Mitsubishi Electric AC Servo System

MR-JET
User's Manual
(Adjustment)

-MR-JET-_G
-MR-JET-_G-N1
SAFETY INSTRUCTIONS

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

In this manual, the safety instruction levels are classified into "WARNING" and "CAUTION".

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

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

Note that the CAUTION level may lead to a serious consequence depending on conditions.

Please follow the instructions of both levels because they are important to personnel safety.

Forbidden actions and required actions are indicated by the following diagrammatic symbols.

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

くださ Indicates a required action. For example, grounding is indicated by ⬇️.

In this manual, precautions for hazards that can lead to property damage, instructions for other functions, and other information are shown separately in the "POINT" area.

After reading this manual, keep it accessible to the operator.
[Installation/wiring]

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

[Setting/adjustment]

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

[Operation]

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

[Maintenance]

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

e-Manuals are Mitsubishi Electric FA electronic book manuals that can be browsed with a dedicated tool. e-Manuals enable the following:

- Searching for desired information in multiple manuals at the same time (manual cross searching)
- Jumping from a link in a manual to another manual for reference
- Browsing for hardware specifications by scrolling over the components shown in product illustrations
- Bookmarking frequently referenced information
- Copying sample programs to engineering tools

If using the servo for the first time, prepare and use the following related manuals to ensure that the servo is used safely. The manuals used differ depending on the interface of the servo amplifier. For details, refer to the User’s Manual (Introduction).

This manual covers the following servo amplifiers.

- MR-JET-_G/MR-JET-_G-N1

U.S. CUSTOMARY UNITS

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

<table>
<thead>
<tr>
<th>Quantity</th>
<th>SI (metric) unit</th>
<th>U.S. customary unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>1 [kg]</td>
<td>2.2046 [lb]</td>
</tr>
<tr>
<td>Length</td>
<td>1 [mm]</td>
<td>0.03937 [inch]</td>
</tr>
<tr>
<td>Torque</td>
<td>1 [N•m]</td>
<td>141.6 [oz•inch]</td>
</tr>
<tr>
<td>Moment of inertia</td>
<td>1 [(× 10^-4 kg•m²)]</td>
<td>5.4675 [oz•inch²]</td>
</tr>
<tr>
<td>Load (thrust load/axial load)</td>
<td>1 [N]</td>
<td>0.2248 [lbf]</td>
</tr>
<tr>
<td>Temperature</td>
<td>N [°C] × 9/5 + 32</td>
<td>N [°F]</td>
</tr>
</tbody>
</table>
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CHAPTER 5 GAIN SWITCHING FUNCTION

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  Servo parameters that are changeable with the gain switching .... 72
A servo amplifier is equipped with various servo parameters that can be used to adjust operation status. To maximize the machine's performance, these servo parameters must be set in accordance with the machine's characteristics. When using the factory setting, the gain adjustment is set to "Auto tuning mode 1". Use each adjustment function to improve the responsiveness.

**Precautions**

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

### 1.1 Adjustment functions available when using the servo amplifier alone

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

<table>
<thead>
<tr>
<th>Adjustment function</th>
<th>Outline</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quick tuning</td>
<td>Use this function to prioritize reduction of the overshoot rather than shortening the settling time. An adjustment is enabled without the positioning operation.</td>
<td><a href="#">Page 12 Quick tuning</a></td>
</tr>
<tr>
<td>Auto tuning mode 1</td>
<td>Use this function to adjust the machine while checking the response waveform when the load to motor inertia ratio of the device is unknown. Also use this function when the load to motor inertia ratio of a machine varies during operation.</td>
<td><a href="#">Page 33 Auto tuning mode 1</a></td>
</tr>
<tr>
<td>Auto tuning mode 2</td>
<td>Use this function to adjust the machine while checking the response waveform when the load to motor inertia ratio of the device is known.</td>
<td><a href="#">Page 37 Auto tuning mode 2</a></td>
</tr>
<tr>
<td>2 gain adjustment mode 1</td>
<td>Use this function for auto tuning a machine that requires path accuracy improvement, such as an XY table or a tandem mechanism, and to suppress inter-axis interference.</td>
<td><a href="#">Page 39 2 gain adjustment mode 1</a></td>
</tr>
<tr>
<td>2 gain adjustment mode 2</td>
<td>Use this function to adjust settling time and overshoot amount after quick tuning or one-touch tuning was performed.</td>
<td><a href="#">Page 40 2 gain adjustment mode 2</a></td>
</tr>
</tbody>
</table>
## Adjustment functions to suppress vibration and to obtain a high level of responsiveness

<table>
<thead>
<tr>
<th>Adjustment function</th>
<th>Outline</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-touch tuning</td>
<td>Use this function to reduce settling time within the designated In-position range.</td>
<td>Page 16 One-touch tuning</td>
</tr>
<tr>
<td>Machine resonance suppression filter</td>
<td>Use this function if machine resonance occurs when the response level is increased in auto tuning or manual mode.</td>
<td>Page 46 Machine resonance suppression filter</td>
</tr>
<tr>
<td>Adaptive filter II</td>
<td>Use this function to adjust the machine resonance suppression filter automatically.</td>
<td>Page 49 Adaptive filter II</td>
</tr>
<tr>
<td>Robust filter</td>
<td>When the load to motor inertia ratio of a machine is 10 times or more, use this filter to further increase the response level of the machine.</td>
<td>Page 55 Robust filter</td>
</tr>
<tr>
<td>Advanced vibration suppression control II</td>
<td>If the vibration is too large when settling during high-speed positioning, use this function to suppress the vibration and also reduce settling time.</td>
<td>Page 56 Advanced vibration suppression control II</td>
</tr>
<tr>
<td>Command notch filter</td>
<td>If the vibration is too large when settling during high-speed positioning, use this function to easily suppress said vibration.</td>
<td>Page 62 Command notch filter</td>
</tr>
<tr>
<td>Command smoothing filter</td>
<td>If the vibration is too large when settling during high-speed positioning, use this function to easily suppress said vibration. In addition, use this function to suppress vibrations in a wide range of frequencies.</td>
<td>Page 69 Command smoothing filter</td>
</tr>
</tbody>
</table>

## Manual adjustment functions to obtain the maximum performance

<table>
<thead>
<tr>
<th>Adjustment function</th>
<th>Outline</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual mode</td>
<td>Use this function if the performance of quick tuning, one-touch tuning, and auto tuning is not satisfactory.</td>
<td>Page 41 Manual mode</td>
</tr>
<tr>
<td>Gain switching function</td>
<td>Use this function for: 1) Reducing the settling time 2) Increasing the gain during servo-lock while suppressing vibration sound during rotation 3) When load fluctuation is too large</td>
<td>Page 70 GAIN SWITCHING FUNCTION</td>
</tr>
<tr>
<td>Speed feed forward</td>
<td>Use this function to improve path accuracy by decreasing droop pulses at the constant speed.</td>
<td>Page 83 SPEED FEED FORWARD CONTROL FUNCTION</td>
</tr>
<tr>
<td>Overshoot suppression function</td>
<td>Use this function to decrease the overshoot.</td>
<td>Page 85 OVERSHOOT SUPPRESSION CONTROL</td>
</tr>
<tr>
<td>Slight vibration suppression function</td>
<td>Use this function to suppress vibration at a servo motor stop.</td>
<td>Page 87 SLIGHT VIBRATION SUPPRESSION CONTROL</td>
</tr>
<tr>
<td>Unbalanced torque offset</td>
<td>Use this function to prevent free fall of a vertical axis when turning on servo-on.</td>
<td>Page 89 UNBALANCED TORQUE OFFSET</td>
</tr>
<tr>
<td>Path tracking model adaptive control</td>
<td>Use this function to suppress overshoot in path control.</td>
<td>Page 93 Path tracking model adaptive control</td>
</tr>
<tr>
<td>Super trace control</td>
<td>Use this function to improve the trackability at acceleration/deceleration in path control.</td>
<td>Page 95 Super trace control</td>
</tr>
<tr>
<td>Lost motion compensation function</td>
<td>Use this function to suppress quadrant projections at speed switching in path control.</td>
<td>Page 97 Lost motion compensation function</td>
</tr>
</tbody>
</table>
## 1.2 Adjustment functions available in combination with MR Configurator2

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

<table>
<thead>
<tr>
<th>Adjustment function</th>
<th>Outline</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine analyzer</td>
<td>Use this function to accurately adjust the mechanical resonance suppression filter when the characteristics of the mechanical resonance are known. With the machine and servo motor connected, the characteristics of the mechanical system can be measured by giving a random vibration command from a personal computer to the servo amplifier and then measuring the responsiveness of the machine.</td>
<td>Page 16 One-touch tuning</td>
</tr>
<tr>
<td>One-touch tuning using the amplifier command method</td>
<td>Use this function to prioritize time reduction of settling and gain adjustment over overshoot suppression. To generate an optimum command inside the servo amplifier and perform one-touch tuning, simply input a travel distance that avoids collision with the machine (a permissible travel distance) when driving the servo motor on MR Configurator2.</td>
<td></td>
</tr>
</tbody>
</table>
ADJUSTMENT PROCEDURE

Adjust the servo amplifier using the following procedure.

1. Set [Pr. PA08.0 Gain adjustment mode selection] to "0". Use this mode to set the same setting value in [Pr. PB07 Model control gain] to all axes when performing interpolation such as path control or tandem drive for a system with 2 axes or more. Do not use this for other purposes.

2. This mode can adjust the servo amplifier without driving the servo motor. Adjust the servo amplifier with this mode when not executing interpolation control.

3. Change the mode to the load to motor inertia ratio monitor mode if no problem appears in the adjustment result of quick tuning.

4. Use one-touch tuning if the quick tuning result is not satisfactory. One-touch tuning offers a higher response level than quick tuning that enables quicker positioning.

---

<table>
<thead>
<tr>
<th>No.</th>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Set [Pr. PA08.0 Gain adjustment mode selection] to &quot;0&quot;. Use this mode to set the same setting value in [Pr. PB07 Model control gain] to all axes when performing interpolation such as path control or tandem drive for a system with 2 axes or more. Do not use this for other purposes.</td>
</tr>
<tr>
<td>2</td>
<td>This mode can adjust the servo amplifier without driving the servo motor. Adjust the servo amplifier with this mode when not executing interpolation control.</td>
</tr>
<tr>
<td>3</td>
<td>Change the mode to the load to motor inertia ratio monitor mode if no problem appears in the adjustment result of quick tuning.</td>
</tr>
<tr>
<td>4</td>
<td>Use one-touch tuning if the quick tuning result is not satisfactory. One-touch tuning offers a higher response level than quick tuning that enables quicker positioning.</td>
</tr>
<tr>
<td>No.</td>
<td>Instructions</td>
</tr>
<tr>
<td>-----</td>
<td>--------------</td>
</tr>
</tbody>
</table>
| (5) | Set [Pr. PA08.0 Gain adjustment mode selection] to "1" or "2".  
- Page 33 Auto tuning mode 1 |
| (6) | [Pr. PA08.0 Gain adjustment mode selection] is automatically set to "4" (2 gain adjustment mode 2) once one-touch tuning is complete.  
- Page 16 One-touch tuning |
| (7) | Set [Pr. PA08.0 Gain adjustment mode selection] to "3".  
Use the manual adjustment for fast settling or high accuracy path control.  
- Page 41 Manual mode |
3  ADJUSTMENT METHOD

3.1  Quick tuning

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

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

Restrictions on quick tuning

Quick tuning is not available in the following situations:

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

Precautions on quick tuning

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

How to use quick tuning

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

Execute quick tuning using the following procedure.

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

1. Turn off servo-on.
2. Set [Pr. PA08.0] to "5" (quick tuning).
3. Set [Pr. PA08.5] to "0" (at initial servo-on after cycling the power).
4. Check the load to motor inertia ratio.
   • When the load to motor inertia ratio is 30 times or less
     Set [Pr. PA08.4] to "0" (load to motor inertia ratio of 30 times or less).
   • When the load to motor inertia ratio is over 30 times but not greater than 100 times, or unknown
     Set [Pr. PA08.4] to "1" (load to motor inertia ratio of 100 times or less).
5. Set the permissible travel distance for quick tuning with [Pr. PA34].
6. Turn on servo-on to adjust servo parameters automatically.
   Quick tuning is then executed at each initial servo-on every time the power is turned on.
7. To retain the tuning results, set [Pr. PA08.0] to "6" (load to motor inertia ratio monitor mode).
When executing quick tuning every time servo-on is turned on

1. Turn off servo-on.
2. Set [Pr. PA08.0] to "5" (quick tuning).
3. Set [Pr. PA08.5] to "1" (at every servo-on).
4. Check the load to motor inertia ratio.
   • When the load to motor inertia ratio is 30 times or less
     Set [Pr. PA08.4] to "0" (load to motor inertia ratio of 30 times or less).
   • When the load to motor inertia ratio is over 30 times but not greater than 100 times, or unknown
     Set [Pr. PA08.4] to "1" (load to motor inertia ratio of 100 times or less).
5. Set the permissible travel distance for quick tuning with [Pr. PA34].
6. Turn on servo-on to adjust servo parameters automatically.
   Quick tuning is then executed each time servo-on is turned on.
7. To retain the tuning results, set [Pr. PA08.0] to "6" (load to motor inertia ratio monitor mode).

