

[Adjustment]

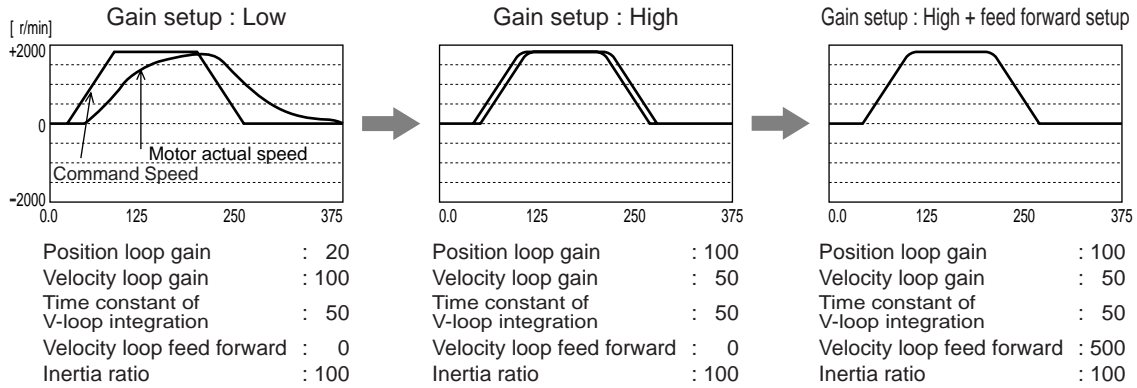
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Gain Adjustment

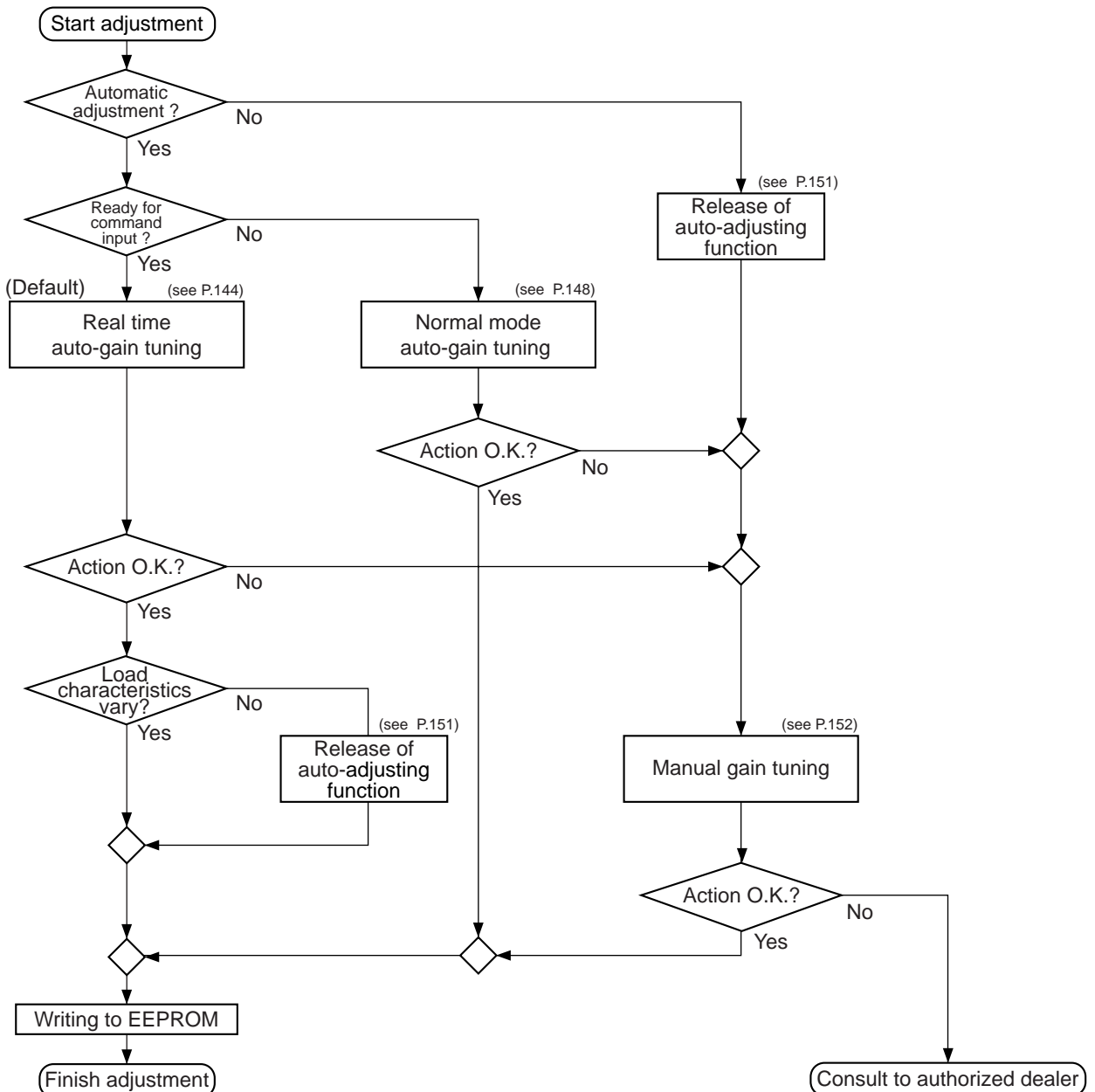
Purpose

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.144
	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.147
	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.148
	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.151
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.152
	Basic procedure	Adjustment of position control mode	P.153
		Adjustment of full-closed control mode	P.154
	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.155
	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.158
	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.160
	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.160
Damping control	Function which reduces vibration by removing the vibration frequency component while the front end of the machine vibrates.	P.161	

