid traverse
[#2002] clamp	Max. speed at cutting feed(G01)
[#2003] smgst	0011 (linear acc/dec)
[#2004] G0tL	100
[#2007] G1tL	100

Refer to [Appendix 2] for the details of position loop gain.

[2] Setup for cutting feed mode adjustment

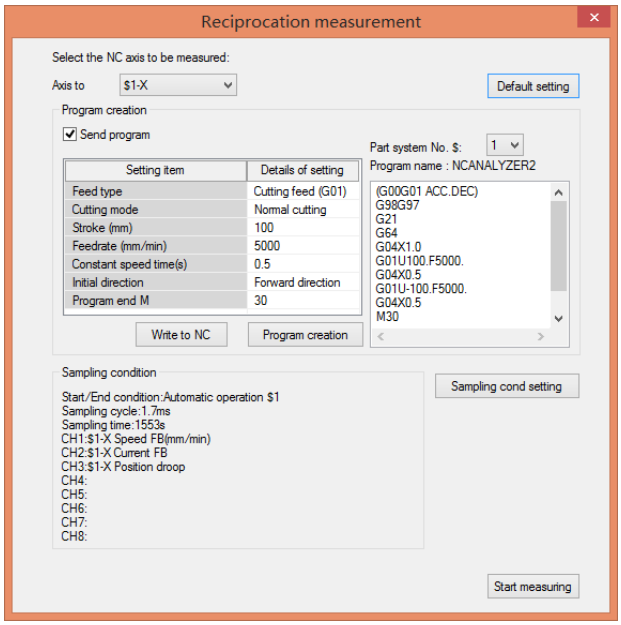
(1) Release the emergency stop button.

(2) Select "Reciprocation measurement" from the menu "Measurement and Adjustment".

(3) Select the axis to adjust in "Axis to measure".

(4) If the setting was changed, click "Program creation".

(5) Click "Start measuring" after completing the setting.



#2002 clamp (Cutting feed clump speed) is set automatically for "feedrate".

When measuring the program registered in the memory, check "Execute the program stored in the NC" to search the program at the NC operation search.

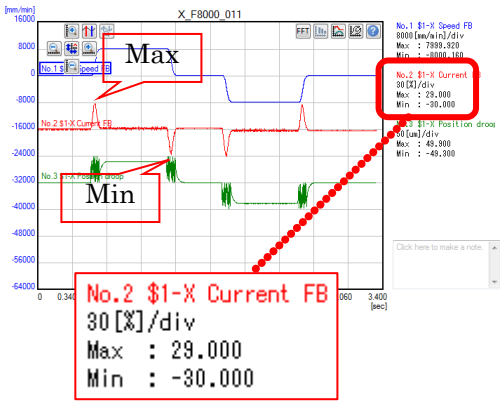
If the speed is not reaching to the set feedrate, set the larger value to "moving distance".

<Sampling setting>
Initial sampling setting for reciprocation measurement is as follow.
Changing the setting is unnecessary.

Channel	Waveform type
CH1	Speed FB(mm/min)
CH2	Current FB
CH3	Position droop

[3] Check the absolute values of max./min. currents

(1) Check whether or not a bigger value of absolute values of "Max" and "Min" is within the allowable current range of "Current FeedBack".



For allowable current range, refer to the column of G1 in the table of [Appendix 1].

In the example on the right, check whether or not "30" is within the allowable current range.

<If the bigger value of absolute values of "Max" and "Min" is high>
-> Increase #2007 G1tL G1 time constant by "+10".

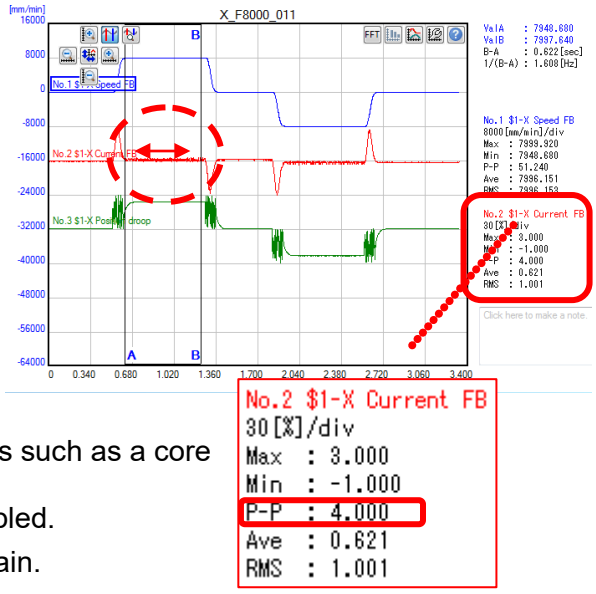
<If the bigger value of absolute values of "Max" and "Min" is low>
-> Decrease #2007 G1tL G1 time constant by "-10".

If parameters are changed, click "Remeasurement" button for readjustment.

[4] Confirm that the current during a constant feedrate is stable

<Points to check>
(1) Are there cyclic fluctuations?
(2) Is there a sudden fluctuation?
(3) Is there a fluctuation of current value at a specific part?

Check the fluctuation in the current by displaying the cursors by button, and move the cursors so that the range to check the fluctuation comes between them, then check the "P-P" value. In the example on the right, "P-P: 4.000 (within 30%)", it is cyclic, and there is no sudden fluctuation, so it is judged that there is no fluctuation in the current.



<If any of the phenomena above is seen>
(1) Check for a mechanical problem (a mechanical looseness such as a core deviation or cover attachment problem).
(2) Lower the position loop gain to check if the current is stabled.

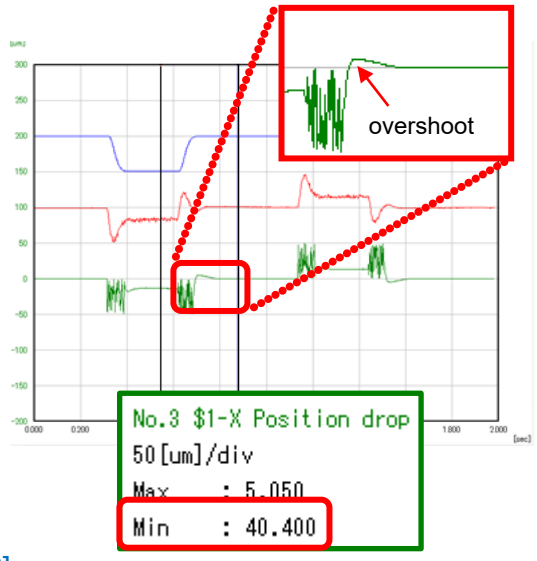
Refer to [Appendix 2] for changing position loop gain.

If parameters are changed, return to [2] for readjustment.

[5] Use "Position Droop" to check for an overshoot

<Criterion value for overshoot>
-During acceleration: 5μm or more
During deceleration and stop: 2μm or more

Check the overshooting amount by displaying the cursor by button, and select as in the figure on the right. In this example, "Max" is "5.050", so remove the overshoot.



<How to remove an overshoot>

(1) Increase #2007 G1tL G1 time constant by "+10".
If the maximum current value during acceleration/deceleration is 50% or less than the adjustment value, do not increase the time constant.

(2) Lower the position loop gain.

For changing the position loop gain, refer to [Appendix 2].

If parameters are changed, return to [2] for readjustment.

[6] Conform that there is no fluctuation in the droop during a constant feedrate

<Criterion value for fluctuation>
3μm or more

Check the "P-P" value during a constant feedrate for droop's fluctuation value.

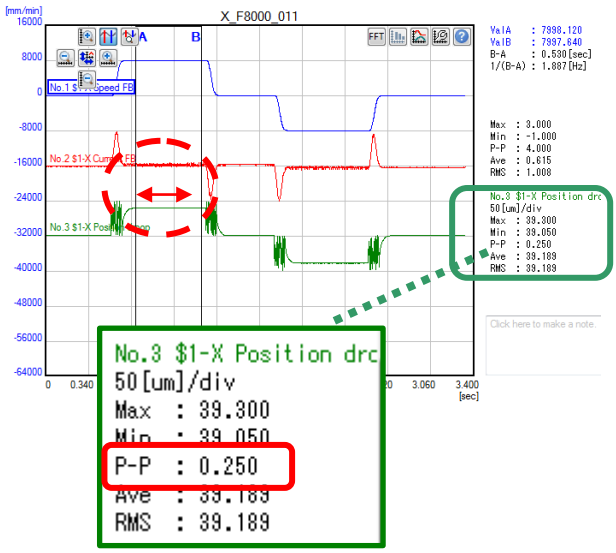
<How to remove a fluctuation>

(1) Check for a mechanical problem (a mechanical looseness such as a core deviation or cover attachment problem). In the case of a gear driven axis there can be an influence of loads between teeth.

(2) Lower the position loop gain.

For changing the position loop gain, refer to [Appendix 2].

If parameters are changed, return to [2] for readjustment.



[7] Setup for rapid traverse mode adjustment

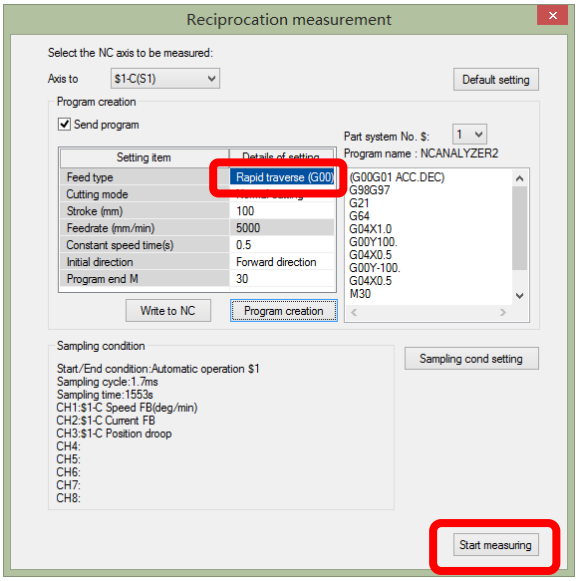
(1) Select "Reciprocation measurement" from the menu "Measurement and Adjustment".

(2) "Rapid traverse (G00)" is set to "Feed type".

(3) Set "Travel distance" to the distance as long as possible in the range.

(4) Click "Measure".

(5) Click "OK", and measure as in [2] Cutting feed mode.



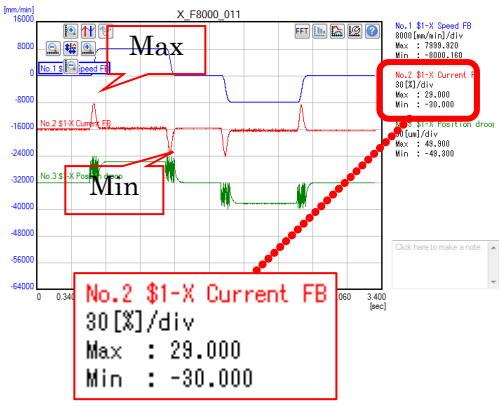
[8] Confirm that the maximum current is within the allowable range in the table

(1) Check whether or not a bigger value of absolute values of "Max" and "Min" are within the allowable current range of "Current FeedBack".

For allowable current range, refer to the column of G0 in the table of [Appendix 1].

<If the bigger value of absolute values of "Max" and "Min" is high>
-> Increase #2004 G0tL (G0 time constant) by "+10".

<If the bigger value of absolute values of "Max" and "Min" is low>
-> Decrease #2004 G0tL (G0 time constant) by "-10".



[9] Confirm that the current during a constant feedrate is stable

<Points to check>

(1) Area there cyclic fluctuations?
(2) Is there a sudden fluctuation?
(3) Is there a fluctuation of current value at a specific part?

Check the fluctuation in the current by displaying the cursor by button, and move the cursors so that the range to check the fluctuation comes between them, then check the "P-P" value. In the example on the right, "P-P: 3.000000 (within 30%)", it is cyclic and there is no sudden fluctuation, so it is judged that there is no fluctuation in the current.

<If any of the phenomena above is seen>

(1) Check for a mechanical problem (a mechanical looseness such as a core deviation or cover attachment problem).

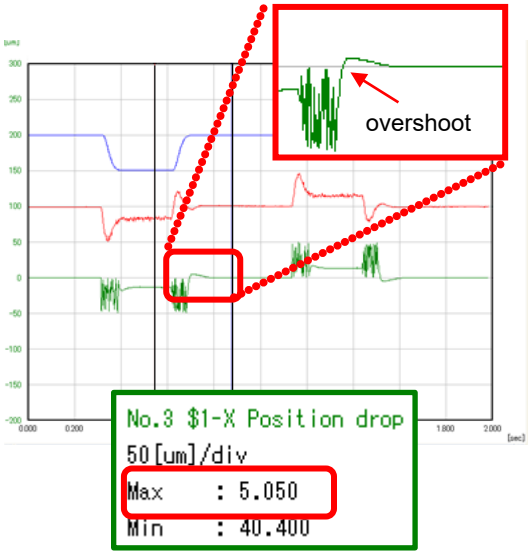
(2) Lower the position loop gain to check if the current is stabled.

For changing the position loop gain, refer to [Appendix 2].

[10] Use "Position Droop" to check for an overshoot

<Criterion value for overshoot>
-During acceleration: 10μm or more
During deceleration and stop: 3μm or more

Check the overshooting amount by displaying the cursors by button, and select as in the figure on the right. In this example "Max" is "5.050", so remove the overshoot.



<How to remove an overshoot>

(1) Increase #2004 G1tL (G0 time constant) by "+10".

If the maximum current value during acceleration/deceleration is 50% or less than the adjustment value, do not increase the time constant.

(2) Lower the position loop gain.

For changing the position loop gain, refer to [Appendix 2].

[11] Confirm that there is no fluctuation in the droop during a constant feedrate

<Criterion value for fluctuation>
5μm or more

Check the "P-P" value during a constant feedrate for droop's fluctuation value.

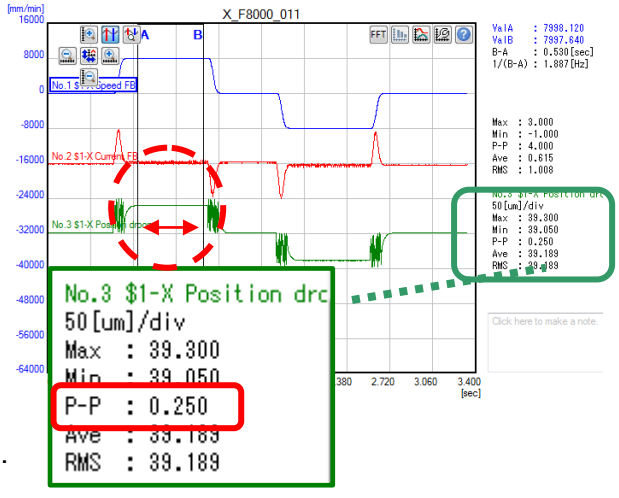
<How to remove a fluctuation>

(1) Check for a mechanical problem (a mechanical looseness such as a core deviation or cover attachment problem).

(2) In the case of a gear driven axis, there can be an influence of loads between teeth.

(3) Lower the position loop gain.

For changing the position loop gain, refer to [Appendix 2].



[12] If a noise/vibration occurs when the machine is actually operated even if the waveform has no problem

(1) Increase #2005 G0t1 G0 time constant until the maximum current becomes the half of the current adjustment value.

(2) If increasing the time constant is not effective, lower the position loop gain.

🔍For changing the position loop gain, refer to [Appendix 2].

💡 Even if there is a problem except for the maximum current that is too large, the adjustment can be finished as long as it does not cause any problem during an actual operation.

[13] When the setting is complete, adjust other axes repeating the procedures from [1].

(1) Adjust other axes using the same position loop gain as of the axis first adjusted.

💡 Rapid traverse time constant and rapid traverse acceleration/deceleration pattern do not have to be the same with other axes.

[14] Check the setting of interpolation axes again

(1) Make sure that the interpolation axes' position loop gains are all the same.

💡 #2203(SV003 PGN1), #2204(SV004 PGN2) and #2257(SV057 SHGC) must be the same among all the axes.

(2) Make sure that the settings of #2007 G1tL G1 time constant of the interpolation axes are all the same.