How to restore to servo parameter values from before quick tuning

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA08.6</td>
<td>Quick tuning - Restore selection</td>
<td>Set whether to restore to the servo parameter values from before quick tuning. The initial value is &quot;0&quot;.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0: Disabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1: Enabled</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>No.</th>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB01</td>
<td>FILT</td>
<td>Adaptive tuning mode (adaptive filter II)</td>
</tr>
<tr>
<td>PB07</td>
<td>PG1</td>
<td>Model control gain</td>
</tr>
<tr>
<td>PB08</td>
<td>PG2</td>
<td>Position control gain</td>
</tr>
<tr>
<td>PB09</td>
<td>VG2</td>
<td>Speed control gain</td>
</tr>
<tr>
<td>PB10</td>
<td>VIC</td>
<td>Speed integral compensation</td>
</tr>
<tr>
<td>PB11</td>
<td>VDC</td>
<td>Speed differential compensation</td>
</tr>
<tr>
<td>PB13</td>
<td>NH1</td>
<td>Machine resonance suppression filter 1</td>
</tr>
<tr>
<td>PB14</td>
<td>NHQ1</td>
<td>Notch shape selection 1</td>
</tr>
<tr>
<td>PB15</td>
<td>NH2</td>
<td>Machine resonance suppression filter 2</td>
</tr>
<tr>
<td>PB16</td>
<td>NHQ2</td>
<td>Notch shape selection 2</td>
</tr>
<tr>
<td>PB18</td>
<td>LPF</td>
<td>Low-pass filter setting</td>
</tr>
<tr>
<td>PB23</td>
<td>VFBF</td>
<td>Low-pass filter selection</td>
</tr>
<tr>
<td>PB50</td>
<td>NH5</td>
<td>Machine resonance suppression filter 5</td>
</tr>
<tr>
<td>PB51</td>
<td>NHQ5</td>
<td>Notch shape selection 5</td>
</tr>
<tr>
<td>PE41</td>
<td>EOP3</td>
<td>Function selection E-3</td>
</tr>
</tbody>
</table>
**Operation of quick tuning**

When quick tuning is started, the servo amplifier applies vibration torque instantly, then adjusts each gain and the machine resonance suppression filter by using the response from that excitation. The maximum vibration torque that can be applied is 60 % of the rated torque. However, the vibration torque is limited by the torque limit value when the torque limit value is less than 60 % of the rated torque. The adjustment takes about 300 [ms].

When magnetic pole detection is executed, quick tuning will be started after the magnetic pole detection.

Once gain adjustment by quick tuning is complete, the gain can be changed as in the manual mode. In addition, the load to motor inertia ratio will be always estimated as in auto tuning mode 1 after gain adjustment.

The following servo parameters are adjusted automatically in quick tuning.

<table>
<thead>
<tr>
<th>No.</th>
<th>Symbol</th>
<th>Name</th>
<th>Setting value after gain adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB01</td>
<td>FILT</td>
<td>Adaptive tuning mode (adaptive filter II)</td>
<td>Automatic setting</td>
</tr>
<tr>
<td>PB06</td>
<td>GD2</td>
<td>Load to motor inertia ratio/load to motor mass ratio</td>
<td>The setting value is set depending on the response waveform during servo motor driving after gain adjustment.</td>
</tr>
<tr>
<td>PB07</td>
<td>PG1</td>
<td>Model control gain</td>
<td>Automatic setting</td>
</tr>
<tr>
<td>PB08</td>
<td>PG2</td>
<td>Position control gain</td>
<td></td>
</tr>
<tr>
<td>PB09</td>
<td>VG2</td>
<td>Speed control gain</td>
<td></td>
</tr>
<tr>
<td>PB10</td>
<td>VIC</td>
<td>Speed integral compensation</td>
<td></td>
</tr>
<tr>
<td>PB11</td>
<td>VDC</td>
<td>Speed differential compensation</td>
<td>Initial value</td>
</tr>
<tr>
<td>PB13</td>
<td>NH1</td>
<td>Machine resonance suppression filter 1</td>
<td>Automatic setting</td>
</tr>
<tr>
<td>PB14</td>
<td>NHQ1</td>
<td>Notch shape selection 1</td>
<td></td>
</tr>
<tr>
<td>PB15</td>
<td>NH2</td>
<td>Machine resonance suppression filter 2</td>
<td></td>
</tr>
<tr>
<td>PB16</td>
<td>NHQ2</td>
<td>Notch shape selection 2</td>
<td></td>
</tr>
<tr>
<td>PB18</td>
<td>LPF</td>
<td>Low-pass filter setting</td>
<td>Initial value</td>
</tr>
<tr>
<td>PB23.1</td>
<td>—</td>
<td>Low-pass filter selection</td>
<td>1</td>
</tr>
<tr>
<td>PB50</td>
<td>NH5</td>
<td>Machine resonance suppression filter 5</td>
<td>Automatic setting</td>
</tr>
<tr>
<td>PB51</td>
<td>NHQ5</td>
<td>Notch shape selection 5</td>
<td></td>
</tr>
<tr>
<td>PE41</td>
<td>EOP3</td>
<td>Function selection E-3</td>
<td>Initial value</td>
</tr>
</tbody>
</table>

**Errors in quick tuning**

Quick tuning may fail under the following conditions:

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

When quick tuning fails, the servo parameter values from before quick tuning will be restored.
3.2 One-touch tuning

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

User command method

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

Amplifier command method

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

Precautions

- When the following servo parameters are set in [Pr. PA08.0 Gain adjustment mode selection], [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio] is estimated at the start of one-touch tuning.
  "0" (2 gain adjustment mode 1 (interpolation mode))
  "1" (auto tuning mode 1)
  "2" (auto tuning mode 2)
  "4" (2 gain adjustment mode 2)
  "6" (load to motor inertia ratio monitor mode)

Restrictions on one-touch tuning

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

Common restrictions on user command method and amplifier command method

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

Restrictions on user command method

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

Restrictions on amplifier command method

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

### Instructions on amplifier command method

- Once one-touch tuning using the amplifier command method is performed, control by commands from a controller will not be available. To enable control from the controller again, reset the controller, cycle the power of the servo amplifier, or reset software.

- Set a permissible travel distance that avoids collision with the machine. In addition, the permissible travel distance may be exceeded because of an overshoot during one-touch tuning. Therefore, set the permissible travel distance with a margin to avoid exceeding the range of a limit switch.

- When the manual mode is selected in [Pr. PA08.0 Gain adjustment mode selection], a load to motor inertia ratio is not estimated. Optimum acceleration/deceleration commands are generated by [Pr. PB06 Load to motor inertia ratio/load to mass ratio] at the start of one-touch tuning. When the load to motor inertia ratio is not accurate, optimum acceleration/deceleration commands may not be generated, causing the tuning to fail.

- When one-touch tuning is started with a USB communication, both the servo motor and the tuning will stop if communication between MR Configurator2 and the servo amplifier is interrupted during the tuning. In addition, the servo parameters return to the status they had at the start of one-touch tuning.

- When one-touch tuning is started during the velocity mode, the mode is switched to the position mode automatically. As a result, the tuning result may differ from the results obtained by using the speed command.
One-touch tuning procedure

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

Perform one-touch tuning using the following procedure.

1. Start
2. Overshoot permissible level setting
   Set the overshoot permissible level for one-touch tuning in [Pr. PA25 One-touch tuning - Overshoot permissible level].
3. Operation
   Rotate the servo motor using the controller. In the user command method, one-touch tuning cannot be performed during a servo motor stop.
4. One-touch tuning start, command method selection
   On MR Configurator2, select "One-touch Tuning" from the Adjustment tab of MR Configurator2. Select "User command method".
5. Response mode selection
   Select the response mode (High mode/Basic mode/Low mode) in the one-touch tuning window of MR Configurator2.
6. One-touch tuning execution
   Click "Start" during servo motor driving.
7. One-touch tuning in progress
   Gains and filters are adjusted automatically. During the process of the tuning, the progress status is displayed in % on MR Configurator2.
8. One-touch tuning complete
   Once one-touch tuning is complete, the parameters will be set automatically. If tuning did not complete properly, a tuning error will be displayed.
   Page 28 Servo parameters adjusted with one-touch tuning
9. Tuning result check
   Check the tuning results.
   If the tuning result is not satisfactory, the servo parameters can be returned to the value from before one-touch tuning or the initial value.
   Page 31 Initializing one-touch tuning
10. End
**Overshoot permissible level setting**
Set the overshoot permissible level for one-touch tuning in [Pr. PA25 One-touch tuning - Overshoot permissible level]. One-touch tuning adjusts the settling time to be as short as possible within the range of the overshoot permissible level. Therefore, when the value set in [Pr. PA25] is too large, reduction of the settling time is prioritized. When the value set in [Pr. PA25] is too small, then reduction of the overshoot is prioritized.

- When the overshoot permissible level is too high

![Diagram of overshoot permissible level setting for high values](image)

- When the overshoot permissible level is too low

![Diagram of overshoot permissible level setting for low values](image)
3.2 One-touch tuning

**Operation**

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

**Command method and response mode selection**

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

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel distance</td>
<td>Set 100 pulses or more in the encoder pulse unit. Setting less than 100 pulses causes the one-touch tuning error &quot;C_04&quot;.</td>
</tr>
<tr>
<td>Servo motor speed</td>
<td>Set 50 r/min (mm/s) or higher. Setting less than 50 r/min (mm/s) may cause the one-touch tuning error &quot;C_05&quot;.</td>
</tr>
<tr>
<td>Acceleration time constant</td>
<td>Set the time to reach 2000 r/min (mm/s) to 5 s or less.</td>
</tr>
<tr>
<td>Deceleration time constant</td>
<td>Set the time to reach 2000 r/min (mm/s) to 5 s or less.</td>
</tr>
<tr>
<td>Dwell time</td>
<td>Set 200 ms or more. If the value is too small, the one-touch tuning error &quot;C_04&quot; may occur.</td>
</tr>
<tr>
<td>One cycle time</td>
<td>Set 30 s or less. Setting over 30 s causes the one-touch tuning error &quot;C_04&quot;.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High mode</td>
<td>This mode is for a system with high rigidity.</td>
</tr>
<tr>
<td>Basic mode</td>
<td>This mode is for a standard system.</td>
</tr>
<tr>
<td>Low mode</td>
<td>This mode is for a system with low rigidity.</td>
</tr>
</tbody>
</table>
Refer to the following table for selecting a response mode.

<table>
<thead>
<tr>
<th>Response mode</th>
<th>Responsiveness</th>
<th>Machine characteristic</th>
<th>Guidelines for corresponding mode and machinery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low mode</td>
<td>Low response</td>
<td>Arm robot</td>
<td></td>
</tr>
<tr>
<td>Basic mode</td>
<td></td>
<td>General machine tool</td>
<td></td>
</tr>
<tr>
<td>High mode</td>
<td>High response</td>
<td>Conveyor</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Precision working</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>machine</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inserter</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mounter</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bonder</td>
<td></td>
</tr>
</tbody>
</table>

One-touch tuning execution

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

For one-touch tuning in the user command method, clicking "Start" during a servo motor stop causes "C_02" or "C_04" to appear in the error code status. (Refer to the following for the error code.)
MR Configurator2 procedure for one-touch tuning using the amplifier command method

Perform one-touch tuning using the following procedure.

1. Start

2. Moving to tuning start position
Move the moving part to the center of the movable range.

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

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

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

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

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

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

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

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

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

12. End

■ Overshoot permissible level setting
Refer to the following for the settings of the overshoot permissible level.

Page 19 Overshoot permissible level setting
Command method selection and permissible travel distance input
Select "Amplifier command method" in the one-touch tuning window of MR Configurator2. Input a permissible travel distance for the amplifier command method in the servo motor-side resolution unit. In the amplifier command method, a servo motor drives in a range between "current value ± permissible travel distance". Input a value for the permissible travel distance that is as large as possible while being within the range where the movable part will not collide with the machine. Inputting a small permissible travel distance decreases the possibility that the moving part will collide with the machine. However, this may lower the estimation accuracy of the load to motor inertia ratio and result in inaccurate tuning.

Response mode selection
Refer to the following for response mode.

Page 20 Command method and response mode selection
One-touch tuning execution

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

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

*1 These items are automatically generated in the servo amplifier.
**Procedure for one-touch tuning via controller**

Perform one-touch tuning using the following procedure.

1. **Start**
2. **Overshoot permissible level setting**
   Set the in-position range for one-touch tuning in [Pr. PA25 One-touch tuning - Overshoot permissible level].
3. **Operation**
   Rotate the servo motor using the controller. One-touch tuning via a controller cannot be performed during a servo motor stop.
4. **Response mode setting, one-touch tuning execution**
   To perform one-touch tuning, write the value of the response mode (High mode/Basic mode/Low mode) in [One-touch tuning mode (Obj. 2D50h)].
5. **One-touch tuning in progress**
   Gains and filters are adjusted automatically. During one-touch tuning, the progress is returned to [One-touch tuning Status (Obj. 2D51h)] in %.
6. **One-touch tuning complete**
   Check whether one-touch tuning is completed normally with [One-touch tuning mode (Obj. 2D50h)]. Once one-touch tuning is complete, the parameters will be set automatically. When the tuning is not completed normally, a tuning error is returned in [One-touch tuning Error Code (Obj. 2D54h)]. Refer to the following.
   Page 31 Initializing one-touch tuning
7. **Tuning result check**
   Check the tuning results.
   If the tuning result is not satisfactory, the servo parameters can be returned to the value from before one-touch tuning or the initial value with [One-touch tuning Clear (Obj. 2D53h)]. Refer to the following.
   Page 31 Initializing one-touch tuning
8. **End**
Object registration
Register the following objects when performing one-touch tuning.

