Panasonic®

Servo System

MINAS A7B Series

Operating Instructions (Tuning)

EtherCAT Rotary Motor

- Thank you for purchasing a Panasonic product.
- Please use it correctly and safely after reading this document and Operating Instructions (Overall) carefully.
- Read *"1.1.1 Safety Precautions"* before use.
- Keep these Operating Instructions safe.
- This product is for industrial use. It cannot be used for any other purpose (e.g., household use).

Rev.1.1

IMG20
Z0924-5055

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Introduction

Servo drivers have many parameters for realizing various control functions and control performance. To obtain the desired control performance, functions appropriate for the characteristics of the target device must be selected, and parameters set while considering balance. Performing these tasks requires knowledge of controls and tuning experience, which is generally complex.

To facilitate setting parameters, this product is equipped with the following automatic tuning functions which automatically perform parameter setting tasks with no initial setting of control gain, or by simply configuring initial settings such as target control performance.

- TUNINGLESS: The driver automatically tunes the inertia ratio, enabling equipment to be operated immediately
- One Minute TUNING: Measuring the characteristics of equipment enables adjustments with control stability to be made in a short time
- precAIse TUNING: AI automatically optimizes even complex adjustments, enabling expert-level tuning

Notes

- Set-up Support Software (PANATERM ver.7) is equipped with AI.

This manual describes these automatic tuning functions and conventional manual tuning, as well as control functions for resolving various control challenges.

— Precautions —

- Unauthorized reproduction or duplication of the contents of the present text, either in whole or in part, is strictly prohibited.
- The contents of the present text (specifications, software versions, etc.) are subject to change without notice.
- Read *“1.1 Precautions”* before using this product.
- Before using the tuning and control functions, properly configure the settings described in *“2.2 Safety Function Setup Before Tuning”* .
- If communication with a host device is required, properly configure communication-related settings to prevent any obstruction to motor rotation.

1 Before Use

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1.1 Precautions

1.1.1 Safety Precautions

■ Must be adhered to

This section explains precautions that must be taken to prevent harm to people and damage to property.

■ The following symbols represent the extent of the harm or damage that may occur through improper use.

⚠ **Danger**	This indicates “a significant risk of death or serious injury”.
⚠ **Caution**	This indicates “a risk of injury or property damage”.

■ The matters to be observed are explained using the following symbols.

🚫	Must not be done.
❗	Must be done.

⚠DANGER

🚫	Do not use in wet places, corrosive atmospheres, inflammable gas atmospheres, atmospheres in which gases of low molecular weight such as helium gas are generated, or near combustible materials.	May cause fire.
	Do not place combustible materials near the motor, driver, regenerative resistor, or dynamic brake resistor.	
	Do not use in places subject to strong vibration or impact.	May cause electric shock, injury, and fire.
	Do not use with the cable immersed in oil or water.	May cause electric shock, malfunction, and damage.
	Do not install next to a heating element, such as a heater or large coil resistor.	May cause fire and malfunction.
	Never connect a commercial power supply directly to the motor.	
	Do not perform wiring or operate with wet hands.	May cause electric shock, injury, and fire.
	Never put your hand inside the driver.	May cause burns and electric shock.
	In the case of a motor with axis end keyway, do not touch the keyway with bare hands.	May cause injury.
	Never touch the rotating portion of the motor while it is running.	
	Do not touch the motor, driver heat sink, regenerative resistor, or dynamic brake resistor, since they become very hot.	May cause burns and parts damage.
	Do not drive the motor with external power.	May cause fire.
	Do not damage the cables, subject them to excessive force, place heavy objects on them, or pinch them.	May cause electric shock, malfunction, and damage.
❗	Install in an area free from excessive dust, water, oil, etc.	Improper installation site conditions may cause electric shock, fire, malfunction or damage.
	Install the motor, driver, and peripheral devices to nonflammable materials such as metal.	Mounting on a flammable material may cause fire.
	Wiring must be carried out by an expert in electrical work.	Wiring by a person with no expertise may cause electrical shock.
	Carry out wiring in accordance with the Operating Instructions.	Incorrect wiring may cause electrical shock, injury, malfunction, or damage.
	After correctly connecting cables, insulate the live parts with insulating material.	Incorrect wiring and short circuits may cause electrical shock, fire, or malfunction.
	Connect to the earth terminals of the motor and driver without fail.	Not grounding may cause electrical shock.
	Install and mount securely to prevent any possible fire or personal injury during an earthquake.	Failure to install properly may cause electric shock, fire, malfunction, or damage.
	Install an emergency stop circuit externally so that operation can be stopped and power turned off immediately in the event of an emergency.	
	Install an overcurrent protection device, residual current device, overheating prevention device, and emergency stop device without fail.	Failure to install and check these may cause electric shock, injury, or fire.
	After an earthquake, always confirm safety.	
	Before moving, wiring, or inspecting the driver, turn off power, wait at least as long as specified on the main unit side panel nameplate, and ensure that there is no risk of electrical shock.	Not turning off the power before these operations may cause electric shock.

⚠ **CAUTION**		
🚫	When transporting the product, do not hold it by the cable or motor axis.	May cause injury.
	Do not drop or tip over the product during transportation or installation.	May cause injury or malfunction.
	Do not stand on or place heavy objects on the product.	May cause electric shock, injury, malfunction, or damage.
	Do not place any objects that would block air passage around the motor, driver, and peripheral devices.	May cause burns or fires.
	Do not use in direct sunlight.	May cause injury or fire.
	Do not block or insert foreign matter into the heat dissipation holes.	May cause electric shock or fire.
	There should be no strong impact on the product.	May cause malfunction.
	There should be no strong impact on the motor axis.	May cause detectors, etc., to malfunction.
	Do not turn the driver main power on and off frequently.	May cause malfunction.
	Never run or stop the motor with the electromagnetic contactor installed on the main power supply side.	
	Do not make extreme gain adjustments or changes in the driver, or destabilize the driving or operation of the machine.	May cause injury.
	Do not use the motor’s built-in brakes to stop a moving load.	May cause injury or malfunction.
	Never modify, dismantle, or repair.	May cause fire, electric shock, injury, or malfunction.
❗	Mount in a manner appropriately matched to the base machine mass and product rated output.	Improper attachment or installation may cause injury or malfunction.
	Observe the specified mounting method and orientation.	
	Only use the eye bolt of the motor for transportation of the motor.	Use for transportation of the machine may cause injury or malfunction.
	Set the motor and driver ambient temperature within the temperature and humidity ranges for use.	Improper attachment or installation may cause injury or malfunction.
	Create the specified clearance in separating the driver from the control panel inner surface and from other devices when installing.	
	Maintain the specified voltage.	Operation at a voltage outside the rated voltage range may cause electric shock, injury, or fire.
	Connect a relay that disconnects in the event of an emergency stop in series with the brake control relay.	Not connecting it may cause injury or malfunction.
	Install safety devices for built-in brake or gear head idling or locking, or grease leakage from gear head.	Non-installation may cause injury, damage, or pollution.
	The servo drive may start up with no warning when power is restored after a blackout, so the machine must be set to ensure the safety of the operator at all times.	May cause injury.
	Use the specified combination of motor and driver.	May cause malfunction or fire if not used in the correct combination.
	To perform a trial run, secure the motor, and install it in the mechanical system after checking its operation while disconnected from the mechanical system.	Use of the wrong model or incorrect wiring may cause injury.
	When an error occurs, clear the error and only restart after eliminating the cause and ensuring safety.	Not eliminating the cause of the error might cause injury.
	If the driver malfunctions, shut off the power on the power supply side of the driver.	Continued passage of a large current may lead to fire.
	Always disconnect the power when not in use for a long time.	Improper operation may cause injury.
	Use a stabilized power supply with double insulation or reinforced insulation for the DC power supply.	May cause electric shock , fire or malfunction.

■ Other precautions

- When disposing of batteries, insulate them with tape and dispose of them in accordance with local regulations.
- When disposing of the Servo driver and motor, they are treated as industrial waste.
- Wrinkling of the label affixed to the motor will not present a problem in use of the motor.

1.1.2 Precautions for Proper Use

- Observe the following precautions when exporting the product or equipment incorporating the product.

  If the end user or end use of this product is related to the military or weaponry, etc., it may be subject to export restrictions as set forth in the Foreign Exchange and Foreign Trade Act or by the regional authority. When exporting, please review and follow the necessary export procedures.
- This product is intended for use with general industrial products. It is not designed or manufactured for use in machines or systems that may cause death on failure. This product is not for use in devices critical to human wellbeing or in specialized environments, such as nuclear power control, aerospace equipment, transportation systems, medical equipment or various safety devices.
- Installation, wiring, operation and maintenance of the equipment should be carried out by qualified and experienced personnel.
- Apply adequate tightening torque to the product mounting screws by taking into consideration the strength of the screws and the characteristics of the material to which the product is installed.
- Install safety equipment when applying this product to systems that could cause serious accidents or damage in the event of product failure.
- Because noise resistance may be affected by wiring conditions (e.g., earthing methods, cable length, signal wire shielding), please confirm the noise resistance of your equipment.
- Ensure that the motor axis is not operated without being electrically grounded, as this may lead to electrolytic corrosion of the motor bearing and increased bearing noise, depending on the machine and the installation environment.
- Some faults may cause the emission of roughly one cigarette's worth of smoke. Please consider these possibilities when using the device in cleanrooms and similar facilities.
- Make sure to follow indications as overloading products can cause loads to collapse.
- Do not use detergents containing benzine, thinner, alcohol, acid, or alkaline, since this may cause discoloration or damage the exterior of the product. When using a neutral detergent, please use a solution diluted to the concentration specified for the neutral detergent you are using.
- Treat as industrial waste on disposal.
- Please ensure that finished equipment complies with standards, laws and regulations, and confirm that the structure, dimensions, lifetime and characteristics of the product are suitable for your installed equipment and components.
- Note that use of this product outside the scope of specifications is not covered under warranty.
- Reverse engineering, decompiling and disassembling of this product is strictly prohibited.

1.1.3 Network Security

As you will use this product connected to a network, your attention is called to the following security risks.

1 Leakage or theft of information through this product

2 Use of this product for fraudulent operation by persons with malicious intent

3 Interference with or stoppage of this product by persons with malicious intent

It is the customer's responsibility to ensure that sufficient network security measures are taken, including the following.

We will not be liable for any damage caused by insufficient network security.

— Precautions —

- This product is to be used in an environment where only a limited number of parties are permitted access to the product.
- This product is not to be installed in locations where the product and its accessories, such as cables, can be easily destroyed.
- This product is to be used on a network that is not connected to the Internet.
- If an external device, such as a computer or tablet, is connected to this product, there are concerns about the effects of computer viruses and unauthorized programs.

  Take appropriate security measures with external devices, such as ensuring that they are checked for computer viruses and that regular cleaning of such viruses is performed before connecting them.
- If this product is turned over to a third party for transfer, disposal, repair, etc., important information may be left recorded in the device.

  Make deletions, etc.. at your own risk, and handle such matters with sufficient care.

1.2 Related Documents

The following are documents related to this product (including this manual). See each document as necessary for safe use of this product.

The documents can be downloaded from the following site.

https://industry.panasonic.com/global/en/

Document name	Abbreviations in this manual	Document No.	Description
Servo System Operating Instructions			
MINAS A7B Series Operating Instructions (Overall) EtherCAT Rotary Motor	OI_O	IMG07	This manual describes the selection, connection, usage, and error handling of servo drivers and servo motors to ensure correct and safe use of this product.
MINAS A7B Series Operating Instructions (Tuning) EtherCAT Rotary Motor	OI_A	IMG20	This document describes the adjustment function of the servo driver.
For MINAS Set-up Support Software (PANATERM ver.7) Operating Manual	PT_OM	IMG15	This document describes how to use PANATERM ver. 7, the setup support software for this product.
Servo Driver Standard Specification			
MINAS A7BSeries Standard Specifications Rotary Motor (Standard / Multi-function / Application specialized)	SS	SX-DSV03714	This document describes the hardware specifications of the servo driver.
Servo Driver Technical Reference			
MINAS A7B Series Technical Reference Functional Specification Rotary Motor (Standard / Multi-function / Application specialized)	TR_FS	SX-DSV03752	This document describes how to use the various functions of the servo driver.
MINAS A7B Series Technical Reference Communication Specification Rotary Motor (Standard / Multi-function / Application specialized)	TR_CS	SX-DSV03755	This document describes the interface that connects the servo driver to the host device.
Motion Controller User's Manual			
GM1 Controller User’s Manual (Operation)	GM1_UM	WUME-GM1OP	This document describes how to use the motion controller GM1.

1.3 Software Version

1.3.1 Notes Regarding Software

This product incorporates open source software (OSS), and usage is pursuant to the terms of the license (see Technical Reference Functional Specification “10 License Terms for Open Source Software (OSS)”). Your company may also have an obligation to use OSS, so please take appropriate measures at your company.

1.3.2 Applicable Software Version

The present manual applies to the following servo driver software versions.

CPU 1 (Software version 1)	Ver.1.05
CPU 2 (Software version 2)	Ver.1.02
Manufacture Software (Software version 3)	Ver.1.01

1.3.3 Software Version Confirmation Method

The above software versions can be confirmed using the following methods.

- Software version 1, Software version 2
  - EtherCAT communication command Obj.3744h:00h “Software version”
    (See Operating Instructions (Overall) “6.3.1 Device Information”)
  - Set-up Support Software (PANATERM ver.7)
- Software version 3
  - EtherCAT communication command Obj.100Ah:00h “Manufacturer software version”
    (See Operating Instructions (Overall) “6.3.1 Device Information”)
  - Set-up Support Software (PANATERM ver.7)

1.3.4 Functions Not Currently Supported

The functions listed in the table below are not currently supported in this software version.

Please note that although the following functions are described in some parts of the text, they are not supported in this software version.

Function name
Batteryless encoder
Full-closed control function (rotary scale)
Virtual full-closed control function
Deterioration diagnosis warning function
Retracting operation function
EoE (Ethernet over EtherCAT)
Touch probe function ● External scale z-phase latch function for semi-closed control
Backlash compensation function

1.3.5 Software Version History

- New software versions are upward compatible with old software versions.

  The parameters used in the old software version can be used as they are in the new software version.

  Parameter factory default values for features added in the new software version are set to values that disable the added features. For this reason, immediately after upgrading, the servo driver will operate in a manner compatible with an older software versions.
- When using the added functions, set parameters in accordance with the explanations of functions in this manual.

Software version		Class	Changed Function Details	Relevant Section	Supported Set-up Support Software (PANATERM ver.7)
CPU1	CPU2				
1.04	1.02	First version	Newly created	—	7.0.0.0 and later
1.05	1.02	Extended Version 1	Monitor Signal Output	OI_O “3.2.8.1”	7.0.3.0 and later
			Position Comparison Output Function	OI_O “8.3”	
			EtherCAT communication Enhancements	OI_O “4.2.2”, “10.2.3” TR_CS “1.2.7”	

1.3.6 Functional Differences from Previous Series

- For differences from the MINAS A6B Series, see Technical Reference Functional Specification “1.2.6 Functional Differences from Previous Series” and Technical Reference Communication Specification “1.2.7 Functional Differences from Previous Series” .
- The MINAS A7B Series may not operate in complete compatibility with previous series (the A6B Series, etc.). Be sure to carry out an evaluation before changing from a previous series to the MINAS A7B Series, as parameter re-tuning may be required.