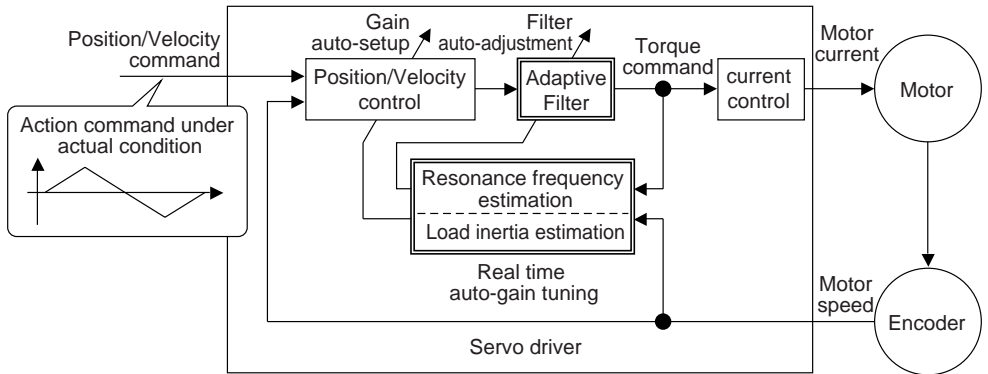
<Remarks>

- 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. Also, an adaptive filter can cope with any load caused by the resonance.



Applicable Range

	Conditions under which the real-time auto-gain tuning is activated
Control mode	<ul style="list-style-type: none"> Real time auto-gain tuning is applicable to all control modes. However, the load inertia estimation will be disabled when a motor trial operation function is executed and a frequency characteristics measurement function of "PANATERM[®]" is used.
Others	<ul style="list-style-type: none"> The servo turns on. Any factors, including Deviation Counter Clear command input inhibition and torque limit, other than control parameter are set appropriately and the motor can rotate normally without any problem.

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.148), or execute the manual auto-gain tuning (refer to P.152).

	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 SV.Pr21 (Real time auto tuning set up) 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 to 6.

When vibration occurs during gain switching, set up 7.

- 3) Set up SV.Pr22 (Machine stiffness at auto tuning) to 0 or smaller value.
- 4) Turn to Servo-ON to run the machine normally.
- 5) Gradually increase SV.Pr22 (Machine stiffness at auto tuning) when you want to obtain a better response.
Lower the value (0 to 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. SPd

Press **M** MODE . PR. 00

Match to the parameter No. to be set up with **▲** **▼** . (Here match to Pr21.) PR. 21

Press **S** SET . 1

Change the setup with **▲** **▼** .

Press **S** SET . PR. 21

Setup of parameter, Pr22

Match to Pr22 with **▲** . PR. 22

Press **S** SET . 4

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

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 --

Writing starts (temporary display). StARt

Finish Finish. rESEt. Error.

Writing completes

Writing error occurs

Press **S** SET to return to **SELECTION display** , after writing finishes.

Real-Time Auto-Gain Tuning Mode

Parameters Which Are Automatically Set

Following parameters are automatically adjusted.

Also following parameters are automatically set up.

SV.PrNo.	Title
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

SV.PrNo.	Title	Setup value
15	Velocity feed forward	300
16	Feed forward filter time constant	50
27	Velocity observer	0
30	2nd gain action set up	1
31	1st control switching mode	10
32	1st control switching delay time	30
33	1st control switching level	50
34	1st control switching hysteresis	33
35	Position loop gain switching time	20

<Notes>

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

Adaptive Filter

Invalidation of Adaptive Filter

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.

The adaptive filter is enabled by setting SV.Pr23 (Adaptive filter mode) to any value other than “0”.

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 (SV.Pr1D and 1E) and the 2nd notch filter (SV.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	<ul style="list-style-type: none"> • Motor speed variation with high harmonic component is generated due to non-linear factors such as backlash.
Command pattern	<ul style="list-style-type: none"> • Acceleration/deceleration is rapid such as 30000[r/min] per 1[s] .

<Notes>

The adaptive filter may be disabled also if SV.Pr23 is set to any value other than “0”. Refer to “Invalidation of Adaptive Filter” on page 151.

How to Operate

1) Validate the adaptive filter by setting up SV.Pr23 (Adaptive filter mode) 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.

