Panasonic

No. SX-DSV01600

FUNCTIONAL DESCRIPTION

MODEL

AC Servo Drive
MINAS-A4N Series (High-speed network Type)

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REVISIONS

Functional Description

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Contents

1. Parameters ····· 1

2. Operation timing ····· 14
2-1 Timing chart after power-up ····· 14
2-2 Servo-ON/OFF timing at standstill ····· 15
2-3 Servo-ON/OFF timing in motion ····· 16
2-4 Timing chart at alarm (during Servo-ON command) ····· 17
2-5 Timing chart at alarm-clear (during Servo-ON command) ····· 18

3. Protective Functions ····· 19
3-1 Protective function ····· 19
3-2 Warning function ····· 25
3-3 Software limit protection ····· 26

4. Front panel display ····· 28
4-1 Appearance of display ····· 28
4-2 7-segment LED ····· 29
4-3 Network status LED ····· 30

5. Absolute encoder and external scale ····· 31
5-1 Absolute encoder ····· 31
5-1-1 Structure of absolute system ····· 31
5-1-2 Absolute data ····· 32
5-1-3 Clearing of absolute data ····· 32
5-2 Absolute External scale ····· 33
5-2-1 Structure of absolute system ····· 33

6. Tuning ····· 34
6-1 Real-time auto-gain tuning ····· 36
6-2 Normal mode auto-gain tuning ····· 40
6-3 Release of automatic tuning ····· 43
6-4 Manual gain tuning ····· 44
6-4-1 Tuning at position control mode ····· 45
6-4-2 Tuning at full-closed control mode ····· 48
6-4-3 Manual gain tuning using gain switching ····· 50
6-4-4 Instantaneous velocity observer ····· 54
6-4-5 Vibration suppression control ····· 56

7. Control block diagram ····· 58
7-1 Position control block diagram ····· 58
7-2 Full-closed control block diagram ····· 58

1. Parameters

<table>
<tr><th>Parameter №</th><th>Name</th><th>Setup Range</th><th>Description</th></tr>
<tr><td>00</td><td>For manufacturer's use</td><td>-</td><td>-</td></tr>
<tr><td>01</td><td>LED display</td><td>0-4</td><td>Selects a data type of display on 7-segment LED of the front panel

0:Normal display ([--]: Servo-OFF, [0]: Servo-ON)
1:Mechanical angle counter in 2 digits hexadecimal number ([0]-[FF])
The [0] means a zero position of the encoder. The counter increases in CCW direction. After exceeding [FF], the counter is reset to [0], then continues to count.
(Note) In case of using an incremental encoder, after turning the power switch on, the display shows [nF] (means "not Fixed") until a zero position of the encoder is detected.
2 : Electrical angle counter in 2 digits hexadecimal number ([0]-[FF])
The [0] means a positive peak voltage of U-phase of motor back-EMF. The counter increases in CCW direction. After exceeding [FF], the counter is reset to [0], then continues to count again
3 : The communication error counter in 2 digits hexadecimal number ([0]-[FF])
The error counter consists of 4 digits and indicates only last 2 digits on display. The error counter counts accumulatelly until [FFFF], then stops to count.
4 : ADDRESS display (RSW setting) in decimal number. ([0]-[32])
The node address which means a MAC-ID is decided by setting the rotary switch(RSW) located on the front panel. The RSW setting is validated only one time after turning powering on. After that, any change of RSW setting is invalidated.</td></tr>
<tr><td>02
*</td><td>Control mode</td><td>0-6</td><td>Selects the control mode of the servo drive. Recommend to set of 0 for position control.

<table><tr><th>Set value</th><th>Control mode</th><th>Code</th></tr><tr><td>0</td><td>Position control</td><td>P</td></tr><tr><td>1-5</td><td>Do not use</td><td>-</td></tr><tr><td>6</td><td>Full-closed control</td><td>F</td></tr></table></td></tr>
<tr><td>03</td><td>Torque limit selection</td><td>1-3</td><td><table><tr><th>Set value</th><th>CCW</th><th>CW</th></tr><tr><td>1</td><td colspan="2">Pr.5E is set to the limit value in both CCW and CW direction.</td></tr><tr><td>2</td><td>Set by Pr.5E.</td><td>Set by Pr.5F.</td></tr><tr><td>3</td><td colspan="2">The limit value and direction is changed by using the TL SW (command byte2 , bit3) via network.</td></tr></table></td></tr>
<tr><td>04
*</td><td>Overtravel input inhibit</td><td>0-2</td><td>Defines whether to enable or disable the CW/CCW overtravel input (X5 CWL: Pin-20, CCWL: Pin-19).

0: In the case of the overtravel input , the motor will stop with the sequence set by Pr.66 (Error response at overtravel limit).
1: The overtravel input is disabled.
2: When the connection of either CW or CCW input becomes open, Err38 (Overtravel inhibit input error) occurs.</td></tr>
<tr><td>05</td><td>For manufacturer's use</td><td>-</td><td>-</td></tr>
<tr><td>06
*</td><td>Address indicated time at power up</td><td>0-1000</td><td>Defines Node address (setting of RSW) display time at the control power-up.
0 to 6: 600 [msec]
7 to 1000: multiply the setting value by 100 [msec]
Note) At power up, displaying Node address takes higher priority than displaying alarm or waring.</td></tr>
<tr><td>07</td><td>Speed monitor (SP) selection</td><td>0-11</td><td>Select the output range of the analog speed monitor.
The value given in ( ) indicates the monitor value at approx. 6 V.
0 to 4: Actual motor speed (0:47, 1:188, 2:750, 3:3000, 4:12000[r/min])
5 to 9: Command speed (5:47, 6:188, 7:750, 8:3000, 9:12000[r/min])
10:Position command status. The 0 in voltage means the position command activating and the 5 in voltage means no position command.
11:Gain switching status. The 0 in voltage means selecting 2nd gain and and the 5 in voltage means selecting 1st gain.
Note : This monitor has some delay because of the internal filtering process.</td></tr>
</table>

Note 1) For those parameters which No. has a suffix of "*", changed contents will be validated after the reset of the control power.
Therefore, after changing the parameter, it is necessary to turn off and on the control power, or to transmit the reset command via the network.

Note 2) For those parameters which No. is marked with (RT), value will be automatically set up during the real-time auto-gain tuning. If you want to change manually, invalidate the real-time auto-gain tuning by setting Pr.21 (Real-time auto-gain tuning setup) to 0, then set up the change.

Note 3) The "Command" means that Data block to be transmitted from the host to the drive via network.
The "Response" means that Data block to be transmitted from the drive to the host.

Parameter №	Name	Setup range	Description
08	Torque monitor (IM) selection	0-14	Select the output range of the analog torque monitor. The value given in ( ) indicates the monitor value at approx. 3 V. 0: Torque command (100[%]) 1 to 5: Position deviation (1:31, 2:125, 3:500, 4:2000, 5:8000[pulse]) 6 to 10: Full-closed deviation (6:31, 7:125, 8:500, 9:2000, 10:8000[pulse]) 11: Torque command (200[%]) 12: Torque command (400[%]) 13:Position command status. The 0 in voltage means the position command activating and the 5 in voltage means no position command. 14:Gain switching status. The 0 in voltage means selecting 2nd gain and and the 5 in voltage means selecting 1st gain. Note : This monitor has some delay because of the internal filtering process.
09	Unit of velocity	0-2	Select a unit of the velocity via a network interface 0: r/min (based on encoder), 1:pulse/s (based on encoder), 2:pulse/s (based on External scale at full-closed control, or based on encoder at the position control).
0A	Inhibit parameter change via network	0-1	Defines whether to enable or disable the parameter change via a network interface. In case of inhibiting a parameter change, the drive replys the command error to the master when the drive received the command for changing the parameters 0: enable 1: disable (inhibit)
0B *	Absolute encoder setup	0-2	Select how to use the absolute encoder. 0: Used as absolute encoder 1: Used as incremental encoder 2: Used as absolute encoder ignoring of overcount error (Note) In case of full-closed control, make sure to select this parameter to 1 as incremental encoder mode. For the incremental encoder, this parameter is invalid.
0C *	Baud rate of RS232	0-5	Defines the RS232 communication speed. 0: 2400[bps] 1: 4800[bps] 2: 9600[bps] 3: 19200[bps] 4: 38400[bps] 5: 57600[bps] The baud rate error is less than +/- 0.5%.
0D	Warning setup of Cumulative COM error	0-32767	Defines the times to indicate the communication warning (Warning No.84). The communication error counter is increased when the communication error occures. Then the communication warning will be indicated when the error counter exceed the value of this parameters. In case of this parameter value setting of 0, the communication error warning is invalidated. To release from the communication warning (Warning No.84), there are 3 ways. a) Set this parameter value to 0. b) Set this parameter value to be a larger number than error counter. c) Clear the communication error counter by turning the power off.
0E	Warning setup of Continuous COM error	0-32767	Defines the times to indicate the continuous communication error warning (Warning No.83). The communication error counter is increased when the continuous communication error occurs. Then, when this error ocuures more than the setting value of this parameter, the continuous communication error warning will be indicated and the error counter will be stopped without counting up. In case of this parameter value setting of 0, the communication error is invalidated. To release from the continuous communication error warning (Warning No.83), there is one way. a) Set this parameter value to 0..
0F	Update counter warning setup	0-32767	If the update counter is not incremented properly and this situation continues for this paramerter value, the update counter warning will occur. Normally, set to 0 (invalid).

Parameter №	Name	Setup range	Description
10 (RT)	1st position loop gain	0-3000	Defines the position loop gain. The unit is [1/s]. As the gain is increased, the servo stiffness in the position control is increased and the settling time becomes shorter. However, if the gain setting is too high, oscillation occurs.
11 (RT)	1st velocity loop gain	1-3500	Defines the speed loop gain. When Pr. 20 (Inertia ratio) is properly set, the unit of this parameter is [Hz]. As the gain is increased, the response in the velocity control is increased. However, if the gain setting is too high, oscillation occurs.
12 (RT)	1st velocity loop integration time constant	1-1000	Lowering the parameter setting, speeds up the integral action. The unit is [ms]. To stop integration with holding the integrated value, set to 999. To disable the integral action, set to 1000.
13 (RT)	1st speed detection filter	0-5	Select the type of the speed detection filter. 0 to 5: Increasing the parameter setting, reduces the motor noise. Normally, set to 0. When the instantaneous velocity observer is enabled (Pr.27 = 1), this parameter is invalid.
14 (RT)	1st torque filter time constant	0-2500	Defines the time constant of the 1st lag filter for torque command. The unit is [10μs]. The machine vibration may be reduced depending on this setting.
15 (RT)	Velocity feed forward	-2000-2000	Defines the speed feed forward value. The unit is [0.1%]. Use this function when particularly high speed response is required.
16 (RT)	Feed forward filter time constant	0-6400	Defines the time constant of the 1st lag filter for speed feed forward. The unit is [10μs].
17	For manufacturer's use	-	-
18 (RT)	2nd position loop gain	0-3000	Set up this parameter only when the gain switching function is used. The function is the same as Pr.10. Refer to Section 6-4.
19 (RT)	2nd velocity loop gain	1-3500	Set up this parameter only when the gain switching function is used. The function is the same as Pr.11. Refer to Section 6-4.
1A (RT)	2nd velocity loop integration time constant	1-1000	Set up this parameter only when the gain switching function is used The function is the same as Pr.12. Refer to Section 6-4.
1B (RT)	2nd speed detection filter	0-5	Set up this parameter only when the gain switching function is used. The function is the same as Pr.13. Refer to Section 6-4.
1C (RT)	2nd torque filter time constant	0-2500	Set up this parameter only when the gain switching function is used. The function is the same as Pr.14. Refer to Section 6-4.
1D	1st notch frequency	100-1500	Notch frequency of the 1st resonance-suppress notch filter is set. Unit: [Hz]. It is used so as to coincide with the resonance frequency of the machine. 100 - 1499: Filter enabled 1500: Filter disabled
1E	1st notch width selection	0-4	Notch width of the 1st resonance suppress notch filter is selected. The larger value provides the wider notch width. Normally, set to 2.
1F	For manufacturer's use	-	-

<table>
<tr><th>Parameter №</th><th>Name</th><th>Setup range</th><th>Description</th></tr>
<tr><td>20
(RT)</td><td>Inertia ratio</td><td>0-10000</td><td>Defines the ratio of load inertia to the motor's rotor inertia. The unit is [%].
Set value [%] = (Load inertia/ rotor inertia) × 100
The estimated inertia ratio during real-time auto tuning will be stored in the EEPROM every 30 minutes.</td></tr>
<tr><td>21</td><td>Real time auto tuning setup</td><td>0-7</td><td>Defines the operation mode of real-time auto tuning. Increasing the set value (3, 6,...) provides higher response to the inertia change during operation. However, operation may become unstable depending on the motion pattern. Normally, set to "1" or "4".
When it is used in vertical axis, set to “4 - 6”.
The gain switching function is valid in the position control and the full-closed mode when this parameter is 1-6. Set to 7 when any influence of gain switching is considered.
<table>
<tr><th>Set value</th><th>Real-time auto tuning</th><th>Degree of inertia change during operation</th></tr>
<tr><td>0</td><td>Disabled</td><td>- - -</td></tr>
<tr><td>1</td><td rowspan="3">Normal mode</td><td>No change</td></tr>
<tr><td>2</td><td>Slowly changes</td></tr>
<tr><td>3</td><td>Rapidly changes</td></tr>
<tr><td>4</td><td rowspan="3">Vertical axis mode</td><td>No change</td></tr>
<tr><td>5</td><td>Slowly changes</td></tr>
<tr><td>6</td><td>Rapidly changes</td></tr>
<tr><td>7</td><td>Gain switching invalid mode</td><td>No change</td></tr>
</table></td></tr>
<tr><td>22</td><td>Machine stiffness at auto tuning</td><td>0-15</td><td>Defines the machine stiffness during execution of real-time auto tuning. Increasing the set value provides higher response. If the parameter value is rapidly changed, the gain significantly changes, applying a shock to the machine. Be sure to set a small value first, and increase it gradually, while monitoring the operating condition.</td></tr>
<tr><td>23</td><td>Adaptive filter mode</td><td>0-2</td><td>Set the operation of the adaptive notch filter.
0: Disabled
1: Enabled
2: Retaining (the adaptive filter frequency is retained when the set value is changed to 2.)
When this parameter is set to 0, Pr.2F becomes 0.
Note: When the vibration suppression filter switching selection (Pr.24) is set to 3,4, or 5, this paramaeter will be set to 0 automatically and the adaptive filter is invalidated.</td></tr>
<tr><td>24
*</td><td>Vibration suppression filter switching selection</td><td>0-5</td><td>Sst the type of vibration suppression filters.
0-1:No switching (1st and 2nd filters are both enabled.) at a effective frequency range of 10.0–200.0Hz
2:switch to either 1st or 2nd filter with direction at a effective frequency range of 10.0 – 200.0Hz
3-4:No switching (1st and 2nd filters are both enabled.) at a effective frequency range of 1.0–200.0Hz
5:switch to either 1st or 2nd filter with direction at a effective frequency range of 1.0 – 200.0Hz

Note: Direction to switch the vibration suppression frequency.
In CCW: 1st vibration suppression frequency (Pr.2B, Pr.2C).
In CW: 2nd vibration suppression frequency (Pr.2D, Pr.2E).
<table>
<tr><th>Set value</th><th>Filter type</th><th>Switching the filter</th></tr>
<tr><td>0</td><td rowspan="3">Nomal
(10.0 – 200.0 Hz)</td><td>Fixed</td></tr>
<tr><td>1</td><td>Fixed</td></tr>
<tr><td>2</td><td>Switch with direction</td></tr>
<tr><td>3</td><td rowspan="3">Low frequency extended
(1.0 – 200.0 Hz)</td><td>Fixed</td></tr>
<tr><td>4</td><td>Fixed</td></tr>
<tr><td>5</td><td>Switch with direction</td></tr>
</table></td></tr>
<tr><td>25</td><td>Normal auto tuning motion setup</td><td>0-7</td><td>Defines the motion pattern of the normal mode auto tuning.
<table>
<tr><th>Set value</th><th>Number of revolutions</th><th>Revolving direction</th></tr>
<tr><td>0</td><td rowspan="4">2[revolution]</td><td>CCW → CW</td></tr>
<tr><td>1</td><td>CW → CCW</td></tr>
<tr><td>2</td><td>CCW → CCW</td></tr>
<tr><td>3</td><td>CW → CW</td></tr>
<tr><td>4</td><td rowspan="4">1[revolution]</td><td>CCW → CW</td></tr>
<tr><td>5</td><td>CW → CCW</td></tr>
<tr><td>6</td><td>CCW → CCW</td></tr>
<tr><td>7</td><td>CW → CW</td></tr>
</table>
Example) Setting this parameter to "0" provides two CCW revolutions and two CW revolutions.</td></tr>
<tr><td>26</td><td>Software limit setup</td><td>0-1000</td><td>Defines the value of allowable over-rotation based on the range of the position command.
The unit is [0.1 rev].
when the set value is 0, the software limit error becomes invalid.
For details, refer to 3-3.</td></tr>
</table>

Parameter №	Name	Setup range	Description
27 (RT)	Velocity observer	0-1	The improvement of precision in speed detection by using the instantaneous velocity observer enables successful combination of the high response and the reduction of vibrations at the time of stopping. 0: Momentary speed observer disabled. 1: Momentary speed observer enabled. It is required to set Pr.20 inertia ratio to as precise as possible value before use. For details, refer to the item 6-4. When the instantaneous velocity observer is enabled, the 1st speed detection filter (Pr.13) and the 2nd speed detection filter (Pr.1B) are disabled. Also, the real-time auto-tuning cannot be used together.
28	2nd notch frequency	100-1500	Defines the notch frequency of the second resonance suppression notch filter. The unit is [Hz]. Match the notch frequency with the machine's resonance frequency. 100 to 1499: Filter enabled 1500: Filter disabled
29	2nd notch width selection	0-4	Select the notch width of the second resonance suppression notch filter. Increasing the set value enlarges the notch width.
2A	2nd notch depth selection	0-99	Select the notch depth of the second resonance suppression notch filter. Increasing the set value reduces the notch depth and the phase delay.
2B	1st vibration suppression frequency	0-2000	Sets vibration suppression frequency for suppressing vibration at the tip of a load . Measures the vibration frequency, and sets it in increments of 0.1[Hz]. In case of Pr.24 setting of 0-2, the frequency should be set in the range from 10.0 to 200.0[Hz] by setting this value from 100 to 2000. The value set in the range from 0 to 99 is disabled. In case of Pr.24 setting of 3-5, the frequency should be set in the range from 1.0 to 200.0[Hz] by setting this value from 10 to 2000. The value set in the range from 0 to 9 is disabled. Refer to 6-4 before use.
2C	1st vibration suppression filter	-200-2000	When setting Pr.2B (1st vibration suppression frequency) effectively, if torque saturation occurs, set a smaller value; if a faster operation is required, set a larger value. Normally, it is set to 0. Unit: 0.1 [Hz] In case of Pr.24 setting of 0-2, the seting value of this parameter should follow the below. -The maximum value of (Pr.2B+Pr.2C) is limited to double of Pr.2B value or 2000 maximum. -The minimum value of (Pr.2B+Pr.2C) is limited to 100. (Pr.2B+Pr.2C≧100). In case of Pr.24 setting of 3-5, the seting value of this parameter should follow the below. -The maximum value of (Pr.2B+Pr.2C) is limited to 6 times of Pr.2B value. -The minimum value of (Pr.2B+Pr.2C) is limited to 10. (Pr.2B+Pr.2C≧10). Refer to 6-4 before use.
2D	2nd vibration suppression frequency	0-2000	The function is the same as Pr.2B. Refer to 6-4 before use.
2E	2nd vibration suppression filter	-200-2000	The function is the same as Pr.2C. Refer to 6-4 before use.
2F	Adaptive filter frequency	0-64	Table No. corresponding to the frequency of the adaptive filter is displayed. This parameter is set automatically and cannot be changed manually when the adaptive filter is enabled (when Pr.23 (adaptive filter mode) is not 0). 0 - 4: Filter disabled 5 - 48: Filter enabled 49 – 64: Whether the filter is enabled or disabled depends on Pr.22. Before using this function, refer to section 8-1. When the adaptive filter is enabled, the parameter is stored in the EEPROM every 30 minutes. And when the adaptive filter is enabled at the next power-ON, the data stored in the EEPROM is used as the initial value to adapt the operation. When desiring to clear and reset this parameter, set the adaptive filter to “disabled” first, and then reset it “enabled”.