  The initial values for the MINAS A7B Series are listed in Operating Instructions (Overall) “6.2 Object Dictionary List” .

1.4 Trademarks

- MINAS, TUNE COMPASS and PANATERM are registered trademarks or trademarks of Panasonic Holdings Corporation in Japan and other countries.
- EtherCAT is a registered trademark and patented technology licensed by Beckhoff Automation GmbH, Germany.

1.5 EtherCAT Communication Overview

EtherCAT is short for “Ethernet for Control Automation Technology”, and is an open network communication between main devices and sub devices using real-time Ethernet developed by Beckhoff Automation GmbH.

EtherCAT is managed by ETG (EtherCAT Technology Group).

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2 Overview of Tuning Functions

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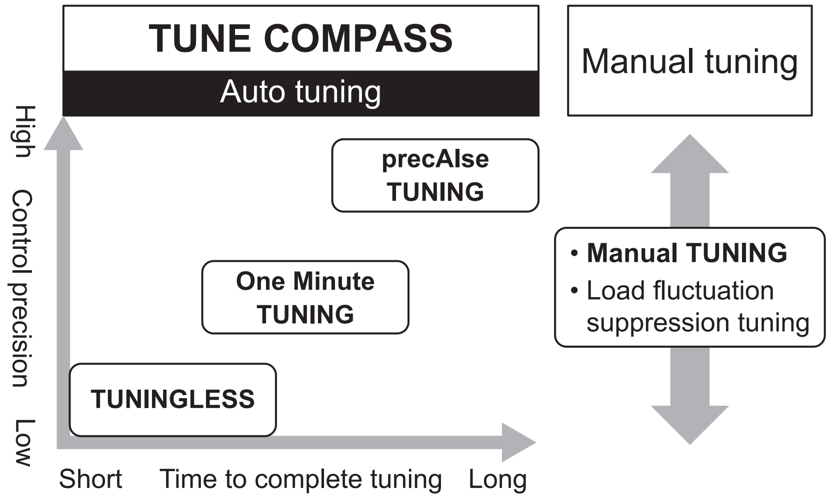
2.1 Types of Tuning and Control Functions

2.1.1 Auto Tuning (TUNE COMPASS) and Manual Tuning

In order to get the best performance out of the device, parameters must be set to optimal values using appropriate control functions, which is generally complex. This product provides the three automatic tuning functions shown in the table below, which automatically tune parameters with no initial setting of control gain, or by simply configuring initial settings such as target control performance. TUNE COMPASS is the collective name for these automatic tuning functions. The functions selected can be tailored to meet customer requirements.

Manual tuning is also possible to ensure the best responsiveness and stability for individual loads.

For specific instructions on selecting tuning means, see *"2.3 Adjustment Workflow"* .



○: Supported ×: Not supported

Function name	Function overview	Operation command		Set-up Support Software (PANATERM ver.7) needed	Reference
		Internal command	Upper command		
Auto tuning (TUNE COMPASS)					
TUNINGLESS	This function automatically tunes inertia based on the actual operation of the motor, using the initial values as parameters. This function is enabled at the time of shipment. This function is useful when you want to move the motor immediately.	○ (*1)	○	×	*"3.1.1 TUNINGLESS"*
One Minute TUNING	A function that automatically tunes various parameters to satisfy target performance by measuring device characteristics and ensuring the control tolerance from the actual operation of the device. This is effective for obtaining a higher control performance in a relatively short time. If there is a change in the device workpiece or position, only specific items can be auto tuned again.	○	×	○	*"3.1.2 One Minute TUNING"*

Function name	Function overview	Operation command		Set-up Support Software (PANATERM ver.7) needed	Reference
		Internal command	Upper command		
precAIse TUNING	This function automatically tunes various parameters while the motor is running, with AI determining the response. It is effective for tuning devices that are difficult to tune and require tuning by skilled operators. The tuning results are expected to exceed those of skilled operators. This is also effective for reducing operator labor hours, because it performs automatic operation using Set-up Support Software (PANATERM ver.7) after initial setting of target performance and multiple operation patterns, etc.	○	×	○	*“3.1.3 precAIse TUNING”*
Manual Tuning					
Manual TUNING	Re-adjustment may be necessary to further improve responsiveness and stability, for example, after auto tuning. In such cases, this function manually sets individual parameters to their optimal values. The dedicated user interface for Set-up Support Software (PANATERM ver.7) , groups the related parameters by control function. Gain adjustment and tuning of vibration suppression filters, etc., can easily be performed manually.	○ (*1)	○	○ (*2)	*“3.2.1 Manual TUNING”*
Load fluctuation suppression tuning (stabilizing load fluctuation applications)	In devices where load inertia fluctuates, vibration may occur due to the effect of load inertia fluctuations. This function reduces this vibration and improves stability.	○ (*1)	○	○ (*2)	*“3.2.2 Load Fluctuation Suppression Tuning (Stabilizing Load Fluctuation Applications)”*

*1 Use the Set-up Support Software (PANATERM ver.7) trial run function.

*2 Can be implemented without Set-up Support Software (PANATERM ver.7) .

2.1.2 Control Functions to Improve Tracking With Respect to Control Commands

These functions are expected to improve tracking with respect to control commands.

A list of functions is shown below.

The “Auto tuning (TUNE COMPASS) supported” column indicates whether or not the parameters can be tuned by each automatic tuning function.

The functions listed in gray in the table below are not currently supported in this software version.

○: Supported ×: Not supported

Function name	Function overview	Auto tuning (TUNE COMPASS) supported			Reference
		TUNING-LESS	One Minute TUNING	precAIse TUNING	
Real-time auto tuning function	This function estimates machine load characteristics in real time and uses those results to automatically perform basic gain setting and load characteristic compensation. The tuning of stiffness parameters should yield a reduction in settling time.	○ (*1)	○	○	*“4.1 Real-time Auto Tuning Function”*
Gain switching function	This function optimizes control based on the operating state of the servo driver by changing settings such as gain types and setting conditions based on command inputs such as torque commands or control data such as position deviation. This is expected to shorten the settling time and suppress fine vibration while stopped.	×	×	○	*“4.2 Gain Switching Function”*
3rd gain switching function	In addition to the normal gain switching function (two-stage gain switching function), this function sets a 3rd gain between both gains. This is expected to shorten the settling time. Overshoot suppression is expected from the gain switching function.	×	×	○	*“4.3 3rd Gain Switching Function”*
Feedforward function	This function performs compensation to minimize the effect of delay caused by feedback control on the command value before the effect is apparent. This is expected to improve tracking of position control and speed control.	○	○	○	*“4.4 Feedforward Function”*
Friction torque compensation function	This function reduces the effect of mechanical system friction and improves responsiveness. This is expected to compensate the effect of friction and improve command tracking.	×	○	○	*“4.5 Friction Torque Compensation Function”*

Function name	Function overview	Auto tuning (TUNE COMPASS) supported			Reference
		TUNING-LESS	One Minute TUNING	precAIse TUNING	
Load fluctuation control function	In devices with which disturbance torque is applied, velocity change may occur due to the disturbance torque. This function reduces this velocity change and improves stability. In devices where load inertia fluctuates, vibration may occur due to the effect of load inertia fluctuations. This function reduces this vibration and improves stability. This is expected to compensate the effect of disturbance torque and inertia change and improve operation stability.	×	○	○	*"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)"* *"4.7 Load Fluctuation Control Function (Load Fluctuation Stabilization Applications)"*
High response current control function	This function improves the responsiveness of the current controller by changing the current response setting to a value greater than the initial value in order to improve the current control responsiveness when operating at low current, such as with a processing machine. This is expected to improve the responsiveness of position control and speed control by enhancing current control performance in locus control.	×	×	○	*"4.8 High Response Current Control Function"*
Quadrant glitch suppression function	This function suppresses quadrant glitches that occur when drawing an arc with two or more axes. This is expected to suppress quadrants glitches during a change of direction in locus control.	×	×	○	*"4.9 Quadrant Glitch Suppression Function"*
Backlash compensation function	When driving a device with backlash (mechanical gap in the drive system), the amount of movement commanded by the host device will differ from the actual amount of movement of the mechanical axis. The backlash compensation function adds a backlash compensation value to the host device position command and drives the motor axis by the command to which the compensation value has been added, thereby matching the amount of movement commanded by the host device with the actual amount of movement of the mechanical axis. In devices with backlash, this is expected to reduce the deviation between the actual amount of movement of the mechanical axis and the amount of movement commanded by the host device.	×	×	×	*"4.10 Backlash Compensation Function"*

*1 Pr0.04 "Inertia ratio" is estimated automatically.

2.1.3 Control Functions for Suppressing Abnormal Noise and Vibration

These functions are expected to suppress abnormal noise and vibration, such as abnormal noise caused by oscillation and residual vibration during positioning.

A list of functions is shown below.

The “Auto tuning (TUNE COMPASS) supported” column indicates whether or not the parameters can be tuned by each automatic tuning function.

○: Supported ×: Not supported

Function name	Function overview	Auto tuning (TUNE COMPASS) supported			Reference
		TUNING-LESS	One Minute TUNING	precAIse TUNING	
Torque filter function	Sounds and vibrations in the high frequency range may occur when the gain is increased. By setting a torque filter, this function is expected to suppress this sound and vibration. This function is expected to suppress sound and vibration in the high frequency range (*1) .	○	○	○	*“5.1 Torque Filter Function”*
2-stage torque filter function	This function sets a 2-stage torque filter to suppress high-frequency vibration components that cannot be removed by the *“5.1 Torque Filter Function”* torque filter alone. This function is expected to suppress sound and vibration in the high frequency range (*1) . The suppression effect is stronger than that of a torque filter.	×	×	○	*“5.2 2-stage Torque Filter Function”*
Notch filter function	When the gain is increased, sounds and vibrations of specific frequencies in the high frequency range may occur. This function suppresses sound and vibration at specific frequencies in the high frequency range by setting a notch filter. This function is expected to suppress noise and vibration caused by mechanical resonance of the device (*2) .	×	○	○	*“5.3 Notch Filter Function”*
Adaptive filter function	This function auto tunes parameters related to notch filters.	×	○	×	*“5.4 Adaptive Filter Function”*
Damping control function	This function reduces residual vibration of approximately 100 Hz or less that occurs at the moving part tip or the overall device during positioning operation by setting a damping filter. This is expected to suppress residual vibration of the at the moving part tip or the overall device during positioning.	×	○	○	*“5.5 Damping Control Function”*

Function name	Function overview	Auto tuning (TUNE COMPASS) supported			Reference
		TUNING-LESS	One Minute TUNING	precAIse TUNING	
Model-type damping filter function	This function reduces residual vibration of approximately 100 Hz or less that occurs at the moving part tip or the overall device during positioning operation by setting a model-type damping filter. This is expected to suppress residual vibration of the at the moving part tip or the overall device during positioning. A shorter settling time is expected than with damping control.	×	×	○	*"5.6 Model-type Damping Filter Function"*
Position command filter function	A function that applies a positional command smoothing filter to a position command to gently accelerate or decelerate the motor. This is expected to suppress vibration and velocity change caused by the command resolution and command updating cycle roughness.	×	○	○	*"5.7 Position Command Filter Function"*
Speed command acceleration/deceleration setting function	This function performs speed control by applying a speed command for which acceleration and deceleration have been tuned inside the servo driver with respect to the speed command input from the host device. In speed control mode, it is expected that there will be a reduction in shocks caused by acceleration changes and that vibration will be suppressed.	×	×	×	*"5.8 Speed Command Acceleration/Deceleration Setting Function"*
Hybrid vibration suppression function	This function suppresses vibration caused by the amount of torsion between the motor and the load in full-closed control mode. This is expected to shorten the settling time.	×	×	×	*"5.9 Hybrid Vibration Suppression Function"*

*1 This product assumes frequencies of 1.5 kHz or more as the high frequency range.

*2 This product assumes frequencies of 600 Hz to 1.5 kHz to be mechanical resonance.

2.1.4 List of Control Functions (By Driver Type)

The table below shows the functions supported by this product by driver type.

The functions listed in gray in the table below are not currently supported in this software version.

○: Supported ×: Not supported

Function name	Driver type		
	A7BE Standard type	A7BF Multi-function type	A7BR Application specialized type
Control functions for control performance			
Real-time auto tuning function	○	○	○
Gain switching function	○	○	○
3rd gain switching function	○	○	○
Feedforward function	○	○	○
Friction torque compensation function	○	○	○
Load fluctuation control function	○	○	○
High response current control function	○	○	○
Quadrant glitch suppression function	○	○	○
Backlash compensation function	○	○	○
Control functions to suppress abnormal noise and vibration			
Torque filter function	○	○	○
2-stage torque filter function	○	○	○
Notch filter function	○	○	○
Adaptive filter function	○	○	○
Damping control function	○	○	○
Model-type damping filter function	○	○	○
Position command filter function	○	○	○
Speed command acceleration/deceleration setting function	○	○	○
Hybrid vibration suppression function	×	○	○

2.1.5 List of Control Functions (By Control Mode)

The table below shows the functions supported by this product by control mode.

The functions listed in gray in the table below are not currently supported in this software version.

○: Supported ×: Not supported

Function name	Control mode			
	Position control	Speed control	Torque control	Full-closed control
Control functions for control performance				
Real-time auto tuning function	○	○	○	○
Gain switching function	○	○	○	○
3rd gain switching function	○	×	×	○
Feedforward function	○	○	×	○
Friction torque compensation function	○	○	○	○
Load fluctuation control function	○	○	×	○
High response current control function	○	○	○	○
Quadrant glitch suppression function	○	×	×	○
Backlash compensation function	○	×	×	○
Control functions to suppress abnormal noise and vibration				
Torque filter function	○	○	○	○
2-stage torque filter function	○	○	○	○
Notch filter function	○	○	○	○
Adaptive filter function	○	○	×	○
Damping control function	○	×	×	○
Model-type damping filter function	○	×	×	×
Position command filter function	○	○	×	○
Speed command acceleration/deceleration setting function	×	○	×	×
Hybrid vibration suppression function	×	×	×	○

2.2 Safety Function Setup Before Tuning

Before tuning any parameters, make sure the following settings are properly configured.

This reduces the impact of unforeseen movements and ensures safer tuning.

Over-travel inhibit input setup ● Pr5.04 “Over-travel inhibit input setup” ● Pr5.05 “Sequence at over-travel inhibit”	This setting prevents moving parts from colliding with the mechanical end.
Torque limit setup ● Pr0.13 “1st torque limit” ● Pr5.11 “Torque setup for emergency stop” ● Pr5.21 “Selection of torque limit” ● Pr5.22 “2nd torque limit”	This setting limits the maximum torque to prevent damage to moving parts.
Overspeed protection setup ● Pr5.13 “Over-speed level setup”	This setting stops the alarm in the event of abnormally high speed.
Position deviation excess protection setup ● Pr0.14 “Position deviation excess setup” ● Pr5.20 “Position setup unit select”	This setting stops the alarm when abnormal position deviation from a command occurs in the position control mode.
Motor working range setup ● Pr5.14 “Motor working range setup” ● Pr6.97 “Function expansion setup 3” :bit 2 “Motor movable range error protection expansion”	This setting stops the alarm when the motor position exceeds the allowable width from the command range in the position control mode.
Hybrid deviation excess protection setup ● Pr3.28 “Hybrid deviation excess setup” ● Pr3.29 “Hybrid deviation clear setup”	This setting prevents abnormal operation due to incorrect external scale settings, etc., in full-closed control mode.
Speed limit setting ● Pr3.17 “Selection of speed limit” ● Pr6.97 “Function expansion setup 3” :bit 12 “Speed limit priority function during torque control”	This setting prevents the speed exceeding the speed limit value in torque control mode.

