

[Adjustment]

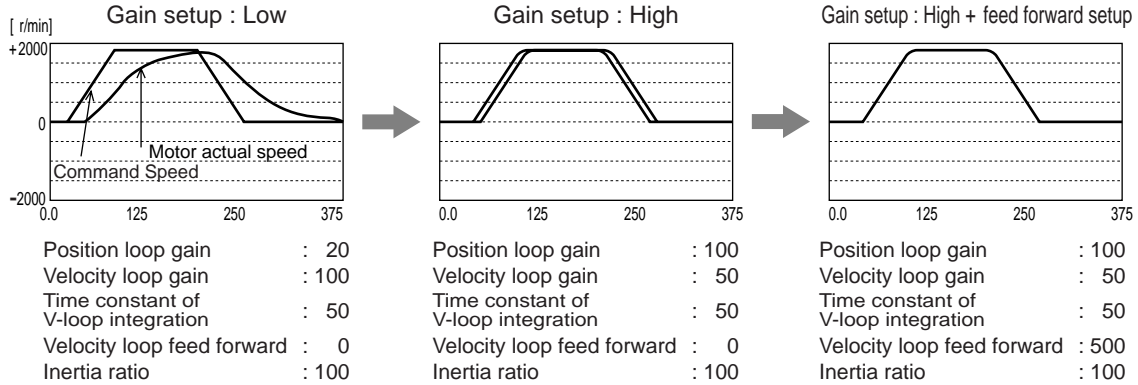
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Gain Adjustment

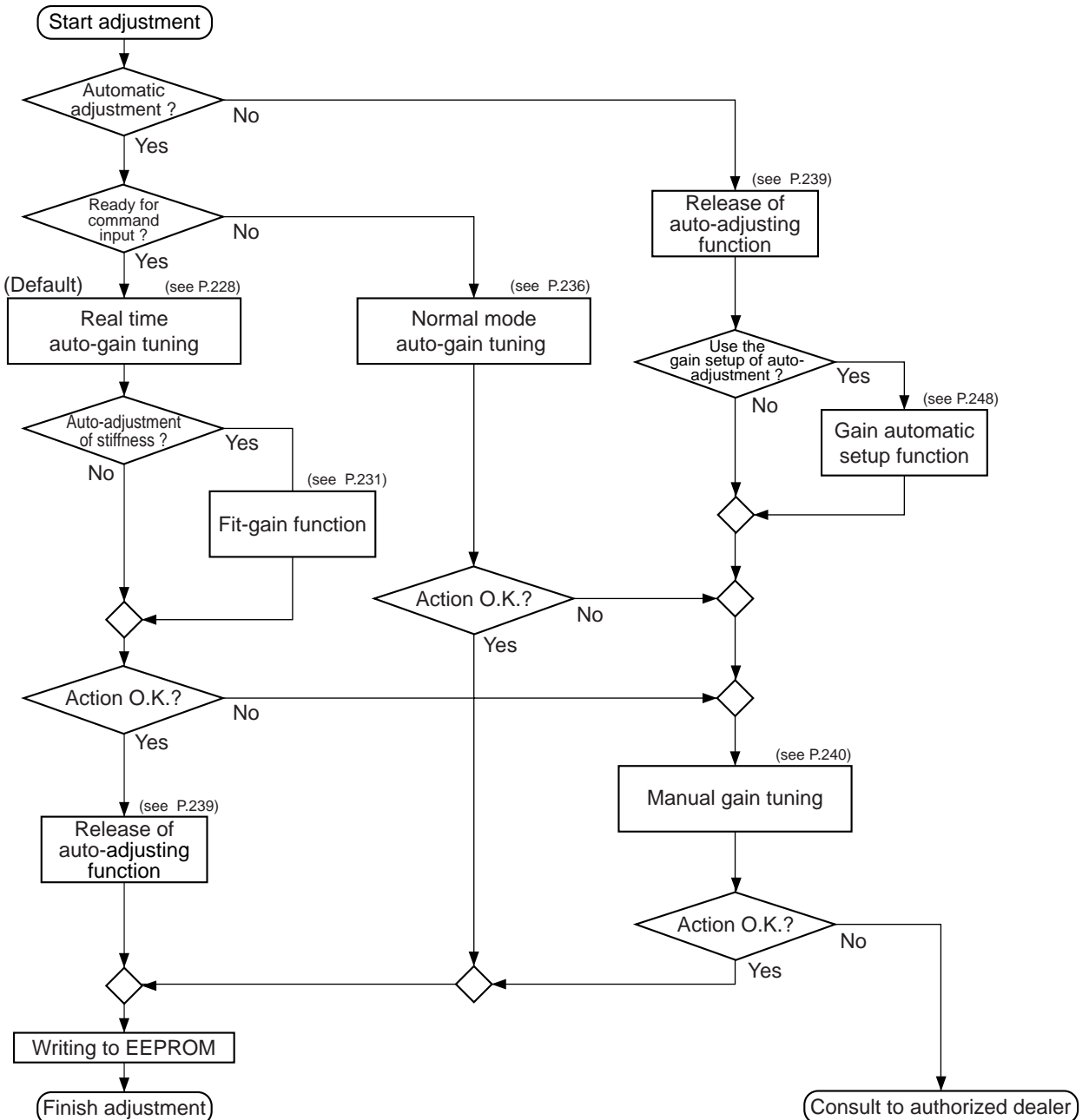
Purpose

It is required for the servo driver to run the motor in least time delay and as faithful as possible against the commands from the host controller. You can make a gain adjustment so that you can run the motor as closely as possible to the commands and obtain the optimum performance of the machine.

<e.g. : Ball screw>



Procedures



Type

Function		Explanation	Pages to refer
Automatic adjustment	Real-time auto-gain tuning	Estimates the load inertia of the machine in real time, and automatically sets up the optimum gain corresponding to this result.	P.228
	Fit-Gain function	Searches automatically the appropriate stiffness setup by entering the certain action pattern repeatedly, to set up the stiffness of real-time auto-gain tuning at position control.	P.231
	Adaptive filter	Reduces the resonance vibration point by automatically setting up the notch filter coefficient which removes the resonance component from the torque command while estimating the resonance frequency from the vibrating component which appears in the motor speed in actual operating condition.	P.234
	Normal mode auto-gain tuning	Sets up the appropriate gain automatically by calculating the load inertia from the torque required to run the motor in the command pattern automatically created in the driver.	P.236
	Release of automatic gain adjusting function	Describes the cautions when you invalidate the real-time auto-gain tuning or adaptive filter which are defaults.	P.239
Manual adjustment	Manual gain tuning (basic)	Execute the manual adjustment when real-time auto-gain tuning cannot be executed due to the limitation of control mode and load condition, or when you want to obtain an optimum response depending on each load.	P.240
	Basic procedure	Adjustment of position control mode	P.241
		Adjustment of velocity control mode	P.241
		Adjustment of torque control mode	P.242
		Adjustment of full-closed control mode	P.242
	Gain switching function	You can expect to reduce vibration at stopping and settling time and to improve command compliance by switching the gains by internal data or external signals.	P.243
	Suppression of machine resonance	When the machine stiffness is low, vibration or noise may be generated due to the distorted axis, hence you cannot set the higher gain. You can suppress the resonance with two kinds of filter.	P.246
	Automatic gain setup function	Initializes the control parameters and gain switching parameters to the values corresponding to the automatic tuning stiffness parameters, before executing the manual auto-gain tuning.	P.248
	Manual gain tuning (application)	You can obtain the higher performance while you are not satisfied with the performance obtained with the basic adjustment, using the following application functions.	P.249
	Instantaneous speed observer	Function which obtains both high response and reduction of vibration at stopping by estimating the motor speed with the load model, and hence improves the accuracy of speed detection.	P.249
Damping control	Function which reduces vibration by removing the vibration frequency component while the front end of the machine vibrates.	P.250	

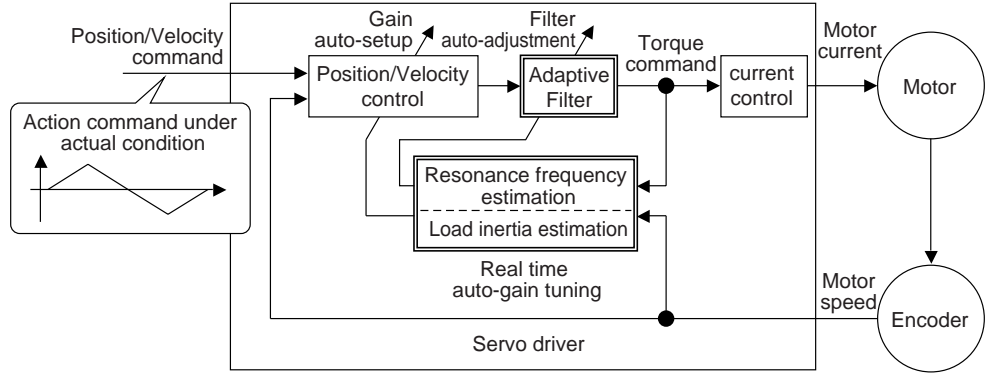
<Remarks>

- Pay extra attention to safety, when oscillation (abnormal noise and vibration) occurs, shut off the main power, or turn to Servo-OFF.

Real-Time Auto-Gain Tuning Mode

Outline

Estimates the load inertia of the machine in real time and sets up the optimum gain automatically responding to the result.



Applicable Range

Real time auto-gain tuning is applicable to all control modes.

Caution

Real-time auto-gain tuning may not be executed properly under the conditions described in the table below. In these cases, use the normal mode auto-gain tuning (refer to P.236 of Adjustment), or execute the manual auto-gain tuning (refer to P.240).