Parameter №	Name	Setup range	Description
30 (RT)	2nd gain action setup	0-1	Set up this parameter when the gain switching function is used. 0: Uses the first gain (Pr. 10 - Pr. 14). 1: Switches between the first gain (Pr. 10 - Pr. 14) and the second gain (Pr. 18 - Pr. 1C). To use this parameter, refer to Section 6-4.
31 (RT)	Gain switching mode	0-10	Defines the trigger for switching gains. 0: Fixed to 1st gain, 1: Fixed to 2nd gain, 2: Gain SW bit of command, 3: Torque command change value, 4:Fixed to 1st gain, 5: Speed command, 6: Position deviation, 7: Position command input, 8: Not in position, 9: Speed, 10: Position command input + speed To use this parameter, refer to Section 6-4.
32 (RT)	Gain switching delay time	0-10000	Defines the time duration from trigger detection to actual gain switching from the 2nd gain to the 1st gain when Pr. 31 is set to 3, 5 - 10. The unit is [166μs]. To use this parameter, refer to Section 6-4.
33 (RT)	Gain switching level	0-20000	Defines the trigger level when Pr. 31 is set to 3,5,6,9, or 10. The unit varies depending on the setting of Pr. 31. To use this parameter, refer to Section 6-4.
34 (RT)	Gain switching hysteresis	0-20000	Defines the hysteresis for trigger judgment when Pr. 31 is set to 3,5,6,9, or 10. The unit varies depending on the setting of Pr. 31. To use this parameter, refer to Section 6-4.
35 (RT)	Position loop gain switching time	0-10000	Used to suppress a rapid increase in the position loop gain when there is a large difference between the first and second position loop gains. When the position loop gain increases, the change occurs in (the set value + 1) x 166[μs]. To use this parameter, refer to Section 6-4.
36	For manufacturer's use	-	-
37	For manufacturer's use	-	-
38	For manufacturer's use	-	-
39	For manufacturer's use	-	-
3A	For manufacturer's use	-	-
3B	For manufacturer's use	-	-
3C	For manufacturer's use	-	-
3D	JOG speed	0-500	Defines the JOG speed in a unit of [r/min] when using the optional console . Note: Make sure to disconnect the communication network during the JOG operation.
3E	For manufacturer's use	-	-
3F	For manufacturer's use	-	-

<table>
<tr><th>Parameter №</th><th>Name</th><th>Setup range</th><th>Description</th></tr>
<tr><td>40</td><td>External Servo-ON enable</td><td>0-1</td><td>Enables the external Servo-ON input (X5 EX-SON: Pin-23).
Regardless of this setting, the external Servo-ON will be enabled while carrying out the normal auto-gain tuning or the frequency characteristics measuring function.
0：disable (to be used as a general input (EX-IN4))
1：enable (turns to Servo-ON under the AND condition with Servo ON command (Byte2,bit7 of the command)</td></tr>
<tr><td>41</td><td>Emergency stop enable</td><td>0-1</td><td>Enables Emergency stop input (X5 EMG-STP: Pin-2)
0：disable, 1：enable (Err.87 will be triggered with open.)</td></tr>
<tr><td>42</td><td>Home input logic</td><td>0-1</td><td>Defines the logic of Home input (X5 HOME: Pin-21).
0：Normally closed
1：Normally open</td></tr>
<tr><td>43
*</td><td>Direction of motion</td><td>0-3</td><td>Defines the positive direction of the motion data transmitted via network and a assignment of overtravel input (CWL, CCWL) on the response byte-3. This setup does not affect the function of over-travel input (X5 CWL: Pin-20, CCWL: Pin-19).
Note: On PANATERM, CCW direction will always be displayed as positive (+) direction.
<table>
<tr><th>Set value</th><th>Positive direction</th><th>Bit-1 of respose byte-3</th><th>Bit-0 of respose byte-3</th></tr>
<tr><td>0</td><td>CW</td><td>CCWL
(Neg)</td><td>CWL
(Pos)</td></tr>
<tr><td>1</td><td>CCW</td><td>CCWL
(Pos)</td><td>CWL
(Neg)</td></tr>
<tr><td>2</td><td>CW</td><td>CWL
(Pos)</td><td>CCWL
(Neg)</td></tr>
<tr><td>3</td><td>CCW</td><td>CWL
(Neg)</td><td>CCWL
(Pos)</td></tr>
</table>
</td></tr>
</table>

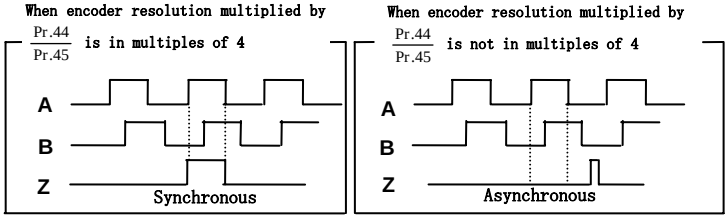
<table>
<tr><th>Parameter №</th><th>Name</th><th>Setup range</th><th>Description</th></tr>
<tr><td>44
*</td><td>Numerator of output pulse ratio</td><td>1-32767</td><td rowspan="2">Defines the number of pulses from the pulse output (X5 OA+: Pin 11, OA-: Pin 12, OB+: Pin 13 and OB-: Pin 14).

In the case of the output of encoder pulses (When the control mode is position control, or Pr.46 is 0 or 1):
Pr.45=0: Pr.44 can be used to set the number of output pulses per motor revolution for OA and OB.
Pulse output resolution per revolution = Pr.44 (numerator of output pulse ratio) x 4

Pr.45≠0: the pulse output resolution per revolution is divided at any ratio according to the following expression.

Pulse output resolution per revolution = $\frac{\text{Pr.44 (numerator of output pulse ratio)}}{\text{Pr.45 (denominator of output pulse ratio)}}$ × Encoder resolution

Note)
- The encoder resolution is 131072[P/r] in the case of 17-bit absolute encoder, and 10000[P/r] in the case of 2500 P/r 5-wire incremental encoder.
- The pulse output resolution per revolution cannot exceed the resolution of an encoder.
(In the case of the above setting, the pulse output resolution per revolution is same as the resolution of an encoder.)
- Phase Z is output once every motor revolution.
When pulse output resolution per revolution calculated by the above expression is in multiples of 4, phase Z is output in synchronization with phase A. Otherwise, as it is output based on the resolution of an encoder, phase Z is not synchronized with phase A and its width becomes narrower than that of phase A.

  </td></tr>
<tr><td>45
*</td><td>Denominator of output pulse ratio</td><td>0-32767</td></tr>
<tr><td colspan="3"></td><td>- In the case of the output of external scale pulses (When the control mode is F and Pr.46 is 2 or 3),

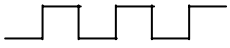
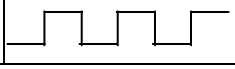
Pr.45=0: No division
Pr.45≠0: the travel distance per output pulse is divided at any ratio according to the following expression.

Note)
- The travel distance per external scale pulse is 0.05[μm] for AT500 series, and 0.5[μm] for ST771 series.
- The setting of Pr.44＞Pr.45 is disabled.
(In the case of the above setting, there is no division.)
- Phase Z is output in synchronization with phase A only when having crossed the absolute position 0 of an external scale after the control power of the amplifier has been turned on.
Thereafter, it is output at the intervals of phase A output pulses, which are set by Pr.47 (Z-phase of external scale set up).

Travel distance per output pulse = $\frac{\text{Pr.45 (denominator of output pulse ratio)}}{\text{Pr.45 (numerator of output pulse ratio)}}$ × Travel distance per external scale pulse</td></tr>
</table>

<table>
<tr><th>Parameter №</th><th>Name</th><th>Setup range</th><th>Description</th></tr>
<tr><td>47
*</td><td>Pulse output logic inversion</td><td>0-3</td><td>Defines the phase B logic and output source of the pulse output (X5 OB+: Pin 13 and OB+: Pin 14).

The positioning of phase B with regard to phase A can be inversed by inversing the phase B pulse logic by using this parameter.

<table>
<tr><th>Set value</th><th>Phase A (OA)</th><th>At the CCW revolution of a motor</th><th>At the CW revolution of a motor</th></tr>
<tr><td></td><td></td><td>  </td><td>  </td></tr>
<tr><td>0,2</td><td>Phase B (OB) not inversed</td><td>  </td><td>  </td></tr>
<tr><td>1,3</td><td>Phase B (OB) inversed</td><td>  </td><td>  </td></tr>
</table>

<table>
<tr><th>Pr.46</th><th>Phase B logic</th><th>Output source</th></tr>
<tr><td>0</td><td>Not inversed</td><td>Encoder position</td></tr>
<tr><td>1</td><td>Inversed</td><td>Encoder position</td></tr>
<tr><td>2 *)</td><td>Not inversed</td><td>External scale position</td></tr>
<tr><td>3 *)</td><td>Inversed</td><td>External scale position</td></tr>
</table>

* The output source of Pr.46=2, 3 is enabled at the time of full-closed control only.</td></tr>
<tr><td>47
*</td><td>Z-phase of external scale set up</td><td>0-32767</td><td>This parameter defines the output intervals of phase Z by using the number of output pulses of external scale's phase A (before being multiplied by 4), when using an external scale as a pulse output source (when Pr.02 (control mode) is 6, and Pr.46 (pulse output logic inversion) is 2 or 3).
- In the case of Pr.47=0:
The phase Z output of an external scale is not performed.
- In the case of Pr.47=1 to 32767:
The external scale phase Z is output in synchronization with phase A only when having crossed the external scale absolute position 0 after the amplifier control power has been turned on.
Thereafter, it is output at the output pulse intervals of phase A, which is set by this parameter.</td></tr>
<tr><td>48</td><td>For manufacturer's use</td><td>-</td><td>-</td></tr>
<tr><td>49</td><td>For manufacturer's use</td><td>-</td><td>-</td></tr>
<tr><td>4A</td><td>For manufacturer's use</td><td>-</td><td>-</td></tr>
<tr><td>4B</td><td>For manufacturer's use</td><td>-</td><td>-</td></tr>
<tr><td>4C</td><td>Smoothing filter</td><td>0-7</td><td>Select the 1st lag filter for position command.
Larger the setup, smoother the command becomes, however, delay to the command will be longer.
0 : Filter is invalid.
1-7 : Filter is valid.</td></tr>
<tr><td>4D
*</td><td>FIR filter set up</td><td>0-31</td><td>Select the FIR smoothing filter covering the position command.
Becomes a moving average filter of (setup + 1).</td></tr>
<tr><td>4E</td><td>For manufacturer's use</td><td>-</td><td>-</td></tr>
<tr><td>4F</td><td>For manufacturer's use</td><td>-</td><td>-</td></tr>
</table>

Parameter №	Name	Setup range	Description
50	For manufacturer's use	-	-
51	For manufacturer's use	-	-
52	For manufacturer's use	-	-
53	For manufacturer's use	-	-
54	For manufacturer's use	-	-
55	For manufacturer's use	-	-
56	For manufacturer's use	-	-
57	For manufacturer's use	-	-
58	For manufacturer's use	-	-
59	For manufacturer's use	-	-
5A	For manufacturer's use	-	-
5B	For manufacturer's use	-	-
5C	For manufacturer's use	-	-
5D	For manufacturer's use	-	-
5E	1st torque limit	0-(500)	Defines the 1st limit value of the motor output torque. The unit is [%]. For the selection of the torque limit, refer to Pr.03.
5F	2nd torque limit	0-(500)	Defines the 2nd limit value of the motor output torque. The unit is [%]. For the selection of the torque limit, refer to Pr.03.

<table>
<tr><th>Parameter №</th><th>Name</th><th>Setup range</th><th>Description</th></tr>
<tr><td>60</td><td>In-position range</td><td>0-32767</td><td>Number of allowable pulses for in-position range is set.
When the positional deviation is less than a set value, COIN output is turned ON.
Use the number of encoder pulses to control the position.
For full-closed control, use the number of pulses of an external scale.</td></tr>
<tr><td>61</td><td>Zero speed</td><td>10-20000</td><td>Sets the threshold level of the zero speed detection.
When the speed is lower than this setting, “Zero speed” is detected.
The unit is [r/min].
Note) The zero speed detection has a hysteresis of 10[r/min].
This parameter is used for detecting In-position. Refer to Pr.63.</td></tr>
<tr><td>62</td><td>For manufacturer’s use</td><td>-</td><td>-</td></tr>
<tr><td>63</td><td>In-position output set up</td><td>0-3</td><td>Sets the operation of the positioning completion signal.
If in-position is ON, Byte2-bit0 of Response becomes 1.
0: Turned on when the position deviation is within the completed poisoning range.
1: Turned on when there is no position command and the position deviation is within the completed positioning range.
2: Turned on when there is no position command, the zero speed detection signal is on, and the position deviation falls within the completed positioning range.
3: Turned on when there is no position command and the position deviation falls within the completed positioning range.
Thereafter, it remains turned on until the next command arrives.</td></tr>
<tr><td>64</td><td>CT-offset re-calibration at servo-on</td><td>0-1</td><td>Sets CT-offset re-adjustment function at servo-on.
0: disable (Adjustment at a control power-up only)
1: enable (Adjustment at both a control power-up and servo-on.

Note) It makes sure not to move the motor at servo-on when using this function, because of avoiding mis-adjustment.</td></tr>
<tr><td>65</td><td>Undervoltage error response at main power-off</td><td>0-1</td><td>Sets the operation required when the main power remains shut off for the time period set by Pr.6D (main power-off detection time) during the servo-on.
0: Servo is turned OFF in accordance with the setting of Pr.67.
After that, if the main power is turned on, the drive will be Servo-ON again.
1: Servo trips when main power undervoltage protection (alarm code No.13).
When Pr.6D is 1000, this parameter is disabled.
When the voltage between P and N of the main power converter drops lower than the specified value before detecting the main power shut-off due to the reason that the Pr.6D set time is too long, a voltage error is caused by the shortage of main power (alarm code No.13).</td></tr>
<tr><td>66
*</td><td>Error response at overtravel limit</td><td>0-2</td><td>Sets the driving condition at slowdown operation when the overtravel input (CCWL: CN X5 Pin 9 or CWL: CN X5 Pin 8) has been active.

<table>
<tr><th>Set value</th><th>During deceleration</th><th>After stopping</th><th>Deviation counter</th></tr>
<tr><td>0</td><td>DB</td><td>Torque command in overtravel inhibit direction = 0</td><td>Retained</td></tr>
<tr><td>1</td><td>Torque command in overtravel inhibit direction = 0</td><td>Torque command in overtravel inhibit direction = 0</td><td>Retained</td></tr>
<tr><td>2</td><td>Emergency stop</td><td>Position command in overtravel inhibit direction = 0</td><td>Cleared before or after deceleration</td></tr>
</table>

(DB: Dynamic brake operation)

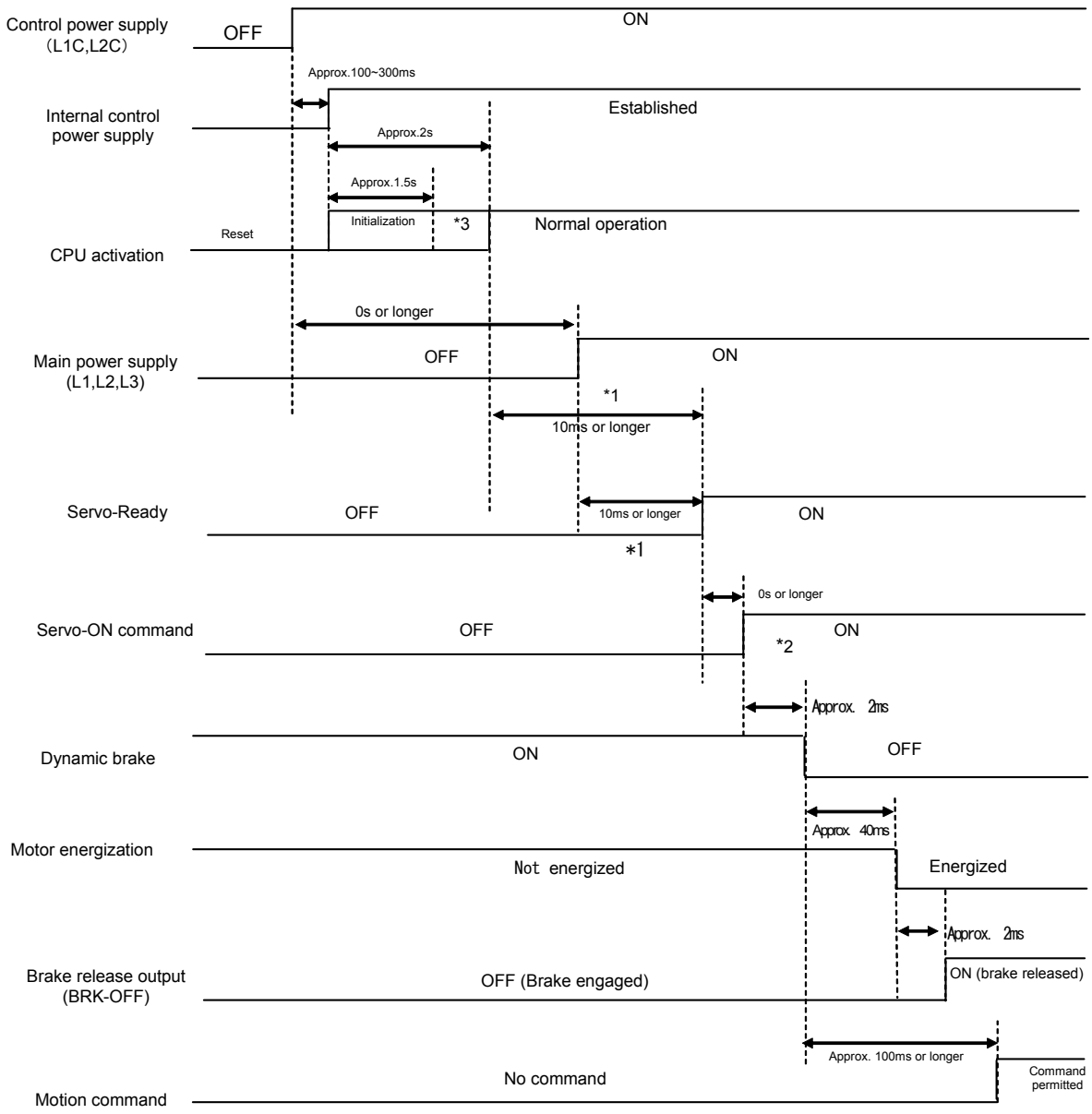
When the set value is 2, the torque limit during the deceleration operation is the set value of Pr.6E (emergency stop torque set up).</td></tr>
</table>