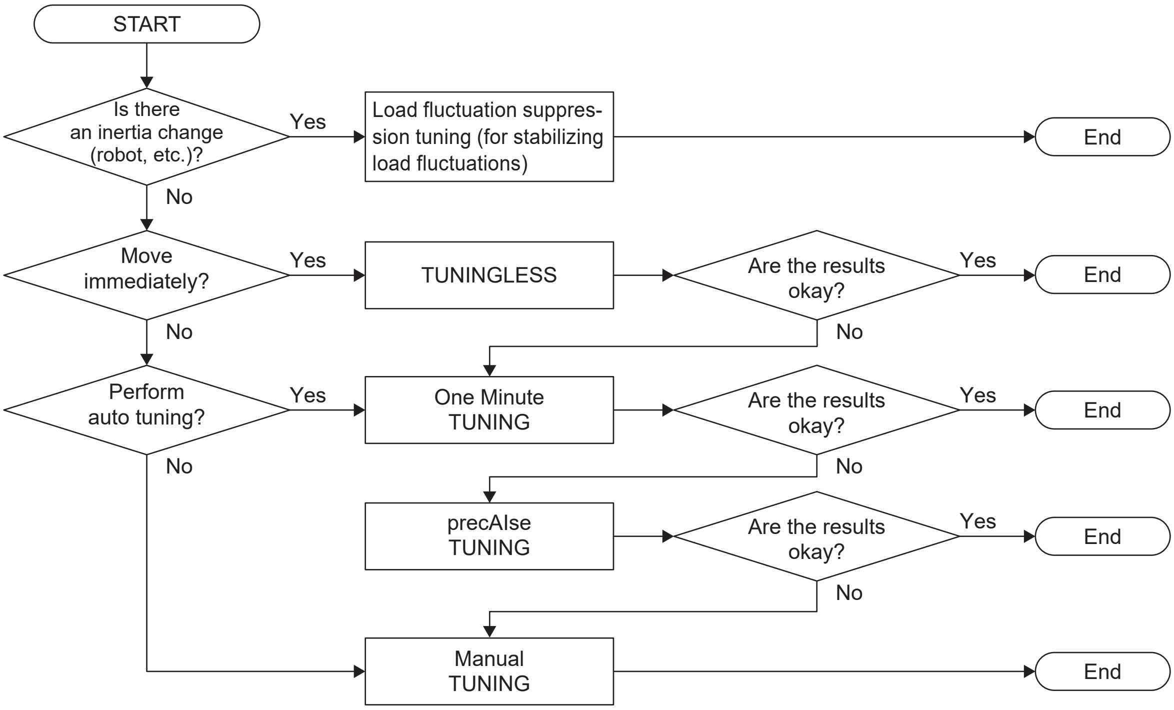
For details, see Operating Instructions (Overall) “7.2.9 Before Gain Tuning Protection Function Setup” and “7.5.2 Velocity Limit Function” .

2.3 Adjustment Workflow

2.3.1 Adjustments at Device Startup

Select the tuning function and adjust the parameters with reference to the following workflow.

Adjustment Workflow at Device Startup



2.3.2 Re-adjustment After Device Startup

- When Set-up Support Software (PANATERM ver.7) is used

  Tuning is made using one of the following.

  - Tuning function - One Minute TUNING: See *"3.1.2.5 Use Cases in Re-adjustment"* for details.
  - Tuning function - Manual TUNING: See *"3.2.1.4.4 Tuning Procedure When Control Challenges Are Identified"* for details.

- When Set-up Support Software (PANATERM ver.7) is not used

  The control functions that address the main issues when re-adjusting are listed in the table below.

  Perform tuning by referring to the reference tuning procedures.

Issues during re-adjustment	Corresponding control function references
Shortening the settling time.	*"4.1 Real-time Auto Tuning Function"* *"5.7 Position Command Filter Function"*
Reducing overshoot/undershoot.	*"4.1 Real-time Auto Tuning Function"* *"4.3 3rd Gain Switching Function"* *"4.4 Feedforward Function"* *"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)"* *"4.8 High Response Current Control Function"*
Reducing abnormal noise and oscillation.	*"5.3 Notch Filter Function"* *"5.7 Position Command Filter Function"*
Reducing vibration just before stopping.	*"5.5 Damping Control Function"* *"5.6 Model-type Damping Filter Function"*
Suppressing velocity changes during constant speed control.	*"4.1 Real-time Auto Tuning Function"* *"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)"* *"4.8 High Response Current Control Function"*
Preventing falling on the vertical axis after servo-on.	*"4.5 Friction Torque Compensation Function"*
Suppressing quadrant glitches when velocity is inverted for processing machines, etc.	*"4.9 Quadrant Glitch Suppression Function"*
Ensuring own axis is not moved when other axes are moved.	*"4.1 Real-time Auto Tuning Function"* *"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)"* *"4.8 High Response Current Control Function"*
Reducing vibration when gain is increased in full-closed control.	*"5.9 Hybrid Vibration Suppression Function"*

3 Details of Tuning Functions

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3.1 Auto Tuning (TUNE COMPASS)

3.1.1 TUNINGLESS

3.1.1.1 Function Overview

This function automatically tunes inertia based on the actual operation of the motor, using the initial values as parameters. This function is enabled in the settings at the time of shipment.

This function is useful when you want to move the motor immediately.

3.1.1.2 Operational Conditions

Item	Operational Conditions
Control mode	● All control modes
Other	● The related parameters (*"7.3 Parameters Related To TUNINGLESS"*) are not changed from the initial values.

— Precautions —

- Since the real-time auto tuning function is enabled while this function is in use, the automatically set parameters cannot be manually changed to any desired value. For details, see *"4.1 Real-time Auto Tuning Function"* .
- While this function is operating, notch filters, damping control, the gain switching function, the load fluctuation control function, the friction compensation function, and the inertia ratio switching function are disabled.
- Under the following conditions, TUNINGLESS inertia estimating may not be performed correctly.

Item	Conditions that obstruct the TUNINGLESS inertia estimation
Load inertia	● When small or large compared to the rotor inertia of the servo motor (less than 3× or 20× or more) ● When load inertia fluctuates
Load	● When machine stiffness is extremely low ● When non-linear characteristics exist, such as backlash
Operation patterns	● When used continuously at low speeds of less than 100 r/min ● When acceleration and deceleration are gentle, less than 2000 r/min in 1 s ● When the acceleration and deceleration torque is small compared to the unbalanced load and viscous friction torque ● When the speed is more than 100 r/min and the acceleration and deceleration condition of more than 2000 r/min in 1 s does not continue for more than 50 ms

3.1.1.3 Parameters That Are Automatically Set and Automatically Tuned

- Pr0.04 "Inertia ratio"

3.1.1.4 Usage

If *"3.1.1.2 Operational Conditions"* is met, setting tasks are not required.

Tuning is performed automatically by operating the motor.

3.1.2 One Minute TUNING

3.1.2.1 Function Overview

A function that automatically tunes various parameters to satisfy target performance by measuring device characteristics and ensuring control tolerance.

This is effective for obtaining a higher control performance in a relatively short time.

If there is a change in the device workpiece or position, only specific items will be auto tuned again.

3.1.2.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control mode, speed control mode
Other	● Set-up Support Software (PANATERM ver.7) is required.

— Precautions —

- Tuning results that satisfy the required performance may not be obtained. In such cases, the tuning results judged to be the best are displayed.
- This tuning is performed in position control mode.

  When One Minute TUNING is started in speed control mode, the driver temporarily changes to position control mode internally to execute tuning.

  The tuning results obtained are tuning results from position control mode and may differ from tuning results obtained in speed control mode (Manual TUNING, etc.).

  After tuning is completed, check the operation in speed control mode.
- The motor rotates during execution of this function. Be careful not to contact moving parts.
- This tuning changes the values of many parameters. If you need the values before tuning, save the data beforehand.
- Under the following conditions, One Minute TUNING inertia estimating may not be performed correctly.

Item	Conditions that obstruct the One Minute TUNING inertia estimation
Load	● When load inertia fluctuates ● When machine stiffness is extremely low ● When non-linear characteristics exist, such as looseness due to backlash

- Do not use this function in a mechanism that causes the moving part to deviate from the operating range when the servo is OFF.

3.1.2.3 Parameters That Are Automatically Set and Automatically Tuned

See *“7.4 Parameters Related To One Minute TUNING”* .

3.1.2.4 Usage

Instructions for use are described according to the following steps.

1. *“Starting the Tuning Function”*
2. *“Initial Settings”*
3. *“Adjustment Operation”*
4. *“Confirming Tuning Results, Ending One Minute TUNING”*

3.1.2.4.1 Starting the Tuning Function

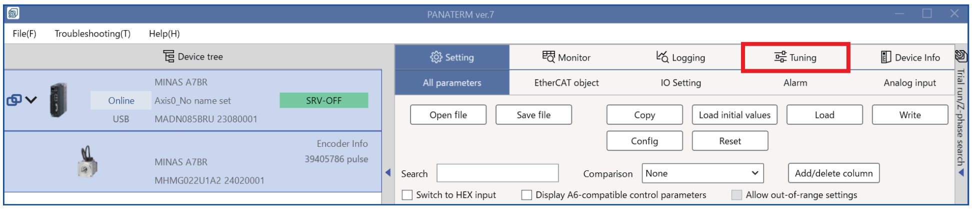
<< Procedure >>

1. Check that Pr0.01 “Control mode setup” is set to the target mode for the operational conditions.

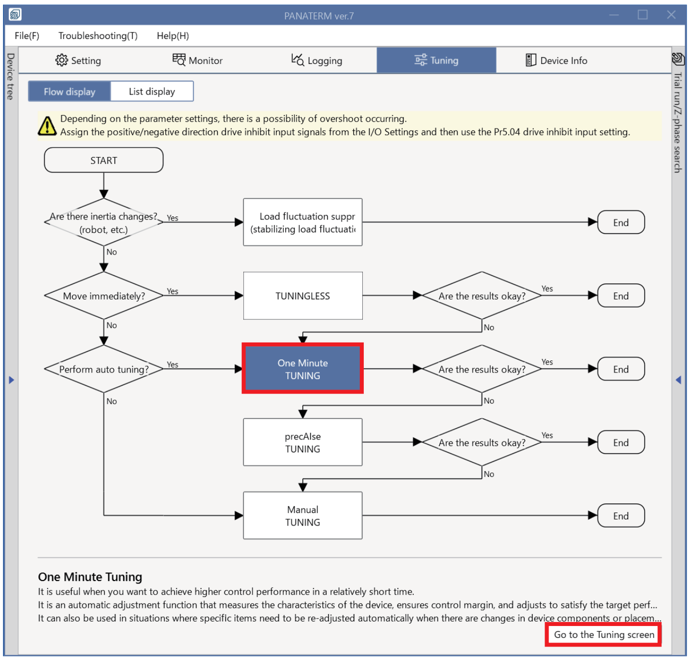
   In position control mode, set parameters related to command division/multiplication (electronic gear ratio) correctly to set the operating range in command units in the initial settings.

2. Activate Set-up Support Software (PANATERM ver.7) .

3. Select one device that you want to tune in the device tree and click the “Tuning” tab.



4. In the “Tuning” tab screen, select “One Minute TUNING”, and click the [Go to the Tuning screen] button.

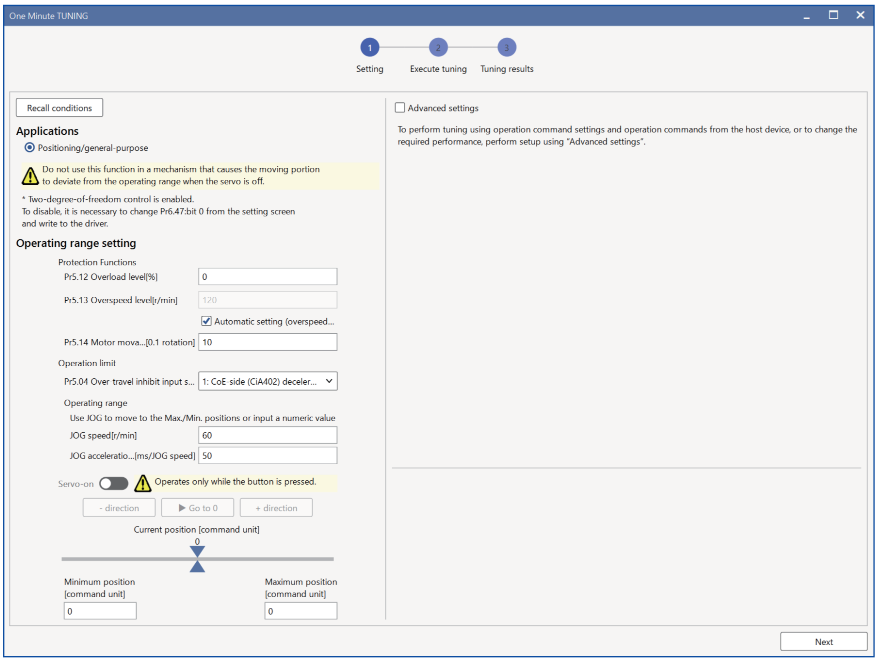


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

One Minute Tuning

It is useful when you want to achieve higher control performance in a relatively short time.
It is an automatic adjustment function that measures the characteristics of the device, ensures control margin, and adjusts to satisfy the target perf...
It can also be used in situations where specific items need to be re-adjusted automatically when there are changes in device components or placem...

The “One Minute TUNING” settings screen is displayed.



Applications

● Positioning/general-purpose

Do not use this function in a mechanism that causes the moving portion to deviate from the operating range when the servo is off.

* Two-degree-of-freedom control is enabled.
To disable, it is necessary to change Pr6.47:bit 0 from the setting screen and write to the driver.

Operating range setting

Protection Functions
Pr5.12 Overload level[%]: 0
Pr5.13 Overspeed level[r/min]: 120
☑ Automatic setting (overspeed...
Pr5.14 Motor mova...[0.1 rotation]: 10

Operation limit
Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min]: 60
JOG acceleratio...[ms/JOG speed]: 50

Servo-on
Operates only while the button is pressed.

Current position [command unit]: 0
Minimum position [command unit]: 0
Maximum position [command unit]: 0

☐ Advanced settings

To perform tuning using operation command settings and operation commands from the host device, or to change the required performance, perform setup using “Advanced settings”.

If the set values of the parameters set before tuning are required, save the data before tuning at this point. For details, see Set-up Support Software (PANATERM ver.7) Operating Manual “8.3 Save File” .

3.1.2.4.2 Initial Settings

<< Procedure >>

1. Starts configuration of initial settings.

- To set new initial settings

  Go to "Step 2".