	Conditions which obstruct real-time auto-gain tuning action
Load inertia	<ul style="list-style-type: none"> The load is too small or large compared to the rotor inertia. (less than 3 times or more than 20 times) The load inertia changes too quickly (10 [s] or less)
Load	<ul style="list-style-type: none"> The machine stiffness is extremely low. A chattering such as backlash exists.
Action pattern	<ul style="list-style-type: none"> The motor is running continuously at low speed of (100 [r/min] or lower). Acceleration/deceleration is slow (2000 [r/min] per 1 [s] or low). Acceleration/deceleration torque is smaller than unbalanced weighted/viscous friction torque. When the speed condition of 100 [r/min] or more and acceleration/deceleration condition of 2000 [r/min] per 1 [s] are not maintained for 80 [ms] .

How to Operate

- 1) Bring the motor to stall (Servo-OFF).
- 2) Set up Pr21 (Setup of real-time auto-gain tuning mode) to 1-7.

Setup value	Real time auto-gain tuning	Varying degree of load inertia in motion
0	(not in use)	—
[1]	normal mode	no change
2		slow change
3		rapid change
4	vertical axis mode	no change
5		slow change
6		rapid change
7	no gain switching mode	no change

When the changing degree of load inertia is large, set up 3 or 6.

When the motor is used for vertical axis, set up 4-6.

When vibration occurs during gain switching, set up 7.

- 3) Set up Pr22 (Machine stiffness at real-time auto-gain tuning) to 0 or smaller value.
- 4) Turn to Servo-ON to run the machine normally.
- 5) Gradually increase Pr22 (Machine stiffness at real-time auto-gain tuning, machine) when you want to obtain a better response. Lower the value (0-3) when you experience abnormal noise or oscillation.
- 6) Write the result to EEPROM when you want to save it.

Insert the console connector to CN X6 of the driver, then turn on the driver power.

r 0

Setup of parameter, Pr21

Press **S**_{SET}.

dP_5Pd

Press **M**_{MODE}.

PA_00

Match to the parameter No. to be set up with **▲** **▼**. (Here match to Pr21.)

PA_21

Press **S**_{SET}.

1

Change the setup with **▲** **▼**.

Press **S**_{SET}.

PA_21

Setup of parameter, Pr22

Match to Pr22 with **▲**.

PA_22

Press **S**_{SET}.

4

Numeral increases with **▲**, and decreases with **▼**. (default values)

Press **S**_{SET}.

Writing to EEPROM

Press **M**_{MODE}.

EE_Set

Press **S**_{SET}.

EEP -

Bars increase as the right fig. shows by keep pressing **▲** (approx. 5sec).

EEP --

EEP ---

Writing starts (temporary display).

StArt

Finish

Finish RESET Error

Writing completes

Writing error occurs

Return to SELECTION display after writing finishes, referring to "Structure of each mode"(P.60 and 61 of Preparation).

Real-Time Auto-Gain Tuning

Parameters Which Are Automatically Set

Following parameters are automatically adjusted. Also following parameters are automatically set up.

PrNo.	Title
10	1st gain of position loop
11	1st gain of velocity loop
12	1st time constant of velocity loop integration
13	1st filter of velocity detection
14	1st time constant of torque filter
18	2nd gain of position loop
19	2nd gain of velocity loop
1A	2nd time constant of velocity loop integration
1B	2nd filter of speed detection
1C	2nd time constant of torque filter
20	Inertia ratio

PrNo.	Title	Setup value
15	Velocity feed forward	300
16	Time constant of feed forward filter	50
27	Setup of instantaneous speed observer	0
30	2nd gain setup	1
31	1st mode of control switching	10
32	1st delay time of control switching	30
33	1st level of control switching	50
34	1st hysteresis of control switching	33
35	Position gain switching time	20
36	2nd mode of control switching	0

<Notes>

- When the real-time auto-gain tuning is valid, you cannot change the parameters which are automatically adjusted.
- Pr31 becomes 10 at position or full closed control and when Pr21 (Setup of real-time auto-gain tuning) is 1 to 6, and becomes 0 in other cases.

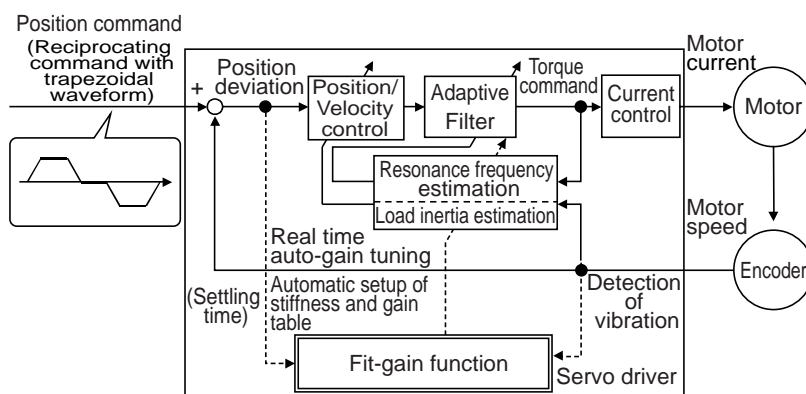
Caution

- (1) After the start-up, you may experience abnormal noise and oscillation right after the first Servo-ON, or increase of Pr22 (Selection of machine stiffness at real-time auto-gain tuning) until the load inertia is identified (estimated) or the adaptive filter is stabilized, however, these are not failures as long as they disappear immediately. If they persist over 3 reciprocating operations, take the following measures in possible order.
 - 1) Write the parameters which have given the normal operation into EEPROM.
 - 2) Lower the setup of Pr22 (Selection of machine stiffness at real time auto-gain tuning).
 - 3) Set up the notch filter manually.
- (2) When abnormal noise and oscillation occur, Pr20 (Inertia ratio) or Pr2F (Adaptive filter frequency) might have changed to extreme values. Take the same measures as the above in these cases.
- (3) Among the results of real-time auto-gain tuning, Pr20 (Inertia ratio) and Pr2F (Adaptive filter frequency) will be written to EEPROM every 30 minutes. When you turn on the power again, the auto-gain tuning will be executed using the latest data as initial values.
- (4) When you validate the real-time auto-gain tuning, Pr27 (Setup of instantaneous speed observer) will be invalidated (0) automatically.
- (5) During the trial run and frequency characteristics measurement of "PANATERM[®]", the load inertia estimation will be invalidated.

Fit-Gain function

Outline

MINAS-A4 series features the Fit-gain function which executes the automatic setup of stiffness corresponding to the machine while the real time auto-gain tuning is used at position control. This function automatically searches the optimum stiffness setup by repeating reciprocating movement at position control.



Applicable Range

This function can be applicable when the following conditions are satisfied in addition to the applicable conditions for real time auto-gain tuning.

	Conditions under which the Fit-gain function is activated
Real time auto-gain tuning action	<ul style="list-style-type: none"> The real-time auto-gain tuning has to work properly. At Servo-ON status Pr21= 1-6 (Not usable when Pr21= 0 or 7)
Adaptive filter	<ul style="list-style-type: none"> The adaptive filter is validated. Pr23= 1 : Validated
Control mode	<ul style="list-style-type: none"> At position control mode Pr02= 0 : Position control Pr02= 3 : 1st control mode of position/velocity control Pr02= 4 : 1st control mode of position/torque control
Action pattern	<ul style="list-style-type: none"> The position command to be for reciprocating movement One position command time to be 50 [ms] or longer. Min. frequency of position command to be 1 [kpps] or more. (To be used for judgment of start and finish of command)

Caution

This function may not work properly under the following conditions in addition to the conditions for real time auto-gain tuning. In these cases, use the normal real-time auto-gain tuning.

	Conditions which obstruct Fit-Gain action
Action pattern	<ul style="list-style-type: none"> The position command is small such as less than 2 revolutions. When the positioning cannot be completed before the start of the next position command even though the positioning command has been completed. Acceleration/deceleration is rapid such as 30000 [r/min] per 1 [s] .

Real-Time Auto-Gain Tuning

Before Operation

Before the start-up of the Fit-Gain function, set up the followings with the Fit-Gain screen and parameter setup mode of the front panel, or the Console or the Setup Support Software, "PANATERM®".

Parameter	Setup value	Notes
Pr21 (Setup of real-time auto-gain tuning mode)	Either of 1-6.	
	1	Normal mode no change
	2	Normal mode slow change
	3	Normal mode rapid change
	4	Vertical axis mode no change
	5	Vertical axis mode slow change
6	Vertical axis mode rapid change	
Pr22 (Selection machine stiffness at real time auto-gain tuning)	0 : Real time stiffness No. 0	You can setup parameters in the left through the EXECUTION display of the Fit-Gain screen on the front panel. (Refer to P.72 of Preparation.)
Pr23 (Setup of adaptive filter)	1 : Valid	
Pr60 (Positioning complete range)	In case of 17bit encoder, 20 pulses or more, In case of 2500P/r encoder, 10 pulses or more,	

How to Operate

Procedures

- Bring the front panel display to EXECUTION display of the Fit-Gain screen.
(For operation of the front panel, refer to P.72 of Preparation.)
- Start up the Fit-Gain function by pressing ∇ for approx. 3sec after lowering the stiffness to 0 while the dot "." on the right lower corner flashes.
- Enter the position command which satisfies the action pattern condition of P.228, "Applicable Range".

<Caution 1>

The Fit-Gain movement requires max. 50 reciprocating movements. The Fit-gain function finishes when the optimum real-time stiffness No. is found in normal case.