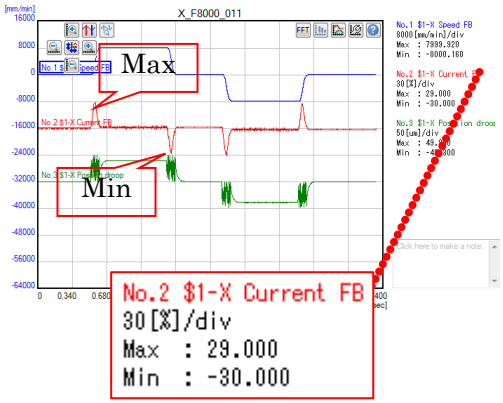
[15] Check with a full stroke operation

(1) Carry out a full stroke operation and check for a vibration/noise during an axis feed again.

(2) Confirm that the current of rapid traverse during acceleration/deceleration is below the adjustment value on the drive monitor.

[Appendix 1] Checking the peak current values

Make sure that a bigger value of absolute values of "Max" and "Min" is within the range below.



MDS-E (200V) series

Motor model name	Setting value	
	G1	G0
HG46	Within 266%	Within 380%
HG56	Within 273%	Within 390%
HG96	Within 182%	Within 260%
HG75	Within 245%	Within 350%
HG105	Within 189%	Within 270%
HG54	Within 294%	Within 420%
HG104	Within 245%	Within 350%
HG154	Within 266%	Within 380%
HG224	Within 217%	Within 310%
HG204	Within 217%	Within 310%

Motor model name	Setting value	
	G1	G0
HG354	Within 294%	Within 420%
HG123	Within 133%	Within 190%
HG223	Within 161%	Within 230%
HG303	Within 168%	Within 240%
HG453	Within 205%	Within 300%
HG703	Within 168%	Within 240%
HG903	Within 203%	Within 290%
HG142	Within 133%	Within 190%
HG302	Within 147%	Within 210%

MDS-EH (400V) series

Motor model name	Setting value	
	G1	G0
HG-H75	Within 245%	Within 350%
HG-H105	Within 189%	Within 270%
HG-H54	Within 294%	Within 420%
HG-H104	Within 245%	Within 350%
HG-H154	Within 266%	Within 380%
HG-H204	Within 217%	Within 310%
HG-H354	Within 231%	Within 330%

Motor model name	Setting value	
	G1	G0
HG-H453	Within 175%	Within 250%
HG-H703	Within 168%	Within 240%
HG-H903	Within 203%	Within 290%
HG-H1502	Within 133%	Within 190%
HQ-H903	Within 175%	Within 250%
HQ-H1103	Within 147%	Within 210%

- If the current is not within the range, increase the time constant.
- If there is a lot of allowance left between each peak (-/+) and each limit of the allowable range, it is possible to shorten the time constant unless an overshoot occurs.

[Appendix 2] How to change the position loop gain during SHG control

When changing the position loop gain, make sure to change three parameters always together (#2203 SV003 PGN1, #2204 SV004 PGN2, #2257 SV057 SHGC) as in the example below.

- When lowering SV003 PGN1 (position loop gain 1) from "33" to "27", it is necessary to change the other two. Change SV004 PGN2 (position loop gain 2) from "88" to "72" and SV057 SHGC (SHG control gain) from "198" to "162".

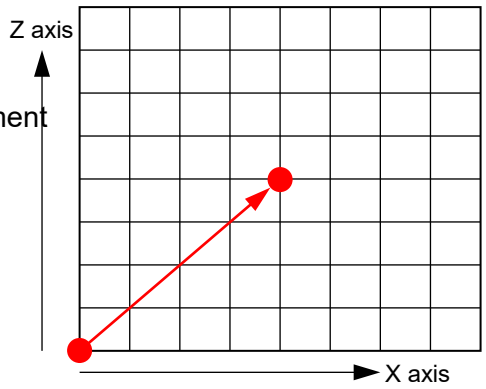
Parameter	Setting value					Setting ratio
[#2203] SV003 PGN1	21	27	33	39	48	1
[#2204] SV004 PGN2	56	72	88	104	128	8/3
[#2257] SV057 SHGC	126	162	198	234	288	6
[#2208] SV008 VIA	Standard setting: 1900 at SHG control					
[#2215] SV015 FFC	Standard setting: 50 at SHG control					

6. Lost Motion Adjustment and Roundness Measurement

[1] Setup for roundness adjustment and measurement

(1) Move the axes to be adjusted by a manual operation (handle/JOG) to a safe position: the center of the machine.

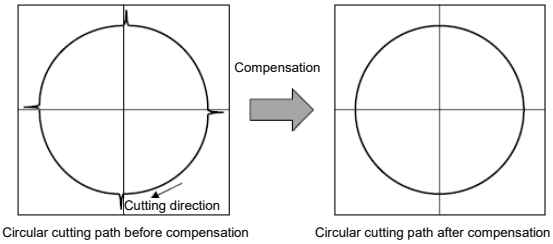
(2) For the adjustment, refer to [2] Lost motion automatic adjustment outline. For the measurement, refer to [7] Roundness measurement. For the manual adjustment, refer to [9] Lost motion parameter manual adjustment.



[2] Lost motion automatic adjustment outline

(1) Lost motion compensation adjustment improves protrusions at quadrant changes.

- Lost motion compensation improves problems such as protrusions at quadrant changes caused by response delay (caused by dead band from friction torsion, expansion/contraction, backlash, etc.) when the machine advance direction reverses, and scratches on work-piece surface during circle cutting due to quadrant change. Type 3 also improves torsion and expansion/contraction influences in the machine system in which compensation amount is changed by travel speed.



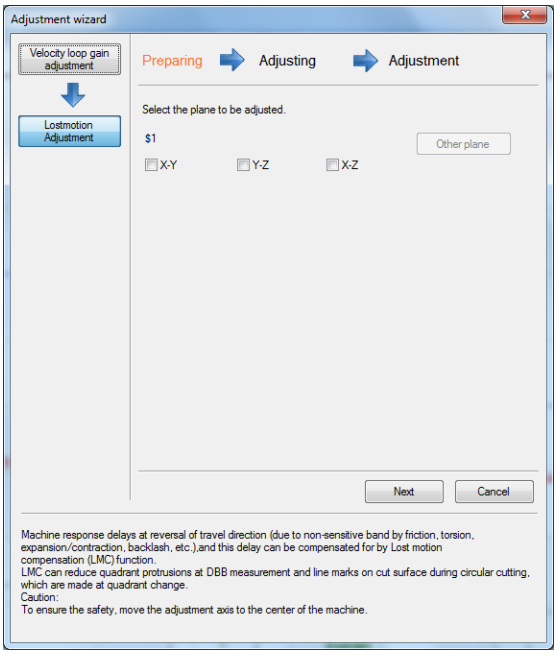
- Adjustment on X-Z plane is described as an example in this manual.

[3] Start the lost motion adjustment function

(1) Select "Lost motion adjustment" from the menu "Adjustment wizard".

(2) Check the plane of "X-Z" to adjust.

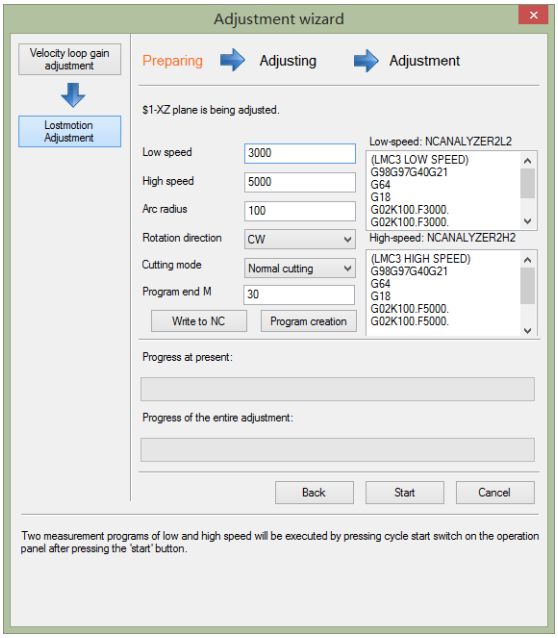
(3) Click "Next".



[4] Lost motion adjustment Setup

Prepare two types of arc cutting programs; one for low-speed cutting, the other for high-speed cutting. Make sure that a difference between the two speeds is distinctive within a practical range.

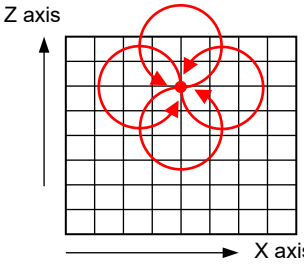
Create low-speed cutting programs for the 1st run.



(1) Set the speed at cutting feed in "Low speed (mm/min)" "High speed (mm/min)".

(2) Set the radius value to measure in "Arc radius (mm)". For the first adjustment, set the sufficiently small value which the axis does not collide even if the axis is moved from the current position to the distance twice as long as the radius in either direction in consideration of safety.

(3) Click "Start".



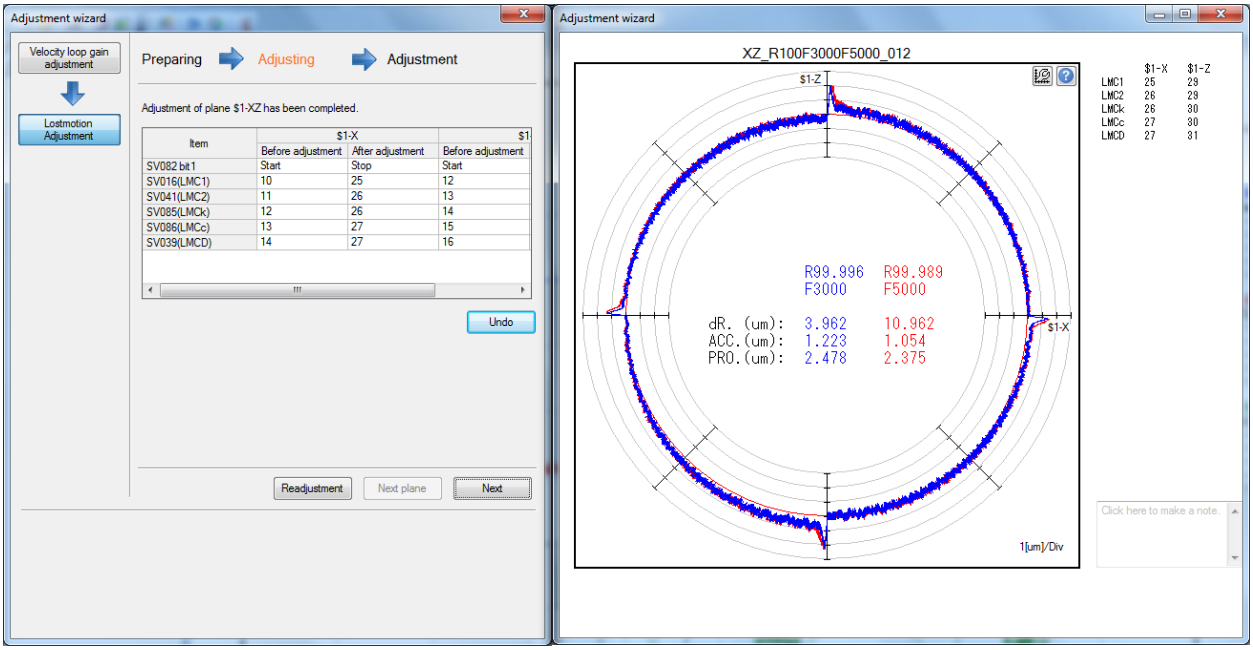
For the first adjustment, set a radius that assures the safety by rotating to either direction.

[5] Lost motion adjustment Waveform display

(1) After completing the adjustment, adjustment parameters are displayed in the left window, waveform at high speed is displayed in the right window.

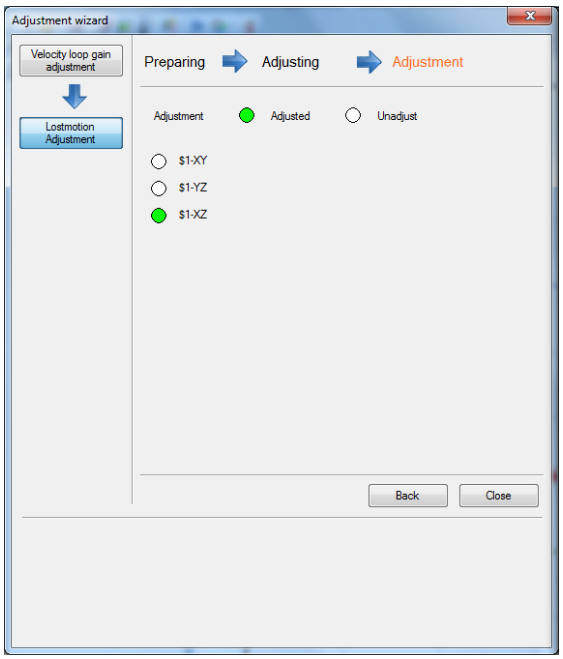
(2) Press "Restore the previous state before adjustment" to restore the parameter before adjustment.

(3) Press "Next" if there is nothing wrong.



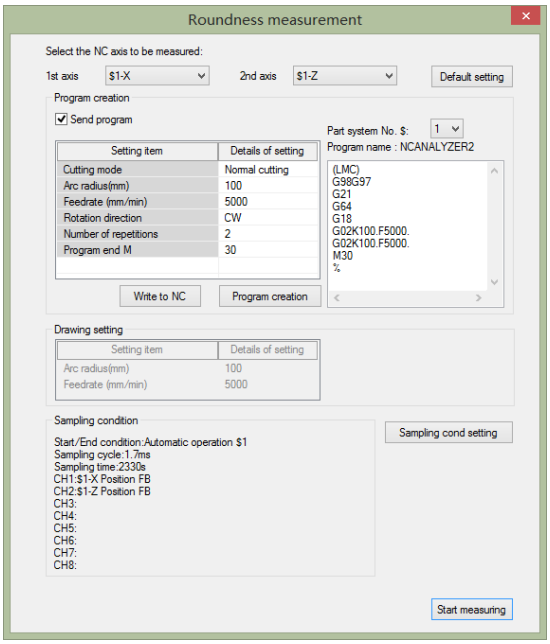
[6] Lost motion automatic adjustment Completion

(1) Plane which was completed adjustment is displayed.
(2) Press "Next".
(3) Press "Close".
(4) To back up the parameter, press "Yes".



[7] Roundness measurement

(1) Select "Roundness measurement" from the menu "Measurement and Adjustment".
(2) Select the plane axis to measure for the "1st axis" and "2nd axis".
(3) After the setting is completed click "Start measuring".



When a program in the actual machine of NC, set "Arc radius (mm)" in "Drawing setting" and "Feedrate (mm/min)".

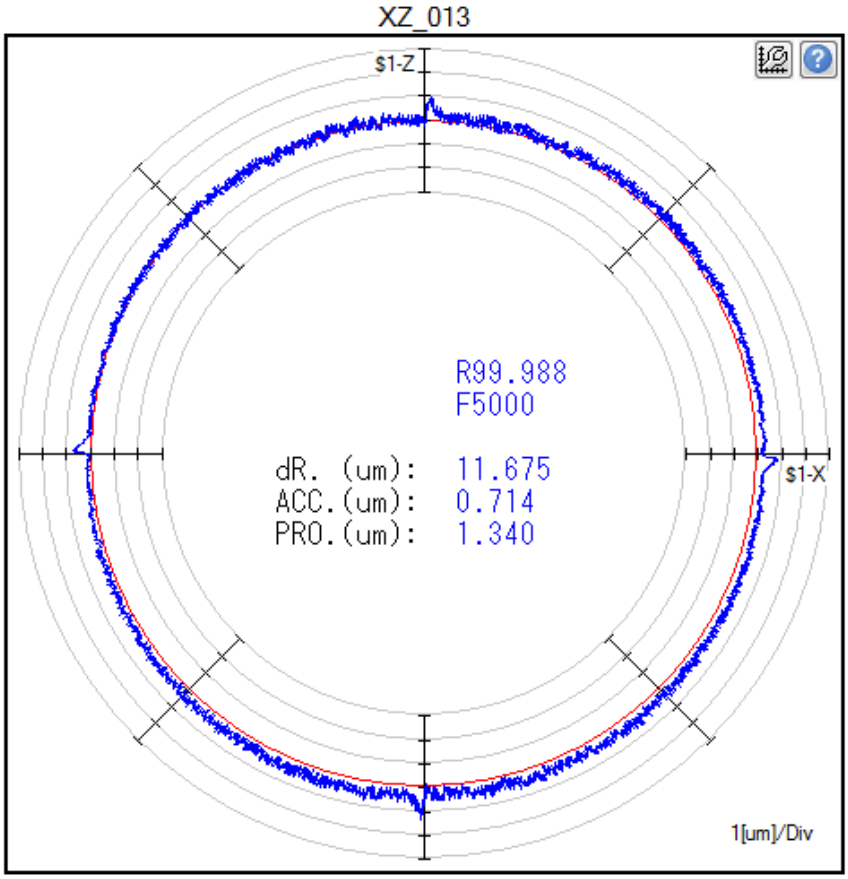
<Sampling setting>>

Initial sampling setting for roundness measurement is as follows. Changing the setting is unnecessary.

