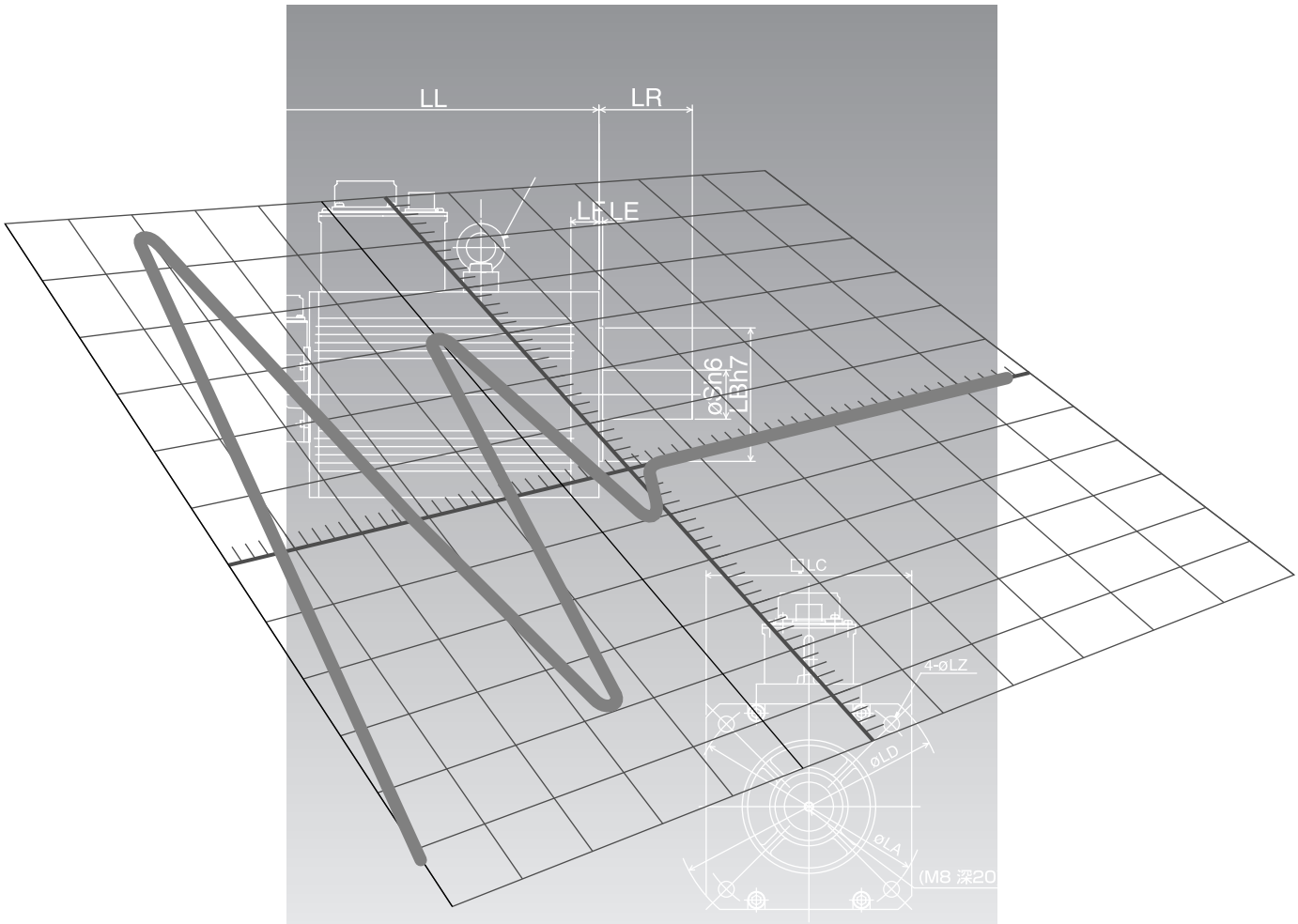


[Adjustments]

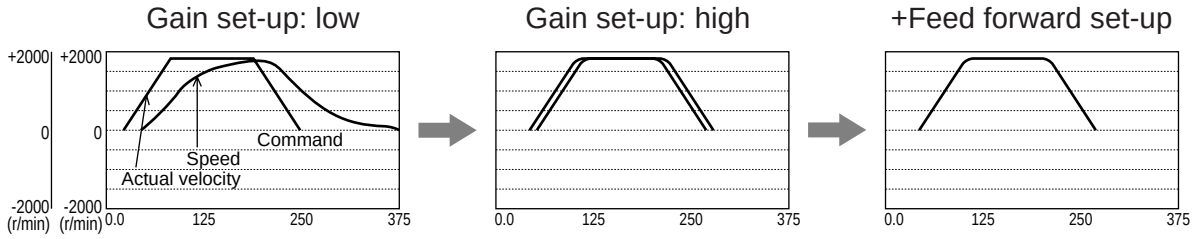
Gain tuning

Gain Adjustment

Purposes of

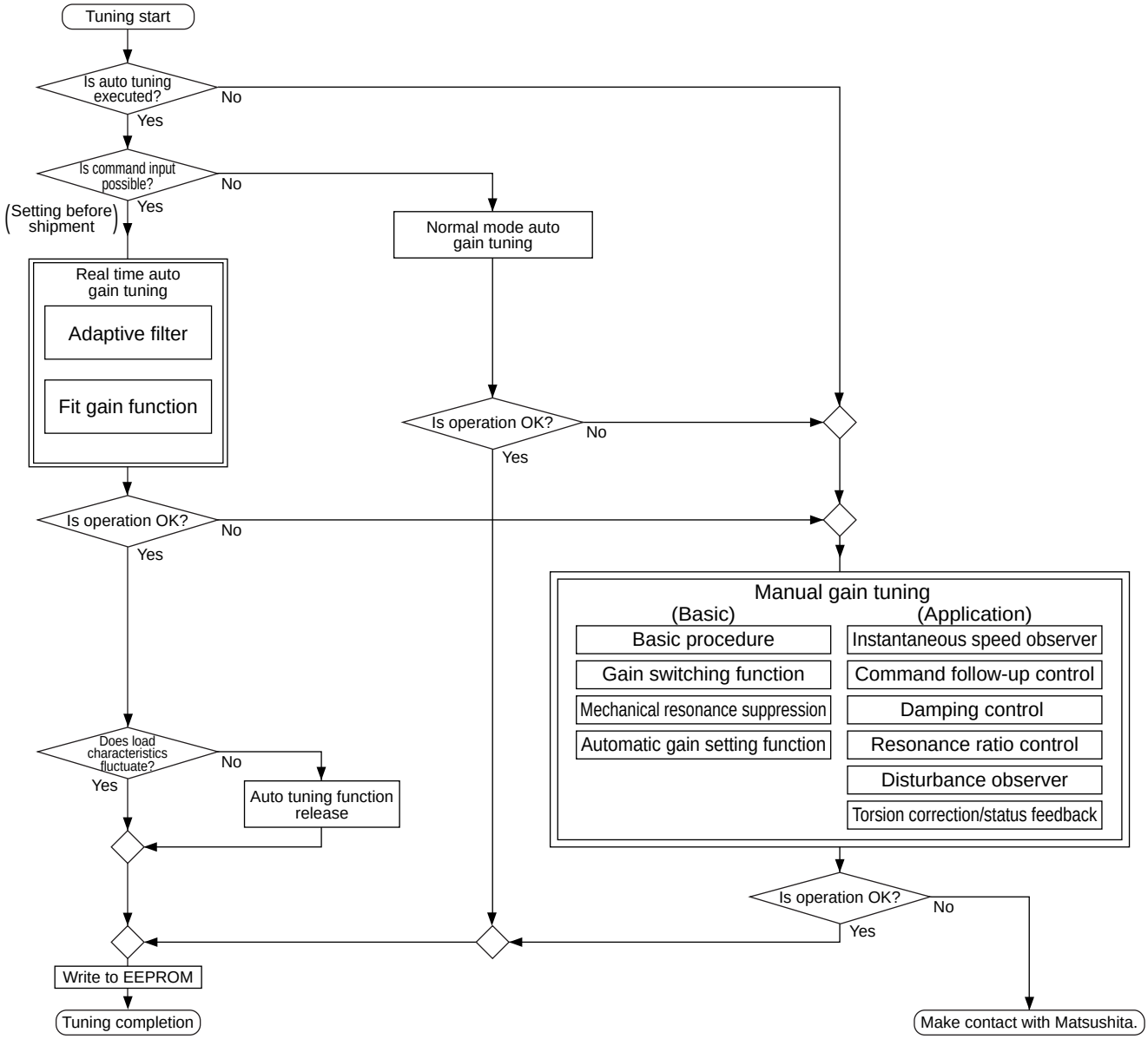
The motor is required to act per any command without any time delay, or without missing any commands. To provide the motor operation more resemble to the command pulse and obtain the best performance of the machine, perform gain adjustment.

<Example: ball screw>



Gain set-up: low		Gain set-up: high		+Feed forward set-up	
Position loop gain	: 20	Position loop gain	: 100	Position loop gain	: 100
Speed loop gain	: 100	Speed loop gain	: 50	Speed loop gain	: 50
Speed loop integration time constant	: 50	Speed loop integration time constant	: 50	Speed loop integration time constant	: 50
Speed feed forward	: 0	Speed feed forward	: 0	Speed feed forward	: 50
Inertia ratio	: 100	Inertia ratio	: 100	Inertia ratio	: 100

How to Adjust Gain



Function			Description	Refaerence Page
Automatic tuning	Real time automatic gain tuning		This function estimates machine's load inertia in real time, and automatically specifies the optimum gain according to the result.	P.188
		Adaptive filter	This function estimates resonance frequency from the frequency component appearing in motor speed in actual operating condition, and reduces vibration at resonance point by automatically specifying the coefficient of the notch filter that eliminates resonance component from torque command.	P.189
		Fit gain function	To improve accuracy of real-time automatic gain tuning for position control, this function automatically searches for the gain that provides the shortest stabilization time when operation of a specified pattern is repeatedly input.	P.190
	Normal mode automatic gain tuning		When the motor is operated based on a command pattern automatically generated by the driver, this function estimates load inertia from the torque required for the operation, and automatically specifies the optimum gain.	P.193
	Disabling of auto tuning function		This function indicates precautions for executing real-time automatic gain tuning with default settings, or for disabling the adaptive filter.	P.196
Manual tuning	Manual gain tuning (Basic)		If automatic gain tuning cannot be executed because of limitation on control mode or load condition, or to ensure the maximum response according to each load, manual tuning should be executed.	P.197
		Basic procedure	For position control	P.198
			For speed control	P.200
			For torque control	P.200
			For full-closed control	P.201
			For hybrid control	P.201
		Gain switching function	By switching gain based on internal data or external signal, this function can reduce vibration at stop, shorten stabilization time, and improve command follow-up performance.	P.202
		Mechanical resonance suppression	When mechanical stiffness is low, resonance due to axial torsion may generate vibration or sound, disabling higher gain setting. In such a condition, this function can suppress resonance by using two types of filters.	P.204
		Automatic gain setting function	This function initializes control parameter or gain switching parameter to the value defined depending on automatic tuning stiffness parameter before execution of manual tuning.	P.206
	Manual gain tuning (Application)		When specifications cannot be satisfied through basic tuning, the following application tuning functions are available to improve performance.	P.207
		Instantaneous speed observer	This function improves the speed detection accuracy by estimating the motor speed with a load model, to ensure balance between high response speed and reduction in vibration at stop.	P.207
		Command follow-up control	This control method maintains position error at nearly "0", and sets the positioning stabilizing time to "0" by improving position command follow-up performance through position integration and feedforward control.	P.208
		Damping control	When vibration occurs with the end of the machine, this function eliminates vibration frequency component from command to suppress vibration.	P.211
		Resonance ratio control	When resonance vibration occurs, this function estimates the axial torque between the motor and load, and corrects the motor torque so that the torsion can be reduced, thus lowering the resonance peak to suppress vibration.	P.212
		Disturbance observer	Using disturbance torque value estimated by the disturbance observer, this function reduces influence of disturbance torque to suppress vibration.	P.213
		Torsion correction/status feedback	Through addition or subtraction of encoder position and external scale position data with speed command or torque command, this function reduces the torsion between the motor and load to suppress vibration.	P.214

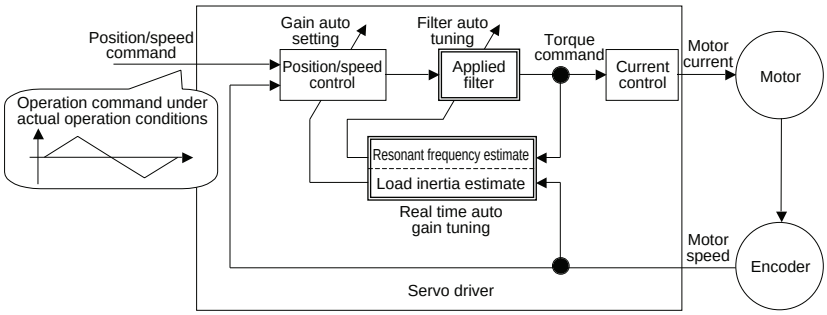
<Note>

- Pay extra attention to safety.
- If the machine enter to oscillation (abnormal sound and vibration) , shut off the power immediately, or change to Servo-OFF.

