MITSUBISHI ELECTRIC

Mitsubishi Electric AC Servo System

MITSUBISHI ELECTRIC SERVO SYSTEM MELSERVO-JET

MR-JET
User's Manual
(Adjustment)

-MR-JET-_G_
-MR-JET-_G_-_N1

SAFETY INSTRUCTIONS

Please read the instructions carefully before using the equipment.
To use the equipment correctly, do not attempt to install, operate, maintain, or inspect the equipment until you have read through this manual, installation guide, and appended documents carefully. Do not use the equipment until you have a full knowledge of the equipment, safety information and instructions.
In this manual, the safety instruction levels are classified into "WARNING" and "CAUTION".

⚠ **WARNING**	Indicates that incorrect handling may cause hazardous conditions, resulting in death or severe injury.
⚠ **CAUTION**	Indicates that incorrect handling may cause hazardous conditions, resulting in medium or slight injury.

Note that the CAUTION level may lead to a serious consequence depending on conditions.
Please follow the instructions of both levels because they are important to personnel safety.
Forbidden actions and required actions are indicated by the following diagrammatic symbols.

	Indicates a forbidden action. For example, "No Fire" is indicated by .
	Indicates a required action. For example, grounding is indicated by .

In this manual, precautions for hazards that can lead to property damage, instructions for other functions, and other information are shown separately in the "Point" area.
After reading this manual, keep it accessible to the operator.

[Installation/wiring]

⚠WARNING

- To prevent an electric shock, turn off the power and wait for 15 minutes or more before starting wiring and/or inspection.
- To prevent an electric shock, ground the servo amplifier.
- To prevent an electric shock, any person who is involved in wiring should be fully competent to do the work.
- To prevent an electric shock, mount the servo amplifier before wiring.
- To prevent an electric shock, connect the protective earth (PE) terminal of the servo amplifier to the protective earth (PE) of the cabinet, then connect the grounding lead wire to the ground.
- To prevent an electric shock, do not touch the conductive parts.

[Setting/adjustment]

⚠WARNING

- To prevent an electric shock, do not operate the switches with wet hands.

[Operation]

⚠WARNING

- To prevent an electric shock, do not operate the switches with wet hands.

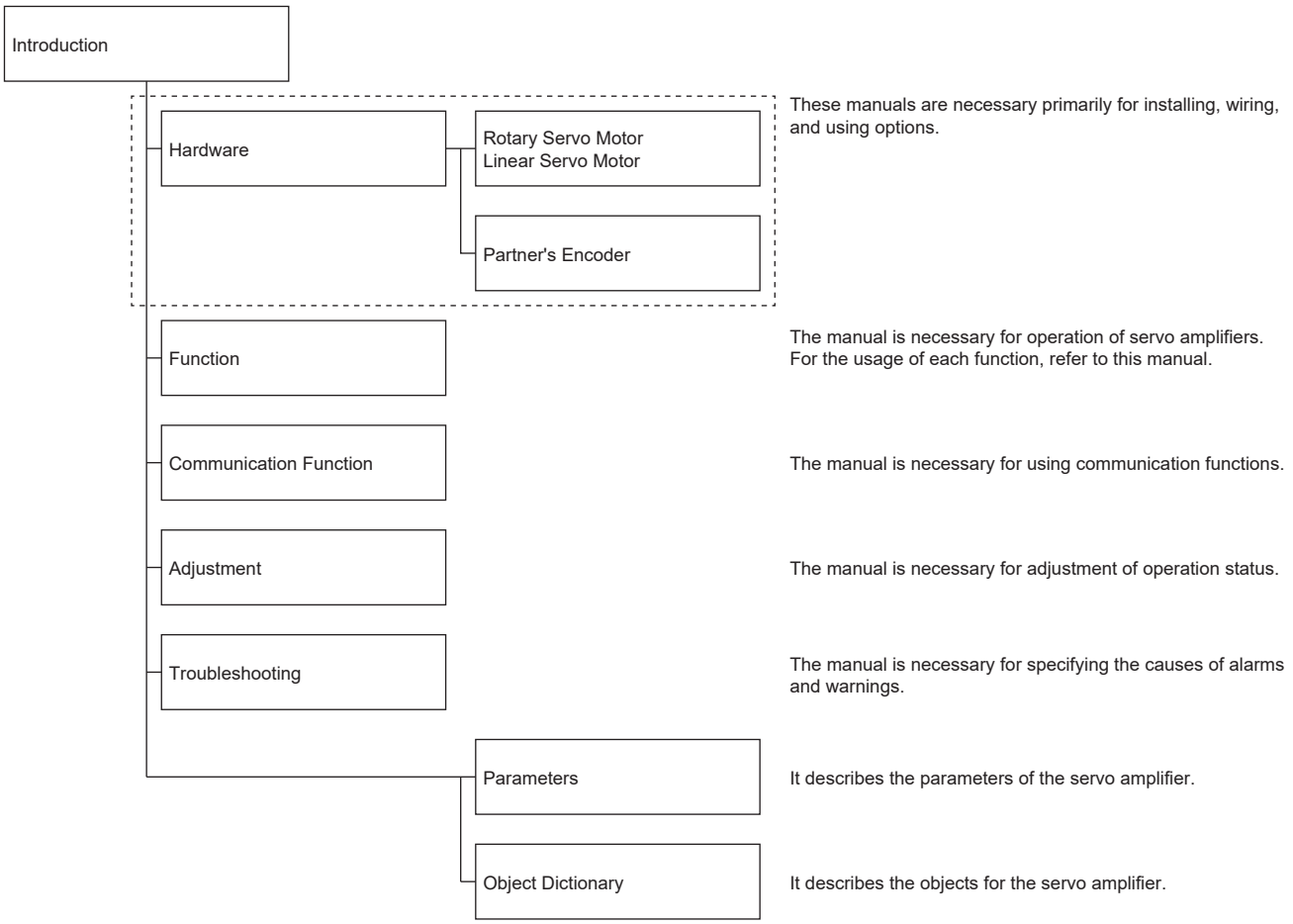
[Maintenance]

⚠WARNING

- To prevent an electric shock, any person who is involved in inspection should be fully competent to do the work.
- To prevent an electric shock, do not operate the switches with wet hands.

ABOUT THE MANUAL

If you are using the servo for the first time, prepare and refer to the related manuals as necessary to ensure safe operation of the servo. For the related manuals, refer to the User's Manual (Introduction).



This manual covers the following servo amplifiers.

- MR-JET-_G_/MR-JET-_G_-_N1

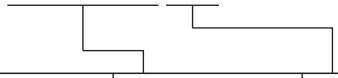
Global standards and regulations

Compliance with the indicated global standards and regulations is current as of the release date of this manual. Some standards and regulations may have been modified or withdrawn.

HOW TO READ OBJECTS

The notation of the object dictionary in the User's Manual is as follows. The following shows an example using [Save all parameters (Obj. 1010h: 01h)].

[Save all parameters (Obj. 1010h: 01h)]



CC-Link IE TSN	Index: 1010h	Sub Index: 01h
CC-Link IE Field Network Basic	Index: 1010h	Sub Index: 01h
EtherCAT	Index: 1010h	Sub Index: 01h
PROFINET	PNU 4112	Subindex 0

U.S. CUSTOMARY UNITS

U.S. customary units are not shown in this manual. Convert the values if necessary according to the following table.

Quantity	SI (metric) unit	U.S. customary unit
Mass	1 [kg]	2.2046 [lb]
Length	1 [mm]	0.03937 [inch]
Torque	1 [N•m]	141.6 [oz•inch]
Moment of inertia	1 [(× 10^{-4} kg•m^2)]	5.4675 [oz•$inch^2$]
Load (thrust load/axial load)	1 [N]	0.2248 [lbf]
Temperature	N [°C] × 9/5 + 32	N [°F]

CONTENTS

SAFETY INSTRUCTIONS . . . 1
ABOUT THE MANUAL . . . 3
HOW TO READ OBJECTS . . . 4
U.S. CUSTOMARY UNITS . . . 4

CHAPTER 1 ADJUSTMENT FUNCTION TYPES 8

1.1 Adjustment functions available when using the servo amplifier alone . . . 8
Functions to automatically adjust machine stability . . . 8
Adjustment functions to suppress vibration and to obtain a high level of responsiveness . . . 9
Manual adjustment functions to obtain the maximum performance . . . 9
1.2 Adjustment functions available in combination with MR Configurator2 . . . 10

CHAPTER 2 ADJUSTMENT PROCEDURE 11

CHAPTER 3 ADJUSTMENT METHOD 13

3.1 Quick tuning . . . 13
Restrictions on quick tuning . . . 13
Precautions on quick tuning . . . 13
Setting method for quick tuning . . . 14
Operation of quick tuning . . . 16
Errors in quick tuning . . . 16
3.2 One-touch tuning . . . 17
Restrictions on one-touch tuning . . . 17
Instructions on one-touch tuning . . . 18
One-touch tuning procedure . . . 19
Progress display during one-touch tuning . . . 28
Servo parameters adjusted with one-touch tuning . . . 29
One-touch tuning stop method . . . 29
One-touch tuning error . . . 30
Initializing one-touch tuning . . . 32
3.3 Auto tuning mode 1 . . . 34
Restrictions on auto tuning mode 1 . . . 34
Precautions on auto tuning mode 1 . . . 34
Adjustment procedure by auto tuning mode 1 . . . 35
Responsiveness setting in auto tuning mode 1 . . . 36
Operation of auto tuning mode 1 . . . 38
3.4 Auto tuning mode 2 . . . 39
Precautions on auto tuning mode 2 . . . 39
Adjustment procedure by auto tuning mode 2 . . . 39
Responsiveness setting in auto tuning mode 2 . . . 40
Operation of auto tuning mode 2 . . . 40
3.5 2 gain adjustment mode 1 . . . 41
Adjustment procedure for 2 gain adjustment mode 1 . . . 41
Operation of 2 gain adjustment mode 1 . . . 42
3.6 2 gain adjustment mode 2 . . . 43
Adjustment procedure for 2 gain adjustment mode 2 . . . 43
Operation of 2 gain adjustment mode 2 . . . 43
3.7 Manual mode . . . 44

Adjustment procedure for the velocity mode . . . 44
Adjustment procedure for position mode and positioning mode . . . 46
3.8 Load to motor inertia ratio monitor mode . . . 49
Precautions on load to motor inertia ratio monitor mode . . . 49
Adjustment procedure for load to motor inertia ratio monitor mode . . . 49
Operation of load to motor inertia ratio monitor mode . . . 49

CHAPTER 4 VIBRATION SUPPRESSION FUNCTION 50

4.1 Filter setting . . . 50
4.2 Machine resonance suppression filter . . . 50
Machine resonance suppression filter restrictions . . . 51
Machine resonance suppression filter precautions . . . 51
Machine resonance suppression filter setting method . . . 51
Operation of machine resonance suppression filter . . . 52
4.3 Adaptive filter II . . . 53
Restrictions on adaptive tuning . . . 54
Precautions for adaptive filter II . . . 54
How to set adaptive filter II . . . 54
Adaptive tuning procedure . . . 55
4.4 Shaft resonance suppression filter . . . 56
Shaft resonance suppression filter restrictions . . . 56
Shaft resonance suppression filter setting method . . . 56
4.5 Low-pass filter . . . 60
Low-pass filter setting method . . . 60
Operation of low-pass filter . . . 60
4.6 Robust filter . . . 60
Robust filter restrictions . . . 60
Robust filter setting method . . . 60
4.7 Advanced vibration suppression control II . . . 61
Advanced vibration suppression control restrictions . . . 62
Advanced vibration suppression control precautions . . . 63
Advanced vibration suppression control setting method . . . 63
Advanced vibration suppression control adjustment method . . . 63
4.8 Command notch filter . . . 67
Command notch filter setting method . . . 68
4.9 Vibration tough drive . . . 71
Vibration tough drive restrictions . . . 71
Vibration tough drive precautions . . . 71
Vibration tough drive setting method . . . 71
Operation of vibration tough drive . . . 72
4.10 Command smoothing filter . . . 74
Restrictions on the command smoothing filter . . . 74
Instructions on the command smoothing filter . . . 74
How to set the command smoothing filter . . . 74

CHAPTER 5 GAIN SWITCHING FUNCTION 75

5.1 Restrictions on gain switching . . . 75
5.2 Precautions on gain switching . . . 75
5.3 Setting method for gain switching . . . 76
Servo parameters for setting the gain switching condition . . . 76

Servo parameters that are changeable with the gain switching . . . 77
Related objects . . . 78
5.4 Examples of gain switching operation . . . 79
Gain switching by servo motor speed . . . 79
Gain switching by signals (CDP/C_CDP/CDP2/C_CDP2) . . . 84
Gain switching by command directions . . . 85
Gain switching by servo motor speed and gain switching 2 (CDP2/C_CDP2) . . . 87

CHAPTER 6 SPEED FEED FORWARD CONTROL FUNCTION 88

6.1 Method for setting the speed feed forward . . . 88

CHAPTER 7 OVERSHOOT SUPPRESSION CONTROL 90

7.1 Restrictions on overshoot suppression control . . . 90
7.2 Settings of the overshoot suppression control . . . 90

CHAPTER 8 SLIGHT VIBRATION SUPPRESSION CONTROL 92

8.1 Restrictions on the slight vibration suppression control . . . 92
8.2 Settings of the slight vibration suppression control . . . 92
8.3 Operation of slight vibration suppression control . . . 92

CHAPTER 9 UNBALANCED TORQUE OFFSET 94

9.1 Setting unbalanced torque offset . . . 94
Automatic setting . . . 94
Manual setting . . . 94

CHAPTER 10 MODEL ADAPTIVE CONTROL 96

10.1 Setting model adaptive control . . . 96
10.2 Disabling model adaptive control . . . 96
Instructions on disabling model adaptive control . . . 96
How to disable model adaptive control . . . 97

CHAPTER 11 PATH CONTROL FUNCTION 98

11.1 Path tracking model adaptive control . . . 98
Setting the path tracking model adaptive control . . . 98
Operation of path tracking model adaptive control . . . 99
11.2 Super trace control . . . 99
Restrictions on super trace control . . . 99
Instructions on super trace control . . . 99
Setting the super trace control . . . 99
Operation of super trace control . . . 100
11.3 Lost motion compensation function . . . 101
Restrictions on the lost motion compensation function . . . 101
Setting the lost motion compensation function . . . 101
Adjusting the lost motion compensation . . . 102
REVISIONS . . . 104
WARRANTY . . . 105
TRADEMARKS . . . 106

1 ADJUSTMENT FUNCTION TYPES

A servo amplifier is equipped with various servo parameters that can be used to adjust operation status. To maximize the machine's performance, these servo parameters must be set in accordance with the machine's characteristics. When using the factory setting, the gain adjustment is set to "Auto tuning mode 1". Use each adjustment function to improve the responsiveness.

Precautions

- When using the torque mode, gain adjustment is not required.
- Before performing gain adjustment, check that your machine is not being operated at the maximum torque of the servo motor. If operated in excess of the maximum torque, the machine may vibrate and operate unexpectedly. In addition, adjust gains taking into account that each machine is different. It is recommended to limit the torque generated by the servo motor during operation to 90 % or less of the maximum torque of the servo motor.
- If the torque of the servo motor reaches the torque limit value, changing the gain will not change the response of the servo motor and gain adjustment cannot be performed accurately.
- When using a linear servo motor, the terms below have the following meanings.

Load to motor inertia ratio → Load to motor mass ratio

Torque → Thrust

1.1 Adjustment functions available when using the servo amplifier alone

The following table shows the adjustment functions available when using the servo amplifier alone.

Functions to automatically adjust machine stability

Adjustment function	Outline	Reference
Quick tuning	Use this function to prioritize reduction of the overshoot rather than shortening the settling time. Adjustment can be performed without driving the servo motor. (Adjustment time: approx. 300 ms)	☞ Page 13 Quick tuning
One-touch tuning	Use this function to reduce settling time within the designated In-position range. Automatic adjustment including the vibration suppression functions such as the machine resonance suppression filter and advanced vibration suppression control II can be performed according to the mechanical characteristics. The command method can be selected from the user command method and the amplifier command method.	☞ Page 17 One-touch tuning
Auto tuning mode 1	Use this function to adjust the machine while checking the response waveform when the load to motor inertia ratio of the device is unknown. Also use this function when the load to motor inertia ratio of a machine varies during operation.	☞ Page 34 Auto tuning mode 1
Auto tuning mode 2	Use this function to adjust the machine while checking the response waveform when the load to motor inertia ratio of the device is known.	☞ Page 39 Auto tuning mode 2
2 gain adjustment mode 1	Use this function for auto tuning a machine that requires path accuracy improvement, such as an XY table or a tandem mechanism, and to suppress inter-axis interference.	☞ Page 41 2 gain adjustment mode 1
2 gain adjustment mode 2	Use this function to adjust settling time and overshoot amount after one-touch tuning.	☞ Page 43 2 gain adjustment mode 2

Adjustment functions to suppress vibration and to obtain a high level of responsiveness

Adjustment function	Outline	Reference
Machine resonance suppression filter	Use this function if machine resonance occurs when the response level is increased in auto tuning or manual mode.	☞ Page 50 Machine resonance suppression filter
Adaptive filter II	Use this function to adjust the machine resonance suppression filter automatically.	☞ Page 53 Adaptive filter II
Robust filter	When the load to motor inertia ratio of a machine is 10 times or more, use this filter to further increase the response level of the machine.	☞ Page 60 Robust filter
Advanced vibration suppression control II	If the vibration is too large when settling during high-speed positioning, use this function to suppress the vibration and also reduce settling time.	☞ Page 61 Advanced vibration suppression control II
Command notch filter	If the vibration is too large when settling during high-speed positioning, use this function to easily suppress said vibration.	☞ Page 67 Command notch filter
Command smoothing filter	If the vibration is too large when settling during high-speed positioning, use this function to easily suppress said vibration. In addition, use this function to suppress vibrations in a wide range of frequencies.	☞ Page 74 Command smoothing filter

Manual adjustment functions to obtain the maximum performance

Adjustment function	Outline	Reference
Manual mode	Use this function if the performance of quick tuning, one-touch tuning, and auto tuning is not satisfactory.	☞ Page 44 Manual mode
Gain switching function	Use this function for: 1) Reducing the settling time 2) Increasing the gain during servo-lock while suppressing vibration sound during rotation 3) When load fluctuation is too large	☞ Page 75 GAIN SWITCHING FUNCTION
Speed feed forward	Use this function to improve path accuracy by decreasing droop pulses at the constant speed.	☞ Page 88 SPEED FEED FORWARD CONTROL FUNCTION
Overshoot suppression function	Use this function to decrease the overshoot.	☞ Page 90 OVERSHOOT SUPPRESSION CONTROL
Slight vibration suppression function	Use this function to suppress vibration at a servo motor stop.	☞ Page 92 SLIGHT VIBRATION SUPPRESSION CONTROL
Unbalanced torque offset	Use this function to prevent free fall of a vertical axis when turning on servo-on.	☞ Page 94 UNBALANCED TORQUE OFFSET
Path tracking model adaptive control	Use this function to suppress overshoot in path control.	☞ Page 98 Path tracking model adaptive control
Super trace control	Use this function to improve the trackability at acceleration/deceleration in path control.	☞ Page 99 Super trace control
Lost motion compensation function	Use this function to suppress quadrant projections at speed switching in path control.	☞ Page 101 Lost motion compensation function

1.2 Adjustment functions available in combination with MR Configurator2

By combining with MR Configurator2 and a servo amplifier, the following adjustment functions can be used additionally.

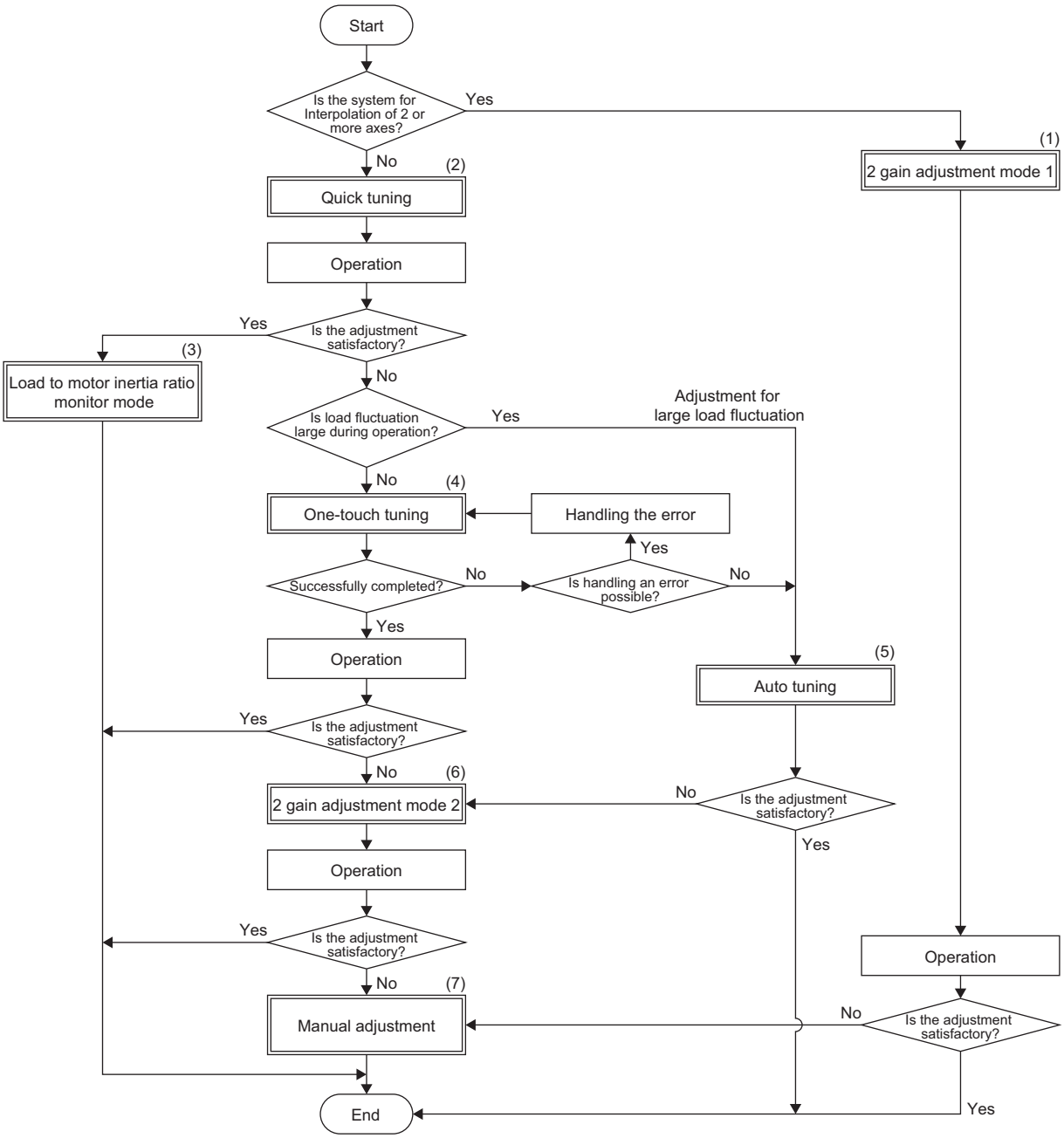
Adjustment function	Outline	Reference
Machine analyzer	Use this function to accurately adjust the mechanical resonance suppression filter when the characteristics of the mechanical resonance are known. With the machine and servo motor connected, the characteristics of the mechanical system can be measured by giving a random vibration command from a personal computer to the servo amplifier and then measuring the responsiveness of the machine.	—
One-touch tuning using the amplifier command method	Use this function to prioritize time reduction of settling and gain adjustment over overshoot suppression. To generate an optimum command inside the servo amplifier and perform one-touch tuning, simply input a travel distance that avoids collision with the machine (a permissible travel distance) when driving the servo motor on MR Configurator2.	☞ Page 17 One-touch tuning

2 ADJUSTMENT PROCEDURE

Adjust the servo amplifier using the following procedure.

Point

- When the servo amplifier with firmware version C4 or later is used, it is recommended to set [Pr. PA24.5 Load to motor inertia ratio/load to motor mass ratio estimation higher precision selection] to "1".When [Pr. PA24.5] is set to "0", [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio] may be estimated at a value smaller than the accurate estimation depending on the operation pattern. Setting [Pr. PA24.5] to "1" with the equipment on which the gain is adjusted may change the actual movement. Check the movement of the equipment after changing the settings.



No.	Instructions
(1)	Set [Pr. PA08.0 Gain adjustment mode selection] to "0". Use this mode to set the same setting value in [Pr. PB07 Model control gain] to all axes when performing interpolation such as path control or tandem drive for a system with 2 axes or more. Do not use this for other purposes. ☞ Page 41 2 gain adjustment mode 1
(2)	This mode can adjust the servo amplifier without driving the servo motor. Adjusting the servo amplifier with this mode is recommended when interpolation control is not executed. ☞ Page 13 Quick tuning
(3)	Change the mode to the load to motor inertia ratio monitor mode if no problem appears in the adjustment result of quick tuning. ☞ Page 49 Load to motor inertia ratio monitor mode
(4)	Use one-touch tuning if the quick tuning result is not satisfactory. One-touch tuning offers a higher response level than quick tuning that enables quicker positioning. ☞ Page 17 One-touch tuning
(5)	Set [Pr. PA08.0 Gain adjustment mode selection] to "1" or "2". In auto tuning, the settling time may vary greatly depending on the load fluctuation. To suppress the fluctuation of the settling time in response to the load fluctuation, use the 2 gain adjustment mode 2. ☞ Page 34 Auto tuning mode 1
(6)	[Pr. PA08.0 Gain adjustment mode selection] is automatically set to "4" (2 gain adjustment mode 2) once one-touch tuning is complete. ☞ Page 17 One-touch tuning
(7)	Set [Pr. PA08.0 Gain adjustment mode selection] to "3". Use the manual adjustment for fast settling or high accuracy path control. ☞ Page 44 Manual mode

3 ADJUSTMENT METHOD

3.1 Quick tuning

To use quick tuning, set [Pr. PA08.0 Gain adjustment mode selection] to "5". Quick tuning performs gain adjustment for the servo amplifier when servo-on is turned on. The characteristics of quick tuning are as follows:

- Has the ability to reduce the overshoot regardless of machine type or load size and is effective when reducing the overshoot is prioritized over shortening the settling time.
- Adjustment available without the positioning operation

Restrictions on quick tuning

Quick tuning is not available in the following situations:

- During one-touch tuning
- In the torque mode
- In the continuous operation to torque control mode
- When using adaptive filter II

Precautions on quick tuning

- Do not use quick tuning in a tandem system.
- Some noise due to the applied vibration torque may occur during quick tuning, but the noise is not an abnormality.
- When the load to motor inertia ratio is more than 100 times, quick tuning cannot adjust the gain appropriately. Adjust the gain by using an alternative method such as auto tuning.
- When quick tuning is enabled (performed), the time until the servo amplifier actually enters the servo-on state after turning on the servo-on command increases by up to 300 ms.
- When the torque limit value is less than 30 % of the rated torque, the torque required for quick tuning cannot be generated, and quick tuning may fail. Set the torque limit value to exceed 30 % of the rated torque for quick tuning.
- If the travel distance for quick tuning exceeds the set value in [Pr. PA34 Quick tuning - Permissible travel distance], quick tuning will be stopped.
- [Pr. PB11 Speed differential compensation] will be changed to the initial value if quick tuning is used.
- When friction is 30 % or more of the rated torque, quick tuning may fail. In this case, adjust the gain with one-touch tuning or auto tuning.

Setting method for quick tuning

How to use quick tuning

Servo parameter	Name	Description
PA08.0	Gain adjustment mode selection	Select the gain adjustment mode. The initial value is "1". 0: 2 gain adjustment mode 1 (interpolation mode) 1: Auto tuning mode 1 2: Auto tuning mode 2 3: Manual mode 4: 2 gain adjustment mode 2 5: Quick tuning mode 6: Load to motor inertia ratio monitor mode
PA08.4	Quick tuning - Load to motor inertia ratio setting	Select the load to motor inertia ratio of the equipment. The initial value is "0". 0: Load to motor inertia ratio of 30 times or less 1: Load to motor inertia ratio of 100 times or less
PA08.5	Quick tuning - Execution selection	Set when to execute quick tuning. The initial value is "0". 0: At initial servo-on after cycling the power (Executes quick tuning at initial servo-on after turning on the power.) 1: At every servo-on (Executes quick tuning every time servo-on is turned on.)
PA34	Quick tuning - Permissible travel distance	Set the permissible travel distance for quick tuning. The initial value is "0". If the travel distance for quick tuning exceeds the setting value, the quick tuning error occurs. When "0" is set, the permissible travel distance for quick tuning is 1.0 rev (10 mm when using a linear servo motor). Setting range: 0 to 100

Execute quick tuning using the following procedure.

■When executing quick tuning at the initial servo-on after turning on the power

1. Turn off servo-on.

2. Set [Pr. PA08.0] to "5" (quick tuning mode).

3. Set [Pr. PA08.5] to "0" (at initial servo-on after cycling the power).

4. Check the load to motor inertia ratio.

• When the load to motor inertia ratio is 30 times or less

Set [Pr. PA08.4] to "0" (load to motor inertia ratio of 30 times or less).

• When the load to motor inertia ratio is over 30 times but not greater than 100 times, or unknown

Set [Pr. PA08.4] to "1" (load to motor inertia ratio of 100 times or less).

5. Set the permissible travel distance for quick tuning with [Pr. PA34].

6. Turn on servo-on to adjust servo parameters automatically.

Quick tuning is then executed at each initial servo-on every time the power is turned on.

7. To retain the tuning results, set [Pr. PA08.0] to "6" (load to motor inertia ratio monitor mode).

■When executing quick tuning every time servo-on is turned on

1. Turn off servo-on.
2. Set [Pr. PA08.0] to "5" (quick tuning mode).
3. Set [Pr. PA08.5] to "1" (at every servo-on).
4. Check the load to motor inertia ratio.

• When the load to motor inertia ratio is 30 times or less

Set [Pr. PA08.4] to "0" (load to motor inertia ratio of 30 times or less).

• When the load to motor inertia ratio is over 30 times but not greater than 100 times, or unknown

Set [Pr. PA08.4] to "1" (load to motor inertia ratio of 100 times or less).

5. Set the permissible travel distance for quick tuning with [Pr. PA34].
6. Turn on servo-on to adjust servo parameters automatically.

Quick tuning is then executed each time servo-on is turned on.