<table>
<thead>
<tr>
<th>Index</th>
<th>Sub</th>
<th>Object</th>
<th>Name</th>
<th>Data Type</th>
<th>Access</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D50h</td>
<td>0</td>
<td>VAR</td>
<td>One-touch tuning mode</td>
<td>U8</td>
<td>rw</td>
<td>00h</td>
<td>Setting “1”, “2”, or “3” starts one-touch tuning. After one-touch tuning is completed, the setting value automatically changes to “0”. 0: One-touch tuning stop in progress 1: Basic mode 2: High mode 3: Low mode</td>
</tr>
<tr>
<td>2D51h</td>
<td>0</td>
<td>VAR</td>
<td>One-touch tuning Status</td>
<td>I8</td>
<td>ro</td>
<td>0</td>
<td>Regardless of whether one-touch tuning is properly completed or not, the setting value is 100 % at the completion. Unit: %</td>
</tr>
<tr>
<td>2D52h</td>
<td>0</td>
<td>VAR</td>
<td>One-touch tuning Stop</td>
<td>U16</td>
<td>wo</td>
<td>0000h</td>
<td>Writing “1EA5h” stops one-touch tuning.</td>
</tr>
<tr>
<td>2D53h</td>
<td>0</td>
<td>VAR</td>
<td>One-touch tuning Clear</td>
<td>U16</td>
<td>wo</td>
<td>0000h</td>
<td>Servo parameters that were changed in one-touch tuning can be restored to the original status. 0000h: Restores to factory setting 0001h: Restores to the value from before one-touch tuning When servo parameters are restored, the setting value of the restored servo parameter is stored in the non-volatile memory.</td>
</tr>
<tr>
<td>2D54h</td>
<td>0</td>
<td>VAR</td>
<td>One-touch tuning Error Code</td>
<td>U16</td>
<td>ro</td>
<td>0000h</td>
<td>The following shows the details of the one-touch tuning error codes. 0000h: Properly completed C_00h: Tuning canceled C_01h: Overshoot exceeded C_02h: Servo-off during tuning C_03h: Control mode error C_04h: Time-out C_05h: Load inertia moment ratio misestimated C_06h: Servo amplifier built-in command start error C_07h: Servo amplifier built-in command generation error C_08h: Stop signal C_09h: Parameter C_0Ah: Alarm C00Fh: One-touch tuning disabled</td>
</tr>
</tbody>
</table>

Overshoot permissible level setting
Refer to the following for the settings of the overshoot permissible level.
Page 19 Overshoot permissible level setting

Operation
Refer to the following for operation.
Page 20 Operation

Response mode selection
Refer to the following for response mode.
Page 20 Command method and response mode selection
Progress display during one-touch tuning

On MR Configurator2

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

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

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

On a controller

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

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA08</td>
<td>ATU</td>
<td>Auto tuning mode</td>
</tr>
<tr>
<td>PA09</td>
<td>RSP</td>
<td>Auto tuning response</td>
</tr>
<tr>
<td>PA24</td>
<td>AOP4</td>
<td>Function selection A-4</td>
</tr>
<tr>
<td>PB01</td>
<td>FILT</td>
<td>Adaptive tuning mode (adaptive filter II)</td>
</tr>
<tr>
<td>PB02</td>
<td>VRFT</td>
<td>Vibration suppression control (advanced vibration suppression control II)</td>
</tr>
<tr>
<td>PB03</td>
<td>PST</td>
<td>Position command speed adjustment time constant (position smoothing)</td>
</tr>
<tr>
<td>PB06</td>
<td>GD2</td>
<td>Load to motor inertia ratio/load to motor mass ratio</td>
</tr>
<tr>
<td>PB07</td>
<td>PG1</td>
<td>Model control gain</td>
</tr>
<tr>
<td>PB08</td>
<td>PG2</td>
<td>Position control gain</td>
</tr>
<tr>
<td>PB09</td>
<td>VG2</td>
<td>Speed control gain</td>
</tr>
<tr>
<td>PB10</td>
<td>VIC</td>
<td>Speed integral compensation</td>
</tr>
<tr>
<td>PB12</td>
<td>OVA</td>
<td>Overshoot amount compensation</td>
</tr>
<tr>
<td>PB13</td>
<td>NH1</td>
<td>Machine resonance suppression filter 1</td>
</tr>
<tr>
<td>PB14</td>
<td>NHQ1</td>
<td>Notch shape selection 1</td>
</tr>
<tr>
<td>PB15</td>
<td>NH2</td>
<td>Machine resonance suppression filter 2</td>
</tr>
<tr>
<td>PB16</td>
<td>NHQ2</td>
<td>Notch shape selection 2</td>
</tr>
<tr>
<td>PB17</td>
<td>NHF</td>
<td>Shaft resonance suppression filter</td>
</tr>
<tr>
<td>PB18</td>
<td>LPF</td>
<td>Low-pass filter setting</td>
</tr>
<tr>
<td>PB19</td>
<td>VRF11</td>
<td>Vibration suppression control 1 - Vibration frequency</td>
</tr>
<tr>
<td>PB20</td>
<td>VRF12</td>
<td>Vibration suppression control 1 - Resonance frequency</td>
</tr>
<tr>
<td>PB21</td>
<td>VRF13</td>
<td>Vibration suppression control 1 - Vibration frequency damping</td>
</tr>
<tr>
<td>PB22</td>
<td>VRF14</td>
<td>Vibration suppression control 1 - Resonance frequency damping</td>
</tr>
<tr>
<td>PB23</td>
<td>VFBF</td>
<td>Low-pass filter selection</td>
</tr>
<tr>
<td>PB46</td>
<td>NH3</td>
<td>Machine resonance suppression filter 3</td>
</tr>
<tr>
<td>PB47</td>
<td>NHQ3</td>
<td>Notch shape selection 3</td>
</tr>
<tr>
<td>PB48</td>
<td>NH4</td>
<td>Machine resonance suppression filter 4</td>
</tr>
<tr>
<td>PB49</td>
<td>NHQ4</td>
<td>Notch shape selection 4</td>
</tr>
<tr>
<td>PB51</td>
<td>NHQ5</td>
<td>Notch shape selection 5</td>
</tr>
<tr>
<td>PB52</td>
<td>VRF21</td>
<td>Vibration suppression control 2 - Vibration frequency</td>
</tr>
<tr>
<td>PB53</td>
<td>VRF22</td>
<td>Vibration suppression control 2 - Resonance frequency</td>
</tr>
<tr>
<td>PB54</td>
<td>VRF23</td>
<td>Vibration suppression control 2 - Vibration frequency damping</td>
</tr>
<tr>
<td>PB55</td>
<td>VRF24</td>
<td>Vibration suppression control 2 - Resonance frequency damping</td>
</tr>
<tr>
<td>PE41</td>
<td>EOP3</td>
<td>Function selection E-3</td>
</tr>
</tbody>
</table>

One-touch tuning stop method

On MR Configurator2

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

On a controller

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

### On MR Configurator2

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

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

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

<table>
<thead>
<tr>
<th>Error code</th>
<th>Servo parameter after the one-touch tuning error occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>C0 _ _</td>
<td>A servo parameter is returned to the value it had at the start of one-touch tuning.</td>
</tr>
<tr>
<td>C1 _ _</td>
<td>The following servo parameters retain the values they had during one-touch tuning. Other servo parameters return to the values they had at the start of one-touch tuning.</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PA08 Auto tuning mode (ATU)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PA09 Auto tuning response (RSP)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB01 Adaptive tuning mode (adaptive filter II) (FILT)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB03 Position command speed adjustment time constant (position smoothing) (PST)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio (GD2)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB08 Position control gain (PG2)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB09 Speed control gain (VG2)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB10 Speed integral compensation (VIC)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB13 Machine resonance suppression filter 1 (NH1)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB14 Notch shape selection 1 (NHQ1)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB15 Machine resonance suppression filter 2 (NH2)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB16 Notch shape selection 2 (NHQ2)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB17 Shaft resonance suppression filter (NHF)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB18 Low-pass filter setting (LPF)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB23 Low-pass filter selection (VFBBF)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB46 Machine resonance suppression filter 3 (NH3)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB47 Notch shape selection 3 (NHQ3)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB48 Machine resonance suppression filter 4 (NH4)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB49 Notch shape selection 4 (NHQ4)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PB51 Notch shape selection 5 (NHQ5)]</td>
</tr>
<tr>
<td></td>
<td>• [Pr. PE41 Function selection E-3 (EOP3)]</td>
</tr>
</tbody>
</table>

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

On a controller

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

Page 29 On MR Configurator2
Initializing one-touch tuning

Servo parameters to be initialized

Initialize one-touch tuning to restore the setting value of the following servo parameters to the factory setting. In addition, [Pr. PA08.0 Gain adjustment mode selection] will be automatically changed to “1” (Auto tuning mode 1).

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Symbol</th>
<th>Name</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA08</td>
<td>ATU</td>
<td>Auto tuning mode</td>
<td>[Pr. PA08.0] is set to “1” (Auto tuning mode 1).</td>
</tr>
<tr>
<td>PA09</td>
<td>RSP</td>
<td>Auto tuning response</td>
<td>—</td>
</tr>
<tr>
<td>PA24</td>
<td>AOP4</td>
<td>Function selection A-4</td>
<td>—</td>
</tr>
<tr>
<td>PB01</td>
<td>FILT</td>
<td>Adaptive tuning mode (adaptive filter II)</td>
<td>—</td>
</tr>
<tr>
<td>PB02</td>
<td>VRFT</td>
<td>Vibration suppression control tuning mode</td>
<td>—</td>
</tr>
<tr>
<td>PB03</td>
<td>PST</td>
<td>Position command speed adjustment time constant (position smoothing)</td>
<td>—</td>
</tr>
<tr>
<td>PB06</td>
<td>GD2</td>
<td>Load to motor inertia ratio/load to motor mass ratio</td>
<td>—</td>
</tr>
<tr>
<td>PB07</td>
<td>PG1</td>
<td>Model control gain</td>
<td>—</td>
</tr>
<tr>
<td>PB08</td>
<td>PG2</td>
<td>Position control gain</td>
<td>—</td>
</tr>
<tr>
<td>PB09</td>
<td>VG2</td>
<td>Speed control gain</td>
<td>—</td>
</tr>
<tr>
<td>PB10</td>
<td>VIC</td>
<td>Speed integral compensation</td>
<td>—</td>
</tr>
<tr>
<td>PB12</td>
<td>OVA</td>
<td>Overshoot amount compensation</td>
<td>—</td>
</tr>
<tr>
<td>PB16</td>
<td>NHQ2</td>
<td>Notch shape selection 2</td>
<td>[Pr. PB16.0 Machine resonance suppression filter 2 selection] is initialized to “0”.</td>
</tr>
<tr>
<td>PB17</td>
<td>NHF</td>
<td>Shaft resonance suppression filter</td>
<td>—</td>
</tr>
<tr>
<td>PB18</td>
<td>LPF</td>
<td>Low-pass filter setting</td>
<td>—</td>
</tr>
<tr>
<td>PB23</td>
<td>VFBF</td>
<td>Low-pass filter selection</td>
<td>—</td>
</tr>
<tr>
<td>PB47</td>
<td>NHQ3</td>
<td>Notch shape selection 3</td>
<td>[Pr. PB47.0 Machine resonance suppression filter 3 selection] is initialized to “0”.</td>
</tr>
<tr>
<td>PB49</td>
<td>NHQ4</td>
<td>Notch shape selection 4</td>
<td>[Pr. PB49.0 Machine resonance suppression filter 4 selection] is initialized to “0”.</td>
</tr>
<tr>
<td>PB51</td>
<td>NHQ5</td>
<td>Notch shape selection 5</td>
<td>[Pr. PB51.0 Machine resonance suppression filter 5 selection] is initialized to “0”.</td>
</tr>
<tr>
<td>PE41</td>
<td>EOP3</td>
<td>Function selection E-3 (Robust filter selection)</td>
<td>—</td>
</tr>
</tbody>
</table>
On MR Configurator2

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

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

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

On a controller

Servo parameters can be returned to the initial value by writing "0000h" to [One-touch tuning Clear (Obj. 2DS3h)].

In addition, write "0001h" to [One-touch tuning Clear (Obj. 2DS3h)] to return servo parameters to the value from before one-touch tuning. The setting value of the returned servo parameter is stored in the non-volatile memory.
3.3 Auto tuning mode 1

The servo amplifier has a real-time auto tuning function which estimates the machine characteristics (load to motor inertia ratio) in real time and automatically sets the optimum gain according to that value. This function allows easier gain adjustment of the servo amplifier.

In auto tuning mode 1, the load to motor inertia ratio of a machine is always estimated, and the optimum gain is automatically set. This mode is the optimum method for adjustment with the response waveform being checked when the load to motor inertia ratio of a device is unknown.

Restrictions on auto tuning mode 1

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

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

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

Precautions on auto tuning mode 1

If sudden disturbance torque is applied during operation, the load to motor inertia ratio may be miscalculated temporarily. In such a case, set [Pr. PA08.0 Gain adjustment mode selection] to "2" (Auto tuning mode 2), and then set the accurate load to motor inertia ratio in [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio].

When auto tuning mode 1 is changed to manual mode, the current control gain and the load to motor inertia ratio estimation value are saved in the non-volatile memory.
Adjustment procedure by auto tuning mode 1

The adjustment procedure is as follows.

1. Auto tuning

2. Repeated acceleration/deceleration

   - Is the estimated value of load to motor inertia ratio stable?
     - Yes
     - No

   - Are auto tuning conditions satisfied?
     - Satisfied
     - Not satisfied

     - If the conditions are not satisfied, it is difficult to estimate the load to motor inertia ratio.

     Set [Pr. PA08.0 Gain adjustment mode selection] to "2", and then manually set [Pr. PB06 Load to motor inertia ratio/load to motor mass ratio].