<table>
<tr><th>Parameter №</th><th>Name</th><th>Setup range</th><th>Description</th></tr>
<tr><td>67</td><td>Error response at main power-off</td><td>0-9</td><td>When Pr.65 (Undervoltage error response at main-power off) is 0, sets the followings after the main power is turned off:
(1) The driving condition during the deceleration operation and after stopping, and
(2) The clearance procedure of deviation counter contents.
<table><tr><th>Set value</th><th>During deceleration</th><th>After stopping</th><th>Deviation counter</th></tr><tr><td>0,4</td><td>DB</td><td>DB</td><td>Cleared</td></tr><tr><td>1,5</td><td>Free run</td><td>DB</td><td>Cleared</td></tr><tr><td>2,6</td><td>DB</td><td>Free</td><td>Cleared</td></tr><tr><td>3,7</td><td>Free run</td><td>Free</td><td>Cleared</td></tr><tr><td>8</td><td>Emergency stop</td><td>DB</td><td>Cleared</td></tr><tr><td>9</td><td>Emergency stop</td><td>Free</td><td>Cleared</td></tr></table>(DB: Dynamic brake operation)
When the set value is 8 or 9, the torque limit during the deceleration is the set value of Pr.6E (emergency stop torque set up)</td></tr>
<tr><td>68</td><td>Error response action</td><td>0-3</td><td>Sets the driving condition during the deceleration or after stopping due to the alarm raised by any protective function.<table><tr><th>Set value</th><th>During deceleration</th><th>After stopping</th><th>Deviation counter</th></tr><tr><td>0</td><td>DB</td><td>DB</td><td>Cleared</td></tr><tr><td>1</td><td>Free run</td><td>DB</td><td>Cleared</td></tr><tr><td>2</td><td>DB</td><td>Free</td><td>Cleared</td></tr><tr><td>3</td><td>Free run</td><td>Free</td><td>Cleared</td></tr></table>(DB: Dynamic brake operation)
The error counter is cleared when an alarm is cleared.</td></tr>
<tr><td>69</td><td>Sequence at Servo-OFF</td><td>0-9</td><td>Sets the followings after servo-off:
(1) The driving condition during the deceleration or after stopping, and
(2) The clearance procedure of the deviation counter.
The relation between the set value and the driving condition/error counter handling condition of Pr.69 is same as that of Pr.67 (error response at main power-off.)</td></tr>
<tr><td>6A</td><td>Mechanical brake delay at motor standstill</td><td>0-100</td><td>Defines the time duration from turn-OFF of the external brake release signal (X5 BRK-OFF: Pins 35 and 36) to motor shutdown, in transition to Servo-OFF during the halt of the motor (servo lock condition).
The unit is [2 ms]. To use this parameter, refer to Section 2-2.</td></tr>
<tr><td>6B</td><td>Mechanical brake delay at motor in motion</td><td>0-100</td><td>Sets the time required until the external brake release signal (X5 BRK-OFF: Pins-35 and 36) is turned off after it is detected that the servo-on input signal has been turned off at the time of servo-off during the motor revolution. The unit is [2 ms]. If the motor speed falls below approx. 30 [r/min] before the preset time is reached, the BRK-OFF signal turns OFF. To use this parameter, refer to Section 2-3.</td></tr>
<tr><td>6C
*</td><td>External regenerative resistor set up</td><td>0-3</td><td>Sets the operation of the regenerative resistor and the regenerative overload protection (Err18).
0: Defines the regenerative resistor overload protection according to the built-in regenerative resistor.
1: Trip occurs due to the over-regenerative load protection (alarm code No.18) when the regenerative external resistor's operating ratio exceeds 10%.
2: Inactivates the regenerative resistor overload protection.
However, enables to operate the external regenerative resistor.
3: Inactivate the regenerative discharge circuit, and processes all regenerative power through built-in capacitors.
When using the built-in resistor, set to 0.</td></tr>
<tr><td>6D
*</td><td>Main power-off detection time</td><td>35-1000</td><td>Defines the time duration before detection of main power interruption after the main power is turned OFF.
The unit is [2 ms]. When the set value is 1000, the detection of main power off is disabled.
The change is enabled when the control power is turned on.</td></tr>
<tr><td>6E</td><td>Emergency stop torque set up</td><td>0-500</td><td>Sets the torque limit of the following time:
1. With Pr.66 (error response at overtravel limit) set to 2, when the deceleration operation is initiated due to drive prohibition,
2. With Pr.67 (error response at main power-off) set to 8 or 9, when the deceleration operation is initiated, or
3. With Pr.69 (sequence at Servo-OFF) set to 8 or 9, when the deceleration operation is initiated.
When the set value is 0, the normal torque limit is used.
Note:This is not for the setting when inputted Energency stop (EMG-STP).</td></tr>
<tr><td>6F</td><td>For manufacturer’s use</td><td>-</td><td>-</td></tr>
</table>

Parameter №	Name	Setup range	Description
70	Position deviation error level	0-32767	Sets a position deviation excess range. The unit is [256 x resolution]. To set it, use the number of encoder pulses for the position control, and the number of external scales pulses for the full-closed control. When this parameter is 0, the error detection is disabled.
71	For manufacturer's use	-	-
72	Overload level	0-500	Sets the overload level. When the set value is 0, the overload level is set to 115[%]. Set it to 0 normally. Only when using any lower overload level, set a desired level before use. The set value of this parameter is limited to 115[%] of the motor rating. The unit is [%].
73	Overspeed level	0-20000	Sets the overspeed level. When the set value is 0, the overspeed level is set to the maximum number of motor revolutions x 1.2. Set it to 0 normally. Only when using any lower overspeed level, set a desired level before use. The set value of this parameter is limited to the minimum number of motor revolutions × 1.2. The unit is [r/min]. Note: The detection error of the set value is ±3[r/min] for the 7-core absolute encoder, and ±36[r/min] for the 5-core incremental encoder.
74 *	Command update period	1-2	Define the period of a command update. 1: 0.5 [ms] 2: 1.0 [ms] Make sure that the period of a command update should be the same as the period of master control. Note: This is not the communication period, which is fixed at 0.5ms.
75	For manufacturer's use	-	-
76	For manufacturer's use	-	-
77	For manufacturer's use	-	-
78 *	Numerator of external scale ratio	0-32767	Sets the ratio of encoder resolution to external scales resolution at the time of full-closed control. $\frac{\text{Encoder resolution per motor revolution}}{\text{External scale resolution per motor revolution}} = \frac{\text{Pr.78} \times 2^{\text{Pr.79}}}{\text{Pr.7A}}$ Pr.78=0: The numerator equals encoder resolution, and Pr.7A can be used to set the external scale resolution. Pr.78≠0: Set the external scale resolution per revolution according to the above expression. Refer to the section 11-6-4 before use. Note: -The actual numerator is calculated as the nth power of the numerator of external scale ratio (Pr.78) × 2 (the set value of Pr.79). The maximum calculated value is 131072. Take note that any larger set value is disabled and 131072 will be the maximum set value. -Any change of this parameter shall be made during the Servo-OFF.
79 *	Multiplier of numerator of external scale ratio	0-17	
7A *	Denominator of external scale ratio	1-32767	
7B *	Hybrid deviation error level	1-10000	-Sets the tolerance in the present position between a motor and an external scale under the full-closed control. -The unit to be used for the setting is [16 × external scale pulse].
7C *	External scale direction	0-1	Sets the polarity of external scale absolute data. 0: data is increased when the detection head moves right (+ count). 1: data is decreased when the detection head moves right (- count). "right" is viewed from the installing side.
7D *	Absolute external scale setup	0-1	Sets the usage of absolute external scale whether to be absolute or incremental scaling. 0: Used as absolute scale 1: Used as incremental scale Note: Set this parameter to 1 in the case of homing with sensor under the full-closed control. However, in normal use, set to 0.
7E	For manufacturer's use	-	-
7F	For manufacturer's use	-	-

2. Operation timing

2-1 Timing chart after power-up



・The above fig. shows the timing from power-up to motion command entry.
・Enter the Servo-ON and motion command according to the timing of the above fig.

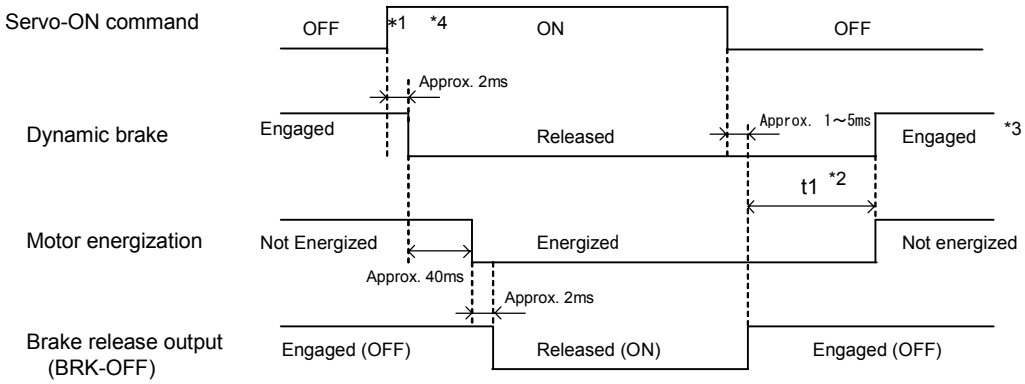
*1. Servo-Ready will be turned on when all of the following conditions are satisfied, " the initialization completed", " Main power established" and "Communication established", then the response Byte2, bit6 will be 1.
Note: The servo drive might not become Servo-Ready state if the Update Counter is not counted up properly.

*2. Servo-ON command will be turned on when both conditions of "Command Byte2, bit7 is 1" and "External Servo-ON (EX-SON) is ON " are satisfied.

*3. After internal control power supply is activated, protective functions start operation approx 1.5s after the CPU's initialization starts. Design the I/0 signal connected with the amplifier (especially linear scale input or CW/CCW overtravel inhibit input that can trigger protective functions) is set before protective functions start operation.

2-2 Servo-ON/OFF timing at a standstill

(Execute Servo-ON/OFF after stopping the motor in normal operation.)



*1. It will not turn to Servo-ON until the motor speed falls below approx. 30r/min.

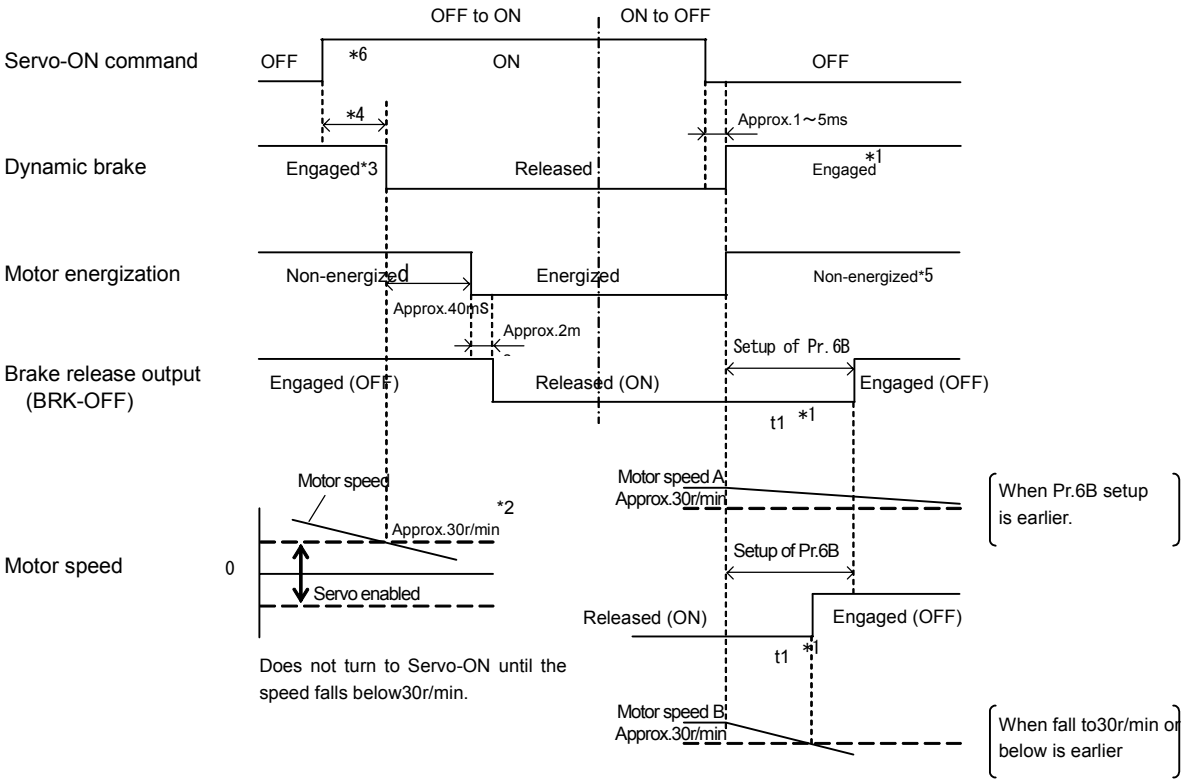
*2. t1 will be determined by the setup of Pr.6A.

*3. The dynamic brake action at Servo-OFF, depends on Pr.69(Sequence at Servo-OFF).

*4. Servo-ON command will be turned on when both “Command Byte2,bit7 is 1” and “External Servo-ON is ON” are satisfied.

2-3 Servo-ON/OFF timing in motion

(Timing for emergency stop or for trip. Do not repeat this operation.)



*1. t1 is either the setup pf Pr.6B, or time for the motor speed to fall below 30r/min, whichever the earlier one.

*2. The drive will not turn to Servo-ON until the motor stops, even if you turn on the Servo-ON input again during the motor deceleration.

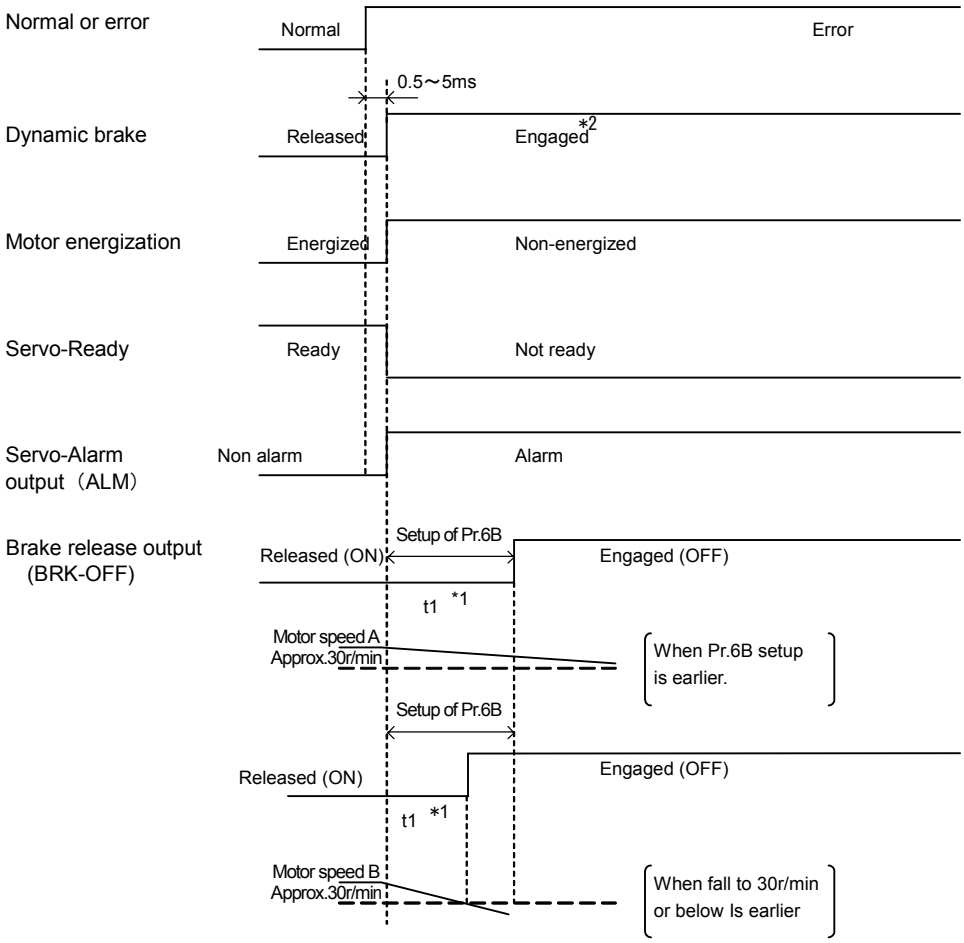
*3. The dynamic brake action at Servo-OFF, depends on Pr.69 (Sequence at Servo-OFF).

*4. The drive does not turn to Servo-OFF until the motor speed falls below approx. 30r/min.

*5. The motor energization status during deceleration at Servo-OFF, depends on Pr.69 (Sequence at Servo-OFF).

*6. Servo-ON command will be turned on when both “Command Byte2,bit7 is 1” and “External Servo-ON (EX-SON) is ON “ are satisfied.

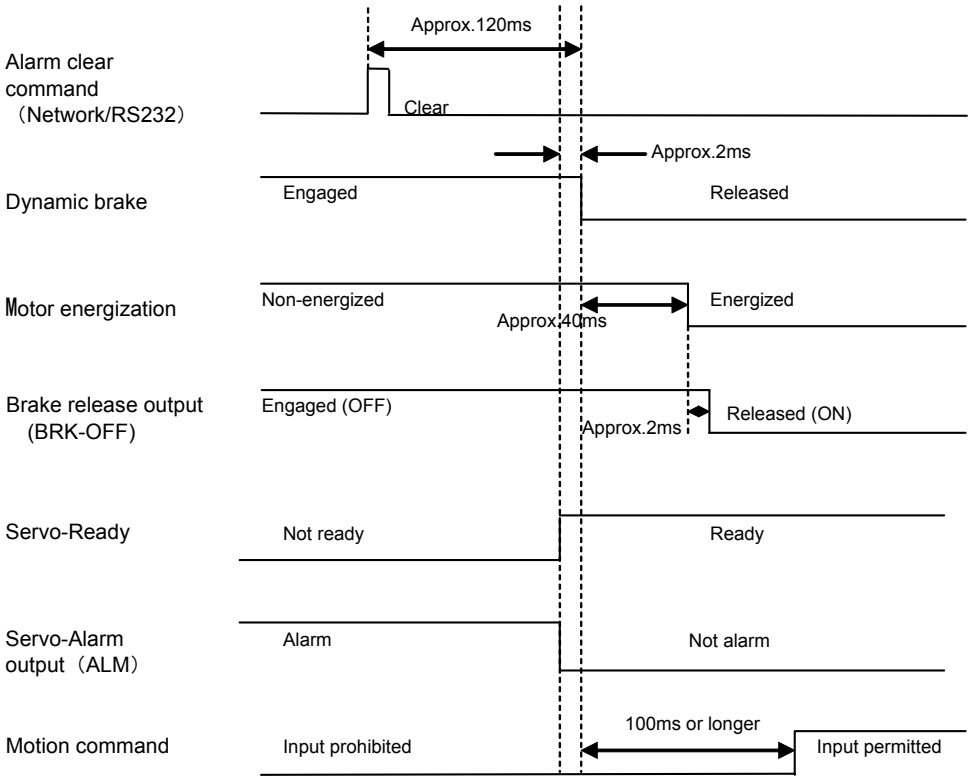
2-4 Timing chart at alarm (during Servo-ON command)



*1. t1 is either the setup of Pr.6B, or the time for the motor speed to fall below 30r/min, whichever the shorter one. If alarm at a standstill, t1 becomes 0.

*2. The dynamic brake action at alarm occurrence depends on Pr.68 (Error response action) .

2-5 Timing chart at alarm-clear (during Servo-ON command)



3. Protective Functions

3-1 Protective function

This servo drive is equipped with various protective functions. When one of these function is activated, the drive will trip and output an alarm signal (ALM), and display the alarm code on 7-segment LED of the front panel.

Protective function	Alarm code No.	Causes	Measures
Control power Under-voltage	11	Voltage between P and N of the converter portion oft he control power supply has fallen below the specified value. 1) Power supply voltage is low. Voltage sag has occurred. 2) Power supply capacity is not enough. Power supply voltage falls down due to inrush current at power-ON. 3) Failure of the servo drive (failure of circuit).	Measure the line voltage of the connector (L1C,L2C) and terminal block（r,t）. 1) Increase the power voltage capacity. Change the power supply. 2) Increase the power source capacity. 3) Replace with a new drive.
Over-voltage	12	Power source voltage has exceeded the permissible input voltage range→voltage between P and N of the convert portion of the control power supply has exceeded the specified value. Voltage surge due to phase-advancing capacitor or UPS. 1) Disconnection of external regenerative resistor. 2) Regenerative resistor is not proper, and cannot absorb the regenerative energy. 3) Failure of the drive (failure of circuit).	Measure the line voltage of the connector (L1, L2, and L3). Enter the correct voltage. Remove the phase-advancing capacitor. 1) Measure the resistance of the external resistor connected between P and B terminal. If the resistance infinite, it shows the disconnection, and replace with a new external resistor. 2) Change to the specified resistance and wattage. 3) Replace with a new drive.
Main power Under-voltage	13	Voltage sag has lasted between L1 and L3 for longer than the specified time by Pr.6D (Main power-off detecting time), while Pr.65 (Undervoltage error response at main power-off) is set to 1, or voltage between P and N of the converter portion of the main power supply has fallen below the specified value during Servo-ON. 1) Power supply voltage is low. Voltage sag has occurred. 2) Voltage sag has occurred. 3) Power supply capacity is not enough…power supply voltage has fallen due to inrush current at power-ON. 4) Phase lack…3-phase drive is driven with single phase. 5) Failure of the drive (failure of circuit).	Measure the line voltage of the connector (L1, L2 and L3). 1) Increase the power supply capacity. Remove the causes of the blow up of the magnetic contactor for the main, then re-enter the power. 2) Check the setup of Pr.6D (Main power-off detection time). Set up each phase correctly. 3) Increase the capacity of the power source. Refer to “Servo drive and list of applicable equipment” for the power source capacity. 4) Connect each phase of the power (L1, L2 and L3) correctly. Use L1 and L3 for single phase 100 and 200V. 5) Replace with a new drive.
Over-current	14 *	Current of the converter portion has exceeded the specified value. 1) Failure of the drive（Circuit, IGBT or other components） 2) Short of motor cable (U, V and W) 3) Ground fault of the motor cable. 4) Motor burn 5) Motor cable contact failure 6) Relay for dynamic brake has melted due to the frequent Servo-ON and OFF. 7) Unmatched motor and drive. 8) Action command input and Servo-ON timing is same, or action command input is ahead.	1) Replace with a new (or working) drive if the current exceeds immediately after the Servo-ON while disconnecting the motor cable. 2) Check if the motor cable connection (U, V and W) is shorted or not, or any pig tail at connector lead. Make a correct wiring of the motor cables. 3) Check the insulation resistance between the motor cable (U, V and W) and earth cable. Replace the motor if the insulation is failure. 4) Check the balance of line resistance of the motor. Replace the motor if the unbalance is found. 5) Check the connector pin fall out of the motor connection, U, V and W. Fix them if you fine any loose pins or fall out. 6) Replace the drive. Stop operating with Servo-ON and OFF. 7) Check the capacity of the motor and the drive with name plate, and change the motor which matches to the drive. 8) Enter the action command input 100ms or longer after the Servo-ON.