7. To retain the tuning results, set [Pr. PA08.0] to "6" (load to motor inertia ratio monitor mode).

How to restore to servo parameter values from before quick tuning

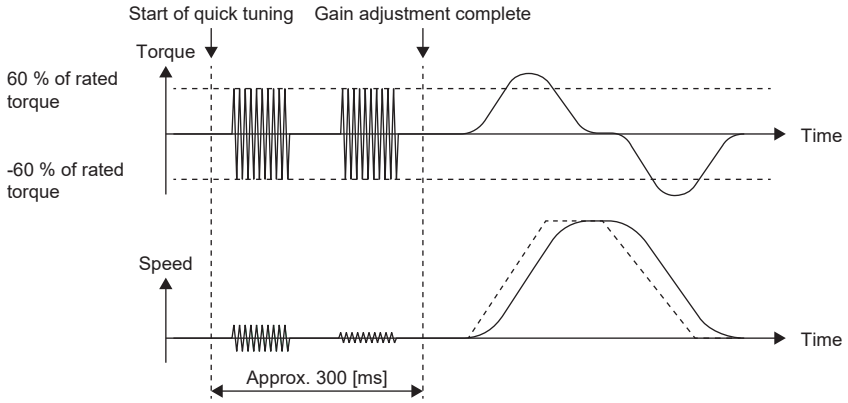
Servo parameter	Name	Description
PA08.6	Quick tuning - Restore selection	Set whether to restore to the servo parameter values from before quick tuning. The initial value is "0". 0: Disabled 1: Enabled

When [Pr. PA08.6] is set to "1" (enabled), the following servo parameters return to the values they had set before quick tuning was executed. If quick tuning has never been performed after power-on or software reset, setting [Pr. PA08.6] to "1" only keeps the current servo parameter values.

No.	Symbol	Name
PB01	FILT	Adaptive tuning mode (adaptive filter II)
PB07	PG1	Model control gain
PB08	PG2	Position control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation
PB11	VDC	Speed differential compensation
PB13	NH1	Machine resonance suppression filter 1
PB14	NHQ1	Notch shape selection 1
PB15	NH2	Machine resonance suppression filter 2
PB16	NHQ2	Notch shape selection 2
PB18	LPF	Low-pass filter setting
PB23	VFBF	Low-pass filter selection
PB50	NH5	Machine resonance suppression filter 5
PB51	NHQ5	Notch shape selection 5
PE41.0	—	Robust filter selection

Operation of quick tuning

When quick tuning is started, the servo amplifier applies vibration torque instantly, then adjusts each gain and the machine resonance suppression filter by using the response from that excitation. The maximum vibration torque that can be applied is 60 % of the rated torque. However, the vibration torque is limited by the torque limit value when the torque limit value is less than 60 % of the rated torque. The adjustment takes about 300 ms.
When magnetic pole detection is executed, quick tuning will be started after the magnetic pole detection.
Once gain adjustment by quick tuning is complete, the gain can be changed as in the manual mode. In addition, the load to motor inertia ratio will be always estimated as in auto tuning mode 1 after gain adjustment.



The following servo parameters are adjusted automatically in quick tuning.

No.	Symbol	Name	Setting value after gain adjustment
PB01	FILT	Adaptive tuning mode (adaptive filter II)	Automatic setting
PB06	GD2	Load to motor inertia ratio/load to motor mass ratio	The setting value is set depending on the response waveform during servo motor driving after gain adjustment.
PB07	PG1	Model control gain	Automatic setting
PB08	PG2	Position control gain	
PB09	VG2	Speed control gain	
PB10	VIC	Speed integral compensation	
PB11	VDC	Speed differential compensation	Initial value
PB13	NH1	Machine resonance suppression filter 1	Automatic setting
PB14	NHQ1	Notch shape selection 1	
PB15	NH2	Machine resonance suppression filter 2	
PB16	NHQ2	Notch shape selection 2	
PB18	LPF	Low-pass filter setting	Initial value
PB23.1	—	Low-pass filter selection	1
PB50	NH5	Machine resonance suppression filter 5	Automatic setting
PB51	NHQ5	Notch shape selection 5	
PE41.0	—	Robust filter selection	Initial value

Errors in quick tuning

Quick tuning may fail under the following conditions:

- When torque reaches the torque limit value during quick tuning
- When the travel distance for quick tuning exceeds the set value in [Pr. PA34 Quick tuning - Permissible travel distance]

When quick tuning fails, the servo parameter values from before quick tuning will be restored.

3.2 One-touch tuning

By turning on one-touch tuning during servo motor operation, one-touch tuning performs an adjustment in accordance with the machine characteristics. One-touch tuning can be performed using either of two methods: the user command method and the amplifier command method.

User command method

The user command method performs one-touch tuning by inputting commands from outside the servo amplifier. Although it is necessary to input commands from outside of the servo amplifier, an optimum adjustment that takes both mechanical characteristics and commands into account can be made.

Amplifier command method

With the amplifier command method, simply input a travel distance that avoids collision with the machine (a permissible travel distance) when driving the servo motor to generate an optimum command inside the servo amplifier and perform one-touch tuning. This method allows for one-touch tuning to be performed more easily than with the user command method as it does not require commands to be generated from outside of the servo amplifier. However, MR Configurator2 is required for performing one-touch tuning using the amplifier command method.

Precautions

- When the following setting values are set in [Pr. PA08.0 Gain adjustment mode selection], [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio] is estimated at the start of one-touch tuning.

"0" (2 gain adjustment mode 1 (interpolation mode))
"1" (auto tuning mode 1)
"2" (auto tuning mode 2)
"4" (2 gain adjustment mode 2)
"6" (load to motor inertia ratio monitor mode)

Restrictions on one-touch tuning

One-touch tuning cannot be performed in the following cases.

Common restrictions on user command method and amplifier command method

- When [Pr. PA21.0 One-touch tuning function selection] is "0" (disabled)
- In the torque mode
- In the continuous operation to torque control mode
- When an alarm or a warning which disrupts the motor driving occurs
- In output signal (DO) forced output and motor-less operation

Restrictions on user command method

- One-touch tuning using the user command method cannot be performed at servo-off.

Restrictions on amplifier command method

- One-touch tuning using the amplifier command method cannot be started while the servo motor is driven.
- One-touch tuning using the amplifier command method cannot be performed when the positioning operation, JOG operation, program operation, and test operation mode of machine analyzer function are being carried out.

Instructions on one-touch tuning

Instructions on amplifier command method

- Once one-touch tuning using the amplifier command method is performed, control by commands from a controller will not be available. To enable control from the controller again, reset the controller, cycle the power of the servo amplifier, or reset software.
- Set a permissible travel distance that avoids collision with the machine. In addition, the permissible travel distance may be exceeded because of an overshoot during one-touch tuning. Therefore, set the permissible travel distance with a margin to avoid exceeding the range of a limit switch.
- When the manual mode is selected in [Pr. PA08.0 Gain adjustment mode selection], a load to motor inertia ratio is not estimated. Optimum acceleration/deceleration commands are generated by [Pr. PB06 Load to motor inertia ratio/load to mass ratio] at the start of one-touch tuning. When the load to motor inertia ratio is not accurate, optimum acceleration/deceleration commands may not be generated, causing the tuning to fail.
- When one-touch tuning is started with a USB communication, both the servo motor and the tuning will stop if communication between MR Configurator2 and the servo amplifier is interrupted during the tuning. In addition, the servo parameters return to the status they had at the start of one-touch tuning.
- When one-touch tuning is started during the velocity mode, the mode is switched to the position mode automatically. As a result, the tuning result may differ from the results obtained by using the speed command.
- If one-touch tuning using the amplifier command method is attempted before magnetic pole detection is performed, one-touch tuning starts after magnetic pole detection is completed.

One-touch tuning procedure

Point

- When the servo amplifier with firmware version C4 or later is used, it is recommended to set [Pr. PA24.5 Load to motor inertia ratio/load to motor mass ratio estimation higher precision selection] to "1".When [Pr. PA24.5] is set to "0", [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio] may be estimated at a value smaller than the accurate estimation depending on the operation pattern. Setting [Pr. PA24.5] to "1" with the equipment on which the gain is adjusted may change the actual movement. Check the movement of the equipment after changing the settings.

MR Configurator2 procedure for one-touch tuning using the user command method

Perform one-touch tuning using the following procedure.

1. Start

2. Overshoot permissible level setting

Set the overshoot permissible level for one-touch tuning in [Pr. PA25 One-touch tuning - Overshoot permissible level].

3. Operation

Rotate the servo motor using the controller. In the user command method, one-touch tuning cannot be performed during a servo motor stop.

4. One-touch tuning start, command method selection

On MR Configurator2, select "One-touch Tuning" from the Adjustment tab of MR Configurator2. Select "User command method".

5. Response mode selection

Select the response mode (High mode/Basic mode/Low mode) in the one-touch tuning window of MR Configurator2.

6. One-touch tuning execution

Click "Start" during servo motor driving.

7. One-touch tuning in progress

Gains and filters are adjusted automatically. During the process of the tuning, the progress status is displayed in % on MR Configurator2.

8. One-touch tuning complete

Once one-touch tuning is complete, the parameters will be set automatically. If tuning did not complete properly, a tuning error will be displayed.

☞ Page 29 Servo parameters adjusted with one-touch tuning

9. Tuning result check

Check the tuning results.

If the tuning result is not satisfactory, the servo parameters can be returned to the value from before one-touch tuning or the initial value.

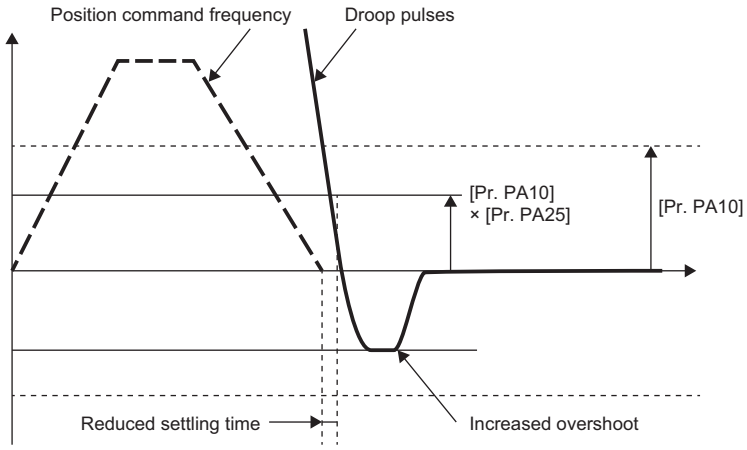
☞ Page 32 Initializing one-touch tuning

10. End

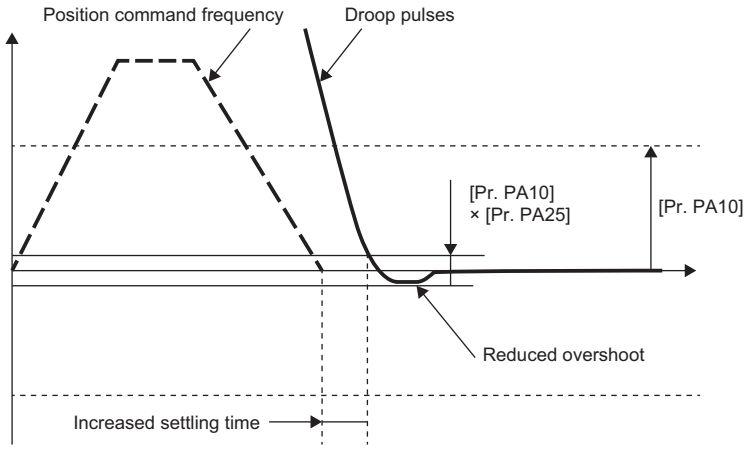
■Overshoot permissible level setting

Set the overshoot permissible level for one-touch tuning in [Pr. PA25 One-touch tuning - Overshoot permissible level]. One-touch tuning adjusts the settling time to be as short as possible within the range of the overshoot permissible level. Therefore, when the value set in [Pr. PA25] is too large, reduction of the settling time is prioritized. When the value set in [Pr. PA25] is too small, then reduction of the overshoot is prioritized.

- When the overshoot permissible level is too high

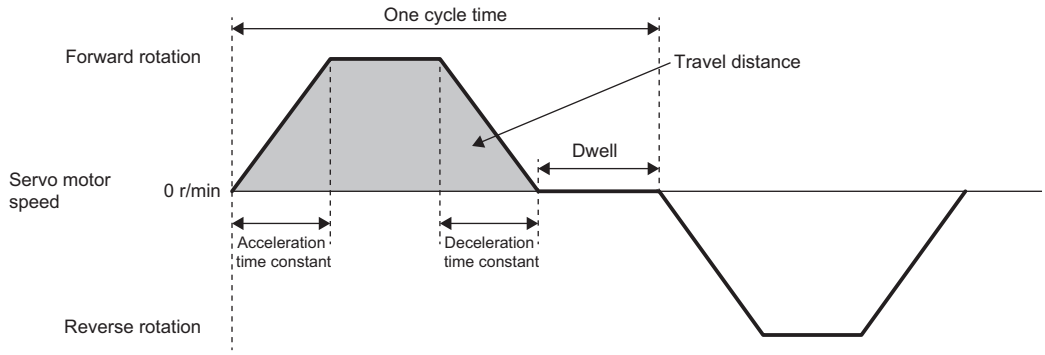


- When the overshoot permissible level is too low



■Operation

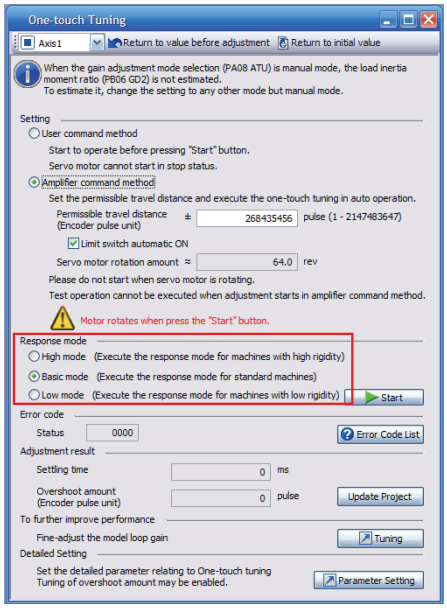
Inputting commands to the servo amplifier that satisfy the following conditions is recommended. A one-touch tuning error may occur if one-touch tuning is performed for a servo amplifier that has commands inputted which do not satisfy these conditions.



Item	Description
Travel distance	Set 100 pulses or more in the encoder pulse unit. Setting less than 100 pulses causes the one-touch tuning error "C_04".
Servo motor speed	Set 50 r/min (mm/s) or higher. Setting less than 50 r/min (mm/s) may cause the one-touch tuning error "C_05".
Acceleration time constant Deceleration time constant	Set the time to reach 2000 r/min (mm/s) to 5 s or less. Set an acceleration time constant/deceleration time constant so that the acceleration/deceleration torque is 10 % or more of the rated torque. The estimation accuracy of the load to motor inertia ratio improves as the acceleration/deceleration torque is larger, and the one-touch tuning result is closer to the optimum value.
Dwell	Set 200 ms or more. If the value is too small, the one-touch tuning error "C_04" may occur.
One cycle time	Set 30 s or less. Setting over 30 s causes the one-touch tuning error "C_04".

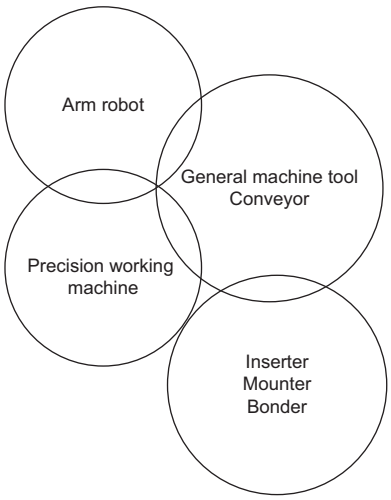
■Command method and response mode selection

Select the user command method in the one-touch tuning window of MR Configurator2 and then select a response mode from three modes. If no vibration sound occurs during tuning, perform one-touch tuning again in the high response mode.



Item	Description
High mode	This mode is for a system with high rigidity.
Basic mode	This mode is for a standard system.
Low mode	This mode is for a system with low rigidity.

Refer to the following table for selecting a response mode.

Response mode			Responsiveness	Machine characteristic
Low mode	Basic mode	High mode		Guidelines for corresponding mode and machinery
			Low response  High response	

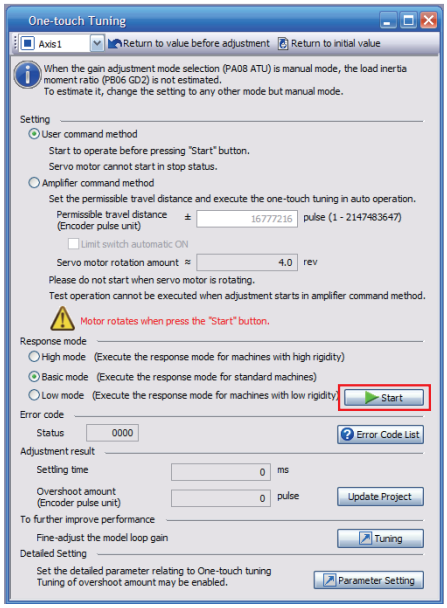
■One-touch tuning execution

Clicking "Start" after selecting the response mode starts one-touch tuning in the user command method.

☞ Page 21 Command method and response mode selection

For one-touch tuning in the user command method, clicking "Start" during a servo motor stop causes "C_02" or "C_04" to appear in the error code status. Refer to "One-touch tuning error" for the error code.

☞ Page 30 One-touch tuning error



MR Configurator2 procedure for one-touch tuning using the amplifier command method

Perform one-touch tuning using the following procedure.

1. Start

2. Moving to tuning start position

Move the moving part to the center of the movable range.

3. Overshoot permissible level setting

Set the overshoot permissible level for one-touch tuning in [Pr. PA25 One-touch tuning - Overshoot permissible level].

4. One-touch tuning start, command method selection

On MR Configurator2, select "One-touch Tuning" from the Adjustment tab of MR Configurator2. Select "Amplifier command method".

5. Permissible travel distance input

In the one-touch tuning window of MR Configurator2, input a maximum travel distance to move the moving part at one-touch tuning.

6. Response mode selection

Select the response mode (High mode/Basic mode/Low mode) in the one-touch tuning window of MR Configurator2.

7. One-touch tuning execution

Click the "Start" button to start one-touch tuning during a servo motor stop. Once tuning starts, the servo motor reciprocates automatically. Performing one-touch tuning during a servo motor rotation causes an error. Once performed, one-touch tuning using the amplifier command method cannot be controlled by commands from the controller.

8. One-touch tuning in progress

Gains and filters are adjusted automatically. During the process of the tuning, the progress status is displayed in % on MR Configurator2.

9. One-touch tuning complete

Once one-touch tuning is complete, the parameters will be set automatically. If tuning did not complete properly, a tuning error will be displayed.

☞ Page 29 Servo parameters adjusted with one-touch tuning

10. Tuning result check

Check the tuning results.

If the tuning result is not satisfactory, the servo parameters can be returned to the value from before one-touch tuning or the initial value. Refer to the following.

☞ Page 32 Initializing one-touch tuning

11. Controller reset, servo amplifier power cycling

After executing one-touch tuning, to restore the control from the controller, reset the controller or cycle the power of the servo amplifier.

12. End

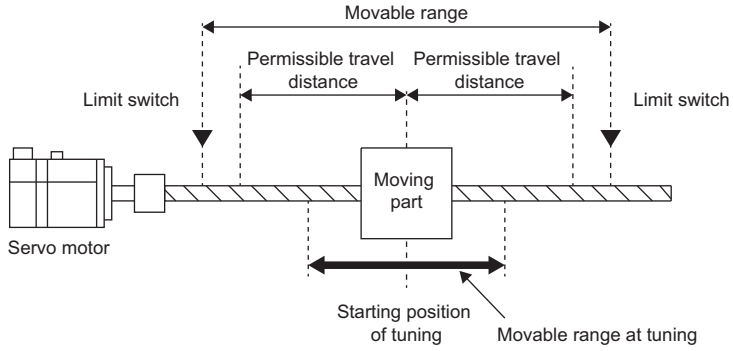
■Overshoot permissible level setting

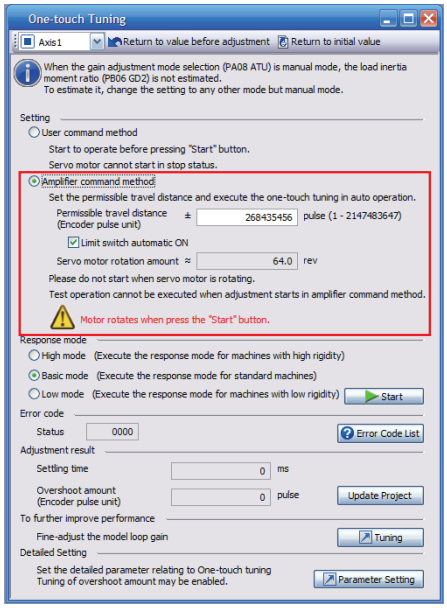
Refer to the following for the settings of the overshoot permissible level.

☞ Page 20 Overshoot permissible level setting

■Command method selection and permissible travel distance input

Select "Amplifier command method" in the one-touch tuning window of MR Configurator2. Input a permissible travel distance for the amplifier command method in the servo motor-side resolution unit. In the amplifier command method, a servo motor drives in a range between "current value ± permissible travel distance". Input a value for the permissible travel distance that is as large as possible while being within the range where the movable part will not collide with the machine. Inputting a small permissible travel distance decreases the possibility that the moving part will collide with the machine. However, this may lower the estimation accuracy of the load to motor inertia ratio and result in inaccurate tuning.





■Response mode selection

Refer to the following for response mode.

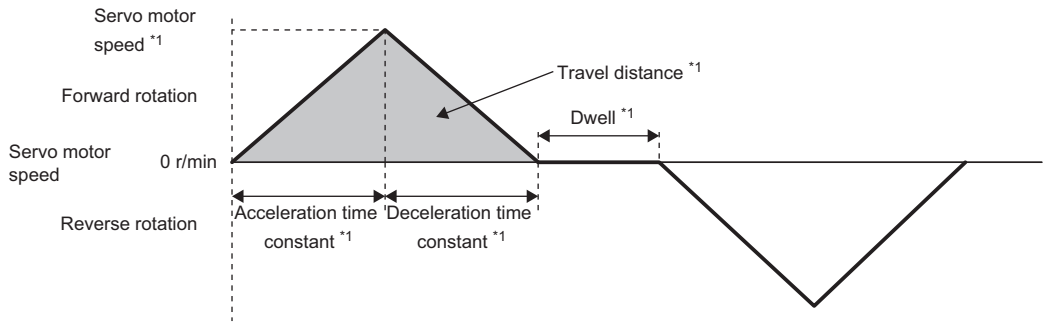
☞ Page 21 Command method and response mode selection

■One-touch tuning execution

Clicking "Start" after selecting a response mode starts the one-touch tuning in the amplifier command method.

☞ Page 21 Command method and response mode selection

Clicking "Start" for one-touch tuning using the amplifier command method while in the servo-off state automatically turns on servo-on and starts one-touch tuning. For one-touch tuning using the amplifier command method, an optimum tuning command like the one shown below is generated inside the servo amplifier after servo-on. After that, one-touch tuning is performed with the servo motor reciprocating.



*1 These items are automatically generated in the servo amplifier.

Item	Description
Travel distance	An optimum travel distance is automatically set in the range not exceeding the user-inputted permissible travel distance with MR Configurator2.
Servo motor speed	A speed that does not exceed the overspeed alarm detection level ([Pr. PC08]) and also does not exceed 1/2 of the rated speed is automatically set.
Acceleration time constant Deceleration time constant	An acceleration time constant/deceleration time constant is automatically set so as not to exceed 60 % of the rated torque and the torque limit value set at the start of one-touch tuning using the amplifier command method.
Dwell	A dwell time in which the one-touch tuning error "C004" does not occur will be automatically set.

Procedure for one-touch tuning via controller

Perform one-touch tuning using the following procedure.

1. Start

2. Overshoot permissible level setting

Set the in-position range for one-touch tuning in [Pr. PA25 One-touch tuning - Overshoot permissible level].

3. Operation

Rotate the servo motor using the controller. One-touch tuning via a controller cannot be performed during a servo motor stop.

4. Response mode setting, one-touch tuning execution

To perform one-touch tuning, write the value of the response mode (High mode/Basic mode/Low mode) in [One-touch tuning mode (Obj. 2D50h)].

5. One-touch tuning in progress

Gains and filters are adjusted automatically. During one-touch tuning, the progress is returned to [One-touch tuning Status (Obj. 2D51h)] in %.

6. One-touch tuning complete

Check whether one-touch tuning is completed normally with [One-touch tuning mode (Obj. 2D50h)]. Once one-touch tuning is complete, the parameters will be set automatically. When the tuning is not completed normally, a tuning error is returned in [One-touch tuning Error Code (Obj. 2D54h)]. Refer to the following.

☞ Page 32 Initializing one-touch tuning

7. Tuning result check

Check the tuning results.

If the tuning result is not satisfactory, the servo parameters can be returned to the value from before one-touch tuning or the initial value with [One-touch tuning Clear (Obj. 2D53h)]. Refer to the following.

☞ Page 32 Initializing one-touch tuning

8. End

■Object registration

Register the following objects when performing one-touch tuning.

Index	Sub	Object	Name	Description
2D50h	0	VAR	One-touch tuning mode	Setting "1", "2", or "3" starts one-touch tuning. After one-touch tuning is completed, the setting value automatically changes to "0". 0: One-touch tuning stop in progress 1: Basic mode 2: High mode 3: Low mode
2D51h	0	VAR	One-touch tuning Status	The one-touch tuning progress is returned. Regardless of whether one-touch tuning is properly completed or not, "100" is returned at the completion. Unit: %
2D52h	0	VAR	One-touch tuning Stop	Writing "1EA5h" stops one-touch tuning.
2D53h	0	VAR	One-touch tuning Clear	Servo parameters that were changed in one-touch tuning can be restored to the original status. 0000h: Restores to factory setting 0001h: Restores to the value from before one-touch tuning When servo parameters are restored, the setting value of the restored servo parameter is stored in the non-volatile memory.
2D54h	0	VAR	One-touch tuning Error Code	The following shows the details of the one-touch tuning error codes. 0000h: Successfully completed C_00h: Tuning canceled C_01h: Overshoot exceeded C_02h: Servo-off during tuning C_03h: Control mode error C_04h: Time-out C_05h: Load inertia moment ratio misestimated C_06h: Servo amplifier built-in command start error C_07h: Servo amplifier built-in command generation error C_08h: Stop signal C_09h: Parameter C_0Ah: Alarm C00Fh: One-touch tuning disabled

■Overshoot permissible level setting

Refer to the following for the settings of the overshoot permissible level.

☞ Page 20 Overshoot permissible level setting

■Operation

Refer to the following for operation.

☞ Page 21 Operation

■Response mode selection

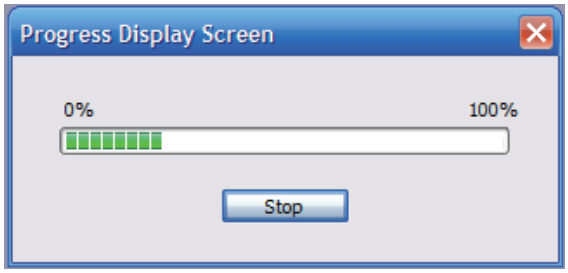
Refer to the following for response mode.

☞ Page 21 Command method and response mode selection

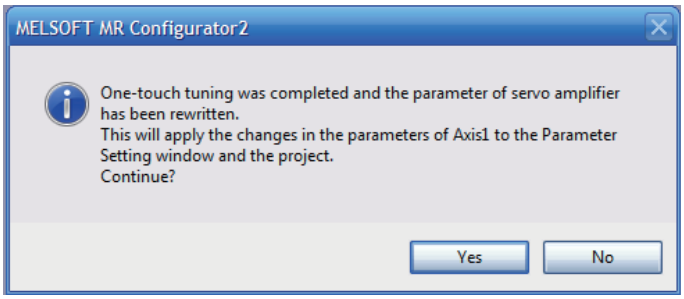
Progress display during one-touch tuning

On MR Configurator2

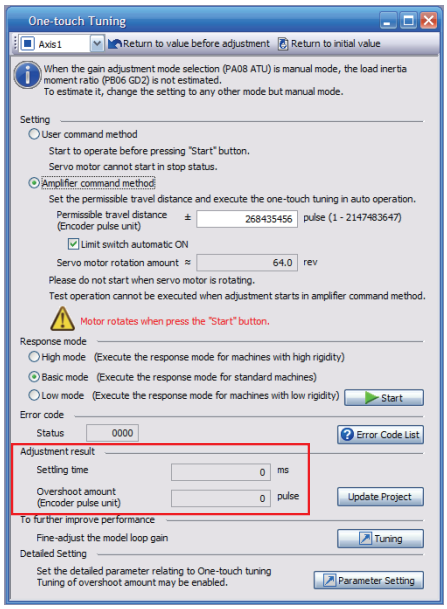
Clicking "Start" for one-touch tuning using the amplifier command method while in the servo-off state automatically turns on servo-on and starts one-touch tuning. For one-touch tuning using the amplifier command method, an optimum tuning command is generated inside the servo amplifier after servo-on. After that, one-touch tuning is performed with the servo motor reciprocating. After tuning is completed or canceled, the servo amplifier is automatically switched to servo-off state.
During one-touch tuning, the progress status is displayed in the progress window as follows. One-touch tuning completes when the progress reaches 100 %.



Completing one-touch tuning starts the writing of servo parameters to the servo amplifier. In addition, the following dialog is displayed after completing one-touch tuning. Select whether or not to reflect the tuning result in the project.



After one-touch tuning is completed, "0000" is displayed in the error code status. The settling time and overshoot amount are displayed in "Adjustment result".



On a controller

The progress of one-touch tuning can be checked with [One-touch tuning Status (Obj. 2D51h)] during one-touch tuning. When the progress reaches 100 %, one-touch tuning is completed and [One-touch tuning mode (Obj. 2D50h)] switches to "0".

Servo parameters adjusted with one-touch tuning

The following servo parameters are set automatically with one-touch tuning. Moreover, [Pr. PA08.0 Gain adjustment mode selection] is set to "4" (2 gain adjustment mode 2) automatically. Other servo parameters are set to an optimum value in accordance with the setting of [Pr. PA09 Auto tuning response].

Servo parameter	Symbol	Name
PA08	ATU	Auto tuning mode
PA09	RSP	Auto tuning response
PA24	AOP4	Function selection A-4
PB01	FILT	Adaptive tuning mode (adaptive filter II)
PB02	VRFT	Vibration suppression control tuning mode (advanced vibration suppression control II)
PB06	GD2	Load to motor inertia ratio/load to motor mass ratio
PB07	PG1	Model control gain
PB08	PG2	Position control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation
PB12	OVA	Overshoot amount compensation
PB13	NH1	Machine resonance suppression filter 1
PB14	NHQ1	Notch shape selection 1
PB15	NH2	Machine resonance suppression filter 2
PB16	NHQ2	Notch shape selection 2
PB17	NHF	Shaft resonance suppression filter
PB18	LPF	Low-pass filter setting
PB19	VRF11	Vibration suppression control 1 - Vibration frequency
PB20	VRF12	Vibration suppression control 1 - Resonance frequency
PB21	VRF13	Vibration suppression control 1 - Vibration frequency damping
PB22	VRF14	Vibration suppression control 1 - Resonance frequency damping
PB23	VFBF	Low-pass filter selection
PB46	NH3	Machine resonance suppression filter 3
PB47	NHQ3	Notch shape selection 3
PB48	NH4	Machine resonance suppression filter 4
PB49	NHQ4	Notch shape selection 4
PB50	NH5	Machine resonance suppression filter 5
PB51	NHQ5	Notch shape selection 5
PB52	VRF21	Vibration suppression control 2 - Vibration frequency
PB53	VRF22	Vibration suppression control 2 - Resonance frequency
PB54	VRF23	Vibration suppression control 2 - Vibration frequency damping
PB55	VRF24	Vibration suppression control 2 - Resonance frequency damping
PE41.0	—	Robust filter selection

One-touch tuning stop method

On MR Configurator2

Clicking the "Stop" button during tuning stops one-touch tuning. If one-touch tuning is stopped, "C000" will be displayed in the error code status. After one-touch tuning is stopped, the servo parameters are restored to the values they had at the start of one-touch tuning. Stop the servo motor before executing one-touch tuning again. In addition, perform one-touch tuning after the moving part is returned to the tuning start position.