     - Adjust [Pr. PA09 Auto tuning response] to achieve the desired response without vibration.

     - Repeated acceleration/deceleration

     - Is the performance satisfactory?
       - No
       - Yes
         - End
         - To 2 gain adjustment mode 2
Responsiveness setting in auto tuning mode 1

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

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

Page 46 Machine resonance suppression filter
Page 49 Adaptive filter II
### ADJUSTMENT METHOD

#### 3.3 Auto tuning mode 1

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

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

Precautions on auto tuning mode 2

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

Adjustment procedure by auto tuning mode 2

Refer to the following.

Page 34 Adjustment procedure by auto tuning mode 1
Responsiveness setting in auto tuning mode 2

Refer to the following.

Page 35 Responsiveness setting in auto tuning mode 1

Operation of auto tuning mode 2

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

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

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

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB07</td>
<td>PG1</td>
<td>Model control gain</td>
</tr>
<tr>
<td>PB08</td>
<td>PG2</td>
<td>Position control gain</td>
</tr>
<tr>
<td>PB09</td>
<td>VG2</td>
<td>Speed control gain</td>
</tr>
<tr>
<td>PB10</td>
<td>VIC</td>
<td>Speed integral compensation</td>
</tr>
</tbody>
</table>
3.5 2 gain adjustment mode 1

Use the 2 gain adjustment mode to match the position control gains of each axes when performing the interpolation operation of servo motors of two or more axes for an X-Y table or the like. In this mode, manually set the model control gain that determines command trackability. Other servo parameters are set automatically.

For 2 gain adjustment mode 1, manually set the model control gain that determines command trackability. The mode constantly estimates the load to motor inertia ratio and automatically sets other servo parameters for optimum gains in accordance with the responsiveness of auto tuning.

Adjustment procedure for 2 gain adjustment mode 1

**Precautions**

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

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

**Servo parameter adjustment method**

[Pr. PB07 Model control gain]

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

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

Position command frequency differs depending on the operation mode.

- **For rotary servo motors**
  
  Position command frequency = \(\frac{\text{Servo motor speed [r/min]}}{\text{Encoder resolution (number of pulses per servo motor revolution)}}\)

- **Linear servo motors**
  
  Position command frequency = \(\text{Speed [mm/s]} + \text{Encoder resolution (travel distance per pulse)}\)
Operation of 2 gain adjustment mode 1

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

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB06</td>
<td>GD2</td>
<td>Load to motor inertia ratio/load to motor mass ratio</td>
</tr>
<tr>
<td>PB08</td>
<td>PG2</td>
<td>Position control gain</td>
</tr>
<tr>
<td>PB09</td>
<td>VG2</td>
<td>Speed control gain</td>
</tr>
<tr>
<td>PB10</td>
<td>VIC</td>
<td>Speed integral compensation</td>
</tr>
</tbody>
</table>

3.6 2 gain adjustment mode 2

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

Adjustment procedure for 2 gain adjustment mode 2

Precautions

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

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

Operation of 2 gain adjustment mode 2

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

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB08</td>
<td>PG2</td>
<td>Position control gain</td>
</tr>
<tr>
<td>PB09</td>
<td>VG2</td>
<td>Speed control gain</td>
</tr>
<tr>
<td>PB10</td>
<td>VIC</td>
<td>Speed integral compensation</td>
</tr>
</tbody>
</table>

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

Page 41 Adjustment procedure for the velocity mode
Page 43 Adjustment procedure for the position mode
3.7 Manual mode

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

Precautions

- If machine resonance occurs, [Pr. PB01.0 Filter tuning mode selection] or machine resonance suppression filter in [Pr. PB13] to [Pr. PB16] and [Pr. PB46] to [Pr. PB51] can be used to suppress machine resonance. Refer to the following.
  - Page 46 Machine resonance suppression filter
  - Page 49 Adaptive filter II

Adjustment procedure for the velocity mode

Servo parameter

The following servo parameters are used for gain adjustment.

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB06</td>
<td>GD2</td>
<td>Load to motor inertia ratio/load to motor mass ratio</td>
</tr>
<tr>
<td>PB07</td>
<td>PG1</td>
<td>Model control gain</td>
</tr>
<tr>
<td>PB09</td>
<td>VG2</td>
<td>Speed control gain</td>
</tr>
<tr>
<td>PB10</td>
<td>VIC</td>
<td>Speed integral compensation</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Explanation on servo parameter</th>
<th>Effect when increasing the responsiveness</th>
<th>Operating status when increase in responsiveness is excessive</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Pr. PB07 Model control gain]</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>This servo parameter determines the responsiveness. Increasing the value improves trackability to a position command, but the servo motor speed is likely to be higher than the command.</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>[Pr. PB09 Speed control gain]</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
<tr>
<td>This servo parameter determines the responsiveness of the speed control loop. Increasing the value improves the responsiveness to the load disturbance, but mechanical vibration is more likely to occur.</td>
<td><img src="image" alt="Diagram" /></td>
<td><img src="image" alt="Diagram" /></td>
</tr>
</tbody>
</table>
3. ADJUSTMENT METHOD

3.7 Manual mode

Adjustment procedure

Servo parameter adjustment method

- [Pr. PB07 Model control gain]
  - As a guide, this servo parameter can be calculated with the following formula.
  - Model control gain guidelines: (1 + Load to motor inertia ratio) x 1/4 to 1/8
  - Speed loop response frequency [Hz] = Speed control gain

- [Pr. PB09 Speed control gain]
  - The actual response frequency of the speed loop can be calculated with the following formula.
  - Speed loop response frequency [Hz] = (1 + Load to motor inertia ratio) x 2π

- [Pr. PB10 Speed integral compensation]
  - This servo parameter determines the time constant for proportional integral control of speed control loop. Decreasing the value improves the responsiveness. If the moment of inertia is large or the mechanical system contains vibratory elements, the mechanical system is liable to vibrate unless the value is increased to some degree.

Procedure

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perform approximate adjustment with the auto tuning. Refer to the following.</td>
</tr>
<tr>
<td>2</td>
<td>Change [Pr. PA08.0 Gain adjustment mode selection] to “3” (manual mode).</td>
</tr>
<tr>
<td>3</td>
<td>Set an estimated value in the load to motor inertia ratio. (If the estimated value by auto tuning is correct, setting change is not required.)</td>
</tr>
<tr>
<td>4</td>
<td>Set a small value to the model control gain. Set a large value to the speed integral compensation.</td>
</tr>
<tr>
<td>5</td>
<td>Increase the speed control gain within the range where vibration or unusual noise is not generated, and return slightly if vibration occurs.</td>
</tr>
<tr>
<td>6</td>
<td>Increase the value until the vibration stops.</td>
</tr>
<tr>
<td>7</td>
<td>Decrease the speed integral compensation within the vibration-free range. If vibration occurs, increase the value until the vibration stops.</td>
</tr>
<tr>
<td>8</td>
<td>Decrease the time constant of the speed integral compensation.</td>
</tr>
<tr>
<td>9</td>
<td>Increase the model control gain, and return slightly if an overshoot occurs.</td>
</tr>
</tbody>
</table>

Fine adjustment

1. While checking the motor status, fine-adjust each gain.

Explanation on servo parameter

- Effect when increasing the responsiveness

  - Command: Servo motor speed
  - Time: Occurrence of vibration and unusual noise (low frequency)

- Operating status when increase in responsiveness is excessive

  - Command: Servo motor speed
  - Time: Occurrence of vibration and unusual noise (high frequency)
As a guide, this servo parameter can be calculated with the following formula.

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

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

### Adjustment procedure for the position mode

#### Servo parameter

The following servo parameters are used for gain adjustment.

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB06</td>
<td>GD2</td>
<td>Load to motor inertia ratio/load to motor mass ratio</td>
</tr>
<tr>
<td>PB07</td>
<td>PG1</td>
<td>Model control gain</td>
</tr>
<tr>
<td>PB08</td>
<td>PG2</td>
<td>Position control gain</td>
</tr>
<tr>
<td>PB09</td>
<td>VG2</td>
<td>Speed control gain</td>
</tr>
<tr>
<td>PB10</td>
<td>VIC</td>
<td>Speed integral compensation</td>
</tr>
</tbody>
</table>

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

#### Explanation on servo parameter

- **[Pr. PB07 Model control gain]**
  This servo parameter determines the responsiveness. Increasing the value improves trackability to a position command, but an overshoot is likely to occur.

- **[Pr. PB08 Position control gain]**
  This parameter is set for increasing the position response to load disturbance. Increasing the value improves the responsiveness, but vibration and noise are more likely to occur.

- **[Pr. PB09 Speed control gain]**
  This servo parameter determines the responsiveness of the speed control loop. Increasing the value improves the responsiveness to the load disturbance, but mechanical vibration is more likely to occur.
Adjustment procedure

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perform approximate adjustment with the auto tuning. Refer to the following.</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>[Pr. PB10 Speed integral compensation] This servo parameter determines the time constant for proportional integral control of speed control loop. Decreasing the value improves the responsiveness. If the moment of inertia ratio is large or the mechanical system contains vibratory element, the mechanical system is liable to vibrate unless the value is increased to some degree.</td>
<td>—</td>
</tr>
<tr>
<td>2</td>
<td>Change [Pr. PB07 Model control gain] as a guide, this servo parameter can be calculated with the following formula.</td>
<td>—</td>
</tr>
<tr>
<td>3</td>
<td>Set an estimated value in the load to motor inertia ratio/load to motor mass ratio. (If the estimated value by auto tuning is correct, setting change is not required.)</td>
<td>—</td>
</tr>
<tr>
<td>4</td>
<td>Set a small value to the model control gain and the position control gain. Set a large value to the speed integral compensation.</td>
<td>—</td>
</tr>
<tr>
<td>5</td>
<td>Increase the speed control gain within the range where vibration or unusual noise is not generated, and return slightly if vibration occurs.</td>
<td>Increase the speed control gain.</td>
</tr>
<tr>
<td>6</td>
<td>Decrease the speed integral compensation within the vibration-free range. If vibration occurs, increase the value until the vibration stops.</td>
<td>Decrease the time constant of the speed integral compensation.</td>
</tr>
<tr>
<td>7</td>
<td>Increase the position control gain, and return slightly if vibration occurs.</td>
<td>Increase the position control gain.</td>
</tr>
<tr>
<td>8</td>
<td>Increase the model control gain, and return slightly if an overshoot occurs.</td>
<td>Increase the model control gain.</td>
</tr>
<tr>
<td>9</td>
<td>If the desired responsiveness cannot be achieved because of mechanical system resonance or the like which stops the gains from being increased, suppressing the resonance with adaptive tuning mode or the machine resonance suppression filter and then following steps 3 to 8 may increase the responsiveness.</td>
<td>Suppress of machine resonance Refer to the following.</td>
</tr>
<tr>
<td>10</td>
<td>While checking the settling characteristic and the motor status, fine-adjust each gain.</td>
<td>Fine adjustment</td>
</tr>
</tbody>
</table>

Servo parameter adjustment method

[Pr. PB07 Model control gain]
As a guide, this servo parameter can be calculated with the following formula.

\[
\text{Model control gain guideline} = \frac{\text{Speed control gain}}{(1 + \text{Load to motor inertia ratio})} \times \left(\frac{1}{4} \text{ to } \frac{1}{2}\right)
\]

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

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

Position command frequency differs depending on the operation mode.
- For rotary servo motors
  
  \[
  \text{Position command frequency} = \frac{\text{Servo motor speed [r/min]}}{60} \times \text{Encoder resolution (number of pulses per servo motor revolution)}
  \]
- Linear servo motors
  
  \[
  \text{Position command frequency} = \frac{\text{Speed [mm/s]}}{60} \times \text{Encoder resolution (travel distance per pulse)}
  \]
3.8 Load to motor inertia ratio monitor mode

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

Precautions on load to motor inertia ratio monitor mode

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

Adjustment procedure for load to motor inertia ratio monitor mode

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

Operation of load to motor inertia ratio monitor mode

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB06</td>
<td>GD2</td>
<td>Load to motor inertia ratio/ load to motor mass ratio</td>
</tr>
</tbody>
</table>
Increasing the servo system response level in a mechanical system that has a unique resonance point may cause resonance (vibration or unusual noise) in the mechanical system at that resonance frequency. By using various type of filters, resonance of the mechanical system can be suppressed, improving the responsiveness of the servo system.

### 4.1 Filter setting

The following filters are available with this servo amplifier.