Protective function	Alarm code No.	Causes	Measures
Overheat	15 *	Heat-sink and power device of the drive have risen over the specified temperature. 1) Ambient temperature has risen over the specified value. 2) Overload has occurred	1) Improve the ambient temperature and cooling conditions 2) Increase the motor and drive capacity. Set up longer acceleration/deceleration time. Reduce the load.
Overload	16	Actual value of the torque command has exceeded the setup of Pr.72 (Overload level), and the overload protection has been triggered according to the time characteristics. 1) Load is heavy and the motor has been running for a long time with actual torque exceeding the rated torque. 2) Oscillation and hunching action due to poor gain adjustment. Motor vibration and abnormal noise. Incorrect setup of Pr.20 (Inertia ratio). 3) Miswiring, disconnection of the motor 4) Machine has collided or the load has gotten heavy. Machine has entangled. 5) Electro magnetic brake has been kept engaged, 6) Miswiring has occurred by connecting the motor cable to other axis, while wiring the multi-axes.	Check if the torque waveform oscillates or not, or swings up and down or not with graphic function of the PANATERM. Check the overload alarm display and load factor with the PANATERM. 1) Increase the motor and drive capacity. Set up longer acceleration/deceleration time. Lower the load. 2) Make a gain adjustment again. 3) Make a motor wiring as per the wiring diagram. Replace the cable. 4) Remove the machine entanglement. Lower the load. 5) Measure the voltage between brake terminals. Release the brake. 6) Make a correct wiring by matching the correct motor and encoder wires to the axis.
Regenerative resistor overload	18 *	Regenerative energy has exceeded the regenerative resistor capacity. 1) Converter voltage has risen due to the regenerative energy during deceleration with larger load inertia and the voltage has further risen due to the lack of absorbing capacity of the regenerative resistor. 2) Regenerative energy has not been absorbed in the specified time due to a high motor speed. 3) Action limit of the external regenerative resistor has been limited to 10% duty.	Check the regenerative resistor's load factor on the monitor screen of the PANATERM. Do not use this resistor for continuous regenerative brake. 1) Check the running pattern (speed monitor). Check the load factor of the regenerative resistor and over-regeneration alarm display. Increase the motor and drive capacity, set up a longer acceleration/declaration time. Use an external regenerative resistor. 2) Check the running pattern (speed monitor). Check the load factor of the regenerative resistor and over-regeneration alarm display. Increase the motor and drive capacity, set up a longer acceleration/declaration time. Lower the motor speed. Use an external regenerative resistor. 3) Set up Pr.6C to 2.

■ Overload time, t [s] can be obtained by the following formula, when a constant torque command has been entered after 3 times or more of overload time constant, while the torque command is 0. [s]

$t\ [s] = -\text{overload time constan [s]} \times \log_e (1 - \text{overload level [\%]} / \text{torque command [\%]})^2$

(Overload time constant [s] depends on the motor.)

<Remarks> Install an external protective equipment such as thermal fuse when you setup Pr.6C to 2, otherwise the protection by the regenerative resistor will be loset and will be heated abnormally and may result in burn out.

Protective function	Alarm code No.	Causes	Measures
Encoder communication error	21 *	Communication between the encoder and the drive has been stopped for certain times and disconnection detecting function has been activated.	Make a wiring connection as per the wiring diagram. Correct the miswiring of the connector pins. Note that the encoder cable to be connected to X6.
Encoder communication data error	23 *	Communication error has occurred in data from the encoder. Mainly data error due to noise. Encoder cable is connected but the communication data has some error.	・ Secure the power supply for the encoder of DC5V±5% (4.75 to 5.25V)…pay extra attention when the encoder cable is long. ・ Separate the encoder and motor cable. ・ Connect the shield to FG…refer to the encoder wiring diagram.
Position deviation error	24	Position deviation pulses have exceeded the setup of Pr.70 （Position deviation error level）. 1) Motor does not follow the command. 2) Setup of Pr.70 (Position deviation error level) is small.	1) Check if the motor runs as per the position command or not. Check if the output torque has not been saturated or not with torque monitor. Make a gain adjustment. Set up Pr.5E (1st torque limit) and Pr.5F(2nd torque limit) to the max. Make the encoder wiring as per the wiring diagram. Set up a longer acceleration/deceleration time. Lower the load and speed. 2) Set up a large value to Pr.70.
Hybrid deviation error	25 *	The position of a load due to an external scale and the position of a motor based on an encoder were displaced each other by not less than the number of pulses set by Pr.7B (Hybrid deviation error level).	• Check the connection between the motor and the load. • Check the connection between the external scale and the servo amplifier. • Check whether the change of motor position (encoder feedback value) and the change of load position (external scale feedback value) have the same sign (+/-) when the load is driven. Check whether the numerator and denominator of external scale ratio (Pr.74, 75 and 76) and the external scale direction (Pr.7C) are set correctly.
Over-speed	26	Motor speed has exceeded the setup of Pr.73 (Overspeed level).	・ Do not give excess action command. ・ Make a gain adjustment when the overshoot has occurred due to poor gain adjustment. ・ Make the encoder wiring as per the wiring diagram.
Motion command error	27	Error in motion command. 1) Error in motion command from the host. 2) Network has been connected to the host during FFT, normal auto-gain tuning and JOG run (for drive alone operation). 3) With PANATERM, the absolute encoder is cleared In this case, no problem.	・ Check if the incorrect motion command has been entered or not. 1) Review the motion command. 2) Do not establish the network during FFT, normal auto-gain tuning and JOG run.
External scale communication data error	28 *	A communication error occurred in the data from an external scale. It is a data error mainly caused by noises. This communication data error occurred in spite of the existence of the connection of the external scale connection cable.	• Secure the power voltage of 5VDC±5% (4.75 to 5.25V) for the external scale. The attention should be paid to this matter especially when using a long external scale connection cable. • In case the motor cable and external scale connection cable are bundled together, make sure to split them. • Connect the shield to FG. Refer to the connection chart of the external scale.
Deviation counter overflow	29	Deviation counter pulses have exceeded 2^{27}(134217728).	・ Check if the motor runs as per the position command ・ Check if the output toque has not been saturated with torque monitor. ・ Make a gain adjustment. ・ Set up Pr.5E (1st torque limit) and Pr.5F (2nd torque limit) to the max. ・ Make the encoder wiring as per the wiring diagram.
Software limit	34	Motor has traveled exceeding the motor movable range set by Pr.26 (Software limit setup) 1) Gain is not proper. 2) Setup of Pr.26 is small.	1) Check the gain (balance of position loop gain and velocity loop gain), and check the inertia ratio. 2) Set up larger value to Pr.26. Invalidate the protective function by setting up Pr.26 to 0.

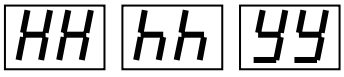
Protective function	Alarm code No.	Causes	Measures
External scale communication error	35 *	Communication between an external scale and the servo drive ceased certain times and the disconnection detecting function was activated.	• Wire the external scale cables as scheduled for connection. Correct any connection error of the connector pins.
EEPROM parameter error	36 *	Data in parameter saved area have been damaged when reading out the data from EEPROM at power-ON.	・ Set up all of parameters again. ・ If the error persists, it might be a failure. Replace the drive or return to the dealer for repair or investigation.
EEPROM check code error	37 *	Writing check data have been damaged when reading the data from EEPROM at power-ON.	The drive might be a failure. Replace the drive or return to the dealer for repair or investigation.
Over-travel inhibit input error	38	Both of CW/CCW over-travel inhibit inputs（CWL: Pin-20 and CCWL: Pin-19）have been open while Pr.04 (Overtravel input inhibit) is set to 0. Either one of CW or CCW over-travel inhibit inputs has been open.	・ Check if any errors exist in switches, cables or power supply connected to the CW/CCW over-travel inputs or not. Especially check if the rise time of the power supply (DC12 to 24V) is slow or not.
Absolute encoder system down error	40 *	Built-in battery voltage has fallen below the specified value because the power supply or battery for the encoder has fallen.	Clear the absolute encoder after connecting the power supply for battery. (Refer to section 5-1-3.). You cannot clear the alarm unless you clear the absolute encoder.
Absolute encoder counter over flow	41 *	Multi-turn counter of the encoder has exceeded the specified value.	・ Set up Pr.0B (Absolute encoder setup) to appropriate value. ・ Limit the travel from the machine origin within 32767 revolutions.
Absolute encoder over-speed	42 *	The motor rotational speed has exceeded the specified value when only the battery power has been supplied during the power shutdown.	・ Check the power supply voltage at encoder side (5V±5%). ・ Check the connecting condition of the connector, X6. You cannot clear the alarm unless you clear the absolute encoder.
Absolute single-turn counter error	44 *	The encoder has detected an error of single turn counter.	Replace with a new motor.
Absolute multi-turn counter error	45 *	The encoder has detected an error of multi- turn counter.	Replace with a new motor.
Absolute encoder status error	47	The encoder has been turning at faster speed than the specified value at power-ON.	Make a wiring so that the motor might not run at power-ON.
Encoder Z-phase error	48 *	Missing of Z-phase pulse of the 2500P/r, 5-wire serial encoder has been detected. Failure of the encoder.	Replace with a new motor.
Encoder commutation signal error	49 *	Logic error of CS signal of the 2500P/r, 5-wire serial encoder has been detected. Failure of the encoder.	Replace with a new motor.

Protective function	Alarm code No.	Causes	Measures
External scale status No.0 error	50 *	The bit 0 of the external scale error code became 1. Check the specification of the external scale.	Clear the external scale error by the use of clear command after removing the cause of the error. Thereafter, turn the control power off for a reset.
External scale status No.1 error	51 *	The bit 1 of the external scale error code became 1. Check the specification of the external scale.	
External scale status No.2 error	52 *	The bit 2 of the external scale error code became 1. Check the specification of the external scale.	
External scale status No.3 error	53 *	The bit 3 of the external scale error code became 1. Check the specification of the external scale.	
External scale status No.4 error	54 *	The bit 4 of the external scale error code became 1. Check the specification of the external scale.	
External scale status No.5 error	55 *	The bit 5 of the external scale error code became 1. Check the specification of the external scale.	
External scale status other errors	58 *	Executed the position-reset command for external scale. Otherwise activated one of the protection functions.	It is required to reset the control power supply after executing the position-reset command.
COM invalid node-address	82 *	Larger value than 31 has been set to the node address (MAC-ID) setup of the rotary switch of the front panel.	Set up the node address (MAC-ID) within 31, then re-enter the power.
COM continuous error	83	Errors have been occurred in multiple times continuously in network command.	・Check the connecting condition of the connector. ・ Replace the communication cable. ・ Change wiring routes when excessive noise is applied to the communication cable.
COM timeout	84	The drive has not received network command for certain time.	・Check the connecting condition of the connector. ・ Replace the communication cable. ・ Change wiring routes when excessive noise is applied to the communication cable.
COM cyclic-data not receivable	86	Errors of network command (C/R bit, MAC-ID, Cyclic command code).	・Check if the network command is correct or not.
Emergency stop inputted	87	Emergency stop input (EMG-STP, Pin-2) has been open when the setup of Pr.41 (Emergency stop endble) is 1 (endble).	・ Check if any errors exist in switches, cables or power supply connected to the emergency stop input or not. Especially check if the rise time of the power supply (DC12 to 24V) is slow or not.
Motor auto recogniction error protection	95 *	Unmatched motor and drive	Replace the motor matching to the drive.
Other errors	Other No. *	Malfunction of the control circuit due to excessive noise or other causes. Some error has occurred inside of the drive while the self-diagnosis function has been activated.	・Turn off the power-ONce, then re-enter. ・If the error persists, it might be a failure. Stop using the product and replace the motor and the drive. Return the product to the dealer for repair or investigation.

・Use the alarm clear function of PANATERM or with network when you clears the alarm.

・For the protective functions with star "*" beside alarm No., you cannot clear with the PANATERM or network. Remove the caused of the alarms and shut off the power to reset

・When the malfunction has occurred to drive's internal control circuit due to excessive noise,



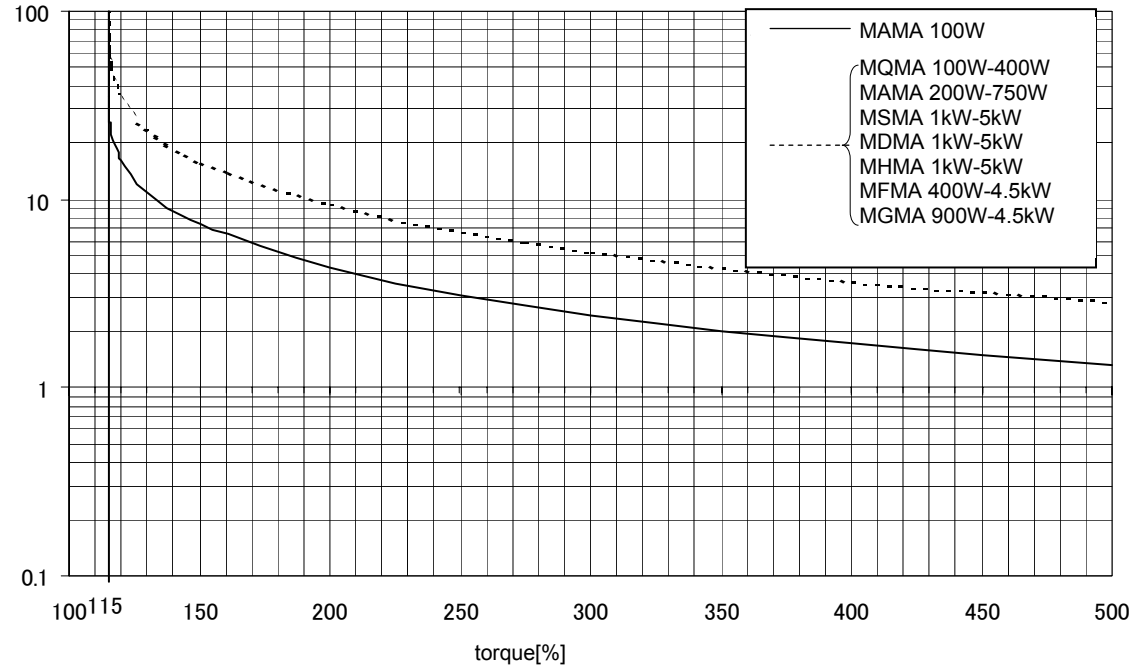
will be displayed. In this case, shut off the power immediately.

• The following alarms will not be stored in alarm history.

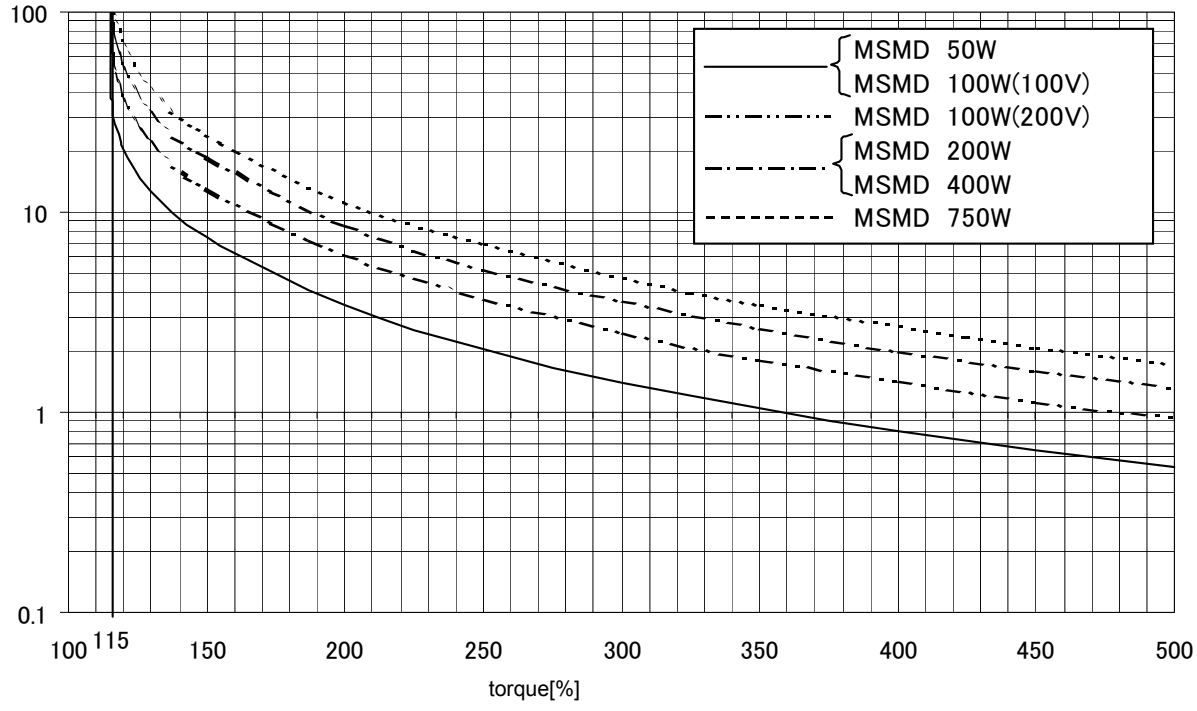
Control power Under-voltage (alarm No.11), Main power Under-voltage (alarm No.13), EEPROM parameter error (alarm No.36), EEPROM check code error (alarm No.37), Over-travel inhibit input error (alarm No.38), Communication time-out (alarm No.84), Emergency stop inputted (alarm No.87), Motor auto recognition error (alarm No.95)

• The overload protection (alarm code No.16) will be clearable in approx. 10s after its activation.

Time scale characteristics of Over-Load protection(Motor type M*MA)



Time scale characteristics of Over-Load protection(Motor type M*MD)



Note:The maximum output torque is different according to each motor.

3-2 Warning function

The warning will be triggered before the protective function is activated, and you can check the conditions such as overload beforehand.

Warning function	Warning code №	Causes	Measures
Overload warning	16	Load has reached to 85% or more of the alarm trigger level of overload protection.	Observe the instruction of section 3-1.
Regenerative overload warning	18	Regeneration has reached to 85% or more of the alarm trigger level for regenerative overload protection	Observe the instruction of section 3-1.
Battery warning	40	Voltage of battery for absolute encoder has fallen below approx. 3.2V.	Replace the battery while keep turning on the control power supply.
Continuous communication error warning	83	Coutinuous communication error counter exceeded the set value of parameter Pr.0D.	•Check wiring of connectors. •Replace the communication cables. •If noise, consider the cable layout.
Cumvlative communication error warning	84	Cumulative communication error counter exceeded the set value of parameter Pr.0E.	•Check wiring of connectors. •Replace the communication cables. •If noise, consider the cable layout.
Update counter warning	86	When update period of command is 1ms, Update coumter is not incremented properly.	•Check increment of update counter. •Check the setting of Pr.74.
Fan lock warning	88	Built-in fan has stopped for longer than 1s (D ,E and F-frame)	If the warning status continues, fan might be a failure and might deteriorate the life of the drive due to the temperature rise. Consult to the dealer.
External scale warning	89	Temperature of external scale goes over 65 degree C. Deficiency of signal strength (need adjustment for instllation) etc…	Check the specification of external scale.