Channel	Waveform type
CH1	1st axis position FB
CH2	2nd axis position FB

[8] Completion of roundness measurement

(1) Roundness waveform and lost motion related parameters are displayed.



	$1-X	$1-Z
LMC1	25	29
LMC2	26	29
LMCk	26	30
LMCc	27	30
LMCD	27	31

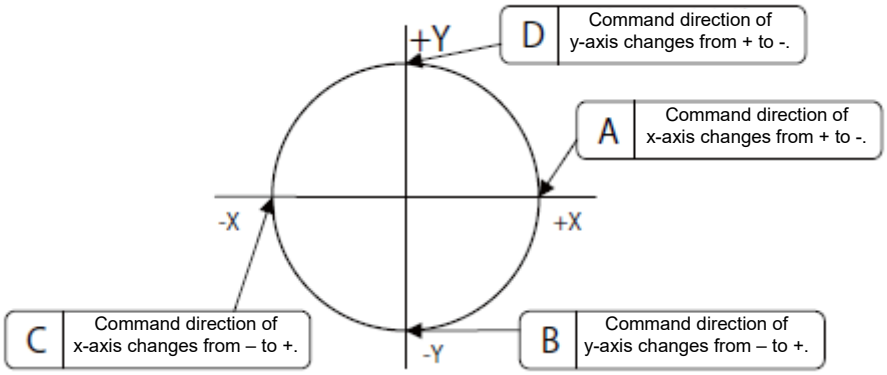
Click here to make a note.

[9] Lost motion parameter manual adjustment

(1) When fine-tuning the adjustment after the automatic adjustment, adjusting the lost motion compensation amount is possible manually.

(2) Set SV041 when the compensation amount is changed in the direction to compensate. Setting of compensation direction is the setting of parameter #1018 ccw as follows.
If only one direction is compensated, set -1 for the non-compensated side.

Compensation point	CW	CCW
A	X axis:SV041	X axis:SV016
B	Y axis:SV016	Y axis:SV041
C	X axis:SV016	X axis:SV041
D	Y axis:SV041	Y axis:SV016



(3) Carry out the roundness measurement under the conditions used in actual cutting according to the machine specifications, and increase/decrease the spring viscosity coefficient (SV086) about ±500 to adjust to make quadrant protrusion minimized.

(4) After adjusting SV086, perform roundness measurement at the low speed again to check the accuracy.

(5) To improve the accuracy more at this time, adjust by increasing/decreasing spring constant (SV085) by 50 while roundness measurement is performed at the low speed.

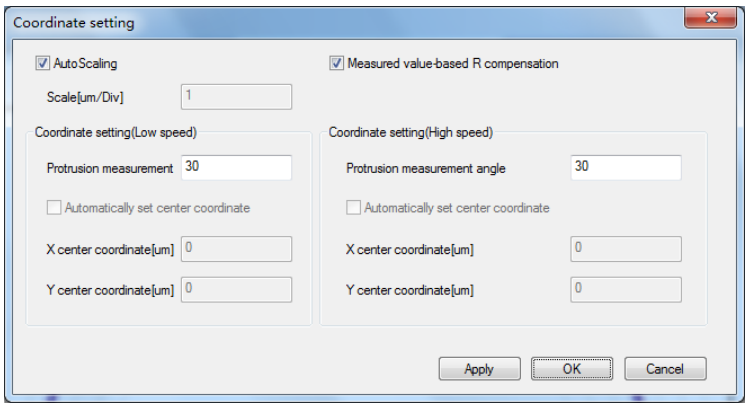
[Appendix] Descriptions of errors（dR/ACC/PRO）and measured radius compensation

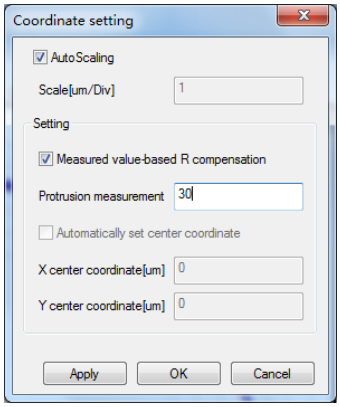
(1) dR: Difference between command radius and measured radius

(2) Measured radius compensation

When measured radius compensation is ON, the radius of the reference circle (red line) is corrected by the radius reduction caused due to servo tracking delay in circular cutting.

An accuracy error display can be enlarged, so you can use this for quadrant projection check. The measured circle waveform is displayed on the reference circle.



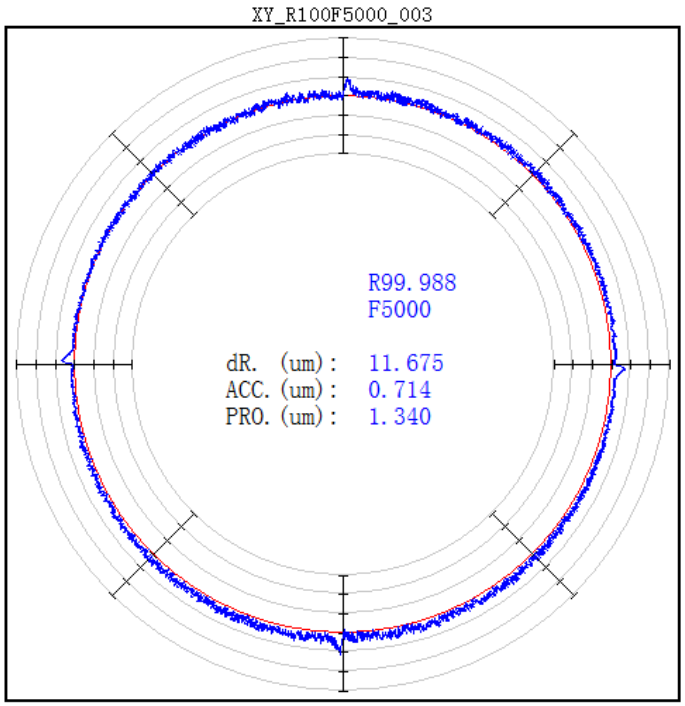


<Example of display when roundness graph measured radius compensation is ON>

When the command radius is 100.000 mm and the measured radius is 99.988 mm:

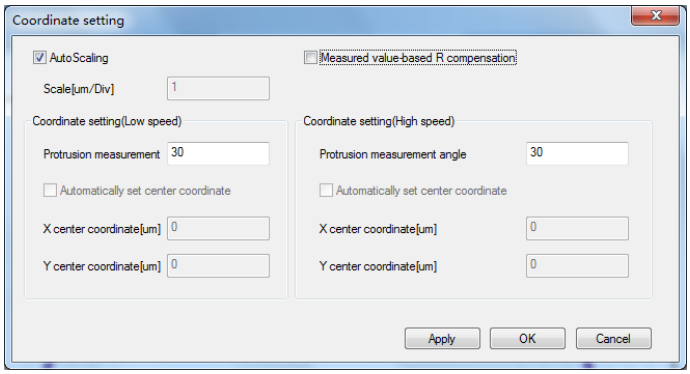
Reference circle of the roundness graph: Measured radius (R99.988)

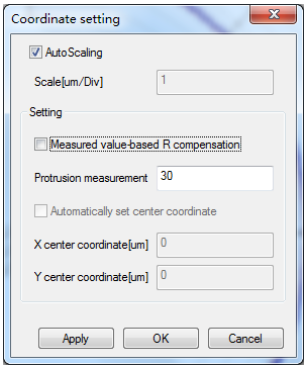
Radius error dR: = 100.000 - 99.988 = 0.012mm（11.675um）



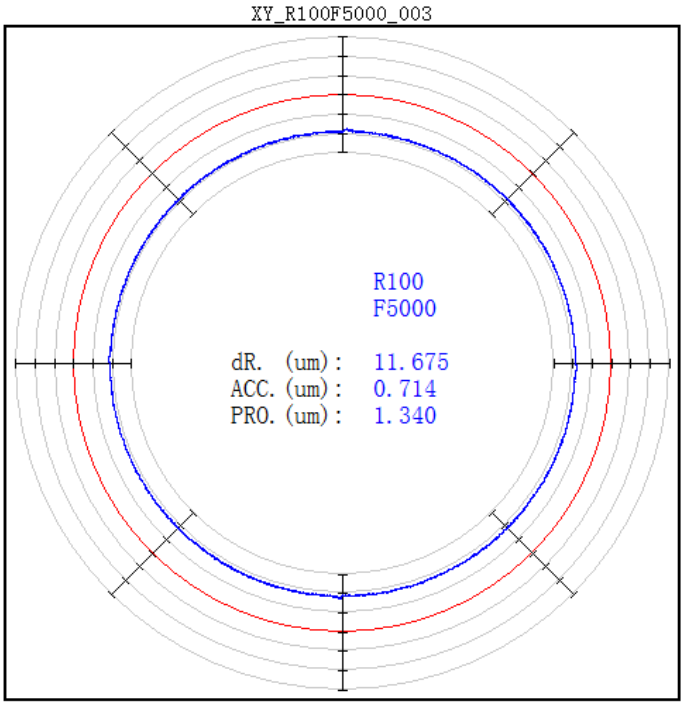
When measured radius compensation is OFF, this is used for checking the radius reduction caused due to servo tracking delay in circular cutting.
Servo tracking delay can be mitigated through high-accuracy control (pre-interpolation acceleration deceleration control + feed-forward control).

The measured circle waveform is displayed inward from the reference circle (red line) of the roundness graph by the measured radius error.





<Example of display when roundness graph measured radius compensation is OFF>
When the command radius is 100.000 mm and the measured radius is 99.988 mm:
Reference circle of the roundness graph: Command radius（R100.000）
Radius error dR: =100.000-99.988=0.012mm（11.675um）

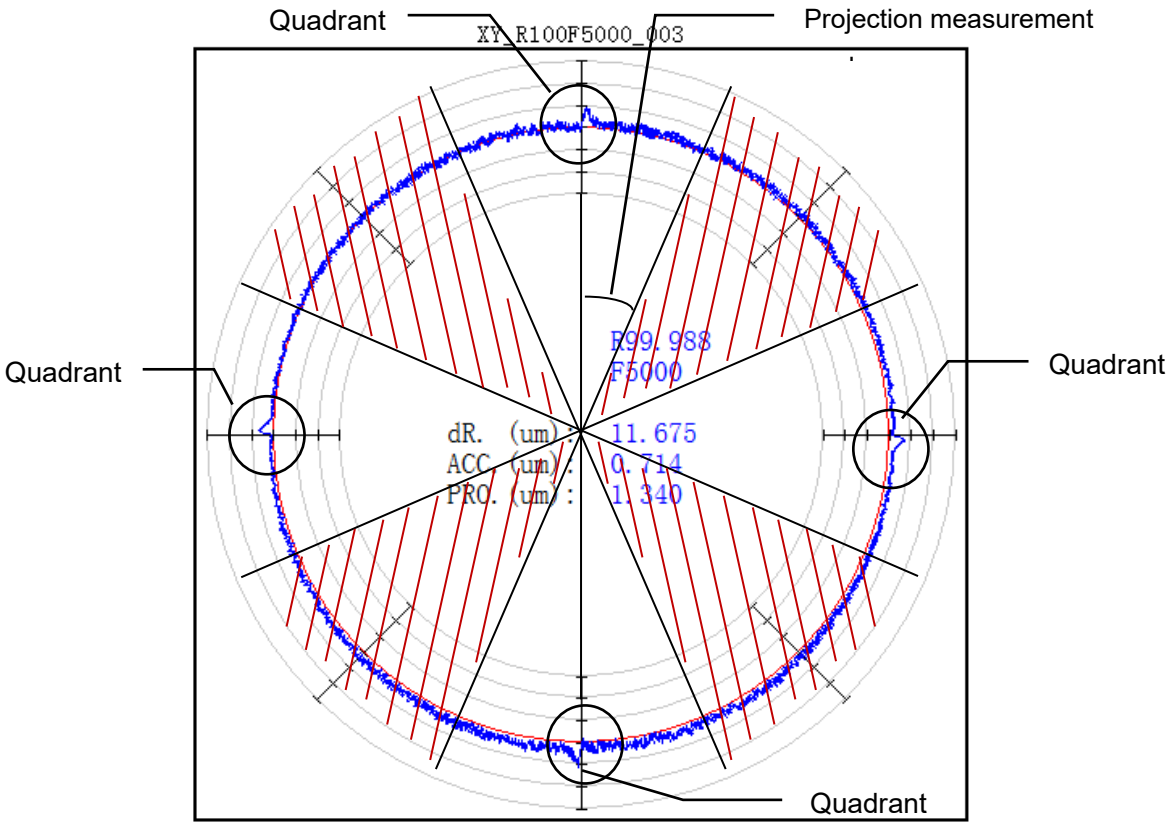


(3) ACC: Error P-P except the vicinity of quadrants

Difference between the maximum and minimum radii of the shaded area below.

(4) PRO: Lost motion error P-P near quadrants

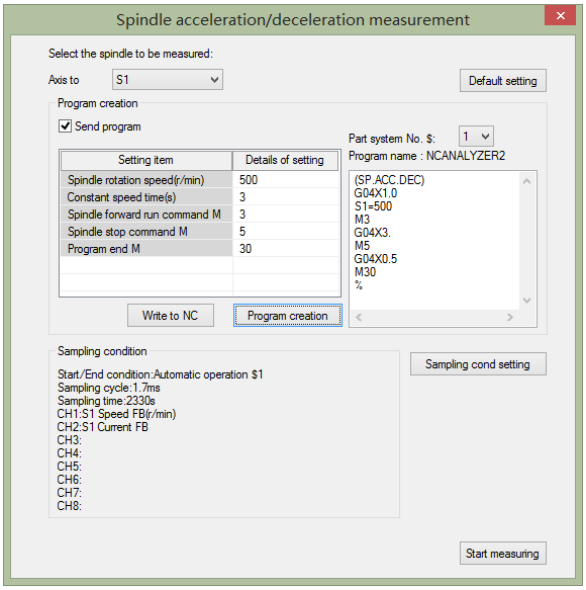
Calculate the difference between the maximum and minimum radii for each white area below, and choose the largest difference among them.



7. Spindle Acceleration/Deceleration Adjustment

[1] Setup for spindle acceleration/deceleration adjustment

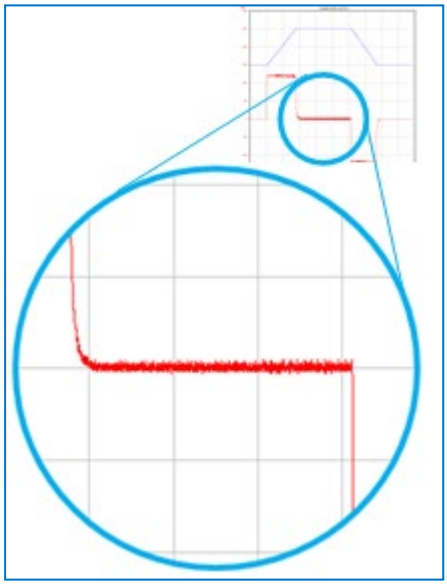
(1) Select "Reciprocation measurement" from the menu "Measurement and Adjustment".
(2) Select the spindle to measure in "Axis to measure".
(3) Set the "Spindle rotation speed(r/min)".
(4) After completing the setting, click "Start measuring".



If the speed does not reach to the speed you set, set the dwell time longer.

[2] Check the waveform of the current feedback.

(1) Check the waveform of the current feedback.
Check a switching from acceleration to constant speed and the waveform during the constant speed.