On a controller

Writing "1EA5" in [One-touch tuning Stop (Obj. 2D52h)] during one-touch tuning stops the tuning. After one-touch tuning is stopped, the servo parameters are restored to the values they had at the start of one-touch tuning. Moreover, stop the servo motor before executing one-touch tuning again.

One-touch tuning error

On MR Configurator2

If a tuning error occurs during the tuning, one-touch tuning is stopped. At this time, as the error code is displayed in the error code status, check the cause of the tuning error. Stop the servo motor before executing one-touch tuning again. In addition, perform one-touch tuning after the moving part is returned to the tuning start position.

Display	Name	Error description	Handling example
C000	Tuning canceled	The "Stop" button was clicked during one-touch tuning.	—
C_01	Overshoot exceeded	The overshoot amount is larger than the value set in [Pr. PA10 In-position range] and [Pr. PA25 One-touch tuning - Overshoot permissible level].	Increase the in-position range or the overshoot permissible level.
C_02	Servo-off during tuning	One-touch tuning using the user command method was attempted during servo-off. The servo amplifier was set to servo-off state during one-touch tuning.	Perform one-touch tuning using the user command method in servo-on state. Do not allow the servo amplifier to enter servo-off state during one-touch tuning.
C_03	Control mode error	One-touch tuning was attempted when the torque mode or continuous operation to torque control mode was selected as the control mode.	Select position mode or velocity mode as the control mode, then perform one-touch tuning without control switching.
		Control switching from the position mode to the velocity mode was attempted during one-touch tuning.	
C_04	Time-out	One cycle time during the operation exceeds 30 s.	Set one cycle time during the operation (time from the command start to the next command start) to 30 s or less.
		The command speed is too slow.	Set the servo motor speed to 100 r/min (mm/s) or higher. An error is less likely to occur if the command speed is higher.
		The dwell time during continuous operation (stop time between commands) is too short.	Set the dwell time to 200 ms or more. An error is less likely to occur as the setting time is longer.
C_05	Load inertia moment ratio misestimated	The estimation of the load to motor inertia ratio at one-touch tuning has failed.	Drive the servo motor under the following conditions: • Time to reach 2000 r/min (mm/s) is the acceleration/deceleration time constant of 5 s or less. • Speed is 50 r/min (mm/s) or higher. • The load to motor inertia ratio to the servo motor is 100 times or less. • The acceleration/deceleration torque is 10 % or more of the rated torque.
		The load to motor inertia ratio cannot be estimated due to the effect of oscillation, etc.	Set [Pr. PA08.0 Gain adjustment mode selection] to "3" (manual mode), and set the correct value of load inertia moment ratio to [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio], then execute one-touch tuning.
C_06	Amplifier command start error	One-touch tuning using the amplifier command method was attempted under the following speed conditions. • Servo motor speed: 20 [r/min (mm/s)] or higher	Perform one-touch tuning using the amplifier command method when the servo motor is at a stop.
C_07	Amplifier command generation error	One-touch tuning (amplifier command) was performed with a permissible travel distance of 100 [pulse] or less in the encoder pulse unit, or with a permissible travel distance that limited the servo motor speed to less than 50 [r/min (mm/s)] when the load to motor inertia ratio was estimated.	Execute one-touch tuning using the amplifier command method after setting the permissible travel distance to be 100 [pulse] or more in the encoder pulse unit, or setting the distance so that the servo motor speed is 50 [r/min (mm/s)] or more at the load to motor inertia ratio estimation. The permissible travel distance required for estimating the load to motor inertia ratio is two or more rotations as a guide value. If [Pr. PA08.0 Gain adjustment mode selection] is set to "3" (manual mode) at the start of one-touch tuning, the load to motor inertia ratio estimation is not performed. If the servo motor speed cannot be set to 50 [r/min (mm/s)] or more because the permissible travel distance is too short, execute one-touch tuning using the amplifier command method while manual mode is set ("3" in [Pr. PA08.0]).
		The overspeed alarm trigger level is set where the servo motor speed becomes 50 [r/min (mm/s)] or less at the time of load to motor inertia ratio estimation.	When estimating the load to motor inertia ratio, set the overspeed alarm trigger level to be 50 [r/min (mm/s)] or more.
		The torque limit value has been set to 0.	Set the torque limit value greater than 0.

Display	Name	Error description	Handling example
C_08	Stop signal	LSP and LSN were turned off during one-touch tuning using the amplifier command method. EM2 was turned off during one-touch tuning using the amplifier command method.	Review the start position and the permissible travel distance for the amplifier command method. After ensuring safety, turn EM2 on.
C_09	Parameter	Servo parameter for manufacturer setting has been changed.	Restore the servo parameters for manufacturer setting to the initial values.
C_0A	Alarm	One-touch tuning using the amplifier command method was attempted while there was an alarm or a warning. An alarm or a warning occurred during one-touch tuning using the amplifier command method.	Start one-touch tuning using the amplifier command method when there is no alarm or warning. Ensure that an alarm or a warning does not occur during one-touch tuning using the amplifier command method.
C00F	One-touch tuning disabled	[Pr. PA21.0 One-touch tuning function selection] is set to "0" (disabled).	Set [Pr. PA21.0 One-touch tuning function selection] to "1" (enabled).

The following table shows servo parameter statuses after a one-touch tuning error has occurred.

Error code	Servo parameter after the one-touch tuning error occurrence
C0 _ _	A servo parameter is returned to the value it had at the start of one-touch tuning.
C1 _ _	The following servo parameters retain the values they had during one-touch tuning. Other servo parameters return to the values they had at the start of one-touch tuning. • [Pr. PA08 Auto tuning mode (ATU)] • [Pr. PA09 Auto tuning response (RSP)] • [Pr. PB01 Adaptive tuning mode (adaptive filter II) (FILT)] • [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio (GD2)] • [Pr. PB08 Position control gain (PG2)] • [Pr. PB09 Speed control gain (VG2)] • [Pr. PB10 Speed integral compensation (VIC)] • [Pr. PB13 Machine resonance suppression filter 1 (NH1)] • [Pr. PB14 Notch shape selection 1 (NHQ1)] • [Pr. PB15 Machine resonance suppression filter 2 (NH2)] • [Pr. PB16 Notch shape selection 2 (NHQ2)] • [Pr. PB17 Shaft resonance suppression filter (NHF)] • [Pr. PB18 Low-pass filter setting (LPF)] • [Pr. PB23 Low-pass filter selection (VFBF)] • [Pr. PB46 Machine resonance suppression filter 3 (NH3)] • [Pr. PB47 Notch shape selection 3 (NHQ3)] • [Pr. PB48 Machine resonance suppression filter 4 (NH4)] • [Pr. PB49 Notch shape selection 4 (NHQ4)] • [Pr. PB50 Machine resonance suppression filter 5 (NH5)] • [Pr. PB51 Notch shape selection 5 (NHQ5)] • [Pr. PE41.0 Robust filter selection]

If the error code is C1 _ _, [Pr. PB07 Model control gain] returns the servo parameters to the value they had at the start of one-touch tuning. If the response from the gain after error code C1 _ _ was output is not satisfactory, adjust [Pr. PB07 Model control gain] manually.

On a controller

If a tuning error occurs during the tuning, one-touch tuning is stopped. At this time, an error code is sent to [One-touch tuning Error Code (Obj. 2D54h)]. Check the cause of the tuning error. Stop the servo motor before executing one-touch tuning again. In addition, perform one-touch tuning after the moving part is returned to the tuning start position.

Refer to the following for the causes of one-touch tuning error occurrence, and the servo parameters after the error.

☞ Page 30 On MR Configurator2

Initializing one-touch tuning

Servo parameters to be initialized

Initialize one-touch tuning to restore the setting value of the following servo parameters to the factory setting.

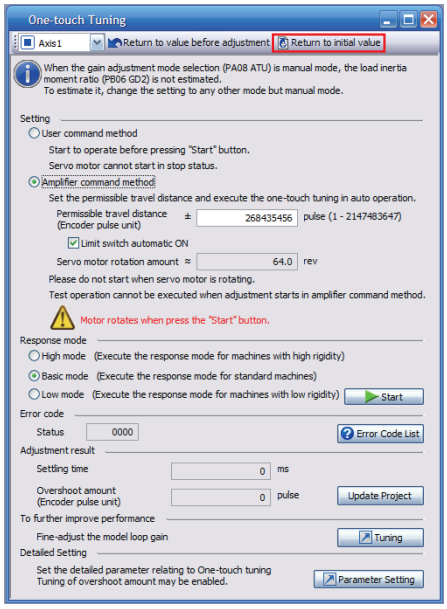
In addition, [Pr. PA08.0 Gain adjustment mode selection] will be automatically changed to "1" (Auto tuning mode 1).

Servo parameter	Symbol	Name	Remark
PA08	ATU	Auto tuning mode	[Pr. PA08.0] is set to "1" (Auto tuning mode 1).
PA09	RSP	Auto tuning response	—
PA24	AOP4	Function selection A-4	—
PB01	FILT	Adaptive tuning mode (adaptive filter II)	—
PB02	VRFT	Vibration suppression control tuning mode (advanced vibration suppression control II)	—
PB06	GD2	Load to motor inertia ratio/load to motor mass ratio	—
PB07	PG1	Model control gain	—
PB08	PG2	Position control gain	—
PB09	VG2	Speed control gain	—
PB10	VIC	Speed integral compensation	—
PB12	OVA	Overshoot amount compensation	—
PB16	NHQ2	Notch shape selection 2	[Pr. PB16.0 Machine resonance suppression filter 2 selection] is initialized to "0".
PB17	NHF	Shaft resonance suppression filter	—
PB18	LPF	Low-pass filter setting	—
PB23	VFBF	Low-pass filter selection	—
PB47	NHQ3	Notch shape selection 3	[Pr. PB47.0 Machine resonance suppression filter 3 selection] is initialized to "0".
PB49	NHQ4	Notch shape selection 4	[Pr. PB49.0 Machine resonance suppression filter 4 selection] is initialized to "0".
PB51	NHQ5	Notch shape selection 5	[Pr. PB51.0 Machine resonance suppression filter 5 selection] is initialized to "0".
PE41.0	—	Robust filter selection	—

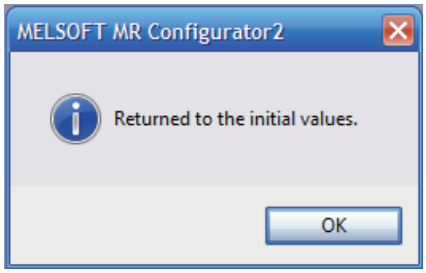
On MR Configurator2

The servo parameters can be returned to the initial value by clicking "Return to initial value" in the one-touch tuning window of MR Configurator2.

In addition, click "Return to value before adjustment" in the one-touch tuning window of MR Configurator2 to return servo parameters to the value that was set before clicking the start button. The setting value of the returned servo parameter is stored in the non-volatile memory.



Once initialization of one-touch tuning is complete, the following window will be displayed. (When returning servo parameters to the initial value.)



On a controller

Servo parameters can be returned to the initial value by writing "0000h" to [One-touch tuning Clear (Obj. 2D53h)].

In addition, write "0001h" to [One-touch tuning Clear (Obj. 2D53h)] to return servo parameters to the value from before one-touch tuning. The setting value of the returned servo parameter is stored in the non-volatile memory.

3.3 Auto tuning mode 1

The servo amplifier has a real-time auto tuning function which estimates the machine characteristics (load to motor inertia ratio) in real time and automatically sets the optimum gain according to that value. This function allows easier gain adjustment of the servo amplifier.
In auto tuning mode 1, the load to motor inertia ratio of a machine is always estimated, and the optimum gain is automatically set. This mode is the optimum method for adjustment with the response waveform being checked when the load to motor inertia ratio of a device is unknown.

Restrictions on auto tuning mode 1

All of the following conditions should be satisfied to use auto tuning mode 1.

- The time until the acceleration/deceleration time constant reaches 2000 r/min (mm/s) is 5 s or less.
- The servo motor speed is 50 r/min (mm/s) or higher.
- The load to the servo motor inertia ratio (the load to mass of the linear servo motor primary-side ratio) is 100 times or less.
- The acceleration/deceleration torque is 10 % or more of the rated torque.

The auto tuning may not function properly under operating conditions where sudden disturbance torque is applied during acceleration/deceleration, or in machines with low rigidity. In such cases, use auto tuning mode 2 or manual mode to adjust the gain.

Precautions on auto tuning mode 1

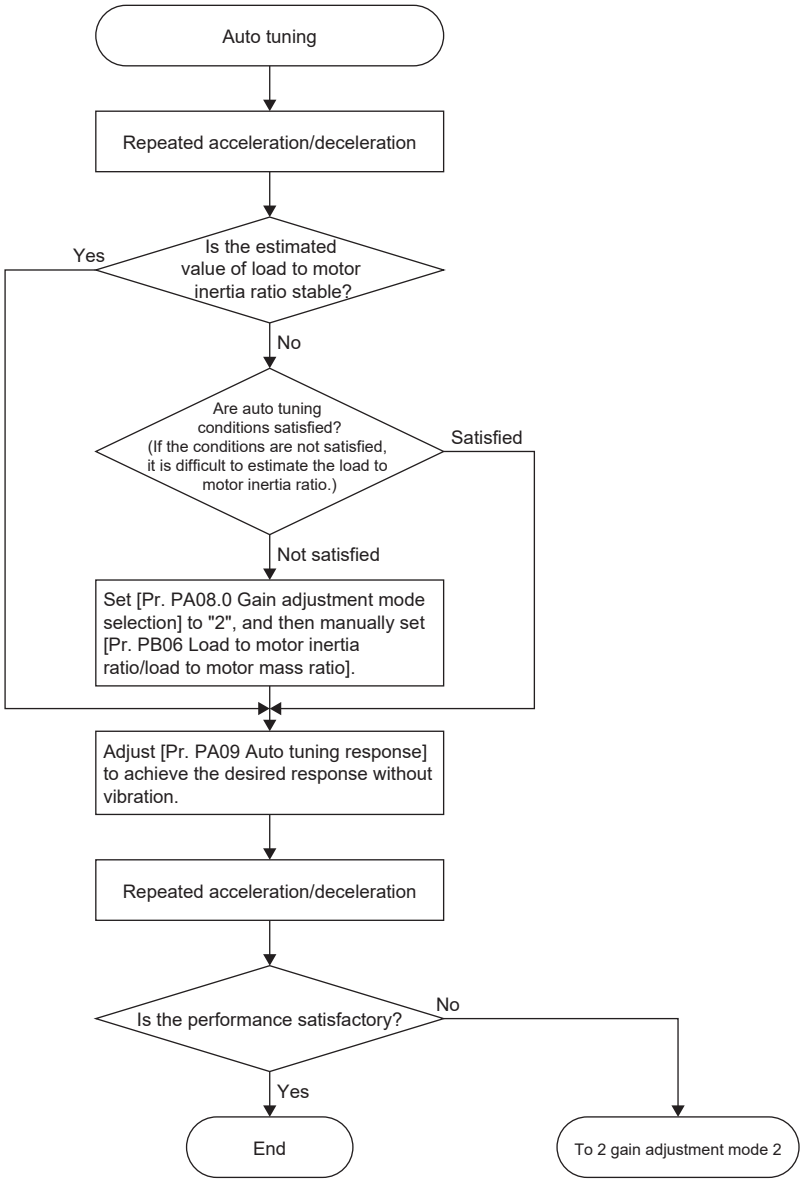
If sudden disturbance torque is applied during operation, the load to motor inertia ratio may be miscalculated temporarily. In such a case, set [Pr. PA08.0 Gain adjustment mode selection] to "2" (Auto tuning mode 2), and then set the accurate load to motor inertia ratio in [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio].
When auto tuning mode 1 is changed to manual mode, the current control gain and the load to motor inertia ratio estimation value are saved in the non-volatile memory.

Adjustment procedure by auto tuning mode 1

Point

- When the servo amplifier with firmware version C4 or later is used, it is recommended to set [Pr. PA24.5 Load to motor inertia ratio/load to motor mass ratio estimation higher precision selection] to "1".When [Pr. PA24.5] is set to "0", [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio] may be estimated at a value smaller than the accurate estimation depending on the operation pattern. Setting [Pr. PA24.5] to "1" with the equipment on which the gain is adjusted may change the actual movement. Check the movement of the equipment after changing the settings.

The adjustment procedure is as follows.



Responsiveness setting in auto tuning mode 1

Set the response level for the entire servo system with [Pr. PA09]. As the responsiveness setting increases, the trackability to the command improves and the settling time becomes shorter, though vibration is more likely to occur. Therefore, set a value to obtain the desired response within the vibration-free range.

If the response level cannot be increased up to the desired level because of machine resonance beyond 100 Hz, [Pr. PB01.0 Filter tuning mode selection] or machine resonance suppression filter in [Pr. PB13] to [Pr. PB16] and [Pr. PB46] to [Pr. PB51] can be used to suppress machine resonance. Suppressing machine resonance may allow the response level to be increased. Refer to the following for the settings of the adaptive tuning mode and the machine resonance suppression filter.

☞ Page 50 Machine resonance suppression filter

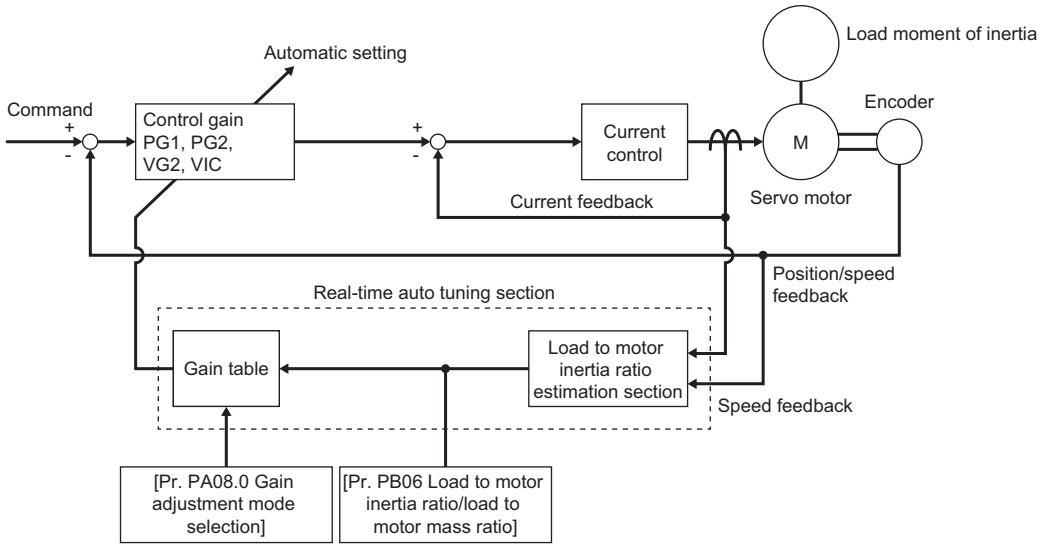
☞ Page 53 Adaptive filter II

• [Pr. PA09]

Setting value	Machine characteristic	
	Responsiveness	Guideline for machine resonance frequency [Hz]
1	Low response ↑	2.7
2		3.6
3		4.9
4		6.6
5		10.0
6		11.3
7		12.7
8		14.3
9		16.1
10		18.1
11		20.4
12		23.0
13		25.9
14		29.2
15		32.9
16		37.0
17		41.7
18		47.0
19		52.9
20	↓ Middle response ↑	59.6
21		67.1
22		75.6
23		85.2
24		95.9
25		108.0
26		121.7
27		137.1
28		154.4
29		173.9
30		195.9
31		220.6
32		248.5
33		279.9
34		315.3
35		355.1
36		400.0
37		446.6
38		501.2
39	↓ High response	571.5
40		642.7

Operation of auto tuning mode 1

The block diagram for auto tuning mode 1 is shown below.



When a servo motor is accelerated/decelerated, the load to motor inertia ratio estimation section always estimates the load to motor inertia ratio from the current and speed of the servo motor. The results of estimation are written to [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio]. These results can be confirmed on the status display screen on MR Configurator2.

If the value of the load to motor inertia ratio is known in advance or the estimation has failed, set [Pr. PA08.0 Gain adjustment mode selection] to "2" (Auto tuning mode 2), and after stopping the estimation of the load inertia moment ratio, set the load to motor inertia ratio ([Pr. PB06]) manually.

Auto tuning results are saved in the non-volatile memory of the servo amplifier every 10 minutes after power-on. At power-on, auto tuning is performed using the value of each control gain saved in the non-volatile memory as the initial value.

The servo parameters that are automatically adjusted in auto tuning mode 1 are shown in the table below.

Servo parameter	Symbol	Name
PB06	GD2	Load to motor inertia ratio/load to motor mass ratio
PB07	PG1	Model control gain
PB08	PG2	Position control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation

3.4 Auto tuning mode 2

Use auto tuning mode 2 when normal gain adjustment cannot be performed using auto tuning mode 1. Since the load to motor inertia ratio is not estimated in this mode, set a correct value of the load to motor inertia ratio in [Pr. PB06]. This mode is the optimum adjustment method for adjusting with the response waveform being checked while the load to motor inertia ratio is known or if gain adjustment using auto tuning mode 1 cannot be executed properly.

Precautions on auto tuning mode 2

When auto tuning mode 2 is changed to manual mode, the current control gains and the load to motor inertia ratio estimation value are saved in the non-volatile memory.

Adjustment procedure by auto tuning mode 2

Refer to the following.

☞ Page 35 Adjustment procedure by auto tuning mode 1

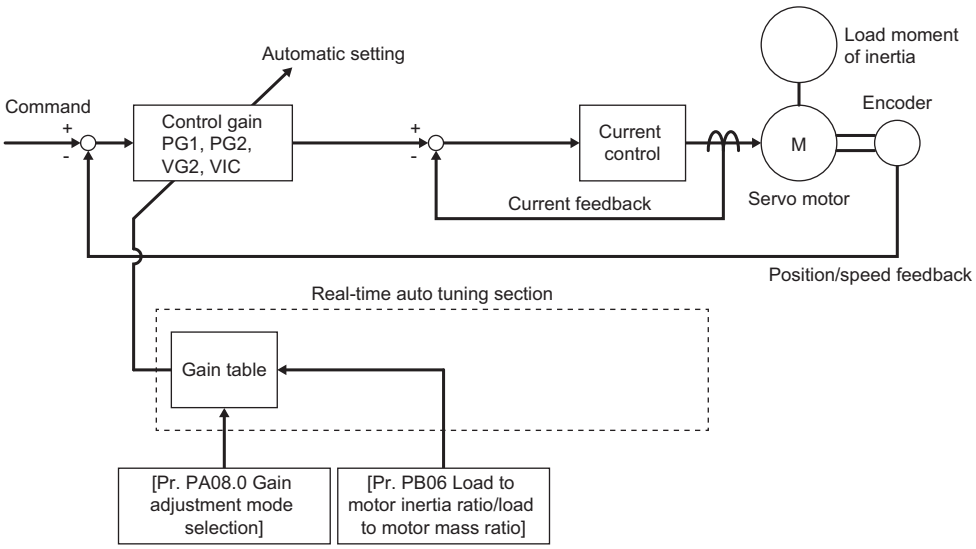
Responsiveness setting in auto tuning mode 2

Refer to the following.

☞ Page 36 Responsiveness setting in auto tuning mode 1

Operation of auto tuning mode 2

The block diagram for auto tuning mode 2 is shown below.



In auto tuning mode 2, the optimum control gain is automatically set based on the internal gain table, the value set for the load inertia moment ratio ([Pr. PB06]), and the responsiveness ([Pr. PA09]).

Auto tuning results are saved in the non-volatile memory of the servo amplifier every 10 minutes after power-on. At power-on, auto tuning is performed using the value of each control gain saved in the non-volatile memory as the initial value.

The servo parameters that are automatically adjusted in auto tuning mode 2 are shown in the table below.

Servo parameter	Symbol	Name
PB07	PG1	Model control gain
PB08	PG2	Position control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation

3.5 2 gain adjustment mode 1

Use the 2 gain adjustment mode to match the position control gains of each axes when performing the interpolation operation of servo motors of two or more axes for an X-Y table or the like. In this mode, manually set the model control gain that determines command trackability. Other servo parameters are set automatically.
For 2 gain adjustment mode 1, manually set the model control gain that determines command trackability. The mode constantly estimates the load to motor inertia ratio and automatically sets other servo parameters for optimum gains in accordance with the responsiveness of auto tuning.

Adjustment procedure for 2 gain adjustment mode 1

Point

- When the servo amplifier with firmware version C4 or later is used, it is recommended to set [Pr. PA24.5 Load to motor inertia ratio/load to motor mass ratio estimation higher precision selection] to "1".When [Pr. PA24.5] is set to "0", [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio] may be estimated at a value smaller than the accurate estimation depending on the operation pattern. Setting [Pr. PA24.5] to "1" with the equipment on which the gain is adjusted may change the actual movement. Check the movement of the equipment after changing the settings.

Precautions

- Set the same value in [Pr. PB07 Model control gain] for the axis used in 2 gain adjustment mode 1 and 2.

Procedure	Operation	Description
1	Set to the auto tuning mode.	Select auto tuning mode 1.
2	During operation, increase the setting value of auto tuning response ([Pr. PA09]) and return the setting if vibration occurs.	Adjustment using auto tuning mode 1
3	Check the value of the model control gain ([Pr. PB07]) and the load to motor inertia ratio ([Pr. PB06]).	Check the upper setting limits.
4	Set [Pr. PA08.0 Gain adjustment mode selection] to "0" (2 gain adjustment mode 1).	Select 2 gain adjustment mode 1 (interpolation mode).
5	When the load to motor inertia ratio is different from the design value, set [Pr. PA08.0 Gain adjustment mode selection] to "4" (2 gain adjustment mode 2), then afterwards set the load to motor inertia ratio ([Pr. PB06]).	Check the load to motor inertia ratio
6	Set the model control gain of all the axes to be interpolated to the same value. At that time, adjust the model loop gain ([Pr. PB07]) to the setting value of the smallest axis.	Set the model control gain.
7	During operation, increase the setting value of the auto tuning response ([Pr. PA09]), and return the setting if vibration occurs.	Adjusting servo stability
8	While checking the interpolation characteristics and the rotation status, increase the model control gain ([Pr. PB07]), and return the gain if an overshoot occurs.	Adjusting position trackability

Servo parameter adjustment method

[Pr. PB07 Model control gain]

This servo parameter determines the response level of the position control loop. Increasing the model loop gain improves trackability to the position command, but overshoot tends to occur at settling time. Number of droop pulses can be calculated with the following formula.

$$\text{Number of droop pulses [pulse]} = \frac{\text{Position command frequency [pulse/s]}}{\text{Model control gain setting value}}$$

Position command frequency differs depending on the operation mode.

■For rotary servo motors

$$\text{Position command frequency} = \frac{\text{Servo motor speed [r/min]}}{60} \times \text{Encoder resolution (number of pulses per servo motor revolution)}$$

■Linear servo motors

Position command frequency = Speed [mm/s] ÷ Encoder resolution (travel distance per pulse)

Operation of 2 gain adjustment mode 1

The block diagram for 2 gain adjustment mode 1 is the same as that for auto tuning mode 1. Servo parameters adjusted automatically differ depending on the mode.

The following servo parameters are adjusted automatically with auto tuning in 2 gain adjustment mode 1.

Servo parameter	Symbol	Name
PB06	GD2	Load to motor inertia ratio/load to motor mass ratio
PB08	PG2	Position control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation

3.6 2 gain adjustment mode 2

Use 2 gain adjustment mode 2 if the one-touch tuning results do not satisfy the required performance or if gain adjustment cannot be executed properly by 2 gain adjustment mode 1. Since the load to motor inertia ratio is not estimated in this mode, set the value of an accurate load to motor inertia ratio in [Pr. PB06]. Once one-touch tuning is complete, [Pr. PA08.0 Gain adjustment mode selection] will be automatically set to "4" (2 gain adjustment mode 2).

Adjustment procedure for 2 gain adjustment mode 2

Precautions

- Set the same value in [Pr. PB07 Model control gain] for the axis used in 2 gain adjustment mode 1 and 2.

Procedure	Operation	Description
1	Set load to motor inertia ratio ([Pr. PB06]).	Check the load to motor inertia ratio
2	Set the model control gain ([Pr. PB07]) of all the axes to be interpolated to the same value. At that time, adjust the model loop gain ([Pr. PB07]) to the setting value of the smallest axis.	Set the model control gain.
3	During operation, increase the setting value of the auto tuning response ([Pr. PA09]), and return the setting if vibration occurs.	Adjusting servo stability
4	As the interpolation characteristics and the rotation status are visually examined, increase the model loop gain ([Pr. PB07]), and return if an overshoot occurs.	Adjusting position trackability

Operation of 2 gain adjustment mode 2

The block diagram for 2 gain adjustment mode 2 is the same as that for auto tuning mode 2. Servo parameters adjusted automatically differ depending on the mode.

The following servo parameters are adjusted automatically with auto tuning in 2 gain adjustment mode 2.

Servo parameter	Symbol	Name
PB08	PG2	Position control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation

Refer to the following for the servo parameter adjustment method of [Pr. PB07 Model control gain].

☞ Page 44 Adjustment procedure for the velocity mode

☞ Page 46 Adjustment procedure for position mode and positioning mode

3.7 Manual mode

When the auto tuning result is not satisfactory, manual adjustment with all of the gain can be performed.

Precautions

- If machine resonance occurs, [Pr. PB01.0 Filter tuning mode selection] or machine resonance suppression filter in [Pr. PB13] to [Pr. PB16] and [Pr. PB46] to [Pr. PB51] can be used to suppress machine resonance. Refer to the following.