(Note) Overload warning, regenerative overload warnning and fan lock warnning will be cleared automatically when remove the causes.
Regarding the battery warning, clear the warning with alarm clear operation after replacing the battery.

3-3 Software limit protection

(1) Outline

You can make an alarm-stop of the motor with software limit protection (alarm code No. 34) when the motor travel exceeds the movable range of the motor set by Pr.26 (Software limit setup) against the position command input range.

(2) Applicable conditions

This function will be activated under the following conditions.

	Condition under which the software limit is activated
Control mode	To be position or Full-closed control mode.
Others	1) During Servo-ON. 2) Pr.26 (Software limit setup) is set to other than 0. 3) Movable range of the motor is within 2147483647 for both CW and CCW direction after the latest 0-clear of the position command input range. If the motor deviate from the above 3) condition, the software limit protection will be invalidated until the condition of "(5) Conditions under which the position command input range is 0-cleared" (later described) is satisfied. Position command input range will be 0-cleared when the drive deviates from the conditions of the above 1) and 2).

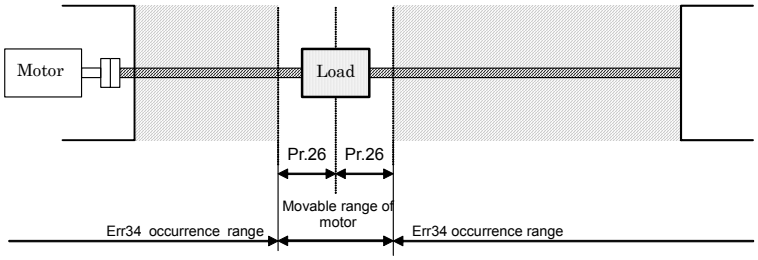
(3)Cautions

- This function is not a protection against the abnormal position command.
- The motor will decelerate and stop according to the setup of Pr.68 (Error response action). Depending on the load, the load might collide and damage the machine end during this deceleration. Set up the range of Pr.26 considering this action at deceleration.
- The Software limit protection will be invalidated during JOG run and frequency characteristics measuring function of the PANATERM.

(4) Example

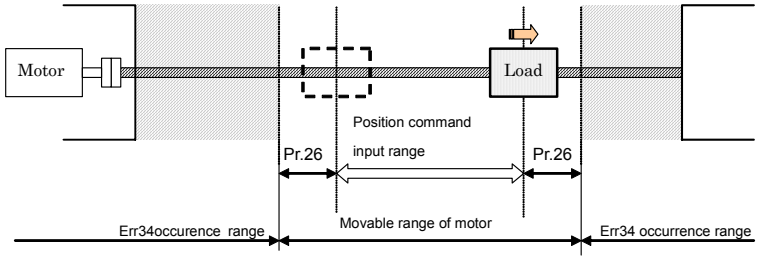
1) When no position command is entered (at Servo-ON)

The movable range of the motor will be the travel range which is set at both sides of the motor with Pr.26, since no postion command is entered. The software limit will be activated when the load enters to the Err43 occurrence range (oblique line range) due to oscillation.



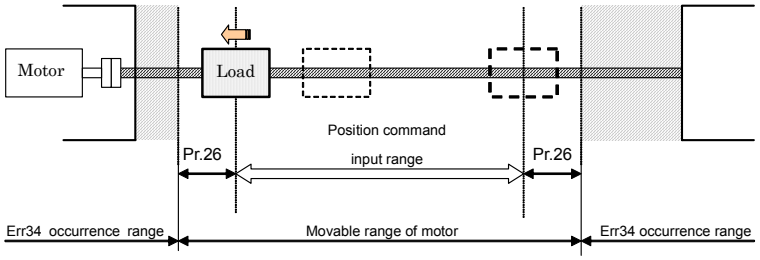
2) When the load moves to the right (at Servo-ON)

When the position command to the right direction is entered, the movable range of the motor will be expanded by the entered position command, and will be the position command input range + Pr.26 setups in both sides.



3) When the load moves to the left (at Servo-ON)

When the position command to the left is entered, the position command input range will be expanded further



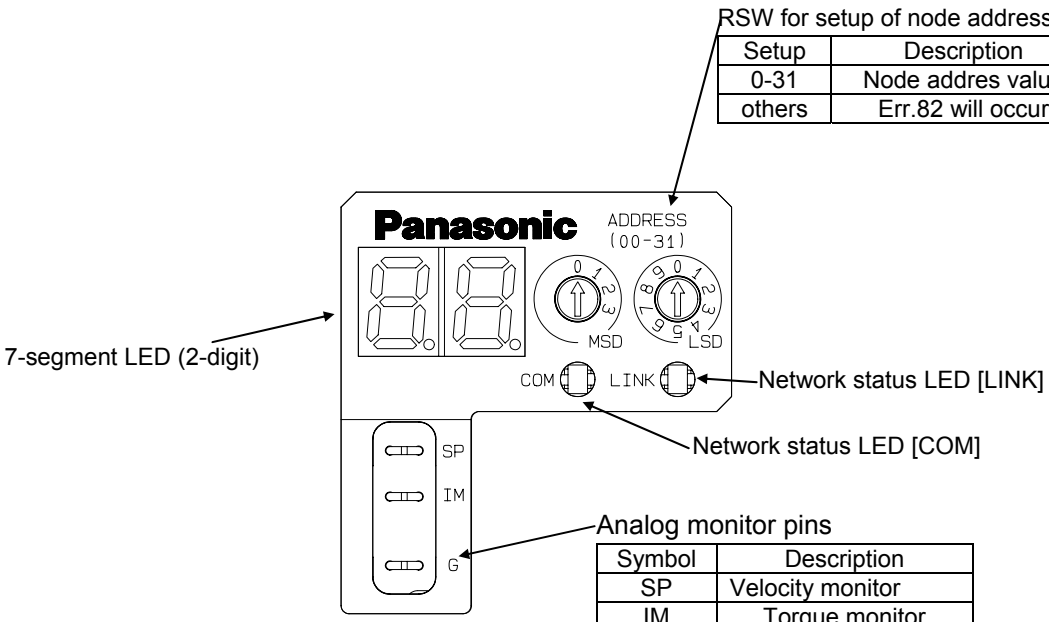
(5) Conditions under which the position command input range is 0-cleared

Position command input range will be 0-cleared under the following conditions.

- at power-up
- while the position deviation is being cleared
- at the start and the end of the normal auto-gain tuning
- when the homing is completed (except when the multi-turn data clear is completed.)

4. Front panel display

4-1 Appearance of display



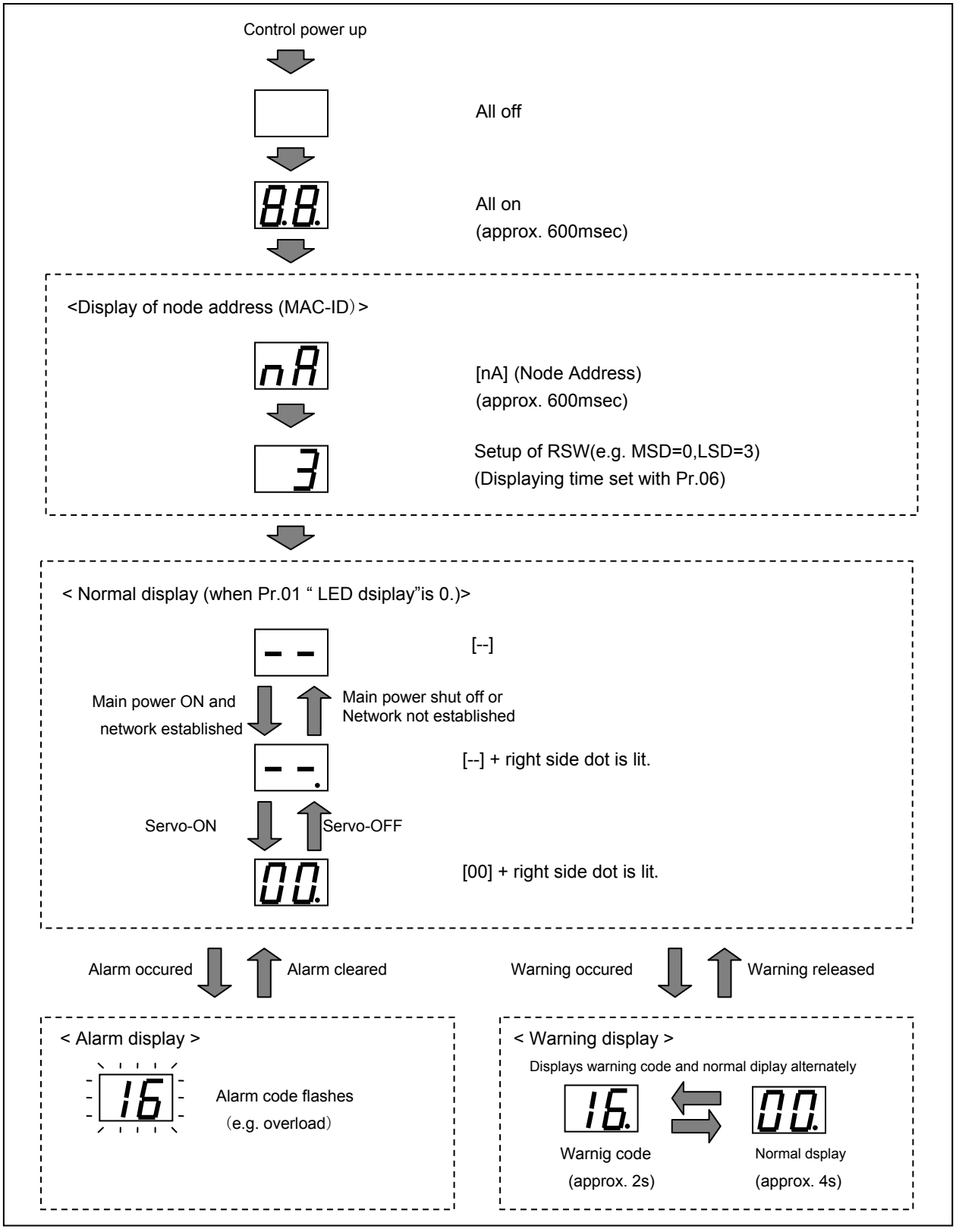
Setup	Description
0-31	Node addres value
others	Err.82 will occur

Symbol	Description
SP	Velocity monitor
IM	Torque monitor
G	Signal ground

4-2 7-segment LED

The following figure shows the state flow of 7-segment LED.

Node address (MAC-ID) value set with RSW will be displayed at power-UP, after that, the setting contents of Pr.01 (LED display) will be displayed. (For details, refer to 1. Parameters.) Note that the alarm code will be displayed at alarm occurrence and warning code will be displayed at warning occurrence as priority.



4-3 Network status LED

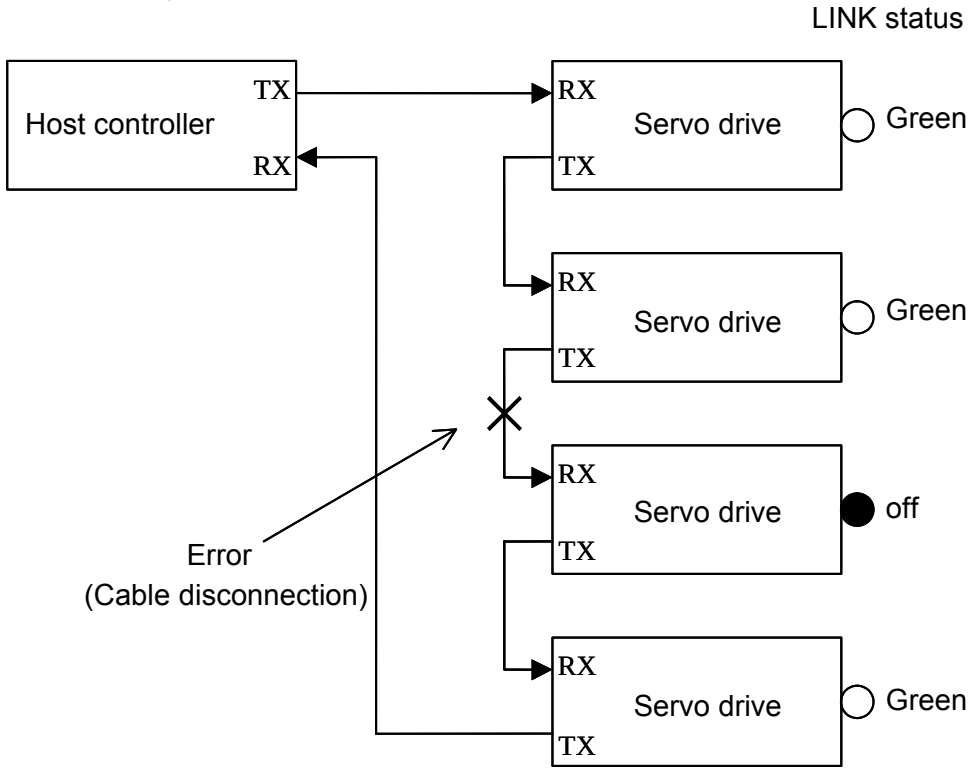
LED state	[COM]	[LINK]
Off	Network not established	No-connection (No power at transmitter node or cable disconnection)
Flashing Green	Network under configuring	-
Solid Green	Network established	proper connecting (TX of transmitter node and RX of own node are electrically connected)
Flashing Red	Clearable alarm relating to network has occurred ・Err.83 " COM continuous error" ・Err.84 " COM timeout " ・Err.86 " COM cyclic-data not receivable "	–
Solid Red	Non-clearable alarm relating to network has occurred ・Err.82 " COM invalid node address "	–

(Note) Even if duplicate alarm relating to the network is occurred after an alarm except the network is occurred, [COM] will change according to the above table.
However, 7-segmernt LED continues showing the previous alarm not relating to the network.

Detection of network cable error with [LINK].

If "LINK" is off while all of the nodes are powered on, check if any error, such as cable disconnection, occurs to the network cable connected to RX of the drive whose LED is off.

<Cable error example>



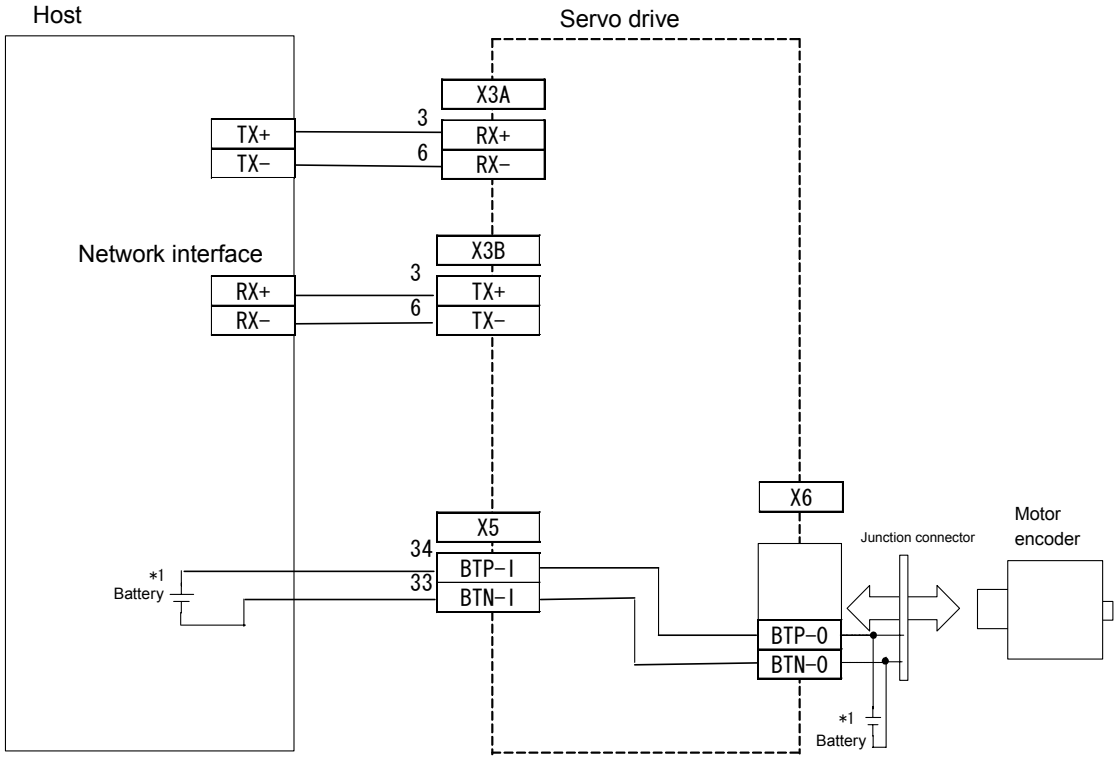
5. Absolute encoder and external scale

5-1 Absolute encoder

When using the motor with absolute encoder or absolute/incremental common encoder, you can compose an absolute system, which does not require to execute a homing operation at power-ON. For that, it is necessary to set Pr.0B (Absolute encoder setup) to “0” after connecting the battery for absolute encoder.
Absolute data will be transmitted to the host controller as actual position in the network response .

5-1-1 Structure of absolute system

(Example of one servo connection)

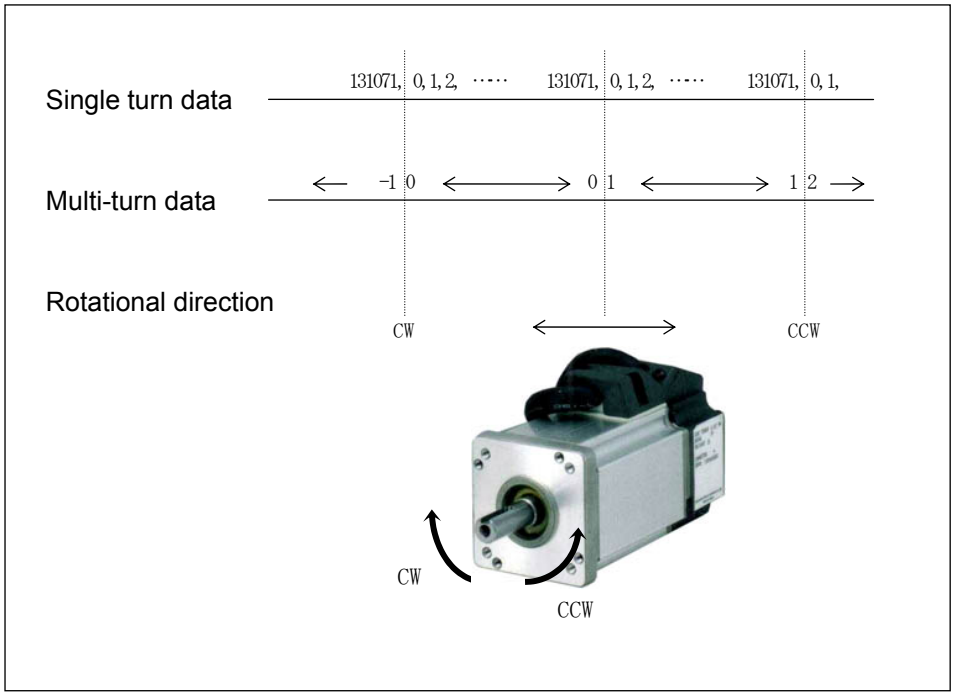


*1. Connect to either X5 or the junction connector between X6 and the encoder , when you connect the battery. Do not connect to both.

Note : During replacing the battery, the control power input must be held ON. If not so, the absolute data will be lost.

5-1-2 Absolute data

Absolute data have two kinds, single turn data which represents the absolute position within single rotation of the motor, and multi-turn data which counts the number of motor rotation.



(Note) For the data via the network, Pr.43 setting defines the relation between the data increment and the rotational direction.