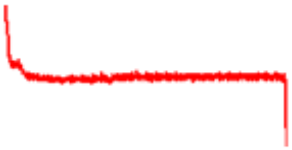
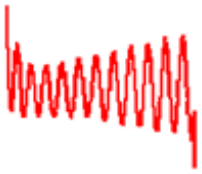
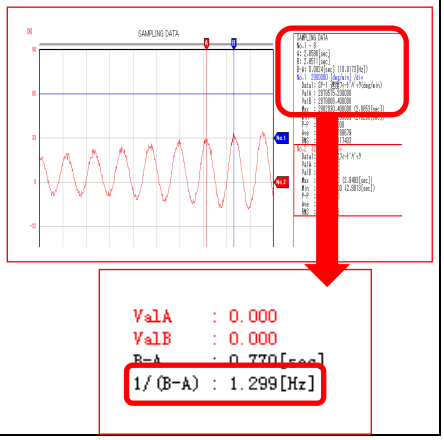


Checkpoints

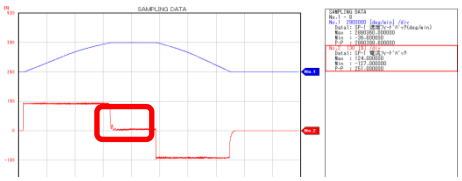
- Constant current amplitude.
- Small current amplitude
- No current amplitude when switching from acceleration to constant speed

In this status, the speed loop gain and position loop gain show proper values.

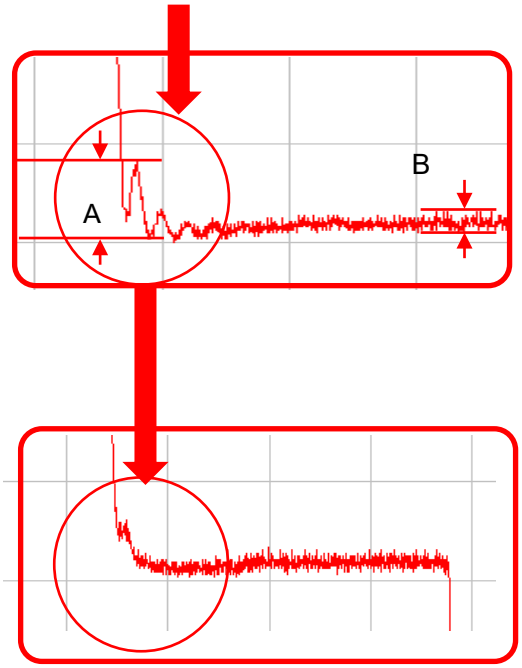
Current feedback waveform example during constant speed

<<Normal waveform>> 	[Waveform status] - Constant current amplitude - Small current amplitude - No large amplitude when switching from acceleration to constant speed
<<Convergent amplitude>> 	[Possible cause] - Low speed gain (SP005 (VGN1)). - High position loop gain (SP001 (PGV)). [Countermeasure] - If the position loop gain is too high even when a speed loop gain is normal, the same waveform appears. Therefore, decrease the position loop gain first.
<<Large amplitude>> 	[Possible cause] - High speed loop gain (SP005 (VGN1)). [Countermeasure] - Decrease the speed loop gain (SP005 (VGN1)).
<<Amplified amplitude>> 	[Possible cause] - High or low speed loop gain (SP005 (VGN1)). [Countermeasure] - For the judgement on whether the speed loop gain is "high" or "low", check the current frequency, and make a judgement on whether the frequency is 100 [Hz] or higher. In the case of the following example, the speed loop gain can be judged as low because the current frequency is 10.8173[Hz]. Therefore, increase the speed loop gain. 

[3] Check the switching waveform from the end of acceleration to the constant speed



(1) The switching waveform from the end of acceleration to the constant speed can be as shown in the figure to the right.
In this case, decrease the speed loop gain advance compensation (SP006 (VIA)).
<<Judgement criteria>>
If the A-width is not larger than 1.5 times the B-width (the maximum current during the constant speed), the waveform is judged to be normal.

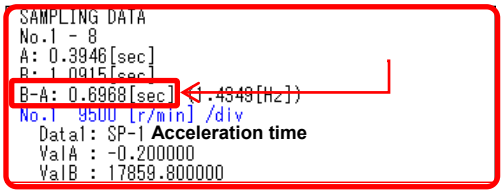


- In the example to the right, the B-width (maximum value) = 20%, the A-width (maximum value)= 50%
  A-width (50%) > B-width (20%)×1.5=30%
  Therefore, it is judged that the adjustment is required.
- Decrease the difference as much as possible even if it is inside the judgement criteria.
- The figure to the right is an example of adjustment result, which shows a waveform when SP006 (VIA):1900 (standard setting value) is decreased to 900.
  The lower limit value of SP006 (VIA) is 600.
  If the waveform is outside the judgement criteria even after the value is decreased to 600, decrease the position loop gain (SP001 (PGV)).

[4] Check the acceleration time.

(1) Check the acceleration time.

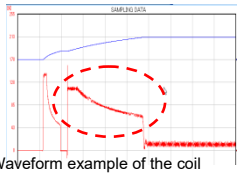
- Since the acceleration time may change according to the temperature of the spindle motor, the acceleration waveform is measured at high temperature (60 °C or higher) and low temperature (around the outside temperature).
- The spindle acceleration time is determined by the following three points:
  - Spindle motor output
  - Spindle unit inertia (including friction)
  - Tool or workpiece inertia



- The acceleration time cannot be shorter than the theoretical acceleration time. The theoretical acceleration time can be calculated using NC servo capacity selection software.
- Obtain the spindle control output 5-bit1 to check the acceleration time using a speed reached signal.

[Caution]

- Enlarge the setting of 1 div (enlarge in the vertical direction) to judge the acceleration time by velocity waveform.
- The current can drop during acceleration as shown at ◌ in the figure to the right, but this is in order because this is caused by the characteristics of the spindle motor.
- When the servo motor is used as a spindle motor, the current value during acceleration differs according to the motor.
- To prevent the motor from being burnt, it is not allowed to change the current limit value (#13153 (SP153)).

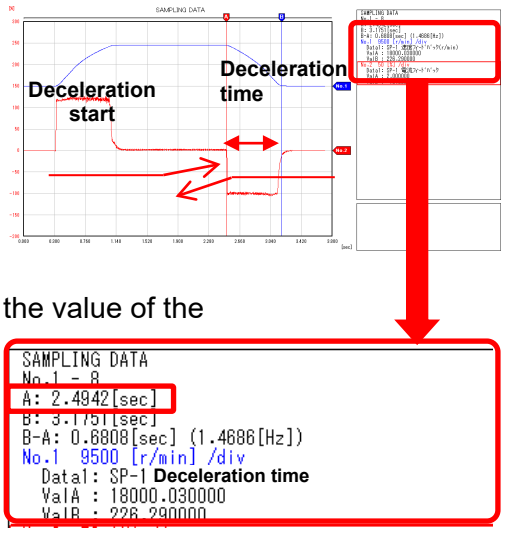


Waveform example of the coil switching specifications

[5] Adjust the deceleration time

(1) Check the waveform during deceleration.

(2) Check the waveform at deceleration start, and make sure that it is not more than ±100%.



- If the difference exceeds ±100%, change the setting values of #13071 (SP71) and #13072 (SP72) by multiplying by 0.7, and check the current value again. If the difference still exceeds ±100% even after changing the parameters, decrease the value of the position loop gain (#13001 (SP001)) by "5".

<<Judgement criteria>>

- Acceleration time ≥ Deceleration time
- Current value at deceleration start in within ±100%.
- Check that the above mentioned conditions are satisfied under the following three sets of conditions:
  - ✧ Check under no load and maximum load (with the maximum tool/workpiece)
  - ✧ Check under low temperature (≈ outside temperature) and high temperature (60 °C or higher) conditions of the spindle motor
  - ✧ Check during deceleration from the maximum rotation speed

💡 Judgment guidelines in the case where the maximum tool/workpiece cannot be prepared

- ✧ Acceleration time ≈ deceleration time
- ✧ Current value at deceleration start is within ±80%
- ✧ Allow some margin when adjusting

[Caution]

- Pay attention to the permissible rotations per minute when the rotations per minute are commanded with the maximum tool (maximum workpiece).

8. Spindle Orientation Adjustment

Orientation accuracy and positioning time can be improved by orientation adjustment.

[1] Parameter setting for orientation adjustment

Set the [#3106] zrn_typ/bitE(Control mode selection during orientation) according to the machine configuration.

Machine configuration		[#3106] zrn_typ/bitE setting value
Machining center		0
Tapping center		0
Lather	Without Spindle C-axis and Synchronous tapping	0
	With spindle C-axis and Synchronous tapping	1

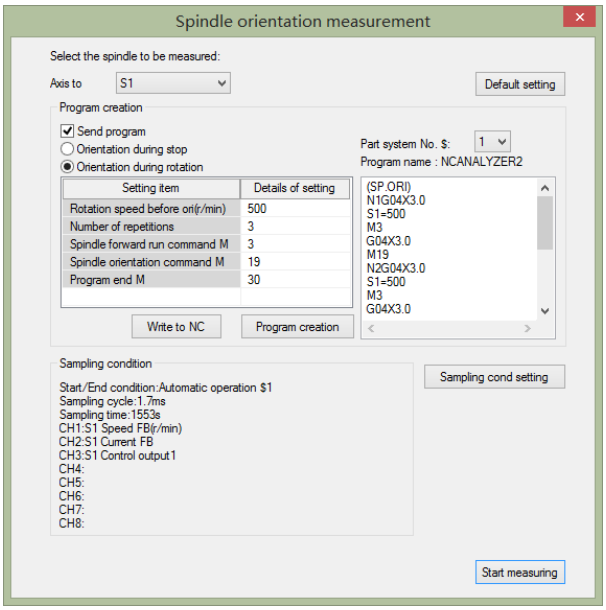
For proximity switch orientation control, execute from [4].

[2] Setup for orientation from the rotating state

(1) Select "Spindle orientation measurement" from the menu "Measurement and Adjustment".

(2) Set a value of "Rotation speed before orientation (r/min)".

(3) After completing the setting, click "Start measuring".



- Since orientation stopping time differs every time, carry out the orientation operation three times. The largest waveform of current during the operation from the deceleration start to in-position completion will be the judgement target for adjustment.
- Current value may change by the rotation speed. Change the value of "Rotation speed before orientation (r/min)", and check the value every 1000 to 2000 rotations until it reaches to the maximum rotation speed.
- As the current waveform is larger during orientation operation, orientation completion time will be longer.

<Sampling setting>

Initial sampling setting for spindle orientation measurement is as follows.

Changing the setting is unnecessary.

Channel	Waveform type
CH1	Speed FB (r/min)
CH2	Current FB
CH3	Control output 1 (*)

(*) "bitC: during in-position" is selected as the initial setting value for Drawing setting of CH3.

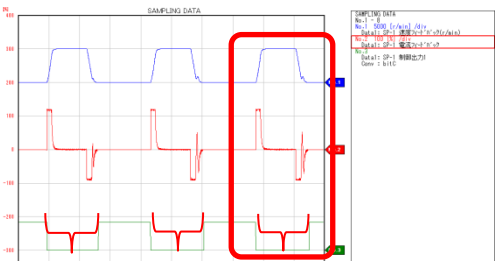
<Relevant parameters for orientation adjustment from the rotating state>

[#3106] zrn_typ/bitE	Position loop gain	Velocity loop gain	Excitation rate	Phase aligning excitation rate
0 (Interpolation mode)	#13002(PGN)	#13008(VGN2) #13009(VIA2) #13010(VIL2)	#13015(PY2)	#13016(DDT)
1 (Non-interpolation mode)	#13001(PGV)	#13005(VGN1) #13006(VIA1) #13007(VIL1)	#13014(PY1)	

[3] Check and adjust waveforms during orientation from the rotating state

Check and adjust the waveform.

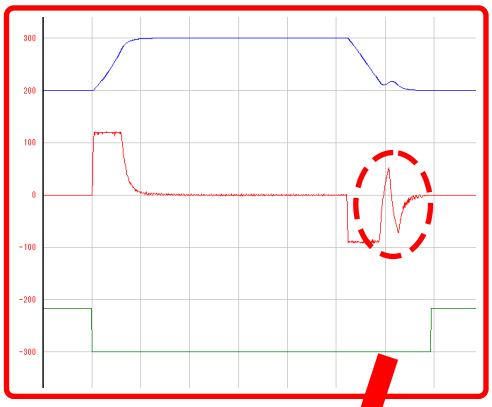
(1) Check the current waveform during the orientation operation, and make sure that the largest current value (at A) in three waveforms is within ±100%.
- If the current value exceeds ±100%, decrease the setting value of #13016 (DDT).

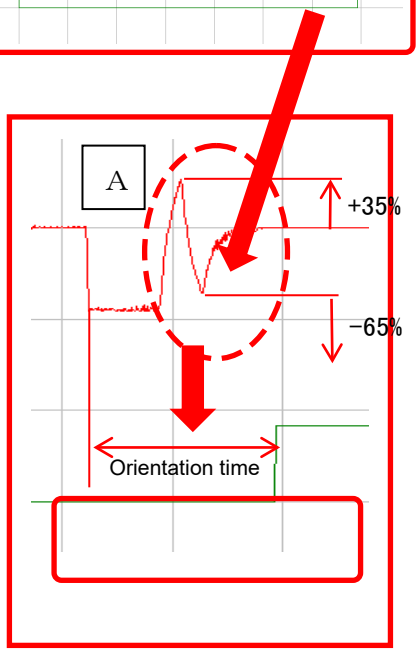


1st time	2nd time	3rd time

- In the figure to the right, since the current value in the third waveform is the largest, check the value at this point.

(2) For the orientation time, check the time from the deceleration start until the signal of "Control output 1" becomes "1".
- If the current value (at A) has margin, it is possible to shorten the orientation time by increasing #13016 (SP16).



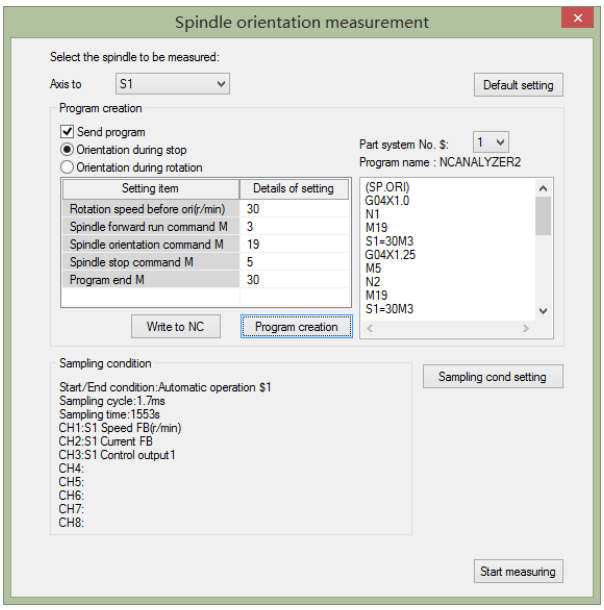


<<Judgment criteria>>
- When checking the current waveform, the current at A is within ±100%
- Orientation time is shorter than acceleration time + 0.4 second (target value)

- In the figure to the right, the current value is judged to be normal because it is inside the judgment criteria as follows:
- Current during orientation operation: +35%, -65%
- Orientation time: 0.352 [sec]

[4] Setup for adjusting the orientation from the stopping state

(1) Select "Orientation during stop".
(2) After completing the setting, click "Start measuring".



- Since the shortcut control shall be set in general, stop the spindle at an approximately 180° position to carry out the adjustment.
- The dwell time in the middle has been set to 1 second so that the spindle stops at an approximately 180° position. If timing is not correct, make fine adjustment of time.
- Since the probability of stopping at an approximately 180° position is low for the first time in the program, check the orientation in the second operation or later.

<Relevant parameters for orientation adjustment from the stopping state>

[#3106] zrn_typ/bitE	Position loop gain	Velocity loop gain	Orientation command speed
0 (interpolation mode)	#13002(PGN)	#13008(VGN2) #13009(VIA2) #13010(VIL2)	#3107(ori_spd)
1 (non-interpolation mode)	#13001(PGV)	#13005(VGN1) #13006(VIA1) #13007(VIL1)	

[5] Check and adjust the orientation from the stopping state

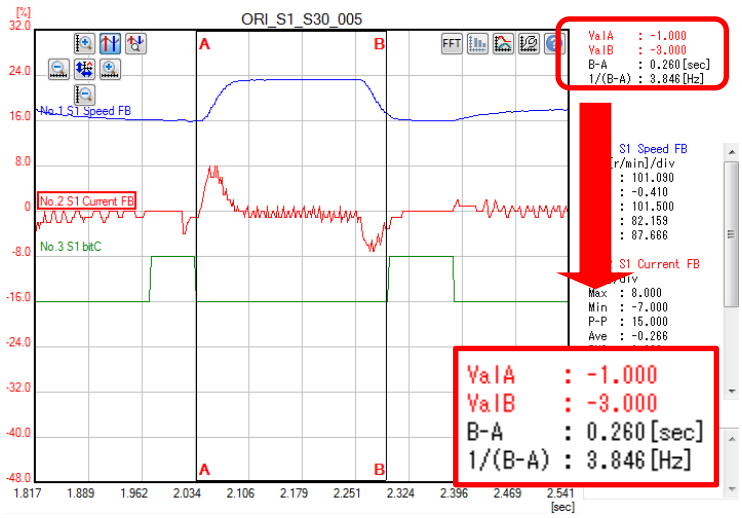
(1) Check the current waveform and orientation time.