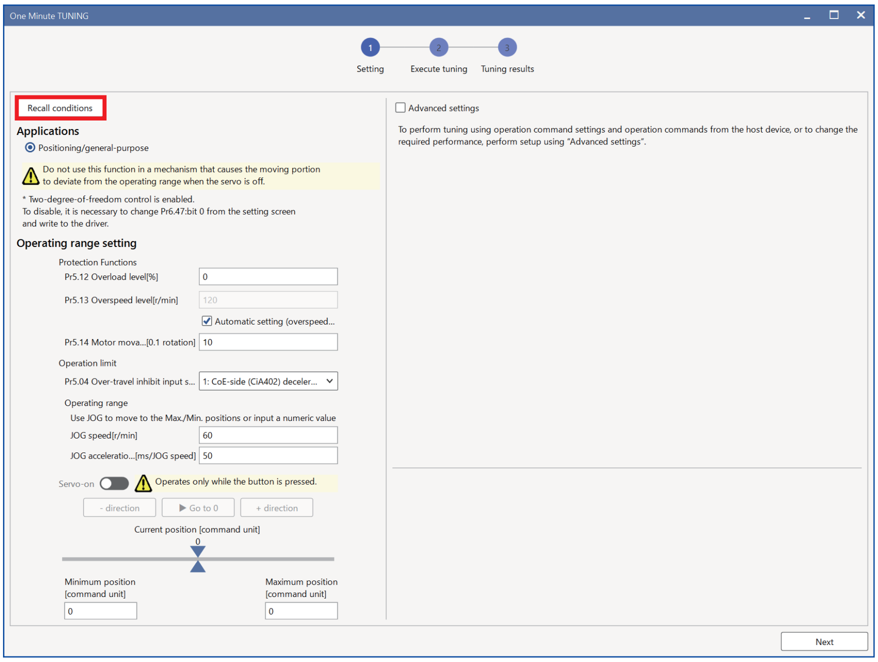
- To use the contents of a previously saved configuration file

  Click on the [Recall conditions] button at the top of the screen to load.

  To modify the settings, go to "Step 2".

  If you do not wish to modify the settings, go to *"3.1.2.4.3 Adjustment Operation"* .

One Minute TUNING Settings Screen



Applications

● Positioning/general-purpose

Do not use this function in a mechanism that causes the moving portion to deviate from the operating range when the servo is off.

* Two-degree-of-freedom control is enabled.
To disable, it is necessary to change Pr6.47:bit 0 from the setting screen and write to the driver.

Operating range setting

Protection Functions

Pr5.12 Overload level[%]: 0

Pr5.13 Overspeed level[r/min]: 120

☑ Automatic setting (overspeed...

Pr5.14 Motor mova...[0.1 rotation]: 10

Operation limit

Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

Operating range

Use JOG to move to the Max./Min. positions or input a numeric value

JOG speed[r/min]: 60

JOG acceleratio...[ms/JOG speed]: 50

Servo-on: Operates only while the button is pressed.

Current position [command unit]: 0

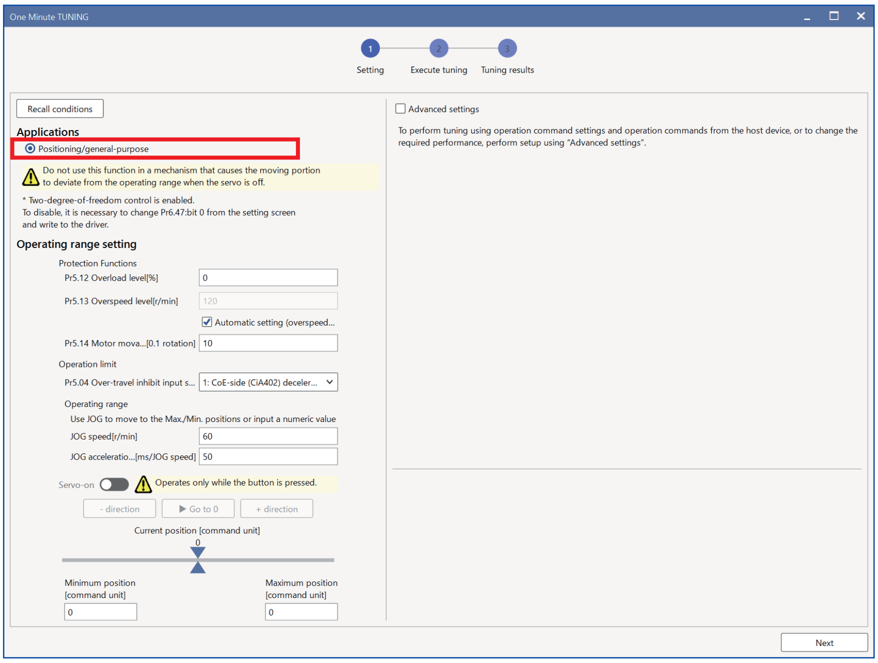
Minimum position [command unit]: 0

Maximum position [command unit]: 0

☐ Advanced settings

To perform tuning using operation command settings and operation commands from the host device, or to change the required performance, perform setup using "Advanced settings".

2. Select the application.



Applications

● Positioning/general-purpose

Do not use this function in a mechanism that causes the moving portion to deviate from the operating range when the servo is off.

* Two-degree-of-freedom control is enabled.
To disable, it is necessary to change Pr6.47:bit 0 from the setting screen and write to the driver.

Operating range setting

Protection Functions

Pr5.12 Overload level[%]: 0

Pr5.13 Overspeed level[r/min]: 120

☑ Automatic setting (overspeed...

Pr5.14 Motor mova...[0.1 rotation]: 10

Operation limit

Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

Operating range

Use JOG to move to the Max./Min. positions or input a numeric value

JOG speed[r/min]: 60

JOG acceleratio...[ms/JOG speed]: 50

Servo-on: Operates only while the button is pressed.

Current position [command unit]: 0

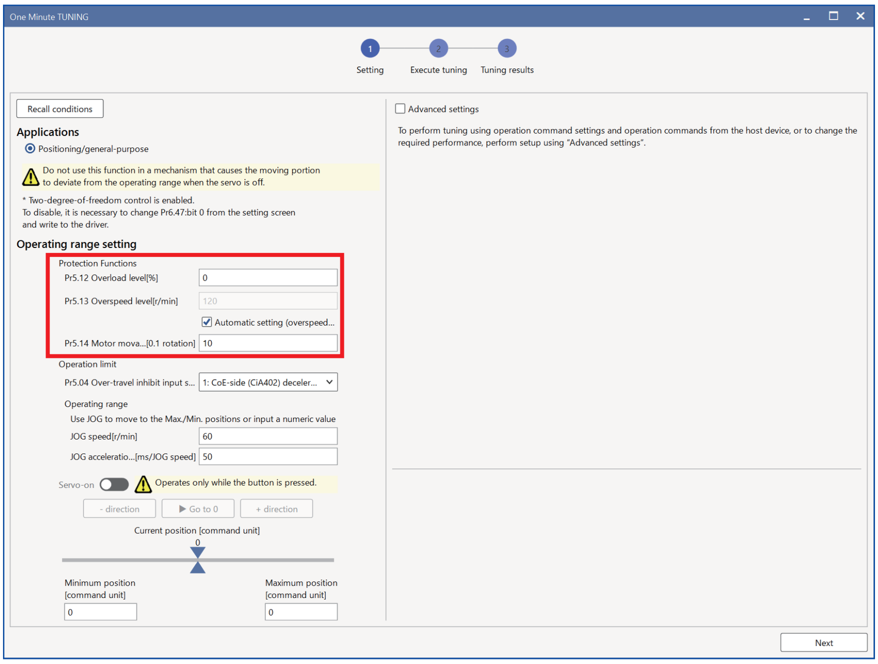
Minimum position [command unit]: 0

Maximum position [command unit]: 0

☐ Advanced settings

To perform tuning using operation command settings and operation commands from the host device, or to change the required performance, perform setup using "Advanced settings".

3. Set the protection functions.



☐ Advanced settings

To perform tuning using operation command settings and operation commands from the host device, or to change the required performance, perform setup using "Advanced settings".

Applications

● Positioning/general-purpose

Do not use this function in a mechanism that causes the moving portion to deviate from the operating range when the servo is off.

* Two-degree-of-freedom control is enabled.
To disable, it is necessary to change Pr6.47:bit 0 from the setting screen and write to the driver.

Operating range setting

Protection Functions
Pr5.12 Overload level[%] 0
Pr5.13 Overspeed level[r/min] 120
☑ Automatic setting (overspeed...
Pr5.14 Motor mova...[0.1 rotation] 10

Operation limit
Pr5.04 Over-travel inhibit input s... 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min] 60
JOG acceleratio...[ms/JOG speed] 50

Servo-on Operates only while the button is pressed.

Current position [command unit]
0

Minimum position [command unit] 0
Maximum position [command unit] 0

- Pr5.12 "Motor overload level setup" [%]

  Sets the motor overload level of effective torque. If this setup value is 0, the motor overload level setup is 115%.

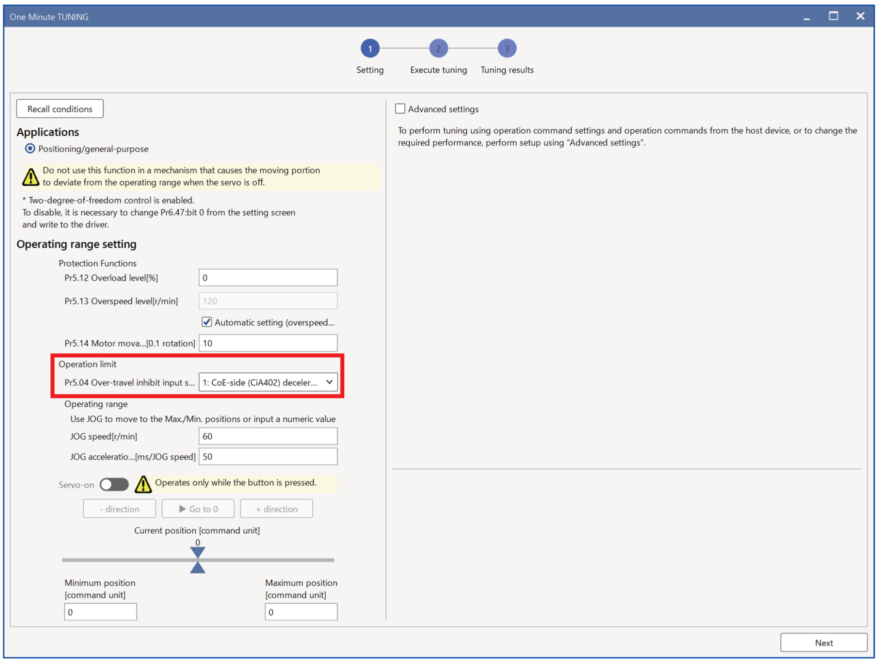
- Pr5.13 "Over-speed level setup" [r/min]

  Sets the judgment level for overspeed. Checking the "Automatic setting (overspeed level)" check box sets the automatically set value. Uncheck the box to allow input of setup values. If this setup value is 0, the over-speed level setup is the internal value of the applicable motor.

- Pr5.14 "Motor working range setup" [0.1 rotation]

  Sets the amount by which the motor is allowed to move outside the input position command range.

4. Sets the operation limit.



☐ Advanced settings

To perform tuning using operation command settings and operation commands from the host device, or to change the required performance, perform setup using "Advanced settings".

Applications

● Positioning/general-purpose

Do not use this function in a mechanism that causes the moving portion to deviate from the operating range when the servo is off.

* Two-degree-of-freedom control is enabled.
To disable, it is necessary to change Pr6.47:bit 0 from the setting screen and write to the driver.

Operating range setting

Protection Functions
Pr5.12 Overload level[%] 0
Pr5.13 Overspeed level[r/min] 120
☑ Automatic setting (overspeed...
Pr5.14 Motor mova...[0.1 rotation] 10

Operation limit
Pr5.04 Over-travel inhibit input s... 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min] 60
JOG acceleratio...[ms/JOG speed] 50

Servo-on Operates only while the button is pressed.

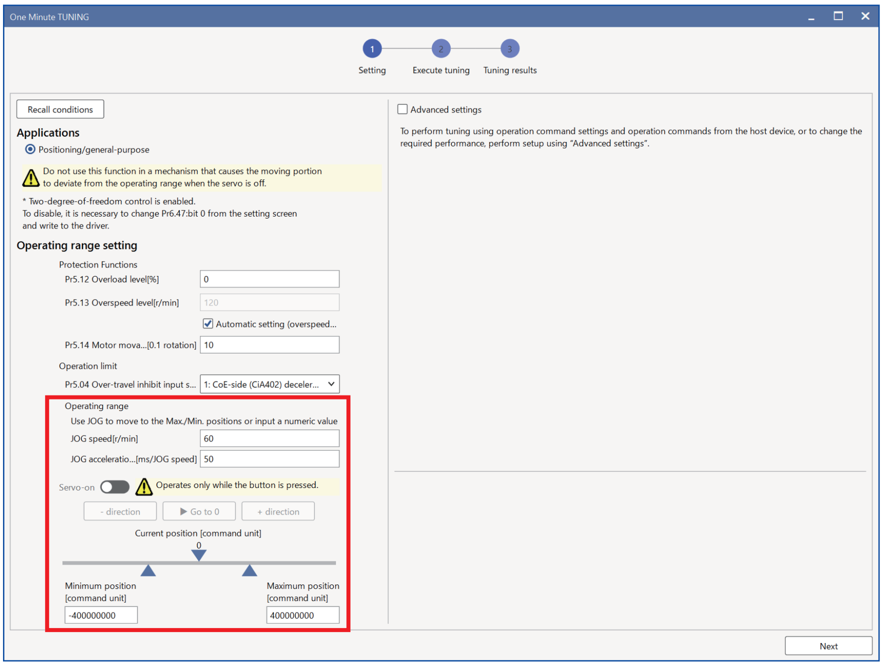
Current position [command unit]
0

Minimum position [command unit] 0
Maximum position [command unit] 0

- Pr5.04 "Over-travel inhibit input setup"

  Sets the input operations for the over-travel inhibit inputs (POT, NOT).

5. Sets the operating range.



☐ Advanced settings

To perform tuning using operation command settings and operation commands from the host device, or to change the required performance, perform setup using "Advanced settings".

Applications

● Positioning/general-purpose

⚠ Do not use this function in a mechanism that causes the moving portion to deviate from the operating range when the servo is off.

* Two-degree-of-freedom control is enabled.
To disable, it is necessary to change Pr6.47:bit 0 from the setting screen and write to the driver.

Operating range setting

Protection Functions
Pr5.12 Overload level[%]: 0
Pr5.13 Overspeed level[r/min]: 120
☑ Automatic setting (overspeed...
Pr5.14 Motor mova...[0.1 rotation]: 10

Operation limit
Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min]: 60
JOG acceleratio...[ms/JOG speed]: 50
Servo-on
⚠ Operates only while the button is pressed.
Current position [command unit]: 0
Minimum position [command unit]: -400000000
Maximum position [command unit]: 400000000

The operating range can be set using JOG operation or by entering a numerical value.

- JOG operation method

1 Sets the JOG speed and JOG acceleration and deceleration time.

JOG speed

Sets the JOG operation speed.

JOG acceleration and deceleration time

Sets the time it takes for the speed of JOG operation to reach the set JOG speed from 0.

2 Sets servo-on.

3 Press the [+ direction] or [- direction] button to move the motor to both ends of the movable range.

The motor runs only as long as the button is pressed, and the values in the "minimum position" and "maximum position" text boxes are updated.

4 When the motor has finished moving to both ends of the movable range, click the [Go to 0] button to return the motor to its initial position.

— Precautions —

- If oscillation occurs during JOG operation, the value of **Advanced settings**>**Tuning conditions**>**Tuning start RTAT machine stiffness setting** should be lowered before performing the JOG operation.