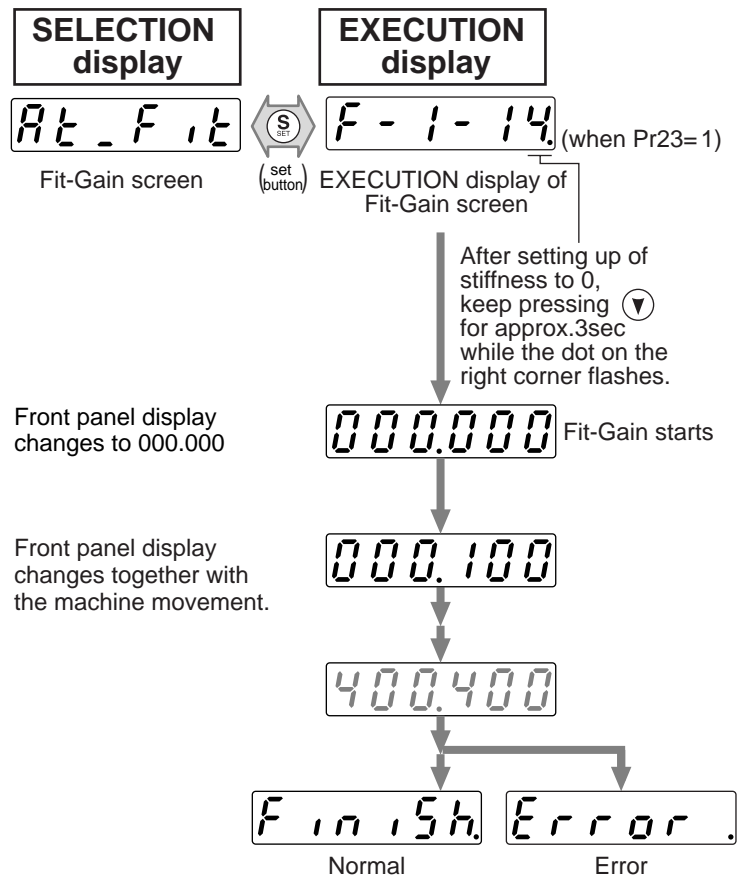
- $[Finish]$ will be displayed when the Fit-Gain function finishes normally, and $[Error]$ will be displayed when this finishes with error.
(You can clear $[Error]$ display by operating any key.)

<Caution 2>

$[Error]$ will be displayed in the following cases.

- No chattering of COIN signal and real-time stiffness NO. without micro vibration, have been found.
- One of the keys of the front panel has been operated during the Fit-Gain action, or applicable condition have not been satisfied.

Example of front panel display



Result of Fit-Gain

`Finish` will be displayed when the Fit-Gain finishes normally, and `Error` will be displayed when it finishes with some error. Write the result to EEPROM when you want to apply the result after the power reset.

[EXECUTION display] Writing of the result from the Fit-Gain screen

Press for approx.3sec to save the present setup to EEPROM.

Parameters Which Are Automatically Set

Following parameters are automatically adjusted.

PrNo.	Title
10	1st gain of position loop
11	1st gain of velocity loop
12	1st time constant of velocity loop integration
13	1st filter of velocity detection
14	1st time constant of torque filter time
18	2nd gain of position loop
19	2nd gain of velocity loop
1A	2nd time constant of velocity loop integration
1B	2nd filter of velocity detection
1C	2nd time constant of torque filter
20	Inertia ratio
22	Selection of machine stiffness at real time auto-gain tuning

Also following parameters are automatically set up.

PrNo.	Title	Setup value
15	Velocity feed forward	300
16	Time constant of feed forward filter	50
27	Setup of instantaneous speed observer	0
30	2nd gain setup	1
31	1st mode of control switching	10
32	1st delay time of control switching	30
33	1st level of control switching	50
34	1st Hysteresis of control switching	33
35	Switching time of position gain	20
36	2nd mode of control switching	0

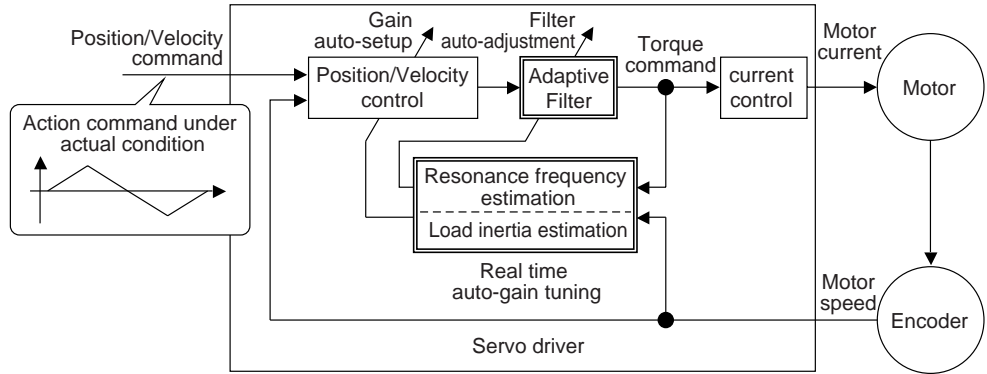
Caution

During the Fit-Gain movement, you may experience some noise and vibration, however, these do not give any trouble since the gain is automatically lowered. If noise and vibration persist, interrupt the Fit-Gain by pressing one of the switches of the front panel.

Adaptive Filter

Outline

Estimates the resonance frequency out of vibration component presented in the motor speed in motion, then removes the resonance component from the torque command by setting up the notch filter coefficient automatically, hence reduces the resonance vibration.



Applicable Range

This function works under the following condition.

Conditions under which the Adaptive filter is activated	
Control Mode	• Applies to other control modes than torque control.

Caution

The adaptive filter may not work properly under the following conditions. In these cases, take measures to resonance according to the manual adjustment procedures, using the 1st notch filter (Pr1D and 1E) and the 2nd notch filter (Pr28 to 2A).

Conditions which obstruct adaptive filter action	
Resonance point	<ul style="list-style-type: none"> • Resonance frequency is lower than 300[Hz] . • Resonance peak is low, or control gain is low where the motor speed is not affected by this. • Multiple resonance points exist.
Load	• Motor speed variation with high harmonic component is generated due to non-linear factors such as backlash.
Command pattern	• Acceleration/deceleration is rapid such as 30000[r/min] per 1[s] .

How to Operate

1) Validate the adaptive filter by setting up Pr23 (Setup of adaptive filter) to 1.

Adaptive filter automatically estimates the resonance frequency out of vibration component presented in the motor speed in motion, then removes the resonance components from the torque command by setting up the notch filter coefficient automatically, hence reduces the resonance vibration.

Setup value	Adaptive filter	Adaptive action
0	Invalid	-
[1]	Valid	Yes
2		No (Hold)

When adaptation finishes (Pr2F does not change), and resonance point seems not change, set up the value to 2.

2) Write the result to EEPROM when you want to save it.

Caution

- (1) After the start-up, you may experience abnormal noise and oscillation right after the first Servo-ON, or when you increase the setup of Pr22 (Selection of machine stiffness at real-time auto-gain tuning), until the load inertia is identified (estimated) or the adaptive filter is stabilized, however, these are not failures as long as they disappear immediately. If they persist over 3 reciprocating operations, take the following measures in possible order.
 - 1) Write the parameters which have given the normal operation into EEPROM.
 - 2) Lower the setup of Pr22 (Selection of machine stiffness at real-time auto-gain tuning).
 - 3) Invalidate the adaptive filter by setting up Pr23 (Setup of adaptive filter mode) to 0.
(Reset of inertia calculation and adaptive action)
 - 4) Set up the notch filter manually.
- (2) When abnormal noise and oscillation occur, Pr2F (Adaptive filter frequency) might have changed to extreme values. Take the same measures as the above in these cases.
- (3) Pr2F (Adaptive filter frequency) will be written to EEPROM every 30 minutes. When you turn on the power again, adaptive action will be executed using the latest data as initial values.
- (4) The adaptive filter is normally invalidated at torque control, however, when you select torque control while you set up Pr02 (Control mode setup) to 4 and 5, the adaptive filter frequency before mode switching will be held.

Invalidation of Adaptive Filter

When you set up Pr23 (Setup of adaptive filter) to 0, the adaptive filter function which automatically follows the load resonance will be invalidated.

If you invalidate the adaptive filter which have been working correctly, noise and vibration may occur due to the effect of resonance which have been suppressed.

Therefore, execute the copying function of the setup of adaptive filter (Pr2F) to the 1st notch frequency (Pr1D) from the Fit-Gain screen of the front panel (refer to P.72, "Fit-Gain Screen" of Preparation), or set up Pr1D (1st notch frequency) manually by using the table below, then invalidate this filter.

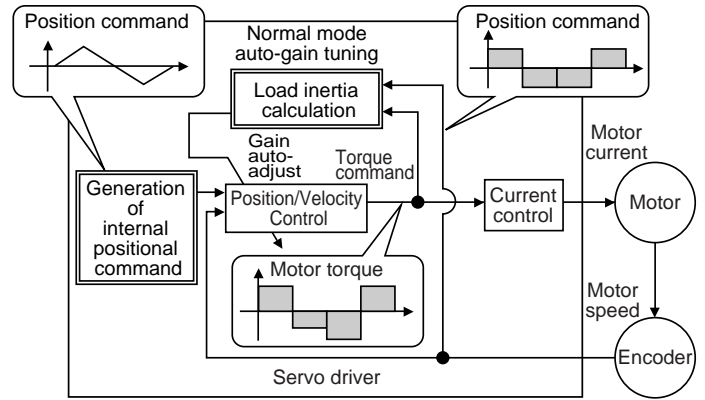
Pr2F	1st notch frequency [Hz]	Pr2F	1st notch frequency [Hz]	Pr2F	1st notch frequency [Hz]
0	(invalid)	22	766	44	326
1	(invalid)	23	737	45	314
2	(invalid)	24	709	46	302
3	(invalid)	25	682	47	290
4	(invalid)	26	656	48	279
5	1482	27	631	49	269 (invalid when Pr22 ≥ 15)
6	1426	28	607	50	258 (invalid when Pr22 ≥ 15)
7	1372	29	584	51	248 (invalid when Pr22 ≥ 15)
8	1319	30	562	52	239 (invalid when Pr22 ≥ 15)
9	1269	31	540	53	230 (invalid when Pr22 ≥ 15)
10	1221	32	520	54	221 (invalid when Pr22 ≥ 14)
11	1174	33	500	55	213 (invalid when Pr22 ≥ 14)
12	1130	34	481	56	205 (invalid when Pr22 ≥ 14)
13	1087	35	462	57	197 (invalid when Pr22 ≥ 14)
14	1045	36	445	58	189 (invalid when Pr22 ≥ 14)
15	1005	37	428	59	182 (invalid when Pr22 ≥ 13)
16	967	38	412	60	(invalid)
17	930	39	396	61	(invalid)
18	895	40	381	62	(invalid)
19	861	41	366	63	(invalid)
20	828	42	352	64	(invalid)
21	796	43	339		

*Set up 1500 to Pr1D (1st notch frequency) in case of "invalid" of the above table.