Real time auto gain tuning

Outline

Load inertia of the machine is estimated at real time, and the optimum gain is set up automatically based on the estimated result. A load, which has a resonance, also can be handled owing to the adaptive filter.



Real-time auto gain tuning is applicable to the following control modes:

Control Modes	Pr02=0: Position control	Pr02=3:Position/speed control	Pr02=6: Speed control
	Pr02=1: Speed control	Pr02=4: Position/torque control	Pr02=10: Speed/semi-closed control
	Pr02=2: Torque control	Pr02=5: Speed/torque control	

Application range

Under the following conditions, the real time auto gain tuning may not function properly.
In such case, use the normal mode auto gain tuning (see page 193 "Adjustments") or manual gain tuning(see page 197 "Adjustments").

	Conditions under which the real time auto gain tuning is prevented from functioning
Load inertia	• When the load inertia is smaller/larger than the rotor inertia (3 times or less; or 20 times or more) • When the load inertia fluctuates
Load	• When the machine stiffness is extremely low • When any unsecured part resides in such as backlash, etc.
Operation pattern	• In case of a continuous low speed operation under 100 [r/min]. • In case of soft acceleration/deceleration under 2000 [r/min] per 1 [s]. • When acceleration/deceleration torque is smaller than unbalanced load/viscous friction torque.

How to use

[1] Stop the motor (Servo-OFF).

[2] Set up Pr21 (Real-time auto tuning set-up) to 1 – 6.
Set up value before shipment is1.

Setting value	Real-time auto tuning	Changing degree of load inertia during operation	Adaptive filter
0	Not used	–	No
[1]	Used	Little change	Yes
2		Change slowly	
3		Change s haply	
4		Little change	No
5		Change slowly	
6		Change s haply	
7	Not used	–	Yes

When the degree of changes in load inertia is large, set 3 or 6 to Pr21.
When the influence of resonance is conceivable, select “adaptive filter YES”.

[3] Set 0 – 2 to Pr22 (machine stiffness at real-time auto tuning)

[4] Turn the servo ON to operate the machine ordinarily.

[5] To improve responsiveness, gradually increase Pr22 (machine stiffness at real-time auto tuning). When you encounter with any abnormal noise or oscillation, however, immediately reset it to a lower value.

[6] To store the result, write the data into the EEPROM.

Description of the adaptive filter

By setting Pr21 (Real-time auto tuning set-up) to 1 – 3 or 7, the adaptive filter is enabled.
In an actual operation state, resonance frequency is estimated based on the vibration component, which appears in motor speed, and resonance point vibration is reduced by removing resonance component from the torque command by the adaptive filter.
The adaptive filter may not function normally under the following conditions. In such a case, take anti-resonance measures using the 1 st . notch frequency (Pr1D and 1E) or second notch filter (Pr28 ~ 2A) in accordance with the manual tuning procedure.
For further information on the notch filter, refer to “To Reduce the Mechanical Resonance” on page 204.

	Conditions under which the adaptive filter is prevented from functioning
Resonance point	• When the resonance frequency is 300 [Hz] or less • When resonance peak is low, or control gain is low; and its influence does not appear on the motor speed • When plural resonance points reside in
Load	• When a motor speed fluctuation having a high frequency component is caused due to a non-linear element such as backlash etc
Command pattern	• When acceleration/deceleration is too sharp like 30000 [r/min] or more per 1 [s]

Parameters, which are set up automatically

The following parameters are tuned automatically.

Parameter No.	Name
10	1st position loop gain
11	1st velocity loop gain
12	1st velocity loop integration time constant
13	1st speed detection filter
14	1st torque filter time constant
18	2nd position loop gain
19	2nd velocity loop gain
1A	2nd velocity loop integration time constant
1B	2nd speed detection filter
1C	2nd torque filter time constant
20	Inertia ratio
2F	Adaptive filter frequency

In addition, the following parameters are also automatically set.

Parameter No.	Name	Set value
15	Velocity feed forward	300
16	Feed forward filter time constant	50
17	1st position integration gain	0
1F	2nd position integration gain	0
27	Disturbance torque observer filter selection	0
30	2nd gain action set-up	1
31	Position control switching mode	10
32	Position control switching delay time	30
33	Position control switching level	50
34	Position control switching hysteresis	33
35	Position loop gain switching time	20
36	Speed control switching mode	0
3A	Torque control switching mode	0

Caution

[1] Immediately after the first turning the servo ON at start up, or when Pr22 (Machine stiffness at real-time auto tuning) is stated up, sometimes a noise or vibration may be generated until the load inertia is determined or the adaptive filter is stabilized. But, when the machine gets stabilized soon, there is no problem. But, when such problem as vibration or noise continues during a period of 3 reciprocal operations, etc occurs frequently, take the following measures.
  1) Write the parameter of normal operation into the EEPROM.
  2) Decrease the Pr22 (Machine stiffness at real-time auto tuning).
  *3) Once set up Pr21 (Real-time auto tuning set-up) to 0 to disable the adaptive filter. Then, enable the real time auto tuning again. (resetting of inertia estimate adaptive operation)
  *4) Set up the notch filter manually.
    * When disabling he real time auto tuning, see page 196 "Disabling of auto tuning function" in Adjustments.

[2] After a noise or vibration has occurred, Pr20 (Inertia ratio) and/or Pr2F (Adaptive filter frequency) may have been changed into an extreme value. In such a case also, take the above measures.

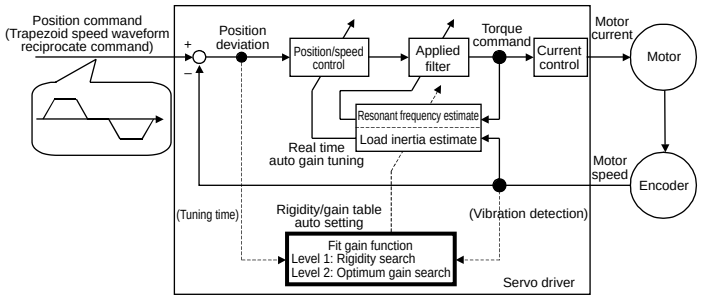
[3] Among results of real-time auto gain tuning, Pr20 (Inertia ratio) and Pr2F (Adaptive filter frequency) are programmed into EEPROM every 30 minutes. When you turn on the power again, auto tuning will be executed using the data as initial value.

Real time auto gain tuning

Fit gain function

Outline

The MINAS-AIII series is equipped with the fit gain function, whereby optimization fitted to devices is further conducted when real-time auto gain tuning is used in position control. Through repetition of certain reciprocal operations in position control, optimal gain setting will be searched full automatically.
In the fit gain function, a user can select 2 ways of searching. In level 2 (stiffness) search, gain will be further fine-tuned so that the shortest settling time will be achieved, after automatic search of optimal real-time stiffness No. with less vibration.

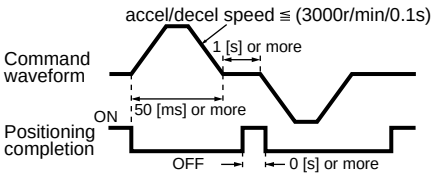


Level 1 Search ⟶ Real-time Stiffness No. Search

Level 2 Search ⟶ Real-time Stiffness No. Search ＋ Fine-tuning of Optimal Gain

Applicable range

This function cannot be applied unless the following conditions, in addition to those for applying real-time auto gain tuning conditions, are met.

	Conditions under which the fit gain function works.
Real time auto gain tuning operation	Real time auto gain tuning works normally.
Control mode	• Position control mode or semi-closed control mode is selected. Pr02 = 0: Position control Pr02 = 3: First control mode of position/speed control Pr02 = 4: First control mode of position/torque control The 2nd control mode of Pr02 =6 or Pr02=10: Semi-closed control • Position command that performs reciprocate operation.
Operation pattern	• One position control should continue for 2 revolutions of the motor or longer. • Period of one position command is 50 [ms] or more. • Time interval from completion of a position command to a next position command should be 1[s]. • Acceleration/deceleration should be not more than 3000r/min/0.1s. • The lowest frequency of a position command should be 1 [kpps] or more. (Necessary for starting and ending of a command) 
Others	• Should be servo ON state.

Before Use

Before starting the fit gain function, set the following with parameter set mode on the front panel or setup assisted software “PANATERM®”:

Parameter	Set value	Remarks
Pr21 (Real-time auto tuning mode setting)	Any of 1 to 3: 1: Almost no change in load inertia and the adaptive filter enabled. 2: Moderate change in load inertia and the adaptive filter enabled. 3: Sharp change in load inertia and the adaptive filter enabled.	The parameters shown to the left can also be set in execution display of the real-time auto gain tuning screen on the front panel. (See page 63)
Pr22 (Real-time auto tuning machine stiffness selection)	0: Real-time stiffness No.0	
Pr23 (Fit gain function mode setting)	1: Level 1 (stiffness) search 2: Level 2 (optimal gain) search	
Pr23 (Positioning completion range)	In the case of a 17-bit encoder, it shall be 20 pulses or more. In the case of a 2500 P/r encoder, it shall be 10 pulses or more.	

Operating Instructions

Operating Procedures

1) Change the display on the front panel to execution display of real-time auto gain tuning screen. (For details on manipulations on the front panel, see pages 57 and 65.)

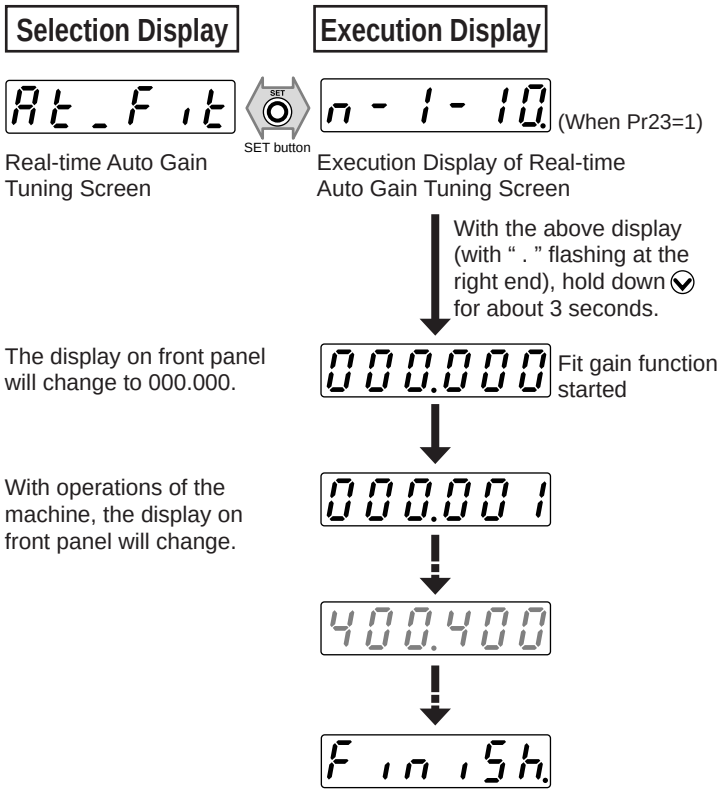
2) Holding down ⌄ on the front panel for about 3 seconds, start the fit gain function.
3) Give a position command that satisfies operating pattern condition of scope on page 190.