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

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

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

Caution

(1) After the start-up, you may experience abnormal noise and oscillation right after the first operation or when you increase the setup of SV.Pr22 (Machine stiffness at auto tuning), until load inertia is identified (estimated) or adaptive filter is stabilized. 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 SV.Pr22 (Machine stiffness at auto tuning).
- 3) Invalidate the adaptive filter by setting up SV.Pr23 (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, SV.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, SV.Pr20 (Inertia ratio) will be written into EEPROM at every 30 minutes. When you turn the power supply on again, auto-gain tuning will be executed using this data as initial values.

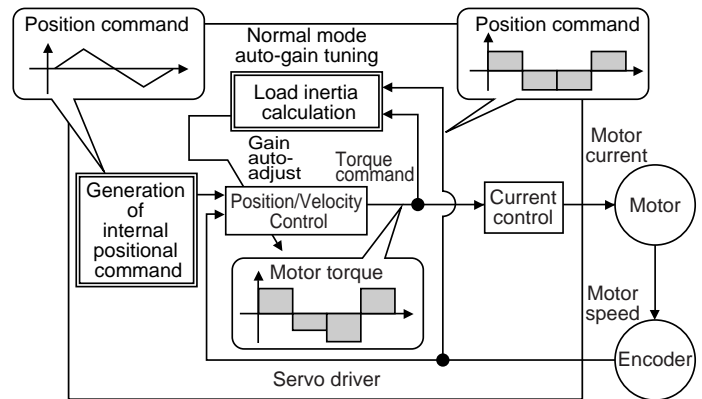
(4) When you enable the real-time auto-gain tuning, SV.Pr27 (Velocity observer) will be disabled automatically.

(5) During the trial run and frequency characteristics measurement of “PANATERM®”, the load inertia estimation will be disabled.

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	• Servo-ON status

<Remarks>

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

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

Caution

Normal mode auto-gain tuning may not 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 SV.Pr5E (Setup of torque limit).
- Please note that each signal of the CW over-travel inhibit input, CCW over-travel inhibit input, emergency stop, deceleration-and-stop and temporary stop is ignored.

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.95, "Auto-Gain Tuning Mode" of Setting 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 SV.Pr25 (Normal auto tuning motion setup). 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

- (1) Set up the action pattern with SV.Pr25.
- (2) Shift the load to the position where no hazard is expected even though the action pattern which is set with SV.Pr25 is executed.
- (3) Prohibit the command entry. (Do not enter the action command during the normal mode auto-gain tuning.)
- (4) Turn to Servo-ON.
- (5) Start up the auto-gain tuning. Use the "PANATERM®".
- (6) Adjust the machine stiffness to the level at which no vibration occurs and obtain the required response.
- (7) 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 position loop gain	12	32	39	48	63	72	90	108	135	162	206	251	305	377	449	557
11	1st velocity loop gain	9	18	22	27	35	40	50	60	75	90	115	140	170	210	250	310
12	1st velocity loop integration time constant	62	31	25	21	16	14	12	11	9	8	7	6	5	4	4	3
13	1st speed detection filter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	1st torque filter time constant *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	Feed forward filter time constant	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
18	2nd position loop gain	19	38	46	57	73	84	105	126	157	188	241	293	356	440	524	649
19	2nd velocity loop gain	9	18	22	27	35	40	50	60	75	90	115	140	170	210	250	310
1A	2nd velocity loop integration time constant	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999	999
1B	2nd speed detection filter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1C	2nd torque filter time constant *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	Velocity observer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	2nd gain action set up	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1st control switching mode	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
32	1st control switching delay time	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
33	1st control switching level	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
34	1st control switching hysteresis	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
35	Position loop gain switching time	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

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

*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 Console

- (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.81, "Structure of Each Mode" of Preparation.

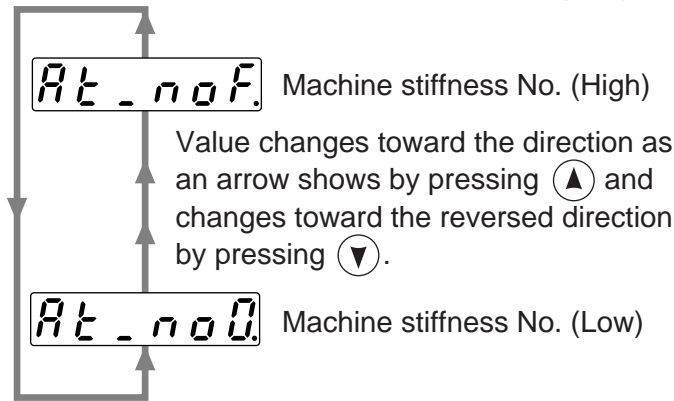
r 0

Display of rotational speed of the motor (initial display)




At.no!