Normal Mode Auto-Gain Tuning

Outline

The motor will be driven per the command with a pattern generated by the driver automatically. The driver estimates the load inertia from the necessary torque, and sets up an appropriate gain automatically.



Applicable Range

This function works under the following condition.

Conditions under which the normal mode auto-gain tuning is activated	
Control mode	Applies to all control modes.
Others	<ul style="list-style-type: none"> • Servo-ON status • No entry of deviation counter clear signal

<Remarks>

Set up the torque limit selection (Pr03) to 1.

When you set up other than 1, driver may not act correctly.

Caution

Normal mode auto-gain tuning may not be work properly under the following conditions. In these cases, set up in manual gain tuning

Conditions which obstruct normal auto-gain tuning	
Load inertia	<ul style="list-style-type: none"> • Too small or too big compared to the rotor inertia (smaller than 3 times or larger than 20 times) • Load inertia varies.
Load	<ul style="list-style-type: none"> • Machine stiffness is extremely low. • Chattering such as backlash exists.

- Tuning error will be triggered when an error, Servo-OFF, the main power shutdown, validation of over-travel inhibition, or deviation counter clear occurs during the normal mode auto-gain tuning.
- If the load inertia cannot be calculated even though the normal mode auto-gain tuning is executed, gain value will not change and be kept as same as that of before the execution.
- The motor output torque during the normal auto-gain tuning is permitted to the max. torque set with Pr5E (Setup of torque limit).

Pay an extra attention to the safety. When oscillation occurs, shut off the main power or turn to Servo-OFF immediately. Bring back the gain to default with parameter setup. Refer to cautions of P.71, "Auto-Gain Tuning Mode" of Preparation as well.

Auto-Gain Tuning Action

(1) In the normal mode auto-gain tuning, you can set up the response with machine stiffness No..

Machine stiffness No.

- Represents the degree of machine stiffness of the customer's machine and have values from 0 to 15. You can set a higher No. to the high stiffness machine and set up a higher gain.
- Usually start setting up with a lower value and increase gradually to repeat auto-gain tuning in the range where no oscillation, no abnormal noise, nor vibration occurs.

(2) This tuning repeats max. 5 cycles of the action pattern set with Pr25 (Normal mode auto-gain tuning action). Action acceleration will be doubled every one cycle after third cycle. Tuning may finish, or action acceleration does not vary before 5th cycle depending on the load, however, this is not an error.

How to Operate

- Set up the action pattern with Pr25.
- Shift the load to the position where no hazard is expected even though the action pattern which is set with Pr25 is executed.
- Prohibit the command entry.
- Turn to Servo-ON.
- Start up the auto-gain tuning.
Use the front panel or the "PANATERM®".
For the operation of the front panel, refer to P.71, "Auto-Gain Tuning Mode" of Preparation.
- Adjust the machine stiffness to the level at which no vibration occurs and obtain the required response.
- Write the result to EEPROM, if it is satisfactory.

Parameters Which Are Automatically Set

Table of auto-gain tuning

Pr No.	Title	Stiffness value															
		0	[1]	2	3	[4]	5	6	7	8	9	10	11	12	13	14	15
10	1st gain of position loop	12	32	39	48	63	72	90	108	135	162	206	251	305	377	449	557
11	1st gain of velocity loop	9	18	22	27	35	40	50	60	75	90	115	140	170	210	250	310
12	1st time constant of velocity loop integration	62	31	25	21	16	14	12	11	9	8	7	6	5	4	4	3
13	1st filter of velocity detection	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	1st time constant of torque filter time *2	253	126	103	84	65	57	45	38	30	25	20	16	13	11	10	10
15	Velocity feed forward	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
16	Velocity FF filter	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
18	2nd gain of position loop	19	38	46	57	73	84	105	126	157	188	241	293	356	440	524	649
19	2nd gain of velocity loop	9	18	22	27	35	40	50	60	75	90	115	140	170	210	250	310
1A	2nd time constant of velocity loop integration	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999
1B	2nd filter of speed detection	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1C	2nd time constant of torque filter *2	253	126	103	84	65	57	45	38	30	25	20	16	13	11	10	10
20	Inertia ratio	Estimated load inertia ratio															
27	Setup of instantaneous velocity observer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	2nd gain setup	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1st mode of control switching *1	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
32	1st delay time of control switching	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
33	1st level of control switching	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
34	1st Hysteresis of control switching	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
35	Switching time of position gain	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
36	2nd mode of control switching	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Adjustment

□ represents parameters with fixed value. Default for A to C-frame is 4, and 1 for D to F-frame.

*1 Stiffness value is 10 for position control and full-closed control, and 0 for velocity control and torque control.

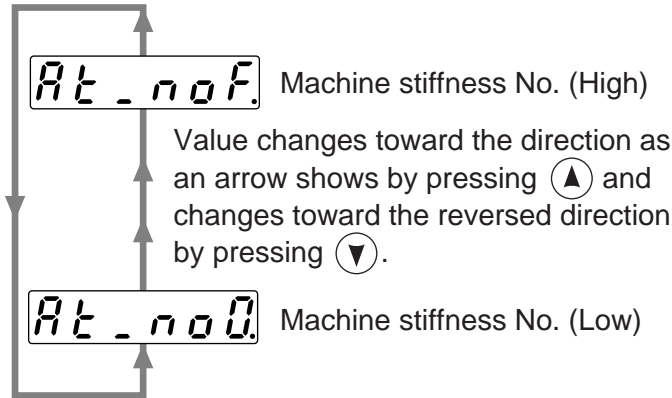
*2 Lower limit for stiffness value is 10 for 17-bit encoder, and 25 for 2500P/r encoder.

Normal Mode Auto-Gain Tuning

How to Operate from the Front Panel

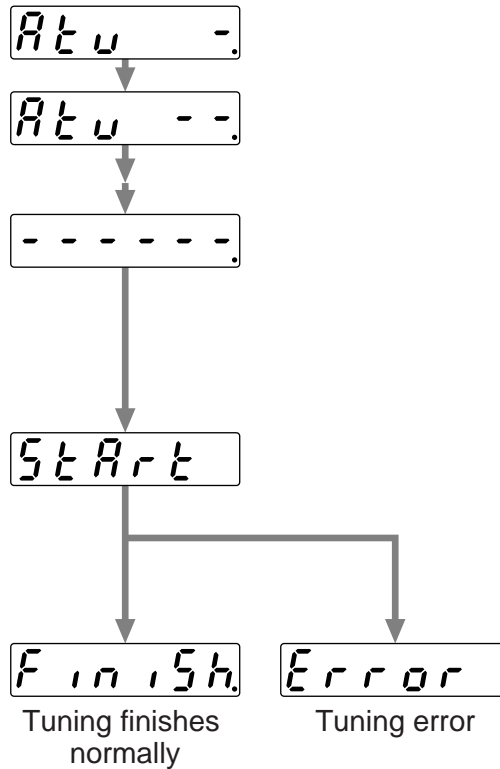
- (1) Turn to the normal auto-gain tuning mode from the monitor mode, by pressing the SET button, then press the mode switching button three times. For details, refer to P.60 and 61, "Structure of Each Mode" of Preparation.
- Display of rotational speed of the motor (initial display)
 Machine stiffness No.

- (2) Enter the machine stiffness No. by pressing .



Drive method	Machine stiffness No.
Ball screw direct connection	8 -14
Ball screw + timing belt	6 -12
Timing belt	4 -10
Gear, Rack & Pinion	2 - 8
Others, low stiffness machine	0 - 8

- (3) Shift to MONITOR/EXECUTION mode by pressing .
- (4) Operation at MONITOR/EXECUTION mode
 Keep pressing until the display changes to .
 • Pin-29 of the connector, CN X5 to be Servo-ON status.
 Keep pressing for approx.3sec, then bar increase as the right fig. shows.



The motor starts rotating.
 For approx. 15 sec, the motor repeats max. 5 cycles of CCW/CW rotation, 2 revolutions each direction per one cycle.
 Tuning may finish before 5th cycles, however, this is not an error.

- (5) Write the gain value to EEPROM to prevent them from being lost due to the power shut off.

<Caution>

Do not use the normal mode auto-gain tuning with the motor and driver alone. Pr20 (Inertia ratio) becomes to 0.

<Notes>

Content	Cause	Measure
Display of error.	One of alarm, Servo-OFF or deviation counter clear has occurred.	<ul style="list-style-type: none"> • Avoid an operation near the limit switch or origin proximity switch. • Turn to Servo-ON. • Release the deviation counter clear
Value of parameter related to gain (such as Pr10) is kept as same as before the execution.	Load inertia cannot be identified.	<ul style="list-style-type: none"> • Lower Pr10 to 10 and Pr11 to 50, then execute the tuning. • Adjust the gain manually. (Calculate the load inertia, and then enter.)
Motor does not run.	CL (Pin-30) of CN X5 is entered.	Turn off the CL (Pin-30) of CN X5.

Release of Automatic Gain Adjusting Function [Adjustment]

Outline

Cautions are described when you want to invalidate the real time auto-gain tuning of default or the adaptive filter.