(Caution 1)
In the fit gain operation, there will be about 50 reciprocal operations at the maximum in level 1 search, and about 250 operations at the maximum in level 2 search. Normally, the fit gain function ends when searching of optimal real-time stiffness No. and fine-tuning of gain are completed.

4) When the fit gain function normally ends, `Error.` appears. If it abnormally ends, `Finish` is displayed. (You clear display of `Error.` through manipulation of some key.)

(Caution 2)
`Error.` is displayed in the following cases:
Level 1 search: Real-time stiffness No. with no vibration and minor vibration could not be found.
Level 2 search: Settling time has not fallen below 1 second.
Others: There was key manipulation on the front panel during fit gain operation, or conditions for application were not met.

Example of Display on Front Panel



Result of Fit Gain

When the fit gain function normally ends, data on real-time stiffness No. and gain will be saved in Pr24 (fit gain function tuning result). If you wish to apply the result obtained through fit gain after power reset, program it into EEPROM (See the description below).
If you do not apply the result, program into EEPROM after clearing the fit gain result with the following procedures:

[Execution Display] Programming or Clearing Result on Real-time Auto Tuning Screen

`n.-1-10`

If you hold down ⌄ on the front panel for about 3 seconds with "n." displayed, fit gain result and current setting will be programmed into EEPROM.
If you hold down ⌃ on the front panel for about 3 seconds with "F." displayed, fit gain result will be cleared (Set "0" to Pr23).

Real time auto gain tuning

Parameters, which are set up automatically

The following parameters are tuned automatically.

Parameter No.	Name
10	1st position loop gain
11	1st velocity loop gain
12	1st velocity loop integration time constant
13	1st speed detection filter
14	1st torque filter time constant
18	2nd position loop gain
19	2nd velocity loop gain
1A	2nd velocity loop integration time constant
1B	2nd speed detection filter
1C	2nd torque filter time constant
20	Inertia ratio
22	Machine stiffness at auto tuning
2F	Adaptive filter frequency
33	Position control switching level
34	Position control switching hysteresis

In addition, the following parameters are also automatically set.

Parameter No.	Name	Set value
15	Velocity feed forward	300
16	Feed forward filter time constant	50
17	1st position integration gain	0
1F	2nd position integration gain	0
27	Disturbance observer filter setting	0
30	2nd gain action set-up	1
31	Position control switching mode	10
32	Position control switching delay time	30
35	Position loop gain switching time	20
36	Speed control switching mode	0
3A	Torque control switching mode	0

Cautions

During fit gain operation, some sound or vibration may be generated. Normally, they will cause no problem, because gain will be lowered automatically. However, sound or vibration continues, press any button on the front panel to suspend fit gain.

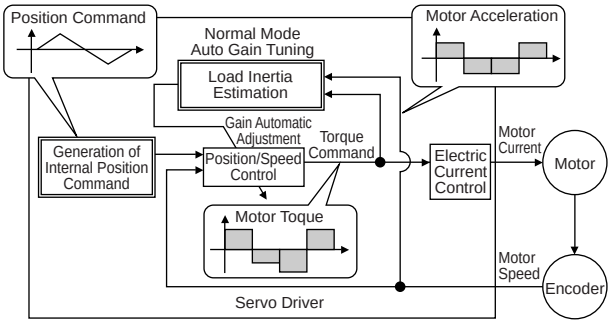
In addition, if abnormal behavior occurs after execution fit gain, change Pr23 (fit gain function mode setting) to “0” (disable) or clear the result of fit gain on the fit gain screen.

Nomal mode auto gain tuning

Fit gain function

Outline

The motor is operated using a command pattern, which is automatically generated by the driver to estimate the load inertia based on the required torque, and proper gain is set up automatically.



Applicable range

This function operates under the following conditions:

	Conditions under which the nomal auto gain tuning works.
Control mode	• Control mode set-up (Pr02) is any one of the following conditions. Pr02 =0: Position control Pr02 =1: Speed control Pr02 =2: Torque control Pr02 =3: Position /speed control Pr02 =4: Position /torque control Pr02 =5: Speed /torque control The 2nd control mode of Pr02=6 or Pr02=10: Semi-closed control
Others	• Servo-ON status • Deviation counter clear signal is not inputted.

Cautions

Under the following conditions, normal mode auto gain tuning may not function normally.
In such case, set up the data in manual gain tuning mode.

	Conditions under which normal mode auto gain tuning is prevented from functioning.
Load inertia	• Load inertia is smaller/larger than the rotor inertia (Less than 3 times, or larger 20 times) • Load inertia fluctuates
Load	• Extremely low machine stiffness • Unsecured part such as backlash etc resides in

- When an error, servo-OFF or deviation counter clear has occurred during auto gain tuning operation, it results in a tuning error.
- Even when the auto gain tuning has carried out, when it has failed in estimating the load inertia value, the gain value is not changed and the previous data remains as it was.
- Motor output torque during auto gain tuning operation is permitted up to the maximum output torque that has been set up by Pr5E (torque limit set-up), and CW/CCW drive prohibition input is ignored.

Be very careful of the safety. If vibration occurs, turn OFF the power or the servo promptly, and return the gain to the set value before shipment with the parameter.

Nomal mode auto gain tuning

Auto gain tuning operation

[1] In the normal mode auto tuning, the response performance is set up by means of machine stiffness number.

> Machine stiffness numbers
> - Machine stiffness numbers are for setting the degree of machine stiffness of the user machine. Setting range is 0-15.
> - A machine, which has higher machine stiffness, allows setting a larger value to obtain a higher gain.
> - Usually, repeat auto gain tuning by increasing stiffness No. in ascending order and stop it when you reach a level in which no oscillation/abnormal noise/vibration will be generated.

[2] Operation pattern set by Pr25 (normal mode auto tuning set-up) is repeated up to 5 cycles. Operation acceleration increases by 2 times per 1 cycle from the third cycle. Depending on the load status, the operation may be terminated without performing 5 cycles, or the operation acceleration may not change. It is not an error.

How to oprate

[1] Set the operation pattern to Pr25.
[2] Move the load to a position where is safe even when the motor performs a operation pattern set up by Pr.25.
[3] Prohibit the command.
[4] Turn the servo ON.
[5] Start the auto gain tuning operation.
Start the operation using the front panel or PANATERM®.
For operating instructions of the front panel, refer to the next page.
[6] Adjust the machine stiffness number so that a desired response is obtained within a level in which any vibration does not occur.
[7] When no problem is found in the result, write the data into the EEPROM.

Parameters, which are set up automatically

The following parameters are tuned automatically.

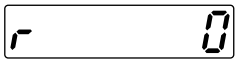
Pr No.	Name
Pr10	1st position loop gain
Pr11	1st velocity loop gain
Pr12	1st velocity loop integration time constant
Pr13	1st speed detection filter
Pr14	1st torque filter time constant
Pr18	2nd position loop gain
Pr19	2nd velocity loop gain
Pr1A	2nd velocity loop integration time constant
Pr1B	2nd speed detection filter
Pr1C	2nd torque filter time constant
Pr20	Inertia ratio

The following parameters are also set up to the following fixed values automatically.

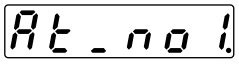
Pr No.	Name	Set value
Pr15	Velocity feed forward	300
Pr16	Feed forward filter time constant	50
Pr17	1st position integration gain	0
Pr1F	2nd position integration gain	0
Pr30	2nd gain action set up	1
Pr31	Position control switching mode	10
Pr32	Position control switching delay time	30
Pr33	Position control switching level	50
Pr34	Position control switching hysteresis	33
Pr35	Position loop gain switching time	20
Pr36	Velocity control switching mode	0
Pr3A	Torque control switching mode	0
Pr7B	Torsion correction gain	0
Pr7C	Torsion and Differential speed detection filter	0
Pr7D	Torsion feedback gain	0
Pr7E	Differential speed feedback gain	0

Operation on front panel

1) Select the Normal Auto Gain Tuning Mode.
Press SET button once and press MODE switching button three times.
See page 56 "Operating procedure" in Preparations.

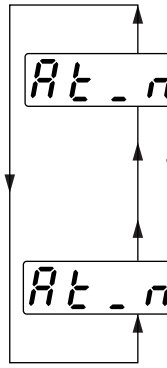


Motor speed display (initial display)



Mechanical stiffness value

2) Press ⌄ or ⌃ button to select the stiffness of the machine.



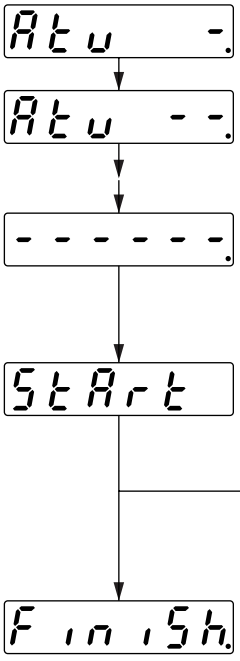
Mechanical stiffness (higher)
Press ⌃, and machine stiffness No. will change in the arrow direction.
Press ⌄, and it will change in the opposite direction.
Mechanical stiffness (lower)

Driving method	Machine Stiffness No.
Ball screw direct connection	8 – 14
Ball screw + timing belt	6 – 12
Timing belt	4 – 10
Gear, or rack & pinion	2 – 8
Other machines with low stiffness	2 – 8

3) Press SET ◎ button to turn to the monitor/execution mode.

4) Operation at the monitor/execution mode:
Keep pressing ⌃ button until StArt appears.
- The connector CN X5 29-pin is in servo ON state.
- Pr1D (notch frequency) is set to 1500.

Keep pressing ⌃ button
(approx. three seconds).
The horizontal bar increases as shown in the right figure.



The motor has started rotating.
Then, for about 15 seconds, the motor rotates twice in CCW/CW directions, which will be regarded as one cycle.
The motor rotates up to 5 cycles. Even when it stops before reaching 5 cycles, it will not be abnormality.

5) Program a gain value into EEPROM so that it will not be lost during shutoff of the power source.

<Caution>
DDo not use the motor driver alone for normal mode auto gain tuning. Pr20 (inertia ratio) will be 0.

<Notes>

Symptom	Cause	Remedy
Error message displayed	Either one of Alarm, Servo-Off or Position Error Counter Clear activated.	• Avoid operation near the limit switch or home position sensor. • Turn to Servo-ON. • Cancel the Position Error Counter Clear.
Values such as Pr10 related to gain, etc. remains same as a value before execution.	The load inertia cannot be calculated.	• Retry by changing Pr10 to 10, and Pr11 to 50. • Execute the manual adjustment.
Motor does not rotate	CL (30pin) of CN X5 is input.	• Turn on CL (30pin) of CN X5.

Disabling of auto tuning function

Outline

Following are the points to note when you disable real-time auto gain tuning of factory setting or adaptive filer.

Cautions

When you disable the auto adjustment function, do so while the motor stops its operation (servo off).

Disabling of the real time auto gain tuning

By setting Pr21 (Real-time auto tuning set-up) to 0 or 7 (adaptive filter only enabled), the auto estimate of Pr20 (Inertia ratio) is terminated and the real time auto gain tuning is disabled.
(However, this change will become valid once the servo turns OFF and then ON again.)
In case that the parameter get an apparently incorrect value due to the remaining estimate result of Pr20 (Inertia ratio), set up an appropriate value manually using the normal mode auto tuning or calculating the value.