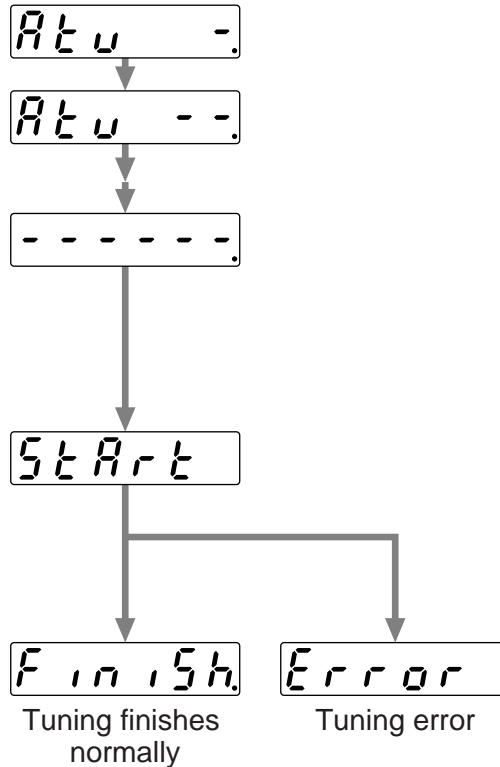
Machine stiffness No.

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



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

- (3) Shift to MONITOR/EXECUTION mode by pressing .
- (4) Operation at MONITOR/EXECUTION mode
Keep pressing  until the display changes to **StArt**.
• 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. SV.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 home sensor switch. • Turn to Servo-ON. • Release the deviation counter clear
Value of parameter related to gain (such as SV/Pr10) is kept as same as before the execution.	Load inertia cannot be identified.	<ul style="list-style-type: none"> • Lower SV.Pr10 to 10 and SV.Pr11 to 50, then execute the tuning. • Adjust the gain manually. (Calculate the load inertia, and then enter.)

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 SV.Pr20 (Inertial ratio) and invalidate the real-time auto-gain tuning by setting up SV.Pr21 (Real time auto tuning set up) to 0.

Note that the calculation result of SV.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 SV.Pr23 (Adaptive filter mode) 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 (SV.Pr2F) to the 1st notch frequency (SV.Pr1D), or set up SV.Pr1D (1st notch frequency) manually by using the table below, then invalidate this filter.

SV.Pr2F	1st notch frequency [Hz]	SV.Pr2F	1st notch frequency [Hz]	SV.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 SV.Pr1D (1st notch frequency) in case of “ invalid ” of the above table.

Manual Gain Tuning (Basic)

As explained previously, MINAS-A4P 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.

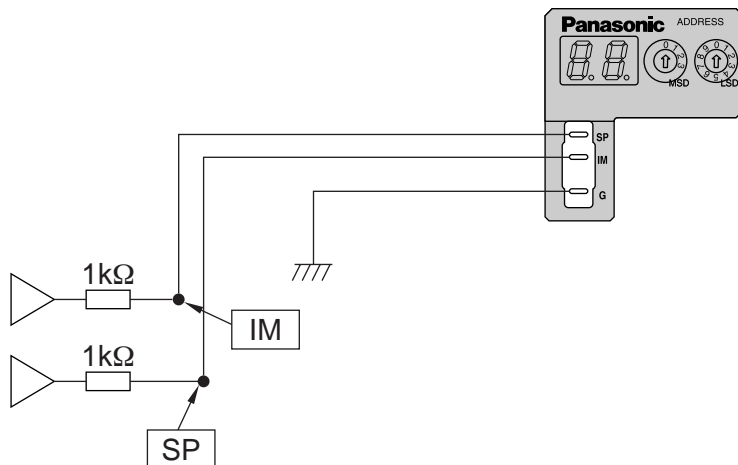
Before Making a Manual Adjustment

You can adjust with the sound or motor (machine) movement by using the 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

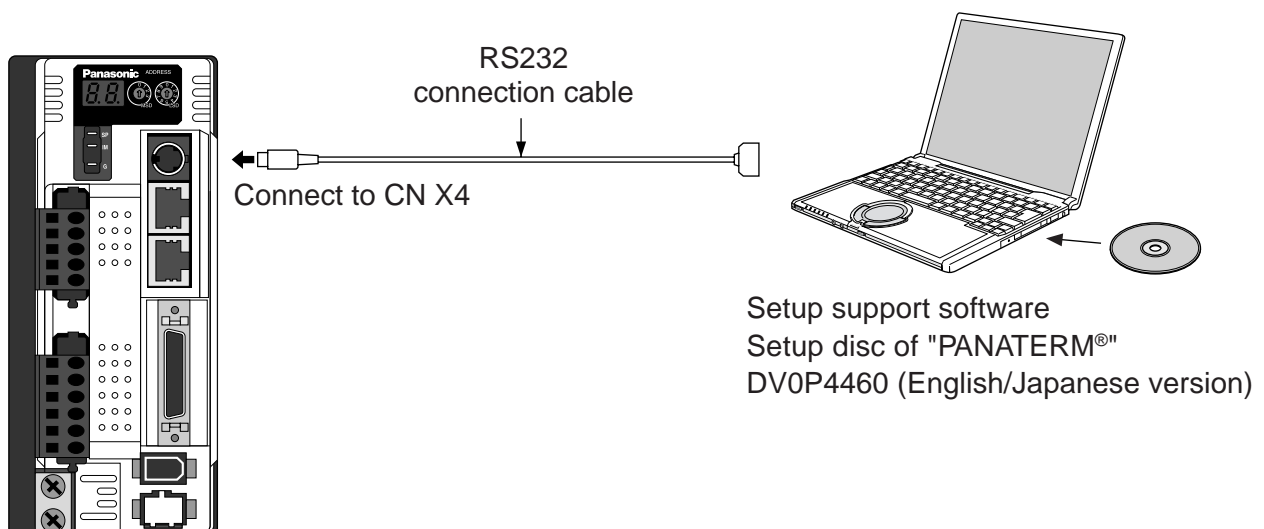
You can measure the actual motor speed, commanded speed, torque and deviation pulses by analog voltage level by using an oscilloscope. Set up the types of the signals or the output voltage level with SV.Pr07 (Speed monitor (SP) selection) and SV.Pr08 (Torque monitor (IM) selection).