(2) Check the current waveform and make sure that the current is within ±100%.

- If the current value exceeds 100%, decrease the value of #3107 (ori_spd).

(3) Check the orientation time (the time from when the "Control output 1" signal drops until it rises after dropping).

- If the current value has margin, increase the value of #3107 (ori_spd).



<<Judgment criteria>>

- Current value during orientation operation is within ±100%
- Orientation time is shorter than 0.4 [sec] (target value)

In the figure to the right, the waveform is judged to be normal because it is inside the judgment criteria as follows:

- Current during orientation operation: +8%, -7%
- Orientation time: 0.260 second

9. Synchronous Tapping Adjustment

[1] Parameter setting for synchronous tapping

(1) Complete adjustment of the servo axis and spindle before synchronous tapping adjustment.
It is postulated that the adjustment of the spindle, as well as servo axis (Normally Z axis) to be synchronized with the spindle, have been completed. If the servo axis requires roundness adjustment, it is also essential to complete roundness adjustment beforehand. This guideline explains adjustment with S3000[r/min] and F1.0 (M6-equivalent).

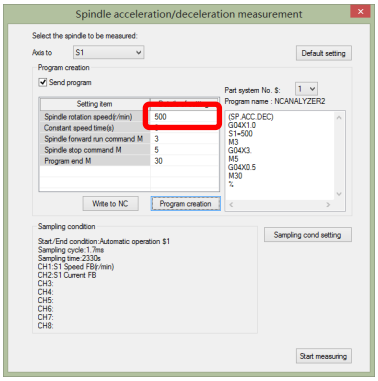
(2) Set the position loop gain for synchronous tapping according to the mechanical structure as shown in the following table.

Parameter	Mechanical structure		Remarks
	Machining center	Lathe	
[#2017] tap_g **[#13002] SP002 PGN**	33	15	Position loop gain (*)
[#2250] SV050 PGN2sp	88	40	Position loop gain 2
[#2258] SV058 SHGCsp	198	90	Position loop gain 3
[#13035] SP035 SFNC3	1600	1600	SHG valid at synchronous tapping

*[#2249]SV049 PGN1sp Position loop gain 1 in spindle synchronous control is set automatically in conjunction with [#2017]] tap_g.

[2] Measure the acceleration time

Measure the acceleration time to the maximum rotation speed of the spindle during synchronous tapping.



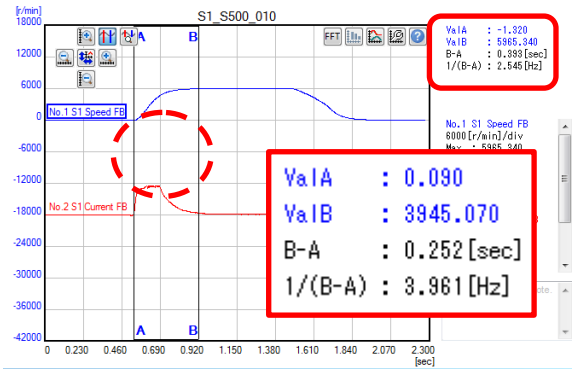
(1) Select the "Spindle acceleration/deceleration measurement" from the menu "Measurement and Adjustment".

(2) Select the spindle to measure in "Axis to measure".

(3) Set the maximum number of rotation at synchronous tapping in "Spindle rotation speed (r/min)".

(4) After completing the setting, click "Start measuring".

(5) When waveform is displayed, click the cursor mark and move the cursor A to the current rise point and move the cursor B to the point where the maximum speed is reached, and then check the time of "B-A:□□□[sec]".

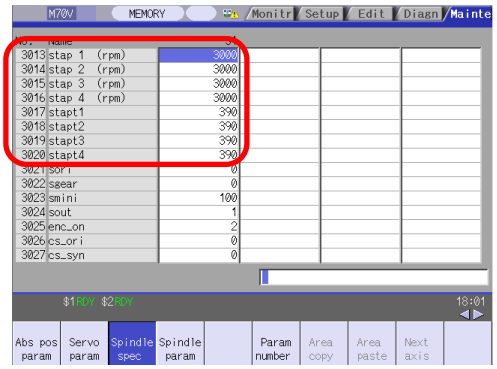


The figure to the right shows "B-A: 0.252 [sec]". Therefore, 0.252 [sec] = approximately 260 [msec].

[3] Set the provisional synchronous tapping time constant

(1) In #3013 to #3016 (stap1 to 4) of the spindle specification parameters, set the commanded rotations per minute (3000 r/min).

(2) In #3017 to #3020 (stapt1 to 4), set the numerical value obtained by multiplying the acceleration time (260 [ms]) checked in [2] by 1.5.



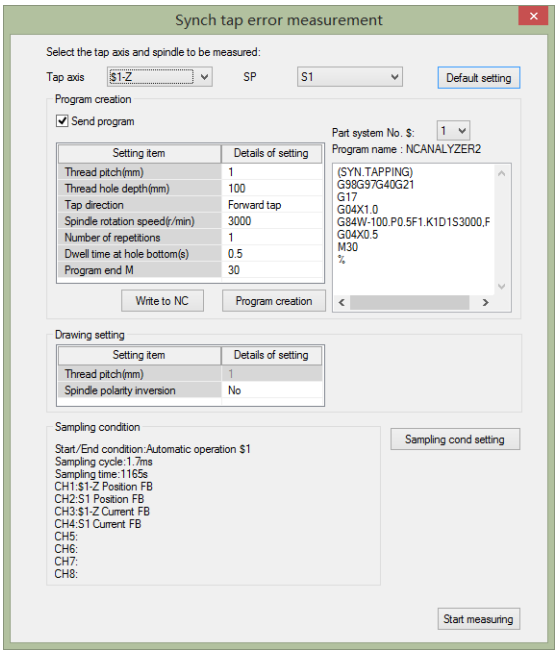
- In the above-mentioned example, according to 260 × 1.5 ≈ 390, set "390".
- This setting value is provisional. The adjustment result is set eventually.

[4] Create a program for measuring the synchronous tapping

(1) Select "Synchronous tapping error measurement" from the menu "Measurement and Adjustment".

(2) Set the maximum number of rotation at synchronous tapping in "Spindle rotation speed (r/min)".

(3) After completing the setting, click "Start measuring".



- Set the thread hole depth to reach to the spindle rotation speed you set.
- When executing a program stored in NC, set "Thread pitch (mm)" in "Drawing setting".

<Sampling setting>

Initial sampling setting for synchronous tapping measurement is as follows. Changing the setting is unnecessary.

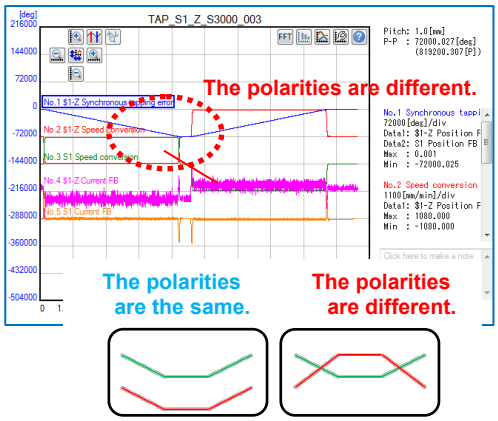
Channel	Selected axis	Wave type
CH1	Servo axis	Position FB (*1)
CH2	Spindle	Position FB (*1)
CH3	Servo axis	Current FB
CH4	Spindle	Current FB (*2)

(*1) Synchronous error calculated from position FB of the two axes at drawing and the value converted to each axis speed are displayed.

(*2) Load meter is selected automatically at high-speed synchronous tapping.

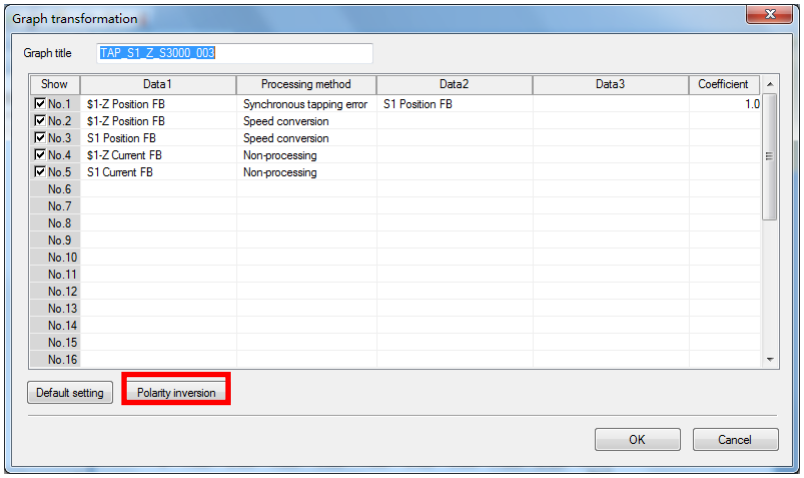
[5] Check the spindle position feedback polarity

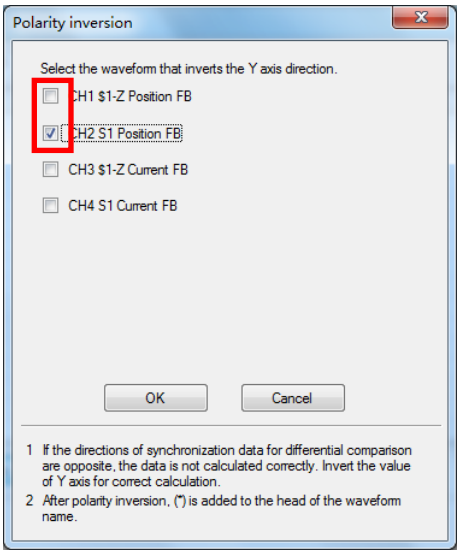
Check that the polarities of waveform for No. 2($1-Z speed conversion) and No. 3 (*) S1 speed conversion) are the same.
If the polarities of "No. 2" and "No. 3" are the same,proceed to [6].
If the polarities are different as shown in the figure to the right, change the settings as follows:



[How to equalize the polarities]

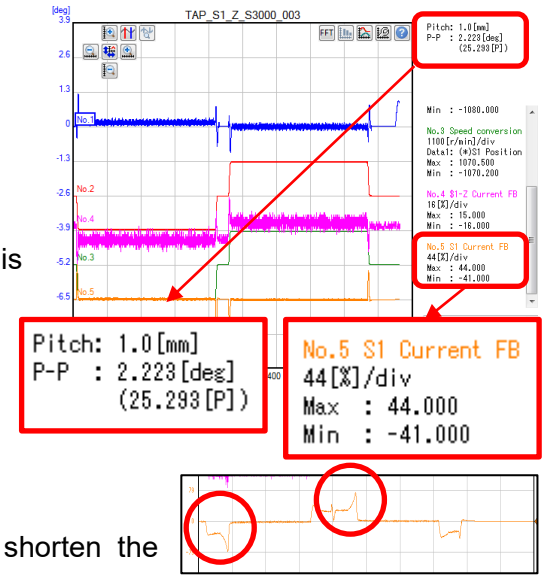
(1) Right-click on the graph, and select the "Graph transformation".
(2) Click "Polarity inversion".
(3) Check the waveform to invert the polarity.
(4) Click "OK".
(5) Make sure that Data 1 of No.2 in "Graph transformation" is converted to "(*)S1 Position FB".
(6) Click "OK".





[6] Check the synchronous tapping error and current waveform.

(1) Check No. 5 "S1 Current FB".
Check the "Max" and "Min" current values during synchronous tapping.



<<Judgement criteria>>
If both "Max" and "Min" are within ±80(%), the current value is judged to be normal.
If at least of the two values exceeds ±80%, prolong the time constant "#3017 to #3020 (stapt1 to 4)".

- In the figure to the right, according to Max:44(%) and Min:-41(%), the current value is judged to be normal.
- If the current value has margin, it is possible to shorten the acceleration/deceleration time for the synchronous tapping by decreasing the time constant set in [3].

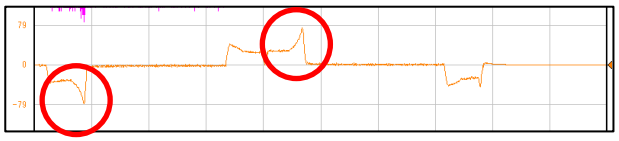
(2) No.1: Check the ""P-P:" value in "Synchronous tapping error".
<<Judgement criteria>>
No more than "Target accuracy (P)" in reference to "[Appendix] Accuracy check list".

If the value is outside the judgement criteria, decrease the position loop gain "#2017 tap_g", "#2250 PGN1sp2", "#2258 SHGCsp" and "#13002 PGN as the following table shown.

Parameter	Setting value					Setting range
[#2017] tap_g	21	27	33	39	48	1
[#2250] SV050 PGN1sp2	56	72	88	104	128	8/3
[#2258] SV058 SHGCsp	126	162	198	234	288	6
[#13002] SP002 PGN	21	27	33	39	48	1

- When F1.0 (M6) is set, if "P-P:" is not more than "12.96°(147[pulse])" the P-P value is judged to be good.
  In the figure to the right, according to "2.223°(25.293[pulse])", the P-P value is judged to be normal.

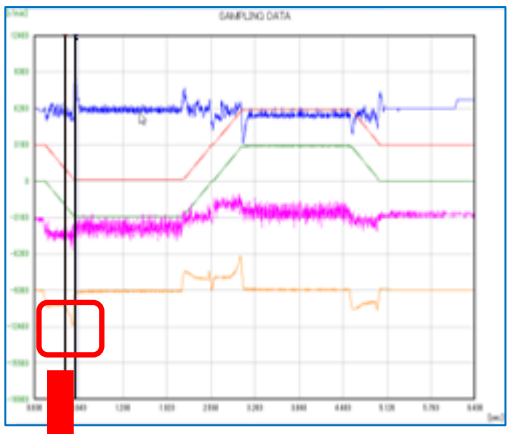
(3) Check the current waveform.



- As a result of checking the waveform, if the waveform height is not even (large irregularity) as shown at ○, it is possible to further shorten the synchronous tapping time constant in [6].
- If the current value and waveform have no margin, adjusting the synchronous tapping has been completed.

[7] Shorten the synchronous tapping time constant

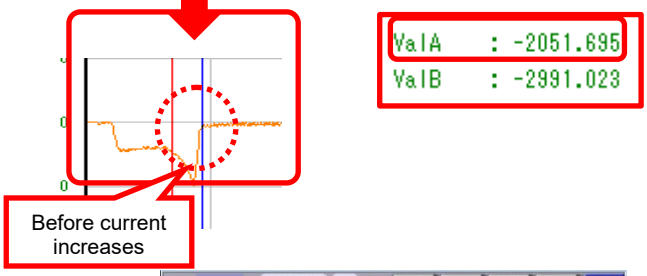
It is possible to shorten the synchronous tapping time constant by using multi-step acceleration/deceleration.



(1) By means of "ShowCursor", move one cursor to "Position before current increases" and move another cursor to "Position after current increased" (refer to the magnified waveform in the figure to the right).

(2) Note down the value of "ValA" in "Speed conversion S1 Position FB".

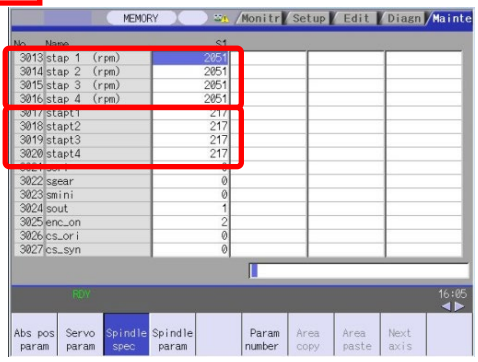
- In the example to the right, note down "2051" according to "ValA:-2051.695".



(3) Set the noted value "2051" in #3013 to 16(stap1 to 4).