- Numerical value input method

1 With the current position as 0, enter the positions at both ends of the operable range in the "Minimum position" and "Maximum position" text boxes in command units.

Check that the set values are appropriate beforehand to prevent the moving part from colliding at both ends.

— Precautions —

- Set the minimum and maximum positions to provide a sufficiently large operable range. Errors occur when the operable range is small. A setting of 0.5 rotations or more is recommended for the motor rotational amount.
- An error may occur if the set value converted to the motor rotational amount is excessive.

6. Each item in “Advanced settings” has a pre-set recommended value. Normally, the settings can be used as they are.
   - To change the setting, such as to change the required performance,

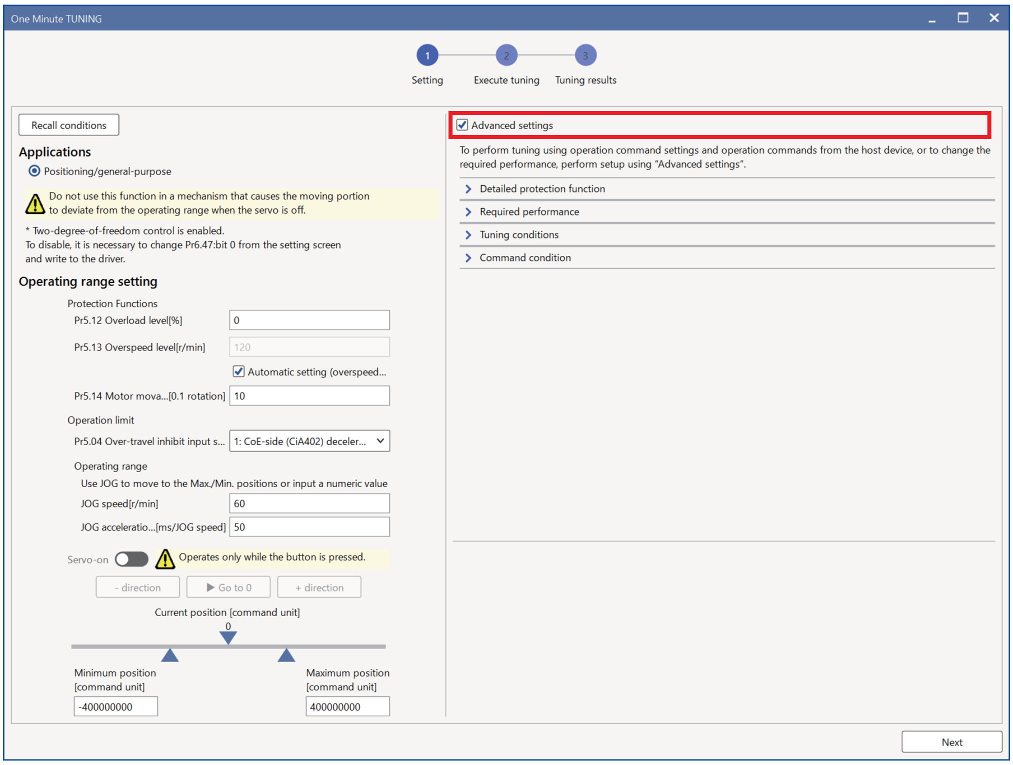
     Go to “Step 7”.
   - To proceed with the settings as they are,

     Go to *“3.1.2.4.3 Adjustment Operation”* .

7. Check the “Advanced settings” check box. The advanced settings items are displayed. Change the settings according to your requirements. See *“Advanced settings items”* below for details of advanced settings items.

   After completing the settings, go to *“3.1.2.4.3 Adjustment Operation”* .

   When changing the settings of the tuning target during re-adjustment, also refer to *“3.1.2.5 Use Cases in Re-adjustment”* to change the settings.



Applications

● Positioning/general-purpose

Do not use this function in a mechanism that causes the moving portion to deviate from the operating range when the servo is off.

* Two-degree-of-freedom control is enabled.
To disable, it is necessary to change Pr6.47:bit 0 from the setting screen and write to the driver.

Operating range setting

Protection Functions

Pr5.12 Overload level[%]: 0

Pr5.13 Overspeed level[r/min]: 120

☑ Automatic setting (overspeed...

Pr5.14 Motor mova...[0.1 rotation]: 10

Operation limit

Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

Operating range

Use JOG to move to the Max./Min. positions or input a numeric value

JOG speed[r/min]: 60

JOG acceleratio...[ms/JOG speed]: 50

Servo-on ○ Operates only while the button is pressed.

- direction | ▶ Go to 0 | + direction

Current position [command unit]: 0

Minimum position [command unit]: -400000000

Maximum position [command unit]: 400000000

☑ Advanced settings

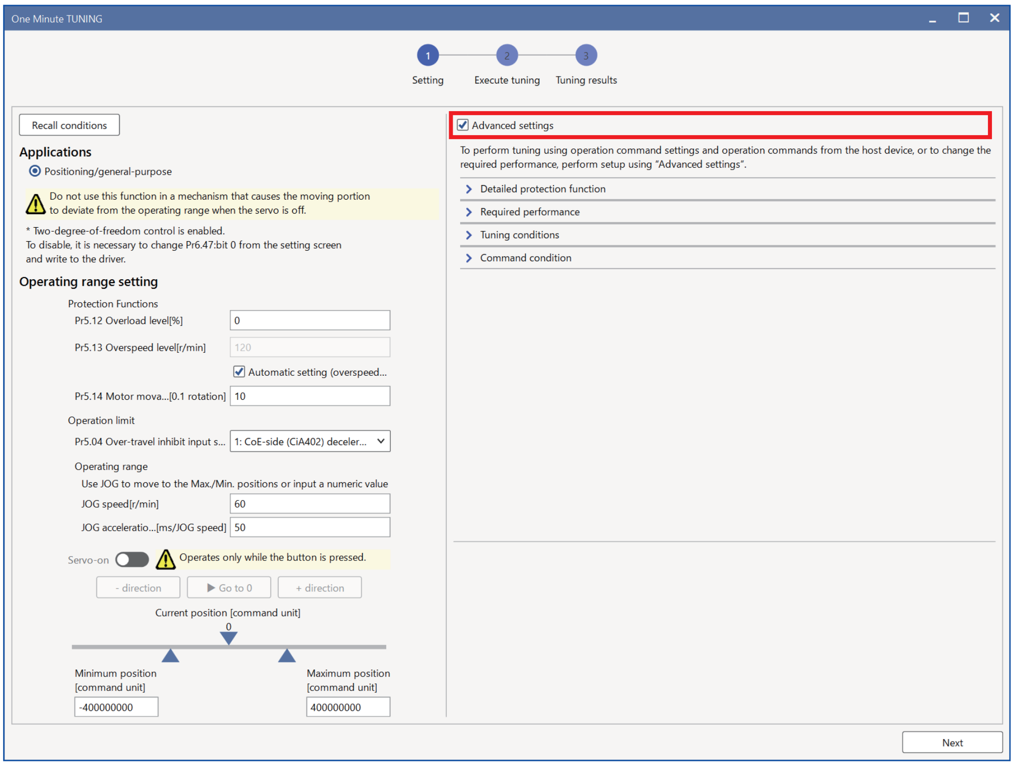
To perform tuning using operation command settings and operation commands from the host device, or to change the required performance, perform setup using “Advanced settings”.

- > Detailed protection function
- > Required performance
- > Tuning conditions
- > Command condition

Advanced Settings Items

Advanced settings for “Step 7”. Configure items as required.

After configuring the settings, go to *“3.1.2.4.3 Adjustment Operation”* .



Applications

● Positioning/general-purpose

Do not use this function in a mechanism that causes the moving portion to deviate from the operating range when the servo is off.

* Two-degree-of-freedom control is enabled.
To disable, it is necessary to change Pr6.47:bit 0 from the setting screen and write to the driver.

Operating range setting

Protection Functions

Pr5.12 Overload level[%]: 0

Pr5.13 Overspeed level[r/min]: 120

☑ Automatic setting (overspeed...

Pr5.14 Motor mova...[0.1 rotation]: 10

Operation limit

Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

Operating range

Use JOG to move to the Max./Min. positions or input a numeric value

JOG speed[r/min]: 60

JOG acceleratio...[ms/JOG speed]: 50

Servo-on — Operates only while the button is pressed.

Current position [command unit]: 0

Minimum position [command unit]: -400000000

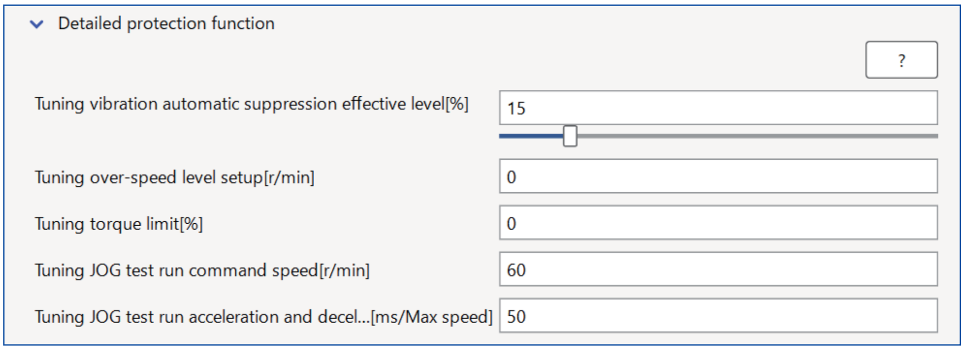
Maximum position [command unit]: 400000000

☑ Advanced settings

To perform tuning using operation command settings and operation commands from the host device, or to change the required performance, perform setup using "Advanced settings".

■ Detailed Protection Function

This setup value is enabled only during One Minute TUNING execution.



Tuning vibration automatic suppression effective level[%]: 15

Tuning over-speed level setup[r/min]: 0

Tuning torque limit[%]: 0

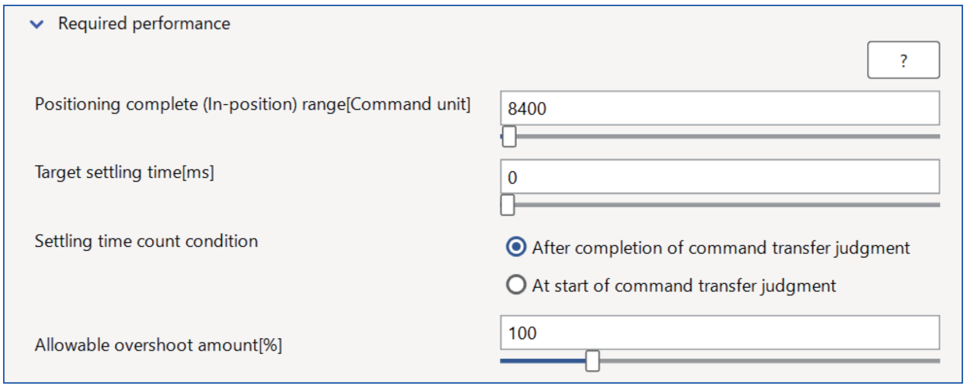
Tuning JOG test run command speed[r/min]: 60

Tuning JOG test run acceleration and decel...[ms/Max speed]: 50

Item	Description
Tuning vibration automatic suppression effective level	If oscillation does not subside when auto tuning is in progress, the gain is automatically lowered to stabilize. Set the vibration level of the torque to be considered as oscillation by half amplitude value (half of the peak-to-peak value) with the rated torque as 100%.
Tuning overspeed level setting	Stops the motor if the motor speed becomes excessive when auto tuning is in progress. Sets the speed in units of [r/min] at which the speed is judged to be excessive. If 0, Pr5.13 "Over-speed level setup" set values are used. **— Precautions —** ● If the set value is less than 1.11 times the rated speed, the device characteristics measuring accuracy may drop and it may not be possible to perform tuning correctly. If the value has not been changed from the initial value, there is no problem.

Item	Description
Tuning torque limit	Sets the value for determining torque saturation when auto tuning is in progress. Sets the ratio when the rated torque is 100% in units of [%]. If 0, setup values enabled by Pr5.21 “Selection of torque limit” are used. For details, see Operating Instructions (Overall) “8.1 Torque Limit Switching Function” . **— Precautions —** ● If the set value is less than 111% the rated speed, the device characteristics measuring accuracy may drop and it may not be possible to perform tuning correctly. If the value has not been changed from the initial value, there is no problem.
Tuning JOG test run command speed	Sets the motor speed in [r/min] units when checking the movable range.
Tuning JOG test run acceleration and deceleration time	Sets the time for acceleration and deceleration of the motor speed when checking the movable range (time from 0 to JOG speed or from JOG speed to 0).

■ Required performance


Required performance

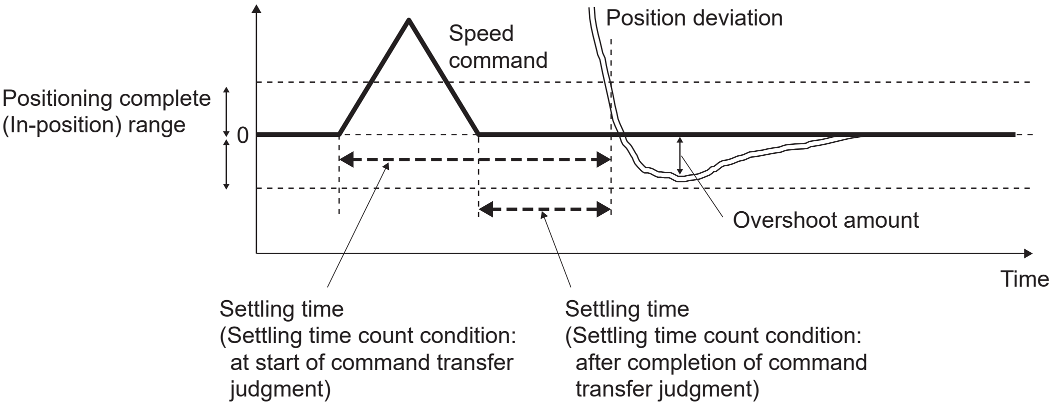
Positioning complete (In-position) range[Command unit]: 8400

Target settling time[ms]: 0

Settling time count condition:
- ● After completion of command transfer judgment
- ○ At start of command transfer judgment

Allowable overshoot amount[%]: 100

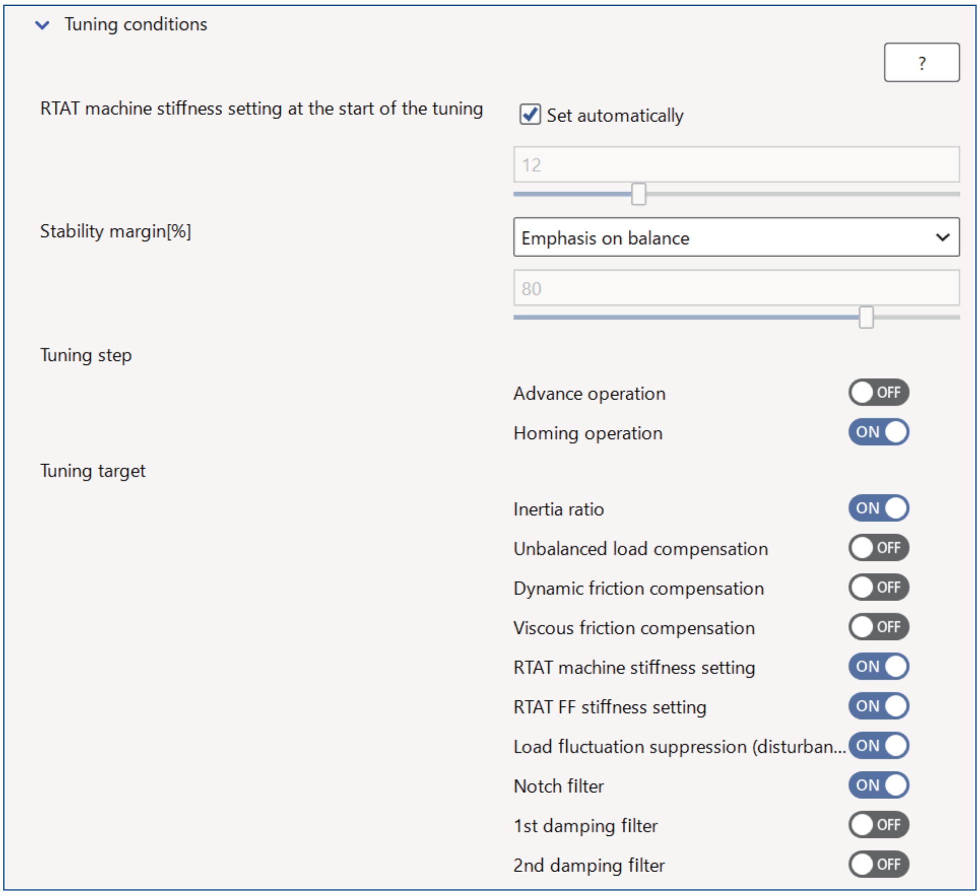
Example of positioning waveform



Item	Description
Positioning complete (In-position) range	Sets the position deviation (difference between command position and actual position) that determines that positioning is complete.
Target settling time	Sets the target time in [ms] units from the timing of the following settling time count condition until convergence to the positioning complete (in-position) range. If the setup value is 0, the settling time is tuned to be the shortest it can be.
Settling time count condition	Selects the timing to be time 0 when calculating the settling time.