Disabling of the adaptive filter

By setting Pr21 (real-time auto tuning set-up) to 0 or to 4-6 (real time auto gain tuning only enabled), the adaptive filter function, which automatically follows up the load resonance, stops.
If the adaptive filter is disabled during operating properly, influence of the suppressed resonance may appear resulting in a noise or vibration etc.
Therefore, when you disable the adaptive filter, on the fit gain screen of the front panel (refer to “Fit Gain Screen” of Preparations volume on page 65), copy frequency of adaptive filter setting (Pr2F) to the 1st notch filter (Pr1D), and disable after suppressing resonance with the 1st notch filter (see page 65) or manually setting Pr1D (the 1st notch frequency) from Pr2F (adaptive filter frequency) by means of the table below.
However, when you execute copy function, Pr1E (first notch selection) will be set to "2".

Pr2F	The 1st Notch Frequency [Hz]
0	1800 (1499)
1	1731 (1499)
2	1666 (1499)
3	1602 (1499)
4	1541 (1499)
5	1482
6	1426
7	1372
8	1319
9	1269
10	1221
11	1174
12	1130
13	1087
14	1045
15	1005
16	967
17	930
18	895
19	861
20	828
21	796

Pr2F	The 1st Notch Frequency [Hz]
22	766
23	737
24	709
25	682
26	656
27	631
28	607
29	584
30	562
31	540
32	520
33	500
34	481
35	462
36	445
37	428
38	412
39	396
40	381
41	366
42	352
43	339

Pr2F	The 1st Notch Frequency [Hz]
44	326
45	314
46	302
47	290
48	279
49	269
50	258
51	248
52	239
53	230
54	221
55	213
56	205
57	197
58	189
59	182
60	175
61	169
62	162
63	156
64	150

* By executing the copy function when Pr2 Fis set up to 0-4, the frequency within the ( ) is set up

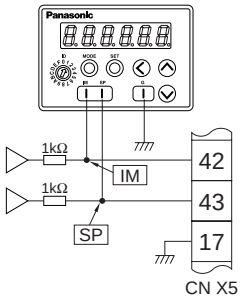
Manual gain turning (Basic)

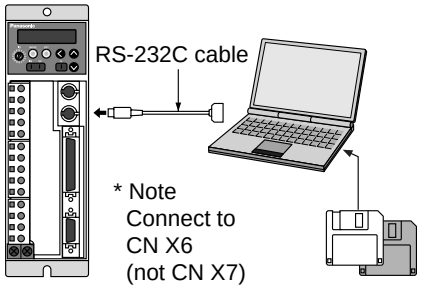
MINAS- AIII series provides the above d escribed auto gain tuning function. However, theremay be a case that fine tuning is required when it is failed to obtain a desired gain aftercarrying out the auto gain tuning due to the load conditions etc; or in a case that the optimumresponse performance or stability is required in accordance with the respective loads, and soon.
In this section, the steps of manual gain tuning will be described on each control mode andfunction.

Before Adjustment

Although adjustment is possible with the motor (machine) behavior or sound, you can achieve quick and reliable adjustment by observing analog waveforms using the monitor function.

1. Analog Monitor Output
   You can measure motor actual speed, command speed, torque and number of deviation pulses by using the oscilloscope at analog voltage level. Use Pr07 (speed monitor selection) and Pr08 (torque monitor selection) to set a type of signal to be output or output voltage level.
   For further information, refer “Wiring to Connector CN X5” and “Parameter Settings” for each control mode.
2. Waveform Graphic Function of PANATERM®
   You can measure command to the motor and behavior of the motor (speed, torque, and deviation pulse) as waveforms on the display of personal computer. For details, refer to “Outline of Setup Assisted Software PANATERM®” of Reference volume on page 236.





Guidance Values of Gains, and How to Adjust

See the table below for the guidance values of gains, if the inertia ratio has been set correctly.

Machine	Position loop gain Pr10	Speed loop gain Pr11	Speed loop integration time constant Pr12
Ball screw	100	50	50
Timing belt	50	25	50
Rack & pinion	50	25	200 – 500

Adjust the
1) Speed loop gain Pr11.
2) Position loop gain, Pr10 ≦ 2 x speed loop gain Pr11 as guidance of operation.
3) Once the position loop gain Pr10 > 5 x speed loop gain Pr11, hunting or oscillation may occur.

<Note>
You cannot adjust the current loop gain.

Functions of Each Control Mode

In each control mode, you can use the functions listed in the following table:

Command	Control mode	Gain switching	Instantaneous speed observer	Command follow-up control	Vibration suppression control	Resonance ratio control	Disturbance observer	Torsion correction	Status FB
Position	Position	○			○		○		
	Semi-closed	○			○		○		
	Position for high-stiffness equipment	○	○	○			○		
	Position for low-stiffness equipment	○			○	○			
Speed	Speed	○					○		
	Speed forlow-stiffness equipment	○	○			○			
Torque	Torque	○							
Full closed loop	Full closed loop	○							
	Hybrid	○							
	External encoder								
	Second full-closed	○	○			○		○	○

Manual gain tuning (Basic)

Tuning of position control mode

Position control system of the MINAS-AIII series is as shown in the following block diagram (see page 72). In this section, the basic tuning procedure circled with double frame, in which parameter is used but gain switching is not used, will be described.

[1] Initial setting of parameter

Return the parameter to the preset value before shipment.

- In case that vibration occurs with the preset value before shipment, reduce the 1st speed loop gain (Pr11) and the 1st position loop gain (Pr10) by the same value.

[2] Setting of inertia ratio

Set up the inertia ratio (Pr20).

- When the inertia ratio (Pr20) has been obtained by the real time auto gain tuning, use the Pr20 set value as it is.
- When the inertia ratio is known by means of calculation etc, input the calculated value.
- When the inertia ratio is unknown, execute the normal mode auto gain tuning to measure the inertia. After the measurement, since the control gain also has been altered, return to the step [1] and carry out initial setting of the parameter.

[3] Upper limit search of speed loop gain

Increase the 1st speed loop gain (Pr11) by 10-increment.

- At this time, increase the 1st position loop gain (Pr10) also to the same value as the 1st speed loop gain (Pr11).
- When vibration begins to be generated, proceed to the step [4] Setting of notch filter.
- When vibration occurs, decrease the 1st speed loop gain (Pr11) promptly, and then decrease the 1st position loop gain (Pr10) to the same value as Pr11, and proceed to the step [4].

[4] Setting of notch filter

Measure the vibration frequency of the torque command using the waveform graphic function or frequency characteristics measurement function etc of the monitor output / Set up support software PANATERM®.

- Based on the measured vibration frequency, carry out one of the steps (A)-(C).
- After the step above, since the upper limit of the 1st speed loop gain (Pr11) may have been change, carry out the step [3] again to check the upper limit.
  Compare the values before and after the above step, continue the tuning using the setting by which the 1st speed loop gain (Pr11) increases more largely.

(A) When the vibration frequency is 1.5 kHz or more

Set up a larger 1st. torque filter time constant (Pr14)

- For the absolute encoder (7-core 17-bit) , set up Pr14 to approx. 25; for the incremental encoder (5-core 2500P/r), set up Pr14 to approx. 63 as a reference target, increase the value until the vibration falls in allowable range.
- When the 1st torque filter time constant (Pr14) is set up too large, vibration of lower frequency may become large. In this case, reduce the value of the 1st speed loop gain (Pr11).

(B) When the vibration frequency is 600 Hz – 1500 Hz

Set up the 1st notch frequency (Pr1D) to the value of vibration frequency.

- When the vibration is not reduced, slightly change the value of Pr1D and 1E.
- Resonance peak can be measured using the frequency characteristic function of the set up support software PANATERM®. Set up the notch filter so as to reduce the resonance peak.
- When vibration of 600Hz or more is still generated, set up the 1st torque filter time constant (Pr14) to a larger value.

(C) When the vibration frequency is 400 – 600Hz

- Measure the resonance frequency using the frequency characteristic function etc of the set up support software PANATERM®.

Set up the 1st notch frequency (Pr1D) to the value of resonance frequency.

- Measure the frequency characteristics again and check that the resonance peak is reduced.
- When the resonance peak is not reduced, adjust the 1st notch width selection (Pr1E) and the 1st notch frequency (Pr1D) so that the resonance peak is reduced.
- As for vibration of which resonance peak is in low frequency and is lower than the anti- resonance frequency, set the 1st speed loop gain (Pr11) to a smaller value.
- When the resonance frequency falls in approx. 350 – 450 Hz, increase the value of the 1st speed loop gain (Pr11) and set the notch filter at a point that vibration begin to be generated. The vibration may be reduced.
- When the vibration is not reduced, disable the notch filter. Determine the value of the first speed loop gain as the upper limit value.

[5] Setting of torque filter time constant

When any operation noise is heard, gradually increase the value of the 1st torque filter time constant (Pr14).
To increase the response, gradually reduce the value of the 1st torque filter time constant (Pr14) and increase the value of the 1st speed loop gain (Pr11).

- As a reference value of the minimum value, it is recommended to set the value, for the absolute encoder (7-core 17-bit), to10; for the incremental encoder (5-core 2500P/r), to 25.

[6] Setting of 1st speed detection filter (Pr13)

To increase the response, gradually reduce the value of the 1st speed detection filter (Pr13) and increase the value of the 1st speed loop gain (Pr11).
In the case that high frequency noise is generated when the value of the 1st speed detection filter (Pr13) is reduced, measure the resonance frequency using the waveform graphic function etc of the Matsushita set up support software PANATERM® and adjust the notch filter in step [4] or the torque filter in step [5].

[7] Setting of 1st position loop gain (Pr10)

Input a value of approx. the value of the first speed loop gain (Pr11) x 1.5 to the 1st position loop gain (Pr10). Then, roughly set up the value of Pr10 so that the positioning setting time is shortened at a certain degree.

- To change the parameter, execute it at a timing of which positional deviation is small.

[8] Setting of 1st speed loop integration time constant (Pr12)

Lower the 1st speed loop integration time constant (Pr12) from the following initial values:

- We recommend that you use an initial value of Pr12=15000/(2p x Pr11).
- Lower Pr12 ≧ 30 by 10.
  Lower 30 > Pr12 ≧ 15 by 5.
  Lower Pr12<15 by 1.
- By setting the first speed loop integration time constant to a smaller value, although it is possible to make the deviation at the positioning closer to 0, the time to reach to the stabilization range may become slower.
- In such a case, by setting the value of the 2nd speed loop integration time constant (Pr1A) during operation to 1000 (disabled) using the gain switching function, it may be increased.

[9] Setting of speed feed forward (Pr15)

Set the speed feed forward (Pr15) to 500 (300 – 700).

- When the value of the speed feed forward (Pr15), although the positional deviation during operation is reduced and the positional deviation after completion of command output is converged sooner, overshoot or vibration becomes to occur more frequently.
- When the operation noise has become larger after setting this parameter, set the feed forward filter setting (Pr17) and the smoothing filter setting (Pr4C) to a larger value respectively.

Tuning of speed control mode

Speed control system of the MINAS- AIII series is as shown in the f ollowing block diagram (see page 106). The tuning steps in speed control is almost the same as that of the position control mode in page 198. Excluding the setting of [7] position loop gain and [9] speed feed forward, follow the steps [1] – [6] and [8] to carry out the tuning.

Tuning of torque control mode

Torque control system of the MINAS-AIII series is as shown in the f ollowing block diagram (page 132). The torque control system is structured based on the speed control loop using Pr56: 4th internal speed as the speed limit. In this section, the setting procedure of the speed limit value will be described.

• Setting of speed limit value

Set up a speed limit value to the 4th Internal speed (Pr56)

- When the motor speed becomes closer to the speed limit value, the control is switched from the torque control mode, in which the control follows up the analogue torque command, to the speed control mode, in which the speed limit value depending on the 4th internal speed (Pr56) is used as the command.
- To obtain an stable operation in the speed limit mode, it is necessary to carry out control gain and filter setting in accordance with the tuning of the speed control mode described above..
- In the case that the speed limit value = 4th internal speed (Pr56) is too low, the speed loop gain is too low or the speed loop integration time constant is set up to 1000 (disabled), since the input to the torque limit shown in the above diagram becomes smaller, there may be a case that torque according to the analogue torque command is not obtained.