For details, refer to P.49, "Wiring to the Connector, CN X5" of Preparation, and P.56, "Parameter Setup" of Setting.



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.103, "Outline of the Setup Support Software, PANATERM[®]".



Adjustment in Position Control Mode

Position control of MINAS-A4P series is described in Block diagram of P.224.
Make adjustment in position control per the following procedures.

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

Servo Parameter No. (SV.Pr* *)	Title of parameter	Standard value	Servo Parameter No. (SV.Pr* *)	Title of parameter	Standard value
10	1st position loop gain	27	20	Inertia ratio	100
11	1st velocity loop gain	15	21	Real time auto tuning set up	0
12	1st velocity loop integration time constant	37	23	Adaptive filter mode	0
13	1st speed detection filter	0	2B	1st vibration suppression frequency	0
14	1st torque filter time constant	152	2C	1st vibration suppression filter	0
15	Velocity feed forward	0	2D	2nd vibration suppression frequency	0
16	Feed forward filter time constant	0	2E	2nd vibration suppression filter	0
18	2nd position loop gain	27	30	2nd gain action set up	0
19	2nd velocity loop gain	15	31	1st control switching mode	0
1A	2nd velocity loop integration time constant	37	32	1st control switching delay time	0
1B	2nd speed detection filter	0	33	1st control switching level	0
1C	2nd torque filter time constant	152	34	1st control switching hysteresis	0
1D	1st notch frequency	1500	35	Position loop gain switching time	0
1E	1st notch width selection	2	4C	Smoothing filter	1
			4D	FIR filter set up	0

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

(3) Make adjustment using the standard values below.

Order	Servo Parameter No. (SV.Pr* *)	Title of parameter	Standard value	How to adjust
1	SV.Pr11	1st velocity loop gain	30	Increase the value within the range where no abnormal noise and no vibration occur. If they occur, lower the value.
2	SV.Pr14	1st torque filter time constant	50	When vibration occurs by changing SV.Pr11, change this value. Setup so as to make SV.Pr11 x SV.Pr14 becomes smaller than 10000. If you want to suppress vibration at stopping, setup larger value to SV.Pr14 and smaller value to SV.Pr11. If you experience too large vibration right before stopping, lower than value of SV.Pr14.
3	SV.Pr10	1st position loop gain	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	SV.Pr12	1st velocity loop integration time constant	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	SV.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. You can improve by setting up SV.Pr16 (Feed forward filter time constant) to larger value.

Manual Gain Tuning (Basic)

Adjustment in Full-Closed Control Mode

Full-closed control of MINAS-A4P series is described in Block diagram of P.225 of Full-Closed Control. Adjustment in full-closed control is almost same as that in position control described in P.153 “Adjustment in Position Control Mode”, and make adjustments of parameters per the procedures except cautions of P.140, “Outline of Full-Closed Control”.

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 (SV.Pr78), the multiplier for numerator of external scale division (SV.Pr79) and denominator of external scale division (SV.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 (SV.Pr78), the multiplier for numerator of external scale division (SV.Pr79) and denominator of external scale division so that the following formula can be established.

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

- 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 SV.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 (SV.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

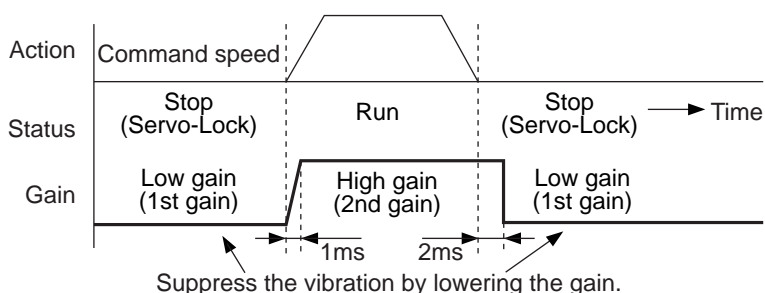
- (1) Enter the position command based on the external scale reference.
- (2) The external scales to used for full-closed control are as follows.
 - AT500 series by Mitutoyo (Resolution 0.05[μm] , max. speed 2[m/s])
 - ST771 by Mitutoyo (Resolution 0.5[μm] , max. speed 2[m/s])
- (3) To prevent the runaway and damage of the machine due to the setup of the external scale, setup the hybrid deviation excess (SV.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 (SV.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.149) as well.