☞ Page 50 Machine resonance suppression filter
☞ Page 53 Adaptive filter II

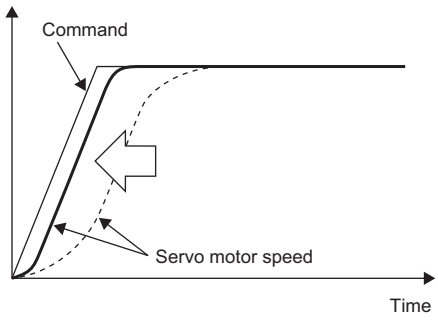
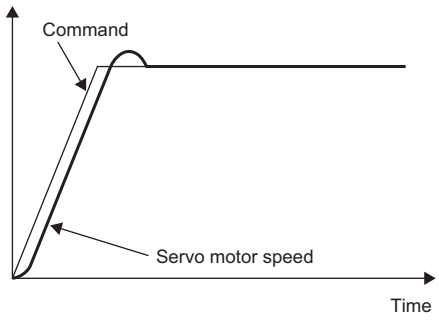
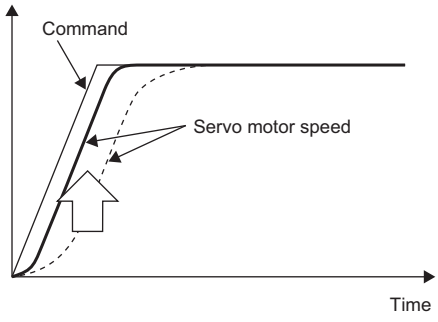
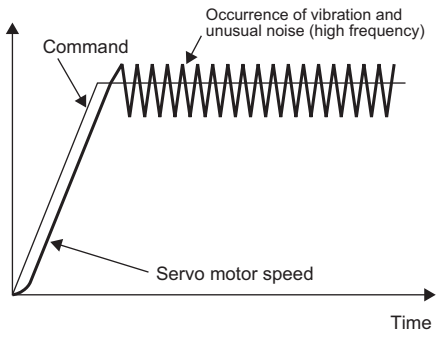
Adjustment procedure for the velocity mode

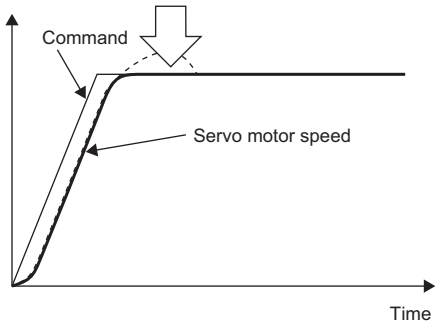
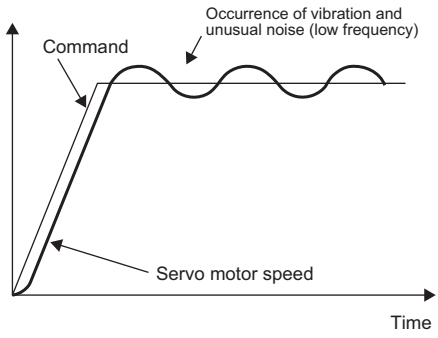
Servo parameter

The following servo parameters are used for gain adjustment.

Servo parameter	Symbol	Name
PB06	GD2	Load to motor inertia ratio/load to motor mass ratio
PB07	PG1	Model control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation

For the effect of each servo parameter, refer to the following diagram.

Explanation on servo parameter	Effect when increasing the responsiveness	Operating status when increase in responsiveness is excessive
[Pr. PB07 Model control gain] This servo parameter determines the responsiveness. Increasing the value improves trackability to a position command, but the servo motor speed is likely to be higher than the command.		
[Pr. PB09 Speed control gain] This servo parameter determines the responsiveness of the speed control loop. Increasing the value improves the responsiveness to the load disturbance, but mechanical vibration is more likely to occur.		

Explanation on servo parameter	Effect when increasing the responsiveness	Operating status when increase in responsiveness is excessive
[Pr. PB10 Speed integral compensation] This servo parameter determines the time constant for proportional integral control of speed control loop. Decreasing the value improves the responsiveness. If the moment of inertia ratio is large or the mechanical system contains vibratory element, the mechanical system is liable to vibrate unless the value is increased to some degree.		

Adjustment procedure

Procedure	Operation	Description
1	Perform approximate adjustment with the auto tuning. Refer to the following. ☞ Page 34 Auto tuning mode 1 The control gain obtained by the auto tuning is the reference value.	—
2	Change [Pr. PA08.0 Gain adjustment mode selection] to "3" (manual mode).	—
3	Set an estimated value in the load to motor inertia ratio/load to motor mass ratio. (If the estimated value by auto tuning is correct, setting change is not required.)	—
4	Set a small value to the model control gain. Set a large value to the speed integral compensation.	—
5	Increase the speed control gain within the range where vibration or unusual noise is not generated, and return slightly if vibration occurs.	Increase the speed control gain.
6	Decrease the speed integral compensation within the vibration-free range. If vibration occurs, increase the value until the vibration stops.	Decrease the time constant of the speed integral compensation.
7	Increase the model control gain, and return slightly if an overshoot occurs.	Increase the model control gain.
8	If the desired responsiveness cannot be achieved because of mechanical system resonance or the like which stops the gains from being increased, suppressing the resonance with adaptive tuning mode or the machine resonance suppression filter and then following steps 3 to 7 may increase the responsiveness.	Suppression of machine resonance Refer to the following. ☞ Page 50 Machine resonance suppression filter ☞ Page 53 Adaptive filter II
9	While checking the motor status, fine-adjust each gain.	Fine adjustment

Servo parameter adjustment method

■[Pr. PB07 Model control gain]

As a guide, this servo parameter can be calculated with the following formula.

$$\text{Model control gain guideline} = \frac{\text{Speed control gain}}{(1 + \text{Load to motor inertia ratio})} \times \left(\frac{1}{4} \text{ to } \frac{1}{8}\right)$$

■[Pr. PB09 Speed control gain]

The actual response frequency of the speed loop can be calculated with the following formula.

$$\text{Speed loop response frequency [Hz]} = \frac{\text{Speed control gain}}{(1 + \text{Load to motor inertia ratio}) \times 2\pi}$$

When adjusting [Pr. PB09 Speed control gain], increase the value gradually. Increasing the setting value causes vibration and resonance. At this time, check the value of [Pr. PB09 Speed control gain]. 70 % to 80 % of the value at which vibration and resonance occurred should be set as the limit value of [Pr. PB09 Speed control gain] in consideration of factors such as variations and margins between devices.

■[Pr. PB10 Speed integral compensation]

As a guide, this servo parameter can be calculated with the following formula.

$$\text{Speed integral compensation setting value [ms]} \geq \frac{\text{2000 to 3000}}{\text{Speed control gain/(1 + Load to motor inertia ratio)}}$$

If the setting value is less than the calculated value, vibration may occur.

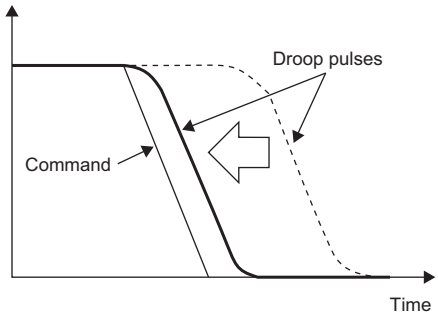
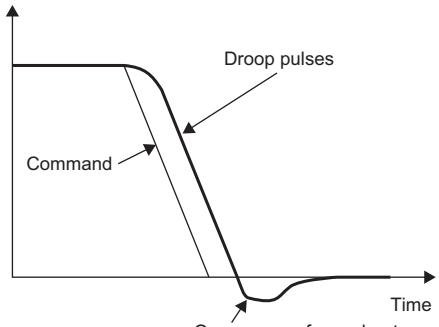
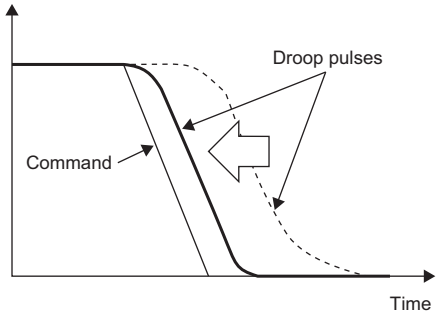
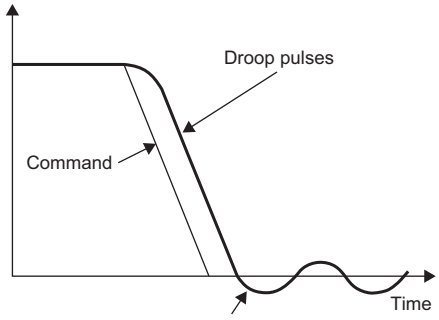
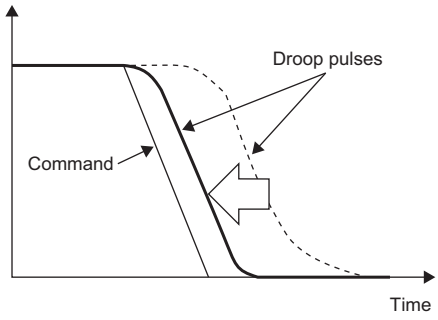
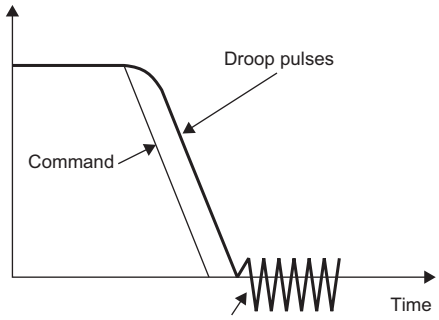
Adjustment procedure for position mode and positioning mode

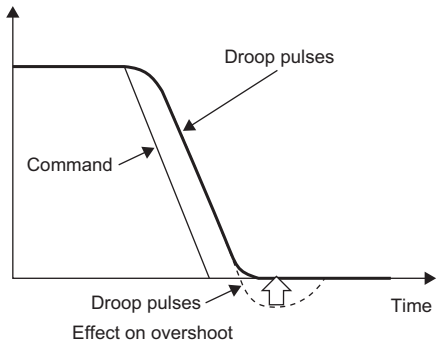
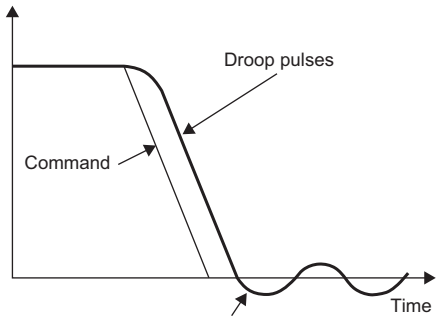
Servo parameter

The following servo parameters are used for gain adjustment.

Servo parameter	Symbol	Name
PB06	GD2	Load to motor inertia ratio/load to motor mass ratio
PB07	PG1	Model control gain
PB08	PG2	Position control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation

For the effect of each servo parameter, refer to the following diagram.

Explanation on servo parameter	Effect when increasing the responsiveness	Operating status when increase in responsiveness is excessive
[Pr. PB07 Model control gain] This servo parameter determines the responsiveness. Increasing the value improves trackability to a position command, but an overshoot is likely to occur.	 Effect on reducing the settling time	 Occurrence of overshoot
[Pr. PB08 Position control gain] This parameter is set for increasing the position response to load disturbance. Increasing the value improves the responsiveness, but vibration and noise are more likely to occur.	 Effect on reducing the settling time	 Occurrence of vibration and unusual noise (low frequency)
[Pr. PB09 Speed control gain] This servo parameter determines the responsiveness of the speed control loop. Increasing the value improves the responsiveness to the load disturbance, but mechanical vibration is more likely to occur.	 Effect on reducing the settling time	 Occurrence of vibration and unusual noise (high frequency)

Explanation on servo parameter	Effect when increasing the responsiveness	Operating status when increase in responsiveness is excessive
[Pr. PB10 Speed integral compensation] This servo parameter determines the time constant for proportional integral control of speed control loop. Decreasing the value improves the responsiveness. If the moment of inertia ratio is large or the mechanical system contains vibratory element, the mechanical system is liable to vibrate unless the value is increased to some degree.	 Effect on overshoot	 Occurrence of vibration and unusual noise (low frequency)

Adjustment procedure

Procedure	Operation	Description
1	Perform approximate adjustment with the auto tuning. Refer to the following. ☞ Page 34 Auto tuning mode 1 The control gain obtained by the auto tuning is the reference value.	—
2	Change [Pr. PA08.0 Gain adjustment mode selection] to "3" (manual mode).	—
3	Set an estimated value in the load to motor inertia ratio/load to motor mass ratio. (If the estimated value by auto tuning is correct, setting change is not required.)	—
4	Set a small value to the model control gain and the position control gain. Set a large value to the speed integral compensation.	—
5	Increase the speed control gain within the range where vibration or unusual noise is not generated, and return slightly if vibration occurs.	Increase the speed control gain.
6	Decrease the speed integral compensation within the vibration-free range. If vibration occurs, increase the value until the vibration stops.	Decrease the time constant of the speed integral compensation.
7	Increase the position control gain, and return slightly if vibration occurs.	Increase the position control gain.
8	Increase the model control gain, and return slightly if an overshoot occurs.	Increase the model control gain.
9	If the desired responsiveness cannot be achieved because of mechanical system resonance or the like which stops the gains from being increased, suppressing the resonance with adaptive tuning mode or the machine resonance suppression filter and then following steps 3 to 8 may increase the responsiveness.	Suppression of machine resonance Refer to the following. ☞ Page 50 Machine resonance suppression filter ☞ Page 53 Adaptive filter II
10	While checking the settling characteristic and the motor status, fine-adjust each gain.	Fine adjustment

Servo parameter adjustment method

■[Pr. PB07 Model control gain]

As a guide, this servo parameter can be calculated with the following formula.

$$\text{Model control gain guideline} = \frac{\text{Speed control gain}}{(1 + \text{Load to motor inertia ratio})} \times \left(\frac{1}{4} \text{ to } \frac{1}{8}\right)$$

Number of droop pulses at the constant speed can be calculated with the following expression.

$$\text{Number of droop pulses [pulse]} = \frac{\text{Position command frequency [pulse/s]}}{\text{Model control gain setting value}}$$

Position command frequency differs depending on the operation mode.

- For rotary servo motors

$$\text{Position command frequency} = \frac{\text{Servo motor speed [r/min]}}{60} \times \text{Encoder resolution (number of pulses per servo motor revolution)}$$

- Linear servo motors

Position command frequency = Speed [mm/s] ÷ Encoder resolution (travel distance per pulse)

■[Pr. PB08 Position control gain]

As a guide, this servo parameter can be calculated with the following formula.

$$\text{Position control gain guideline} = \frac{\text{Speed control gain}}{(1 + \text{Load to motor inertia ratio})} \times \left(\frac{1}{4} \text{ to } \frac{1}{8} \right)$$

■[Pr. PB09 Speed control gain]

The actual response frequency of the speed loop can be calculated with the following formula.

$$\text{Speed loop response frequency [Hz]} = \frac{\text{Speed control gain}}{(1 + \text{Load to motor inertia ratio}) \times 2\pi}$$

When adjusting [Pr. PB09 Speed control gain], increase the value gradually. Increasing the setting value causes vibration and resonance. At this time, check the value of [Pr. PB09 Speed control gain]. 70 % to 80 % of the value at which vibration and resonance occurred should be set as the limit value of [Pr. PB09 Speed control gain] in consideration of factors such as variations and margins between devices.

■[Pr. PB10 Speed integral compensation]

As a guide, this servo parameter can be calculated with the following formula.

$$\text{Speed integral compensation setting value [ms]} \geq \frac{2000 \text{ to } 3000}{\text{Speed control gain}/(1 + \text{Load to motor inertia ratio})}$$

If the setting value is less than the calculated value, vibration may occur. If the droop pulses vibrate during a stop, increasing the value in [Pr. PB10 Speed integral compensation] is effective.

3.8 Load to motor inertia ratio monitor mode

The servo amplifier has a function which estimates the machine characteristic (load to motor inertia ratio) in real time. This mode does not change the set gains, but estimates the load to motor inertia ratio.

Precautions on load to motor inertia ratio monitor mode

Only estimation of the load to motor inertia ratio is executed by this mode. Therefore, the estimated load to motor inertia ratio is not used in controlling by the servo amplifier, and the responsiveness decreases in comparison with the same setting in the manual mode.

Adjustment procedure for load to motor inertia ratio monitor mode

Point

- When the servo amplifier with firmware version C4 or later is used, it is recommended to set [Pr. PA24.5 Load to motor inertia ratio/load to motor mass ratio estimation higher precision selection] to "1".When [Pr. PA24.5] is set to "0", [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio] may be estimated at a value smaller than the accurate estimation depending on the operation pattern. Setting [Pr. PA24.5] to "1" with the equipment on which the gain is adjusted may change the actual movement. Check the movement of the equipment after changing the settings.

This mode enables manual adjustment by all the gains. However, use the gains adjusted by quick tuning as a standard. Refer to the adjustment procedure for manual mode when adjusting the gains with this mode.

☞ Page 47 Adjustment procedure

Operation of load to motor inertia ratio monitor mode

The operation of the load to motor inertia ratio estimation performed in this mode is the same as that of auto tuning mode 1. The servo parameter that is automatically adjusted in this mode is shown in the table below.

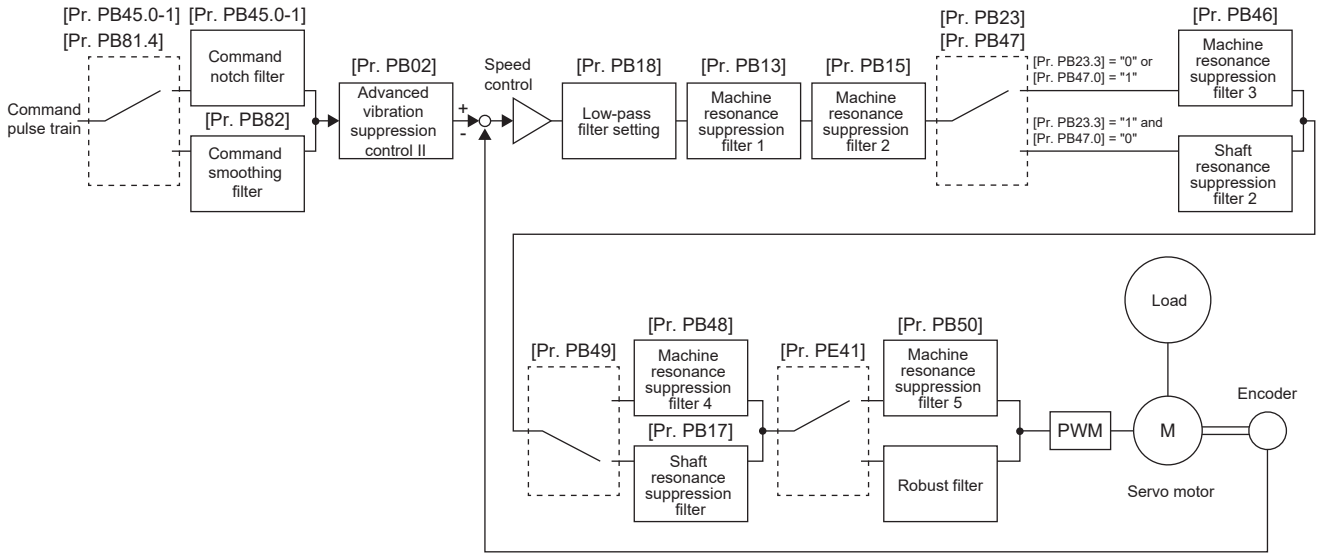
Servo parameter	Symbol	Name
PB06	GD2	Load to motor inertia ratio/load to motor mass ratio

4 VIBRATION SUPPRESSION FUNCTION

Increasing the servo system response level in a mechanical system that has a unique resonance point may cause resonance (vibration or unusual noise) in the mechanical system at that resonance frequency. By using various type of filters, resonance of the mechanical system can be suppressed, improving the responsiveness of the servo system.

4.1 Filter setting

The following filters are available with this servo amplifier.



4.2 Machine resonance suppression filter

Using the machine resonance suppression filter and adaptive tuning can suppress the resonance of the mechanical system. When the mechanical system resonates and does not meet the required performance, use the machine resonance suppression filter.

The following five machine resonance suppression filters can be set simultaneously using a setting range of 10 Hz to 9000 Hz.

Filter	Servo parameter	Servo parameter that is updated with the vibration tough drive function	Servo parameter automatically adjusted with one-touch tuning	Servo parameter automatically adjusted with quick tuning
Machine resonance suppression filter 1	PB01/PB13/PB14	PB01/PB13	PB01/PB13/PB14	PB01/PB13/PB14
Machine resonance suppression filter 2	PB15/PB16	PB15/PB16	PB15/PB16	PB15/PB16
Machine resonance suppression filter 3	PB46/PB47	—	PB46/PB47	—
Machine resonance suppression filter 4	PB48/PB49	—	PB48/PB49	—
Machine resonance suppression filter 5	PB50/PB51	—	PB50/PB51	PB50/PB51

Precautions

- If the frequency of machine resonance is unknown, decrease the notch frequency from higher to lower. The optimum notch frequency is set at the point where vibration is minimal.
- By using the machine analyzer in MR Configurator2 to understand the mechanical characteristics, the frequency and characteristics of the notch can be determined.

Machine resonance suppression filter restrictions

- Enabling the machine resonance suppression filter 4 disables the shaft resonance suppression filter. Using the shaft resonance suppression filter is recommended because it has been adjusted optimally in accordance with the usage situation. The shaft resonance suppression filter is enabled as a default.

Machine resonance suppression filter precautions

- The machine resonance suppression filter is a delay factor for the servo system. Therefore, the vibration increases if an incorrect resonance frequency is set or the notch characteristics are too deep or too wide.
- A deeper notch has a higher effect on the machine resonance suppression but increases the phase delay, and this may cause a higher vibration.
- A wider notch has a higher effect on the machine resonance suppression, but increases the phase delay and vibration.

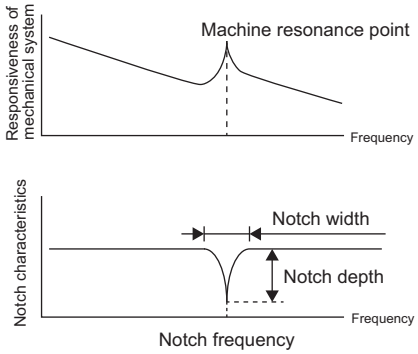
Machine resonance suppression filter setting method

Set the machine resonance suppression filter with the servo parameters shown below.

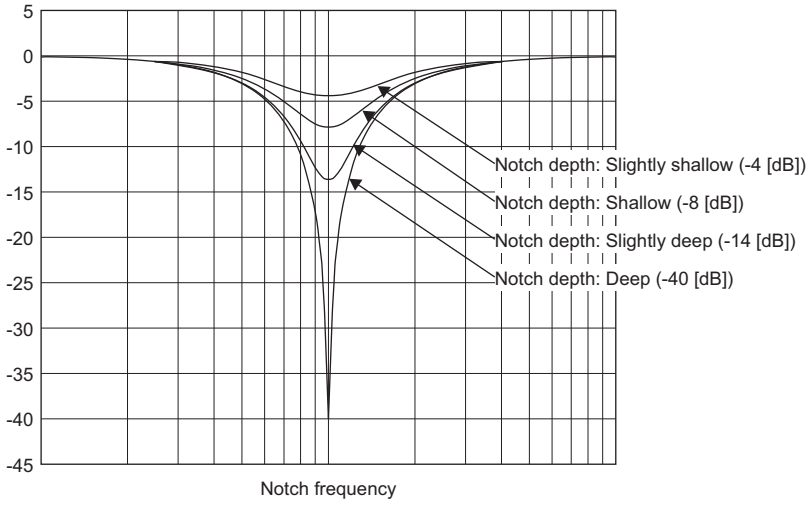
Item	Servo parameter			Remark
	Enable/Disable	Notch frequency	Notch depth, notch width	
Machine resonance suppression filter 1	[Pr. PB01.0 Filter tuning mode selection]	[Pr. PB13 Machine resonance suppression filter 1]	[Pr. PB14.1 Notch depth selection 1] [Pr. PB14.2 Notch width selection 1]	—
Machine resonance suppression filter 2	[Pr. PB16.0 Machine resonance suppression filter 2 selection]	[Pr. PB15 Machine resonance suppression filter 2]	[Pr. PB16.1 Notch depth selection] [Pr. PB16.2 Notch width selection]	—
Machine resonance suppression filter 3	[Pr. PB47.0 Machine resonance suppression filter 3 selection]	[Pr. PB46 Machine resonance suppression filter 3]	[Pr. PB47.1 Notch depth selection] [Pr. PB47.2 Notch width selection]	Shaft resonance suppression filter 2 cannot be set when machine resonance suppression filter 3 is enabled.
Machine resonance suppression filter 4	[Pr. PB49.0 Machine resonance suppression filter 4 selection]	[Pr. PB48 Machine resonance suppression filter 4]	[Pr. PB49.1 Notch depth selection] [Pr. PB49.2 Notch width selection]	Shaft resonance suppression filter cannot be set when machine resonance suppression filter 4 is enabled.
Machine resonance suppression filter 5	[Pr. PB51.0 Machine resonance suppression filter 5 selection]	[Pr. PB50 Machine resonance suppression filter 5]	[Pr. PB51.1 Notch depth selection] [Pr. PB51.2 Notch width selection]	Machine resonance suppression filter 5 cannot be used when the robust filter is enabled (i.e., when [Pr. PE41.0 Robust filter selection] is set to "1" (enabled)).

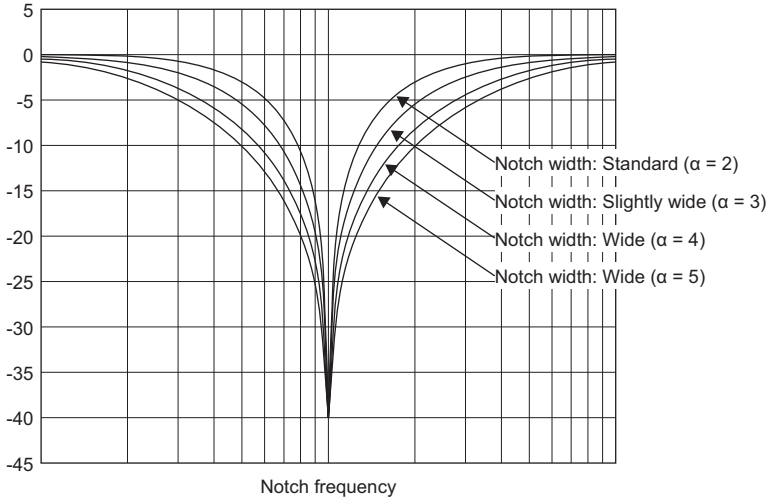
Operation of machine resonance suppression filter

The machine resonance suppression filter is a filter function (notch filter) that decreases the gain of the specific frequency to suppress the mechanical system resonance. The frequency (notch frequency), the depth, and size at which the gain is decreased can be set.



The characteristics of the machine resonance suppression filter change according to notch depth and width selections as follows.

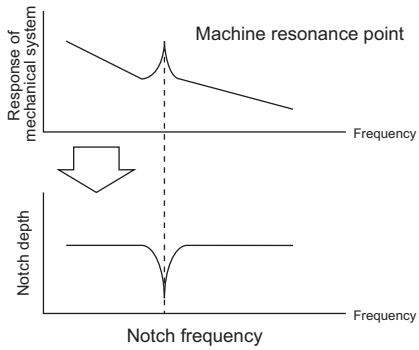




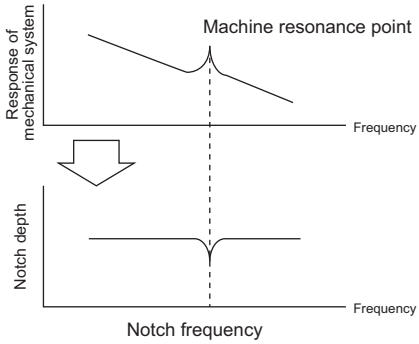
4.3 Adaptive filter II

Adaptive filter II (adaptive tuning) is a function in which the servo amplifier detects machine resonance for a certain period of time and sets the filter characteristics automatically to suppress mechanical system vibration. Since the filter characteristics (frequency and depth) are set automatically, there is no need to be aware of the resonance characteristics of the mechanical system. When the mechanical characteristics are unknown even at mechanical resonance occurrence, the use of the adaptive tuning is recommended.

- When machine resonance is large and frequency is low



- When machine resonance is small and frequency is high



Precautions

- The machine resonance frequency which adaptive filter II (adaptive tuning) can respond to is about 100 Hz to 2.25 kHz. As for the resonance frequency out of the range, set adaptive filter II manually.
- When adaptive tuning is executed, machine resonance is detected for a maximum of 10 s and a filter is generated. After filter generation, the adaptive tuning mode automatically shifts to the manual setting.
- Adaptive tuning generates an optimum filter with the currently set control gain. If vibration occurs when the response setting is increased, execute adaptive tuning again.
- Adaptive tuning generates a filter with an optimum notch depth for the set control gain. To allow a wider range of the resonance frequency for filtering, increase the notch depth in the manual setting.
- Adaptive tuning is ineffective on a mechanical system with complex resonance characteristics.

Restrictions on adaptive tuning

Adaptive tuning cannot be used while quick tuning is in progress.

Precautions for adaptive filter II

- When the adaptive tuning is executed, vibration sound increases as the vibration signal is forcibly added for several seconds.
- In the high-accuracy mode, the frequency is estimated more accurately than in the standard mode, but the sound during adjustment is larger.

How to set adaptive filter II

Select the filter tuning setting method of [Pr. PB01 Adaptive tuning mode (adaptive filter II)].