#### 4.2 Machine resonance suppression filter

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

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

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

**Precautions**

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

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

Machine resonance suppression filter precautions

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

Machine resonance suppression filter setting method

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

<table>
<thead>
<tr>
<th>Item</th>
<th>Servo parameter</th>
<th>Notch frequency</th>
<th>Notch depth, notch width</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine resonance</td>
<td>[Pr. PB01.0 Filter tuning mode selection]</td>
<td>[Pr. PB13 Machine resonance suppression filter 1]</td>
<td></td>
<td>---</td>
</tr>
<tr>
<td>suppression filter 1</td>
<td></td>
<td>[Pr. PB14.1 Notch depth selection 1]</td>
<td>[Pr. PB14.2 Notch width selection 1]</td>
<td></td>
</tr>
<tr>
<td>Machine resonance</td>
<td>[Pr. PB16.0 Machine resonance suppression filter 2 selection]</td>
<td>[Pr. PB15 Machine resonance suppression filter 2]</td>
<td></td>
<td>---</td>
</tr>
<tr>
<td>suppression filter 2</td>
<td></td>
<td>[Pr. PB16.1 Notch depth selection 2]</td>
<td>[Pr. PB16.2 Notch width selection 2]</td>
<td></td>
</tr>
<tr>
<td>Machine resonance</td>
<td>[Pr. PB47.0 Machine resonance suppression filter 3 selection]</td>
<td>[Pr. PB46 Machine resonance suppression filter 3]</td>
<td></td>
<td>Shaft resonance suppression filter 2 cannot be set when machine resonance suppression filter 3 is enabled.</td>
</tr>
<tr>
<td>suppression filter 3</td>
<td></td>
<td>[Pr. PB47.1 Notch depth selection 3]</td>
<td>[Pr. PB47.2 Notch width selection 3]</td>
<td></td>
</tr>
<tr>
<td>Machine resonance</td>
<td>[Pr. PB49.0 Machine resonance suppression filter 4 selection]</td>
<td>[Pr. PB48 Machine resonance suppression filter 4]</td>
<td></td>
<td>Shaft resonance suppression filter cannot be set when machine resonance suppression filter 4 is enabled.</td>
</tr>
<tr>
<td>suppression filter 4</td>
<td></td>
<td>[Pr. PB49.1 Notch depth selection 4]</td>
<td>[Pr. PB49.2 Notch width selection 4]</td>
<td></td>
</tr>
<tr>
<td>Machine resonance</td>
<td>[Pr. PB51.0 Machine resonance suppression filter 5 selection]</td>
<td>[Pr. PB50 Machine resonance suppression filter 5]</td>
<td></td>
<td>Machine resonance suppression filter 5 cannot be used when the robust filter is enabled (i.e., when [Pr. PE41.0 Robust filter selection] is set to &quot;1&quot; (enabled)).</td>
</tr>
<tr>
<td>suppression filter 5</td>
<td></td>
<td>[Pr. PB51.1 Notch depth selection 5]</td>
<td>[Pr. PB51.2 Notch width selection 5]</td>
<td></td>
</tr>
</tbody>
</table>
Operation of machine resonance suppression filter

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

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

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

- When machine resonance is large and frequency is low

- When machine resonance is small and frequency is high

**Precautions**

- The machine resonance frequency which adaptive filter II (adaptive tuning) can respond to is about 100 Hz to 2,250 kHz. As for the resonance frequency out of the range, set adaptive filter II manually.
- When adaptive tuning is executed, machine resonance is detected for a maximum of 10 s and a filter is generated. After filter generation, the adaptive tuning mode automatically shifts to the manual setting.
- Adaptive tuning generates an optimum filter with the currently set control gain. If vibration occurs when the response setting is increased, execute adaptive tuning again.
- Adaptive tuning generates a filter with an optimum notch depth for the set control gain. To allow a wider range of the resonance frequency for filtering, increase the notch depth in the manual setting.
- Adaptive tuning is ineffective on a mechanical system with complex resonance characteristics.

**Restrictions on adaptive tuning**

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

**Precautions for adaptive filter II**

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

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

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

<table>
<thead>
<tr>
<th>Setting value</th>
<th>Filter tuning mode selection</th>
<th>Automatically set servo parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Disabled</td>
<td>—</td>
</tr>
<tr>
<td>1</td>
<td>Automatic setting</td>
<td>PB13/PB14</td>
</tr>
<tr>
<td>2</td>
<td>Manual setting</td>
<td>—</td>
</tr>
</tbody>
</table>

• [Pr. PB01.3 Tuning accuracy selection]

0: Standard
1: High accuracy

Adaptive tuning procedure

- If the vibration frequency cannot be estimated when tuning is executed during strong vibration or oscillation, decrease the response setting temporarily down to the vibration level and execute tuning again.

- The response level has been reached to the machine limit.
- The machine is too complicated to provide the optimum filter.
4.4 Shaft resonance suppression filter

When a load is mounted to the servo motor shaft, resonance by shaft torsion during servo motor drive generates high frequency mechanical vibration. The shaft resonance suppression filter suppresses this vibration.

Selecting "Automatic setting" sets the filter automatically based on the servo motor used and the load to motor inertia ratio. If the resonance frequency is high, disable the setting to increase the responsiveness of the servo amplifier.

Precautions

- It is recommended that [Pr. PB23.0 Shaft resonance suppression filter selection] and [Pr. PB23.3 Shaft resonance suppression filter selection 2] be set to (automatic setting) "0" and "1" respectively, as deterioration in performance may occur if there are changes in the setup of [Pr. PB23.0 Shaft resonance suppression filter selection], [Pr. PB23.3 Shaft resonance suppression filter 2 selection], and [Pr. PB17.0-1 Shaft resonance suppression filter frequency selection].

Shaft resonance suppression filter restrictions

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

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

Shaft resonance suppression filter setting method

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB23.0</td>
<td>Shaft resonance suppression filter selection</td>
</tr>
<tr>
<td></td>
<td>0: Automatic setting</td>
</tr>
<tr>
<td></td>
<td>1: Manual setting</td>
</tr>
<tr>
<td></td>
<td>2: Disabled</td>
</tr>
<tr>
<td>PB23.3</td>
<td>Shaft resonance suppression filter 2 selection</td>
</tr>
<tr>
<td></td>
<td>0: Disabled</td>
</tr>
<tr>
<td></td>
<td>1: Automatic setting</td>
</tr>
</tbody>
</table>

When [Pr. PB23.0] is set to "0" (automatic setting), [Pr. PB17.0-1] will be set automatically.

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

<table>
<thead>
<tr>
<th>Setting value</th>
<th>Frequency [Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Disabled</td>
</tr>
<tr>
<td>01</td>
<td>Disabled</td>
</tr>
<tr>
<td>02</td>
<td>4500</td>
</tr>
<tr>
<td>03</td>
<td>3000</td>
</tr>
<tr>
<td>04</td>
<td>2250</td>
</tr>
<tr>
<td>05</td>
<td>1800</td>
</tr>
<tr>
<td>06</td>
<td>1500</td>
</tr>
<tr>
<td>07</td>
<td>1285</td>
</tr>
<tr>
<td>08</td>
<td>1125</td>
</tr>
<tr>
<td>09</td>
<td>1000</td>
</tr>
<tr>
<td>0A</td>
<td>900</td>
</tr>
<tr>
<td>0B</td>
<td>818</td>
</tr>
<tr>
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### 4.4 Shaft resonance suppression filter

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<tr>
<th>Setting value</th>
<th>Frequency [Hz]</th>
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<td>9F</td>
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</table>
4.5 Low-pass filter

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

Low-pass filter setting method

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB23.1</td>
<td>Low-pass filter selection</td>
</tr>
<tr>
<td></td>
<td>0: Automatic setting</td>
</tr>
<tr>
<td></td>
<td>1: Manual setting</td>
</tr>
<tr>
<td></td>
<td>2: Disabled</td>
</tr>
</tbody>
</table>

Operation of low-pass filter

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

\[
\text{Filter frequency (rad/s)} = \frac{\sqrt{G^2} \times 8}{1 + \frac{G}{D^2}}
\]

4.6 Robust filter

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

Robust filter restrictions

Enabling the robust filter disables machine resonance suppression filter 5.

Robust filter setting method

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE41.0</td>
<td>Robust filter selection</td>
</tr>
<tr>
<td></td>
<td>0: Disabled</td>
</tr>
<tr>
<td></td>
<td>1: Enabled</td>
</tr>
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</table>
4.7 Advanced vibration suppression control II

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

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

**Precautions**

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

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

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

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

<table>
<thead>
<tr>
<th>Vibration suppression control</th>
<th>Usable range</th>
<th>Recommended setting range</th>
</tr>
</thead>
</table>
| Vibration suppression control 1 | [Pr. PB19] > \( \frac{1}{2\pi} \times (0.9 \times [Pr. PB07]) \)  
[Pr. PB20] > \( \frac{1}{2\pi} \times (0.9 \times [Pr. PB07]) \) | [Pr. PB19] > \( \frac{1}{2\pi} \times (1.5 \times [Pr. PB07]) \)  
[Pr. PB20] > \( \frac{1}{2\pi} \times (1.5 \times [Pr. PB07]) \) |
| Vibration suppression control 2 | When [Pr. PB19] < [Pr. PB52]  
[Pr. PB52] > (5.0 + 0.1 × [Pr. PB07])  
[Pr. PB52] > (5.0 + 0.1 × [Pr. PB07])  
1.1 < [Pr. PB52]/[Pr. PB19] < 5.5  
[Pr. PB07] < \( 2\pi \times (0.3 \times [Pr. PB19] + 1/8 \times [Pr. PB52]) \) | When [Pr. PB19] < [Pr. PB52]  
[Pr. PB52], [Pr. PB53] > 6.25 Hz  
1.1 < [Pr. PB52]/[Pr. PB19] < 4  
[Pr. PB07] < 1/3 \times (4 \times [Pr. PB19] + 2 \times [Pr. PB52]) |

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

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

<table>
<thead>
<tr>
<th>Vibration suppression control</th>
<th>Usable range</th>
<th>Recommended setting range</th>
</tr>
</thead>
</table>
| Vibration suppression control 1 | [Pr. PB07] < \( 2\pi \times [Pr. PB19]/0.9 \)  
[Pr. PB07] < \( 2\pi \times [Pr. PB20]/0.9 \) | Range that meets all of the following conditions  
[Pr. PB07] < \( 2\pi \times [Pr. PB19]/1.5 \)  
[Pr. PB07] < \( 2\pi \times [Pr. PB20]/1.5 \) |
| Vibration suppression control 2 | When [Pr. PB19] < [Pr. PB52]  
[Pr. PB07] < \( (Pr. PB52 – 5.0) \times 10 \)  
[Pr. PB07] < \( (Pr. PB53 – 5.0) \times 10 \)  
1.1 < [Pr. PB52]/[Pr. PB19] < 5.5  
[Pr. PB07] < \( 2\pi \times (0.3 \times [Pr. PB19] + 1/8 \times [Pr. PB52]) \) | Range that meets all of the following conditions  
[Pr. PB07] < \( (Pr. PB52 – 5.0) \times 10 \)  
[Pr. PB07] < \( (Pr. PB53 – 5.0) \times 10 \)  
1.1 < [Pr. PB52]/[Pr. PB19] < 5.5  
[Pr. PB07] < \( 2\pi \times (0.3 \times [Pr. PB19] + 1/8 \times [Pr. PB52]) \) |

The calculation example is shown in the following table.

<table>
<thead>
<tr>
<th>Vibration suppression control</th>
<th>Servo parameter setting example</th>
<th>Usable range</th>
<th>Recommended setting range</th>
</tr>
</thead>
</table>
| Vibration suppression control 1 | [Pr. PB19]  
[Pr. PB20] | 20  
20 | [Pr. PB07] < 139.6  
[Pr. PB07] < 63.7 |
| Vibration suppression control 2 | [Pr. PB19]  
[Pr. PB20]  
[Pr. PB52]  
[Pr. PB53] | 20  
20  
30  
30 | [Pr. PB07] < 61.26  
[Pr. PB07] < 46.44 |

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

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

Advanced vibration suppression control setting method

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

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

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

<table>
<thead>
<tr>
<th>Setting value</th>
<th>Vibration suppression control 1 - Tuning mode selection</th>
<th>Automatically set servo parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<td>—</td>
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<tr>
<td>1</td>
<td>Automatic setting</td>
<td>PB19/PB20/PB21/PB22</td>
</tr>
<tr>
<td>2</td>
<td>Manual setting</td>
<td>—</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Setting value</th>
<th>Vibration suppression control 2 - Tuning mode selection</th>
<th>Automatically set servo parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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</tr>
<tr>
<td>1</td>
<td>Automatic setting</td>
<td>PB52/PB53/PB54/PB55</td>
</tr>
<tr>
<td>2</td>
<td>Manual setting</td>
<td>—</td>
</tr>
</tbody>
</table>

Advanced vibration suppression control adjustment method

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

The following is a flowchart of vibration suppression control 1. When using Vibration suppression control 2, set [Pr. PB02.1 Vibration suppression control 2 tuning mode] to "1" (automatic setting), and execute Vibration suppression control tuning.
When adjusting the vibration suppression control manually based on the result of the machine analyzer or the vibration waveform of the load side, set the following parameters. Set the following servo parameters to meet the applicable and recommended range. Refer to the following.

Caution: Page 57 Advanced vibration suppression control restrictions

<table>
<thead>
<tr>
<th>Setting item</th>
<th>Vibration suppression control 1</th>
<th>Vibration suppression control 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration suppression control - Vibration frequency</td>
<td>[Pr. PB19]</td>
<td>[Pr. PB52]</td>
</tr>
<tr>
<td>Vibration suppression control - Resonance frequency</td>
<td>[Pr. PB20]</td>
<td>[Pr. PB53]</td>
</tr>
<tr>
<td>Vibration suppression control - Vibration frequency damping</td>
<td>[Pr. PB21]</td>
<td>[Pr. PB54]</td>
</tr>
<tr>
<td>Vibration suppression control - Resonance frequency damping</td>
<td>[Pr. PB22]</td>
<td>[Pr. PB55]</td>
</tr>
</tbody>
</table>
The servo parameters are set using the following procedure.

1. Select "2" (manual setting) in [Pr. PB02.0 Vibration suppression control 1 - Tuning mode selection] or "2" (manual setting) in [Pr. PB02.1 Vibration suppression control 2 - Tuning mode selection].

2. Set "Vibration suppression control for vibration suppression control" and "Resonance frequency for vibration suppression control" as follows.
   - When a vibration peak can be checked with machine analyzer in MR Configurator2 or with external measuring equipment
     If the frequency characteristic of the machine can be measured using machine analyzer in MR Configurator2 or external equipment, set the frequency trough of the gain characteristic to the vibration frequency setting, and the frequency crest as the resonance frequency setting.