Caution

Execute the release of the automatic adjusting functions while all action stop (Servo-OFF)

Invalidation of Real-Time Auto-Gain Tuning

You can stop the automatic calculation of Pr20 (Inertial ratio) and invalidate the real-time auto-gain tuning by setting up Pr21 (Real-time auto-gain tuning setup) to 0.

Note that the calculation result of Pr20 (Inertia ratio) will be held, and if this parameter becomes abnormal value, use the normal mode auto-gain tuning or set up proper value manually obtained from formula or calculation.

Invalidation of Adaptive Filter

When you set up Pr23 (Setup of adaptive filter) to 0, adaptive filter function which automatically follows the load resonance will be invalidated.

If you invalidate the adaptive filter which have been working correctly, noise and vibration may occur due to the effect of resonance which have been suppressed.

Therefore, execute the copying function of the setup of adaptive filter (Pr2F) to the 1st notch frequency (Pr1D) from the Fit-gain screen of the front panel (refer to P.72, "Fit-Gain Screen" of Preparation), or set up Pr1D (1st notch frequency) manually by using the table below, then invalidate this filter.

Pr2F	1st notch frequency [Hz]	Pr2F	1st notch frequency [Hz]	Pr2F	1st notch frequency [Hz]
0	(invalid)	22	766	44	326
1	(invalid)	23	737	45	314
2	(invalid)	24	709	46	302
3	(invalid)	25	682	47	290
4	(invalid)	26	656	48	279
5	1482	27	631	49	269 (invalid when Pr22 ≥ 15)
6	1426	28	607	50	258 (invalid when Pr22 ≥ 15)
7	1372	29	584	51	248 (invalid when Pr22 ≥ 15)
8	1319	30	562	52	239 (invalid when Pr22 ≥ 15)
9	1269	31	540	53	230 (invalid when Pr22 ≥ 15)
10	1221	32	520	54	221 (invalid when Pr22 ≥ 14)
11	1174	33	500	55	213 (invalid when Pr22 ≥ 14)
12	1130	34	481	56	205 (invalid when Pr22 ≥ 14)
13	1087	35	462	57	197 (invalid when Pr22 ≥ 14)
14	1045	36	445	58	189 (invalid when Pr22 ≥ 14)
15	1005	37	428	59	182 (invalid when Pr22 ≥ 13)
16	967	38	412	60	(invalid)
17	930	39	396	61	(invalid)
18	895	40	381	62	(invalid)
19	861	41	366	63	(invalid)
20	828	42	352	64	(invalid)
21	796	43	339		

*Set up 1500 to Pr1D (1st notch frequency) in case of "invalid" of the above table.

Manual Gain Tuning (Basic)

As explained previously, MINAS-A4 series features the automatic gain tuning function, however, there might be some cases where this automatic gain tuning cannot be adjusted properly depending on the limitation on load conditions. Or you might need to readjust the tuning to obtain the optimum response or stability corresponding to each load.

Here we explain this manual gain tuning method by each control mode and function.

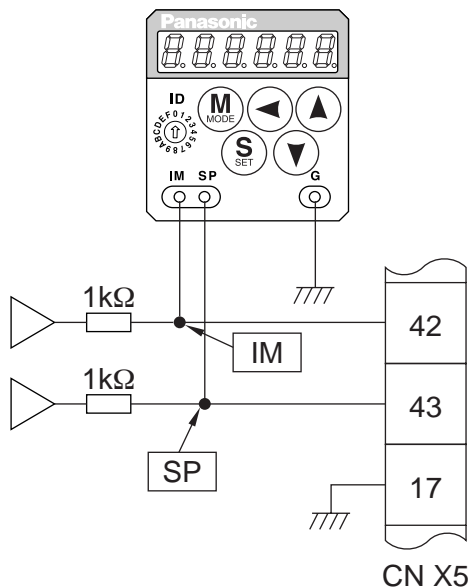
Before Making a Manual Adjustment

You can adjust with the sound or motor (machine) movement by using the front panel or the console, however, you can adjust more securely by using wave graphic function of the setup support software, PANATERM®, or by measuring the analog voltage waveform using a monitoring function.

1. Analog monitor output

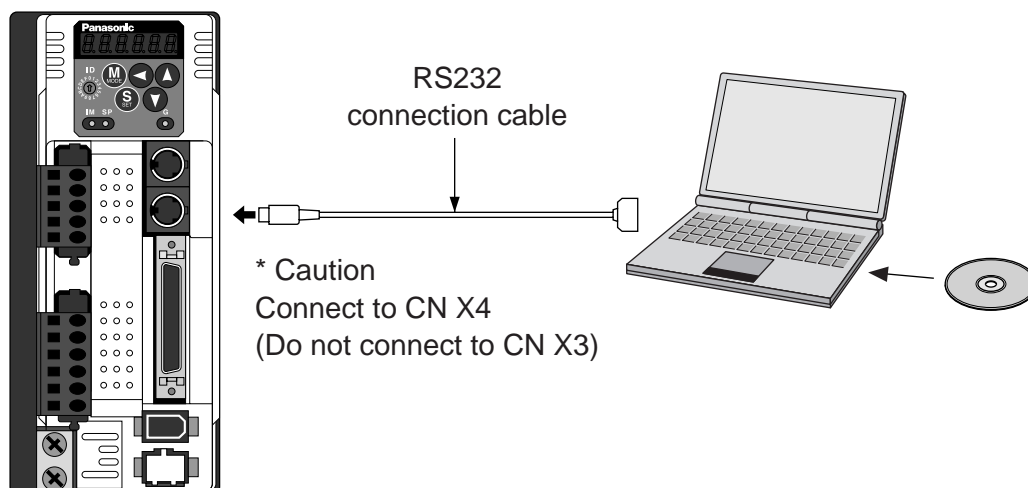
You can measure the actual motor speed, commanded speed, torque and deviation pulses by analog voltage level by using an oscilloscope. Set up the types of the signals or the output voltage level with Pr07 (Selection of speed monitor) and Pr08 (Selection of torque monitor).

For details, refer to P.41, "Wiring to the Connector, CN X5" of Preparation, and "Parameter Setup" of each control mode.



2. Waveform graphic function of the PANATERM®

You can display the command to the motor, motor movement (speed, torque command and deviation pulses) as a waveform graphic on PC display. Refer to P.276, "Outline of the Setup Support Software, PANATERM®" of Supplement.



Adjustment in Position Control Mode

Position control of MINAS-A4 series is described in Block diagram of P.82.
Make adjustment in position control per the following procedures.

(1) Set up the following parameters to the values of the table below.

Parameter No. (Pr□□)	Title of parameter	Standard value	Parameter No. (Pr□□)	Title of parameter	Standard value
10	1st gain of position loop	27	20	Inertia ratio	100
11	1st gain of velocity loop	15	21	Setup of real time auto-gain tuning mode	0
12	1st time constant of velocity loop integration	37	23	Adaptive filter setup mode	0
13	1st filter of velocity detection	0	2B	1st damping frequency	0
14	1st time constant of torque filter time	152	2C	Setup of 1st damping filter	0
15	Velocity feed forward	0	2D	2nd damping frequency	0
16	Time constant of feed forward filter	0	2E	Setup of 2nd damping filter	0
18	2nd gain of position loop	27	30	2nd gain setup	0
19	2nd gain of velocity loop	15	31	Mode of position control switching	0
1A	2nd time constant of velocity loop integration	37	32	Delay time of position control switching delay	0
1B	2nd filter of speed detection	0	33	Level of position control switching	0
1C	2nd time constant of torque filter	152	34	Hysteresis at position control switching	0
1D	Selection of 1st notch frequency	1500	35	Position gain switching time	0
1E	Selection of 1st notch width	2	4C	Setup of smoothing filter	1
			4D	Setup of FIR filter	0

(2) Enter the inertia ratio of Pr20. Measure the ratio or setup the calculated value.

(3) Make adjustment using the standard values below.

Order	Parameter No. (Pr□□)	Title of parameter	Standard value	How to adjust
1	Pr11	1st gain of velocity loop	30	Increase the value within the range where no abnormal noise and no vibration occur. If they occur, lower the value.
2	Pr14	1st time constant of torque filter	50	When vibration occurs by changing Pr11, change this value. Setup so as to make Pr11 x Pr14 becomes smaller than 10000. If you want to suppress vibration at stopping, setup larger value to Pr14 and smaller value to Pr11. If you experience too large vibration right before stopping, lower than value of Pr14.
3	Pr10	1st gain of position loop	50	Adjust this observing the positioning time. Larger the setup, faster the positioning time you can obtain, but too large setup may cause oscillation.
4	Pr12	1st time constant of velocity loop integration	25	Setup this value within the range where no problem occurs. If you setup smaller value, you can obtain a shorter positioning time, but too small value may cause oscillation. If you setup too large value, deviation pulses do not converge and will be remained.
5	Pr15	Velocity feed forward	300	Increase the value within the range where no abnormal noise occurs. Too large setup may result in overshoot or chattering of position complete signal, hence does not shorten the settling time. If the command pulse is not even, you can improve by setting up Pr16 (Feed forward filter) to larger value.

Adjustment in Velocity Control Mode

Velocity control of MINAS-A4 series is described in Block Diagram of P.126 of Velocity Control Mode. Adjustment in velocity control is almost same as that in position control described in "Adjustment in Position Control Mode", and make adjustments of parameters per the procedures except the gain setup of position loop and the setup of velocity feed forward.

Manual Gain Tuning (Basic)

Adjustment in Torque Control Mode

Torque control of MINAS-A4 series is described in P.160, "Block Diagram" of Torque Control Mode. This torque control is based on velocity control while making the 4th speed of speed setup of Pr56 or SPR/SPL input as a speed limit. Here we explain the setup of speed limiting value.

• Setup of speed limiting value

Setup the speed limiting value to the 4th speed of speed setup (Pr56) (when torque command selection (Pr5B) is 0.) or to the analog speed command input (SPR/TRQR/SPL) (when torque command selection (Pr5B) is 1).