5-1-3 Clearing of absolute data

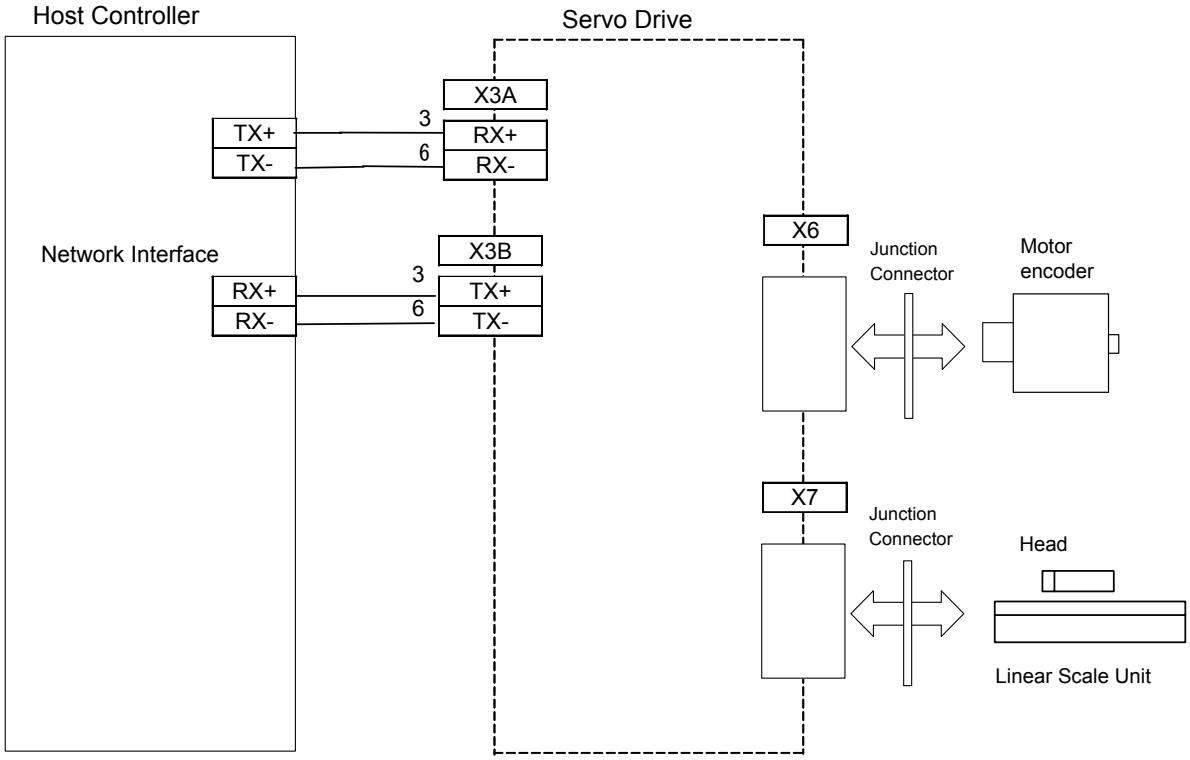
Multi-turn data of the absolute data is hold by the battery in power off.
Therefore, when you start up the machine for the first time, it is required to make the multi-turn data to 0 by encoder clearing at the home position after installing the battery.
The encoder clearing can be done with PANATERM, or with the network.

(Note) After clearing the absolute data, turn off and on the power without fail.
When using PANATERM, Err.27 will occur after clearing.
However, there is no problem becase of a step for safety.
In addition, the single-turn data cannot be cleared.

5-2 Absolute External scale

5-2-1 Structure of absolute system

(Example of one servo connection)



Notes :

- The battery is not used.
- For the way to initialize the absolute position to 0, refer to the specification of the external scale.

6. Tuning

Execute the gain tuning as per the next fig.

6-1 Real-time auto-gain tuning

In defaults, Real-time auto-gain tuning is validated.

DriveThe motor under the actual machine condition, and make an adjustment with Pr.22 (Machine stiffness at real-time auto tuning).

6-2 Normal mode auto-gain tuning

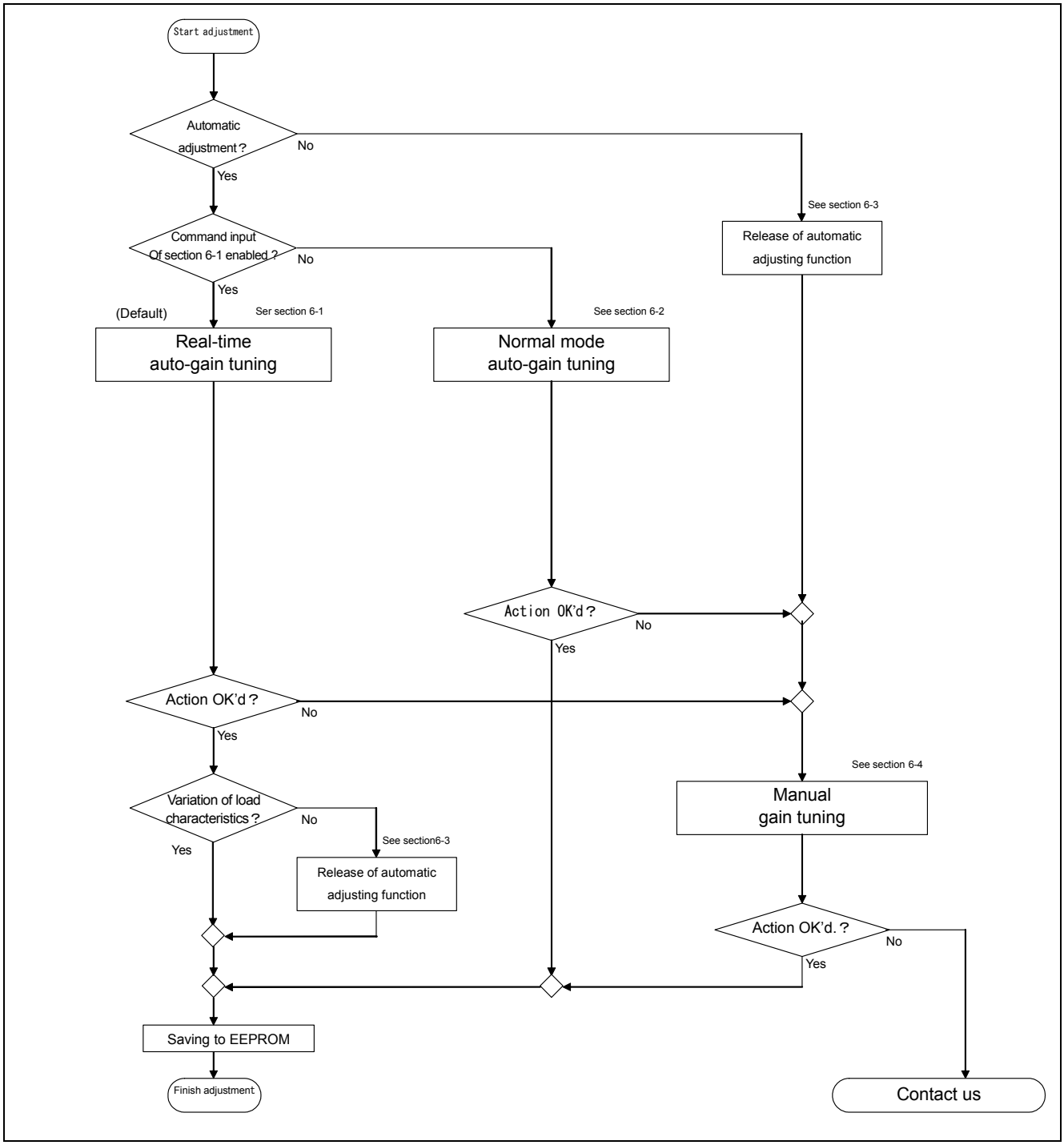
You can use the normal mode auto-gain tuning where the tuning will be executed by using the internally generated command, when you cannot enter the command input matching up the conditions.

6-3 Release of automatic tuning

When you do not use the automatic adjusting function or you cannot obtain the satisfactory result from the adjustment, release the automatic adjusting function.

6-4 Manual gain tuning

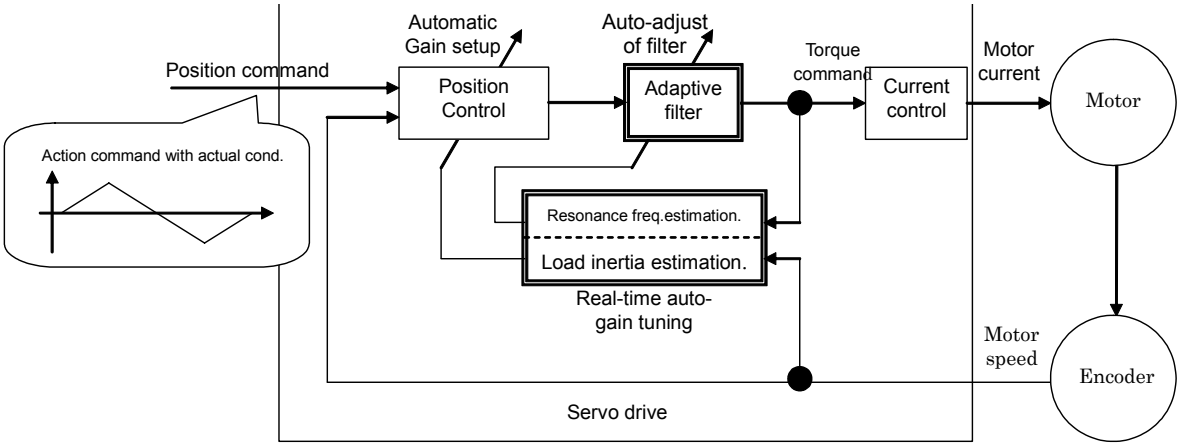
You can make a manual gain tuning matching to each machine.


Start adjustment
Automatic adjustment ?
No
Yes
See section 6-3
Release of automatic adjusting function
Command input Of section 6-1 enabled ?
No
Yes
(Default)
Ser section 6-1
Real-time auto-gain tuning
See section 6-2
Normal mode auto-gain tuning
Action OK'd ?
No
Yes
Action OK'd ?
No
Yes
See section 6-4
Manual gain tuning
Variation of load characteristics ?
No
Yes
See section6-3
Release of automatic adjusting function
Action OK'd. ?
No
Yes
Saving to EEPROM
Finish adjustment
Contact us

6-1 Real-time auto-gain tuning

(1) Outline

This function estimates the load inertia in real-time, and sets up the optimum gain automatically corresponding to the result. This also corresponds to the load which has resonance with the adaptive filter.



(2) Applicable conditions

□ This function will be active under the following conditions

	Conditions under which the real-time auto-gain tuning is active
Control mode	Active for all control modes. Note that load inertia estimation will be invalidated at JOG run and frequency characteristics measurement with the PANATERM.
Others	•at Servo-On status •Other parameters such as torque limit, than control parameters are properly set so as not to disturb the normal motor operation.

(3) Attention

□ The real-time auto-gain tuning might not work properly under the following conditions. In these cases, use the normal mode auto-gain tuning or set up with the manual gain tuning.

	Conditions which obstruct the real-time auto-gain tuning
Load inertia	•The load inertia is too small or too large compared to the rotor inertia (less than 3 times, or more than 20 times). •The load inertia varies
Load	•The machine stiffness is extremely low. •The chattering such as backlash exists.
Running pattern	•Speed is lower than 100[r/min], and motor runs continuously at low speed. •Acceleration/deceleration is slow (2000[r/min] per 1[s] or low). •Speed condition of 100[r/min] or more and acceleration/deceleration of 2000[r/min] per 1[s] or more does not last for longer than 50[ms]. •Acceleration/deceleration torque is smaller than unbalance weighted torque and viscous friction torque.

(4) How to use

1) Stop the motor (Servo-OFF).

2) Set up Pr.21（Real-time auto-gain tuning setup）to 1 to 7.
Default is 1.

Setup	Real-time auto-gain tuning	Varying degree of load inertia
0	Disable	————
1	Normal moe	No change
2		Slow change
3		Rapid change
4	Vertical axis mode	No change
5		Slow change
6		Rapid change
7	Gain switching disabled mode	No change

Set up 3 or 6 when the varying degree of the load inertia is large.
Set up to 4 to 6 when you use the motor in vertical axis application
Set up 7 when the motion change due to the gain switching is obstructive in your application such as CP control.
Validate Pr.23 (Adaptive filter mode) when resonance gives some affect.

3) Set up Pr.22 (Machine stiffness at real-time auto-gain tuning) to 0 or lower value.

4) Turn to Servo-ON and activate the machine as usual.

5) Increase the setup of Pr.22 (Machine stiffness at real-time auto-gain tuning) gradually when you want to increase the response. Bring the setup back when abnormal noise or oscillation occurs.

6) Save the result to EEPROM when you want to store the result.

(5) Parameters setuped automatically

Following parameters will be automatically adjusted.

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

Also the following parameters will be set up automatically to the fixed values of the table below.

Parameter №	Name	Valve
Pr.15	Velocity feed forward	300
Pr.16	Feed forward filter time constant	50
Pr.27	Velocity observer	0
Pr.30	2nd gain action setup	1
Pr.31	Gain switching mode	10 *1
Pr.32	Gain switching delay time	30
Pr.33	Gain switching level	50
Pr.34	Gain switching Hysteresis	33
Pr.35	Position loop gain switching time	20

*1) When Pr.21 is from 1 to 6, Pr.31 is set to 10.
When Pr.21 is 7, Pr.31 is set to 0.

(6) Adaptive filter

Adaptive filter will be validated by setting Pr.23 (Aaptive filter mode)to other than 0.

This function estimates the resonance frequency from the vibrating component which appears on the motor speed, and removes the resonance component from the torque command with adaptive filter, thus reduces the resonance vibration.

Adaptive filter might not work properly under the following conditions. In these cases, make a resonance measure using Pr.1D,1E (1st notch filter) and Pr.28-2A (2nd notch filter) according to the manual adjusting procedures.

	Condition which obstruct the adaptive filter action
Resonance point	・Resonance frequency is lower than 300[Hz]. ・Resonance peal is low, or control gain is low, so that the motor speed will not be affected. ・Multiple resonance points exist.
Load	・Motor speed variation with harmonic components occurs due to non-linear factor such as backlash.
Command pattern	・Acceleration/deceleration is such rapid as 30000[r/min] per 1[s] or more.

Adaptive filter will be invalidated when Pr.2F(Adaptive filter frequency)<=4.
There are other cases than Pr.23 is 0, when the adaptive filter will be invalidated while Pr.2F(Adaptive frequency)<=4.
Refer to section 6-3, 4)Invalidation of adaptive filter.

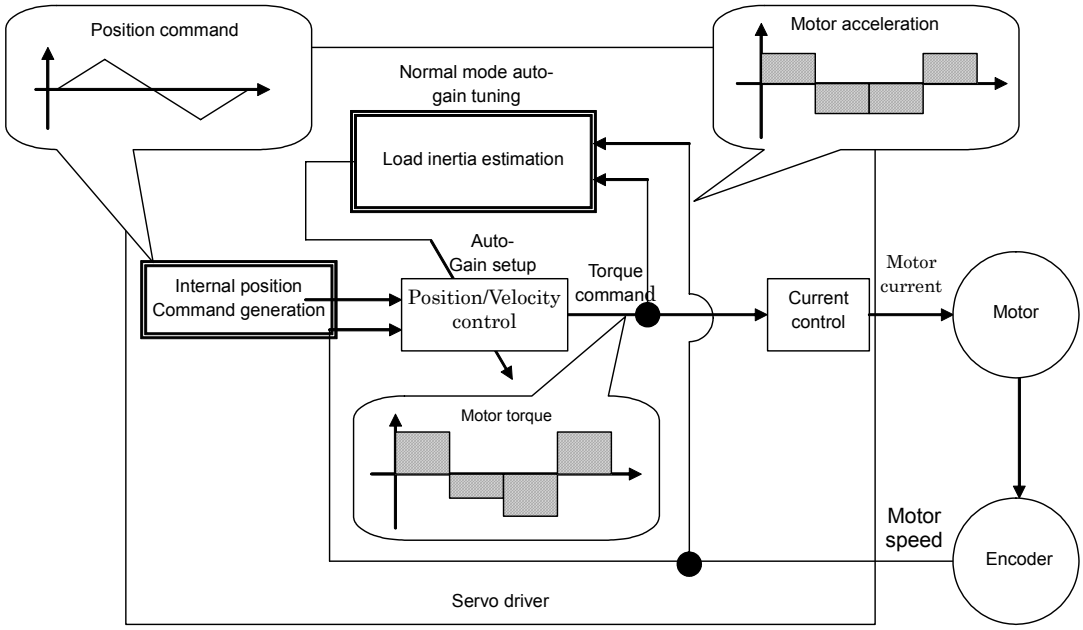
(7) Attention 2

1) Abnormal noise or oscillation might occur right after the first Servo-ON in start up, or until the load inertia is identified or adaptive filter is stabilized while increasing the setup of Pr.22 (Machine stiffness at real-time auto-gain tuning), however, Those are not errors as long as they become stabilized soon. When oscillation occurs frequently or noise continues for more than 3 reciprocal cycles, take the following measures.
   a) Save the parameters which have made a normal operation to EEPROM once.
   b) Lower the setup of Pr.22 (Machine stiffness at real-time auto-gain tuning).
   c) Invalidate the adaptive filter by setting up Pr.23 (Adaptive filter mode） to 0.
   d) Set up the notch filter manually.
2) Setups of Pr.20 (Inertia ratio) and Pr.2F (Adaptive filter frequency)might have changed to extreme values after abnormal noise and oscillation have occurred. Take the same measures as above.
3) Among the results of real-time auto-gain tuning, Pr.20 (Inertia ratio)and Pr.2F (Adaptive filter frequency)will be written to EEPROM every 30 minutes, and auto-tuning will be executed at the next time after the re-entry of the power, taking these values as initial values.
4) Pr.27 (Velocity observer) will automatically set to “0” (invalidated) when you validate the real-time auto-gain tuning.

6-2 Normal mode auto-gain tuning

(1) Outline

This function automatically set up the appropriate gain by running the load in the command pattern generated inside of the drive automatically, and will estimate the load inertia from the necessary torque.



(2) Applicable conditions

☐ This function will be activated under the following conditions.

	Conditions which activates normal mode auto-gain tuning
Control mode	・All of control modes.
Network	・Not established
External Servo-On input (EX-SON)	・External Servo-ON (EX-SON) to be ON(closed status).

Note 1) Set up Pr.03 (Torque limit selection) to 1 and Pr.04(Overtravel inhibit input) to 1. This function will not be activated if these are set to other than 1.

Note 2) The drive will trip when you establish the network during the normal mode auto-gain tuning due to alarm code No.27 (Command error protection).

(3) Attention

☐ Normal auto-gain tuning may not work properly under the following conditions.
In those cases set up the manual gain tuning.

	Conditions which obstruct the normal auto-gain tuning
Load inertia	・Load inertia is too small or too large. (Less than 3 times or larger than 20 times) ・Load inertia varies.
Load	・Machine stiffness is extremely low. ・Chattering such as backlash exists.

☐ Tuning error will be activated when error and Servo-OFF have occurred, or network has been established during auto-gain tuning.

☐ External Servo-ON input (EX-SON) will be automatically validated during auto-gain tuning, regardless of the setup of Pr.40 (External Servo-ON input validation). Auto-gain tuning cannot be executed out unless you connect the external Servo-ON input.

☐ If the load inertia cannot be estimated after carrying out auto-gain tuning, gain will not be changed and will be kept the same value before tuning.

☐ Output torque will be permitted to the max. output torque set by Pr.5E (1st torque limit), and CW and CCW over-travel inhibit input will be ignored.

Pay extra attention to the safety. Shut off the main power when oscillation occurs and return the gain to default with parameter setup.

(4) Auto-gain tuning action

1) Set up the response with machine stiffness No. at normal mode auto-gain tuning.

Machine stiffness No.

□ represents the degree of machine stiffness, ranging from 0 to 15.
Higher the stiffness the machine has, higher the No. you can set and higher the gain you can set.

□ Start with lower stiffness № and repeat the auto-gain tuning by setting larger setup until oscillation, abnormal noise and vibration occur.

2) Repeats the action pattern set by Pr.25 (Normal auto-gain tuning motion setup) by max. 5 cycles. Action acceleration will be doubled per cycle from the 3rd cycle. Cycle may finish before 5th cycle, or acceleration may not vary, however, these are not errors.

(5) How to operate

1) Execute when the network has not been established and no alarm has occurred.

2) Set up the action pattern with Pr.25.

3) Shift the load to where the motor action per the setup of Pr.25 may not give any trouble.

4) Turn ON the external Servo-ON input. (Drive does not turn to Servo-ON at this moment.)