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

![Diagram of gain characteristics and phase](image)
3. Set "Vibration suppression control - Vibration frequency damping setting" and "Vibration suppression control - Resonance frequency damping setting". Regular adjustment of the damping setting is not required. Decrease the damping setting to (1) further enhance the vibration suppression effect, or (2) to measure the droop pulses when the vibration suppression control is invalid, and sustain the amplitude of the droop pulses at settling time. If the amplitude of the droop pulses are decreasing quickly, increase the damping setting. By setting the damping setting appropriately, the effect of vibration suppression is enhanced.

- If the amplitude of the droop pulses is sustained

![Diagram showing vibration suppression effect](image1.png)

- If the amplitude of the droop pulses are decreasing quickly

![Diagram showing droop pulse decrease](image2.png)
4.8 Command notch filter

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

- When command notch filter is disabled

![Diagram showing position and load side](image)

- When command notch filter is enabled

![Diagram showing position and load side](image)

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

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

**Precautions**

- Using advanced vibration suppression control II and the command notch filter can suppress the load-side vibration of three different frequencies.

- The frequency of machine vibration that can be supported by the command notch filter is specifically between 1.12 Hz and 2000 Hz. Set a frequency close to the machine vibration frequency and within the range.

- When [Pr. PB45 Command notch filter] is changed during the positioning operation, the changed setting is not reflected. The setting value is reflected after waiting for the following time once the servo motor stops (after servo-lock).

<table>
<thead>
<tr>
<th>Setting frequency for command notch filter before the change</th>
<th>Waiting time for reflection of the change after servo-lock</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 Hz or more</td>
<td>Approx. 150 ms</td>
</tr>
<tr>
<td>1.12 Hz or more to less than 4.5 Hz</td>
<td>Approx. 500 ms</td>
</tr>
</tbody>
</table>
Command notch filter setting method

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

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

<table>
<thead>
<tr>
<th>Setting value</th>
<th>Frequency [Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
<td>Disabled</td>
</tr>
<tr>
<td>01</td>
<td>2000</td>
</tr>
<tr>
<td>02</td>
<td>1000</td>
</tr>
<tr>
<td>03</td>
<td>666</td>
</tr>
<tr>
<td>04</td>
<td>500</td>
</tr>
<tr>
<td>06</td>
<td>400</td>
</tr>
<tr>
<td>07</td>
<td>333</td>
</tr>
<tr>
<td>08</td>
<td>285</td>
</tr>
<tr>
<td>09</td>
<td>250</td>
</tr>
<tr>
<td>0A</td>
<td>222</td>
</tr>
<tr>
<td>0B</td>
<td>200</td>
</tr>
<tr>
<td>0C</td>
<td>181</td>
</tr>
<tr>
<td>0D</td>
<td>166</td>
</tr>
<tr>
<td>0F</td>
<td>153</td>
</tr>
<tr>
<td>10</td>
<td>142</td>
</tr>
<tr>
<td>11</td>
<td>133</td>
</tr>
<tr>
<td>12</td>
<td>125</td>
</tr>
<tr>
<td>13</td>
<td>117</td>
</tr>
<tr>
<td>14</td>
<td>111</td>
</tr>
<tr>
<td>15</td>
<td>105</td>
</tr>
<tr>
<td>16</td>
<td>100</td>
</tr>
<tr>
<td>17</td>
<td>95</td>
</tr>
<tr>
<td>19</td>
<td>90</td>
</tr>
<tr>
<td>1A</td>
<td>86</td>
</tr>
<tr>
<td>1B</td>
<td>83</td>
</tr>
<tr>
<td>1C</td>
<td>80</td>
</tr>
<tr>
<td>1D</td>
<td>76</td>
</tr>
<tr>
<td>1E</td>
<td>74</td>
</tr>
<tr>
<td>1F</td>
<td>71</td>
</tr>
<tr>
<td>21</td>
<td>66</td>
</tr>
<tr>
<td>22</td>
<td>62</td>
</tr>
<tr>
<td>23</td>
<td>58</td>
</tr>
<tr>
<td>24</td>
<td>55</td>
</tr>
<tr>
<td>25</td>
<td>52</td>
</tr>
<tr>
<td>26</td>
<td>50</td>
</tr>
<tr>
<td>27</td>
<td>47</td>
</tr>
<tr>
<td>29</td>
<td>45</td>
</tr>
<tr>
<td>2A</td>
<td>43</td>
</tr>
<tr>
<td>2B</td>
<td>41</td>
</tr>
<tr>
<td>2C</td>
<td>40</td>
</tr>
<tr>
<td>2D</td>
<td>38</td>
</tr>
<tr>
<td>2E</td>
<td>37</td>
</tr>
<tr>
<td>2F</td>
<td>35</td>
</tr>
<tr>
<td>30</td>
<td>34.5</td>
</tr>
<tr>
<td>31</td>
<td>33.3</td>
</tr>
<tr>
<td>Setting value</td>
<td>Frequency [Hz]</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>32</td>
<td>31.3</td>
</tr>
<tr>
<td>33</td>
<td>29.4</td>
</tr>
<tr>
<td>34</td>
<td>27.8</td>
</tr>
<tr>
<td>35</td>
<td>26.3</td>
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<td>36</td>
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<tr>
<td>38</td>
<td>23.8</td>
</tr>
<tr>
<td>39</td>
<td>22.7</td>
</tr>
<tr>
<td>3A</td>
<td>21.7</td>
</tr>
<tr>
<td>3B</td>
<td>20.8</td>
</tr>
<tr>
<td>3C</td>
<td>20.0</td>
</tr>
<tr>
<td>3D</td>
<td>19.2</td>
</tr>
<tr>
<td>3E</td>
<td>18.5</td>
</tr>
<tr>
<td>3F</td>
<td>17.9</td>
</tr>
<tr>
<td>40</td>
<td>17.2</td>
</tr>
<tr>
<td>41</td>
<td>16.7</td>
</tr>
<tr>
<td>42</td>
<td>15.6</td>
</tr>
<tr>
<td>43</td>
<td>14.7</td>
</tr>
<tr>
<td>44</td>
<td>13.9</td>
</tr>
<tr>
<td>45</td>
<td>13.2</td>
</tr>
<tr>
<td>46</td>
<td>12.5</td>
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<tr>
<td>48</td>
<td>11.9</td>
</tr>
<tr>
<td>49</td>
<td>11.4</td>
</tr>
<tr>
<td>4A</td>
<td>10.9</td>
</tr>
<tr>
<td>4B</td>
<td>10.4</td>
</tr>
<tr>
<td>4C</td>
<td>10</td>
</tr>
<tr>
<td>4D</td>
<td>9.6</td>
</tr>
<tr>
<td>4E</td>
<td>9.3</td>
</tr>
<tr>
<td>4F</td>
<td>8.9</td>
</tr>
<tr>
<td>50</td>
<td>8.6</td>
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<td>8.3</td>
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<tr>
<td>58</td>
<td>6.0</td>
</tr>
<tr>
<td>59</td>
<td>5.7</td>
</tr>
<tr>
<td>5A</td>
<td>5.4</td>
</tr>
<tr>
<td>5B</td>
<td>5.2</td>
</tr>
<tr>
<td>5C</td>
<td>5.0</td>
</tr>
<tr>
<td>5D</td>
<td>4.8</td>
</tr>
<tr>
<td>5E</td>
<td>4.6</td>
</tr>
<tr>
<td>5F</td>
<td>4.5</td>
</tr>
<tr>
<td>60</td>
<td>4.31</td>
</tr>
<tr>
<td>61</td>
<td>4.17</td>
</tr>
<tr>
<td>62</td>
<td>3.91</td>
</tr>
<tr>
<td>63</td>
<td>3.68</td>
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<td>3.47</td>
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<td>65</td>
<td>3.29</td>
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<tr>
<td>66</td>
<td>3.13</td>
</tr>
<tr>
<td>68</td>
<td>2.98</td>
</tr>
<tr>
<td>69</td>
<td>2.84</td>
</tr>
<tr>
<td>6A</td>
<td>2.72</td>
</tr>
</tbody>
</table>
### 4.8 Command notch filter

#### Setting value

<table>
<thead>
<tr>
<th>Setting value</th>
<th>Depth [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>6B</td>
<td>2.60</td>
</tr>
<tr>
<td>6C</td>
<td>2.50</td>
</tr>
<tr>
<td>6D</td>
<td>2.40</td>
</tr>
<tr>
<td>6E</td>
<td>2.31</td>
</tr>
<tr>
<td>6F</td>
<td>2.23</td>
</tr>
<tr>
<td>71</td>
<td>2.08</td>
</tr>
<tr>
<td>72</td>
<td>1.95</td>
</tr>
<tr>
<td>73</td>
<td>1.84</td>
</tr>
<tr>
<td>74</td>
<td>1.74</td>
</tr>
<tr>
<td>75</td>
<td>1.64</td>
</tr>
<tr>
<td>76</td>
<td>1.56</td>
</tr>
<tr>
<td>78</td>
<td>1.49</td>
</tr>
<tr>
<td>79</td>
<td>1.42</td>
</tr>
<tr>
<td>7A</td>
<td>1.36</td>
</tr>
<tr>
<td>7B</td>
<td>1.30</td>
</tr>
<tr>
<td>7C</td>
<td>1.25</td>
</tr>
<tr>
<td>7D</td>
<td>1.20</td>
</tr>
<tr>
<td>7E</td>
<td>1.16</td>
</tr>
<tr>
<td>7F</td>
<td>1.12</td>
</tr>
</tbody>
</table>

- [Pr. PB45.2 Notch depth selection]

#### Setting value

<table>
<thead>
<tr>
<th>Setting value</th>
<th>Frequency [Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-40.0</td>
</tr>
<tr>
<td>1</td>
<td>-24.1</td>
</tr>
<tr>
<td>2</td>
<td>-18.1</td>
</tr>
<tr>
<td>3</td>
<td>-14.5</td>
</tr>
<tr>
<td>4</td>
<td>-12.0</td>
</tr>
<tr>
<td>5</td>
<td>-10.1</td>
</tr>
<tr>
<td>6</td>
<td>-8.5</td>
</tr>
<tr>
<td>7</td>
<td>-7.2</td>
</tr>
<tr>
<td>8</td>
<td>-6.0</td>
</tr>
<tr>
<td>9</td>
<td>-5.0</td>
</tr>
<tr>
<td>A</td>
<td>-4.1</td>
</tr>
<tr>
<td>B</td>
<td>-3.3</td>
</tr>
<tr>
<td>C</td>
<td>-2.5</td>
</tr>
<tr>
<td>D</td>
<td>-1.8</td>
</tr>
<tr>
<td>E</td>
<td>-1.2</td>
</tr>
<tr>
<td>F</td>
<td>-0.6</td>
</tr>
</tbody>
</table>
4.9 Vibration tough drive

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

Vibration tough drive restrictions

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

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

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

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

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

Vibration tough drive precautions

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

Vibration tough drive setting method

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Description</th>
</tr>
</thead>
</table>
| PA20.1          | Vibration tough drive selection  
|                 | 0: Disabled  
|                 | 1: Machine resonance suppression filter change mode enabled  
|                 | 2: Machine resonance suppression filter automatic setting mode  
|                 | When using the vibration tough drive, it is recommended to use "2" (machine resonance suppression filter automatic setting mode). |
Operation of vibration tough drive

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

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

The servo parameters are updated according to the table above.
The timing chart of the vibration tough drive is shown as follows:

- **Torque**
- **ALM (Malfunction)**
- **WNG (Warning)**
- **MTTR (During tough drive)**

- **ALM (Malfunction)**:
  - ON
  - OFF

- **WNG (Warning)**:
  - ON
  - OFF

- **MTTR (During tough drive)**:
  - ON
  - OFF

The machine resonance is detected and the filter is automatically configured. MTTR (During tough drive) is not turned on in the vibration tough drive function.
4.10 Command smoothing filter

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

Precautions

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

Restrictions on the command smoothing filter

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

Instructions on the command smoothing filter

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

How to set the command smoothing filter

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB81.4</td>
<td>Position command smoothing filter Initial value: 0h (disabled)</td>
</tr>
<tr>
<td>PB82</td>
<td>Position command smoothing filtering time constant Initial value: 0.0</td>
</tr>
</tbody>
</table>

Time constant [ms] can be obtained by dividing 1000 by the frequency [Hz].

For example, set 1.0 [ms] to suppress vibrations at a frequency of 1000 [Hz] or higher, and set 100.0 [ms] to suppress vibrations at a frequency of 10 [Hz] or higher.
5 GAIN SWITCHING FUNCTION

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

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

5.1 Restrictions on gain switching

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

5.2 Precautions on gain switching

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

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

Servo parameters for setting the gain switching condition

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

[Pr. PB26 Gain switching function]

Select the gain switching condition.