Item	Description
Allowable overshoot amount	Sets the maximum allowable position deviation after position deviation reaches 0. Sets this as a percentage of the positioning complete (in-position) range in [%] units. **— Precautions —** ● The deviation of the command position deviation relative to the command input before position command filter is calculated. For details, see Operating Instructions (Overall) “3.2.8 Wiring to Connector X7 (Connecting to External Monitor)” .

■ Tuning conditions



Tuning conditions

RTAT machine stiffness setting at the start of the tuning ☑ Set automatically 12

Stability margin[%] Emphasis on balance 80

Tuning step

Advance operation OFF

Homing operation ON

Tuning target

Inertia ratio ON

Unbalanced load compensation OFF

Dynamic friction compensation OFF

Viscous friction compensation OFF

RTAT machine stiffness setting ON

RTAT FF stiffness setting ON

Load fluctuation suppression (disturban... ON

Notch filter ON

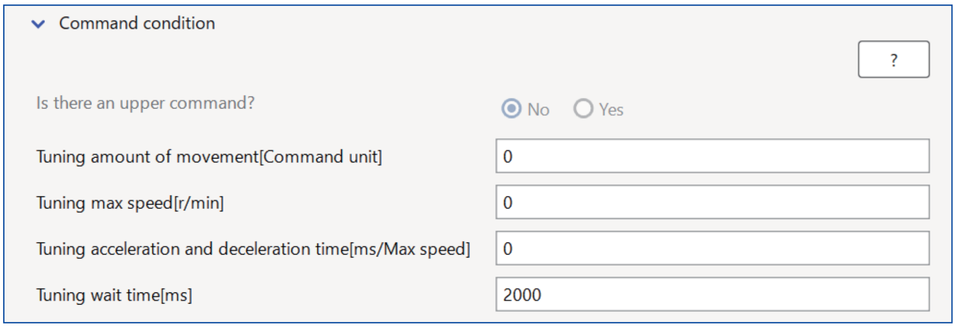
1st damping filter OFF

2nd damping filter OFF

Item	Description
RTAT machine stiffness setting at the start of the tuning	Configures the real-time auto-tuning machine stiffness setup for auto tuning startup. When tuning for the first time, do not change the setting and use by checking the “Set automatically” check box.
Stability margin	Sets the control tolerance for the tuning results. **Control tolerance** Tolerance for changes to the characteristics of machine axes that can be driven stably You can choose from the following four items. ● Emphasis on responsiveness: 60% ● Emphasis on balance: 80% ● Emphasis on stability: 100% ● Manual: The lower slide bar can be used to set any value. The higher the value, the higher the control stability against changes in characteristics, but the lower the suppression against disturbance. When the two-degree-of-freedom control mode is disabled, not only is the suppression of disturbance reduced, but also the command responsiveness. If the set value is 0, the setting is the same as for “Emphasis on balance”.

Item	Description
Tuning step	Select whether to perform advance operation and homing operation. If performing these operations, set to “ON”. Advance operation: Operation to check the operating range Homing operation: Operation for moving to the initial position after completion of auto tuning
Tuning target	The tuning target can be selected arbitrarily. When switched to “ON”, the item is subject to tuning. When tuning for the first time, do not change the setting before use. **— Precautions —** ● When setting the “Inertia ratio” to “OFF”, make sure the appropriate inertia ratio for the device being tuned is set in Pr0.04 “Inertia ratio” . If the appropriate inertia ratio is not set in Pr0.04 “Inertia ratio” with inertia ratio excluded from tuning, the correct tuning results may not be obtained. ● When two-degree-of-freedom control mode is disabled, “Viscous friction compensation” is set to “OFF”.

■ Command conditions



Command condition

?

Is there an upper command? ● No ○ Yes

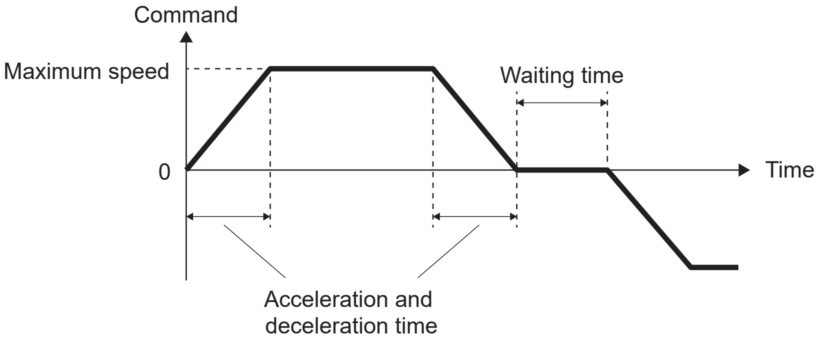
Tuning amount of movement[Command unit]: 0

Tuning max speed[r/min]: 0

Tuning acceleration and deceleration time[ms/Max speed]: 0

Tuning wait time[ms]: 2000

Image of the motor operation pattern



Item	Description
Is there an upper command?	Select whether to use an upper command as an operation command during command response measurement. The current version of Set-up Support Software (PANATERM ver.7) does not support the “Yes” for upper commands. Only “No” can be selected.
Tuning amount of movement	Sets the amount of movement when the motor operation pattern for command response measurement in the automatic adjustment process is generated inside the driver. If the set value is 0, the servo driver automatically sets the value within the operating range set by “Step 5”. **— Precautions —** ● Set a value larger than the positioning complete (In-position) range. If it is smaller, an error occurs. The upper-limit value that can be set is 1073741823.

Item	Description
Tuning max speed	Sets the maximum speed when the motor operation pattern for command response measurement in the automatic adjustment process is generated inside the driver. If the set value is 0, the servo driver automatically sets the value within the tuning overspeed level setting set in detailed protection function. **— Precautions —** ● Set a value smaller than the over-speed level setup. If it is larger, an error occurs.
Tuning acceleration and deceleration time	Sets the acceleration and deceleration time (from 0 to maximum speed or from maximum speed to 0) when the motor operation pattern for command response measurement in the automatic adjustment process is generated inside the driver. If the set value is 0, the servo driver automatically sets the value within the range below the tuning torque limit set in detailed protection function.
Tuning wait time	Sets the waiting time between operations when the motor operation pattern for command response measurement in the automatic adjustment process is generated inside the driver. **— Precautions —** ● Set a sufficiently large value for the waiting time so that the previous positioning operation does not affect measurement, and so that measurement can be performed correctly even if settling time during tuning is long. The time that can be set is limited to between 501 and 9000 ms.

After configuring the settings, go to *“3.1.2.4.3 Adjustment Operation”* .

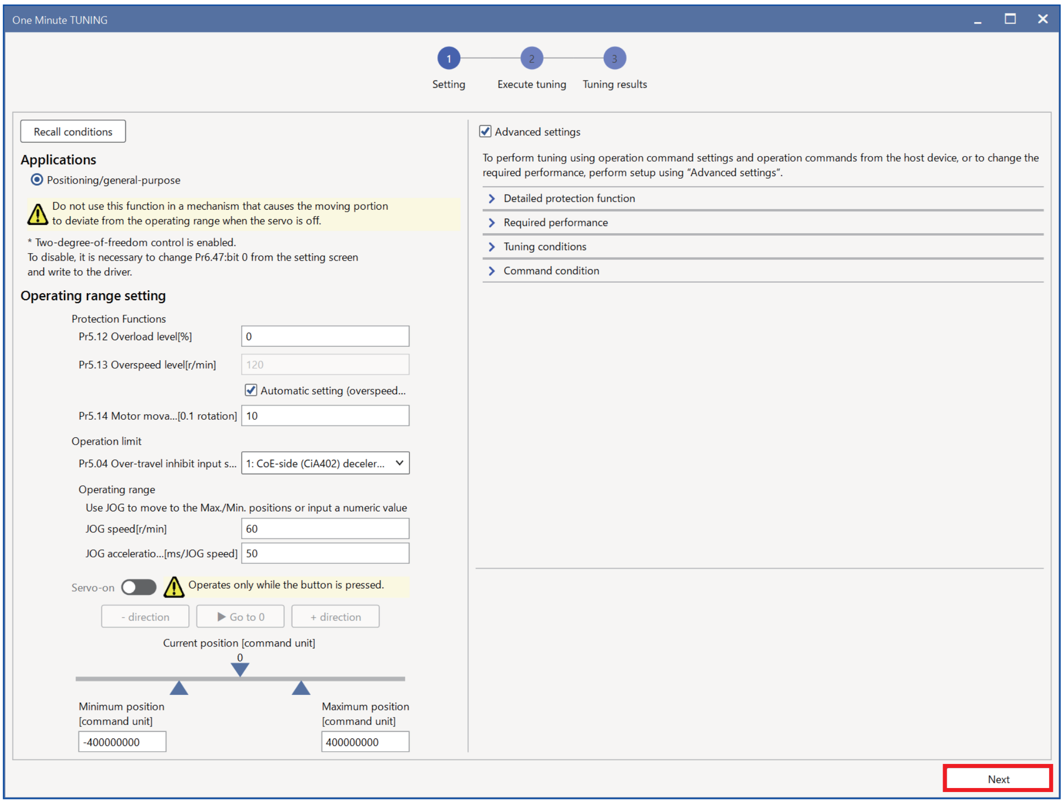
3.1.2.4.3 Adjustment Operation

<< Procedure >>

1. After finishing configuring the *"initial settings"* , click the [Next] button. This displays the Execute Tuning screen.

— Precautions —

- If "Step 5" of *"3.1.2.4.2 Initial Settings"* is not set for the operating range, the [Next] button cannot be clicked.



○ Positioning/general-purpose

Do not use this function in a mechanism that causes the moving portion to deviate from the operating range when the servo is off.

* Two-degree-of-freedom control is enabled.
To disable, it is necessary to change Pr6.47:bit 0 from the setting screen and write to the driver.

Operating range setting

Protection Functions
Pr5.12 Overload level[%]: 0
Pr5.13 Overspeed level[r/min]: 120
☑ Automatic setting (overspeed...
Pr5.14 Motor mova...[0.1 rotation]: 10

Operation limit
Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min]: 60
JOG acceleratio...[ms/JOG speed]: 50

Operates only while the button is pressed.

Current position [command unit]: 0
Minimum position [command unit]: -400000000
Maximum position [command unit]: 400000000

☑ Advanced settings

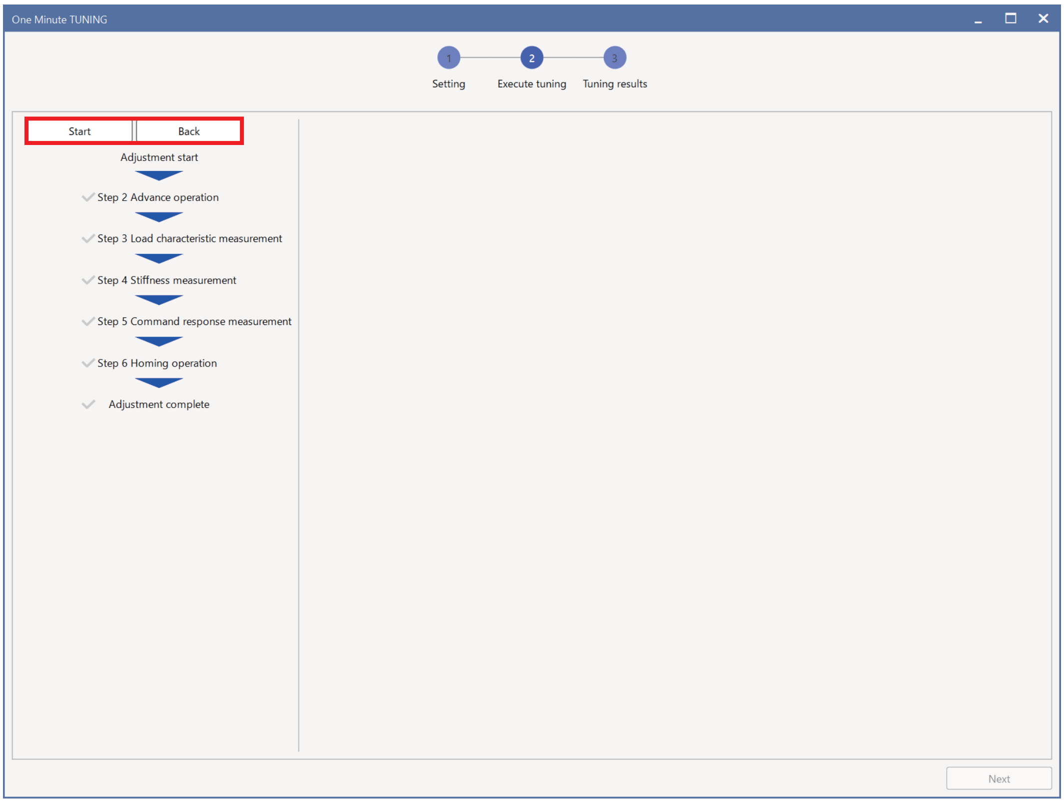
To perform tuning using operation command settings and operation commands from the host device, or to change the required performance, perform setup using "Advanced settings".

- › Detailed protection function
- › Required performance
- › Tuning conditions
- › Command condition

2. Click the [Start] button to start auto tuning and the motor starts moving.

   Click the [Back] button to return to the settings screen.