Tuning of full closed loop control mode

Full-closed control system of the MINAS-AIII series is as shown in the following block diagram (see page 159).
In the full-closed control mode, excluding the cautions (difference in command unit, unit conversion of the position loop gain is necessary and difference in command division scale ratio etc) as described in page 156 "Full-closed control", the tuning can be carried out by following the same steps as "Tuning of position control mode" in page 198.
In this section, the setting of the external scale ratio, the hybrid error and the hybrid control in the initial setting of the full-closed control will be described.

• Setting of external scale ratio

Set up the external scale ratio using the numerator of external scale ratio (Pr74), the multiplier of numerator of external scale ratio (Pr75) and the denominator of external scale ratio (Pr76).

- Check the number of encoder pulses per motor rotation and the number of external scale pulses per motor rotation, set up the numerator of external scale ratio (Pr74), multiplier of numerator of external scale ratio (Pr75) and denominator of external scale ratio (Pr76) so that the following formula is fulfilled.

$$\frac{\text{Pr74 } \boxed{1} \times 2^{\text{Pr75}\boxed{17}}}{\text{Pr74 } \boxed{5000}} = \frac{\text{Number of encoder pulses per motor rotation}}{\text{Number of external scale pulses per motor rotation}}$$

- If the ratio is incorrect, the difference between the position calculated from the encoder pulse and the position calculated from the external scale pulse is increased. Particularly, when it is driven a long distance, a hybrid error (Err25) occurs.

• Setting of hybrid error

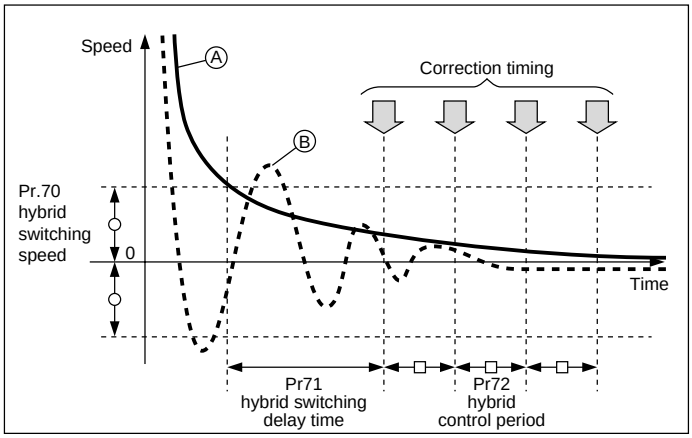
Set up the hybrid error (Pr73) in a range of minimum value in which the difference between the motor (encoder) position and the load (external scale) position is determined as "too-large".

- Check an excessive hybrid error (Err.25) as in addition to the above-mentioned factor, reverse connection or loose connection between the motor and load, etc. may also cause it.

Setting for hybrid control

Setting for hybrid control at Pr02 = 8 is as shown in the block diagram below (see page 298).
In this section, the setting of hybrid correction switching will be described.

- Hybrid control is a control mode intended to ensure the response performance during operation and the external scale accuracy during a stop, in which, while constantly operating in semi-closed control mode, and after a motor stop, the difference between the external scale position and the encoder position is calculated at a specific period and is added to the position command as the correction command.
- In a state that the command pulse is not fed, as shown in the diagram below, from a point of time when a state of Pr70 (hybrid switching speed) or less has passed the point of Pr71 (hybrid shifting delay time), the above-described correction is applied at period of Pr72 (hybrid control period).
- The following diagram shows a case in which speed changes smoothly Ⓐ. However, as a case of Ⓑ, when the hybrid correction is applied before the vibration is converged, a large correction amount may cause vibration resulting in an oscillation adversely. In such a case, set up the Pr71(hybrid shifting delay time) longer to start the correction operation later.



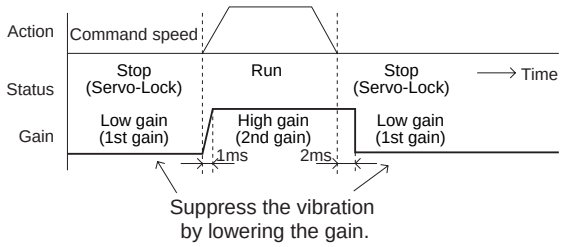
Manual gain tuning (Basic)

Adjustment upon switching gain

You can set not only the 1st gain but also 2nd gain manually. You can utilize the function of switching from the 1st to 2nd gain in a machine with higher responsiveness.

<Example>

This is the example in which you reduce noise by switching to low gain setting after the motor stops (servo lock), when you feel uneasy about sound during stoppage of the motor.



Parameter No.	Parameter	Guideline	How to adjust
Pr10	1st position Loop Gain	Same as 2nd position loop gain	–
Pr11	1st speed loop gain	Same as 2nd speed loop gain	If the motor does not generate abnormal sound when it stops (servo lock), the parameter setting is acceptable. If the motor generates abnormal sound, reduce the set value.
Pr12	1st speed integration time constant	50	If the motor normally operates, the parameter setting is acceptable. Reducing the set value provides improved motor response. However, if the parameter setting is too low, oscillation occurs.
Pr13	1st speed detection filter	0	Fixed
Pr14	1st torque filter time constant	Same as 2nd torque filter constant	If the motor does not generate abnormal sound when it stops (servo lock), the parameter setting is acceptable. If the motor generates abnormal sound, change the set value.
Pr18	2nd position loop gain	50	If the motor normally operates, the parameter setting is acceptable. Increasing the set value provides improved motor response. However, if the parameter setting is too high, oscillation occurs.
Pr19	2nd speed loop gain	30	If the motor does not generate abnormal sound during operation, the parameter setting is acceptable. If the motor generates abnormal sound, reduce the set value.
Pr20	Inertia ratio		**Set up this parameter correctly at first.**
Pr30	2nd gain action set-up	1	–
Pr31	Position control switching mode	7	–
Pr1A	2nd speed integration time constant	1000	–
Pr1B	2nd speed detection filter	0	Fixed
Pr1C	2nd torque filter time constant	50	If the motor does not generate abnormal sound during operation, the parameter setting is acceptable. If the motor generates abnormal sound, change the set value.

Gain Switching Conditions

• Position Control Mode

(○: the parameter valid, – : invalid)

Gain switching conditions			Parameters for position control		
			Delay time *1	Level	Hysteresis *2
Pr31	Switching conditions	Figure	Pr32	Pr33	Pr34
0	Fixed to 1st gain		—	—	—
1	Fixed to 2nd gain		—	—	—
2	Gain switching input, 2nd gain selected with GAIN On		—	—	—
3	2nd gain selected with a large torque command differential	A	○	○*3 [0.05%/166µs]	○*3 [0.05%/166µs]
4	Fixed to 1st gain		—	—	—
5	Large target speed commanded	C	○	○ [r/min]	○ [r/min]
6	Large position error	D	○	○ [pulse]*4	○ [pulse]*4
7	Position command existing	E	○	—	—
8	Positioning incomplete	F	○	—	—
9	Speed	A	○	○ [r/min]	○ [r/min]
10	Presence of a command + speed	G	○	○ [r/min]*6	○ [r/min]*6

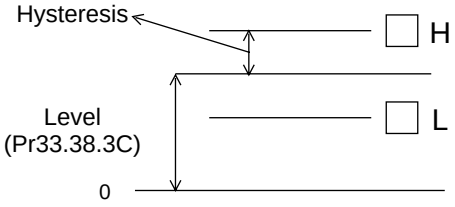
• Speed Control Mode

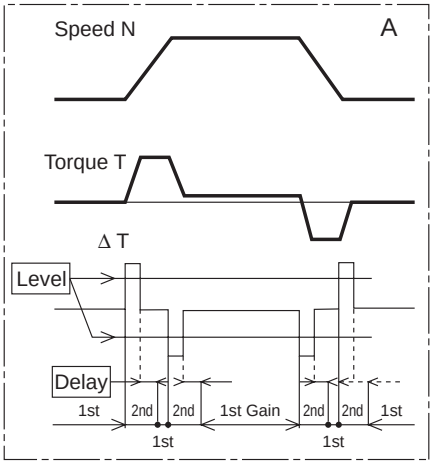
Gain switching conditions			Parameters for speed control		
			Delay time *1	Level	Hysteresis *2
Pr36	Switching conditions	Figure	Pr37	Pr38	Pr39
0	Fixed to 1st gain		—	—	—
1	Fixed to 2nd gain		—	—	—
2	Gain switching input, 2nd gain selected with GAIN On		—	—	—
3	2nd gain selected with a large torque command differential	A	○	○*3 [0.05%/166µs]	○*3 [0.05%/166µs]
4	2nd gain selected with a large speed command differential	B	○	○*5 [10(r/min)/s]	○*5 [10(r/min)/s]
5	Large speed command	C	○	○ [r/min]	○ [r/min]

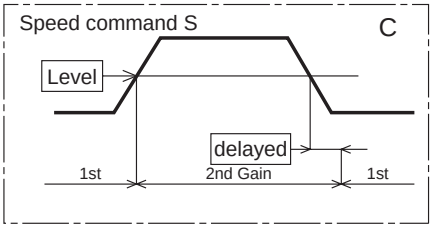
• **Torque Control Mode**

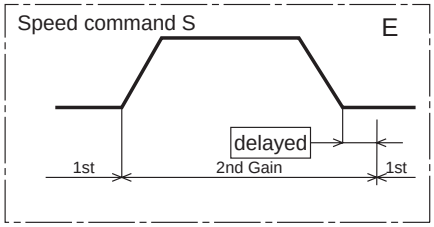
Gain switching conditions			Parameters for speed control		
			Delay time *1	Level	Hysteresis *2
Pr3A	Switching conditions	Figure	Pr3B	Pr3C	Pr3D
0	Fixed to 1st gain		—	—	—
1	Fixed to 2nd gain		—	—	—
2	Gain switching input, 2nd gain selected with GAIN On		—	—	—
3	2nd gain selected with a large torque command differential	A	○	○*3 [0.05%/166µs]	○*3 [0.05%/166µs]

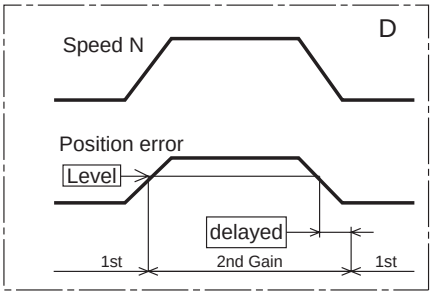
*1 Delay time (parameters Pr32, Pr37 and Pr3B) become effective when returning from 2nd gain to 1st gain.
*2 For the definitions of hysteresis parameters (Pr34, Pr39 and Pr3D), see the right figure.
*3 Set the value 200 in the case that 10% torque-fluctuation happens within 166µs.
10% / 166µs = Setting value 200 x [0.05% / 166µs]
*4 Resolution of encoders
*5 Set the value 1 in the case that 10r/min speed changes within 1s.
*6 When Pr31=10, delay time, level and hysteresis have different meaning than usual (See Figure G).

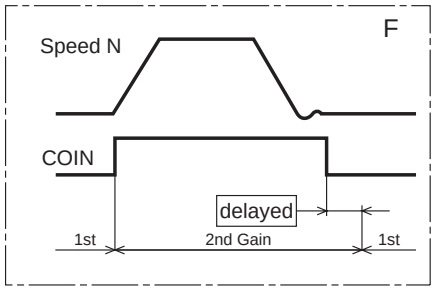


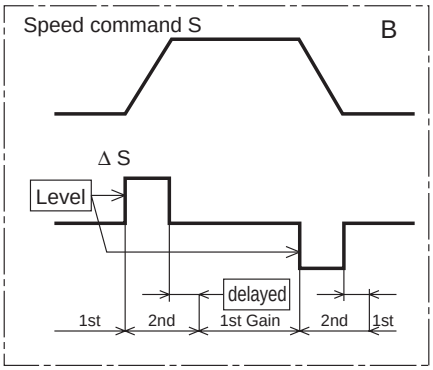


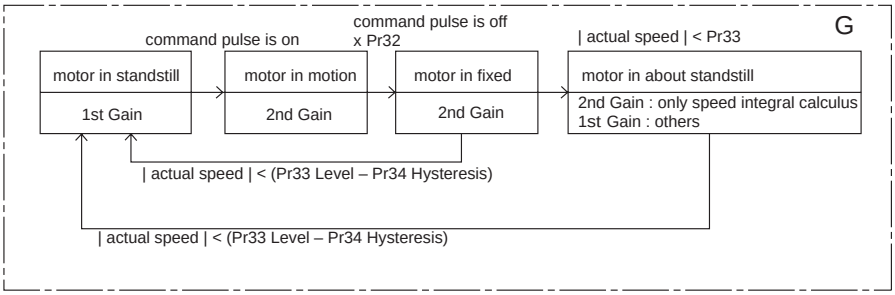












<Notes>

The figures above do not reflect the gain switching timing delay caused by hysteresis (parameters Pr34, Pr39 and Pr3D) .