(4) In #3017 to 20(stapt1 to 4), calculate the value as shown below and set it.

$$\#3017 \text{ to } 3020 = \frac{(\#3017 \text{ to } 3020 \text{ before change})}{(\#3017 \text{ to } 3020 \text{ after change})} \times \#3013 \text{ to } 3016 \text{ after change}$$

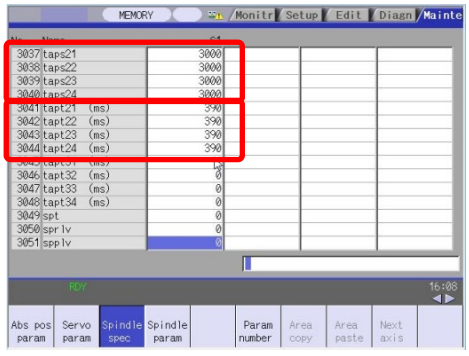


- In this case, the value is calculated as follows: "267(=390÷3000×2051)".

If "Value before current increases" has margin, it is possible to set the value obtained by subtracting 50 [ms] and therefore the setting value in #3017 to 20 is "217".

(5) Set the same value as the time constant "#3017 to #3020 (stapt1 to 4)" set for the second step "#3041 to #3044 (tapt21 to 24)" in the multi-acceleration/deceleration.

- In this example, according to the value judged to be "not more than 80 (%)" when it was measured, set "3000" in "#3037 to 40 taps21 to 24" as the second step speed, and set "390" in "#3041 to 44 taps21 to 24" as the second step time constant.



[8] Check the waveform after shortening the time constant

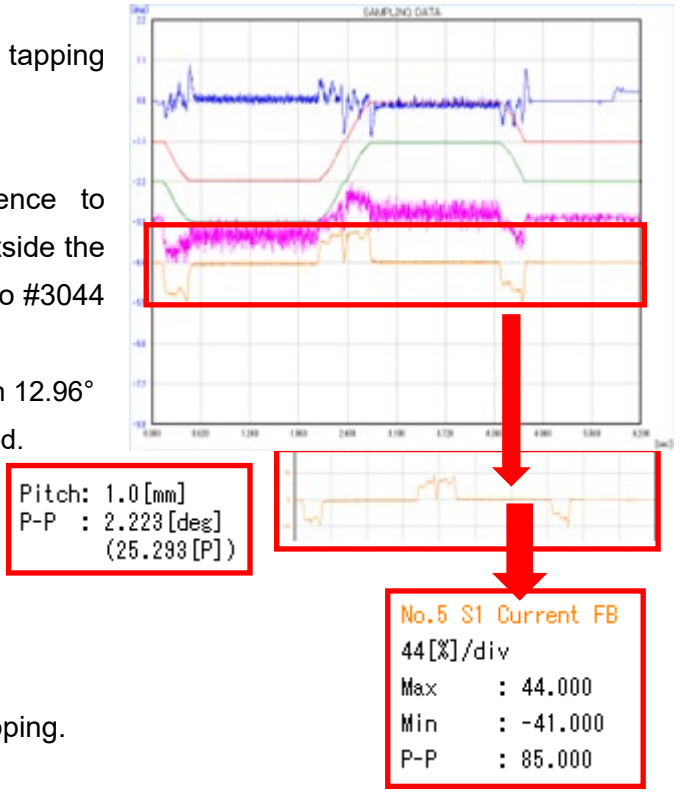
Check the waveform during synchronous tapping.

(1) Check the "P-P:" value in No. 1: "Synchronous tapping error".

<<Judgement criteria>>

Not more than "Target accuracy (P)" in reference to "[Appendix 1] Accuracy check list". If the value is outside the judgment criteria, prolong the time constant "#3041 to #3044 (tap21 to 24)".

- When F1.0 (M6) is set, if "P-P" is not more than 12.96° (147 [pulse]), the P-P value is judged to be good.
  In the figure to the right,
  according to 2.007500 (23 [pulse]),
  the P-P value is judged to be normal.



(2) Check No. 5 "S1 Current FB". Check the "Max" and "Min" current values during synchronous tapping.

<<Judgement criteria>>

If both "Max" and "Min" are within ±80 (%), the current value is judged to be normal.

If the value is outside the judgment criteria, prolong the time constant "#3041 to #3044 (tap21 to 24)".

- In the figure to the right, according to Max: 44 (%) and Min: -41 (%), the current value is judged to be normal.

(3) Check No. 5 "S1 Current FB" waveform.

As a result of checking the waveform, since the height of the waveform is almost even, there is no room for improvement (shortening). If the current value and waveform have no margin, adjusting the synchronous tapping has been completed.

[Appendix 1] Accuracy check list for synchronous tapping

Target accuracy for synchronous tapping adjustment is as follows.

Thread diameter	Pitch	Target accuracy[P]	Target accuracy[°]
M1	0.25	180	15.84
M2	0.4	164	14.40
M3	0.5	205	18.00
M4	0.7	205	18.00
M5	0.8	200	17.55
M6	1	147	12.96
M8	1.25	138	12.10
M10	1.5	131	11.52
M12	1.75	138	12.14
M14 **M16**	2	133	11.70
M18 **M20** **M22**	2.5	126	11.09
M24 **M27**	3	112	9.84
M30 **M33**	3.5	110	9.67

10. Spindle C-Axis Adjustment

[1] Parameter setting for spindle C-axis

(1) Set spindle parameters and servo parameters as follows.

<Related spindle parameters>

Parameter	Setting value
[#13002] SP002 PGN	33
[#13008] SP008 VGN2	the value of SP005 after spindle acc/dec adjustment (Initial setting value: 150)
[#13009] SP009 VIA2	1900
[#13010] SP010 VIL2	0
[#13035] SP035 SFNC3	0200:(bit9=1) Speed loop gain set 2 selection

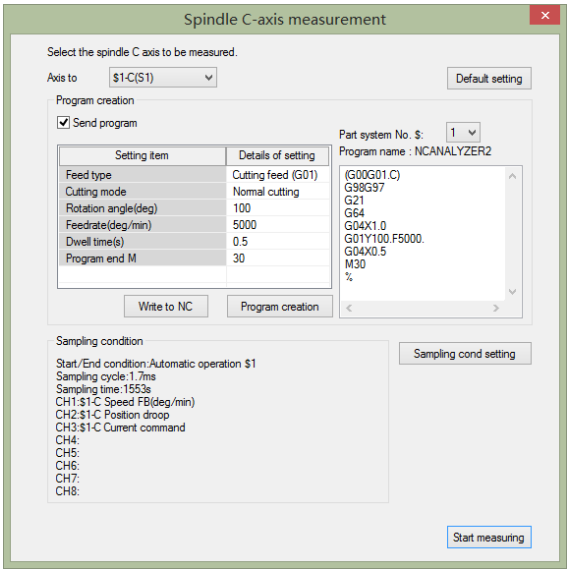
<Related servo parameters>

Set the axis to interpolate with spindle at tapping.

Parameter	Setting value
[#2003] SV003 PGN1	Set the same value as spindle parameter “SP002”
[#2004] SV004 PGN2	Set the 8/3 times of the SV003 value
[#2057] SV057 SHGC	Set the 6 times of the SV003 value

[2] Spindle C-axis setting

(1) Select “Spindle C-axis measurement” from the menu “Measurement and Adjustment”.
(2) Select the spindle to measure in “Axis to measure”.
(3) Prepare the program of F20 cutting feedrate.
(4) After completing the setting, click “Start measuring”.



<Sampling setting>

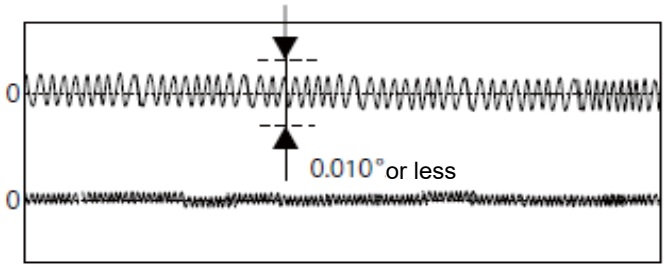
Initial sampling setting for spindle C-axis measurement is as follows. Changing the setting is unnecessary.

Channel	Waveform type
CH1	Speed FB(deg/min)
CH2	Position droop
CH3	Current command

[3] Adjustment at C-axis operation.

(1) Measure the waveform at cutting feed in the stop state or G01 F20 during the C-axis mode (servo ON state).

(2) Check if droop variation is within 0.010 degree.



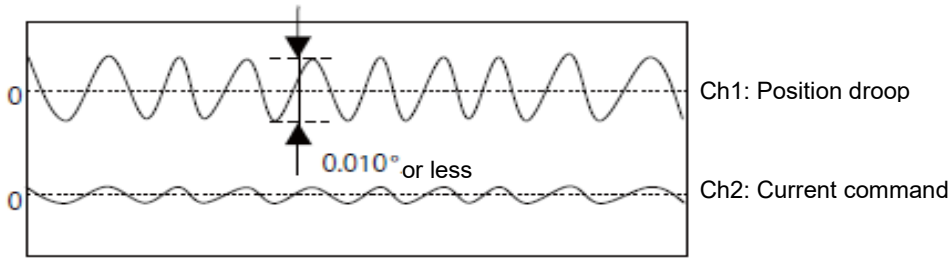


Fig. Waveform at cutting feed with G01 F20 (Reference)

(3) When the accuracy is out of its criterion, increase the value of SP008(VGN2) by 10 to adjust the accuracy to meet the criterion. However, the limit setting value is up to 150 × [Inertia ratio].

[4] Setting for notch filter

Since motors sometimes rotate while brake is applied, resonant sound may be made during spindle C-axis operation.

In that case, measure the resonance frequency from waveform of current command, and set the value to SP038 FHz1 (notch filter 1).

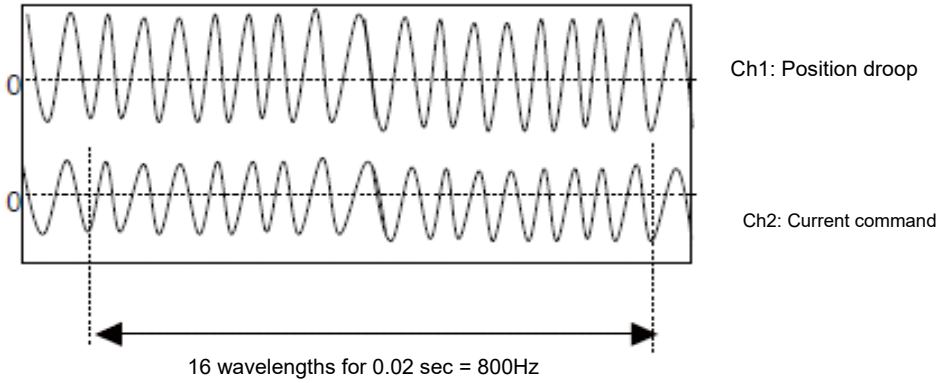
Depth of the filter is set with SP034 SFNC2/bit1,2,3 by using set frequency.

When notch filter is set, perform the acceleration/deceleration operation at the maximum speed again to check that no abnormal vibration or noise is generated.

<Notch filter frequency and standard depth setting>

Parameter	Frequency and standard depth setting		
[#13038]SP038 FHz1 Notch filter frequency	2000(Hz) to 400(Hz)	399(Hz) to 200(Hz)	To 190(Hz)
[#13034]SP034 SFNC2 Depth of notch filter1	bit3=0 bit2=0 bit1=0 Setting value: XXX0	bit3=0 bit2=1 bit1=0 Setting value:XXX4	bit3=1 bit2=0 bit1=0 Setting value:XXX8

Setting example: When there are 16 wavelengths for 0.02sec



Therefore, set 800 for SP038 FHz1 and set XXX0 for SP034 SFNC2. At that time, measure position droop and current command, and adjust frequency of notch filter and depth to make position droop within the criterion.

When interpolating with other NC, adjust time constant by Reciprocation measurement.

11. Spindle Synchronization Adjustment

[1] Parameter setting for spindle synchronization

(1) Check that acceleration/deceleration adjustment is completed for each spindle beforehand.

(2) Set the parameters as follows.

(3) Set the switching parameters according to the control application. Parameters to be used vary according to the switching parameters.

<Parameters for spindle synchronization setting>

Parameter	Setting value
[#13002] SP003 PGS	15 (*)
[#13036] SP036 SFNC4	bit4=1 (SHG control valid) Switch bit1, bit2 by the application

(*) When the setting value of SP003 is changed, set the same setting value for reference spindle and synchronized spindle.

<Parameters to switch velocity loop gain >

Control	Both griping control	Polygon
Setting to switch	SP036/bit1=0	SP036/bit1=1
Velocity loop gain	SP005 VGN1	SP008 VGN2
Velocity loop advance compensation	SP006 VIA1	SP009 VIA2
Velocity loop delay compensation	SP007 VIL1	SP010 VIL2

<Parameters to switch the smallest excitation rate>

Control	Both gripping control	Polygon
Setting to switch	SP036/bit2=0	SP036/bit2=1
The smallest excitation rate	SP014 PY1	SP015 PY2

[2] Setup for spindle synchronization adjustment

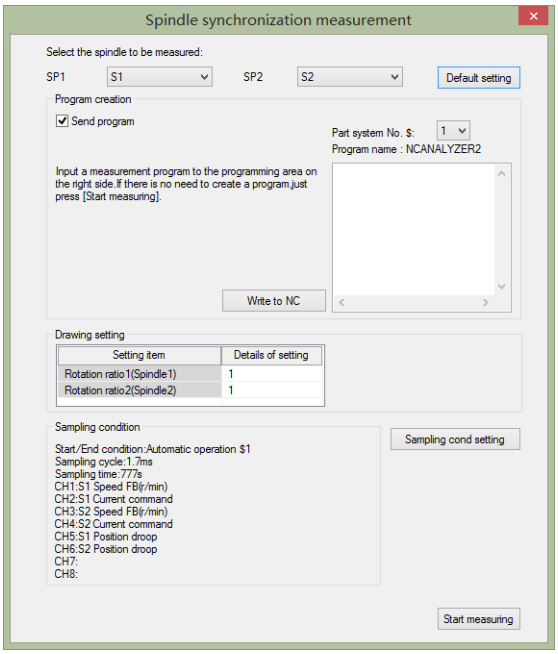
(1) Select “Reciprocation measurement” from the menu “Measurement and Adjustment”.

(2) Select the spindles to measure in “Spindle1” and “Spindle2”. Set the reference spindle in “Spindle1”.

(3) Set the number of rotations as spindle synchronization in “Rotation ratio1(Spindle1) ” and “Rotation ratio2(Spindle2)”.

(4) After completing the setting, click “Start measuring”.

When executing a program stored in NC, set the number of rotations in Drawing setting.



<Sampling setting>

Initial sampling setting for spindle synchronization measurement is as follows. Changing the setting is unnecessary.

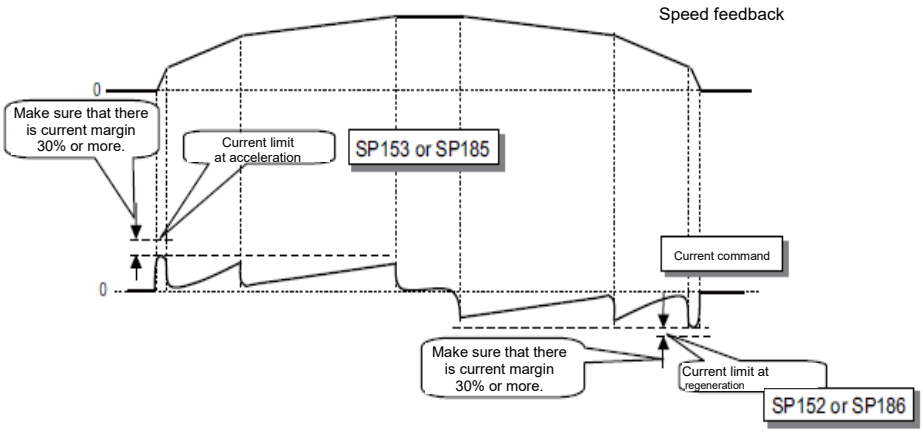
Channel	Selecting axis	Waveform type
CH1	Reference spindle	Speed FB (r/min)
CH2	Reference spindle	Current command
CH3	Synchronized spindle	Speed FB (r/min)
CH4	Synchronized spindle	Current command
CH5	Reference spindle	Position droop (*)
CH6	Synchronized spindle	Position droop (*)

(*) Synchronization error calculated from position droop of the 2 spindles is displayed for the initial setting.

[3] Check the current margin

Set spindle synchronization mode, and accelerate or decelerate up to maximum rotation speed. At this time, check that current value at acceleration and deceleration have 30% or more of margin for the current limit value at this time. Also check that abnormal movement cannot be seen from the current waveform.