Servo Parameter No. (SV.Pr**)	Title of parameter	Execute manual gain-tuning without gain switching	Set up the same value as SV.Pr10-14 (1st gain) to SV.Pr18-1C (2nd gain)	Set up SV.Pr30-35 (Gain switching condition)	Adjust SV.Pr11 and 14 at stopping (1st gain)
10	1st position loop gain	63			
11	1st velocity loop gain	35			27
12	1st velocity loop integration time constant	16			
13	1st speed detection filter	0			
14	1st torque filter time constant	65			84
15	Velocity feed forward	300			
16	Feed forward filter time constant	50			
18	2nd position loop gain		63		
19	2nd velocity loop gain		35		
1A	2nd velocity loop integration time constant		16		
1B	2nd speed detection filter		0		
1C	2nd torque filter time constant		65		
30	2nd gain action set up	0		1	
31	1st control switching mode			7	
32	1st control switching delay time			30	
33	1st control switching level			0	
34	1st control switching hysteresis			0	
35	Position loop gain switching time			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		
SV.Pr31	Switching condition to 2nd gain	Fig.	Delay time * 1 SV.Pr32	Level SV.Pr33	Hysteresis * 2 SV.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

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

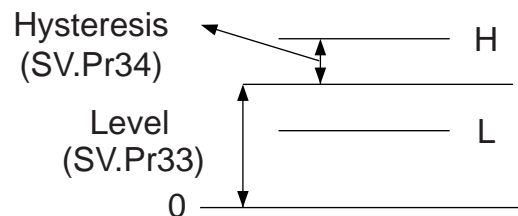
*2 Hysteresis is defined as the fig. below shows.

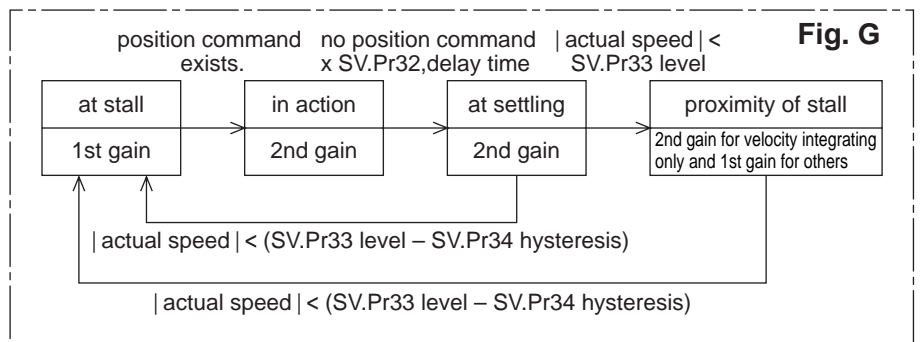
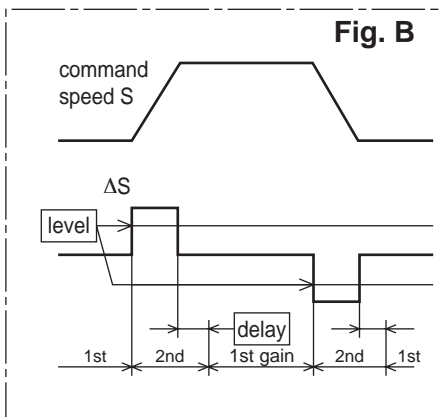
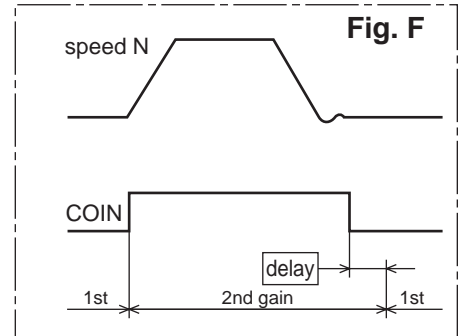
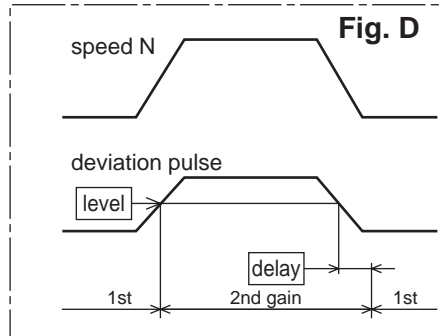
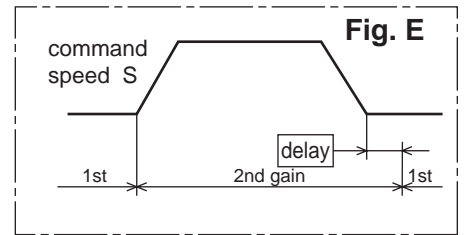
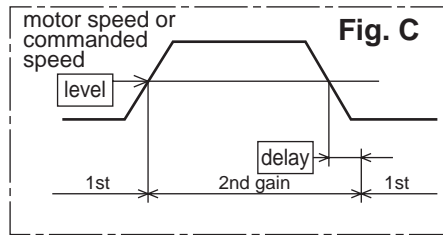
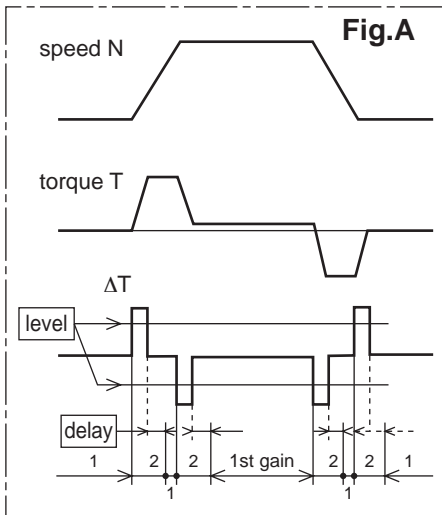
*3 When you make it a condition that there is 10% torque variation during 166μs, set up the value to 200.
 $10\%/166\mu s = \text{Setup value } \boxed{200} \times [0.05\%/166\mu s]$