- When the motor speed approaches to the speed limiting value, torque control following the analog torque command shifts to velocity control based on the speed limiting value which will be determined by the 4th speed of speed setup (Pr56) or the analog speed command input (SPR/TRQR/SPL).
- In order to stabilize the movement under the speed limiting, you are required to set up the parameters according to the above-mentioned "Adjustment in Velocity Control Mode".
- When the speed limiting value = 4th speed of speed setup (Pr56), the analog speed command input is too low or the velocity loop gain is too low, or when the time constant of the velocity loop integration is 1000 (invalid), the input to the torque limiting portion of the above fig. becomes small and the output torque may not be generated as the analog torque command.

Adjustment in Full-Closed Control Mode

Full-closed control of MINAS-A4 series is described in Block diagram of P.191 of Full-Closed Control. Adjustment in full-closed control is almost same as that in position control described in P.241 "Adjustment in Position Control Mode", and make adjustments of parameters per the procedures except cautions of P.190, "Outline of Full-Closed Control" (difference of command unit, necessity of position loop unit conversion and difference of electronic gear).

Here we explain the setup of external scale ratio, hybrid deviation excess and hybrid control at initial setup of full-closed control.

1) Setup of external scale ratio

Setup the external scale ratio using the numerator of external scale division (Pr78), the multiplier for numerator of external scale division (Pr79) and denominator of external scale division (Pr7A).

- Check the encoder pulse counts per one motor revolution and the external scale pulse counts per one motor revolution, then set up the numerator of external scale division (Pr78), the multiplier for numerator of external scale division (Pr79) and denominator of external scale division so that the following formula can be established.

$$\frac{\text{Pr78 } \boxed{1} \times 2^{\text{Pr79 } \boxed{17}}}{\text{Pr7A } \boxed{5000}} = \frac{\text{Number of encoder pulses per motor rotation}}{\text{Number of external scale pulses per motor rotation}}$$

- If this ratio is incorrect, a gap between the position calculated from the encoder pulse counts and that of calculated from the external scale pulse counts will be enlarged and hybrid deviation excess (Err.25) will be triggered when the work or load travels a long distance.
- When you set up Pr78 to 0, the encoder pulse counts will be automatically set up.

2) Setup of hybrid deviation excess

Set up the minimum value of hybrid deviation excess (Pr78) within the range where the gap between the motor (encoder) position and the load (external scale) position will be considered to be an excess.

- Note that the hybrid deviation excess (Error code No.25) may be generated under other conditions than the above 1), such as reversed connection of the external scale or loose connection of the motor and the load.

Caution

- (1) Enter the command pulses based on the external scale reference.
- (2) The external scales to be used for full-closed control are as follows.
 - AT500 series by Mitutoyo (Resolution 0.05[μm] , max. speed 2[m/s])
 - ST771 by Mitutoyo (Resolution 0.5[μm] , max. speed 2[m/s])
- (3) To prevent the runaway and damage of the machine due to the setup of the external scale, setup the hybrid deviation excess (Pr7B) to the appropriate value, in the unit of external scale resolution.

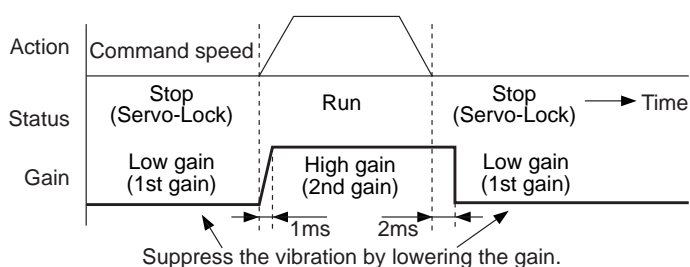
(4) **We recommend the external scale as $1/20 \leq \text{external scale ratio} \leq 20$.**

If you setup the external scale ratio to smaller value than 50/position loop gain (Pr10 and 18), you may not be able to control by one pulse unit. If you set up too large external scale ratio, you may expect larger noise in movement.

Gain Switching Function

At manual gain tuning, you can set 2nd gain manually in addition to 1st gain and you can switch the gain depending on the various requirements of the action such cases as,

- you want to increase the response by increasing the gain in motion
- you want to increase the servo-lock stiffness by increasing the gain at stopping
- switch to the optimum gain according to the action mode
- lower the gain to suppress the vibration at stopping.



<Example>

Following is the example when you want to reduce the noise at motor in stall (Servo-Lock), by setting up to lower gain after the motor stops.

- Make adjustment referring to the auto-gain tuning table (P.237) as well.

Parameter No. (Pr□□)	Title of parameter	Execute manual gain-tuning without gain switching	Set up the same value as Pr10-14 (1st gain) to Pr18-1C (2nd gain)	Set up Pr30-35 (Gain switching condition)	Adjust P411 and 14 at stopping (1st gain)
10	1st gain of position loop	63			
11	1st gain of velocity loop	35			27
12	1st time constant of velocity integration	16			
13	1st filter of velocity detection	0			
14	1st time constant of torque filter	65			84
15	Velocity feed forward	300			
16	Filter of velocity feed forward	50			
18	2nd gain of position loop		63		
19	2nd gain of velocity loop		35		
1A	2nd time constant of velocity integration		16		
1B	2nd filter of velocity detection		0		
1C	2nd time constant of torque filter time		65		
30	Action setup of 2nd gain	0		1	
31	1st mode of control switching			7	
32	1st delay time of control switching			30	
33	1st level of control switching			0	
34	1st hysteresis of control switching			0	
35	Switching time of position gain			0	
20	Inertia ration	<ul style="list-style-type: none"> • Enter the known value from load calculation • Measure the inertia ratio by executing normal auto-gain tuning • Default is 250 			

Manual Gain Tuning (Basic)

Setup of Gain Switching Condition

- Positioning control mode, Full-closed control mode (○ : Corresponding parameter is valid, – : invalid)

Setup of gain switching condition			Setup parameters at position control, full-closed control		
Pr31	Switching condition to 2nd gain	Fig.	Delay time * 1	Level	Hysteresis *2
			Pr32	Pr33	Pr34
0	Fixed to 1st gain		-	-	-
1	Fixed to 2nd gain		-	-	-
2	Gain switching input, GAIN ON		-	-	-
3	Variation of torque command is large.	A	○	○ *3 [0.05%/166μs]	○ *3 [0.05%/166μs]
4	Fixed to 1st gain		-	-	-
5	Speed command is large.	C	○	○ [r/min]	○ [r/min]
6	Position deviation/Full-closed position deviation is large	D	○	○ *4 [pulse]	○ *4 [pulse]
7	Position command exists.	E	○	-	-
8	Not in positioning complete nor in full-closed positioning complete	F	○	-	-
9	Speed	C	○	○ [r/min]	○ [r/min]
10	Command exists + velocity	G	○	○ [r/min] *6	○ [r/min] *6

- Velocity control mode

Setup of gain switching condition			Setup parameters at velocity control mode		
Pr31,36	Switching condition to 2nd gain	Fig.	Delay time * 1	Level	Hysteresis * 2
			Pr32, 37	Pr33, 38	Pr34, 39
0	Fixed to 1st gain		-	-	-
1	Fixed to 2nd gain		-	-	-
2	Gain switching input, GAIN ON		-	-	-
3	Variation of torque command is large.	A	○	○ *3 [0.05%/166μs]	○ *3 [0.05%/166μs]
4	Variation of speed command is large.	B	○	○ *5 [10(r/min)/s]	○ *5 [10(r/min)/s]
5	Speed command is large.	C	○	○ [r/min]	○ [r/min]

- Torque control mode

Setup of gain switching condition			Setup parameters at torque control mode		
Pr31,36	Setup of gain switching condition	Fig.	Delay time * 1	Level	Hysteresis * 2
			Pr32, 37	Pr33, 38	Pr34, 39
0	Fixed to 1st gain		-	-	-
1	Fixed to 2nd gain		-	-	-
2	Gain switching input, GAIN ON		-	-	-
3	Variation of torque command is large.	A	○	○ *3 [0.05%/166μs]	○ *3 [0.05%/166μs]

*1 Delay time (Pr32 and 37) will be valid only when returning from 2nd to 1st gain.

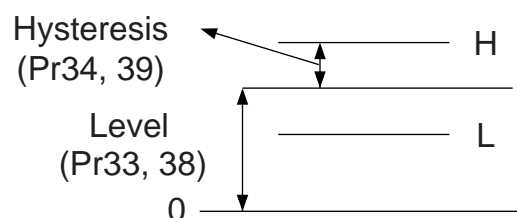
*2 Hysteresis is defined as the fig. below shows.