- [Pr. PB01.0 Filter tuning mode selection]

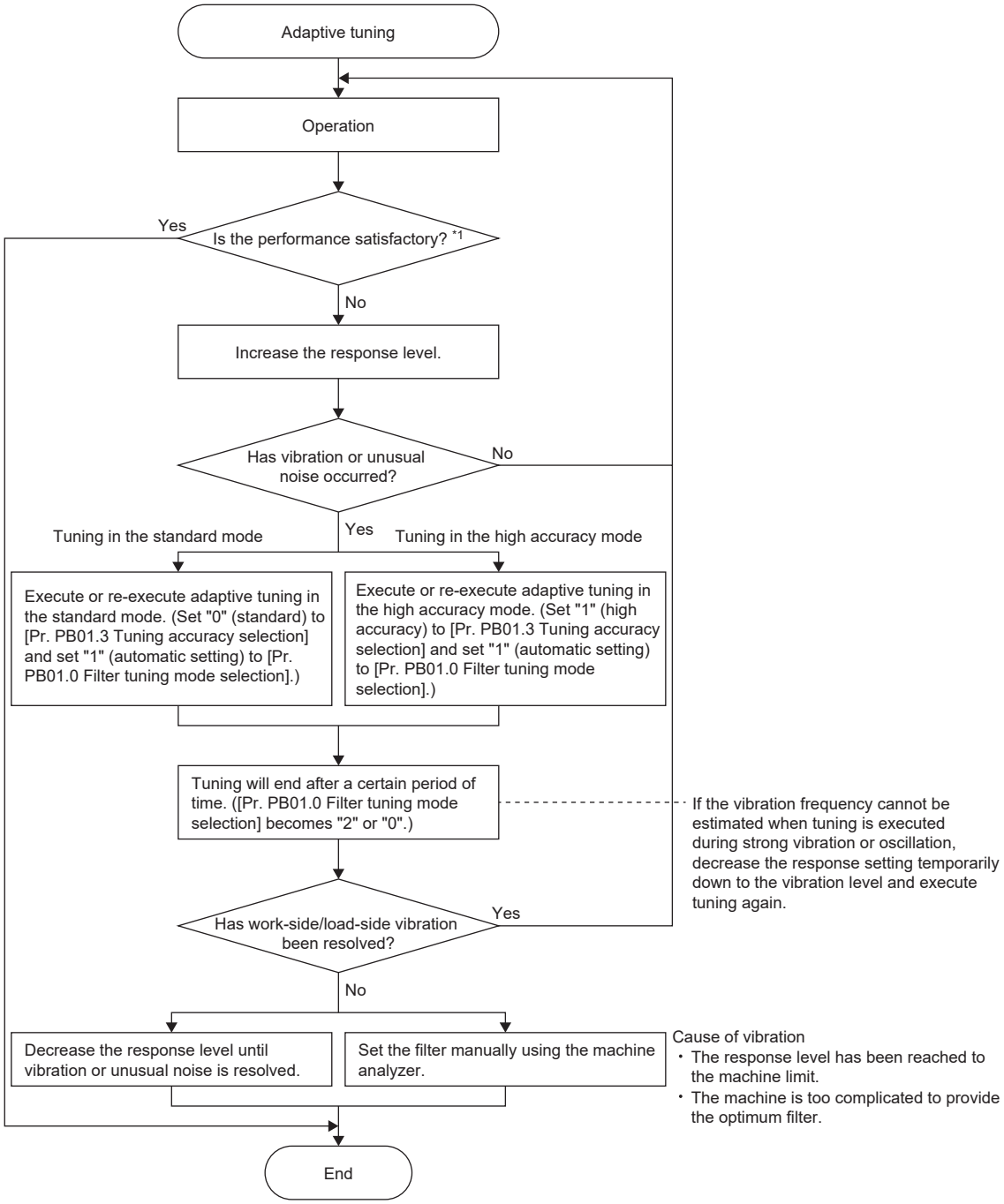
Setting value	Filter tuning mode selection	Automatically set servo parameter
0	Disabled	—
1	Automatic setting	PB13/PB14
2	Manual setting	—

- [Pr. PB01.3 Tuning accuracy selection]

0: Standard

1: High accuracy

Adaptive tuning procedure



*1 If vibration or noise occurs even with the required response satisfied, lower the response.

4.4 Shaft resonance suppression filter

When a load is mounted to the servo motor shaft, resonance by shaft torsion during servo motor drive generates high frequency mechanical vibration. The shaft resonance suppression filter suppresses this vibration.
Selecting "Automatic setting" sets the filter automatically based on the servo motor used and the load to motor inertia ratio. If the resonance frequency is high, disable the setting to increase the responsiveness of the servo amplifier.

Precautions

- Optimum settings are configured for the servo motor used and the load to motor inertia ratio by default. It is recommended that [Pr. PB23.0 Shaft resonance suppression filter selection] and [Pr. PB23.3 Shaft resonance suppression filter 2 selection] be set to (automatic setting) "0" and "1" respectively, as deterioration in performance may occur if there are changes in the setup of [Pr. PB23.0], [Pr. PB23.3], and [Pr. PB17.0-1 Shaft resonance suppression filter setting - Frequency selection].

Shaft resonance suppression filter restrictions

Shaft resonance suppression filter cannot be set when machine resonance suppression filter 4 is enabled.
Shaft resonance suppression filter 2 cannot be set when machine resonance suppression filter 3 is enabled.

Shaft resonance suppression filter setting method

Set [Pr. PB23.0 Shaft resonance suppression filter selection].

Servo parameter	Description
PB23.0	Shaft resonance suppression filter selection 0: Automatic setting 1: Manual setting 2: Disabled
PB23.3	Shaft resonance suppression filter 2 selection 0: Disabled 1: Automatic setting

When [Pr. PB23.0] is set to "0" (automatic setting), [Pr. PB17.0-1] will be set automatically.
When [Pr. PB23.0] is set to "1" (manual setting), [Pr. PB17.0-1] can be set manually. The setting values are as follows.

Setting value	Frequency [Hz]
00	Disabled
01	Disabled
02	4500
03	3000
04	2250
05	1800
06	1500
07	1285
08	1125
09	1000
0A	900
0B	818
0C	750
0D	692
0E	642
0F	600
10	562
11	529
12	500
13	473
14	450

Setting value	Frequency [Hz]
15	428
16	409
17	391
18	375
19	360
1A	346
1B	333
1C	321
1D	310
1E	300
1F	290
20	Disabled
21	Disabled
22	Disabled
23	Disabled
24	Disabled
25	Disabled
26	Disabled
27	Disabled
28	4500
29	4000
2A	3600
2B	3272
2C	3000
2D	2769
2E	2571
2F	2400
30	2250
31	2117
32	2000
33	1894
34	1800
35	1714
36	1636
37	1565
38	1500
39	1440
3A	1384
3B	1333
3C	1285
3D	1241
3E	1200
3F	1161
40	1125
41	1090
42	1058
43	1028
44	1000
45	972
46	947
47	923
48	900
49	878

Setting value	Frequency [Hz]
4A	857
4B	837
4C	818
4D	800
4E	782
4F	765
50	750
51	734
52	720
53	705
54	692
55	679
56	666
57	654
58	642
59	631
5A	620
5B	610
5C	600
5D	590
5E	580
5F	571
60	562
61	553
62	545
63	537
64	529
65	521
66	514
67	507
68	500
69	493
6A	486
6B	480
6C	473
6D	467
6E	461
6F	455
70	450
71	444
72	439
73	433
74	428
75	423
76	418
77	413
78	409
79	404
7A	400
7B	395
7C	391
7D	387
7E	382

Setting value	Frequency [Hz]
7F	378
80	375
81	371
82	367
83	363
84	360
85	356
86	352
87	349
88	346
89	342
8A	339
8B	336
8C	333
8D	330
8E	327
8F	324
90	321
91	318
92	315
93	313
94	310
95	307
96	305
97	302
98	300
99	297
9A	295
9B	292
9C	290
9D	288
9E	285
9F	283

4.5 Low-pass filter

When a ball screw or the like is used, resonance of a high frequency may occur as the response level of the servo system is increased. To prevent this, the low-pass filter has been enabled for a torque command as the initial value. Use automatic setting as normal setup. To increase the responsiveness, set the filter frequency of the low-pass filter manually.

Low-pass filter setting method

Set [Pr. PB23.1 Low-pass filter selection]. When [Pr. PB23.1] is set to "1" (manual setting), the filter frequency can be set through [Pr. PB18 Low-pass filter setting].

Servo parameter	Description
PB23.1	Low-pass filter selection 0: Automatic setting 1: Manual setting 2: Disabled

Operation of low-pass filter

When [Pr. PB23.1 Low-pass filter selection] is set to "0" (automatic setting), the filter frequency is automatically adjusted to the value of the following equation.

$$\text{Filter frequency ([rad/s])} = \frac{VG2}{1 + GD2} \times 8$$

4.6 Robust filter

The robust filter provides both high response and stability to large inertia devices driven by belts and gears, such as printing and packaging machines, which is difficult to achieve with the conventional control. Greater stability can be ensured by gradually reducing the torque of the wide frequency range. When the load to motor inertia ratio of a machine is 10 times or more, use this filter to further increase the response level of the machine.

Robust filter restrictions

Enabling the robust filter disables machine resonance suppression filter 5.

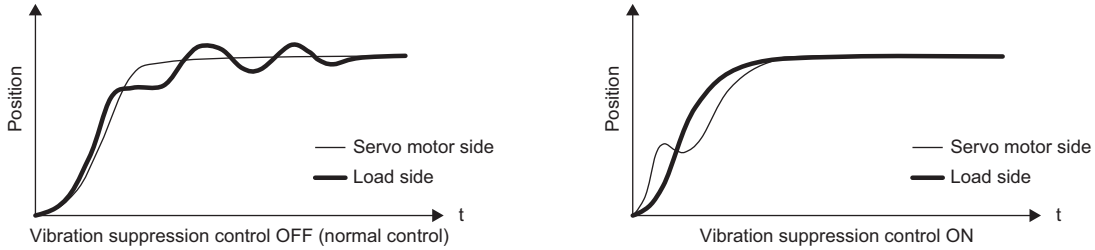
Robust filter setting method

Set [Pr. PE41.0 Robust filter selection]. The characteristics of the robust filter are calculated automatically from the servo parameter.

Servo parameter	Description
PE41.0	Robust filter selection 0: Disabled 1: Enabled

4.7 Advanced vibration suppression control II

Use the vibration suppression control to further suppress the load-side vibration of relatively low frequency of around 100 Hz or less, such as work-side vibration and shaking base. Settling time can be shortened by suppressing the residual vibration. The residual vibration is suppressed by adjusting the movement of the servo motor side from inside the servo amplifier and performing positioning.



Executing advanced vibration suppression control II estimates the load side vibration frequency automatically, and suppresses load side vibration up to a maximum of two different frequencies. When the vibration suppression control tuning mode is set as "Automatic setting", the mode shifts to the "Manual setting" after the positioning operation is performed the predetermined number of times. When the mode is set to the "Manual setting", vibration suppression control 1 can be adjusted with [Pr. PB19] to [Pr. PB22], and vibration suppression control 2 can be adjusted with [Pr. PB52] to [Pr. PB55].

Precautions

- The machine resonance frequency supported in the vibration suppression control tuning mode is 1.0 Hz to 100.0 Hz. As for the vibration out of the range, set advanced vibration suppression control II manually.
- Vibration suppression control tuning sets the optimum servo parameter with the currently set control gain. When the response setting is increased, set vibration suppression control tuning again.

Advanced vibration suppression control restrictions

- This setting is enabled when [Pr. PA08.0 Gain adjustment mode selection] is set to "2" (auto tuning mode 2), "3" (manual mode), or "4" (2 gain adjustment mode 2).
- When using vibration suppression control 2, it is necessary to set [Pr. PA24.0 Vibration suppression mode selection] to "1" (3 inertia mode).
- The value of [Pr. PB07 Model control gain], vibration frequency, and resonance frequency have the following usable range and recommended range. Calculate these ranges using the formulas in the following two tables.

When calculating the setting value of [Pr. PB19], [Pr. PB20], [Pr. PB52], and [Pr. PB53] by using [Pr. PB07]

This example shows a case where [Pr. PB19] < [Pr. PB52].

Vibration suppression control	Usable range	Recommended setting range
Vibration suppression control 1	[Pr. PB19] > 1/2π × (0.9 × [Pr. PB07]) [Pr. PB20] > 1/2π × (0.9 × [Pr. PB07])	[Pr. PB19] > 1/2π × (1.5 × [Pr. PB07]) [Pr. PB20] > 1/2π × (1.5 × [Pr. PB07])
Vibration suppression control 2	When [Pr. PB19] < [Pr. PB52] [Pr. PB52] > (5.0 + 0.1 × [Pr. PB07]) [Pr. PB53] > (5.0 + 0.1 × [Pr. PB07]) 1.1 < [Pr. PB52]/[Pr. PB19] < 5.5 [Pr. PB07] < 2π (0.3 × [Pr. PB19] + 1/8 × [Pr. PB52])	When [Pr. PB19] < [Pr. PB52] [Pr. PB52], [Pr. PB53] > 6.25 Hz 1.1 < [Pr. PB52]/[Pr. PB19] < 4 [Pr. PB07] < 1/3 × (4 × [Pr. PB19] + 2 × [Pr. PB52])

When calculating the setting value of [Pr. PB07] by using [Pr. PB19], [Pr. PB20], [Pr. PB52], and [Pr. PB53]

This example shows a case where [Pr. PB19] < [Pr. PB52].

Vibration suppression control	Usable range	Recommended setting range
Vibration suppression control 1	Range that meets all of the following conditions [Pr. PB07] < 2π × [Pr. PB19]/0.9 [Pr. PB07] < 2π × [Pr. PB20]/0.9	Range that meets all of the following conditions [Pr. PB07] < 2π × [Pr. PB19]/1.5 [Pr. PB07] < 2π × [Pr. PB20]/1.5
Vibration suppression control 2	• When [Pr. PB19] < [Pr. PB52] Range that meets all of the following conditions [Pr. PB07] < ([Pr. PB52] – 5.0) × 10 [Pr. PB07] < ([Pr. PB53] – 5.0) × 10 1.1 < [Pr. PB52]/[Pr. PB19] < 5.5 [Pr. PB07] < 2π (0.3 × [Pr. PB19] + 1/8 × [Pr. PB52]) • When [Pr. PB52] ≤ [Pr. PB19] Range that meets all of the following conditions [Pr. PB07] < ([Pr. PB19] – 5.0) × 10 [Pr. PB07] < ([Pr. PB20] – 5.0) × 10 1.1 < [Pr. PB19]/[Pr. PB52] < 5.5 [Pr. PB07] < 2π (0.3 × [Pr. PB52] + 1/8 × [Pr. PB19])	• When [Pr. PB19] < [Pr. PB52] Range that meets all of the following conditions [Pr. PB52], [Pr. PB53] > 6.25 Hz 1.1 < [Pr. PB52]/[Pr. PB19] < 4 [Pr. PB07] < 1/3 × (4 × [Pr. PB19] + 2 × [Pr. PB52]) • When [Pr. PB52] ≤ [Pr. PB19] Range that meets all of the following conditions [Pr. PB19], [Pr. PB20] > 6.25 Hz 1.1 < [Pr. PB19]/[Pr. PB52] < 4 [Pr. PB07] < 1/3 × (4 × [Pr. PB52] + 2 × [Pr. PB19])

The calculation example is shown in the following table.

Vibration suppression control	Servo parameter setting example		Usable range	Recommended setting range
	No.	Value		
Vibration suppression control 1	[Pr. PB19]	20	[Pr. PB07] < 139.6	[Pr. PB07] < 83.7
	[Pr. PB20]	20		
Vibration suppression control 2	[Pr. PB19]	20	[Pr. PB07] < 61.26	[Pr. PB07] < 46.44
	[Pr. PB20]	20		
	[Pr. PB52]	30		
	[Pr. PB53]	30		

- If [Pr. PB25.0 Model adaptive control selection] is set to "2" (disabled (PID control)), the vibration suppression control cannot be used.

Advanced vibration suppression control precautions

- Stop the servo motor before changing the servo parameters related to vibration suppression control. Failing to do so will cause an unexpected movement of the servo motor or other parts in the system.
- Vibration suppression control tuning is unable to be estimated normally if the residual vibration at the servo motor side is small.

Advanced vibration suppression control setting method

Set [Pr. PB02 Vibration suppression control tuning mode (advanced vibration suppression control II)]. When using one vibration suppression control, set [Pr. PB02.0 Vibration suppression control 1 - Tuning mode selection] to "1" (automatic setting). When using two vibration suppression controls, set [Pr. PA24.0 Vibration suppression mode selection] to "1" (3 inertia mode), [Pr. PB02.0] to "1" (automatic setting), and [Pr. PB02.1 Vibration suppression control 2 - Tuning mode selection] to "1" (automatic setting).

Set [Pr. PA24] to "1" (3 inertia mode), [Pr. PB02.0] to "1" (automatic setting), and [Pr. PB02.1] to "1" (automatic setting) as a standard. If using one vibration suppression control is assessed to be optimal inside the servo amplifier, only vibration suppression control 1 or vibration suppression control 2 automatically becomes enabled.

- [Pr. PB02.0 Vibration suppression control 1 - Tuning mode selection]

Setting value	Vibration suppression control 1 - Tuning mode selection	Automatically set servo parameter
0	Disabled	—
1	Automatic setting	PB19/PB20/PB21/PB22
2	Manual setting	—

- [Pr. PB02.1 Vibration suppression control 2 - Tuning mode selection]

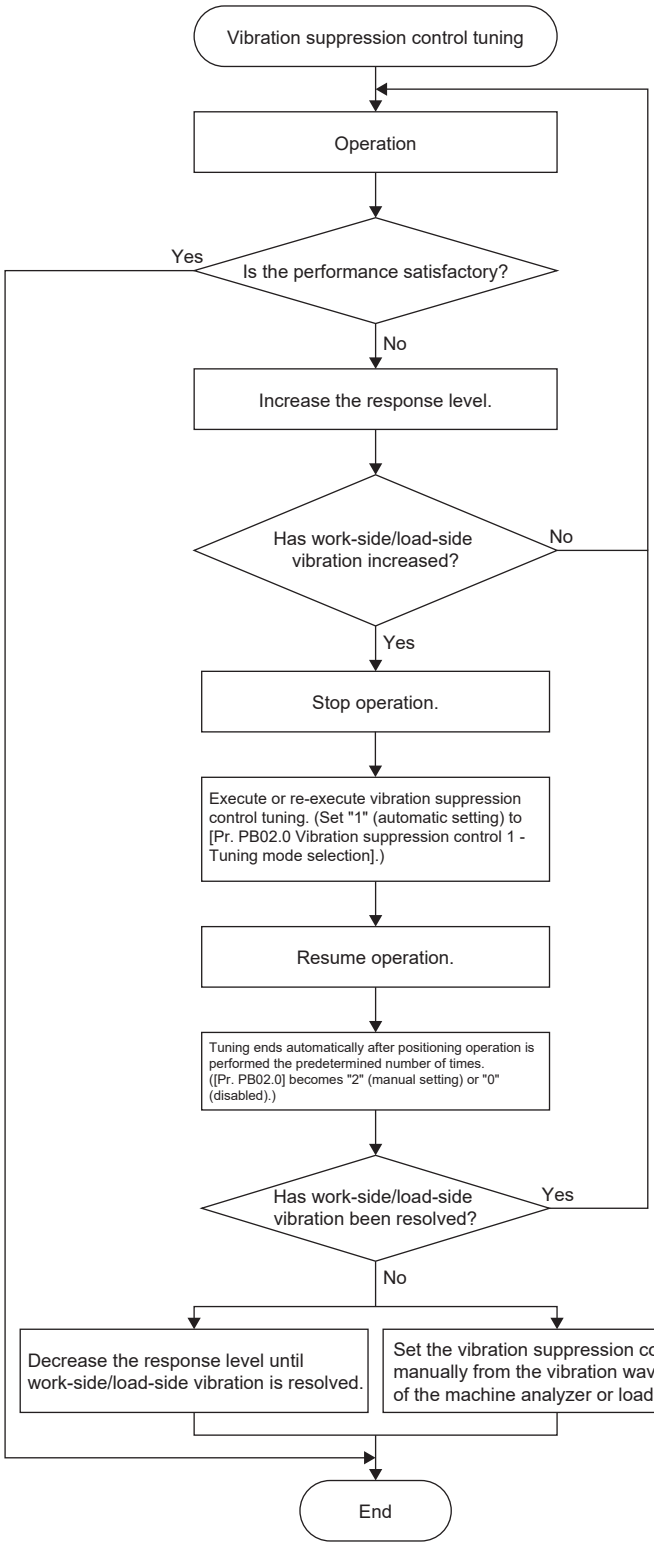
Setting value	Vibration suppression control 2 - Tuning mode selection	Automatically set servo parameter
0	Disabled	—
1	Automatic setting	PB52/PB53/PB54/PB55
2	Manual setting	—

Advanced vibration suppression control adjustment method

Point

- When load-side vibration is not transferred to the servo motor-side, setting the servo motor-side vibration frequency is not effective. In addition, vibration suppression control tuning may not be able to accurately set the vibration frequency automatically.
- When the anti-resonance frequency and resonance frequency can be checked using the machine analyzer or external equipment, set different values (do not set the same value) to improve the vibration suppression performance.

The following is a flowchart of vibration suppression control 1. When using Vibration suppression control 2, set [Pr. PB02.1 Vibration suppression control 2 - Tuning mode selection] to "1" (automatic setting), and execute Vibration suppression control tuning.



Cause of vibration

- The load-side vibration frequency cannot be estimated because the load-side vibration has not been transmitted to the servo motor side.
- The model control gain value has been reached to the response level of the load-side vibration frequency (vibration suppression control limit).

When adjusting the vibration suppression control manually based on the result of the machine analyzer or the vibration waveform of the load side, set the following parameters. Set the following servo parameters to meet the applicable and recommended range. Refer to the following.

☞ Page 62 Advanced vibration suppression control restrictions

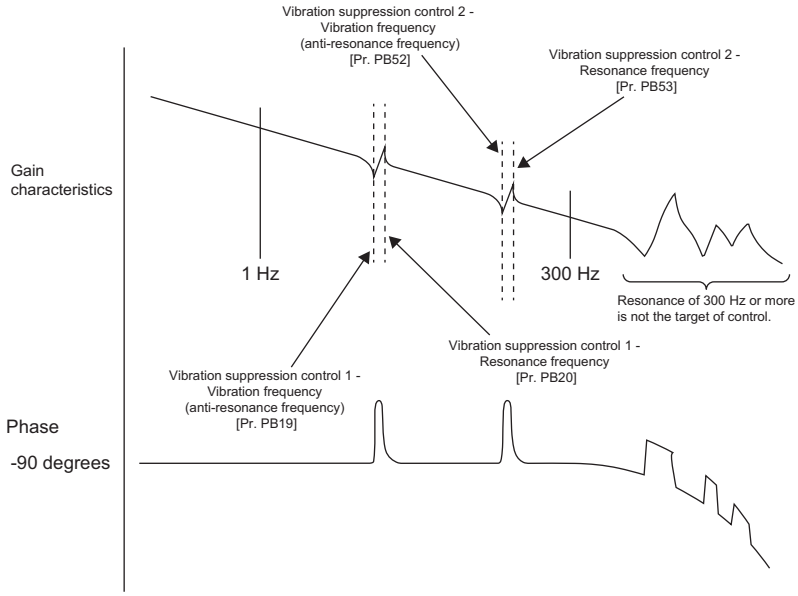
Setting item	Vibration suppression control 1	Vibration suppression control 2
Vibration suppression control - Vibration frequency	[Pr. PB19]	[Pr. PB52]
Vibration suppression control - Resonance frequency	[Pr. PB20]	[Pr. PB53]
Vibration suppression control - Vibration frequency damping	[Pr. PB21]	[Pr. PB54]
Vibration suppression control - Resonance frequency damping	[Pr. PB22]	[Pr. PB55]

The servo parameters are set using the following procedure.

1. Select "2" (manual setting) in [Pr. PB02.0 Vibration suppression control 1 - Tuning mode selection] or "2" (manual setting) in [Pr. PB02.1 Vibration suppression control 2 - Tuning mode selection].
2. Set "Vibration suppression control for vibration suppression control" and "Resonance frequency for vibration suppression control" as follows.

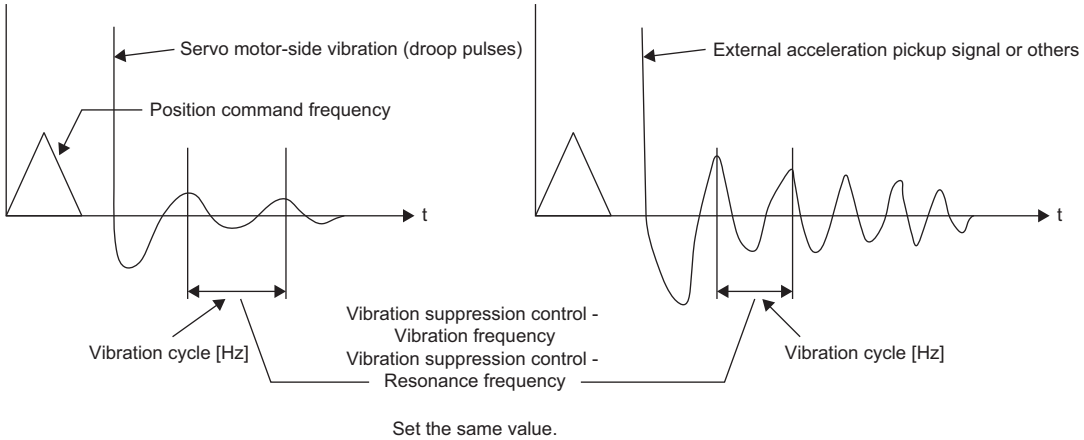
• When a vibration peak can be checked with machine analyzer in MR Configurator2 or with external measuring equipment

If the frequency characteristic of the machine can be measured using machine analyzer in MR Configurator2 or external equipment, set the frequency trough of the gain characteristic to the vibration frequency setting, and the frequency crest as the resonance frequency setting.



• When vibration can be confirmed using a monitor signal or an external sensor

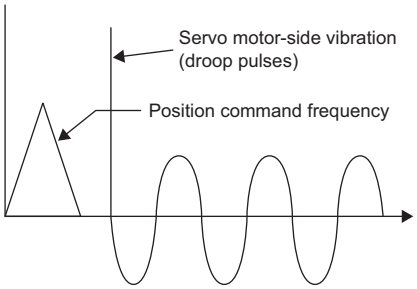
If the time waveform of a monitor and an external sensor can be measured, measure the droop pulses, and set the droop pulse vibration cycle of the settling time as the vibration and resonance frequency.



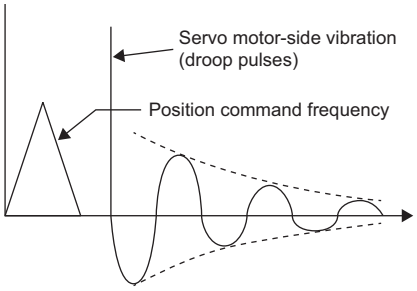
3. Set "Vibration suppression control - Vibration frequency damping setting" and "Vibration suppression control - Resonance frequency damping setting".

Regular adjustment of the damping setting is not required. Decrease the damping setting to (1) further enhance the vibration suppression effect, or (2) to measure the droop pulses when the vibration suppression control is invalid, and sustain the amplitude of the droop pulses at settling time. If the amplitude of the droop pulses are decreasing quickly, increase the damping setting. By setting the damping setting appropriately, the effect of vibration suppression is enhanced.

- If the amplitude of the droop pulses is sustained



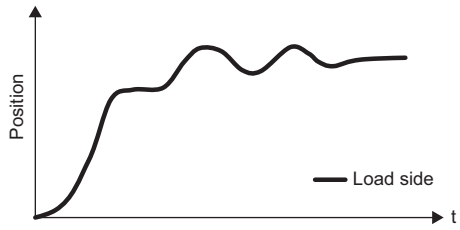
- If the amplitude of the droop pulses are decreasing quickly



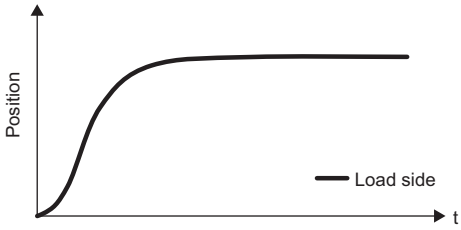
4.8 Command notch filter

The command notch filter is a filter function that lowers the gain of a specific frequency contained in a position command to suppress load-side vibration, such as work-side vibration and a base shake. The frequency to decrease the gain and the notch depth can be set with this function.

- When command notch filter is disabled



- When command notch filter is enabled



The command notch filter has a longer settling time than that of advanced vibration suppression control II, but can easily suppress vibration. Advanced vibration suppression control II and command notch filter characteristics are shown in the following table.

Function	Command notch filter	Advanced vibration suppression control II
Servo parameter	[Pr. PB45]	[Pr. PB01] [Pr. PB19] [Pr. PB20] [Pr. PB21] [Pr. PB22] [Pr. PB52] [Pr. PB53] [Pr. PB54] [Pr. PB55]
Automatic estimation	Not available	Available
Restriction on [Pr. PB07 Model control gain]	No	Yes

Precautions

- Using advanced vibration suppression control II and the command notch filter can suppress the load-side vibration of three different frequencies.
- The frequency of machine vibration that can be supported by the command notch filter is specifically between 1.12 Hz and 2000 Hz. Set a frequency close to the machine vibration frequency and within the range.
- When [Pr. PB45 Command notch filter] is changed during the positioning operation, the changed setting is not reflected. The setting value is reflected after waiting for the following time once the servo motor stops (after servo-lock).

Setting frequency for command notch filter before the change	Waiting time for reflection of the change after servo-lock
4.5 Hz or more	Approx. 150 ms
1.12 Hz or more to less than 4.5 Hz	Approx. 500 ms

Command notch filter setting method

Set [Pr. PB45 Command notch filter] as shown below. For the setting frequency of the command notch filter, set the closest value to the load-side vibration frequency [Hz]. Refer to the following for the vibration frequency check method of the load side.

☞ Page 63 Advanced vibration suppression control adjustment method

• [Pr. PB45.0-1 Command notch filter setting frequency selection]

Setting value	Frequency [Hz]
00	Disabled
01	2000
02	1000
03	666
04	500
06	400
07	333
08	285
09	250
0A	222
0B	200
0C	181
0D	166
0F	153
10	142
11	133
12	125
13	117
14	111
15	105
16	100
17	95
19	90
1A	86
1B	83
1C	80
1D	76
1E	74
1F	71
21	66
22	62
23	58
24	55
25	52
26	50
27	47
29	45
2A	43
2B	41
2C	40
2D	38
2E	37
2F	35
30	34.5
31	33.3

Setting value	Frequency [Hz]
32	31.3
33	29.4
34	27.8
35	26.3
36	25.0
38	23.8
39	22.7
3A	21.7
3B	20.8
3C	20.0
3D	19.2
3E	18.5
3F	17.9
40	17.2
41	16.7
42	15.6
43	14.7
44	13.9
45	13.2
46	12.5
48	11.9
49	11.4
4A	10.9
4B	10.4
4C	10
4D	9.6
4E	9.3
4F	8.9
50	8.6
51	8.3
52	7.8
53	7.4
54	6.9
55	6.6
56	6.3
58	6.0
59	5.7
5A	5.4
5B	5.2
5C	5.0
5D	4.8
5E	4.6
5F	4.5
60	4.31
61	4.17
62	3.91
63	3.68
64	3.47
65	3.29
66	3.13
68	2.98
69	2.84
6A	2.72

Setting value	Frequency [Hz]
6B	2.60
6C	2.50
6D	2.40
6E	2.31
6F	2.23
71	2.08
72	1.95
73	1.84
74	1.74
75	1.64
76	1.56
78	1.49
79	1.42
7A	1.36
7B	1.30
7C	1.25
7D	1.20
7E	1.16
7F	1.12

• [Pr. PB45.2 Notch depth selection]

Setting value	Depth [dB]
0	-40.0
1	-24.1
2	-18.1
3	-14.5
4	-12.0
5	-10.1
6	-8.5
7	-7.2
8	-6.0
9	-5.0
A	-4.1
B	-3.3
C	-2.5
D	-1.8
E	-1.2
F	-0.6

4.9 Vibration tough drive

Vibration tough drive function is a function to instantaneously update the machine resonance suppression filter, and to prevent vibration when machine resonance occurs due to the oscillation during adjustment and aging of the machine. By using this function, the equipment continues to operate normally even when an alarm occurs. When continuing operation is required even with an aging machine, the use of this function is recommended.