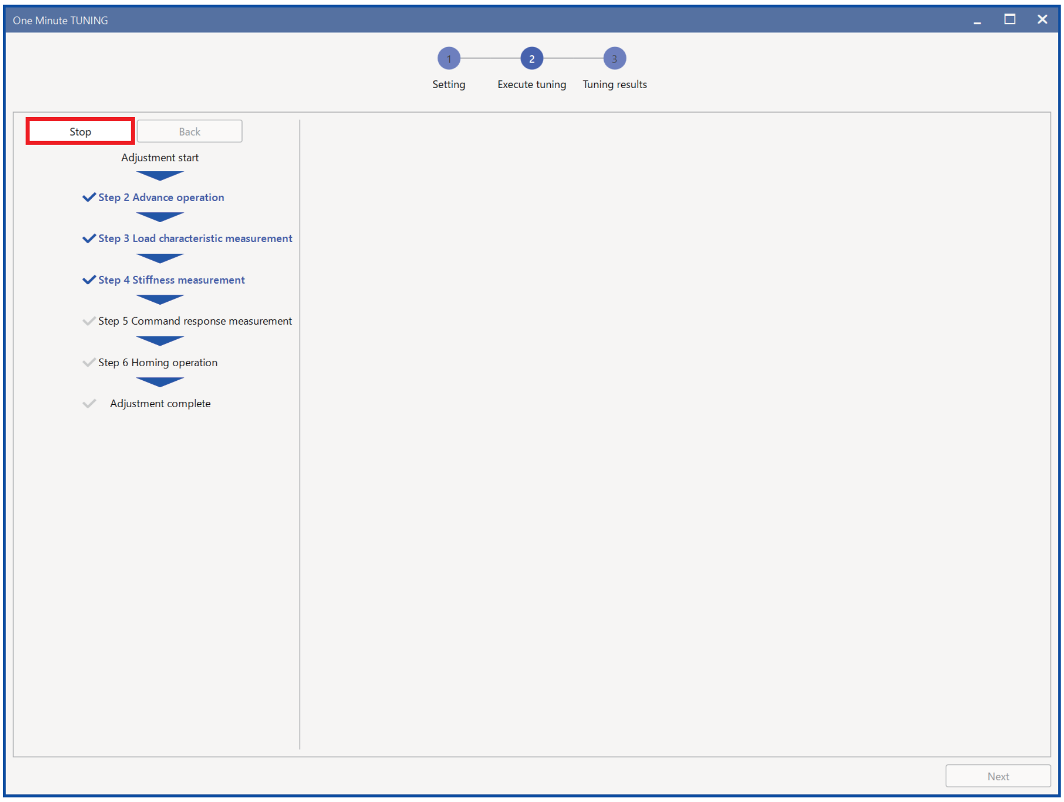
One Minute TUNING Execute Tuning Screen



3. Once auto tuning is started, the parameters are tuned based on the "Step 2" to "Step 6" settings of *"3.1.2.4.2 Initial Settings"* while the motor is running.

   If you wish to stop the auto tuning process midway, click the [Stop] button. Clicking the [Stop] button discards all values of parameters being tuned and returns them to the values before tuning started.

   One Minute TUNING In Progress Screen



Adjustment start

✓ Step 2 Advance operation

✓ Step 3 Load characteristic measurement

✓ Step 4 Stiffness measurement

✓ Step 5 Command response measurement

✓ Step 6 Homing operation

✓ Adjustment complete

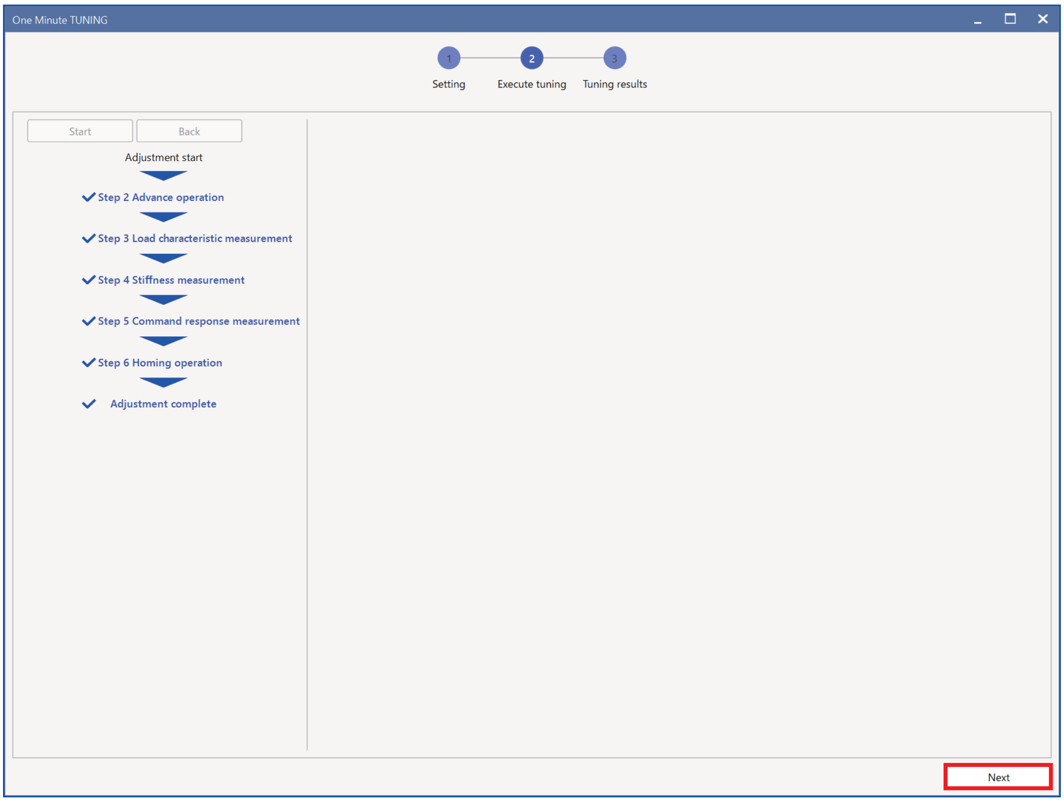
— Precautions —

- If an error occurs during operation, resolve according to the message. For details on error content, see *"7.6 List of Errors Related to One Minute TUNING"* .
- Error no. 1537 "Device characteristics measuring error 1" may occur, and the error may not be resolved even after action is taken. In such cases, perform manual tuning. For details on manual tuning, See *"3.2 Manual Tuning"* .
- If an error occurs during tuning and the machine stops, there is no homing operation for the initial position.
- If power is interrupted when tuning is in progress, the servo driver parameters must be initialized manually.

4. Tuning is complete when all steps are checked with a check mark.

Click the [Next] button.

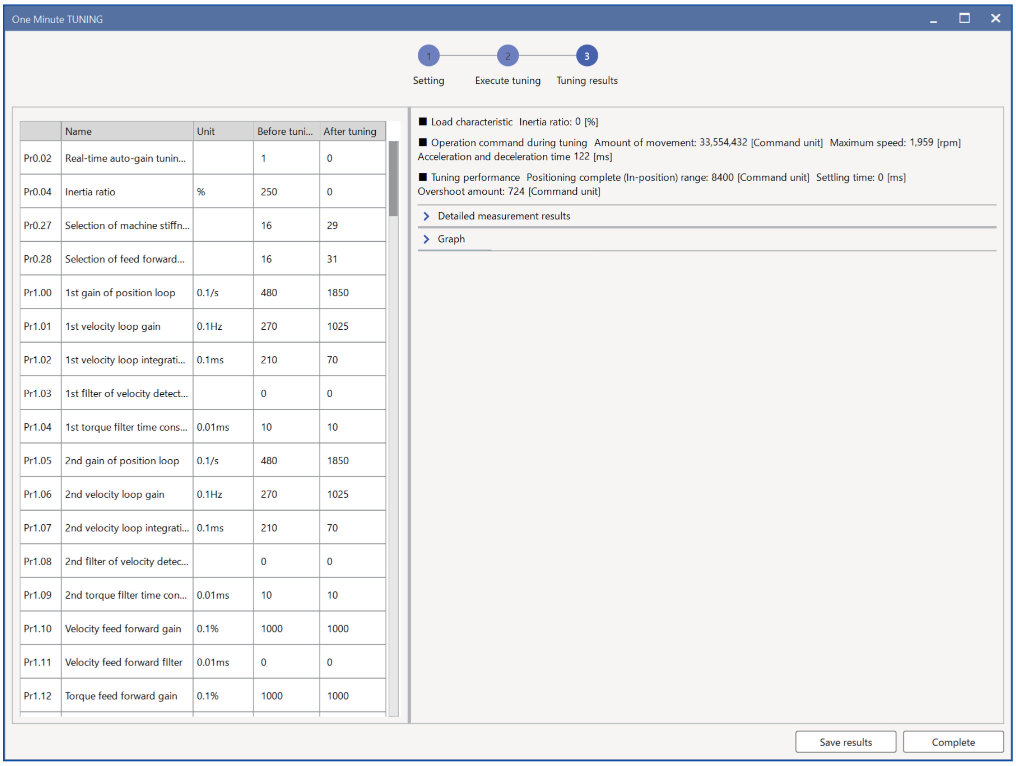
One Minute TUNING Completion Screen



Adjustment start

- ✓ Step 2 Advance operation
- ✓ Step 3 Load characteristic measurement
- ✓ Step 4 Stiffness measurement
- ✓ Step 5 Command response measurement
- ✓ Step 6 Homing operation
- ✓ Adjustment complete

The tuning results screen is displayed.



	Name	Unit	Before tuni...	After tuning
Pr0.02	Real-time auto-gain tunin...		1	0
Pr0.04	Inertia ratio	%	250	0
Pr0.27	Selection of machine stiffn...		16	29
Pr0.28	Selection of feed forward...		16	31
Pr1.00	1st gain of position loop	0.1/s	480	1850
Pr1.01	1st velocity loop gain	0.1Hz	270	1025
Pr1.02	1st velocity loop integrati...	0.1ms	210	70
Pr1.03	1st filter of velocity detect...		0	0
Pr1.04	1st torque filter time cons...	0.01ms	10	10
Pr1.05	2nd gain of position loop	0.1/s	480	1850
Pr1.06	2nd velocity loop gain	0.1Hz	270	1025
Pr1.07	2nd velocity loop integrati...	0.1ms	210	70
Pr1.08	2nd filter of velocity detec...		0	0
Pr1.09	2nd torque filter time con...	0.01ms	10	10
Pr1.10	Velocity feed forward gain	0.1%	1000	1000
Pr1.11	Velocity feed forward filter	0.01ms	0	0
Pr1.12	Torque feed forward gain	0.1%	1000	1000

■ Load characteristic Inertia ratio: 0 [%]

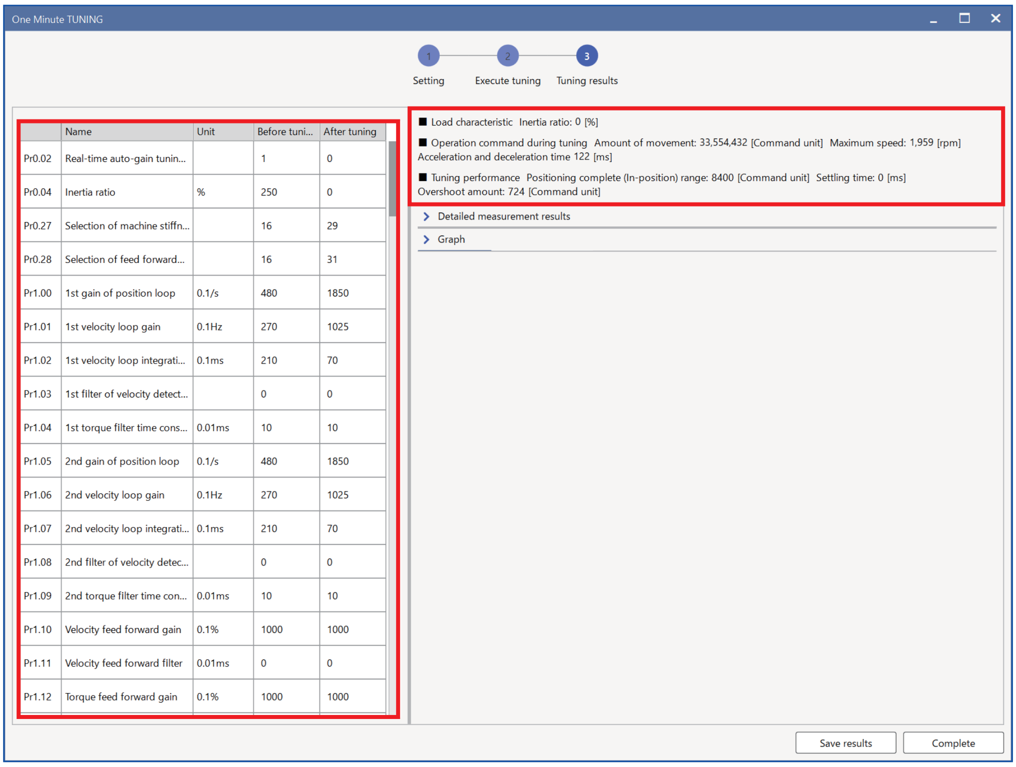
■ Operation command during tuning Amount of movement: 33,554,432 [Command unit] Maximum speed: 1,959 [rpm]
Acceleration and deceleration time 122 [ms]

■ Tuning performance Positioning complete (In-position) range: 8400 [Command unit] Settling time: 0 [ms]
Overshoot amount: 724 [Command unit]

3.1.2.4.4 Confirming Tuning Results, Ending One Minute TUNING

The left side of the tuning results screen displays the parameters before and after tuning. A summary is displayed in the upper right-hand corner of the tuning results screen.