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB26.0</td>
<td>Gain switching selection 0: Disabled 1: Signal (CDP/C_CDP) 2: Command frequency 3: Droop pulses 4: Servo motor speed 5: Command direction When “1” is selected, the gain changes to “Gain after gain switching” by using the control command (C_CDP) from the controller or the input device CDP (Gain switching).</td>
</tr>
<tr>
<td>PB26.1</td>
<td>Gain switching - Condition selection 0: Gain after “Gain switching” is enabled with the value of the gain switching condition or more 1: Gain after “Gain switching” is enabled with the value of the gain switching condition or less The gain switching condition varies depending on the setting value of [Pr. PB26.0]. Page 72 Combination of [Pr. PB26.0] and [Pr. PB26.1]</td>
</tr>
<tr>
<td>PB26.2</td>
<td>Gain switching time constant - Disabling condition selection 0: Switching time constant enabled 1: Time constant disabled at switching 2: Time constant disabled at return</td>
</tr>
<tr>
<td>PB26.4</td>
<td>Gain switching 2 selection 0: Disabled 1: Signal (CDP2/C_CDP2) 2: The same condition as [Pr. PB26.0 Gain switching selection] When “1” is selected, the gain changes to “Gain after gain switching 2” by using the control command (C_CDP2) from the controller or the input device CDP2 (Gain switching 2). When “1” is set in [Pr. PB26.0] while “2” has been selected for this servo parameter, the gain changes to “Gain after gain switching 2” by the control command (C_CDP2) from the controller or the input device CDP2 (Gain switching 2).</td>
</tr>
<tr>
<td>PB26.5</td>
<td>Gain switching selection during a stop 0: Gain switching 2 during a stop is disabled 1: Gain switching 2 during a stop is enabled This servo parameter is enabled in the following condition: [Pr. PB26.4] is set to “2” (the same condition as [Pr. PB26.0 Gain switching selection]) and [Pr. PB26.0] is set to “5” (command direction) in the position mode.</td>
</tr>
</tbody>
</table>
**Combination of [Pr. PB26.0] and [Pr. PB26.1]**

<table>
<thead>
<tr>
<th>[Pr. PB26.1 Gain switching - Condition selection]</th>
<th>[Pr. PB26.0 Gain switching selection]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Gain after “Gain switching” is enabled with the signal ON</td>
<td>Gain after “Gain switching” is enabled with the condition value or more for gain switching</td>
</tr>
<tr>
<td>1</td>
<td>Gain after “Gain switching” is enabled with the signal OFF</td>
</tr>
</tbody>
</table>

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

When “2” (Command frequency), “3” (Droop pulses), or “4” (Servo motor speed) is selected in [Pr. PB26.0 Gain switching selection], set [Pr. PB27] for the level to switch the gain to “Gain switching”.

When “2” (the same condition as [Pr. PB26.0]) is selected in [Pr. PB26.4 Gain switching 2 selection], set the level for switching the gain to “Gain switching 2” in [Pr. PB65].

The setting unit is shown in the following table.

<table>
<thead>
<tr>
<th>Gain switching condition</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Command frequency</td>
<td>[kpulse/s]</td>
</tr>
<tr>
<td>Droop pulses</td>
<td>[pulse]</td>
</tr>
<tr>
<td>Servo motor speed</td>
<td>[r/min][mm/s]</td>
</tr>
</tbody>
</table>

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

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

### Servo parameters that are changeable with the gain switching

<table>
<thead>
<tr>
<th>Control gain</th>
<th>Before gain switching</th>
<th>After gain switching</th>
<th>After gain switching 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Servo parameter</td>
<td>Symbol</td>
<td>Servo parameter</td>
<td>Symbol</td>
</tr>
<tr>
<td>Load to motor inertia ratio/load</td>
<td>GD2</td>
<td>GB2</td>
<td>GB2</td>
</tr>
<tr>
<td>to motor mass ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model control gain</td>
<td>PG1</td>
<td>PG1B</td>
<td>PG1B</td>
</tr>
<tr>
<td>Position control gain</td>
<td>PG2</td>
<td>PG2B</td>
<td>PG2B</td>
</tr>
<tr>
<td>Speed control gain</td>
<td>VG2</td>
<td>VG2B</td>
<td>VG2B</td>
</tr>
<tr>
<td>Speed integral compensation</td>
<td>VIC</td>
<td>VICB</td>
<td>VICB</td>
</tr>
<tr>
<td>Vibration suppression control 1</td>
<td>VRF11</td>
<td>VRF1B</td>
<td>VRF1B</td>
</tr>
<tr>
<td>Vibration frequency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration suppression control 1</td>
<td>VRF12</td>
<td>VRF2B</td>
<td>VRF2B</td>
</tr>
<tr>
<td>Resonance frequency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration suppression control 1</td>
<td>VRF13</td>
<td>VRF3B</td>
<td>VRF3B</td>
</tr>
<tr>
<td>Vibration frequency damping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration suppression control 1</td>
<td>VRF14</td>
<td>VRF4B</td>
<td>VRF4B</td>
</tr>
<tr>
<td>Resonance frequency damping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration suppression control 2</td>
<td>VRF21</td>
<td>VRF21B</td>
<td>VRF21B</td>
</tr>
<tr>
<td>Vibration frequency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration suppression control 2</td>
<td>VRF22</td>
<td>VRF22B</td>
<td>VRF22B</td>
</tr>
<tr>
<td>Resonance frequency</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration suppression control 2</td>
<td>VRF23</td>
<td>VRF23B</td>
<td>VRF23B</td>
</tr>
<tr>
<td>Vibration frequency damping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vibration suppression control 2</td>
<td>VRF24</td>
<td>VRF24B</td>
<td>VRF24B</td>
</tr>
<tr>
<td>Resonance frequency damping</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**[Pr. PB06] to [Pr. PB10]**

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

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

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

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

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

Set the position control gain after gain switching.

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

Set the speed control gain after gain switching.

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

Set the speed integral compensation after gain switching.

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

Set the model control gain after gain switching.

These servo parameters are enabled when "1" (signal (CDP/C_CDP)) is selected in [Pr. PB26.0 Gain switching selection], and the signal is turned on.

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

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

Related objects

Objects in gain switching and gain switching 2

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

<table>
<thead>
<tr>
<th>Index</th>
<th>Sub</th>
<th>Object</th>
<th>Name</th>
<th>Data Type</th>
<th>Access</th>
<th>Default</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D01h</td>
<td>0</td>
<td>VAR</td>
<td>Control DI1</td>
<td>U16</td>
<td>rw</td>
<td>0000h</td>
<td>Bit 4: C_CDP (Gain switching)</td>
</tr>
<tr>
<td>2D05h</td>
<td>0</td>
<td>VAR</td>
<td>Control DI5</td>
<td>U16</td>
<td>rw</td>
<td>0000h</td>
<td>Bit 4: C_CDP2 (Gain switching 2)</td>
</tr>
<tr>
<td>2D11h</td>
<td>0</td>
<td>VAR</td>
<td>Status DO1</td>
<td>U16</td>
<td>ro</td>
<td>0000h</td>
<td>Bit 4: S_CDP (During gain switching)</td>
</tr>
<tr>
<td>2D15h</td>
<td>0</td>
<td>VAR</td>
<td>Status DO5</td>
<td>U16</td>
<td>ro</td>
<td>0000h</td>
<td>Bit 4: S_CDP2 (During gain switching 2)</td>
</tr>
</tbody>
</table>
5.4 Examples of gain switching operation

Gain switching by servo motor speed

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

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

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

<table>
<thead>
<tr>
<th>When [Pr. PB65] ≥ [Pr. PB27]</th>
</tr>
</thead>
</table>
| For the case of [Pr. PB65] ≥ [Pr. PB27], the gain switches to "Gain after gain switching" when the absolute value of the servo motor speed exceeds the value of [Pr. PB27]. In addition, when the absolute value of the servo motor speed exceeds the value of [Pr. PB65], the gain switches to "Gain after switching 2".

<table>
<thead>
<tr>
<th>Load to motor inertia ratio/load to motor mass ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Pr. PB06] → [Pr. PB29] → [Pr. PB67] → [Pr. PB29] → [Pr. PB06] → [Pr. PB29] → [Pr. PB68] → [Pr. PB29] → [Pr. PB06]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Position control gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Pr. PB08] → [Pr. PB30] → [Pr. PB68] → [Pr. PB30] → [Pr. PB08] → [Pr. PB30] → [Pr. PB68] → [Pr. PB30] → [Pr. PB08]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Speed control gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Pr. PB09] → [Pr. PB31] → [Pr. PB69] → [Pr. PB31] → [Pr. PB09] → [Pr. PB31] → [Pr. PB69] → [Pr. PB31] → [Pr. PB09]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Speed integral compensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Pr. PB10] → [Pr. PB32] → [Pr. PB70] → [Pr. PB32] → [Pr. PB10] → [Pr. PB32] → [Pr. PB70] → [Pr. PB32] → [Pr. PB10]</td>
</tr>
</tbody>
</table>
When [Pr. PB65] is set to "0"
When [Pr. PB65] is set to "0", the gain does not switch to "Gain after gain switching 2". When the absolute value of the servo motor speed exceeds the value of [Pr. PB27], the gain switches.

- **When [Pr. PB65] < [Pr. PB27]**
  For the case of [Pr. PB65] < [Pr. PB27], the gain does not switch to "Gain after gain switching". When the absolute value of the servo motor speed exceeds the value of [Pr. PB65], the gain switches to "Gain after gain switching 2". However, the gain does not switch to "Gain after gain switching" even when the absolute value exceeds the value of [Pr. PB27].
When [Pr. PB26.1 Gain switching - Condition selection] is set to "1" (enables the gain after gain switching even when the value set in the conditions for gain switching is not reached)

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

- **When [Pr. PB65] ≤ [Pr. PB27]**

  For the case of [Pr. PB65] ≤ [Pr. PB27], the gain switches to "Gain after gain switching 2" when the absolute value of the servo motor speed is less than the value of [Pr. PB65]. In addition, when the absolute value of the servo motor speed exceeds the value of [Pr. PB65] and less than the value of [Pr. PB27], the gain switches to "Gain after gain switching". When the absolute value of the servo motor speed is equal to or more than the value of [Pr. PB27], "Gain before gain switching" is used.
When [Pr. PB65] is set to "0"
When [Pr. PB65] is set to "0", the gain does not switch to "Gain after gain switching 2". When the absolute value of the servo motor speed is less than the value of [Pr. PB27], the gain switches to "Gain after gain switching".

When [Pr. PB65] > [Pr. PB27]
For the case of [Pr. PB65] > [Pr. PB27], the gain does not switch to "Gain after gain switching". When the absolute value of the servo motor speed is less than the value of [Pr. PB65], the gain switches to "Gain after gain switching 2". However, the gain does not switch to "Gain after gain switching" even when the absolute value is less than the value of [Pr. PB27].
Gain switching by signals (CDP/C_CDP/CDP2/C_CDP2)

The following illustrates an example where [Pr. PB26.0 Gain switching selection] is set to "1" (signal (CDP/C_CDP)).

Gain switching by control commands from the controller

The following shows the timing chart.

![Timing Chart]

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

The following illustrates an example where [Pr. PB26.0 Gain switching selection] is set to "5" (command direction) and [Pr. PB26.4 Gain switching 2 selection] is set to "2" (the same condition as [Pr. PB26.0]).

The gain switches depending on the command direction of a command pulse frequency and a speed command. A positive direction for the command direction is CCW regardless of the setting in [Pr. PA14 Travel direction selection]. When switching the gain by the command direction, the operation condition varies depending on whether "Gain switching during a stop" is enabled or disabled. However, "Gain switching during a stop" is enabled only in the position mode. Refer to the following table for details.

- In the position mode

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

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

- In the velocity mode

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

*1 If the mode is switched to the position mode, the gain changes to the "Gain after gain switching 2".
### When gain switching 2 during a stop is disabled

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

![Diagram of gain switching when Gain switching 2 during a stop is disabled](image)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pr.</th>
<th>Setting 1</th>
<th>Setting 2</th>
<th>Setting 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load to motor inertia ratio/load to motor mass ratio</td>
<td>PB06</td>
<td>→ PB29</td>
<td>→ PB06</td>
<td>→ PB06</td>
</tr>
<tr>
<td>Position control gain</td>
<td>PB08</td>
<td>→ PB30</td>
<td>→ PB08</td>
<td>→ PB08</td>
</tr>
<tr>
<td>Speed control gain</td>
<td>PB09</td>
<td>→ PB31</td>
<td>→ PB09</td>
<td>→ PB09</td>
</tr>
<tr>
<td>Speed integral compensation</td>
<td>PB10</td>
<td>→ PB32</td>
<td>→ PB10</td>
<td>→ PB10</td>
</tr>
</tbody>
</table>

### When gain switching 2 during a stop is enabled

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

![Diagram of gain switching when Gain switching 2 during a stop is enabled](image)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pr.</th>
<th>Setting 1</th>
<th>Setting 2</th>
<th>Setting 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load to motor inertia ratio/load to motor mass ratio</td>
<td>PB06</td>
<td>→ PB67</td>
<td>→ PB68</td>
<td>→ PB06</td>
</tr>
<tr>
<td>Position control gain</td>
<td>PB08</td>
<td>→ PB69</td>
<td>→ PB08</td>
<td>→ PB08</td>
</tr>
<tr>
<td>Speed control gain</td>
<td>PB09</td>
<td>→ PB70</td>
<td>→ PB09</td>
<td>→ PB09</td>
</tr>
<tr>
<td>Speed integral compensation</td>
<td>PB10</td>
<td>→ PB71</td>
<td>→ PB10</td>
<td>→ PB10</td>
</tr>
</tbody>
</table>
Gain switching by servo motor speed and gain switching 2 (C_CDP2)

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

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

| Load to motor inertia ratio/load to motor mass ratio | [Pr. PB06] → [Pr. PB06] → [Pr. PB06] → [Pr. PB07] → [Pr. PB07] |
| Model control gain | [Pr. PB07] → [Pr. PB07] → [Pr. PB07] → [Pr. PB07] |
| Position control gain | [Pr. PB08] → [Pr. PB08] → [Pr. PB08] → [Pr. PB08] |
| Speed control gain | [Pr. PB09] → [Pr. PB09] → [Pr. PB09] → [Pr. PB09] |
| Speed integral compensation | [Pr. PB10] → [Pr. PB10] → [Pr. PB10] → [Pr. PB10] |
| Vibration suppression control 1 - Vibration frequency | [Pr. PB19] → [Pr. PB19] → [Pr. PB19] → [Pr. PB19] |
| Vibration suppression control 1 - Vibration frequency/damping coefficient | [Pr. PB20] → [Pr. PB20] → [Pr. PB20] → [Pr. PB20] |
| Vibration suppression control 2 - Vibration frequency | [Pr. PB21] → [Pr. PB21] → [Pr. PB21] → [Pr. PB21] |
| Vibration suppression control 2 - Vibration frequency/damping coefficient | [Pr. PB22] → [Pr. PB22] → [Pr. PB22] → [Pr. PB22] |
| Vibration suppression control 3 - Vibration frequency | [Pr. PB23] → [Pr. PB23] → [Pr. PB23] → [Pr. PB23] |
| Vibration suppression control 3 - Vibration frequency/damping coefficient | [Pr. PB24] → [Pr. PB24] → [Pr. PB24] → [Pr. PB24] |

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

CDL 0 r/min
-CDL

Gain switching by servo motor speed and gain switching 2 (C_CDP2)
**When "Time constant disabled at switching" is selected in "Gain switching time constant - Disabling condition selection"**

The time constant is disabled at gain switching. The time constant becomes enabled at gain return. The following illustrates an example where [Pr. PB26.0 Gain switching selection] is set to "4" (Servo motor speed).