Vibration tough drive restrictions

The vibration tough drive function does not detect a vibration of 100 Hz or less.
Vibration tough drive can be used in the following cases.

When [Pr. PA20.1 Vibration tough drive selection] is set to "1" (machine resonance suppression filter change mode enabled)

- When machine resonance suppression filter 1 is manually set, and the detected machine resonance frequency is within the ±30 % range of the set value for [Pr. PB13 Machine resonance suppression filter 1]
- When machine resonance suppression filter 2 is enabled, and the detected machine resonance frequency is within the ±30 % range of the set value for [Pr. PB15 Machine resonance suppression filter 2]

When [Pr. PA20.1 Vibration tough drive selection] is set to "2" (machine resonance suppression filter automatic setting mode)

- When [Pr. PB01.0 Filter tuning mode selection] is set to "0" (disabled), and machine resonance suppression filter 1 has been disabled
- When [Pr. PB16.0 Machine resonance suppression filter 2 selection] is set to "0" (disabled), and machine resonance suppression filter 2 has been disabled
- When machine resonance suppression filter 1 is manually set, and the detected machine resonance frequency is within the ±30 % range of the set value for [Pr. PB13 Machine resonance suppression filter 1]
- When machine resonance suppression filter 2 is enabled, and the detected machine resonance frequency is within the ±30 % range of the set value for [Pr. PB15 Machine resonance suppression filter 2]

Vibration tough drive precautions

- Although [Pr. PB13] and [Pr. PB15] are constantly updated by the vibration tough drive function, the setting value is only written to the non-volatile memory once per five minutes.
- In vibration tough drive function, [Pr. PB46 Machine resonance suppression filter 3], [Pr. PB48 Machine resonance suppression filter 4], and [Pr. PB50 Machine resonance suppression filter 5] are not updated.

Vibration tough drive setting method

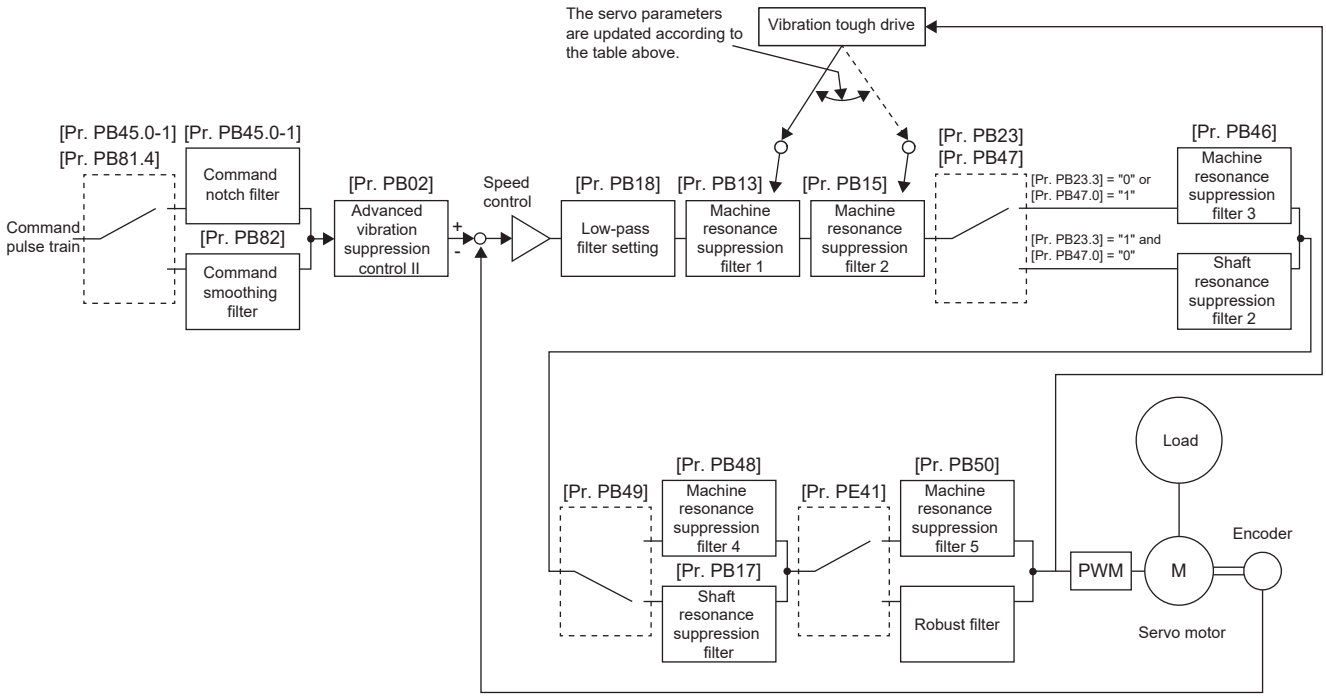
Setting [Pr. PA20.1 Vibration tough drive selection] to "1" (machine resonance suppression filter change mode) or "2" (machine resonance suppression filter automatic setting mode) causes [Pr. PB13 Machine resonance suppression filter 1] and [Pr. PB15 Machine resonance suppression filter 2] to be automatically set when the oscillation level set in [Pr. PF23 Vibration tough drive - Oscillation detection level] is exceeded. This will suppress the vibration of the equipment.

Servo parameter	Description
PA20.1	Vibration tough drive selection 0: Disabled 1: Machine resonance suppression filter change mode enabled 2: Machine resonance suppression filter automatic setting mode When using the vibration tough drive, it is recommended to use "2" (machine resonance suppression filter automatic setting mode).

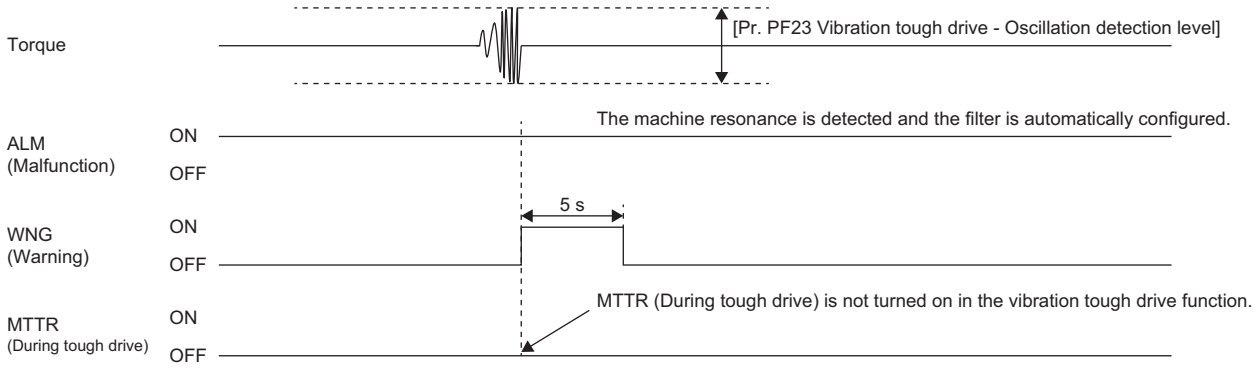
Operation of vibration tough drive

The function block diagram for the vibration tough drive function is shown below. If the oscillation level exceeds the level set in [Pr. PF23 Vibration tough drive - Oscillation detection level], [Pr. PB13 Machine resonance suppression filter 1] and [Pr. PB15 Machine resonance suppression filter 2] will be set according to the detected machine resonance frequency and the machine resonance suppression filter being used. At this time, [AL. 0F0 Tough drive warning] is outputted for 5 s, and the number of tough drive operations is incremented once.

[Pr. PA20.1]	Machine resonance suppression filter 1	Machine resonance suppression filter 2	Servo parameter that is set with the vibration tough drive function
1	Disabled	Disabled	The vibration tough drive does not operate.
	Enabled	Disabled	[Pr. PB13]
	Disabled	Enabled	[Pr. PB15]
	Enabled	Enabled	The detected machine resonance frequency is compared with the setting values of [Pr. PB13] and [Pr. PB15], and then the setting value closest to the detected machine resonance frequency is updated. If the detected machine resonance frequency is the center value of [Pr. PB13] and [Pr. PB15], [Pr. PB13] is updated.
2	Disabled	Disabled	[Pr. PB13]
	Enabled	Disabled	If the oscillation cannot be suppressed even when [Pr. PB15] is set, [Pr. PB13] is updated.
	Disabled	Enabled	If the oscillation cannot be suppressed even when [Pr. PB13] is set, [Pr. PB15] is updated.
	Enabled	Enabled	The detected machine resonance frequency is compared with the setting values of [Pr. PB13] and [Pr. PB15], and then the setting value closest to the detected machine resonance frequency is updated. If the detected machine resonance frequency is the center value of [Pr. PB13] and [Pr. PB15], [Pr. PB13] is updated.



The timing chart of the vibration tough drive is shown as follows:



4.10 Command smoothing filter

The command smoothing filter removes frequency components above the set frequency (= 1/filter time constant [s]) for the position command. Use this filter to suppress a wide range of frequencies.

Precautions

Even if [Pr. PB82 Position command smoothing filter time constant] is changed during the positioning operation, the new setting value will not be applied. The new setting value is applied 150 ms after the servo motor has stopped (after servo-lock).

Restrictions on the command smoothing filter

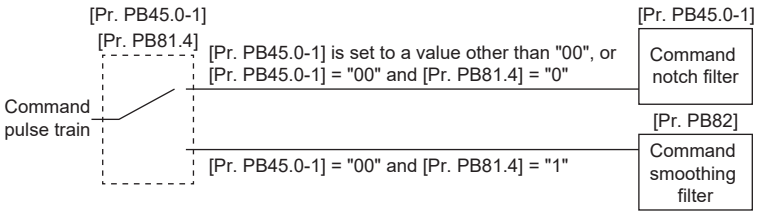
- The command smoothing filter is available only in position mode and positioning mode.
- This filter and [Pr. PB45 Command notch filter] are mutually exclusive. The filter is available only when [Pr. PB45.0-1 Command notch filter setting frequency selection] is set to "00" (disabled). When a value other than "00" (disabled) is set in [Pr. PB45.0-1], the filter is disabled regardless of the setting value of [Pr. PB81.4 Position command smoothing filter].

Instructions on the command smoothing filter

- The deceleration time is extended by a command smoothing filtering time constant in addition to the deceleration time set in the acceleration/deceleration function. Confirm that the servo motor stops as intended (time and position) before using the command smoothing filter.

How to set the command smoothing filter

Set [Pr. PB81.4] to "1" (enabled), and set the command smoothing filtering time constant in [Pr. PB82].



Time constant [ms] can be obtained by dividing 1000 by the frequency [Hz].
For example, set 1.0 [ms] to suppress vibrations at a frequency of 1000 [Hz] or higher, and set 100.0 [ms] to suppress vibrations at a frequency of 10 [Hz] or higher.

Servo parameter	Description
PB81.4	Position command smoothing filter Initial value: 0h (disabled)
PB82	Position command smoothing filter time constant Initial value: 0.0

5 GAIN SWITCHING FUNCTION

This function enables the gain switching. The gains can be switched depending on whether the motor is in rotation/stop, or on the command directions. Using a control command from a controller can also switch the gains during operation. The gain switching is used when:

- Increasing the gain during the servo-lock is required, but decreasing the gains is also needed to suppress drive noise during rotation.
- Increasing the gains during settling is needed in order to shorten the settling time.
- Since the load to motor inertia ratio varies greatly during a stop (e.g. a large load is placed on a carrier), switch the gains using a control command from an input device or a controller to ensure the stability of the servo system.

5.1 Restrictions on gain switching

- When [Pr. PA08.0 Gain adjustment mode selection] is set to a value other than "3" (manual mode), the gain switching cannot be used.
- Gain switching vibration suppression control ([Pr. PB33] to [Pr. PB36]/[Pr. PB56] to [Pr. PB59]) and [Pr. PB60 Gain switching - Model control gain] can be used when the input device (CDP) or Bit 4 (C_CDP) of [Control DI 1 (Obj. 2D01h)] is turned on.
- Gain switching 2 vibration suppression control ([Pr. PB71] to [Pr. PB74]/[Pr. PB75] to [Pr. PB78]) and [Pr. PB79 Gain switching 2 - Model control gain] can be used when the input device (CDP2) or Bit 4 (C_CDP2) of [Control DI5 (Obj. 2D05h)] is turned on.
- Gain switching is enabled in the position mode and positioning mode when the direction command is selected for gain switching and gain switching during a stop is enabled.
- In the continuous operation to torque control mode, the gain cannot be switched by the command direction.
- Slight vibration suppression control does not allow switching of the load to motor inertia ratio/load to motor mass ratio, the model control gain, the position control gain, the speed control gain, and the speed integral compensation.

5.2 Precautions on gain switching

- If the gain difference is too large at gain switching, and the value in [Pr. PB28 Gain switching time constant] is too small, the machine may operate unexpectedly at gain switching. In this case, increase the value in [Pr. PB28 Gain switching time constant].
- When the conditions for "Gain switching" and "Gain switching 2" are established at the same time, "Gain switching 2" is enabled.

5.3 Setting method for gain switching

When using the gain switching, set the parameters as follows.

Servo parameters for setting the gain switching condition

Servo parameter	Symbol	Name	Unit	Description
PB26	*CDP	Gain switching function	—	Select the switching condition.
PB27	CDL	Gain switching condition	[kpulse/s]/ [pulse]/ [r/min]/ [mm/s]	Set the condition values to switch the original gain to the gain for "Gain switching".
PB28	CDT	Gain switching time constant	[ms]	Set the time constant for the original gain to be switched to the gain for "Gain switching".
PB65	CDL2	Gain switching 2 condition	[kpulse/s]/ [pulse]/ [r/min]/ [mm/s]	Set the condition values to switch the gain to the gain for "Gain switching 2". The setting value is to be larger than in [Pr. PB27 Gain switching condition]. When this setting value is "0", the gain is not switched to the gain for "Gain switching 2".
PB66	CDT2	Gain switching 2 time constant	[ms]	Set the time constant for the gain to be switched to the gain for "Gain switching 2".

[Pr. PB26 Gain switching function]

Select the gain switching condition.

Servo parameter	Description
PB26.0	Gain switching selection 0: Disabled 1: Signal (CDP/C_CDP) 2: Command frequency 3: Droop pulses 4: Servo motor speed 5: Command direction When "1" is selected, the gain changes to "Gain after gain switching" by the control command from the controller or input device.
PB26.1	Gain switching condition selection 0: Gain after "Gain switching" is enabled with the value of the gain switching condition or more 1: Gain after "Gain switching" is enabled with the value of the gain switching condition or less The gain switching condition varies depending on the setting value of [Pr. PB26.0]. ☞ Page 77 Combination of [Pr. PB26.0] and [Pr. PB26.1]
PB26.2	Gain switching time constant - Disabling condition selection 0: Switching time constant enabled 1: Time constant disabled at switching 2: Time constant disabled at return
PB26.4	Gain switching 2 selection 0: Disabled 1: Signal (CDP2/C_CDP2) 2: The same condition as [Pr. PB26.0 Gain switching selection] When "1" is selected, the gain changes to "Gain after gain switching 2" by the control command from the controller or input device. When "1" is set in [Pr. PB26.0] while "2" has been selected for this servo parameter, the gain changes to "Gain after gain switching 2" by the control command from the controller or the input device.
PB26.5	Gain switching selection during a stop 0: Gain switching 2 during a stop is disabled 1: Gain switching 2 during a stop is enabled This servo parameter is enabled in the following condition: [Pr. PB26.4] is set to "2" (the same condition as [Pr. PB26.0 Gain switching selection]) and [Pr. PB26.0] is set to "5" (command direction) in the position mode and the positioning mode.

■Combination of [Pr. PB26.0] and [Pr. PB26.1]

[Pr. PB26.1 Gain switching condition selection]	[Pr. PB26.0 Gain switching selection]				
	1	2	3	4	5
0	Gain after "Gain switching" is enabled with the signal ON	Gain after "Gain switching" is enabled with the condition value or more for gain switching			Gain after "Gain switching" is enabled with the negative direction command
1	Gain after "Gain switching" is enabled with the signal OFF	Gain after "Gain switching" is enabled with the condition value or less for gain switching			Gain after "Gain switching" is enabled with the positive direction command

[Pr. PB27 Gain switching condition], [Pr. PB65 Gain switching 2 condition]

When "2" (Command frequency), "3" (Droop pulses), or "4" (Servo motor speed) is selected in [Pr. PB26.0 Gain switching selection], set [Pr. PB27] for the level to switch the gain to "Gain switching".
When "2" (the same condition as [Pr. PB26.0]) is selected in [Pr. PB26.4 Gain switching 2 selection], set the level for switching the gain to "Gain switching 2" in [Pr. PB65].
The setting unit is shown in the following table.

Gain switching condition	Unit
Command frequency	[kpulse/s]
Droop pulses	[pulse]
Servo motor speed	[r/min]/[mm/s]

[Pr. PB28 Gain switching time constant], [Pr. PB66 Gain switching 2 time constant]

The primary delay filter can be set to each gain in gain switching. If the gain difference is too large at gain switching, use these servo parameters for purposes such as suppressing the shock applied to the machine.

Servo parameters that are changeable with the gain switching

Control gain	Before gain switching		After gain switching		After gain switching 2	
	Servo parameter	Symbol	Servo parameter	Symbol	Servo parameter	Symbol
Load to motor inertia ratio/load to motor mass ratio	PB06	GD2	PB29	GD2B	PB67	GD2C
Model control gain	PB07	PG1	PB60	PG1B	PB79	PG1C
Position control gain	PB08	PG2	PB30	PG2B	PB68	PG2C
Speed control gain	PB09	VG2	PB31	VG2B	PB69	VG2C
Speed integral compensation	PB10	VIC	PB32	VICB	PB70	VICC
Vibration suppression control 1 - Vibration frequency	PB19	VRF11	PB33	VRF1B	PB71	VRF1C
Vibration suppression control 1 - Resonance frequency	PB20	VRF12	PB34	VRF2B	PB72	VRF2C
Vibration suppression control 1 - Vibration frequency damping	PB21	VRF13	PB35	VRF3B	PB73	VRF3C
Vibration suppression control 1 - Resonance frequency damping	PB22	VRF14	PB36	VRF4B	PB74	VRF4C
Vibration suppression control 2 - Vibration frequency	PB52	VRF21	PB56	VRF21B	PB75	VRF21C
Vibration suppression control 2 - Resonance frequency	PB53	VRF22	PB57	VRF22B	PB76	VRF22C
Vibration suppression control 2 - Vibration frequency damping	PB54	VRF23	PB58	VRF23B	PB77	VRF23C
Vibration suppression control 2 - Resonance frequency damping	PB55	VRF24	PB59	VRF24B	PB78	VRF24C

[Pr. PB06] to [Pr. PB10]

These servo parameters are the same as in the manual mode. Set values for the load to motor inertia ratio, position control gain, model control gain, speed control gain and speed integral compensation before gain switching.

[Pr. PB19] to [Pr. PB22]/[Pr. PB52] to [Pr. PB55]

These servo parameters are the same as in the manual mode. Set values for the vibration frequency, resonance frequency, vibration frequency damping and resonance frequency damping before gain switching.

[Pr. PB29 Gain switching - Load to motor inertia ratio/load to motor mass ratio], [Pr. PB67 Gain switching 2 - Load to motor inertia ratio/load to motor mass ratio]

Set the load to motor inertia ratio after gain switching. If the load to motor inertia ratio does not change, set the same value as [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio].

[Pr. PB30 Gain switching - Position control gain], [Pr. PB68 Gain switching 2 - Position control gain]

Set the position control gain after gain switching.

[Pr. PB31 Gain switching - Speed control gain], [Pr. PB69 Gain switching 2 - Speed control gain]

Set the speed control gain after gain switching.

[Pr. PB32 Gain switching - Speed integral compensation], [Pr. PB70 Gain switching 2 - Speed integral compensation]

Set the speed integral compensation after gain switching.

[Pr. PB60 Gain switching - Model control gain], [Pr. PB79 Gain switching 2 - Model control gain]

Set the model control gain after gain switching.
These servo parameters are enabled when "1" is selected in [Pr. PB26.0 Gain switching selection], and the signal is turned on.

Vibration suppression control after gain switching ([Pr. PB33] to [Pr. PB36]/[Pr. PB56] to [Pr. PB59]), and Gain switching 2 - Vibration suppression control ([Pr. PB71] to [Pr. PB79])

Set the vibration suppression control after gain switching.
These servo parameters are enabled when "1" is selected in [Pr. PB26.0 Gain switching selection], and the signal is turned on.

Related objects

Objects in gain switching and gain switching 2

Using [Control DI1 (Obj. 2D01h)] and [Control DI5 (Obj. 2D05h)] can switch gains with the control command of the controller. In addition, using [Status DO1 (Obj. 2D11h)] and [Status DO5 (Obj. 2D15h)] can obtain the variable gain status.

Index	Sub	Object	Name	Description
2D01h	0	VAR	Control DI1	Bit 4: C_CDP (Gain switching)
2D05h	0	VAR	Control DI5	Bit 4: C_CDP2 (Gain switching 2)
2D11h	0	VAR	Status DO1	Bit 4: S_CDPS (Variable gain enabled)
2D15h	0	VAR	Status DO5	Bit 4: S_CDPS2 (Variable gain enabled 2)

5.4 Examples of gain switching operation

Gain switching by servo motor speed

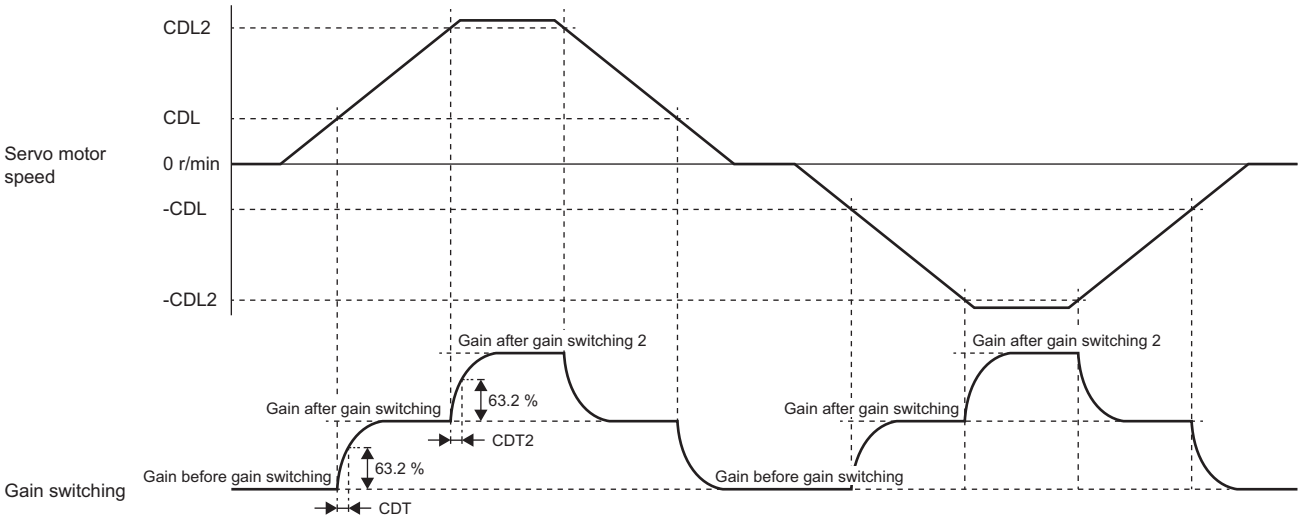
The following illustrates an example where [Pr. PB26.0 Gain switching selection] is set to "4" (servo motor speed) and [Pr. PB26.4 Gain switching 2 selection] is set to "2" (the same condition as [Pr. PB26.0 Gain switching selection]).

When [Pr. PB26.1 Gain switching condition selection] is set to "0" (enables the gain after gain switching when the value set in the conditions for gain switching is reached)

Depending on the values in [Pr. PB27 Gain switching condition] and [Pr. PB65 Gain switching 2 condition], the gain will switch as follows.

■When [Pr. PB65] ≥ [Pr. PB27]

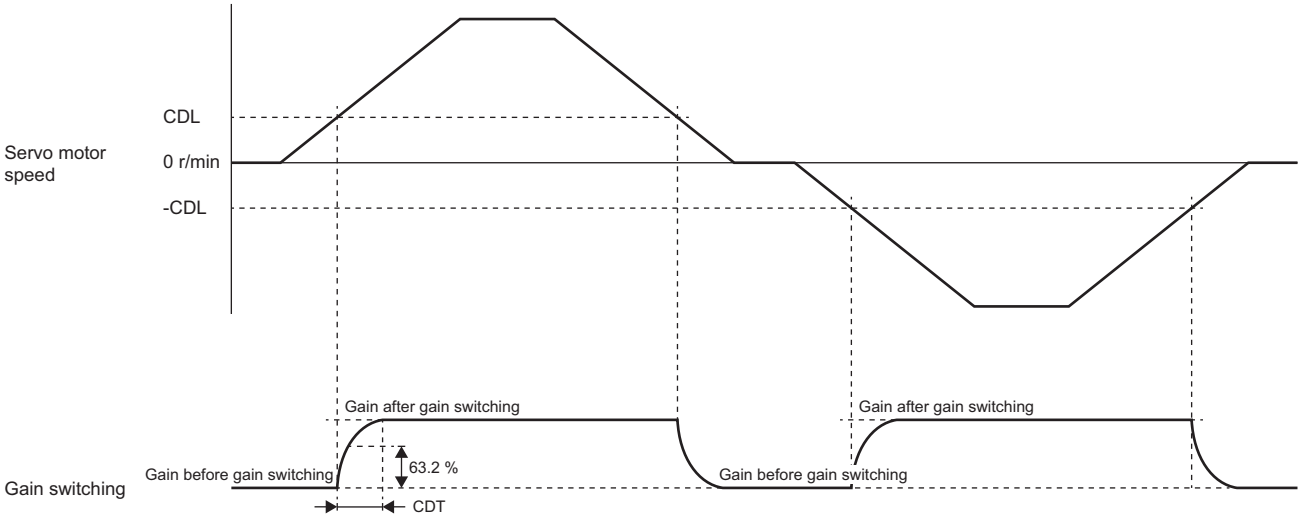
For the case of [Pr. PB65] ≥ [Pr. PB27], the gain switches to "Gain after gain switching" when the absolute value of the servo motor speed exceeds the value of [Pr. PB27]. In addition, when the absolute value of the servo motor speed exceeds the value of [Pr. PB65], the gain switches to "Gain after switching 2".



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB67]	→ [Pr. PB29]	→ [Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB67]	→ [Pr. PB29]	→ [Pr. PB06]	
Position control gain	[Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB68]	→ [Pr. PB30]	→ [Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB68]	→ [Pr. PB30]	→ [Pr. PB08]	
Speed control gain	[Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB69]	→ [Pr. PB31]	→ [Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB69]	→ [Pr. PB31]	→ [Pr. PB09]	
Speed integral compensation	[Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB70]	→ [Pr. PB32]	→ [Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB70]	→ [Pr. PB32]	→ [Pr. PB10]	

■When [Pr. PB65] is set to "0"

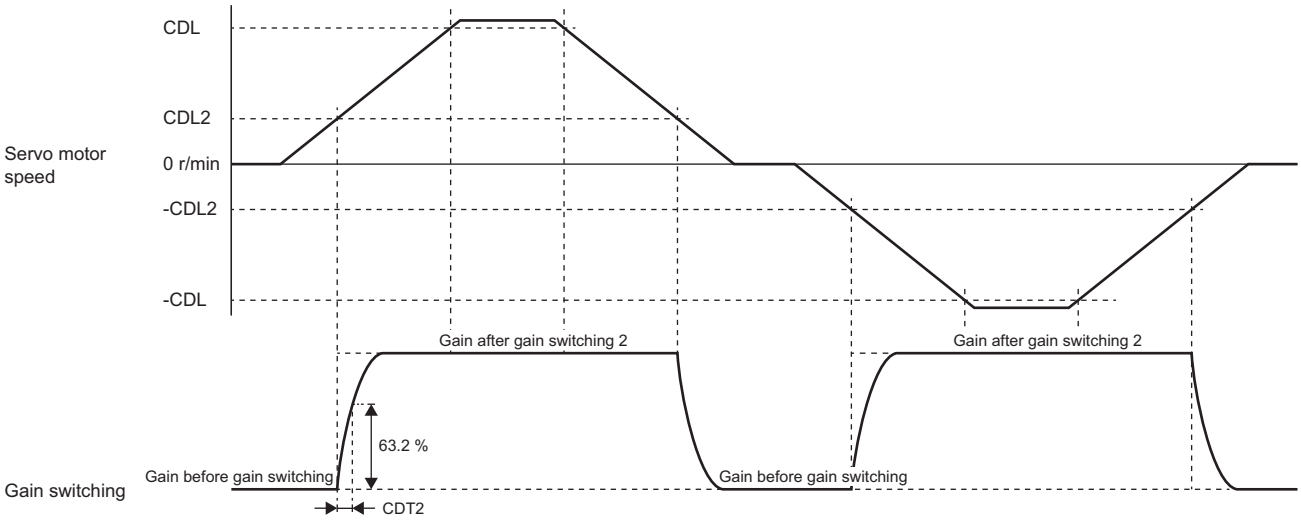
When [Pr. PB65] is set to "0", the gain does not switch to "Gain after gain switching 2". When the absolute value of the servo motor speed exceeds the value of [Pr. PB27], the gain switches.



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB06]
Position control gain	[Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB08]
Speed control gain	[Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB09]
Speed integral compensation	[Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB10]

■When [Pr. PB65] < [Pr. PB27]

For the case of [Pr. PB65] < [Pr. PB27], the gain does not switch to "Gain after gain switching". When the absolute value of the servo motor speed exceeds the value of [Pr. PB65], the gain switches to "Gain after gain switching 2". However, the gain does not switch to "Gain after gain switching" even when the absolute value exceeds the value of [Pr. PB27].