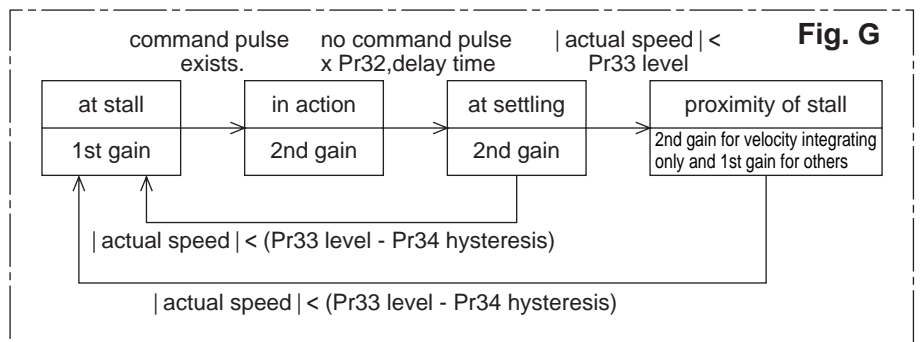
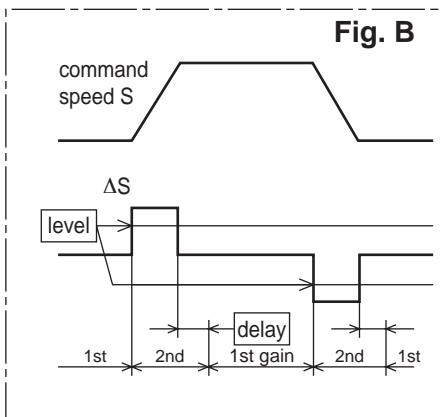
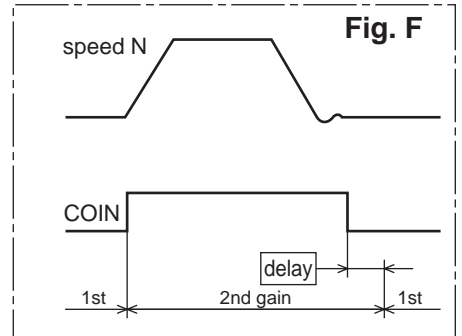
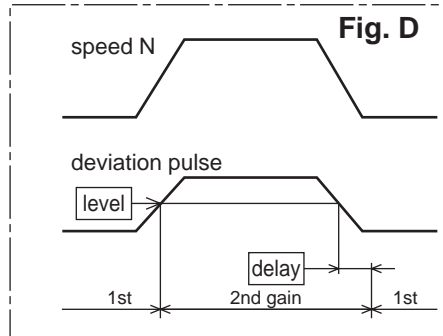
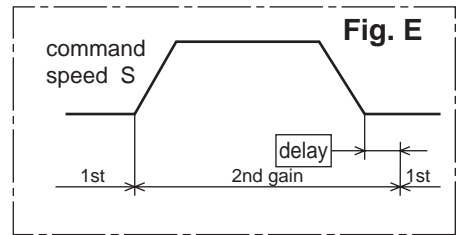
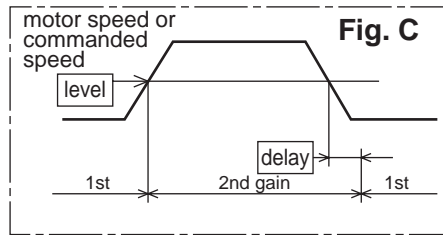
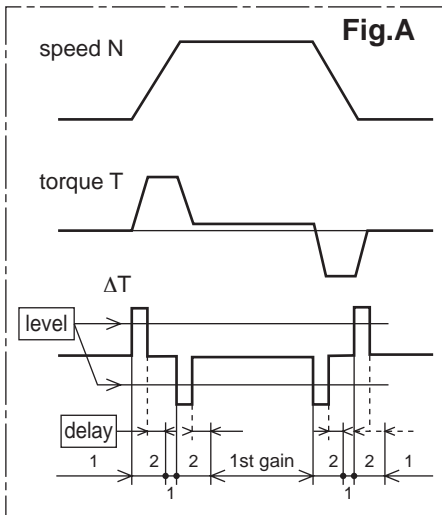
*3 When you make it a condition that there is 10% torque variation during 166μs, set up the value to 200.
 $10\%/166\mu s = \text{Setup value } [200] \times [0.05\%/166\mu s]$

*4 Designate with either the encoder resolution or the external scale resolution depending on the control mode.

*5 When you make it a condition that there is speed variation of 10r/min in 1s, set up the value to 1.

*6 When Pr31= 10, the meanings of delay time, level and hysteresis are different from the normal. (refer to Fig. G)





<Caution>

Above Fig. does not reflect a timing lag of gain switching due to hysteresis (Pr34 and 39).

Manual Gain Tuning (Basic)

Suppression of Machine Resonance

In case of a low machine stiffness, you cannot set up a higher gain because vibration and noise occur due to oscillation caused by axis distortion or other causes. You can suppress the resonance using two types of filter in these cases.

1. Torque command filter (Pr14 and Pr1C)

Sets up the filter time constant so as to damp the frequency at vicinity of resonance frequency

You can obtain the cut off frequency of the torque command filter in the following formula.

Cut off frequency (Hz) $f_c = 1 / (2\pi \times \text{parameter setup value} \times 0.00001)$

2. Notch filter

• Adaptive filter (Pr23, Pr2F)

MINASA-4 series feature the adaptive filter. With this filter you can control vibration of the load which resonance points vary by machine by machine and normal notch filter or torque filter cannot respond.

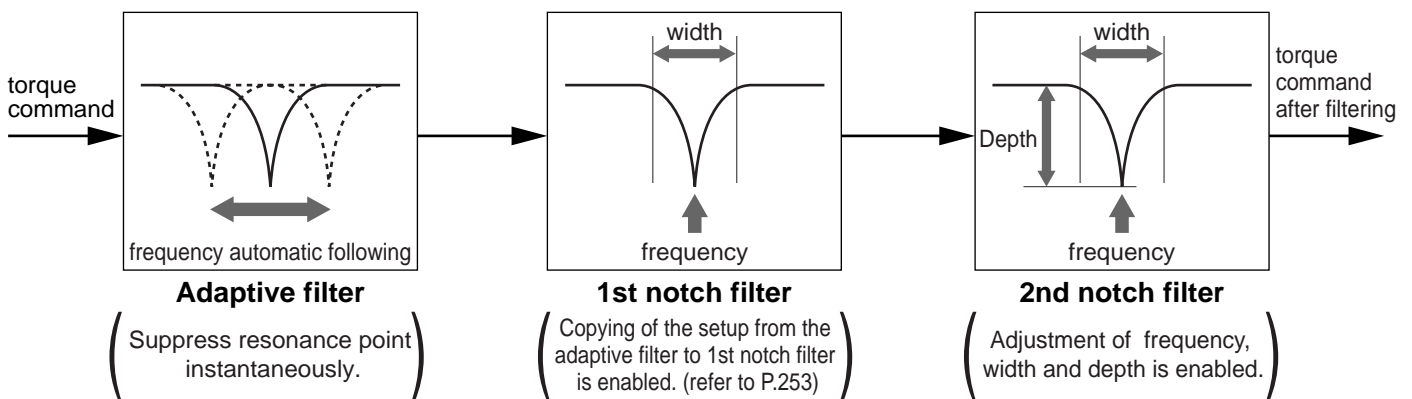
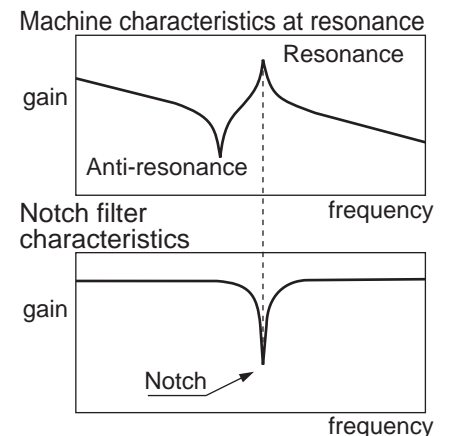
The adaptive filter is validated by setting up Pr23 (Adaptive filter mode setup) to 1.

Pr23	Setup of adaptive filter mode	1 : Adaptive filter is valid.
Pr2F	Adaptive filter frequency	Displays the table No, corresponding to adaptive filter frequency (not changeable)

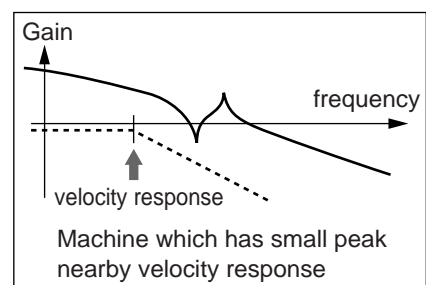
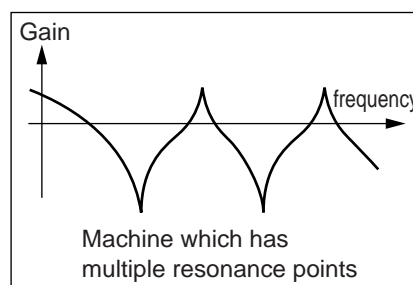
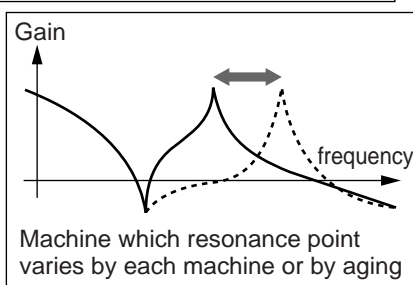
• 1st and 2nd notch filter (Pr1D, 2E, 28, 29 and 2A)

MINASA-4 series feature 2 normal notch filters. You can adjust frequency and width with the 1st filter, and frequency, width and depth with the 2nd filter.

Pr1D	1st notch frequency	Set up lower a frequency by 10% from the measured one through frequency characteristics analysis of the PANATERM®.
Pr1E	1st notch width selection	Set up according to the resonance characteristics.
Pr28	2nd notch frequency	Set up lower a frequency by 10% from the measured one through frequency characteristics analysis of the PANATERM®.
Pr29	Selection of 2nd notch width	Set up according to the resonance characteristics.
Pr2A	Selection of 2nd notch depth	



Example of application machine



How to Check the Resonance Frequency of the Machine

- (1) Start up the Setup Support Software, "PANATERM®" and bring the frequency characteristics measurement screen.
- (2) Set up the parameters and measurement conditions. (Following values are standard.)
 - Set up Pr11 (1st gain of velocity loop) to 25 or so. (to lower the gain and make it easy to identify the resonance frequency)
 - Set up the amplitude to 50 (r/min) or so. (not to saturate the torque)
 - Make the offset to 100 (r/min) or so. (to increase the speed detecting data and to avoid the measurement error in the vicinity of speed-zero)
 - Polarity is made CCW with "+" and CW with "-".
 - Setup the sampling rate to 0. (setup range to be 0-7.)
- (3) Execute the frequency characteristic analysis.