(Note) When the margin is 30% or less, adjust by extending the time constant of acceleration/deceleration so that the margin to be 30% or more.



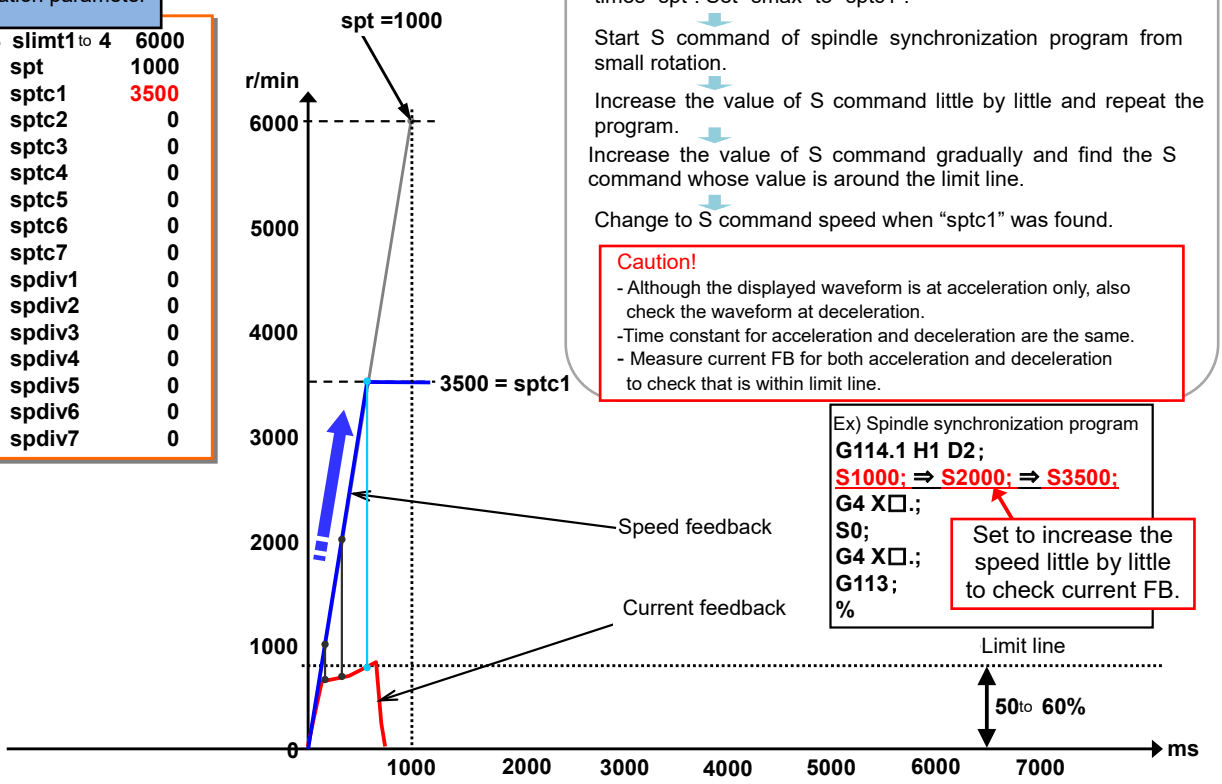
Output waveform at spindle synchronization

[4] Multi-step acceleration/deceleration setting

Set time constant and speed for multi-step acceleration/deceleration as follows.

Spindle specification parameter

#3001 to 3004	slimt1 to 4	6000
#3049	spt	1000
#3054	sptc1	3500
#3055	sptc2	0
#3056	sptc3	0
#3057	sptc4	0
#3058	sptc5	0
#3059	sptc6	0
#3060	sptc7	0
#3061	spdiv1	0
#3062	spdiv2	0
#3063	spdiv3	0
#3064	spdiv4	0
#3065	spdiv5	0
#3066	spdiv6	0
#3067	spdiv7	0



Set acceleration/deceleration time of smax × about 1.5 times “spt”. Set “smax” to “sptc1”.

Start S command of spindle synchronization program from small rotation.

Increase the value of S command little by little and repeat the program.

Increase the value of S command gradually and find the S command whose value is around the limit line.

Change to S command speed when “sptc1” was found.

Caution!
- Although the displayed waveform is at acceleration only, also check the waveform at deceleration.
-Time constant for acceleration and deceleration are the same.
- Measure current FB for both acceleration and deceleration to check that is within limit line.

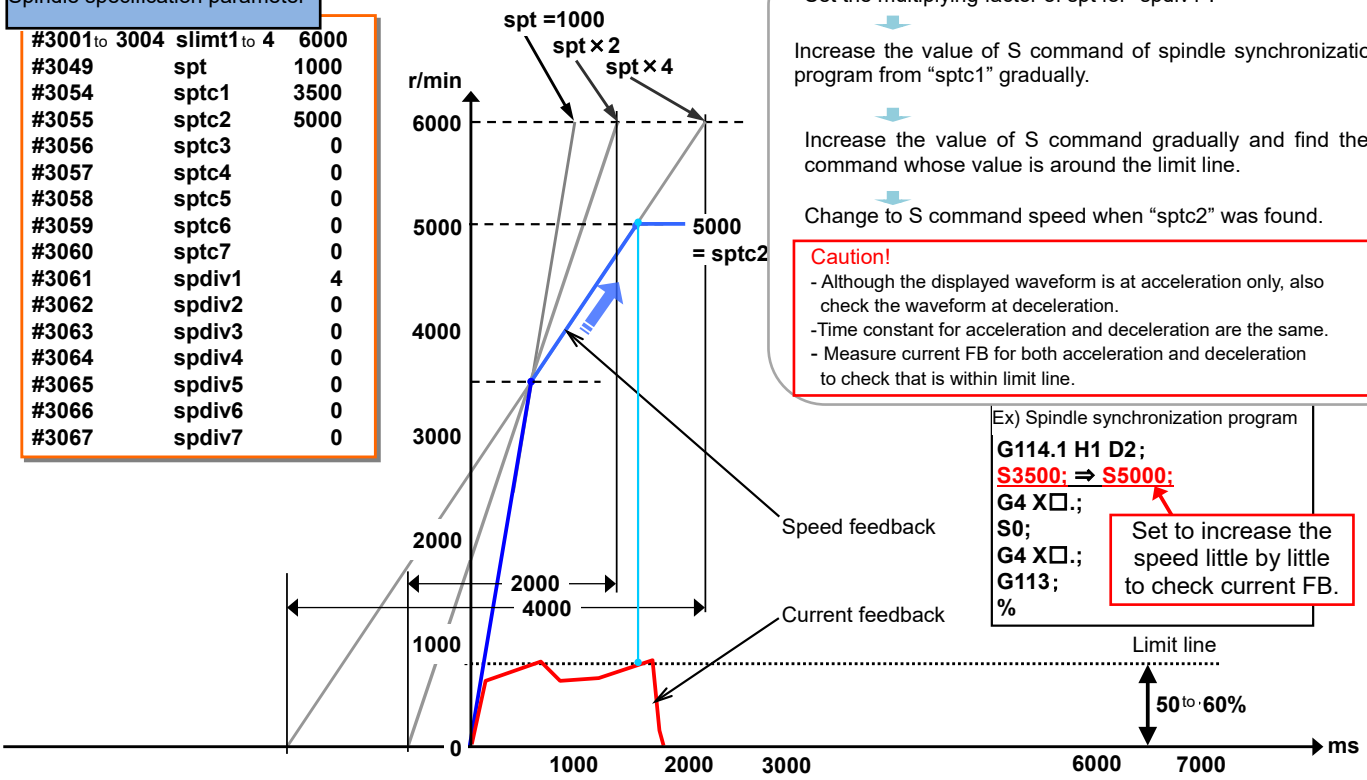
Ex) Spindle synchronization program

G114.1 H1 D2;
S1000; ⇒ S2000; ⇒ S3500;
G4 X☐.;
S0;
G4 X☐.;
G113;
%

Set to increase the speed little by little to check current FB.

Spindle specification parameter

#3001 to 3004	slimt1 to 4	6000
#3049	spt	1000
#3054	sptc1	3500
#3055	sptc2	5000
#3056	sptc3	0
#3057	sptc4	0
#3058	sptc5	0
#3059	sptc6	0
#3060	sptc7	0
#3061	spdiv1	4
#3062	spdiv2	0
#3063	spdiv3	0
#3064	spdiv4	0
#3065	spdiv5	0
#3066	spdiv6	0
#3067	spdiv7	0



Set “smax” to “sptc2”.
Set the multiplying factor of spt for “spdiv1”.

Increase the value of S command of spindle synchronization program from “sptc1” gradually.

Increase the value of S command gradually and find the S command whose value is around the limit line.

Change to S command speed when “sptc2” was found.

Caution!
- Although the displayed waveform is at acceleration only, also check the waveform at deceleration.
-Time constant for acceleration and deceleration are the same.
- Measure current FB for both acceleration and deceleration to check that is within limit line.

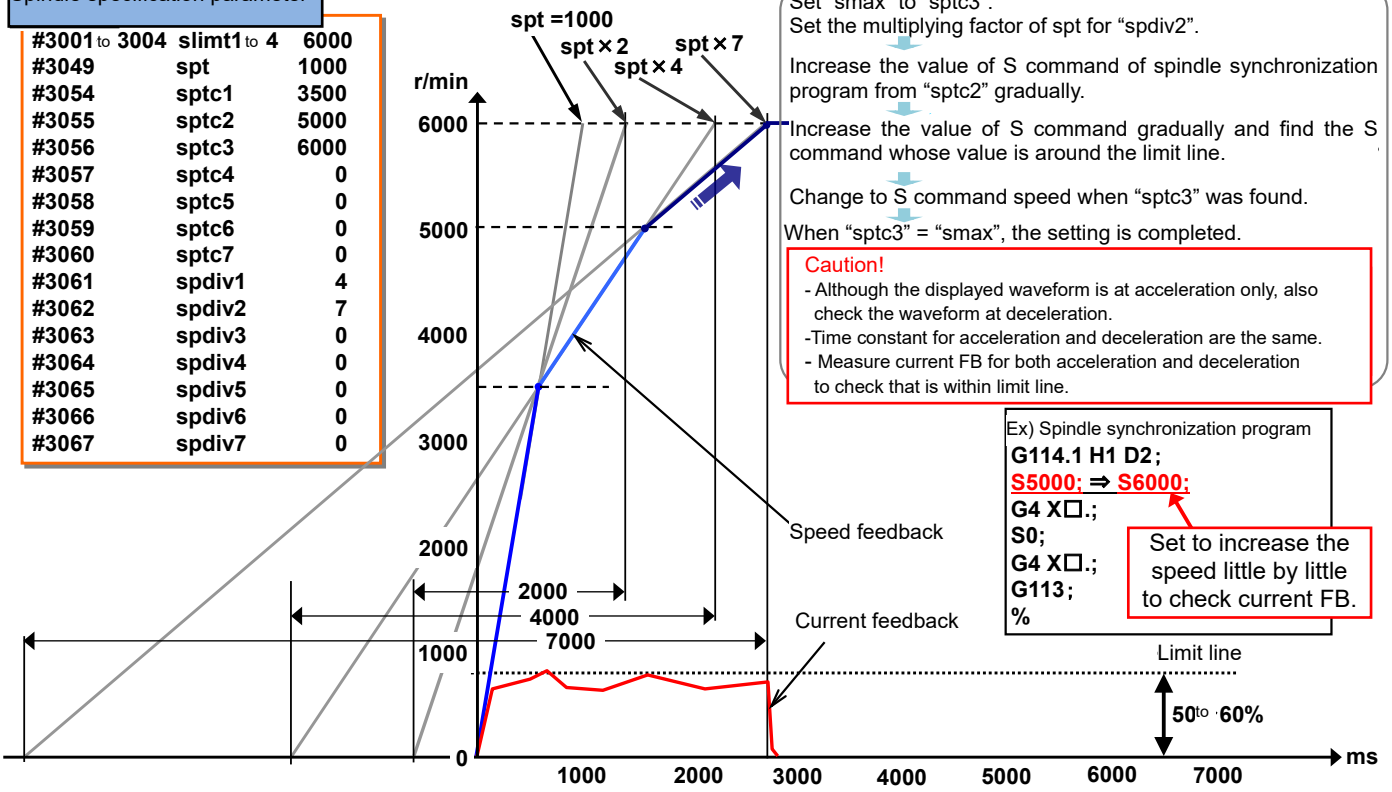
Ex) Spindle synchronization program

G114.1 H1 D2;
S3500; ⇒ S5000;
G4 X☐.;
S0;
G4 X☐.;
G113;
%

Set to increase the speed little by little to check current FB.

Spindle specification parameter

#3001 to 3004	slimt1 to 4	6000
#3049	spt	1000
#3054	sptc1	3500
#3055	sptc2	5000
#3056	sptc3	6000
#3057	sptc4	0
#3058	sptc5	0
#3059	sptc6	0
#3060	sptc7	0
#3061	spdiv1	4
#3062	spdiv2	7
#3063	spdiv3	0
#3064	spdiv4	0
#3065	spdiv5	0
#3066	spdiv6	0
#3067	spdiv7	0



Set "smax" to "sptc3".
Set the multiplying factor of spt for "spdiv2".

Increase the value of S command of spindle synchronization program from "sptc2" gradually.

Increase the value of S command gradually and find the S command whose value is around the limit line.

Change to S command speed when "sptc3" was found.

When "sptc3" = "smax", the setting is completed.

Caution!
- Although the displayed waveform is at acceleration only, also check the waveform at deceleration.
- Time constant for acceleration and deceleration are the same.
- Measure current FB for both acceleration and deceleration to check that is within limit line.

Ex) Spindle synchronization program

```
G114.1 H1 D2;
S5000; ⇒ S6000;
G4 X□.;
S0;
G4 X□.;
G113;
%
```

Set to increase the speed little by little to check current FB.

12. Arbitrary Data Calculation

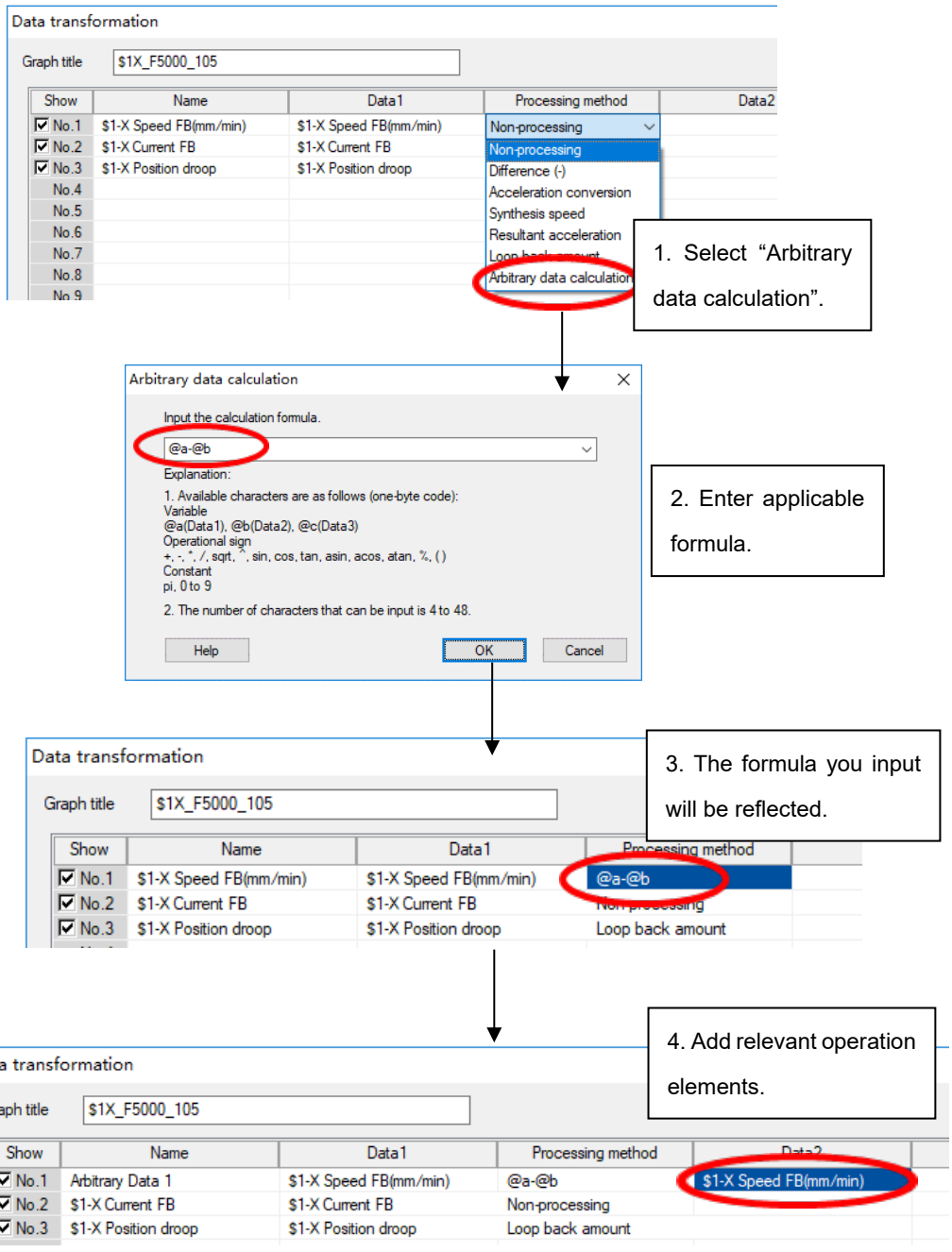
[1] Create a Calculation

(1) On [Data transformation] screen for time series waveform, select [Arbitrary data calculation].