*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 SV.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 (SV.Pr34).

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 (SV.Pr14 and SV.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 (SV.Pr23, SV.Pr2F)

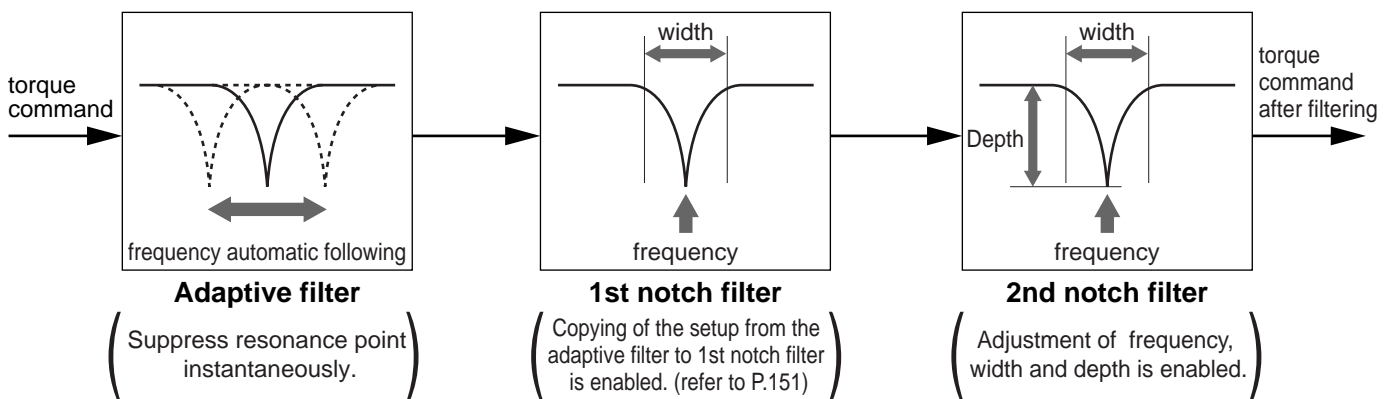
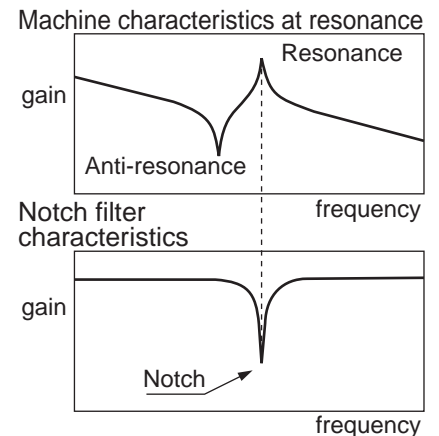
MINASA-A4P series feature the adaptive filter. With this filter you can control vibration of the load which resonance points vary by machine by machine and normal notch filter or torque filter cannot respond. The adaptive filter is validated by setting up SV.Pr23 (Adaptive filter mode) to 1.