5) Start up the auto-gain tuning.
Use the PANATERM to start up. (Turns to Servo-On automatically at this moment.)

6) Adjust the machine stiffness No. so that required response can be obtained within the range no vibration occurs.

7) Save the result to EEPROM if it is satisfactory.

(6) Parameters setuped automatically set.
The following parameters will be automatically adjusted.

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

The following parameters are automatically set to the fixed value as the table below shows.

Parameter №	Name	Valve
Pr.15	Velocity feed forward	300
Pr.16	Feed forward filter time constant	50
Pr.27	Velocity observer	0
Pr.30	2nd gain action setup	1
Pr.31	Gain switching mode	10
Pr.32	Gain switching delay time	30
Pr.33	Gain switching level	50
Pr.34	Gain switching hysteresis	33
Pr.35	Position gain loop switching time	20

6-3 Release of automatic tuning

(1) Outline

Cautions when you invalidate the real-time auto-gain tuning (default) or adaptive filter are described here.

(2) Cautions

Release the automatic tuning after stopping the motion.

(3) Invalidation of the real-time auto-gain tuning

You can invalidate the real-time auto-gain tuning by setting up Pr.21(Real-time auto-gain tuning setup) to 0 to stop the automatic estimation of Pr.20 (Inertia ratio).
Use the normal mode auto-gain tuning, or set up the proper value obtained form the calculation manually, if this parameter has been abnormal value since the estimated result of Pr. 20 (Inertial ratio) will be hold.

(4) Invalidation of the adaptive filter

You can stop the adaptive filter function which automatically follow the load resonance by setting up Pr.23(Adaptive filter mode)to 0.
If you invalidate the adaptive filter which has been working correctly, noise and vibration might occur due to the appearance of the suppressed resonance affect.
Invalidate the adaptive filter by setting up Pr.1D (1st notch frequency) manually using the value of Pr.2F(Adaptive filter frequency)of the table below. [s]

Pr.2F	1st notch frequency[Hz]
0	(invalid)
1	(invalid)
2	(invalid)
3	(invalid)
4	(invalid)
5	1482
6	1426
7	1372
8	1319
9	1269
10	1221
11	1174
12	1130
13	1087
14	1045
15	1005
16	967
17	930
18	895
19	861
20	828
21	796
22	766
23	737
24	709
25	682
26	656
27	631
28	607
29	584
30	562
31	540
32	520

Pr.2F	1st notch frequency[Hz]
33	500
34	481
35	462
36	445
37	428
38	412
39	396
40	381
41	366
42	352
43	339
44	326
45	314
46	302
47	290
48	279
49	269(Invalid when Pr.22□15)
50	258(Invalid when Pr.22□15)
51	248(Invalid when Pr.22□15)
52	239(Invalid when Pr.22□15)
53	230(Invalid when Pr.22□15)
54	221(Invalid when Pr.22□14)
55	213(Invalid when Pr.22□14)
56	205(Invalid when Pr.22□14)
57	197(Invalid when Pr.22□14)
58	189(Invalid when Pr.22□14)
59	182(Invalid when Pr.22□13)
60	(invalid)
61	(invalid)
62	(invalid)
63	(invalid)
64	(invalid)

□ Set up 1500 to Pr.1D (1st notch frequency) if the above table shows (invalid).

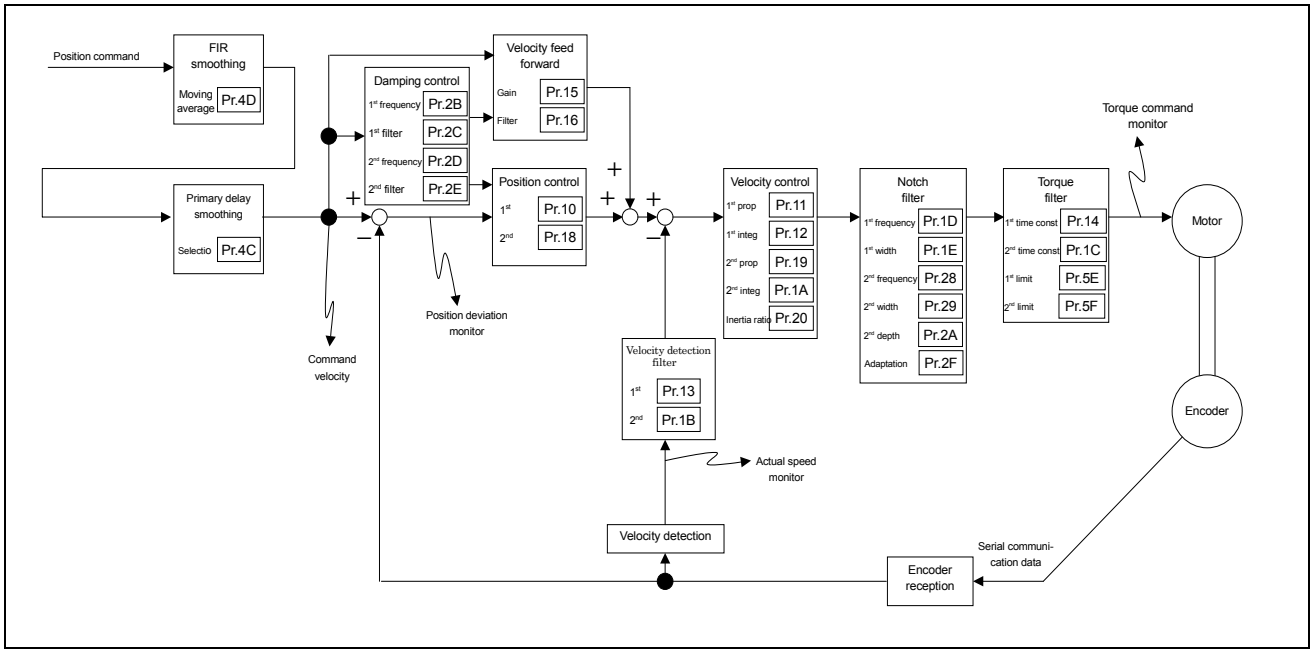
6-4 Manual gain tuning

Outline

There are some cases where automatic gain tuning cannot bring a better gain adjustment due to the limitation of load condition, or you are required to re-adjust the gain to obtain optimum response and stability corresponding to each load.
Hereunder, manual gain tuning methods are explained by control mode and by function.

6-4-1 Tuning at position control mode

Position control is composed as the block diagram of fig. below. Basic adjusting procedures are explained here using the double-framed parameters of the fig. below.



Block diagram of position control

1) Initial setup of parameters

Return the parameters to defaults.

・If the motor oscillates with default, lower the setups of Pr.11 （1st velocity loop gain） and Pr.10 (1st position loop gain) by the same value.

2) Setup of inertia ratio

Set up the inertia ratio（Pr.20）.

・If the Pr.20 (Inertia ratio) have been obtained through the real-time auto-gain tuning, use this value
・If the inertia ration have been known through load calculation, set the calculated value.
・If the inertia ratio has not been know, execute the real-time auto-gain tuning to measure the Inertia ratio. Since the velocity gain will also change, return to 1) and execute the parameter initial setup after the measurement.

3) Investigation of the upper limit of velocity loop gain

Increase the setup of Pr.11 （1st velocity loop gain） by 10 each.

・Increase the setups of Pr.10 (1st position loop gain) and Pr.11 (1st velocity loop) gain.
・When vibration start occurring, proceed to 4) Setup of notch filter.
・When oscillation occurs, lower the setup of Pr.11 （1st velocity loop gain） quickly and lower the setup of Pr.10 （1st position loop gain） to the same value, then proceed to 4).

4) Setup of notch filter

Measure the vibration frequency of torque command by using the monitor output, graphic function or frequency characteristics measuring function of the PANATERM.

・Take measures of (A) to (C) depending on the measured vibration frequency.
・Upper limit of Pr.11 （1st velocity loop gain） might be changed after the measures are taken. Carry out 3) to check the upper limit. Keep adjusting so as the setup of Pr.11 (1st velocity loop gain) might be increased compared to that of before the measures.

（A） when the vibration suppression frequency is 1.5kHz or more.

Increase the 1st torque filter time constant（Pr.14）

・Increase the set up until vibration becomes larger beyond the acceptable range, targeting 25 in case of an absolute encode-wire (7-wire, 17-bit) and 64 in case of incremental encoder (5-wire, 2500P/r).
・Vibration at lower frequency might be increased when you set up Pr.14 (1st torque filter time constant) too large. In this case, lower the setup of Pr.11 (1st velocity loop gain).

（B） when the vibration suppression frequency is 600Hz-1500Hz.

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

・Change the setup Pr.1D and 1E a little if the vibration is not reduced.
・You can measure the resonance peak with the frequency characteristics measuring function of the setup support software, PANATERM. Set up the notch filter so that the resonance peak may be suppressed.
・Set up a larger value to Pr.14 (1st torque filter time constant) if you still experience the vibration with 600Hz or more.

（C） when the vibration suppression frequency is 400-600Hz.
・Measure the resonance frequency with the frequency characteristics measuring function of the setup support software, PANATERM.

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

・Measure the frequency characteristics again and check if the resonance peak has been reduced or not.
・Adjust Pr.1E（1st notch width selection）and Pr.1D（1st notch frequency）so that the resonance peak might be reduced if the resonance peak has not been reduced.
・Set up a smaller value to Pr.11 (1st velocity loop gain) when the resonance peak is in lower frequency and the vibrating frequency is lower than the anti-resonance frequency.
・Increase the setup of Pr.11 (1st velocity loop gain) when the resonance frequency is 350-450Hz, and set up the notch filter if vibration occurs. You might expect the reduction of vibration.
・Invalidate the notch filter when vibration cannot be reduced. Set up the upper limit value to the 1st gain of velocity loop.

4) Setup of time constant of torque filter

Set up a larger value to Pr.14 (1st torque filter time constant) little by little when the running noise is annoying. Set up a smaller value to Pr.14 (1st torque filter time constant) little by little to increase Pr.11 (1st velocity loop gain) when you want to improve the response.

・As a minimum target, 10 is recommended for the absolute encoder (7-wire, 17-bit) and 25 for the incremental encoder (5-wire, 2500P/r).

6) Setup of Pr.13 (1st speed detection filter)

Set up a larger value to Pr.13 (1st speed detection filter) little by little to increase Pr.11 (1st velocity loop gain) when you want to improve the response.

Measure the resonance frequency using graphic function of the setup support software, PANATERM and adjust the notch filter of 4) or torque filter of 5), when the noise with harmonic frequency occurs while you lower the setup of Pr.13 (1st speed detection filter.

7) Setup of Pr.10 (1st position loop gain)

Set up Pr.10 (1st position loop gain) the value with 1.5 times of Pr.11 (1st velocity loop gain) value. Set up broadly to shorten the settling time of positioning to some degree.

・Change this parameter while the position deviation is small.

8) Setup of Pr.12 (1st velocity integration time constant)

Set up Pr.12 (1st velocity integration time constant) as Pr.12＝（4000-2000）／（2π×Pr.11）.

・You can dog in the deviation at positioning to 0 quickly by setting up a smaller 1st time constant of velocity loop integration, however, it might take longer time to reach to the settle-in width first.

・You can expect to improve the above by setting up Pr.1A in motion (2nd velocity loop integration time constant) to 1000 (invalid).

9) Setup of Pr.15 (Velocity feed forward)

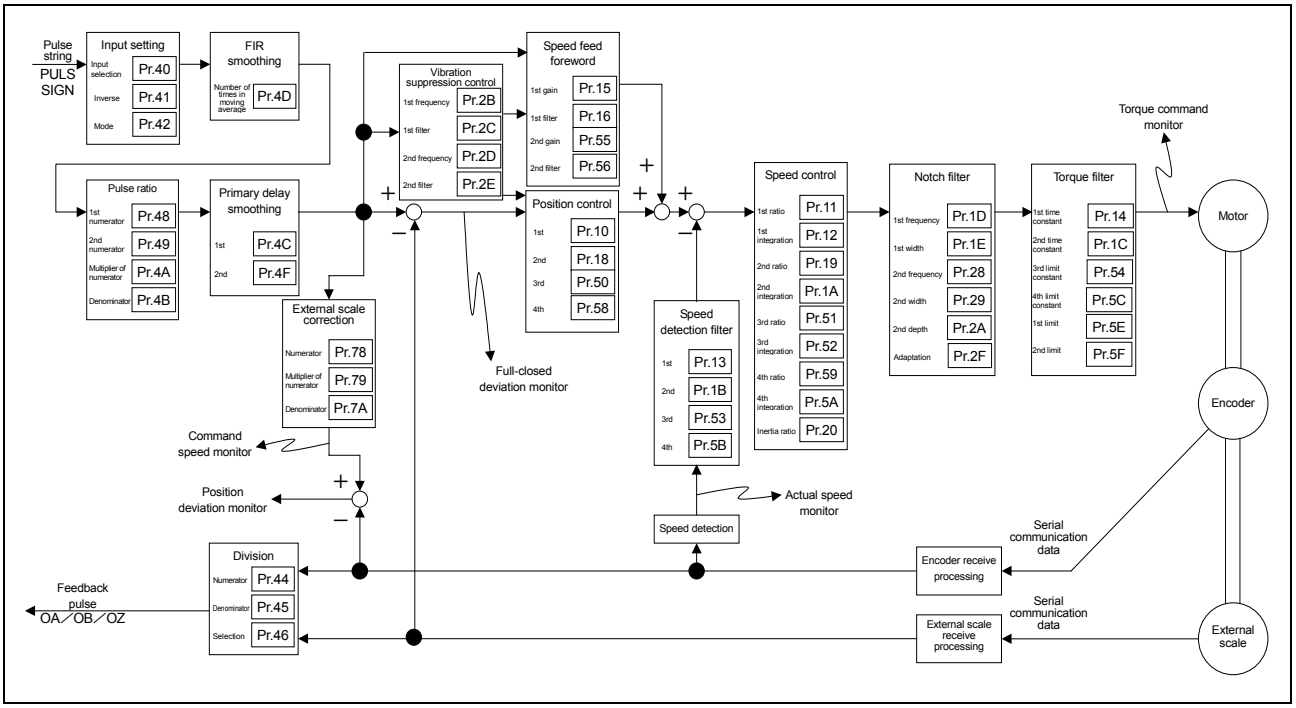
Set up Pr.15 (Velocity feed forward) to 500（300-700）.

・Position deviation in motion will be reduced and position deviation will converge quickly after the command output is finished by setting up a larger value to Pr.15 (Velocity feed forward), however, overshoot or vibration might occur easily.

・Set up larger values to Pr.16 (Feed forward filter time constant) and Pr.4C (Smoothing filter) when you experience a larger running noise after setting this parameter.

6-4-2 Tuning at full-closed control mode

The full-closed control is intended to directly detect the position of a controlled machine by using an externally located scale, and control its position by feeding it back the result of such detection. For example, it can be controlled without any influence of ball screw errors or position changes due to temperature variation.
With the full-closed control system incorporated, the submicron high precision positioning can be realized.
Full-closed control system is as shown in the following block diagram.
In the full-closed control mode, excluding the precautions (difference in command unit, difference in command pulse ratio, etc.) as described at the end of this clause, the tuning can be carried out by following the same steps as "Adjustment at position control mode" in sect.6-4-1.
In this section, the setting of the external scale ratio, the hybrid error and the hybrid control in the initial setting of the full-closed control will be described.



[1] Setting of external scale ratio

Set up the external scale ratio using the numerator of external scale ratio (Pr.78), the multiplier of numerator of external scale ratio (Pr.79) and the denominator of external scale ratio (Pr.7A).

- Check the number of encoder pulses per motor rotation and the number of external scale pulses per motor rotation, set up the numerator of external scale ratio (Pr.78), multiplier of numerator of external scale ratio (Pr.79) and denominator of external scale ratio (Pr.7A) so that the following formula is fulfilled.

$$\frac{\text{Pr.78}\ [1] \times 2^{\text{Pr.79}\ [17]}}{\text{Pr.7A}\ [5000]} = \frac{\text{Number of encoder pulses per motor rotation}}{\text{Number of external scale pulses per motor rotation}}$$

- If the ratio is incorrect, the difference between the position calculated from the encoder pulse and the position calculated from the external scale pulse is increased. Particularly, when it is driven a long distance, a hybrid deviation error (Err.25) occurs.
- When Pr.78 is set to 0, the encoder resolution is automatically set to a numerator.

[2] Hybrid deviation error setup

Set the hybrid deviation error level (Pr.7B) to the minimum value within the range where the difference of a position between a motor (encoder) and a load (external scale) can be considered excessive.

- As for the hybrid deviation error (alarm code No.25), make sure to check its reason carefully as it also occurs due to a reason other than that stated in the above item (1), such as the reverse connection of an external scale, the loosened connection between a motor and a load, etc.

Attention

(1) Input a command pulse on the basis of an external scale.
In the full-closed control mode, the encoder is used for the speed control and the external scale is used for the position control.

(2) Note that multiplier of numerator of command pulse ratio differs from the position control since one pulse of the command is set to one pulse of the external scale.

(3) External scales, which can be used for the full-closed control, are as listed below.
- AT500 series made by Mitutoyo Corporation
- ST771 series made by Mitutoyo Corporation

(4) To prevent the breakage of a machine due to excursion based on the setting of the above external scales, set the hybrid deviation error level (Pr.7B) to a proper value in units of external scale resolution.

(5) For an external scale, the value of $1/20 \leq$ External scale ratio ≤ 20 is recommended.
If the external scale ratio is set to a value less than 50 / Position loop gain (Pr.10, 18), its control per pulse may become impossible.
The larger the external scale ratio is, the bigger the operation noises may be.

6-4-3 Manual gain tuning using gain switching

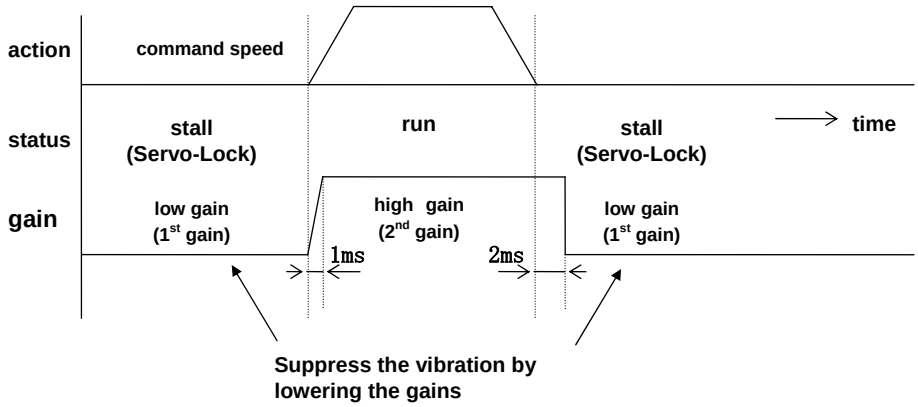
(1) Outline

By gain switching with internal data or switching inputs from the network (Gain SW), you can expect to,

- suppress the vibration lowering the gain at stall (Servo-Lock),
- reduce the settling time increasing the gain at stopping (settling),
- improve the command linearity increasing the gain in motion and
- switch the gain through the network depending on the application and etc.

(2) Example

The following shows the setup procedures to obtain the high response in position control, by using the gain switching function. Generally set up a high gain by making the velocity integration to off to obtain a high-speed response in motion, set up a lower gain to suppress the vibration after stalling.