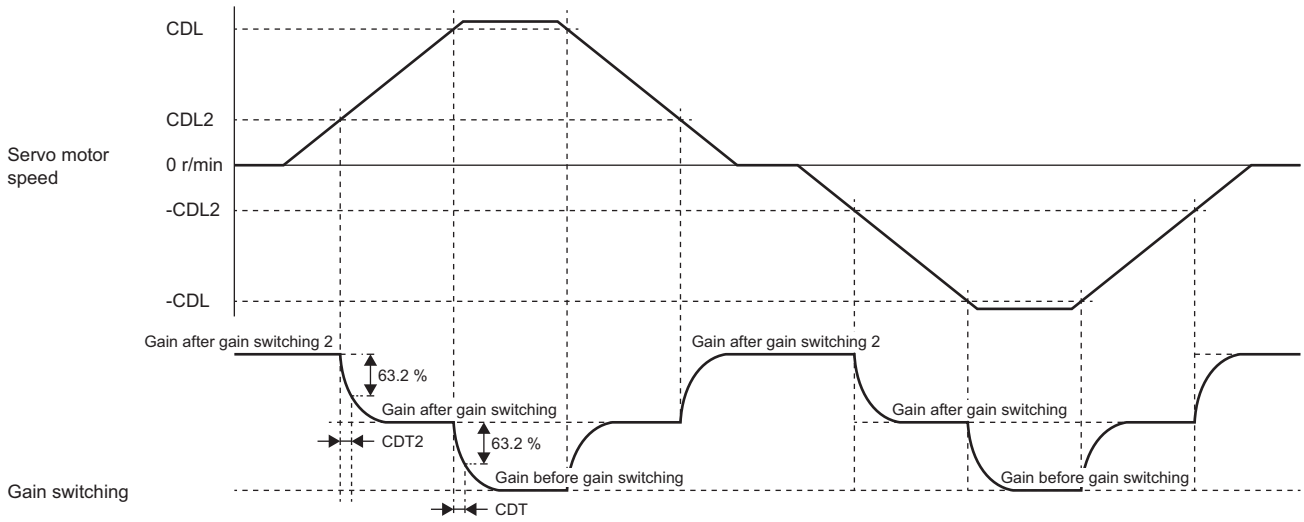
Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	→	[Pr. PB67]	→ [Pr. PB06]	→	[Pr. PB67]	→ [Pr. PB06]
Position control gain	[Pr. PB08]	→	[Pr. PB68]	→ [Pr. PB08]	→	[Pr. PB68]	→ [Pr. PB08]
Speed control gain	[Pr. PB09]	→	[Pr. PB69]	→ [Pr. PB09]	→	[Pr. PB69]	→ [Pr. PB09]
Speed integral compensation	[Pr. PB10]	→	[Pr. PB70]	→ [Pr. PB10]	→	[Pr. PB70]	→ [Pr. PB10]

When [Pr. PB26.1 Gain switching condition selection] is set to "1" (enables the gain after gain switching even when the value set in the conditions for gain switching is not reached)

Depending on the values in [Pr. PB27 Gain switching condition] and [Pr. PB65 Gain switching 2 condition], the gain will switch as follows.

■When [Pr. PB65] ≤ [Pr. PB27]

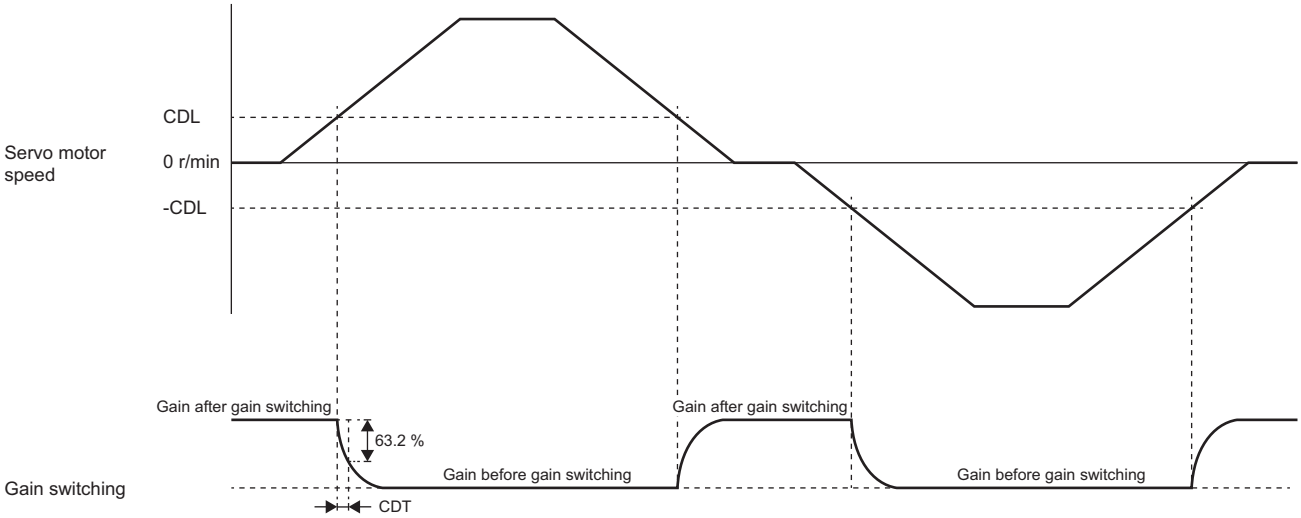
For the case of [Pr. PB65] ≤ [Pr. PB27], the gain switches to "Gain after gain switching 2" when the absolute value of the servo motor speed is less than the value of [Pr. PB65]. In addition, when the absolute value of the servo motor speed exceeds the value of [Pr. PB65] and less than the value of [Pr. PB27], the gain switches to "Gain after gain switching". When the absolute value of the servo motor speed is equal to or more than the value of [Pr. PB27], "Gain before gain switching" is used.



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB67]	→ [Pr. PB29]	→ [Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB67]	→ [Pr. PB29]	→ [Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB67]	
Position control gain	[Pr. PB68]	→ [Pr. PB30]	→ [Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB68]	→ [Pr. PB30]	→ [Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB68]	
Speed control gain	[Pr. PB69]	→ [Pr. PB31]	→ [Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB69]	→ [Pr. PB31]	→ [Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB69]	
Speed integral compensation	[Pr. PB70]	→ [Pr. PB32]	→ [Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB70]	→ [Pr. PB32]	→ [Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB70]	

■When [Pr. PB65] is set to "0"

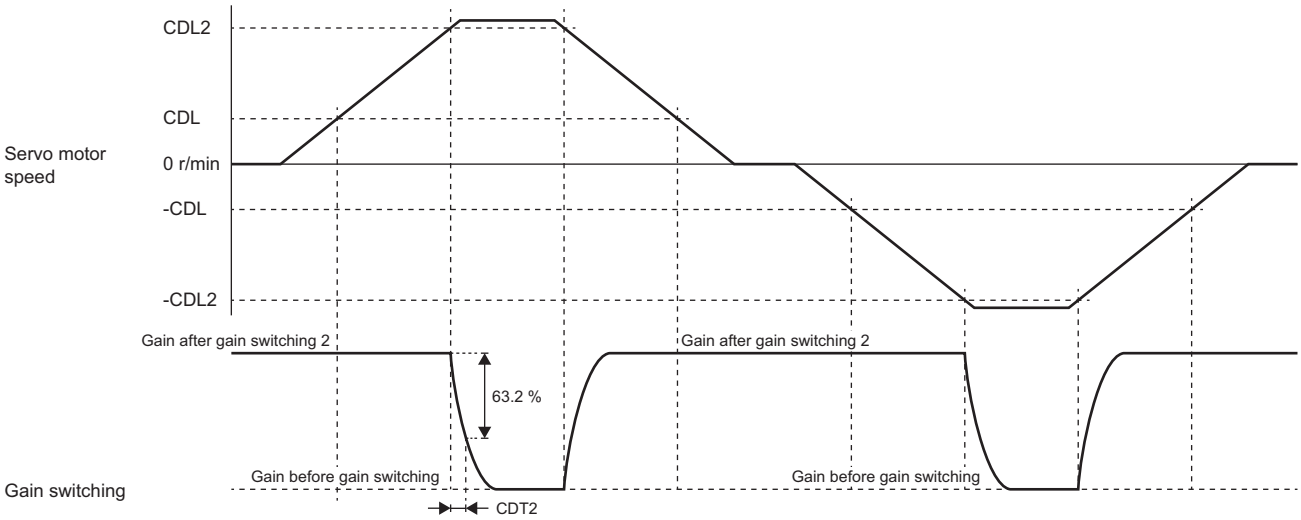
When [Pr. PB65] is set to "0", the gain does not switch to "Gain after gain switching 2". When the absolute value of the servo motor speed is less than the value of [Pr. PB27], the gain switches to "Gain after gain switching".



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB29]	→ [Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB06]	→ [Pr. PB29]
Position control gain	[Pr. PB30]	→ [Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB08]	→ [Pr. PB30]
Speed control gain	[Pr. PB31]	→ [Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB09]	→ [Pr. PB31]
Speed integral compensation	[Pr. PB32]	→ [Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB10]	→ [Pr. PB32]

■When [Pr. PB65] > [Pr. PB27]

For the case of [Pr. PB65] > [Pr. PB27], the gain does not switch to "Gain after gain switching". When the absolute value of the servo motor speed is less than the value of [Pr. PB65], the gain switches to "Gain after gain switching 2". However, the gain does not switch to "Gain after gain switching" even when the absolute value is less than the value of [Pr. PB27].

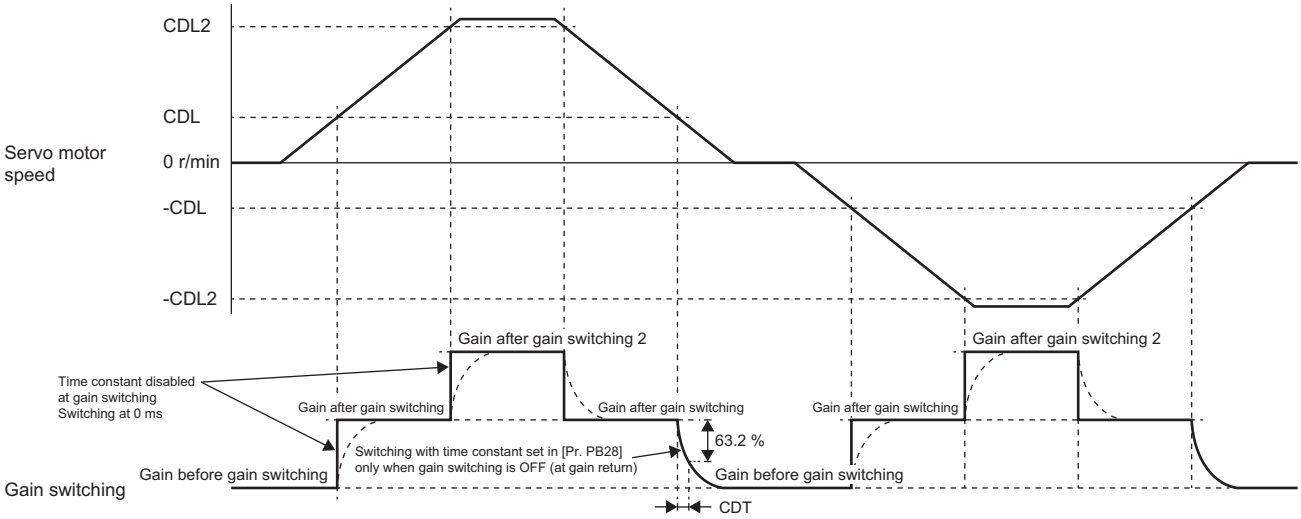


Load to motor inertia ratio/load to motor mass ratio	[Pr. PB67] →	[Pr. PB06]	→ [Pr. PB67] →	→ [Pr. PB06]	→ [Pr. PB67]
Position control gain	[Pr. PB68] →	[Pr. PB08]	→ [Pr. PB68] →	→ [Pr. PB08]	→ [Pr. PB68]
Speed control gain	[Pr. PB69] →	[Pr. PB09]	→ [Pr. PB69] →	→ [Pr. PB09]	→ [Pr. PB69]
Speed integral compensation	[Pr. PB70] →	[Pr. PB10]	→ [Pr. PB70] →	→ [Pr. PB10]	→ [Pr. PB70]

When "Time constant disabled at switching" is selected in "Gain switching time constant - Disabling condition selection"

The time constant is disabled at gain switching. The time constant becomes enabled at gain return.

The following illustrates an example where [Pr. PB26.0 Gain switching selection] is set to "4" (Servo motor speed).

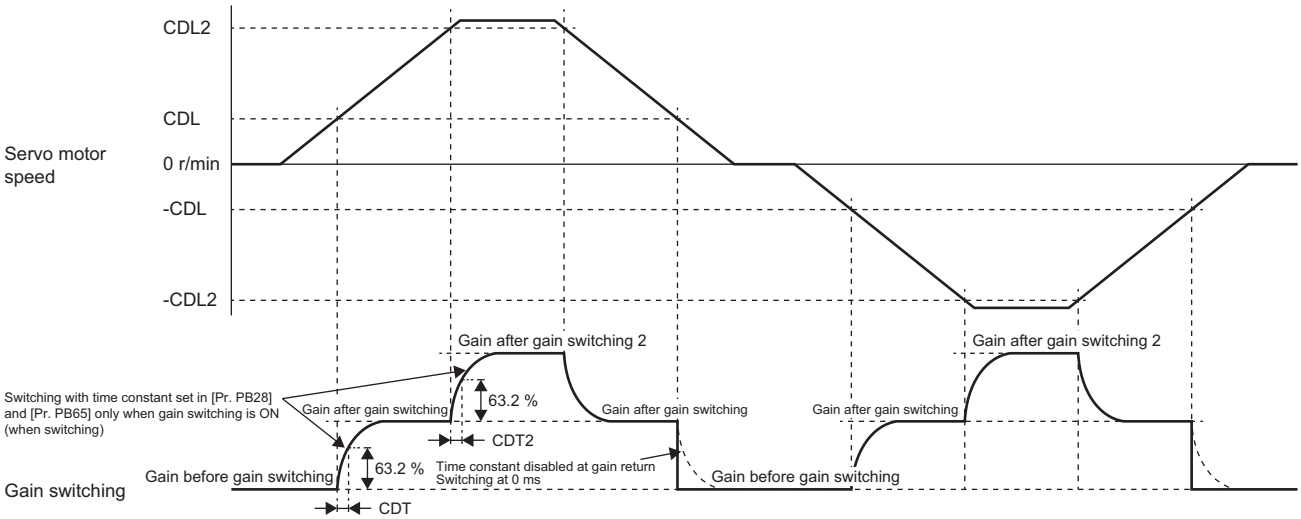


Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB67]	→ [Pr. PB29]	→ [Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB67]	→ [Pr. PB29]	→ [Pr. PB06]
Position control gain	[Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB68]	→ [Pr. PB30]	→ [Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB68]	→ [Pr. PB30]	→ [Pr. PB08]
Speed control gain	[Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB69]	→ [Pr. PB31]	→ [Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB69]	→ [Pr. PB31]	→ [Pr. PB09]
Speed integral compensation	[Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB70]	→ [Pr. PB32]	→ [Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB70]	→ [Pr. PB32]	→ [Pr. PB10]

When "Time constant disabled at return" is selected in "Gain switching time constant - Disabling condition selection"

The time constant is enabled at gain switching. The time constant becomes disabled at gain return.

The following illustrates an example where [Pr. PB26.0 Gain switching selection] is set to "4" (Servo motor speed).



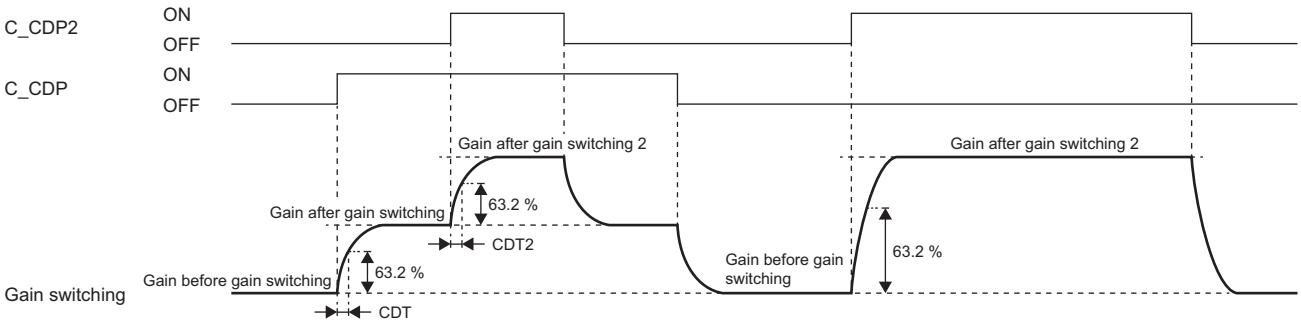
Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB67]	→ [Pr. PB29]	→ [Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB67]	→ [Pr. PB29]	→ [Pr. PB06]
Position control gain	[Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB68]	→ [Pr. PB30]	→ [Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB68]	→ [Pr. PB30]	→ [Pr. PB08]
Speed control gain	[Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB69]	→ [Pr. PB31]	→ [Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB69]	→ [Pr. PB31]	→ [Pr. PB09]
Speed integral compensation	[Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB70]	→ [Pr. PB32]	→ [Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB70]	→ [Pr. PB32]	→ [Pr. PB10]

Gain switching by signals (CDP/C_CDP/CDP2/C_CDP2)

The following illustrates an example where [Pr. PB26.0 Gain switching selection] is set to "1".

Gain switching by control commands from the controller

The following shows the timing chart.



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	→ [Pr. PB29]	→ [Pr. PB67]	→ [Pr. PB29]	→ [Pr. PB06]	→	[Pr. PB67]	→ [Pr. PB06]
Model control gain	[Pr. PB07]	→ [Pr. PB60]	→ [Pr. PB79]	→ [Pr. PB60]	→ [Pr. PB07]	→	[Pr. PB79]	→ [Pr. PB07]
Position control gain	[Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB68]	→ [Pr. PB30]	→ [Pr. PB08]	→	[Pr. PB68]	→ [Pr. PB08]
Speed control gain	[Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB69]	→ [Pr. PB31]	→ [Pr. PB09]	→	[Pr. PB69]	→ [Pr. PB09]
Speed integral compensation	[Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB70]	→ [Pr. PB32]	→ [Pr. PB10]	→	[Pr. PB70]	→ [Pr. PB10]
Vibration suppression control 1 - Vibration frequency	[Pr. PB19]	→ [Pr. PB33]	→ [Pr. PB71]	→ [Pr. PB33]	→ [Pr. PB19]	→	[Pr. PB71]	→ [Pr. PB19]
Vibration suppression control 1 - Resonance frequency	[Pr. PB20]	→ [Pr. PB34]	→ [Pr. PB72]	→ [Pr. PB34]	→ [Pr. PB20]	→	[Pr. PB72]	→ [Pr. PB20]
Vibration suppression control 1 - Vibration frequency/damping coefficient	[Pr. PB21]	→ [Pr. PB35]	→ [Pr. PB73]	→ [Pr. PB35]	→ [Pr. PB21]	→	[Pr. PB73]	→ [Pr. PB21]
Vibration suppression control 1 - Resonance frequency/damping coefficient	[Pr. PB22]	→ [Pr. PB36]	→ [Pr. PB74]	→ [Pr. PB36]	→ [Pr. PB22]	→	[Pr. PB74]	→ [Pr. PB22]
Vibration suppression control 2 - Vibration frequency	[Pr. PB52]	→ [Pr. PB56]	→ [Pr. PB75]	→ [Pr. PB56]	→ [Pr. PB52]	→	[Pr. PB75]	→ [Pr. PB52]
Vibration suppression control 2 - Resonance frequency	[Pr. PB53]	→ [Pr. PB57]	→ [Pr. PB76]	→ [Pr. PB57]	→ [Pr. PB53]	→	[Pr. PB76]	→ [Pr. PB53]
Vibration suppression control 2 - Vibration frequency/damping coefficient	[Pr. PB54]	→ [Pr. PB58]	→ [Pr. PB77]	→ [Pr. PB58]	→ [Pr. PB54]	→	[Pr. PB77]	→ [Pr. PB54]
Vibration suppression control 2 - Resonance frequency/damping coefficient	[Pr. PB55]	→ [Pr. PB59]	→ [Pr. PB78]	→ [Pr. PB59]	→ [Pr. PB55]	→	[Pr. PB78]	→ [Pr. PB55]

Gain switching by command directions

The following illustrates an example where [Pr. PB26.0 Gain switching selection] is set to "5" (command direction) and [Pr. PB26.4 Gain switching 2 selection] is set to "2" (the same condition as [Pr. PB26.0]).
The gain switches depending on the command direction of a command pulse frequency and a speed command. A positive direction for the command direction is CCW regardless of the setting in [Pr. PA14 Travel direction selection].
When switching the gain by the command direction, the operation condition varies depending on whether "Gain switching during a stop" is enabled or disabled. However, gain switching during a stop is enabled only in position mode and positioning mode. Refer to the following table for details.

- In the position mode and positioning mode

[Pr. PB26.5 Gain switching selection during a stop]	Command pulse frequency			
	Forward rotation (CCW) or positive direction	0 and INP is turned off	0 and INP is turned on	Reverse rotation (CW) or negative direction
0	Before gain switching	The current gain value is retained	The current gain value is retained	After gain switching
1	Before gain switching	The current gain value is retained	After gain switching 2 *1	After gain switching

*1 If the mode is switched to the velocity mode while 0 and INP are turned on, the "Gain after gain switching 2" is retained even after switching the mode.

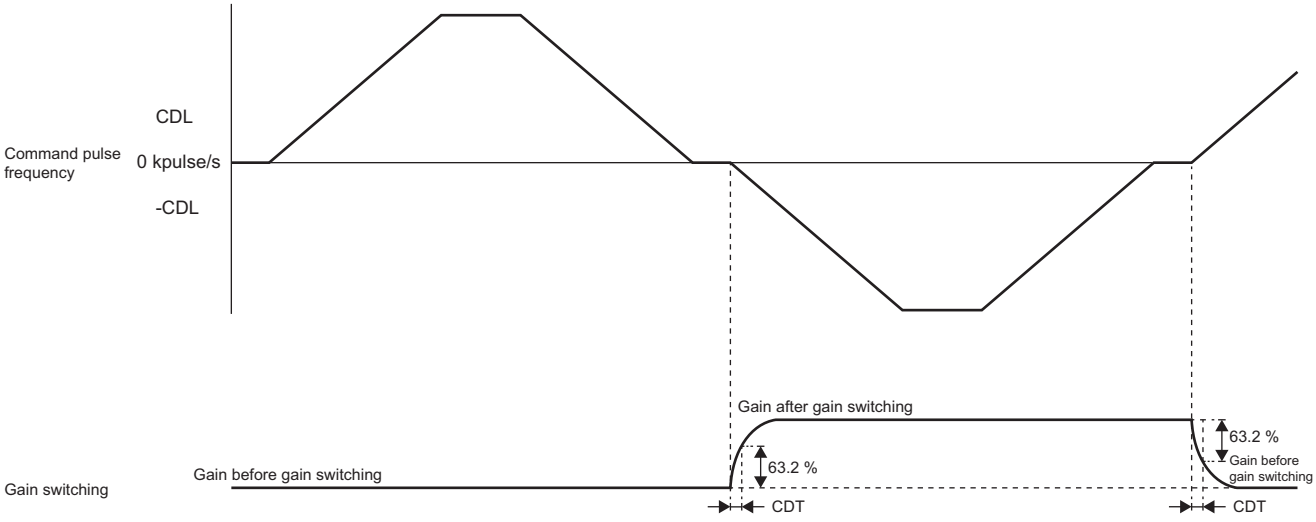
- In the velocity mode

[Pr. PB26.5 Gain switching selection during a stop]	Speed command			
	Forward rotation (CCW) or positive direction	0, and ZSP is turned off	0, and ZSP is turned on	Reverse rotation (CW) or negative direction
0	Before gain switching	The current gain value is retained	The current gain value is retained	After gain switching
1	Before gain switching	The current gain value is retained	The current gain value is retained *1	After gain switching

*1 If the mode is switched to the position mode, the gain changes to the "Gain after gain switching 2".

When gain switching 2 during a stop is disabled

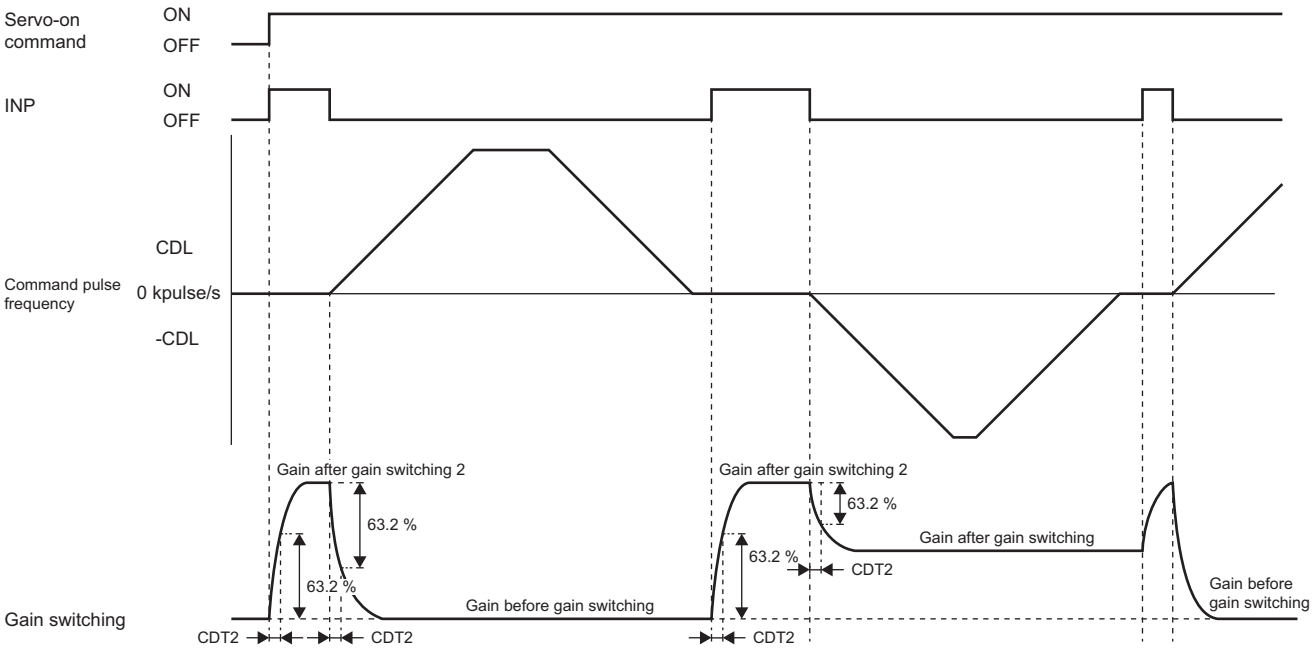
The timing chart of gain switching when the "Gain switching 2 during a stop" is disabled is shown as follows: In the velocity mode, replace the command pulse frequency with the speed command.



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	→	[Pr. PB29]	→	[Pr. PB06]
Position control gain	[Pr. PB08]	→	[Pr. PB30]	→	[Pr. PB08]
Speed control gain	[Pr. PB09]	→	[Pr. PB31]	→	[Pr. PB09]
Speed integral compensation	[Pr. PB10]	→	[Pr. PB32]	→	[Pr. PB10]

When gain switching 2 during a stop is enabled

The timing chart of gain switching when the "Gain switching 2 during a stop" is enabled is shown as follows:

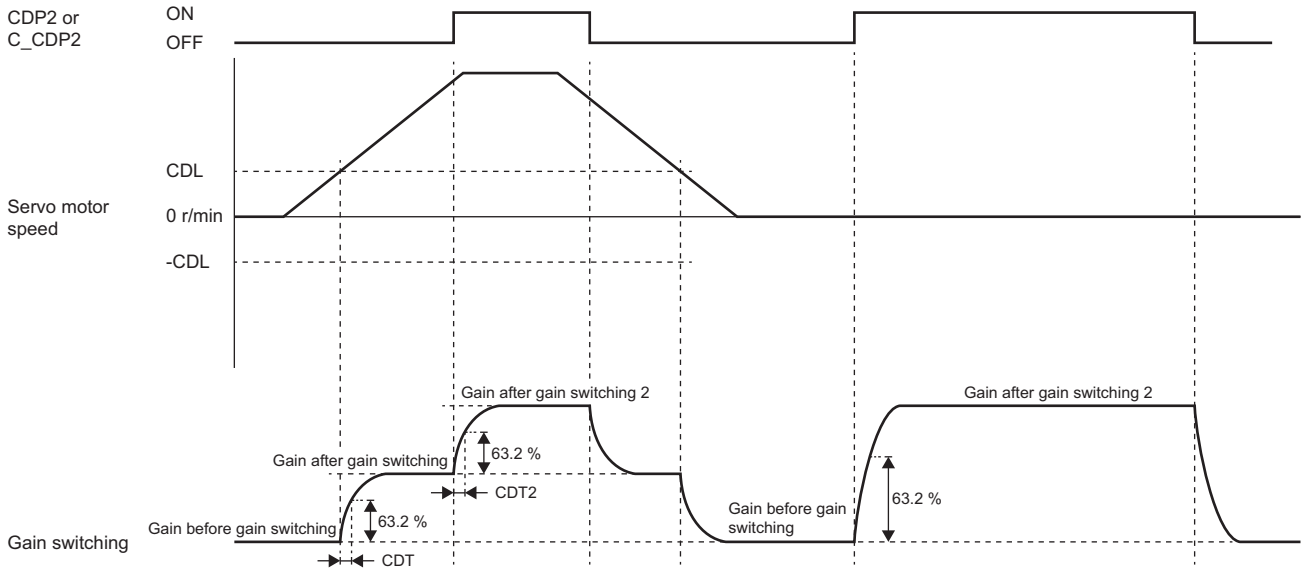


Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06] → [Pr. PB67] → [Pr. PB06]	→ [Pr. PB67]	→ [Pr. PB29]	→	[Pr. PB06]
Position control gain	[Pr. PB08] → [Pr. PB68] → [Pr. PB08]	→ [Pr. PB68]	→ [Pr. PB30]	→	[Pr. PB08]
Speed control gain	[Pr. PB09] → [Pr. PB69] → [Pr. PB09]	→ [Pr. PB69]	→ [Pr. PB31]	→	[Pr. PB09]
Speed integral compensation	[Pr. PB10] → [Pr. PB70] → [Pr. PB10]	→ [Pr. PB70]	→ [Pr. PB32]	→	[Pr. PB10]

Gain switching by servo motor speed and gain switching 2 (CDP2/C_CDP2)

The following illustrates an example where [Pr. PB26.0 Gain switching selection] is set to "4" (servo motor speed) and [Pr. PB26.4 Gain switching 2 selection] is set to "1" (signal (CDP2/C_CDP2)).

In this case, the setting of [Pr. PB65 Gain switching 2 condition] is disabled, and "Gain switching 2" can be enabled/disabled by turning on/off Bit 4 (C_CDP2) of [Control DI 5 (Obj. 2D05h)] or the input device CDP2 (Gain switching 2). In addition, gain switching 2 vibration suppression control ([Pr. PB71] to [Pr. PB74]/[Pr. PB75] to [Pr. PB78]) and [Pr. PB79 Gain switching 2 - Model control gain] are used while Bit 4 (C_CDP2) of [Control DI 5 (Obj. 2D05h)] or the input device CDP2 (Gain switching 2) is on.