Manual gain tuning (Basic)

To Reduce the Mechanical Resonance

If the machine is not stiff, vibration and noise may be generated due to the resonance by shaft torsion, which may interfere to set-up the higher gains. You can suppress the resonance by 2 types of the filters.

1. Torque command filter (Pr14 and Pr1C)

Set a filter time constant so that attenuation takes place around resonance frequency. You can determine cutoff frequency with the following expression:

Cutoff Frequency (Hz) fc = 1/(2p x parameter set value x 0.00001)

2. Notch filter

• Adaputive filter (Pr21 and Pr2F)

In MINAS-A III series, vibration at load that is difficult to accommodate with the conventional notch filter or torque filter, for instance, because a resonance point varies for every device can be controlled by using an adaptive filter. You can enable the adaptive filter by setting 1-3 or 7 to Pr21 (real-time auto gain tuning mode setting).

Pr21	Real time auto tuning set up	1~3 and 7 : adptive filter actived

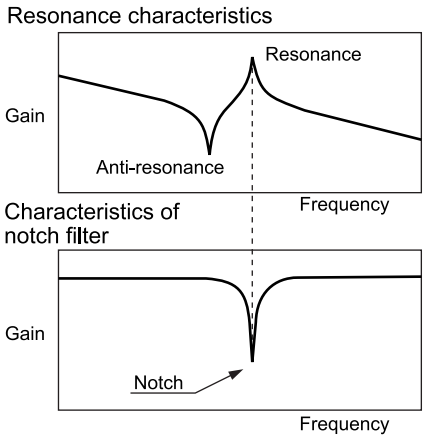
Pr2F	Adaptive filter frequency	disply the table number of adaptive filter frequency (can not change)

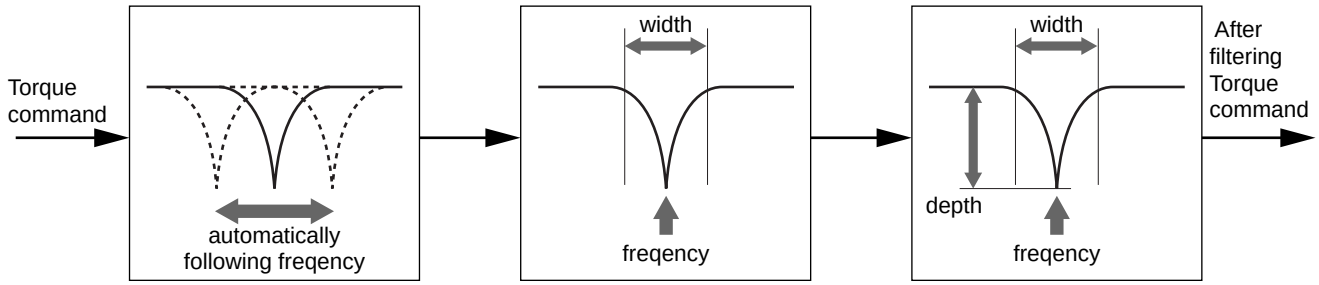
• 1st and 2nd notch filter (Pr1D, Pr1E, Pr28, Pr29 and Pr2A)

MINAS-AIII series is equipped with 2 normal notch filters: the 1st notch filter makes it possible to adjust frequency and width, while the 2nd notch filter makes it possible to adjust by frequency, width, and depth parameters.

Pr1D	1st notch frequency	Set this about 10% lower than the resonance frequency measured by the frequency characteristics analysis function of PANATERM®.
Pr1E	1st notch width selection	Setting by the resonance frequency characteristics.

Pr28	2nd notch frequency	Set this about 10% lower than the resonance frequency measured by the frequency characteristics analysis function of PANATERM®.
Pr29	2nd notch width selection	Setting by the resonance frequency characteristics.
Pr2A	2nd notch depth selection	



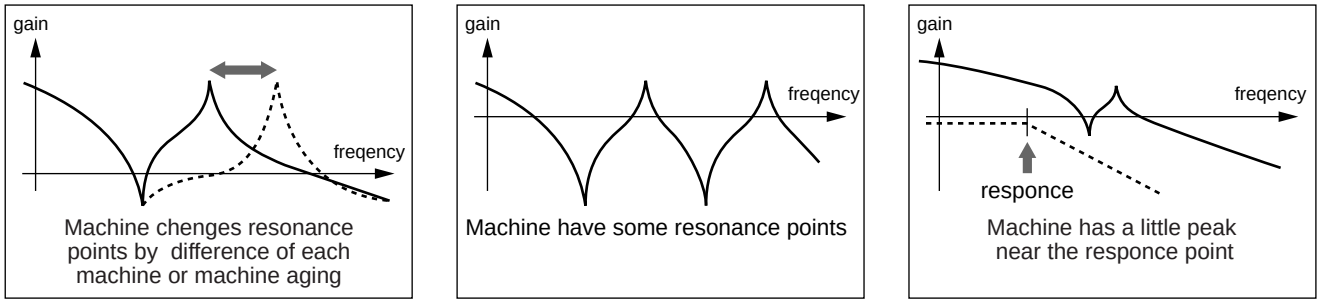


Adaptive filter
(Suppress resonance points in an instance)

1st notch filter
(Present adaptive filter setting is copied to the first notch filter. (See page 196))

2nd notch filter
(Adjastable freqency, width and depth)

Applications



How to measure the resonance frequency of a machine system

1) Log-on PANATERM® and open the frequency characteristics screen.
2) Set the following parameters and measuring conditions. Note that the values shown below are for reference only.
   - Decrease the value of Pr11 (1st speed loop gain) to 25 (to make the resonance frequency more distinguishable).
   - Set the amplitude to 50 r/min (so that the torque may not saturate).
   - Set the offset to 100 r/min. (to increase the amount of speed detection information, and run the motor in one-way rotation).
   - Polarities: (+) for CCW and (–) for CW.
   - Set the sampling rate to 1 (from a range between 0 and 7).
3) Start the frequency characteristics analysis function.

<Notes>

- Before starting the measurement, make sure that the machine does not move beyond the limit. Approximate speed = Offset (r/min.) x 0.017 x (Sampling rate + 1)
  With a larger offset value, good results can be obtained, though the speed becomes higher.
- Set-up Pr22 (Real time auto tuning mode set-up) to 0.

<Notes>

- Set-up the offset larger than the amplitude setting, and with one-way rotation so that you can obtain better results.

Relationship between Gain Adjustment and Mechanical Stiffness

To increase the mechanical stiffness,

1) The machine (motor load) should be firmly secured to a rigid foundation.
2) The coupling between the motor and machine should be designed with high stiffness for servo motors.
3) The timing belt should have a larger width. The tension of the timing belt should be adjusted according to the allowable axial load of the motor.
4) The gears should have a smaller backlash.
   - The inherent frequency (resonance) of the machine significantly affects the gain adjustment of the servo motor.

   If the machine has a lower resonance frequency (i.e. lower stiffness), you can't set the high response of the servo system.

Manual gain tuning (Basic)

Gain auto setting function

Outline

Gain auto setting function is for initializing the control parameter/gain switching parameter to a gain setting of the auto tuning corresponding to the stiffness before carrying out manual tuning.

Cautions

Before executing the gain auto setting function, terminate the operation.

How to use

Refer to “Real-time Auto Gain Tuning Screen” of Preparations volume on page 65.

[1] Once stop the operation.

[2] Start gain automatic setting function on the real-time auto gain tuning screen.

[3] When gain automatic setting normally ends, F in 1Sh appears. If it abnormally ends, Error is displayed. (You can clear these displays through some key manipulation.)

Parameters, which are set up automatically.

The following parameters are tuned automatically.

Parameter No.	Parameters for position control
Pr10	1st position loop gain
Pr11	1st velocity loop gain
Pr12	1st velocity loop integration time constant
Pr13	1st speed detection filter
Pr14	1st torque filter time constant
Pr18	2nd position loop gain
Pr19	2nd velocity loop gain
Pr1A	2nd velocity loop integration time constant
Pr1B	2nd speed detection filter
Pr1C	2nd torque filter time constant
Pr20	Inertia ratio

The following parameters are also set up to the following fixed values automatically.

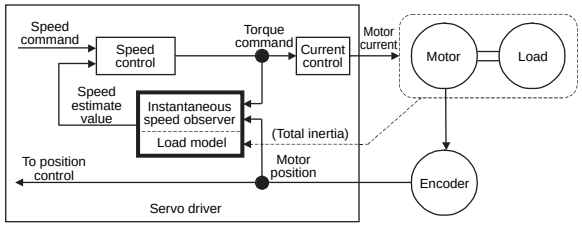
Parameter No.	Parameters for position control	Set value
Pr15	Velocity feed forward	300
Pr16	Feed forward filter time constant	50
Pr17	1st position integration gain	0
Pr1F	2nd position integration gain	0
Pr30	2nd gain action set-up	1
Pr31	Position control switching mode	10
Pr32	Position control switching delay time	30
Pr33	Position control switching level	50
Pr34	Position control switching hysteresis	33
Pr35	Position loop gain switching time	20
Pr36	Speed control switching mode	0
Pr3A	Torque control switching mode	0
Pr7B	Torsion correction gain	0
Pr7C	Torsion and Differential speed detection filter	0
Pr7D	Torsion feedback gain	0
Pr7E	Differential speed feedback gain	0

Manual gain tuning (Application)

Instantaneous speed observer

Outline

Instantaneous speed observer is a function in which the speed detection accuracy is increased by estimating motor speed using a load model to increase the response performance and to reduce the vibration after a stop.



Applicable range

This function is applicable under the following condition.

	Conditions under which the instantaneous speed observer functions
Control mode	• Any one of the position control for high-stiffness equipment, speed control forlow-stiffness equipment or second full-closed control. • The combined motor encoder shall be a 17-bit absolute/increment. Pr02 = 11: position control for high-stiffness equipment Pr02 = 13: speed control for low-stiffness equipment Pr02 = 14: second full-closed control

Cautions

Under the following conditions, the function may not work normally, or the intended effect may not be obtained.

	Conditions under which the effect of the instantaneous speed observer is prevented
Load	• Compared to the inertia load including the motor and load as a unit, error is too different from that of the actual equipment . • Example) A large resonance point resides in the frequency zone of 300 [Hz] or less; A non-linear factor such as large backlash etc resides in, and so on. • Load inertia changes • An external disturbance torque of large high frequency component is applied
Other	• Positioning setting range is too narrow

How to use

[1] Setting of inertia ratio (Pr20)

Set up an inertia ratio as precise as possible.

- When an applicable inertia ratio (Pr20) has been already obtained through the real time auto gain tuning during an ordinary position control etc, use it as the setting value of Pr20 as it is.
- When the inertia ratio is known via calculation etc, input the calculated value.
- When the inertia ratio is unknown, once change to the ordinary position control (Pr02 = 0) to carry out the normal mode auto gain tuning and measure the inertia.

[2] Tuning in ordinary position control

- See page 198 "Tuning of position control mode".