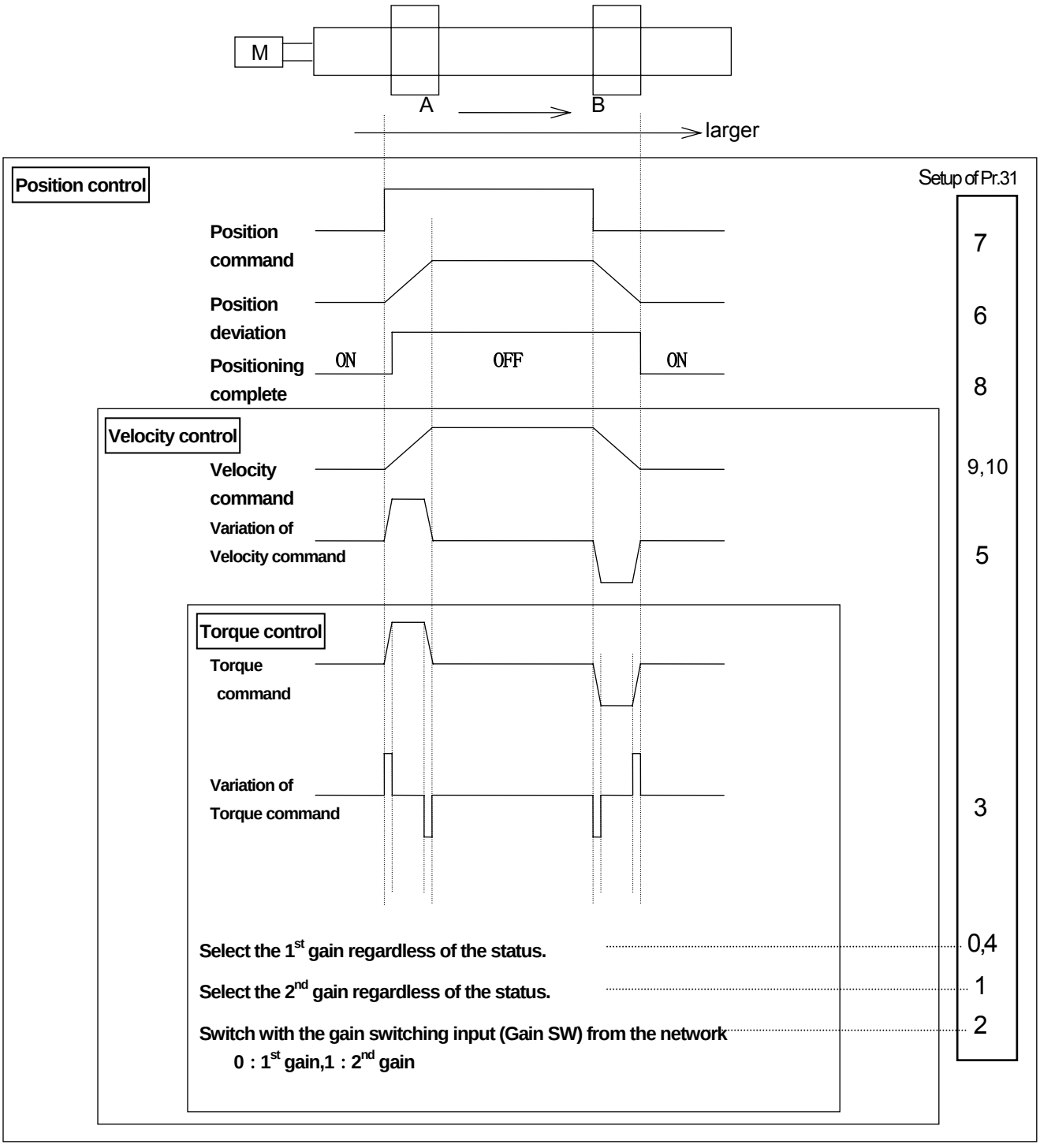


Parameters to be set up	Setup	Contents
Pr.30 (2nd gain action setup)	1	Use the 2nd gain.
Pr.31 (Gain switching mode)	7	Use the 2nd gain while position command exists.
Pr.32 (Gain switching delay time)	12	Use the 2nd gain if no position command (Variation of command position in 166μs is 0.) lasts for 2ms.
Pr.35 (Position loop gain switching time)	5	Implement the ramp response of (5+1)×166μs=1ms during the shift from low gain to high gain of position loop gain.
Pr.10 (1st position loop gain) Pr.11 (1st velocity loop gain) Pr.12 (1st velocity integration time constant) Pr.13 (1st speed detection filter) Pr.14 (1st torque filter time constant)	—	Set up the gains as stall.
Pr.18 (2nd position loop gain) Pr.19 (2nd velocity loop gain) Pr.1A (2nd velocity integration time constant) Pr.1B (2nd speed detection filter) Pr.1C (2nd torque filter time constant)	—	Set up the gains in motion.

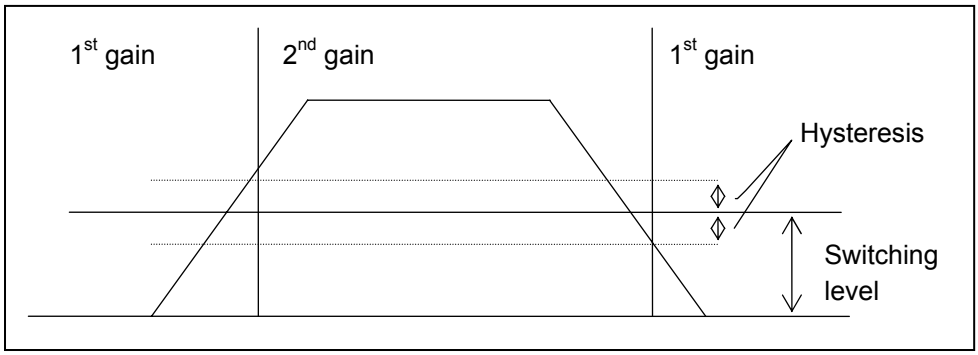
(3) How to set

Suppose the load travels from A to B position and the internal status of the drive changes as the fig. below shows. Hereunder we explain how to set up the related parameters when you use the gain switching function.

1) Set up the conditions for gain switching with the following parameters.
Pr.31 （1st /2nd gain switching mode）



2) Set up the switching level and Hysteresis depending on the switching conditions.



Setup parameters for switching level and Hysteresis vary depending on control mode.

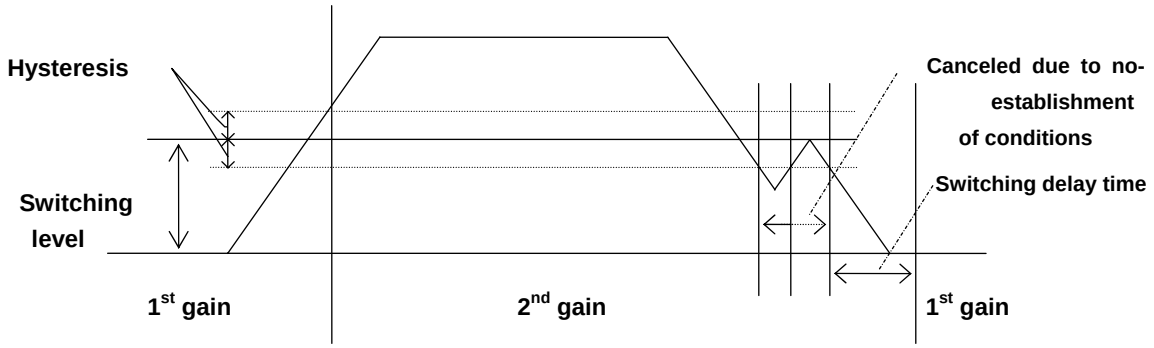
Switching level	Pr.33
Hysteresis	Pr.34

Note that the setup units also vary depending on the switching conditions.

Switching condition (Setup of Pr.31)		Setup unit of Pr.33 and 34
0	Fixed to 1st gain	No setup necessary
1	Fixed to 2nd gain	
2	Gain switching input(Gain SW) from the network	
3	Large variation of torque command	[0.05%/166μs] Set up 200 supposing that there might have been 10% torque variation in 166μs
4	Fixed to 1st gain	[10(r/min)/s]
5	Velocity command	[r/min]
6	Position deviation	[pulse] (encoder resolution)
7	Position command exists	One or more command pulses in 166μs
8	Positioning not completed	Position deviation counter pulses are larger than Pr.60(Positioning complete range).
9	Speed	[r/min]
10	Command exists ＋speed	Switches to the 2nd gain while the position command exists. Switches to the 1st gain when no-position command status lasts for Pr.32[×166μs], and the speed falls below Pr.33-Pr.34[r/min]

3) Set up the switching delay time.

Set up the time delay for switching from Pr.18 to Pr.1C (2nd gain) to Pr.10 to Pr.14 (1st gain). Switching conditions have to be established continuously during the switching delay time for the switching from the 2nd to the 1st.

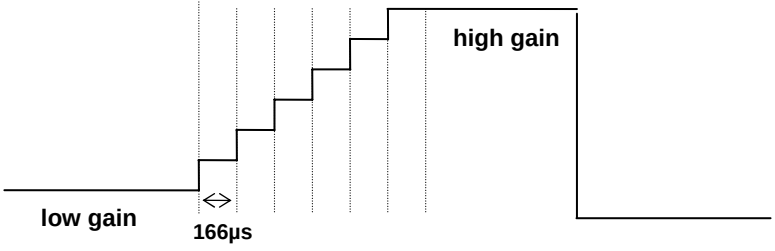


4) Set up the switching time of position gain.

Switch the position loop gain gradually to avoid any trouble caused by a rapid change to a higher gain., while the velocity loop gain, time constant of velocity integration, velocity detection filter and time constant of torque filter can be switched instantaneously.

When Pr.35(Position loop gain switching time)is 0,

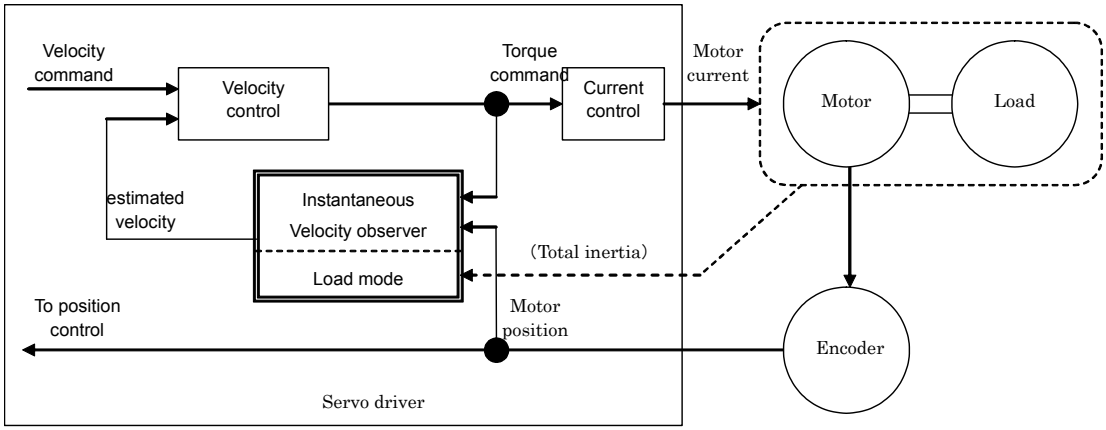
When Pr.35(Position loop gain switching time)is 5,



6-4-4 Instantaneous velocity observer

(1) Outline

This function estimates the motor velocity using a load model and improves the velocity detecting accuracy and establishes both high-speed response and reduction of vibration at stall.



(2) Applicable conditions

☐ Following conditions have to be satisfied to apply this function.

	Condition which activates the instantaneous velocity observer
Control mode	・At position control
Encoder	・To be 17-bit absolute encoder

(3) Attention

□ This function may not work properly or enough effect cannot be obtained under the following conditions.

	Conditions which obstruct instantaneous velocity observer
Load	・Estimated inertia load (as motor and load together) greatly deviates from the actual machine. e.g.) Large resonance point exists at frequency band below 300[Hz] . Non-linear factor such as large backlash exists. ・Load inertia varies. ・Disturbance torque with harmonic has been applied.
Others	・Positioning settle-in range is very narrow.

(4) How to use

1) Pr.20 (Setup of inertia ratio)

Set up as exact the inertia ratio as possible.

・Use the setup of Pr.20 as it is when the Pr.20 (Inertia ratio) has been obtained through the real-time auto-gain tuning and which is applicable to normal position control.
・Enter the value which is obtained through load calculation.
・Measure the inertia by normal mode auto-gain tuning when the inertia ratio is not known.

2) Adjustment at normal position control

・Refer to section 6-4-1.

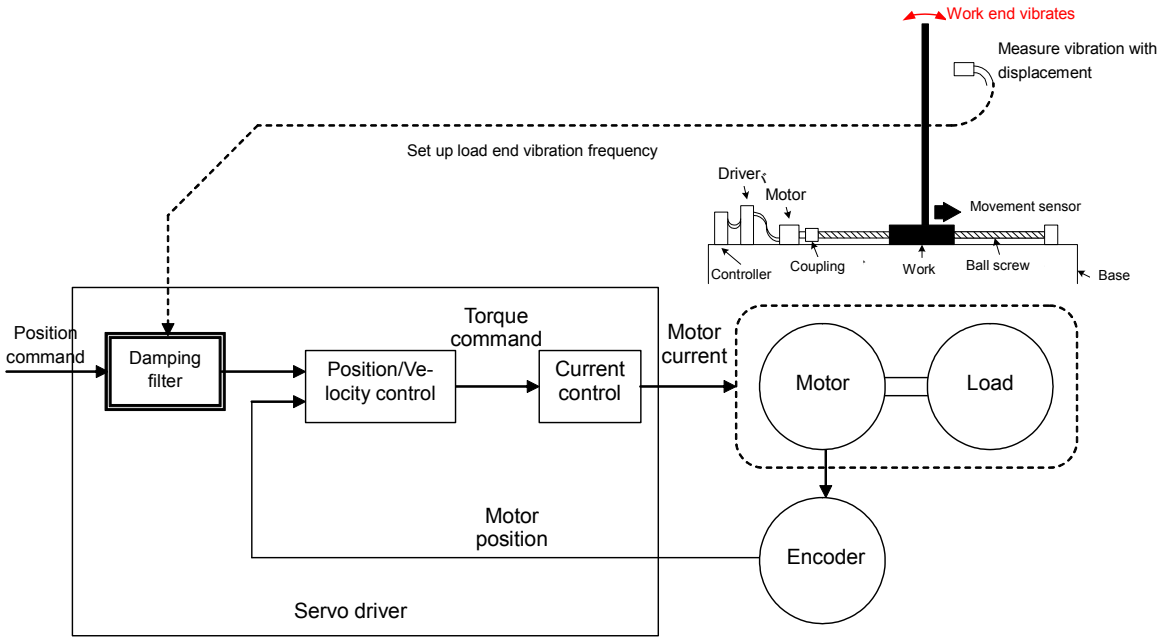
3) Setup of Pr.27 (Velocity observer)

・Set up Pr.27(Velocity observer)to 1 to switch the velocity detecting method to instantaneous velocity observer.
・Return to the original setting if the torque waveform variation or running noise increases, and re-check the above cautions and 1).
・If you experience the reduction of torque wave form and running noise, search for the setup by making micro-adjustment of Pr.20 (Inertia ratio) to obtain the least variation while monitoring the position deviation waveform and actual speed waveform.
Since the optimum value of Pr.20(Inertia ratio)will vary when you change the position loop gain and velocity loop gain, make micro-adjustment again.

6-4-5 Vibration suppression control

(1) Outline

This function reduces the vibration by removing the vibration frequency from the command while the load end vibrates.



(2) Applicable condition

□ This function will be applicable under the following condition

	Condition under which the vibration suppression control works
Control mode	・To be at position control mode

(3) Attention

Stop all of actions when you change the parameters.

□ This function may not work properly or no effect to be seen under the following conditions.

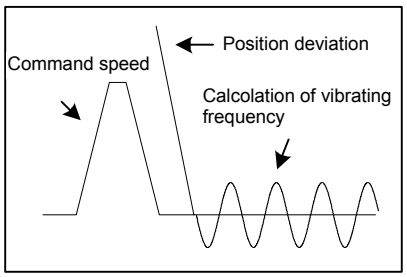
	Conditions which obstruct the vibration suppression control
Load	・Vibration has been initiated by other factors than the command (such as an external force). ・Ratio ob resonance frequency and anti-resonance frequency is large. ・Vibration frequency is out of 10.0～200.0[Hz] range.

(4) How to use

1) Setup of vibration suppression frequency (1st : Pr.2B,2nd : Pr.2D)

Measure the vibrating frequency of the load end. Read out the vibrating frequency [Hz] from the measured waveform when you directly measure the load end vibration with such meter as laser displacement meter, and enter them to the vibration suppression frequency(Pr.2B,Pr.2D).

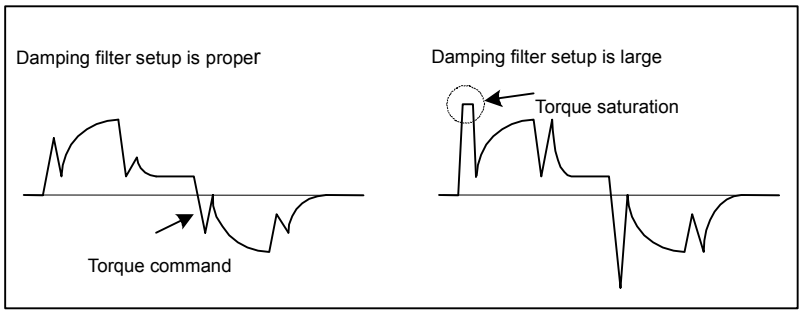
If no such meter is available, use the graphic function of the setup support software, PANATERM to read out the residual vibration frequency [Hz] from the position deviation waveform, and set them to the vibration suppression frequency.



2) Setup of vibration suppression filter (1st : Pr.2C,2nd : Pr.2E)

Set up o first.

You can reduce the settling time by increasing the values; however, torque ripple at the command changing point may be increased as well as the fig. below shows. Set up within a range where no torque saturation occurs under the actual working conditions. Vibration suppression effect will be reduced when the torque saturation occurs



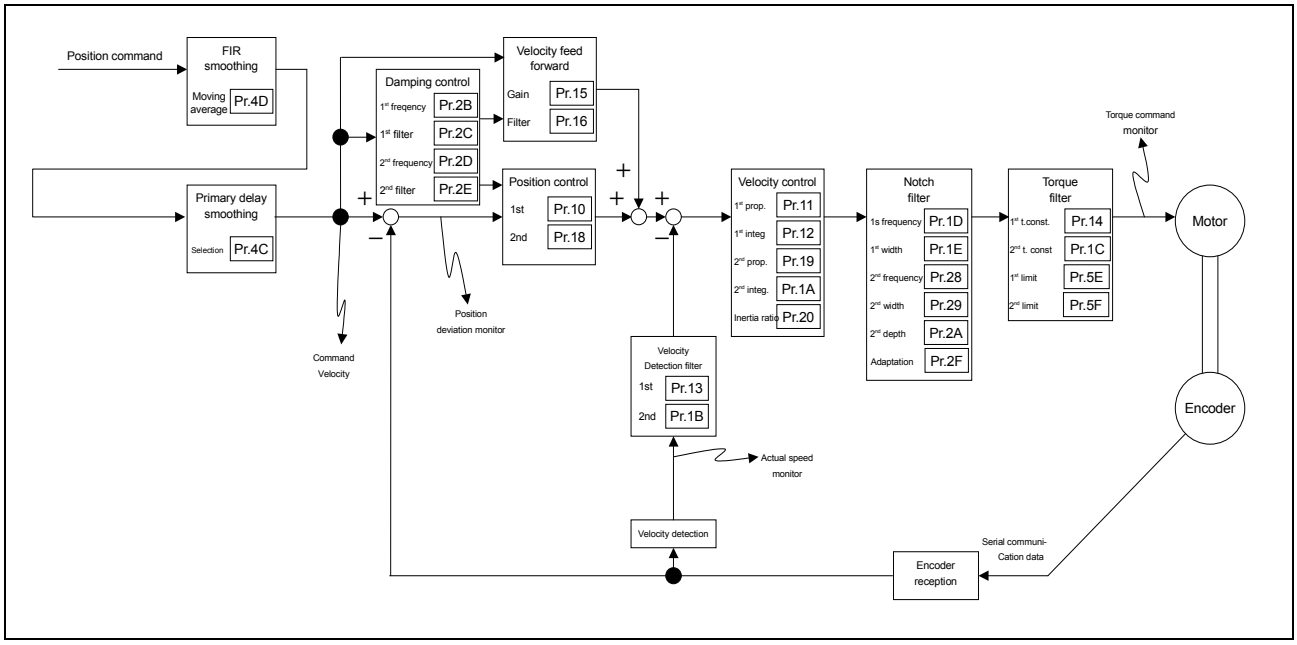
3) Setup of vibration suppression filter switching selection(Pr.24).

You can switch the vibration suppression filter depending on the vibration status of the load.

Pr.24	Switching mode
0,1	No switching (Both of them are valid.)
2	Switches by command direction. CCW direction : 1st vibration suppression frequency CW direction : 2nd vibration suppression frequency

7. Control block diagram

7-1 Position control block diagram



7-2 Full-closed control block diagram