<Remarks>

- Make sure that the revolution does not exceed the travel limit before the measurement.
Standard revolutions are,
Offset (r/min) x 0.017 x (sampling rate + 1)
Larger the offset, better measurement result you can obtain, however, revolutions may be increased.
- Set up Pr23 (Setup of adaptive filter mode) to 0 while you make measurement.

<Notes>

- When you set a larger value of offset than the amplitude setup and make the motor run to the one direction at all time, you can obtain a better measurement result.
- Set up a smaller sampling rate when you measure a high frequency band, and a larger sampling rate when you measure a low frequency band in order to obtain a better measurement result.
- When you set a larger amplitude, you can obtain a better measurement result, but noise will be larger. Start a measurement from 50 [r/min] and gradually increase it.

Relation of Gain Adjustment and Machine Stiffness

In order to enhance the machine stiffness,

- (1) Install the base of the machine firmly, and assemble them without looseness.
 - (2) Use a coupling designed exclusively for servo application with high stiffness.
 - (3) Use a wider timing belt. Belt tension to be within the permissible load to the motor shaft.
 - (4) Use a gear reducer with small backlash.
- Inherent vibration (resonance frequency) of the machine system has a large effect to the gain adjustment of the servo.
You cannot setup a higher response of the servo system to the machine with a low resonance frequency (machine stiffness is low).

Manual Gain Tuning (Basic)

Automatic Gain Setup Function

Outline

This function initializes control parameters and gain switching parameters to the gain setups corresponding to the stiffness during auto-gain tuning, before executing a manual tuning.

Caution

When you execute the automatic gain setup function, stop the action first then make a change.

How to Use

Refer to P.72, "Fit-Gain Screen" of Preparation.

- (1) Stop the action first.
- (2) Start up the automatic gain setup function from the fit-gain screen of the front panel.
- (3) `Finish` will be displayed when the automatic gain setup completes normally, and `Error` will be displayed when it completes with error.
(This display can be cleared by pressing any key.)
- (4) If you want to store the measurement, write it to EEPROM.

Parameters Which Are Automatically Set

Parameters Which Are Automatically Set

Parameter No.	Title of parameter
10	1st gain of position loop
11	1st gain of velocity loop
12	1st time constant of velocity loop integration
13	1st filter of speed detection
14	1st time constant of torque filter time
18	2nd gain of position loop
19	2nd gain of velocity loop
1A	2nd time constant of velocity loop integration
1B	2nd filter of speed detection
1C	2nd time constant of torque filter

Parameters Which Setup Values Are Automatically Fixed

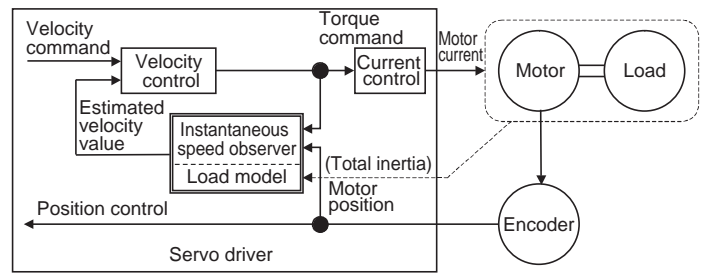
Parameter No.	Title of parameter	Setup value
15	Velocity feed forward	300
16	Time constant of feed forward filter	50
27	Instantaneous speed observer	0
30	2nd gain setup	1
31	1st control switching mode	10*1
32	1st delay time of control switching	30
33	1st level of control switching	50
34	1st Hysteresis of control switching	33
35	Switching time of position gain	20
36	2nd mode of control switching	0

*1 In case of position and full-closed control, this becomes 10, and 0 in case of velocity and torque control.

Instantaneous Speed Observer

Outline

This function enables both realization of high response and reduction of vibration at stopping, by estimating the motor speed using a load model, hence improving the accuracy of the speed detection.



Applicable Range

This function can be applicable only when the following conditions are satisfied.

Conditions under which the instantaneous speed observer is activated	
Control mode	<ul style="list-style-type: none"> Control mode to be either or both position control or/and velocity control. Pr02 = 0 : Position control Pr02 = 1 : Velocity control Pr02 = 3 : Position and Velocity control Pr02 = 4 : Position control only Pr02 = 5 : Position control only
Encoder	<ul style="list-style-type: none"> 7-wire absolute encoder

Caution

This function does not work properly or no effect is obtained under the following conditions.

Conditions which obstruct the instantaneous speed observer effect	
Load	<ul style="list-style-type: none"> Gap between the estimated total load inertia (motor + load) and actual machine is large. e.g.) Large resonance point exists in frequency band of 300[Hz] or below. Non-linear factor such as large backlash exists. Load inertia varies. Disturbance torque with harmonic component is applied.
Others	<ul style="list-style-type: none"> Settling range is very small.

How to Use

(1) Setup of inertia ratio (Pr20)

Set up as exact inertia ratio as possible.

- When the inertia ratio (Pr20) is already obtained through real-time auto-gain tuning and is applicable at normal position control, use this value as Pr20 setup value.
- When the inertia ratio is already known through calculation, enter this calculated value.
- When the inertia ration is not known, execute the normal mode auto-gain tuning and measure the inertia ratio.

(2) Adjustment at normal position control

Refer to P.241, "Adjustment at Position Control Mode".

(3) Setup of instantaneous velocity observer (Pr27)

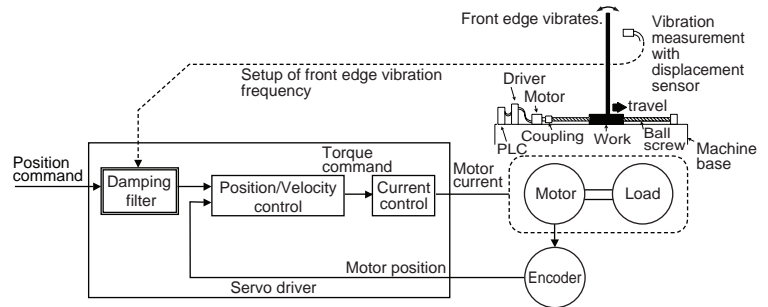
- You can switch the velocity detecting method to instantaneous velocity observer by setting up Pr27 (Setup of instantaneous speed observer) to 1.
- When you experience a large variation of the torque waveform or noise, return this to 0, and reconfirm the above cautions and (1).
- When you obtain the effect such as a reduction of the variation of the torque waveform and noise, search an optimum setup by making a fine adjustment of Pr20 (Inertia ratio) while observing the position deviation waveform and actual speed waveform to obtained the least variation. If you change the position loop gain and velocity loop gain, the optimum value of the inertia ratio (Pr20) might have been changed, and you need to make a fine adjustment again.

Manual Gain Tuning (Application)

Damping Control

Outline

This function reduces the vibration by removing the vibration frequency component from the command when the load end of the machine vibrates.



Applicable Range

This function can only be applicable when the following conditions are satisfied.

Conditions under which the damping control is activated	
Control mode	<ul style="list-style-type: none"> Control mode to be either or both position control or/and full-closed control. Pr02 = 0 : Position control Pr02 = 3 : 1st control mode of position and velocity control Pr02 = 4 : 1st control mode of position control and torque control Pr02 = 6 : Full-closed control

Caution

When you change the parameter setup or switch with VS-SEL, stop the action first then execute.

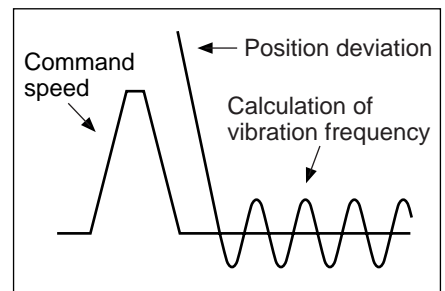
This function does not work properly or no effect is obtained under the following conditions.

Conditions which obstruct the damping control effect	
Load	<ul style="list-style-type: none"> Vibration is triggered by other factors than command (such as disturbance). Ratio of resonance frequency and anti-resonance frequency is large. Vibration frequency is out of the range of 10.0-200.0 [Hz] .

How to Use

(1) Setup of damping frequency (1st : Pr2B, 2nd : Pr2D)

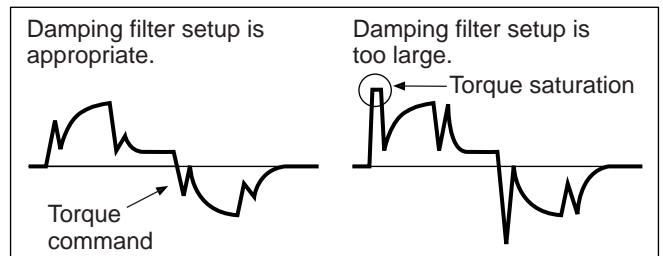
Measure the vibration frequency of the front edge of the machine. When you use such instrument as laser displacement meter, and can directly measure the load end vibration, read out the vibration frequency from the measured waveform and enter it to Pr2B or Pr2D (Damping frequency).



(2) Setup of damping filter (1st : Pr2C, 2nd : Pr2E)

First, set up 0.

You can reduce the settling time by setting up larger value, however, the torque ripple increases at the command changing point as the right fig. shows. Setup within the range where no torque saturation occurs under the actual condition. If torque saturation occurs, damping control effect will be lost.



<Remark>

Limit the damping filter setup with the following formula.
 $10.0 \text{ [Hz]} - \text{Damping frequency} \leq \text{Damping filter setup} \leq \text{Damping frequency}$

(3) Setup of damping filter switching selection (Pr24)

You can switch the 1st or the 2nd damping filter depending on the vibration condition of the machine.

Pr24	Switching mode
0	No switching (Both of 2 are valid.)
1	Switch with VS-SEL input. Open : 1st damping filter Close : 2nd damping filter
2	Switch with command direction. CCW : 1st damping filter CW : 2nd damping filter