[3] Setting of the 1st/2nd speed detection filter (Pr13 and Pr1B)

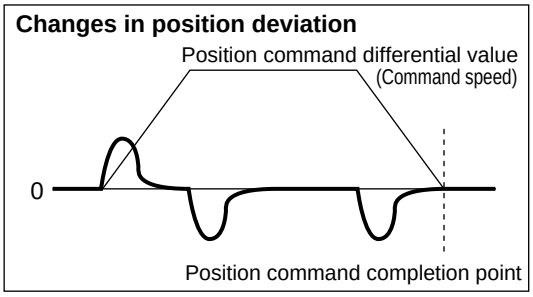
- Setting 6 to the 1st/2nd speed detection filter (Pr13 and Pr1B) switches the speed detection method to instantaneous speed observer.
- Then, if variations in torque waveforms or operating sound increases, immediately reset to original setting and recheck cautions and (1) described above.
- If some effects such as decreased torque waveforms variations or operating sound, etc., have been achieved, find setting where variations are minimized, by fine-tuning inertia ratio (Pr20) while observing position deviation waveforms or actual speed waveforms. In addition, since an optimal value of inertia ratio (Pr20) may change when you have made a change to a position loop gain or speed loop gain, execute fine-tuning again.
- If you use gain switching, change in ascending order of operating time of the 1st/2nd gain. As sound may be generated at timing of switching, select setting that is used for both as far as possible.

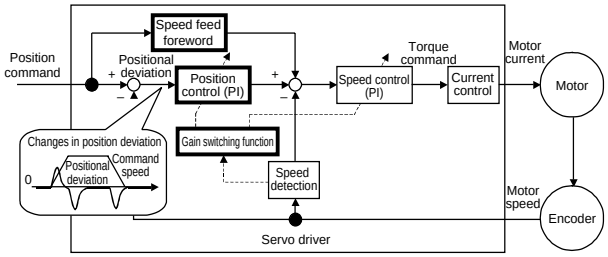
Manual gain tuning (Application)

Command follow-up control

Outline

Command follow-up control is a control mode in which, by utilizing the position integration function and the feed forward function, the follow-up performance to the position command is increased, and by controlling the position error so as to become close to 0, the stabilizing time is made zero.





Applicable range

This function is applicable to the following condition.

	Condition under which the command follow-up control functions
Control mode	• Position control for high-stiffness equipment • The combined motor encoder shall be a 17-bit absolute/increment. Pr02 = 11: position control for high-stiffness equipment

Cautions

Under the following conditions, the function may not work normally, or the intended effect may not be obtained.

	Condition under which the effect of the command follow-up control is prevented
Command pattern	• A command pattern in which the command speed comes to 0 before the positionerror is converged during deceleration Example) a small shift amount; a large command acceleration/deceleration, etc
Load	• Stiffness of the load is low Example) A large resonance point resides in the frequency band of 300 [Hz] or less, etc

• In the command follow-up control, a positional deviation is always around 0 even during operation. Thus, COIN (positioning completion signal) may continue to be ON. Determine on completion of positioning in terms of command pulse output signal of the host controller.

How to use

[1] Tuning in ordinary position control

• See page 198 "Tuning of position control mode".

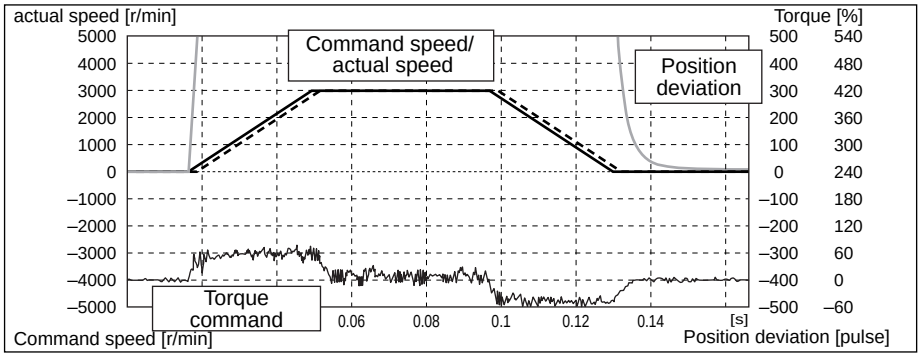
[2] Gain switching setting

• Referring to sect.11-6-5, set up the following items.
Pr18 – 1C (2nd gain) = Pr10 – 14 (1st gain)
Pr17 (1st position integration gain) = 0
Pr1F (2nd position integration gain) = 0
Pr30 (2nd gain action set-up) = 1
Pr31 (Position control switching mode) = 7
Pr32 (Position control switching delay time) = 0
Pr33 (Position control switching level) = 0
Pr34 (Position control switching hysteresis) = 0
Pr35 (Position loop gain switching time) = 0

[3] Setting of speed integration gain

• Set up Pr12 (1st speed loop integration time constant) using the following formula as a reference.
Pr12 = 50000/(Pr11 x 2 π)
• Enable the Pr1A (2nd speed loop integration time constant).
Pr12 = 1000

Example 1) By carrying out the tuning up to this point, the response waveform during trapezoid drive be comes as shown below.



[4] Setting of FIR filter 1

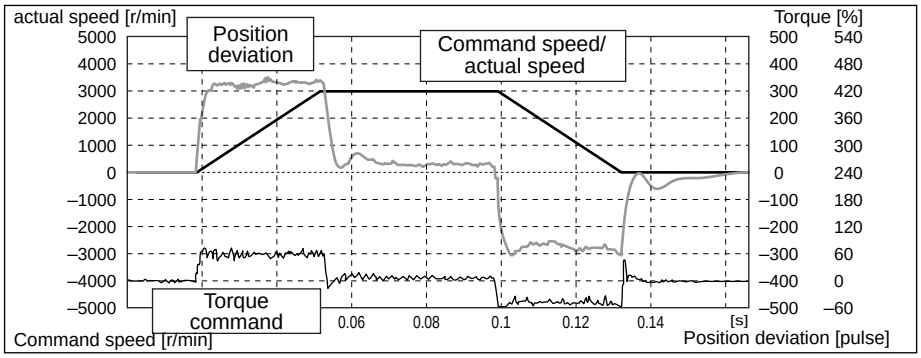
- Check the position command input using the command speed monitor etc of the Matsushita set up support software PANATERM®, and check that the command speed changes smoothly at every sampling.
- When the fluctuation of the command waveform are too large, measure the cycle of the fluctuation and turn the servo OFF once. Then, set up Pr4E (FIR filter 1 setting) so as to fulfill the following formula, and reset the control power.

  (Pr4E (FIR filter 1setting) setting value + 1) x 166.6 [μs] ≦ fluctuation cycle [s]

[5] Setting of speed feed forward

- Set up Pr15 (Speed feed forward) to 1000.
- In the case that operation noise becomes larger again when inputting a command, turn the servo OFF once. Then, set up Pr4F (FIR filter 2 setting) to a larger value and reset the control power to check for operation noise.

Example 2) By carrying out the tuning up to this point, the response waveform during trapezoid drive becomes as shown below.

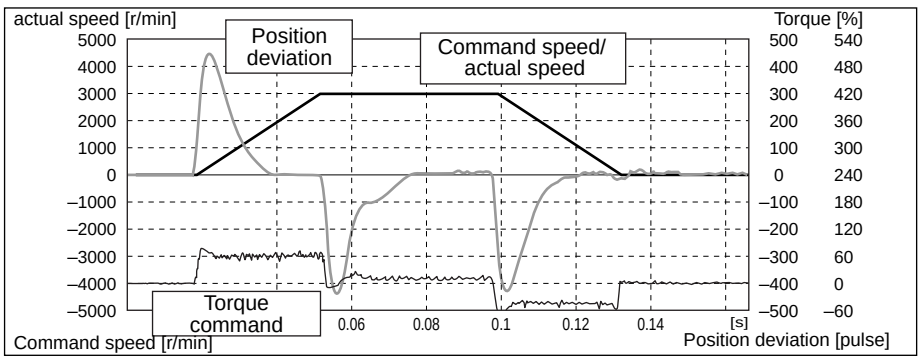


[6] Setting of position integration gain

- Set up Pr1F (2nd position integration gain) using the following formula as a reference.

  Pr1F = (Pr18 x 2)/30

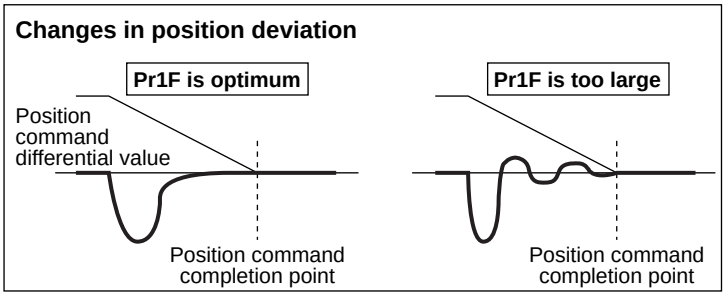
Example 3) By carrying out the tuning up to this point, the response waveform during trapezoid drive becomes as shown below.



Manual gain tuning (Application)

[7] Fine-tuning of Pr1F (2nd position integration gain)

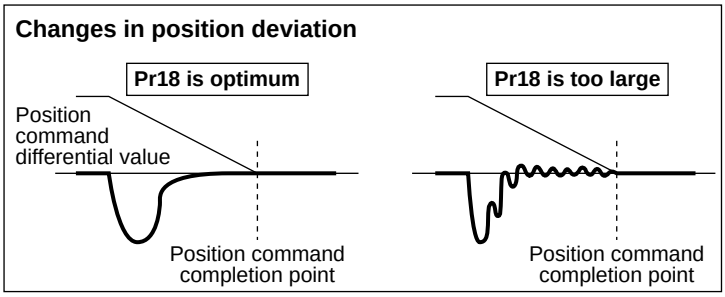
- Tune Pr1F (2nd position integration gain) to converge the position error to 0 swiftly.
- Gradually increase Pr1F to set it up so as to converge the position command without fluctuation like the waveform shown in the right diagram before the position command completes. If Pr1F is too large, a fluctuation is caused like the waveform shown in the right diagram.



- When the viscous friction is too large, the convergence value of the position error deviates from 0. In such case, as shown in "the case of too-large viscous friction", tune Pr1A (2nd speed loop integration time constant) so that the convergence value is 0.

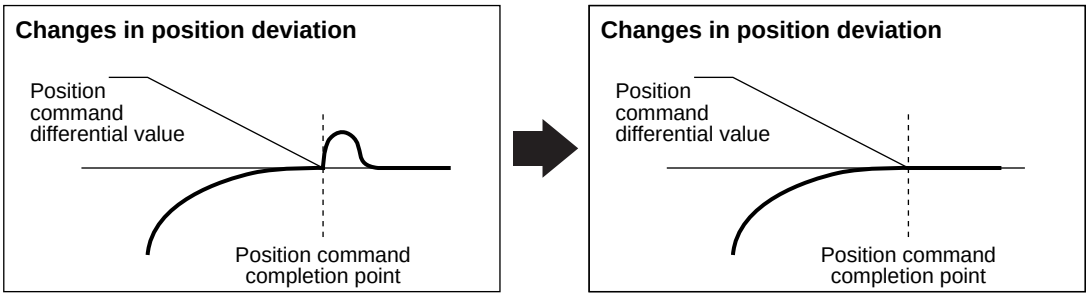
[8] Fine-tuning of Pr18 (2nd position loop gain)

- When position error during operation converges to a target value too late, tune Pr18 (2nd position loop gain).
- By setting Pr18 and Pr1F (2nd position integration gain), the position error converges to the target value swiftly. However, too-large value causes vibration as shown in the right diagram. Set up them to an appropriate value free from vibration. Also, tune Pr1A (2nd speed loop integration time constant) so that the convergence value of the position error becomes 0.