---

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

The time constant is enabled at gain switching. The time constant becomes disabled at gain return. The following illustrates an example where [Pr. PB26.0 Gain switching selection] is set to "4" (Servo motor speed).
6 SPEED FEED FORWARD CONTROL FUNCTION

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

6.1 Method for setting the speed feed forward

Setting a value in [Pr. PB04 Feed forward gain] enables the speed feed forward.

The droop pulses at a constant speed decrease in accordance with the value in [Pr. PB04], as shown in the following.

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

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

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

7.1 Restrictions on overshoot suppression control

- Overshoot suppression control is enabled in the position mode.
- When [Pr. PB25.0 Model adaptive control selection] is set to “2” (disabled), overshoot suppression control cannot be used.

7.2 Settings of the overshoot suppression control

When using overshoot suppression control, set the dynamic friction torque or thrust in relation to the servo motor rated speed in [Pr. PB12 Overshoot amount compensation] as the rated torque in percentage unit. If the response level is too low or if the torque/thrust is limited, the efficiency of overshoot suppression control may decrease.

Calculate the dynamic friction torque or thrust in relation to the servo motor rated speed from the torque at constant speed.

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

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

8.1 Restrictions on the slight vibration suppression control

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

8.2 Settings of the slight vibration suppression control

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB24.0</td>
<td>Slight vibration suppression control selection</td>
</tr>
<tr>
<td>0: Disabled</td>
<td></td>
</tr>
<tr>
<td>1: Enabled</td>
<td></td>
</tr>
</tbody>
</table>

8.3 Operation of slight vibration suppression control

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

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

9.1 Setting unbalanced torque offset

Set the unbalanced torque offset using the following procedure.

**Automatic setting**

1. Servo parameter setting
   Set [Pr. PE41.6 Unbalanced torque offset setting selection] to “1” (automatic setting).

2. Estimating friction
   Complete friction estimation for both the forward and reverse rotations.
   For the procedure of friction estimation, refer to "Vibration estimation function" in the following manual.
   MR-JET User’s Manual (Function)
   Once friction estimation is complete for both the forward and reverse rotations, the value of [Pr. PE47 Unbalanced torque offset] will be set automatically according to the estimated friction value.

**Manual setting**

1. Servo parameter setting
   Set [Pr. PE41.6 Unbalanced torque offset setting selection] to “0” (manual setting).

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

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

\[
\text{Unbalanced torque ['%'] = \frac{(\text{Torque in forward direction feed ['%']} + \text{Torque in reverse direction feed ['%']})}{2}}
\]
10 MODEL ADAPTIVE CONTROL

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

10.1 Setting model adaptive control

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

10.2 Disabling model adaptive control

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

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Symbol</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB08</td>
<td>PG2</td>
<td>Position control gain</td>
</tr>
<tr>
<td>PB09</td>
<td>VG2</td>
<td>Speed control gain</td>
</tr>
<tr>
<td>PB10</td>
<td>VIC</td>
<td>Speed integral compensation</td>
</tr>
</tbody>
</table>

Notes:

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

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

Notes:

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

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB25.0</td>
<td>Model adaptive control selection</td>
</tr>
<tr>
<td></td>
<td>0: Enabled (model adaptive control)</td>
</tr>
<tr>
<td></td>
<td>2: Disabled (PID control)</td>
</tr>
</tbody>
</table>
For machines that require a high path accuracy, such as processors, the following functions enable the path accuracy to be improved.

### 11.1 Path tracking model adaptive control

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

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

![Diagram 1](image1.png)

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

![Diagram 2](image2.png)

**Setting the path tracking model adaptive control**

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

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA24.0</td>
<td>Vibration suppression mode selection</td>
</tr>
<tr>
<td></td>
<td>0: Standard mode</td>
</tr>
<tr>
<td></td>
<td>1: 3 inertia mode</td>
</tr>
<tr>
<td></td>
<td>2: Low response mode</td>
</tr>
<tr>
<td></td>
<td>4: Path tracking mode</td>
</tr>
</tbody>
</table>
Operation of path tracking model adaptive control

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

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

Restrictions on super trace control

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

Instructions on super trace control

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

Setting the super trace control

The adjustment procedure for super trace control is as follows.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perform gain adjustment with quick tuning, one-touch tuning, auto tuning, or other means.</td>
</tr>
<tr>
<td></td>
<td>☐ Page 12 Quick tuning</td>
</tr>
<tr>
<td></td>
<td>☐ Page 16 One-touch tuning</td>
</tr>
<tr>
<td></td>
<td>☐ Page 33 Auto tuning mode 1</td>
</tr>
<tr>
<td>2</td>
<td>Change [Pr. PA08.0 Gain adjustment mode selection] to &quot;3&quot; (manual mode).</td>
</tr>
<tr>
<td>3</td>
<td>Change [Pr. PB04 Feed forward gain] and perform adjustment so that the droop pulses become 0 at the constant speed.</td>
</tr>
<tr>
<td>4</td>
<td>Change [Pr. PD13.2 INP output signal ON condition selection] to &quot;1&quot; (within the in-position range and at the completion of command output).</td>
</tr>
<tr>
<td>5</td>
<td>Change [Pr. PA22.1 Super trace control function selection] to &quot;2&quot; (enabled).</td>
</tr>
<tr>
<td>6</td>
<td>Change [Pr. PB07 Model control gain] to adjust the droop pulses at acceleration/deceleration.</td>
</tr>
</tbody>
</table>
Operation of super trace control

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

<table>
<thead>
<tr>
<th>Control</th>
<th>Position command (the same command)</th>
<th>Droop pulses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal control</td>
<td></td>
<td><img src="normal_control.png" alt="Diagram" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td><img src="normal_droop.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Feed forward gain</td>
<td></td>
<td><img src="feed_forward_gain.png" alt="Diagram" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td><img src="feed_forward_droop.png" alt="Diagram" /></td>
</tr>
<tr>
<td>Super trace control</td>
<td></td>
<td><img src="super_trace_control.png" alt="Diagram" /></td>
</tr>
<tr>
<td></td>
<td></td>
<td><img src="super_trace_droop.png" alt="Diagram" /></td>
</tr>
</tbody>
</table>

Droop pulses are always generated for Normal control.

Droop pulses are generated at acceleration/deceleration for Feed forward gain.

Droop pulses are almost 0 at any time including acceleration/deceleration for Super trace control.
11.3 Lost motion compensation function

The lost motion compensation function improves the response delay (caused by a non-sensitive band due to friction, twist, expansion, and backlash) generated when the machine travel direction is reversed. With this function, protrusions at a quadrant change and streaks at a quadrant change during circular cutting can be improved.

This function is effective when high path trackability is required, such as drawing an arc with an XY table.

Restrictions on the lost motion compensation function

The lost motion compensation is enabled in the position mode.

Setting the lost motion compensation function

Set the lost motion compensation using the following procedure.

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

Select the lost motion compensation function.

<table>
<thead>
<tr>
<th>Servo parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE48.0</td>
<td>Lost motion compensation type selection</td>
</tr>
<tr>
<td></td>
<td>0: Disabled</td>
</tr>
<tr>
<td></td>
<td>1: Enabled</td>
</tr>
<tr>
<td>PE48.1</td>
<td>Lost motion compensation dead band unit setting</td>
</tr>
<tr>
<td></td>
<td>0: 1 pulse unit</td>
</tr>
<tr>
<td></td>
<td>1: 1 kpulse unit</td>
</tr>
</tbody>
</table>

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

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

Unbalanced torque offset ([Pr. PE47])

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

Lost motion compensation timing ([Pr. PE49])

The delay time of the lost motion compensation start timing is set with this parameter. When a protrusion occurs belatedly, set the lost motion compensation timing corresponding to the occurrence timing of the protrusion.
**Lost motion compensation dead band ([Pr. PE50])**

When the travel direction reverses frequently around the zero speed, unnecessary lost motion compensation is triggered by the travel direction being switched. By setting the lost motion compensation dead band, the speed is recognized as 0 when the fluctuation of the droop pulse is the setting value or less. This prevents unnecessary lost motion compensation.

When the value of this parameter is changed, the compensation timing is also changed. Therefore re-adjust the value of the lost motion compensation timing ([Pr. PE49]).

**Lost motion filter setting ([Pr. PE46])**

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

**Adjusting the lost motion compensation**

Adjust the lost motion compensation using the following procedure.

**Measure the torque**

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

**Setting the lost motion compensation amount**

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

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

**Checking protrusions**

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

**Adjusting the lost motion compensation amount**

If the projections are still found, the compensation is insufficient. Increase the lost motion compensation amount by approximately 0.5 % until no projection is generated. If notches are generated, the compensation is excessive. Decrease the lost motion compensation amount by approximately 0.5 % until no notch is generated. Different compensation values can be set for:

1) When the forward rotation (CCW) switches to the reverse rotation (CW)
2) When the reverse rotation (CW) switches to the forward rotation (CCW)
### Adjusting the lost motion compensation timing

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

![Compensation](image)

**Travel direction**

- Delayed timing before compensation
- Delayed timing after compensation

### Adjusting the lost motion compensation dead band

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

![Compensation](image)

**Travel direction**

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

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

<table>
<thead>
<tr>
<th>Revision date</th>
<th>*Manual number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 2019</td>
<td>IB(NA)-0300473ENG-A</td>
<td>First edition</td>
</tr>
<tr>
<td>July 2020</td>
<td>IB(NA)-0300473ENG-B</td>
<td>■The following functions are added:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Linear servo motor control mode, continuous operation to torque control mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>■Edited sections:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chapter 1, Section 3.1, Section 3.2, Section 3.3, Section 3.7, Section 5.1</td>
</tr>
</tbody>
</table>

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WARRANTY

Warranty

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

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

[Limitations]
(1) You are requested to conduct an initial failure diagnosis by yourself, as a general rule. It can also be carried out by us or our service company upon your request and the actual cost will be charged. However, it will not be charged if we are responsible for the cause of the failure.
(2) This limited warranty applies only when the condition, method, environment, etc. of use are in compliance with the terms and instructions in the instruction manual and user manual for the Product and the caution label affixed to the Product.
(3) Even during the term of warranty, the repair cost will be charged on you in the following cases;
   1. a failure caused by your improper storing or handling, carelessness or negligence, etc., and a failure caused by your hardware or software problem
   2. a failure caused by any alteration, etc. to the Product made on your side without our approval
   3. a failure which may be regarded as avoidable, if your equipment in which the Product is incorporated is equipped with a safety device required by applicable laws and has any function or structure considered to be indispensable according to a common sense in the industry
   4. a failure which may be regarded as avoidable if consumable parts designated in the instruction manual, etc. are duly maintained and replaced
   5. any replacement of consumable parts (battery, fan, smoothing capacitor, etc.)
   6. a failure caused by external factors such as inevitable accidents, including without limitation fire and abnormal fluctuation of voltage, and acts of God, including without limitation earthquake, lightning and natural disasters
   7. a failure generated by an unforeseeable cause with a scientific technology that was not available at the time of the shipment of the Product from our company
   8. any other failures which we are not responsible for or which you acknowledge we are not responsible for

2. Term of warranty after the stop of production
(1) We may accept the repair at charge for another seven (7) years after the production of the product is discontinued. The announcement of the stop of production for each model can be seen in our Sales and Service, etc.
(2) Please note that the Product (including its spare parts) cannot be ordered after its stop of production.

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

4. Exclusion of loss in opportunity and secondary loss from warranty liability
Regardless of the gratis warranty term, Mitsubishi shall not be liable for compensation to:
(1) Damages caused by any cause found not to be the responsibility of Mitsubishi.
(2) Loss in opportunity, lost profits incurred to the user by Failures of Mitsubishi products.
(3) Special damages and secondary damages whether foreseeable or not, compensation for accidents, and compensation for damages to products other than Mitsubishi products.
(4) Replacement by the user, maintenance of on-site equipment, start-up test run and other tasks.

5. Change of Product specifications
Specifications listed in our catalogs, manuals or technical documents may be changed without notice.

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

MELSERVO is a trademark or registered trademark of Mitsubishi Electric Corporation in Japan and/or other countries. All other product names and company names are trademarks or registered trademarks of their respective companies.
Specifications are subject to change without notice.

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