(2) On [Arbitrary data calculation] screen, enter the applicable formula in the entry field then press [OK].

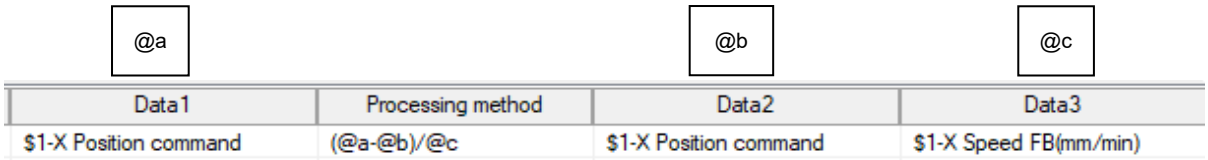
(3) The formula you input will be reflected in the [Processing method] column.

(4) Add relevant operation elements.



■ Available variables

Arbitrary data calculation provides three variables (@a: Data 1, @b: Data2, @c: Data 3).



*1 When the number of the variables differs within the operation, an insufficient number of variable will be dealt as “0”.

*2 @a, @b, and @c can be upper case (@A, @B, and @C). Note that no space or any other characters shall be inserted between “@” and characters (a, b or c).

■ Available constants

0 through 9, pi(π)

*1 Accepts decimal and negative values.

*2 Some operation results may have errors for the constant "pi" is predetermined as pi=3.14159265358979323846264338327 95.

*3 All data will be calculated in double.

■ Available operators are as follows.

No.	Operators	Operation	Examples
1	+	Addition	@a+@b,@a+1
2	-	Subtraction	@a-@b,@a-10
3	*	Multiplication	@a*@b,@a*2
4	/	Division	@a/@b,@a/3
5	sqrt	Square root	sqrt@a
6	^	Power	@a^2
7	sin	Sin function	sin@a
8	cos	Cosine function	cos@a
9	tan	Tangent function	tan@a
10	asin	Inverse sine function	asin@a
11	acos	Inverse cosine function	acos@a
12	atan	Inverse tangent function	atan@a
13	%	Reminder function	@a%@b
14	( )	Parentheses	(@a+@b)*3

* Space character can be inserted between operator and variable/constant.

Example Both “(@a+@b)*@c” and “(@a + @b) * @c” have the same effect.

■ Precedence among available operators are as follows.

Precedence among available operators:	Operators
High	( )
	sqrt , ^
↓	* , / , %
	sin , cos , tan , asin , acos , atan
Low	+ , -

[APPENDIX 1] Details of Operators

1. + (Addition) - (Subtraction)

■ Data

Data	Variables			Constants		Arithmetic data
	@a	@b	@c	0 through 9	pi	
S1	○	○	○	○	○	○
S2	○	○	○	○	○	○

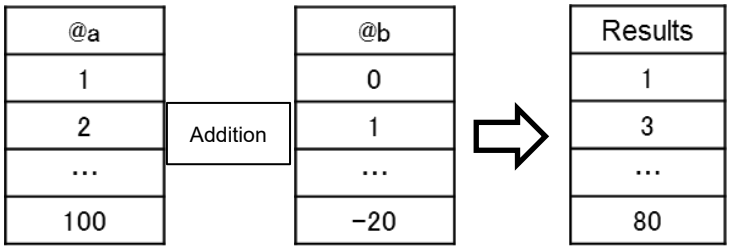
○: Available -: Not available △: Partially available

S1: The data that precedes the operator.

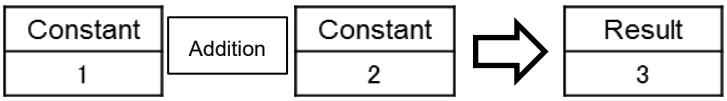
S2: The data that follows the operator.

■ How the operator works

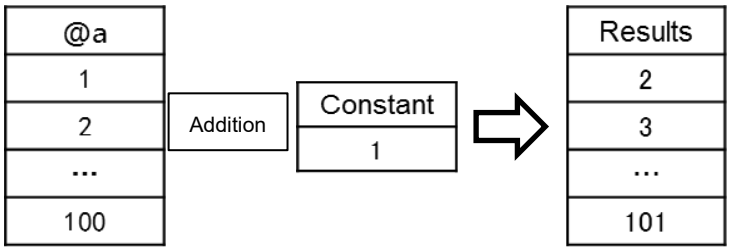
(1) When adding variable to variable, returns the additions of corresponding data.



(2) When adding constant to constant, returns elementary addition operation.



(3) When adding constant to variables, returns the addition by adding the constant to each variable.



(4) Arithmetic data represents the result acquired from other operations. Example: @a+@b*2

2. * (Multiplication) / (Division)

■ Data

Data	Variables			Constants		Arithmetic data
	@a	@b	@c	0 through 9	pi	
S1	○	○	○	○	○	○
S2	○	○	○	○	○	○

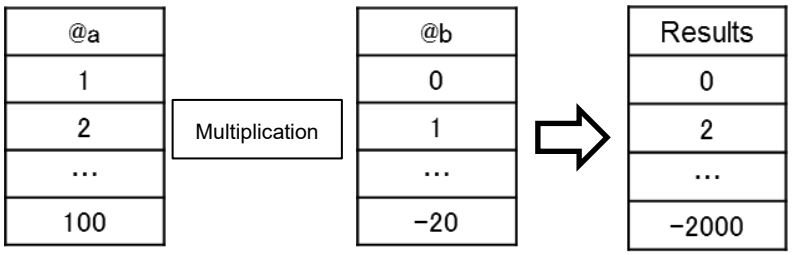
○: Available -: Not available △: Partially available

S1: The data that precedes the operator.

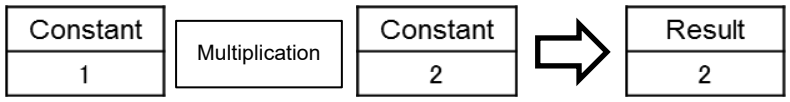
S2: The data that follows the operator.

■ How the operator works

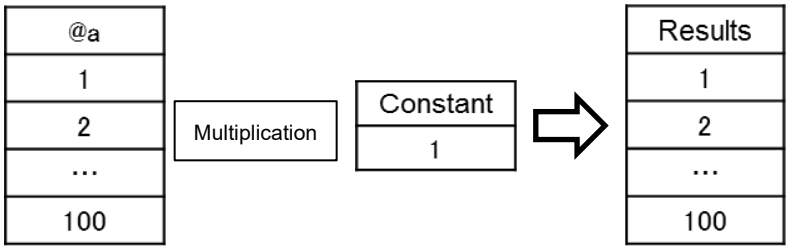
(1) When multiplying variable with variable, returns the multiplication of corresponding data.



(2) When multiplying constant with constant, returns elementary multiplication operation.



(3) When multiplying constant with variables, returns the multiplication by multiplying each variable with the constant.



(4) Division

When S2 is constant, “0”, returns an error message.

When S2 is a variable and “0” is assigned to the variable, the result is “0”.

3. sqrt（Square root）

■ Data

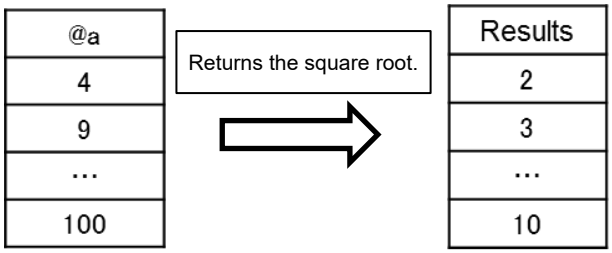
Data	Variables			Constants		Arithmetic data
	@a	@b	@c	0 through 9	pi	
D	○	○	○	○	○	○

○: Available -: Not available △: Partially available

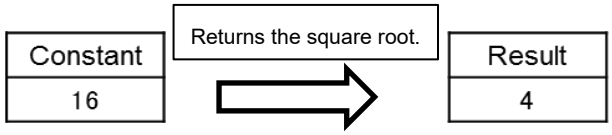
D: The data that is dealt within the operators.

■ How the operator works

(1) When operating a variable, returns a result of corresponding data.



(2) When operating a constant, returns a result of elementary square root operation.



(3) When D is less than 0.

When D is a constant, returns an error message.

When D is a variable and less than “0”, the result is “0”.

4. ^ (Power)

■ Data

Data	Variables			Constants		Arithmetic data
	@a	@b	@c	0 through 9	pi	
S1	○	○	○	△	○	○
S2	○	○	○	△	○	○

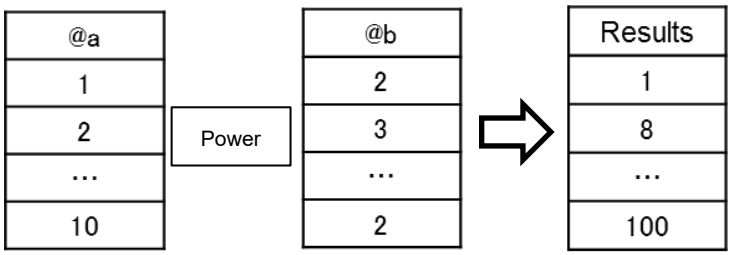
○: Available -: Not available △: Partially available

S1: The data that precedes the operator.

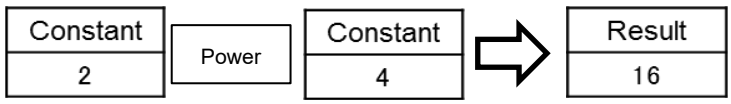
S2: The data that follows the operator.

■ How the operator works

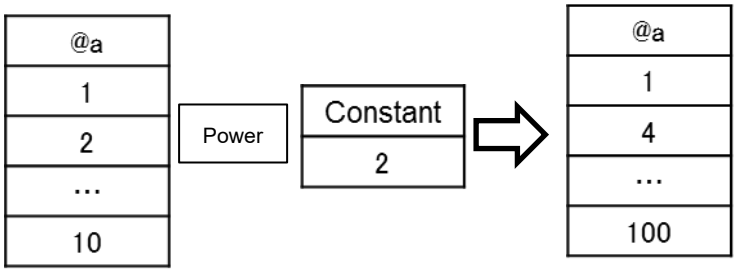
(1) When the base and the exponent are both a variable, returns a result of corresponding data.



(2) When the base and the exponent are both a constant, returns a result of elementary mathematical operation.



(3) When the base is an array of variable and the exponent is a constant, returns the results by operating each variable with the constant (exponent).



(4) When both S1 and S2 are 0.

When both S1 and S2 are constants, returns an error message.

When either S1 or S2 is a variable, or when both are variables, the result is “0”.

5. sin , cos , tan , asin , acos , atan （Trigonometric functions）

■ Data

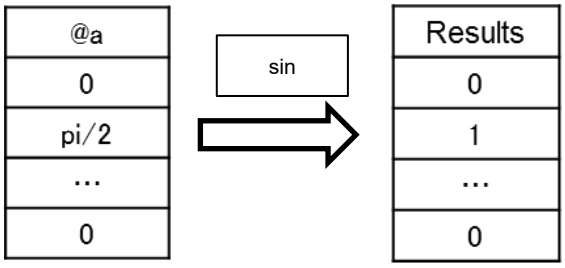
Data	Variables			Constants		Arithmetic data
	@a	@b	@c	0 through 9	pi	
D	○	○	○	○	○	○

○: Available -: Not available △: Partially available

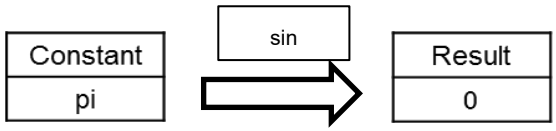
D: The data that is dealt within the operators.

■ How the operator works

(1) When operating a variable, returns a result of corresponding data.



(2) When operating a constant, returns a result of elementary sin operation.



(3) The range of data for each trigonometric function is as shown below.

Function	Range of value	Display range of the result
sin	*1 *2	[-1,+1]
cos	*1 *2	[-1,+1]
tan	(-pi/2,+pi/2) *1 *2	[-1633123935195370, +1633123935195370] *3
asin	[-1,+1]	(-1.570796, +1.570796) *1
acos	[-1,+1]	(0, +3.141593) *1
atan	*2	(-1.570796, +1.570796) *1

*1

The input data (D) for sin, cos, and tan provides its unit in radians. For example, sin(pi/2) = 1

The resulting data for asin, acos, and atan provides its unit in radians. For example, asin(1) = pi/2≠1.570796

*2

The maximum number of significant digits is 15-digit. If the number of digits of the data exceeds the maximum number of significant digits, an improper result may be induced.

*3

For pi is a finite value, the maximum and minimum are not infinity value.

(4) When D exceeds the range of value and is a constant, returns an error message.

When D is a variable, the result is “0”.

6. % (Reminder function)

■ Data

Data	Variables			Constants		Arithmetic data
	@a	@b	@c	0 through 9	pi	
S1	○	○	○	○	○	○
S2	○	○	○	△	○	○

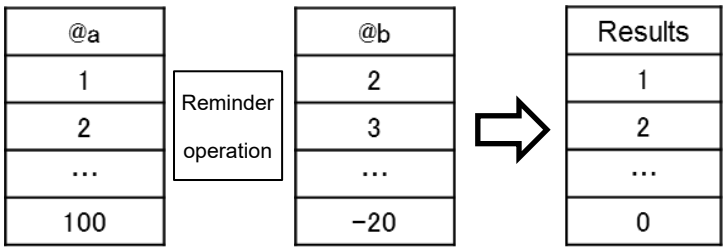
○: Available -: Not available △: Partially available

S1: The data that precedes the operator.

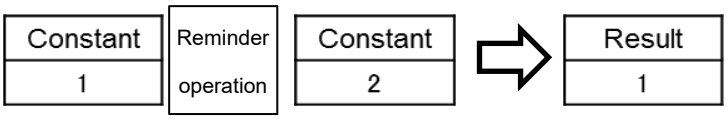
S2: The data that follows the operator.

■ How the operator works

(1) When S1 and S2 are both variables, returns a result of corresponding data.



(2) When S1 and S2 are both constants, returns a result of elementary arithmetic operation.



(3) When S2 includes 0.

When S2 is a constant, returns an error message.

When S2 is a variable, the result is “0”.

(4) The reminder function returns the result with the same sign with S1.

See an example below.

S1	S2	Results
-13	4	-1
-13	-4	-1
13	-4	1
13	4	1

7. ( ) (Parentheses)

■ Data

Data	Variables			Constants		Arithmetic data
	@a	@b	@c	0 through 9	pi	
D	○	○	○	○	○	○

○: Available -: Not available △: Partially available

D: The data that is dealt within the operators.

■ How the operator works

(1) Use Parentheses within a variable, a constant, and arithmetic operation.

(2) The arithmetic within the parentheses has the precedence among the operations.

(3) @a = (@a) , @b = (@b) ,@c = (@c)

(4) When using pi within the operators below, enclose with parentheses.

sqrt, sin, cos, tan, asin, acos, atan

Revision History

Date of revision	Manual No.	Revision details
Mar. 2020	IB(NA)1501592-A	First edition created.

Notice

Every effort has been made to keep up with software and hardware revisions in the contents described in this manual. However, please understand that in some unavoidable cases simultaneous revision is not possible.

Please contact your Mitsubishi Electric dealer with any questions or comments regarding the use of this product.

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Specifications are subject to change without notice.