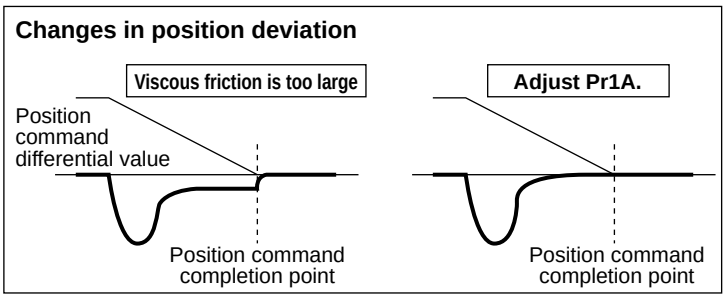
[9] Fine-tuning of gain switching timing

- To reduce fluctuation during setting, tune the gain switching timing.
- After setting Pr31 (Position control switching mode) to 5 (switching via command speed), increase or decrease Pr33 (Position control switching level) to tune the timing of the gain switching. While gradually increasing Pr31 from approx. 20 by10 increments, and set it to a value at which the vibration becomes minimum.



[10] Fine tuning of Pr1A (2nd speed loop integration time constant)

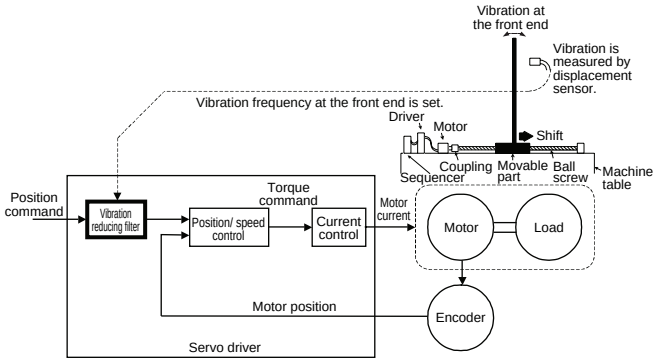
When the viscous friction is too large, the convergence value of the position error immediately before the position command completes varies as shown in the right diagram. In this case, the convergence value can be adjusted via Pr1A (2nd speed loop integration time constant). Adjust Pr1A so that the convergence value of the position error immediately before the position command completes become 0. The larger viscous friction requires the smaller value of Pr1A.



Vibration suppression control

Outline

Vibration suppression control is a function by which, when the front end of a tool vibrates, the vibration is reduced by removing vibration frequency component from the command.



Applicable range

This function is applicable to the following conditions.

	Command under which the command slave control functions
Control mode	• Any one of the position control, semi-closed control or position control for low-stiffness equipment Pr02 = 0: position control Pr02 = 3: first control mode of position / speed control Pr02 = 4: first control mode of position / torque control second control mode of Pr02 = 6 or Pr02 = 10: semi-closed control Pr02 = 12: position control (for low stiffness load)

Cautions

Before changing parameter setting, make sure to stop the operation.

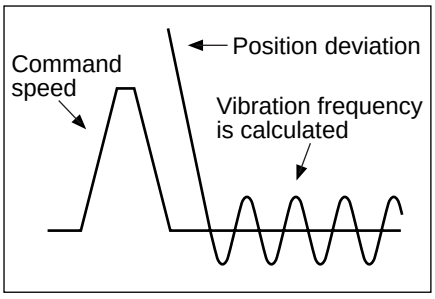
• Under the following conditions, the function may not work normally, or the intended effect may not be obtained.

	Conditions under which the effect of the vibration suppression control is prevented
Load	• When vibration is generated by a cause (external force etc.) other than the command • When the ratio between the resonance frequency and anti-resonance frequency is too large • Vibration frequency is too high (100 [Hz] or more).

How to use

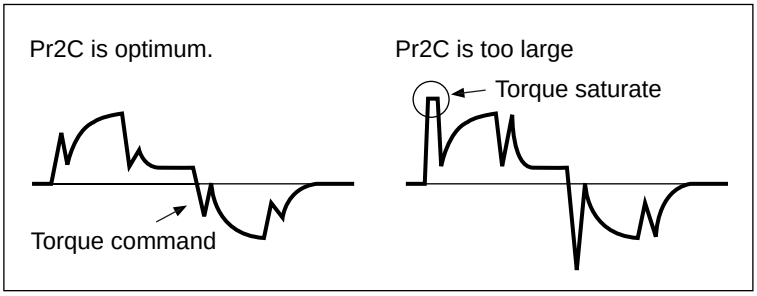
[1] Setting of vibration suppression frequency (Pr2B)

Measure the vibration frequency at the front end of the tool.
When the vibration can be directly measured using a laser displacement meter etc, read the vibration frequency [Hz] from the measured waveform and input to the vibration suppression frequency (Pr2B).
When there is no measuring equipment, read the frequency [Hz] of the residual vibration from position error waveform as shown in the diagram below using the waveform graphic function of the Matsushita set up support software PANATERM®, and set up the value.



[2] Setting of vibration suppression filter setting (Pr2C)

First, set up the value to 0.
By setting a large value, although the stabilizing time can be shortened, torque ripples increase at the changing point of the command as shown in the diagram below. Set up the value within a range that torque saturation does not occur under actually used conditions. If torque saturation occurs, the vibration suppression performance is decreased.

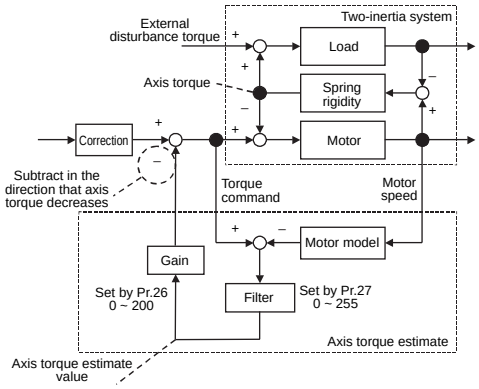


Manual gain tuning (Application)

Resonance ratio control

Outline

Resonance ratio control is a function by which, when vibration is caused by resonance, the resonance peak and vibration are reduced by estimating shaft torque between the motor and the load, and the motor torque is corrected so that the torsion becomes small.



Applicable range

This function is applicable to the following conditions.

	Conditions under which the resonance ratio control functions
Control mode	• Any one of the position control for low-stiffness equipment, speed control for low-stiffness equipment or second full-closed control • The combined motor encoder shall be a 17-bit absolute/increment. Pr02 = 12: position control for low-stiffness equipment Pr02 = 13: speed control for low-stiffness equipment Pr02 = 14: second full-closed control

Cautions

Under the following conditions, the function may not work normally, or the intended effect may not be obtained.

	Conditions under which the effect of the resonance ratio control is prevented
Load	• Vibration frequency is too high (200 [Hz] or more) • Plural resonance points reside in a low frequency zone.

How to use

[1] Setting of disturbance torque observer filter selection (Pr27)

Measure the frequency [Hz] at the resonance point using the frequency characteristics measurement function of the Matsushita set up support software PANATERM®, and set up the disturbance torque observer filter selection (Pr27) so that the cutoff frequency [Hz] of the filter is larger than that value.

Cutoff frequency [Hz] = disturbance torque observer filter selection (Pr27) x 3.7[Hz]

Cutoff frequency [Hz] ≧ frequency [Hz] at the resonance point

A larger filter setting value provides an estimation of shaft torque with smaller delay resulting in an enhanced resonance suppression performance, but operation noise is increased.

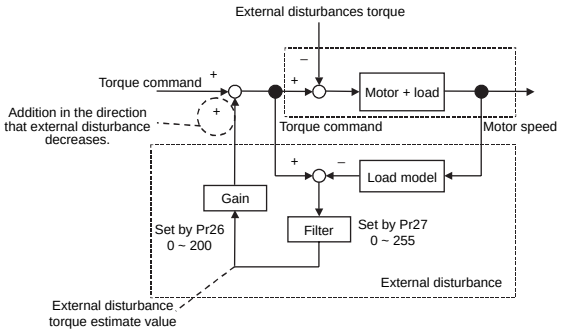
[2] Setting of disturbance torque compensation gain (Pr26)

While operating the actual machine, check the position error and torque waveform etc and gradually increase the disturbance torque compensation gain (Pr26). A larger value of the gain provides an enhanced resonance suppression performance, but operation noise is increased. In this case, alter the disturbance torque observer filter setting (Pr27) to search the optimum setting in which well-balance is obtained.

Disturbance observer

Outline

Disturbance observer is a function by which, using a disturbance torque estimate value which is estimated by the disturbance observer, influence of disturbance torque and vibration are reduced.



Applicable range

This function is applicable to the following conditions.

	Conditions under which the disturbance observer functions
Control mode	• Any one of the position control, speed control, semi-closed control or position control for high-stiffness equipment Pr02 = 0: position control Pr02 = 1: speed control Pr02 = 3: both of position and speed control Pr02 = 4: first control mode of position / torque control Pr02 = 5: first control mode speed /torque control Second control mode of Pr02 = 6 or Pr02 = 10: semi-closed control Pr02 = 11: position control for high-stiffness equipment

Cautions

Under the following conditions, the intended effect may not be obtained.

	Conditions under which the effect of the disturbance observer is prevented
Command pattern	• In a control mode other than Pr02 = 11: position control for high-stiffness equipment, when the motor speed [r/min] is less than the following values For 17bit (131072 resolution 7-serial) encoder: 50 [r/min] For 2500P/r (10000resolution 5-serial) encoder: 600 [r/min]
Load	• When the resonance point resides under the cutoff frequency estimated by disturbance observer • High frequency component is included in the disturbance torque

How to use

[1] Setting of disturbance torque observer filter selection (Pr27)

While operating the actual machine, in a state that influence of an disturbance appears, gradually increase the setting value of the disturbance torque observer filter selection (Pr27).

Cutoff frequency [Hz] = Disturbance torque observer filter selection (Pr27) x 3.7 [Hz]

By setting a larger filter setting value, a disturbance torque with less delay can be estimated resulting in an enhanced suppression performance against the influence of the disturbance, but operation noise is increased. Search a well-balanced setting.

[2] Setting of disturbance torque compensation gain (Pr26)

(Position control for high-stiffness equipment (Pr02 = 11) only requires to be set up)

For position control for high-stiffness equipment (Pr02 = 11), after setting the disturbance torque observer filter selection (Pr27), set a larger value to the disturbance torque compensation gain (Pr26).

By setting the gain to a larger value, an enhanced suppression performance against the external disturbance, but operation noise is increased. In combination with the disturbance torque observer filter selection (Pr27), search a well-balanced setting.

Manual gain tuning (Application)

Torsion correction / Status feed back control

Outline

Status feed back control is a function in which, by adding the difference (torsion) between the encoder position and the external scale position from speed command or torque command, torsion between the motor and the load is reduced to reduce the vibration.

Applicable range

This function is applicable to the following conditions.

	Condition under which the torsion correction/ status feedback control functions
Control mode	• Second full-closed control mode • The combined motor encoder shall be a 17-bit absolute/increment. Pr02 = 14 : second full-closed control

Cautions

Under the following conditions, the intended effect may not be obtained.

	Conditions under which the torsion correction/status feedback control is prevented from functioning
Load	• When resonance point resides in a frequency zone of 200 [Hz] or more • Torsion is too small

The torsion correction and the status feedback control commonly use Pr7C as the filter setting. Therefore, use the respective functions separately.

How to use [1] : Torsion correction

[1] Setting of torsion and Differential speed detection filter (Pr7C)

Set the initial value for the torsion and Differential speed detection filter (Pr7C) in accordance with the following formula:

Torsion and Differential speed detection filter (Pr7C) = 1st position loop gain (Pr10) x 2

[2] Setting of torsion correction gain (Pr7B)

While driving in the second full-closed control mode, gradually increase the torsion correction gain(Pr7B), check the changes in response of the full-closed position error.

When the response performance is increased, while tuning the torsion and differential speed detection filter (Pr7C), search an appropriate combination that the optimum repose is obtained.

How to use [2] : Status feedback control

[1] Setting of torsion and differential speed detection filter (Pr7C)

Set up the initial value using the following formula:

Torsion and Differential speed detection filter (Pr7C) = 1st position loop gain (Pr10) x 2

[2] Setting of torsion feedback gain (Pr7D) and differential speed feedback gain (Pr7E)

While driving in the second full-closed control, scale ratio the values of torsion feedback gain (Pr7D) and the differential speed feedback gain (Pr7E), check the changes of the response of the full-closed position error.

When the response performance is increased, while tuning the torsion and differential speed detection filter (Pr7C) also, search an appropriate combination that the optimum repose is obtained.