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

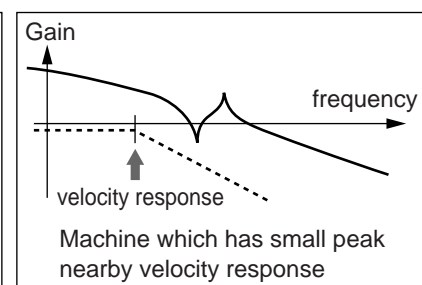
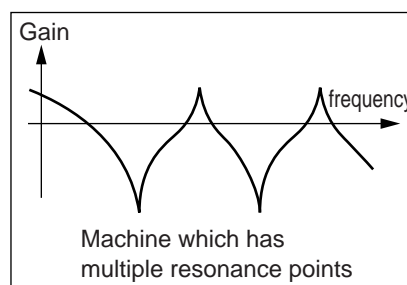
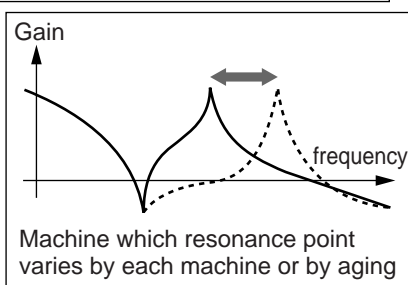
• 1st and 2nd notch filter (SV.Pr1D, 2E, 28, 29 and 2A)

MINASA-A4P 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.

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



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 SV.Pr11 (1st velocity loop gain) 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 to 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 SV.Pr23 (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,

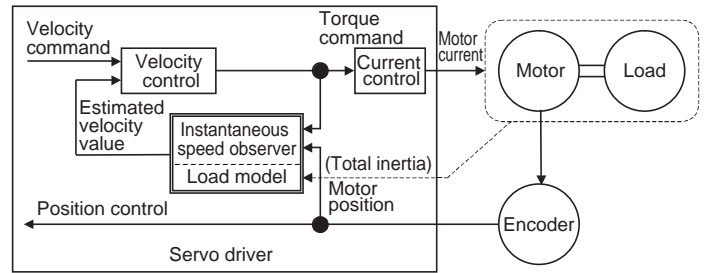
- (1) Install the base of the machine firmly, and assemble them without looseness.
 - (2) Use a coupling designed exclusively for servo application with high stiffness.
 - (3) Use a wider timing belt. Belt tension to be within the permissible load to the motor shaft.
 - (4) Use a gear reducer with small 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 (Application)

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	• Control mode to be position control. (SV.Pr02 = 0)
Encoder	• 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	• Settling range is very small.

How to Use

(1) Setup of inertia ratio (SV.Pr20)

Set up as exact inertia ratio as possible.

- When the inertia ratio (SV.Pr20) is already obtained through real-time auto-gain tuning and is applicable at normal position control, use this value as SV.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.153, "Adjustment at Position Control Mode".

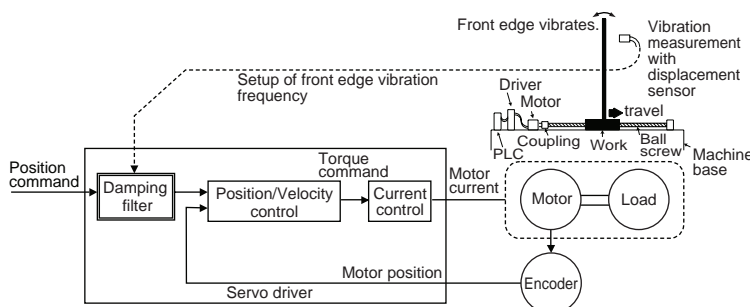
(3) Setup of instantaneous velocity observer (SV.Pr27)

- You can switch the velocity detecting method to instantaneous velocity observer by setting up SV.Pr27 (Velocity 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 SV.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 (SV.Pr20) might have been changed, and you need to make a fine adjustment again.

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. SV.Pr02 = 0 : Position control SV.Pr02 = 6 : Full-closed control

Caution

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

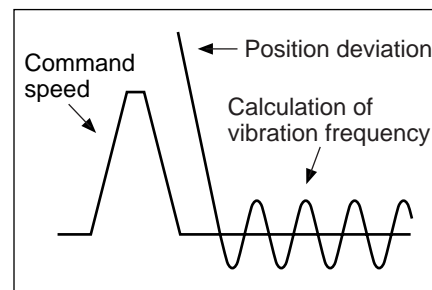
This function does not work properly or no effect is obtained under the following conditions.

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 to 200.0 [Hz] .

How to Use

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

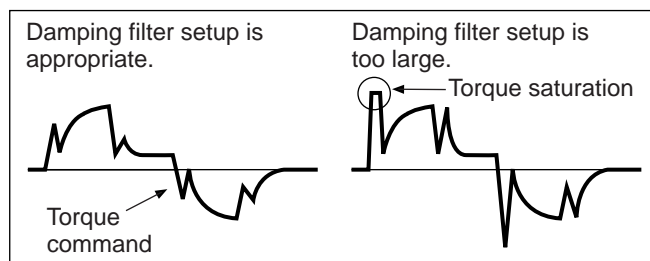
Measure the vibration frequency of the front edge of the machine. When you use such instrument as laser displacement meter, and can directly measure the load end vibration, read out the vibration frequency from the measured waveform and enter it to SV.Pr2B or SV.Pr2D (2nd vibration suppression frequency).



(2) Setup of damping filter (1st : SV.Pr2C, 2nd : SV.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 (SV.Pr24)

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

SV.Pr24	Switching mode
0, 1	No switching (Both of 2 are valid.)
2	Switch with command direction. CCW : 1st damping filter CW : 2nd damping filter