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	→	→ [Pr. PB67]	→ [Pr. PB06]		→	[Pr. PB67]	→ [Pr. PB06]
Model control gain	[Pr. PB07]	→	→ [Pr. PB79]	→ [Pr. PB07]		→	[Pr. PB79]	→ [Pr. PB07]
Position control gain	[Pr. PB08]	→ [Pr. PB30]	→ [Pr. PB68]	→ [Pr. PB30]	→ [Pr. PB08]	→	[Pr. PB68]	→ [Pr. PB08]
Speed control gain	[Pr. PB09]	→ [Pr. PB31]	→ [Pr. PB69]	→ [Pr. PB31]	→ [Pr. PB09]	→	[Pr. PB69]	→ [Pr. PB09]
Speed integral compensation	[Pr. PB10]	→ [Pr. PB32]	→ [Pr. PB70]	→ [Pr. PB32]	→ [Pr. PB10]	→	[Pr. PB70]	→ [Pr. PB10]
Vibration suppression control 1 - Vibration frequency	[Pr. PB19]	→	→ [Pr. PB71]	→ [Pr. PB19]		→	[Pr. PB71]	→ [Pr. PB19]
Vibration suppression control 1 - Resonance frequency	[Pr. PB20]	→	→ [Pr. PB72]	→ [Pr. PB20]		→	[Pr. PB72]	→ [Pr. PB20]
Vibration suppression control 1 - Vibration frequency/damping coefficient	[Pr. PB21]	→	→ [Pr. PB73]	→ [Pr. PB21]		→	[Pr. PB73]	→ [Pr. PB21]
Vibration suppression control 1 - Resonance frequency/damping coefficient	[Pr. PB22]	→	→ [Pr. PB74]	→ [Pr. PB22]		→	[Pr. PB74]	→ [Pr. PB22]
Vibration suppression control 2 - Vibration frequency	[Pr. PB52]	→	→ [Pr. PB75]	→ [Pr. PB52]		→	[Pr. PB75]	→ [Pr. PB52]
Vibration suppression control 2 - Resonance frequency	[Pr. PB53]	→	→ [Pr. PB76]	→ [Pr. PB53]		→	[Pr. PB76]	→ [Pr. PB53]
Vibration suppression control 2 - Vibration frequency/damping coefficient	[Pr. PB54]	→	→ [Pr. PB77]	→ [Pr. PB54]		→	[Pr. PB77]	→ [Pr. PB54]
Vibration suppression control 2 - Resonance frequency/damping coefficient	[Pr. PB55]	→	→ [Pr. PB78]	→ [Pr. PB55]		→	[Pr. PB78]	→ [Pr. PB55]

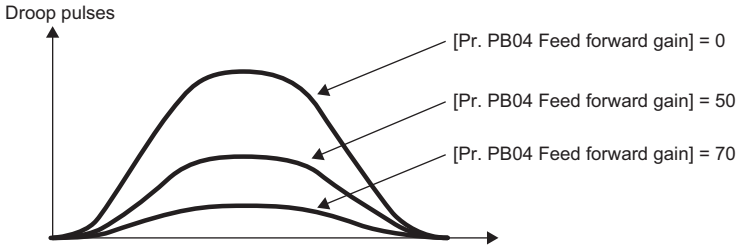
6 SPEED FEED FORWARD CONTROL FUNCTION

This function calculates a speed command required to drive the servo motor based on the position command in the position mode and positioning mode, and preset the calculated speed command to decrease the droop pulses at a constant speed. This function is recommended for increasing the path accuracy and shortening the settling time.

6.1 Method for setting the speed feed forward

Setting a value in [Pr. PB04 Feed forward gain] enables the speed feed forward.
The droop pulses at a constant speed decrease in accordance with the value in [Pr. PB04], as shown in the following.

$$\text{Number of droop pulses [pulse]} = \frac{\text{Position command frequency [pulse/s]}}{\text{Model control gain setting value}} \times \frac{\text{100 - Feed forward gain [\%]}}{\text{100}}$$



When [Pr. PB04] is set to "100", a large overshoot occurs at acceleration/deceleration although the droop pulses at a constant speed become "0".

MEMO

7 OVERSHOOT SUPPRESSION CONTROL

Overshoot suppression control is a function that decreases overshoot at positioning for machines with high friction. Use this function when the overshoot does not decrease even after adjusting [Pr. PB07 Model control gain].

7.1 Restrictions on overshoot suppression control

- Overshoot suppression control is enabled only in position mode and positioning mode.
- When [Pr. PB25.0 Model adaptive control selection] is set to "2" (disabled (PID control)), overshoot suppression control cannot be used.

7.2 Settings of the overshoot suppression control

When using overshoot suppression control, set the dynamic friction torque in relation to the rated torque at the servo motor rated speed in [Pr. PB12 Overshoot amount compensation] in percentage unit. Alternatively, set a percentage of dynamic friction force against the continuous thrust at linear servo motor rated speed. If the response level is low and the torque/thrust is limited, the efficiency of overshoot suppression control may decrease.
Calculate the dynamic friction torque or thrust in relation to the servo motor rated speed from the torque at constant speed.

$$\text{Dynamic friction torque at servo motor rated speed/Thrust [\%]} = \text{Torque at constant speed [\%]} \times \frac{\text{Servo motor speed at constant speed [r/min]}}{\text{Servo motor rated speed [r/min]}}$$

MEMO

8 SLIGHT VIBRATION SUPPRESSION CONTROL

This function suppresses the variation of the pulses generated at each servo motor stop.

8.1 Restrictions on the slight vibration suppression control

- Slight vibration suppression control is enabled only in the position mode and positioning mode.
- Slight vibration suppression control is enabled when [Pr. PA08.0 Gain adjustment mode selection] is set to "3" (manual mode).

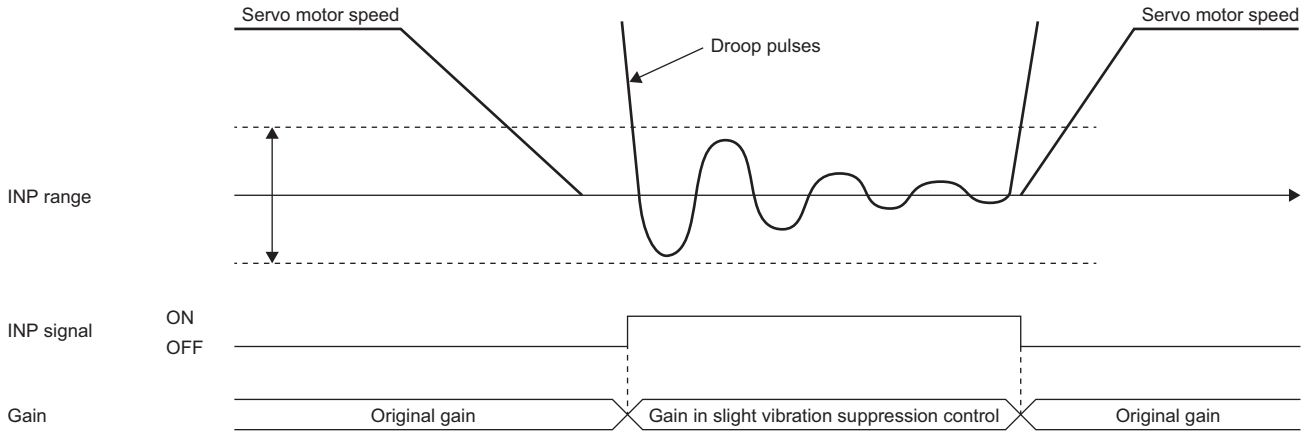
8.2 Settings of the slight vibration suppression control

When using slight vibration suppression control, set the following servo parameters.

Servo parameter	Description
PB24.0	Slight vibration suppression control selection 0: Disabled 1: Enabled

8.3 Operation of slight vibration suppression control

The slight vibration suppression control function changes the gain from the rising edge position of INP (In-position) OFF to ON to suppress the variation of the pulses generated at a servo motor stop. When slight vibration suppression control is enabled, the gain is calculated automatically in the servo amplifier. If the droop pulses exceed the in-position range while driving the servo motor, the gain changes back to the original gain.



MEMO

9 UNBALANCED TORQUE OFFSET

For a vertical axis, the effects of gravity cause unbalanced torque. Therefore, the vertical axis may fall slightly immediately after servo-on. To prevent the vertical axis from falling, the unbalanced torque of a machine can be set as an unbalanced torque offset to cancel the unbalanced torque. For machines where unbalanced torque does not occur, setting the unbalanced torque offset is unnecessary.

9.1 Setting unbalanced torque offset

Set the unbalanced torque offset using the following procedure.

Automatic setting

1. Servo parameter setting

Set [Pr. PE41.6 Unbalanced torque offset setting selection] to "1" (automatic setting).

2. Estimating friction

Complete friction estimation for both the forward and reverse rotations.

For the procedure of friction estimation, refer to "Vibration estimation function" in the following manual.

📖MR-JET User's Manual (Function)

Once friction estimation is complete for both the forward and reverse rotations, the value of [Pr. PE47 Unbalanced torque offset] will be set automatically according to the estimated friction value.

Manual setting

1. Servo parameter setting

Set [Pr. PE41.6 Unbalanced torque offset setting selection] to "0" (manual setting).

2. Measure the torque

Use MR Configurator2 to measure the torque in the forward direction feed and reverse direction feed.

3. Setting an unbalanced torque offset

Calculate unbalanced torque from the measurement result of the torque, then set the unbalanced torque value in [Pr. PE47 Unbalanced torque offset].

$$\text{Unbalanced torque [\%]} = \frac{\text{(Torque in forward direction feed [\%])} + \text{(Torque in reverse direction feed [\%])}}{2}$$

MEMO

10 MODEL ADAPTIVE CONTROL

This function enables control according to the ideal model that is both stable and highly responsive. The two-degrees-of-freedom model adaptive control enables the response to be set to the command and to the disturbance separately. This function is enabled by default. Refer to the following for disabling this function.

☞ Page 96 Disabling model adaptive control

10.1 Setting model adaptive control

The characteristics of the model adaptive control is changeable with [Pr. PA24.0 Vibration suppression mode selection]. For performing path tracking, set "4" (path tracking mode). This setting improves the path accuracy. Refer to the following for details.

☞ Page 98 Path tracking model adaptive control

Servo parameter	Description
PA24.0	Vibration suppression mode selection 0: Standard mode 1: 3 inertia mode 2: Low response mode 4: Path tracking mode

10.2 Disabling model adaptive control

The servo amplifier has model adaptive control. The servo amplifier with model adaptive control uses a virtual motor model inside the servo amplifier and drives the servo motor following the output of the motor model. Disabling model adaptive control means to drive the servo motor with PID control instead.

The following shows the available servo parameters when model adaptive control is disabled.

Servo parameter	Symbol	Name
PB08	PG2	Position control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation

Instructions on disabling model adaptive control

- The following functions are not available when model adaptive control is disabled.

Function	Servo parameter	Explanation
Forced stop deceleration function	PA04	When the forced stop deceleration function is enabled, disabling the model adaptive control triggers [AL. 037 Parameter error]. The forced stop deceleration function is enabled at the factory setting. Set [Pr. PA04.3 Forced stop deceleration function selection] to "0" (forced stop deceleration function disabled).
Vibration suppression control 1	PB02/PB19/PB20	Vibration suppression control uses model adaptive control. Therefore, vibration suppression control cannot be used when model adaptive control is disabled.
Vibration suppression control 2	PB02/PB52/PB53	
Overshoot amount compensation	PB12	The overshoot amount compensation uses data which are also used by model adaptive control. Therefore, the overshoot amount compensation is disabled when model adaptive control is disabled.
Super trace control	PA22	The super trace control uses the model adaptive control. Disabling the model adaptive control will also disable the super trace control.

- Change the servo parameters only when the servo motor is at a stop.
- When setting auto tuning response ([Pr. PA09]), change the setting value one by one to adjust with checking operation status of the servo motor.

How to disable model adaptive control

When disabling model adaptive control, set [Pr. PB25.0 Model adaptive control selection] to "2" (disabled (PID control)).

Servo parameter	Description
PB25.0	Model adaptive control selection 0: Enabled (model adaptive control) 2: Disabled (PID control)

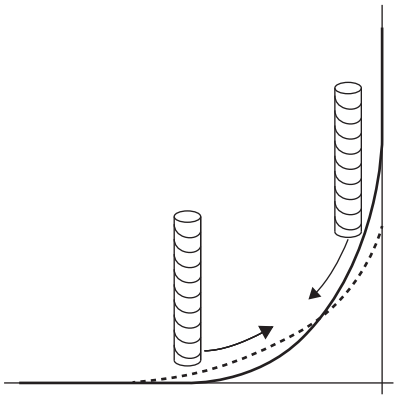
11 PATH CONTROL FUNCTION

For machines that require a high path accuracy, such as processors, the following functions enables the path accuracy to be improved.

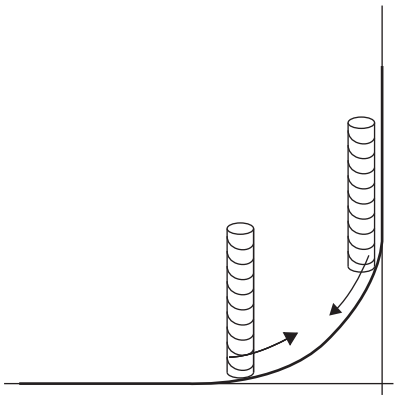
11.1 Path tracking model adaptive control

Model adaptive control reduces the settling time in positioning control, and path tracking model adaptive control reduces the overshoot and improves path accuracy. Use this function on machines that require a high path accuracy, such as processors. In addition, path-tracking model adaptive control reduces tracking errors in reciprocation.

- When [Pr. PA24.0 Vibration suppression mode selection] is set to a value other than "4"



- When [Pr. PA24.0 Vibration suppression mode selection] is set to "4"



Setting the path tracking model adaptive control

When using the path tracking model adaptive control, set [Pr. PA24.0 Vibration suppression mode selection] to "4" (path tracking mode).

Servo parameter	Description
PA24.0	Vibration suppression mode selection 0: Standard mode 1: 3 inertia mode 2: Low response mode 4: Path tracking mode

Operation of path tracking model adaptive control

In path tracking model adaptive control, changing the characteristics of model adaptive control enables the overshoot to be suppressed when the servo motor stops. When [Pr. PA24.0 Vibration suppression mode selection] is set to "0" (standard mode), "1" (3 inertia mode), or "2" (low response mode), shortening the settling time during positioning is prioritized; when set to "4" (path tracking mode), path smoothing is prioritized. Setting "4" (path tracking mode) enables the overshoot to be suppressed without a precise adjustment of [Pr. PB07 Model control gain].

11.2 Super trace control

Super trace control is a function that uses the ideal model inside the servo amplifier to reduce droop pulses at the uniform acceleration/deceleration to almost 0. Use this function on machines that require a high path accuracy, such as processors.

Restrictions on super trace control

- Super trace control is enabled only in position mode and positioning mode.
- When [Pr. PB25.0 Model adaptive control selection] is set to "2" (disabled (PID control)), super trace control cannot be used.

Instructions on super trace control

- When using super trace control, use the speed feed forward control function as well.
- In super trace control, INP (in-position) may remain on because the droop pulses become close to 0 during the servo motor control. Change [Pr. PD13.2 INP output signal ON condition selection] to "1" (within the in-position range and at the completion of command output).
- When using super trace control, it is recommended that the acceleration time constant up to the rated speed be set to 1 s or more.

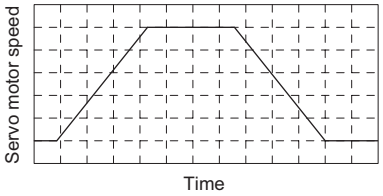
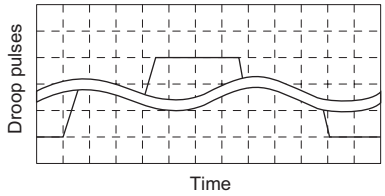
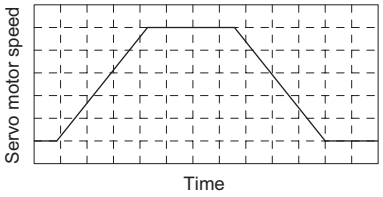
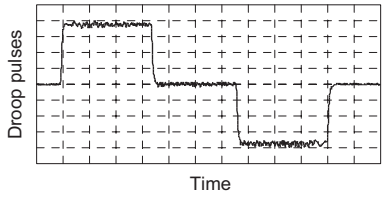
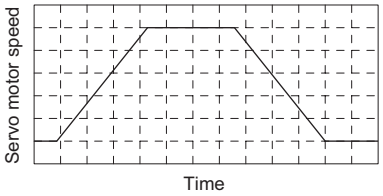
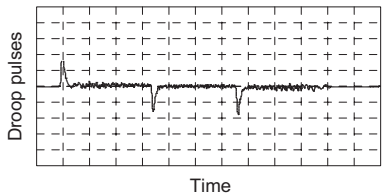
Setting the super trace control

The adjustment procedure for super trace control is as follows.

Procedure	Operation
1	Perform gain adjustment with quick tuning, one-touch tuning, auto tuning, or other means. ☞ Page 13 Quick tuning ☞ Page 17 One-touch tuning ☞ Page 34 Auto tuning mode 1
2	Change [Pr. PA08.0 Gain adjustment mode selection] to "3" (manual mode).
3	Change [Pr. PB04 Feed forward gain] and perform adjustment so that the droop pulses become 0 at the constant speed.
4	Change [Pr. PD13.2 INP output signal ON condition selection] to "1" (within the in-position range and at the completion of command output).
5	Change [Pr. PA22.1 Super trace control function selection] to "2" (enabled).
6	Change [Pr. PB07 Model control gain] to adjust the droop pulses at acceleration/deceleration.

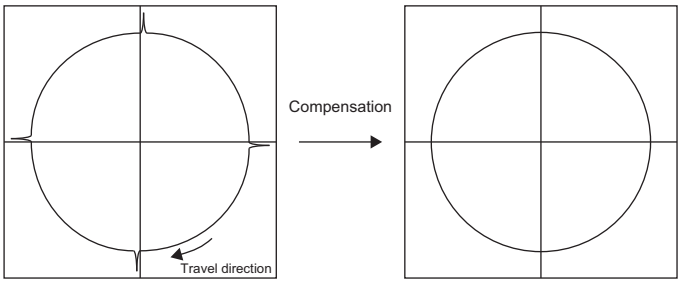
Operation of super trace control

Super trace control uses the ideal model held inside the servo amplifier to compensate for droop pulses at the constant speed and at uniform acceleration/deceleration which the feed forward gain could not reduce to 0.

Control	Position command (the same command)	Droop pulses
Normal control		 Droop pulses are always generated
Feed forward gain		 Droop pulses are generated at acceleration/deceleration
Super trace control		 Droop pulses are almost 0 at any time including acceleration/deceleration

11.3 Lost motion compensation function

The lost motion compensation function improves the response delay (caused by a non-sensitive band due to friction, twist, expansion, and backlash) generated when the machine travel direction is reversed. With this function, protrusions at a quadrant change and streaks at a quadrant change during circular cutting can be improved.
This function is effective when high path trackability is required, such as drawing an arc with an XY table.



Trace before compensation　　Trace after compensation

Restrictions on the lost motion compensation function

The lost motion compensation is enabled in the position mode and positioning mode.

Setting the lost motion compensation function

Set the lost motion compensation using the following procedure.

Lost motion compensation function selection ([Pr. PE48])

Select the lost motion compensation function.

Servo parameter	Description
PE48.0	Lost motion compensation type selection 0: Lost motion compensation disabled 1: Lost motion compensation enabled
PE48.1	Lost motion compensation dead band unit setting 0: 1 pulse unit 1: 1 kpulse unit

Lost motion compensation amount ([Pr. PE44]/[Pr. PE45])

Set the same value for the lost motion compensation amount for both the direction from forward to reverse rotation and from reverse to forward rotation. When the size of the protrusions differ depending on the travel direction, set the different compensation amount for each travel direction. Set two times the usual value of the friction torque and adjust the value while actually checking the protrusions.

Unbalanced torque offset ([Pr. PE47])

For a vertical axis, set an unbalanced torque offset by referring to the following.

☞ Page 94 UNBALANCED TORQUE OFFSET

Lost motion compensation timing ([Pr. PE49])

The delay time of the lost motion compensation start timing is set with this parameter. When a protrusion occurs belatedly, set the lost motion compensation timing corresponding to the occurrence timing of the protrusion.

Lost motion compensation dead band ([Pr. PE50])

When the travel direction reverses frequently around the zero speed, unnecessary lost motion compensation is triggered by the travel direction being switched. By setting the lost motion compensation dead band, the speed is recognized as 0 when the fluctuation of the droop pulse is the setting value or less. This prevents unnecessary lost motion compensation.
When the value of this parameter is changed, the compensation timing is also changed. Therefore re-adjust the value of the lost motion compensation timing ([Pr. PE49]).

Lost motion filter setting ([Pr. PE46])

Usually the lost motion filter setting does not need to be changed. When a value other than 0.0 ms is set in this parameter, the high-pass filter output value of the set time constant is applied to the compensation and lost motion compensation amount continues.

Adjusting the lost motion compensation

Adjust the lost motion compensation using the following procedure.

Measure the torque

Use MR Configurator2 to measure the torque in the forward direction feed and reverse direction feed.

Setting the lost motion compensation amount

Calculate the friction torque from the torque measurement result, and then set a value twice the friction torque in [Pr. PE44] and [Pr. PE45] as the lost motion compensation amount.

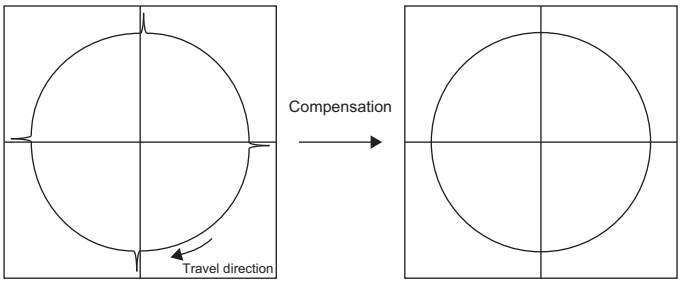
$$\text{Friction torque [\%]} = \frac{|(\text{Torque in forward direction feed [\%]}) - (\text{Torque in reverse direction feed [\%]})|}{2}$$

Checking protrusions

Drive the servo motor and check that the protrusions are corrected.

Adjusting the lost motion compensation amount

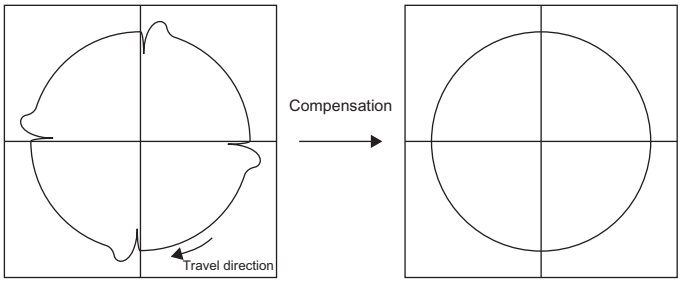
If the projections are still found, the compensation is insufficient. Increase the lost motion compensation amount by approximately 0.5 % until no projection is generated. If notches are generated, the compensation is excessive. Decrease the lost motion compensation amount by approximately 0.5 % until no notch is generated. Different compensation values can be set for:
1) When the forward rotation (CCW) switches to the reverse rotation (CW)
2) When the reverse rotation (CW) switches to the forward rotation (CCW)



Trace before compensation　　Trace after compensation

Adjusting the lost motion compensation timing

When the machine has low rigidity, the speed loop gain is set lower than the standard setting value, or the servo motor is rotating at high speed, quadrant projections may occur behind the quadrant change points. In this case, you can suppress the quadrant projections by delaying the lost motion compensation with [Pr. PE49 Lost motion compensation timing]. To adjust the compensation timing, increase the setting value of [Pr. PE49] by approximately 0.5 ms, starting from 0 ms (initial value).

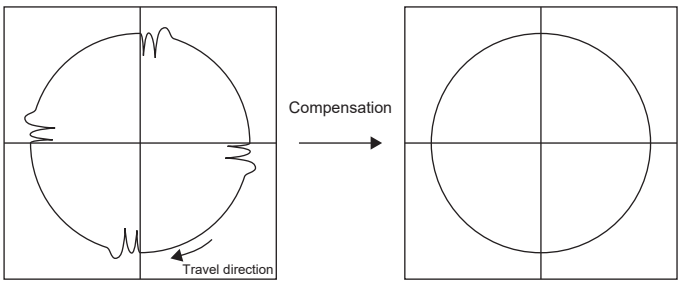


Delayed timing before compensation　　Delayed timing after compensation

Adjusting the lost motion compensation dead band

Set [Pr. PE50 Lost motion compensation dead band] when the lost motion compensation is executed twice around a quadrant change point. Increase the setting value to stop the lost motion compensation from being executed twice. Setting [Pr. PE50] may change the compensation timing. Adjust the lost motion compensation timing again.

☞ Page 103 Adjusting the lost motion compensation timing



Non-sensitive band and delayed timing before compensation　　Non-sensitive band and delayed timing after compensation

REVISIONS

*The manual number is given on the bottom left of the back cover.

Revision date	*Manual number	Description
November 2019	IB(NA)-0300473ENG-A	First edition
July 2020	IB(NA)-0300473ENG-B	■The following functions are added: Linear servo motor control mode, continuous operation to torque control mode ■Edited: Chapter 1, Section 3.1, Section 3.2, Section 3.3, Section 3.7, Section 5.1
March 2021	IB(NA)-0300473ENG-C	■The following function is added: Positioning mode (point table method) ■Edited: Section 3.7, Section 4.10, Section 5.1, Section 5.3, Section 5.4, Chapter 6, Section 7.1, Section 8.1, Section 11.2, Section 11.3
July 2022	IB(NA)-0300473ENG-D	■Edited: Chapter 2, Section 3.1, Section 3.2, Section 3.3, Section 3.5, Section 3.8, Section 4.2, Section 5.3, Section 5.4, Section 11.3
January 2023	IB(NA)-0300473ENG-E	■Edited: Chapter 2, Section 4.2, Section 4.4
October 2024	IB(NA)-0300473ENG-F	■Edited: Section 1.1, Chapter 2
October 2026	IB(NA)-0300473ENG-G	■Added/edited: HOW TO READ OBJECTS, Chapter 2, Section 3.2

This manual confers no industrial property rights or any rights of any other kind, nor does it confer any patent licenses. Mitsubishi Electric Corporation cannot be held responsible for any problems involving industrial property rights which may occur as a result of using the contents noted in this manual.

© 2019 MITSUBISHI ELECTRIC CORPORATION

WARRANTY

Warranty

1. Warranty period and coverage

We will repair any failure or defect hereinafter referred to as "failure" in our FA equipment hereinafter referred to as the "Product" arisen during warranty period at no charge due to causes for which we are responsible through the distributor from which you purchased the Product or our service provider. However, we will charge the actual cost of dispatching our engineer for an on-site repair work on request by customer in Japan or overseas countries. We are not responsible for any on-site readjustment and/or trial run that may be required after a defective unit is repaired or replaced.

[Term]

For terms of warranty, please contact your original place of purchase.

[Limitations]

(1) You are requested to conduct an initial failure diagnosis by yourself, as a general rule.
It can also be carried out by us or our service company upon your request and the actual cost will be charged. However, it will not be charged if we are responsible for the cause of the failure.

(2) This limited warranty applies only when the condition, method, environment, etc. of use are in compliance with the terms and conditions and instructions that are set forth in the instruction manual and user manual for the Product and the caution label affixed to the Product.

(3) Even during the term of warranty, the repair cost will be charged on you in the following cases;

1. a failure caused by your improper storing or handling, carelessness or negligence, etc., and a failure caused by your hardware or software problem
2. a failure caused by any alteration, etc. to the Product made on your side without our approval
3. a failure which may be regarded as avoidable, if your equipment in which the Product is incorporated is equipped with a safety device required by applicable laws and has any function or structure considered to be indispensable according to a common sense in the industry
4. a failure which may be regarded as avoidable if consumable parts designated in the instruction manual, etc. are duly maintained and replaced
5. any replacement of consumable parts (battery, fan, smoothing capacitor, etc.)
6. a failure caused by external factors such as inevitable accidents, including without limitation fire and abnormal fluctuation of voltage, and acts of God, including without limitation earthquake, lightning and natural disasters
7. a failure generated by an unforeseeable cause with a scientific technology that was not available at the time of the shipment of the Product from our company
8. any other failures which we are not responsible for or which you acknowledge we are not responsible for

2. Term of warranty after the stop of production

(1) We may accept the repair at charge for another seven (7) years after the production of the product is discontinued. The announcement of the stop of production for each model can be seen in our Sales and Service, etc.

(2) Please note that the Product (including its spare parts) cannot be ordered after its stop of production.

3. Service in overseas countries

Our regional FA Center in overseas countries will accept the repair work of the Product. However, the terms and conditions of the repair work may differ depending on each FA Center. Please ask your local FA center for details.

4. Exclusion of loss in opportunity and secondary loss from warranty liability

Regardless of the gratis warranty term, Mitsubishi shall not be liable for compensation to:

(1) Damages caused by any cause found not to be the responsibility of Mitsubishi.

(2) Loss in opportunity, lost profits incurred to the user by Failures of Mitsubishi products.

(3) Special damages and secondary damages whether foreseeable or not, compensation for accidents, and compensation for damages to products other than Mitsubishi products.

(4) Replacement by the user, maintenance of on-site equipment, start-up test run and other tasks.

5. Change of Product specifications

Specifications listed in our catalogs, manuals or technical documents may be changed without notice.

6. Application and use of the Product

(1) For the use of our AC Servo, its applications should be those that may not result in a serious damage even if any failure or malfunction occurs in AC Servo, and a backup or fail-safe function should operate on an external system to AC Servo when any failure or malfunction occurs.

(2) Our AC Servo is designed and manufactured as a general purpose product for use at general industries.
Therefore, applications substantially influential on the public interest for such as atomic power plants and other power plants of electric power companies, and also which require a special quality assurance system, including applications for railway companies and government or public offices are not recommended, and we assume no responsibility for any failure caused by these applications when used.
In addition, applications which may be substantially influential to human lives or properties for such as airlines, medical treatments, railway service, incineration and fuel systems, man-operated material handling equipment, entertainment machines, safety machines, etc. are not recommended, and we assume no responsibility for any failure caused by these applications when used.
We will review the acceptability of the abovementioned applications, if you agree not to require a specific quality for a specific application. Please contact us for consultation.

(3) Mitsubishi Electric shall have no responsibility or liability for any problems involving programmable controller trouble and system trouble caused by DoS attacks, unauthorized access, computer viruses, and other cyberattacks.

TRADEMARKS

MELSERVO is a trademark or registered trademark of Mitsubishi Electric Corporation in Japan and/or other countries.
All other product names and company names are trademarks or registered trademarks of their respective companies.

TRANSLATION OF THE ORIGINAL INSTRUCTIONS

IB(NA)-0300473ENG-G(2610)MEE
MODEL:
MODEL CODE:

MITSUBISHI ELECTRIC CORPORATION

HEAD OFFICE: TOKYO BLDG., 2-7-3, MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN
NAGOYA WORKS: 1-14, YADA-MINAMI 5-CHOME, HIGASHI-KU, NAGOYA 461-8670, JAPAN

When exported from Japan, this manual does not require application to the Ministry of Economy, Trade and Industry for service transaction permission.

Specifications are subject to change without notice.
Compliance with the indicated global standards and regulations is current as of the release date of this manual.