One Minute TUNING Results Screen



	Name	Unit	Before tuni...	After tuning
Pr0.02	Real-time auto-gain tunin...		1	0
Pr0.04	Inertia ratio	%	250	0
Pr0.27	Selection of machine stiffn...		16	29
Pr0.28	Selection of feed forward...		16	31
Pr1.00	1st gain of position loop	0.1/s	480	1850
Pr1.01	1st velocity loop gain	0.1Hz	270	1025
Pr1.02	1st velocity loop integrati...	0.1ms	210	70
Pr1.03	1st filter of velocity detect...		0	0
Pr1.04	1st torque filter time cons...	0.01ms	10	10
Pr1.05	2nd gain of position loop	0.1/s	480	1850
Pr1.06	2nd velocity loop gain	0.1Hz	270	1025
Pr1.07	2nd velocity loop integrati...	0.1ms	210	70
Pr1.08	2nd filter of velocity detec...		0	0
Pr1.09	2nd torque filter time con...	0.01ms	10	10
Pr1.10	Velocity feed forward gain	0.1%	1000	1000
Pr1.11	Velocity feed forward filter	0.01ms	0	0
Pr1.12	Torque feed forward gain	0.1%	1000	1000

■ Load characteristic Inertia ratio: 0 [%]

■ Operation command during tuning Amount of movement: 33,554,432 [Command unit] Maximum speed: 1,959 [rpm]
Acceleration and deceleration time 122 [ms]

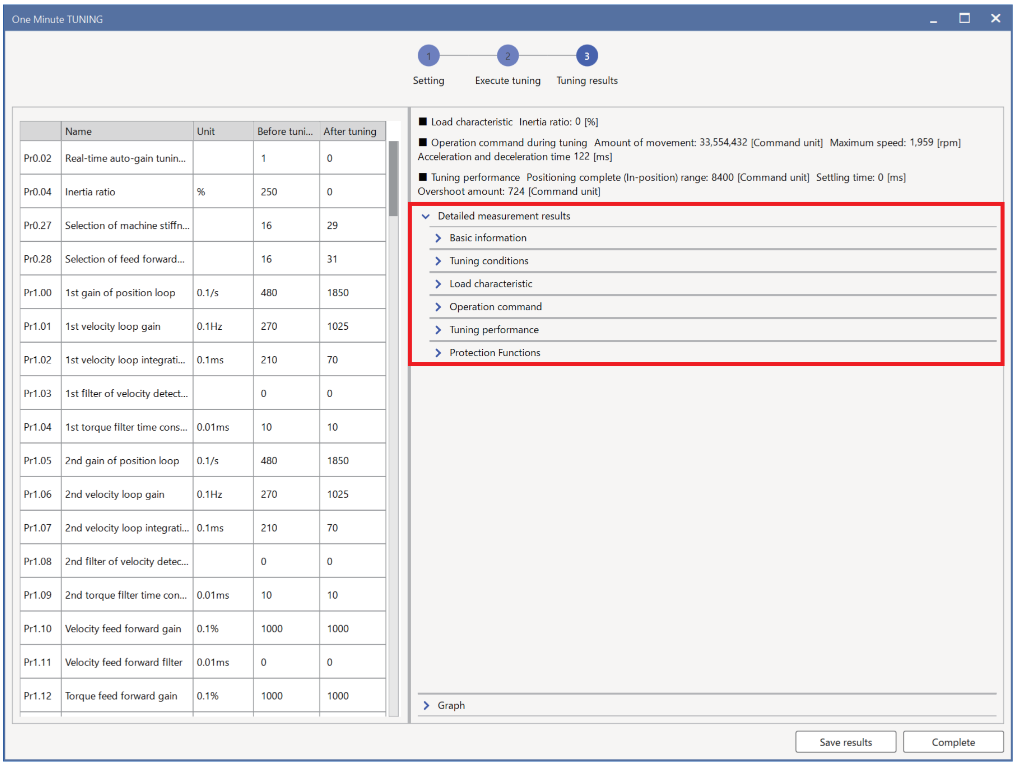
■ Tuning performance Positioning complete (In-position) range: 8400 [Command unit] Settling time: 0 [ms]
Overshoot amount: 724 [Command unit]

> Detailed measurement results

> Graph

<< Procedure >>

1. To see details of the tuning results, click “>” in “> Detailed measurement results” to expand details of the measurement results.



	Name	Unit	Before tuni...	After tuning
Pr0.02	Real-time auto-gain tunin...		1	0
Pr0.04	Inertia ratio	%	250	0
Pr0.27	Selection of machine stiffn...		16	29
Pr0.28	Selection of feed forward...		16	31
Pr1.00	1st gain of position loop	0.1/s	480	1850
Pr1.01	1st velocity loop gain	0.1Hz	270	1025
Pr1.02	1st velocity loop integrati...	0.1ms	210	70
Pr1.03	1st filter of velocity detect...		0	0
Pr1.04	1st torque filter time cons...	0.01ms	10	10
Pr1.05	2nd gain of position loop	0.1/s	480	1850
Pr1.06	2nd velocity loop gain	0.1Hz	270	1025
Pr1.07	2nd velocity loop integrati...	0.1ms	210	70
Pr1.08	2nd filter of velocity detec...		0	0
Pr1.09	2nd torque filter time con...	0.01ms	10	10
Pr1.10	Velocity feed forward gain	0.1%	1000	1000
Pr1.11	Velocity feed forward filter	0.01ms	0	0
Pr1.12	Torque feed forward gain	0.1%	1000	1000

■ Load characteristic Inertia ratio: 0 [%]

■ Operation command during tuning Amount of movement: 33,554,432 [Command unit] Maximum speed: 1,959 [rpm]
Acceleration and deceleration time 122 [ms]

■ Tuning performance Positioning complete (In-position) range: 8400 [Command unit] Settling time: 0 [ms]
Overshoot amount: 724 [Command unit]

⌄ Detailed measurement results
- > Basic information
- > Tuning conditions
- > Load characteristic
- > Operation command
- > Tuning performance
- > Protection Functions

> Graph

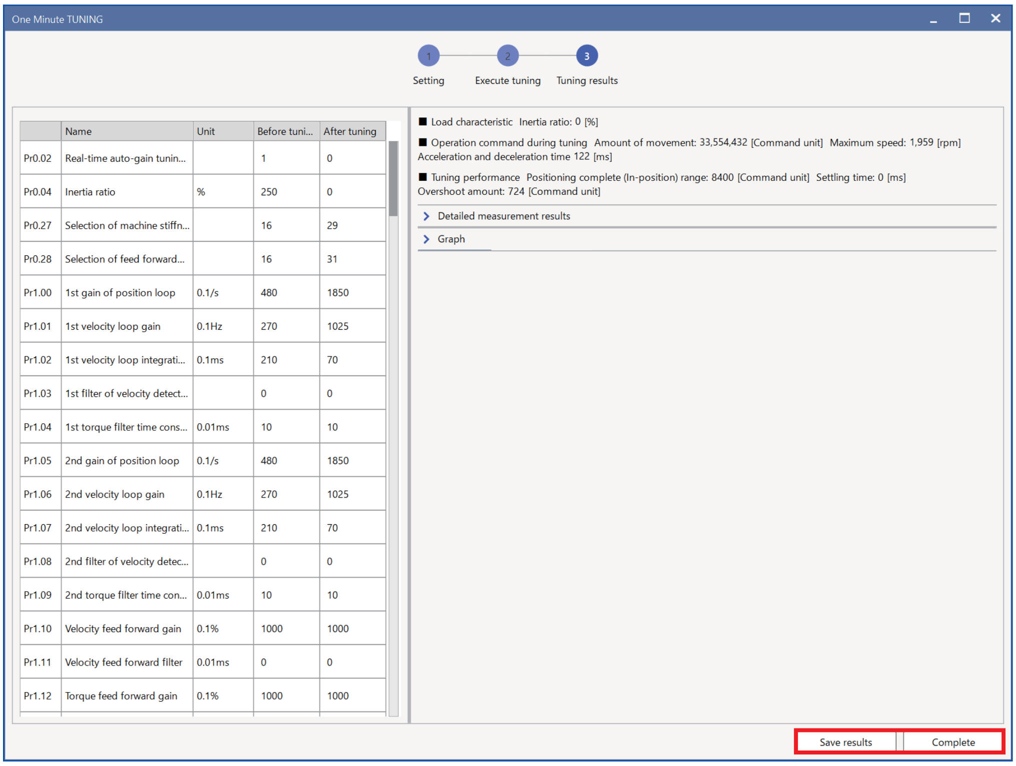
Click “>” by each item displayed to expand it, allowing you to check detailed information on tuning conditions and tuning performance.

Item	Check item
Basic information	● Date and time of measurement ● Driver information (Model No., Serial No.) ● Motor information (Model No., Serial No.)
Tuning conditions	Set in initial setting. ● Application ● Positioning complete (In-position) range ● Target settling time ● Settling time count condition ● Allowable overshoot amount ● Stability margin ● RTAT machine stiffness setting at the start of the tuning ● Tuning step (advance operation, homing operation) ● Tuning target (inertia ratio, etc.)
Load characteristics	Calculated during the adjustment process. ● Inertia ratio ● Unbalanced load ● Dynamic friction torque ● Viscous friction torque ● Resonance frequency ● Vibration frequency
Operation command	Set in initial setting. ● Tuning Amount of movement ● Tuning Max speed ● Tuning Acceleration and deceleration time ● Tuning Wait time ● Command time ● Command speed (maximum) ● Command speed (minimum) ● Command amount of movement
Tuning performance	Measured during the adjustment process. ● Settling time ● Overshoot amount ● INP change count ● Vibration level ● Effective load factor ● Takt ● Velocity zero cross count ● Motor speed (maximum) ● Motor speed (minimum) ● Torque command (maximum) ● Torque command (minimum) ● Position deviation (maximum) ● Position deviation (minimum) ● Fine vibration count ● INP change count at settling time ● Regenerative load factor

Item	Check item
Protection functions	Set in initial setting. ● Tuning vibration automatic suppression effective level ● Tuning operating range upper limit ● Tuning operating range lower limit ● Tuning over-speed level setup ● Tuning torque limit

2. To save the settings and information on the adjustment process (*“3.1.2.4.2 Initial Settings”* to *“3.1.2.4.3 Adjustment Operation”*) to a file, click the [Save results] button. A save file dialog box opens. Set the folder to save to and the file name, and save the file.

To end One Minute TUNING, click the [Complete] button.



	Name	Unit	Before tuni...	After tuning
Pr0.02	Real-time auto-gain tunin...		1	0
Pr0.04	Inertia ratio	%	250	0
Pr0.27	Selection of machine stiffn...		16	29
Pr0.28	Selection of feed forward...		16	31
Pr1.00	1st gain of position loop	0.1/s	480	1850
Pr1.01	1st velocity loop gain	0.1Hz	270	1025
Pr1.02	1st velocity loop integrati...	0.1ms	210	70
Pr1.03	1st filter of velocity detect...		0	0
Pr1.04	1st torque filter time cons...	0.01ms	10	10
Pr1.05	2nd gain of position loop	0.1/s	480	1850
Pr1.06	2nd velocity loop gain	0.1Hz	270	1025
Pr1.07	2nd velocity loop integrati...	0.1ms	210	70
Pr1.08	2nd filter of velocity detec...		0	0
Pr1.09	2nd torque filter time con...	0.01ms	10	10
Pr1.10	Velocity feed forward gain	0.1%	1000	1000
Pr1.11	Velocity feed forward filter	0.01ms	0	0
Pr1.12	Torque feed forward gain	0.1%	1000	1000

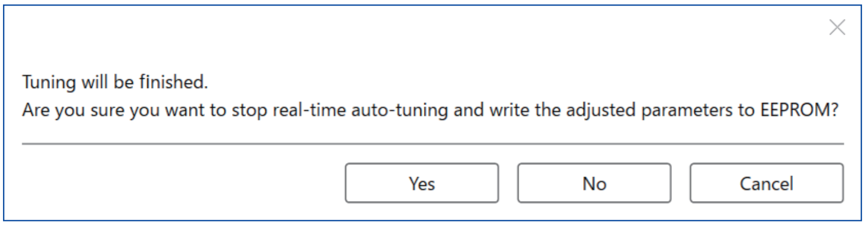
■ Load characteristic Inertia ratio: 0 [%]

■ Operation command during tuning Amount of movement: 33,554,432 [Command unit] Maximum speed: 1,959 [rpm] Acceleration and deceleration time 122 [ms]

■ Tuning performance Positioning complete (In-position) range: 8400 [Command unit] Settling time: 0 [ms] Overshoot amount: 724 [Command unit]

A confirmation dialog box is displayed asking if you want to write the parameters from the tuning results to EEPROM.

- Click the [Yes] button to end One Minute TUNING with parameters written to EEPROM.
- Click the [No] button to end One Minute TUNING without parameters written to EEPROM.
- Click the [Cancel] button to close the confirmation dialog box and return to the tuning results screen.



Tuning will be finished.
Are you sure you want to stop real-time auto-tuning and write the adjusted parameters to EEPROM?

3.1.2.5 Use Cases in Re-adjustment

With One Minute TUNING, if there is a change in the device workpiece or position, only specific items can be auto tuned again.

Read out a previously saved configuration file, configure the appropriate settings for the tuning target in *“Advanced settings”* (*“3.1.2.4.2 Initial Settings”* “Step 6” onward), and execute One Minute TUNING.

The table below shows reasons for re-adjustment and examples of setting items to be turned ON for tuning at that time.

Reason for re-adjustment	Re-adjustment method	ON setting items to be tuned
A component of the device moving part was changed.	Settings such as inertia ratio and machine stiffness require re-adjusting due to inertia fluctuations.	● Inertia ratio ● RTAT machine stiffness setting ● RTAT FF stiffness setting ● Load fluctuation suppression ● Notch filter
Vibration as a result of a change in position.	Re-adjust damping control (damping filter) to suppress vibration.	● RTAT FF stiffness setting ● Load fluctuation suppression ● 1st damping filter ● 2nd damping filter
Abnormal noise occurred due to aging.	Re-adjust the notch filter to suppress mechanical resonance.	● Load fluctuation suppression ● Notch filter

3.1.3 precAIse TUNING

3.1.3.1 Function Overview

This function automatically tunes various parameters while the motor is running, with AI determining the motor response.

It is effective for tuning devices that are difficult to tune and require tuning by skilled operators. The tuning results are expected to exceed those of skilled operators.

This is also effective for reducing operator labor hours, because it performs automatic operation using Set-up Support Software (PANATERM ver.7) after initial setting of target performance and multiple operation patterns, etc.

3.1.3.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control and two-degree-of-freedom control mode enabled
Real-time auto tuning control type	● Two-degree-of-freedom Control Mode for Standard Type
Load fluctuation control function	● The load fluctuation control function is enabled and load fluctuation compensation gain is 90 % or more ● Load fluctuation control function disabled
Other	● Set-up Support Software (PANATERM ver.7) is required.

— Precautions —

- The motor rotates during execution of this function. Be careful not to contact moving parts.
- Tuning results that satisfy the required performance may not be obtained. In such cases the tuning results judged to be the best are displayed.
- This tuning changes the values of many parameters. If you need the values before tuning, save the data beforehand.
- Depending on the initial parameter settings, the following may occur when tuning is in progress. Initial settings must be configured to ensure the motor operates properly.
  - The motor operates in an unintended position, direction, or amount of movement (for example, when the rotational direction setup is incorrect)
  - he motor oscillates (for example, when the maximum value of the tuning range for the parameter to be tuned is too large)
  - AI set values are not reflected (for example, when the mode is one in which the parameter to be tuned is automatically set)
  - An alarm is triggered and tuning is aborted (For example, when the detection level of the protection function is set too low. If an alarm is triggered and the response in the initial settings is unclear, please contact us.)
- Depending on what the parameters are when the tuning is initiated, oscillation may occur while the tuning is in progress. Please use OneMinuteTUNING or similar software to perform tuning beforehand to ensure that no oscillation occurs with all the operation patterns that will be set and that they all operate normally.

3.1.3.3 Parameters That Are Automatically Set and Automatically Tuned

Parameters selected in *“Initial settings”* (“Step 2”) in the usage instructions

3.1.3.4 Usage

Instructions for use are described according to the following steps.

1 *“Starting the Tuning Function”*

2 *“Initial Settings”*

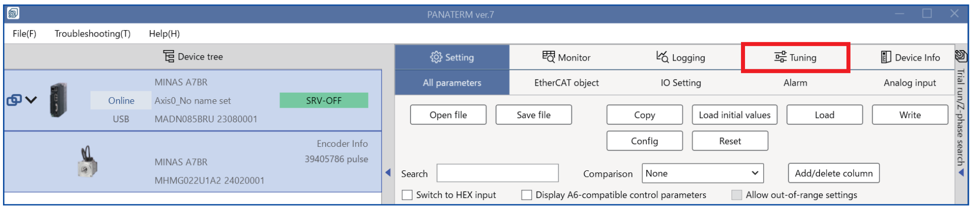
3 *“Adjustment Operation”*

4 *“Confirming Tuning Results, Ending precAIse TUNING”*

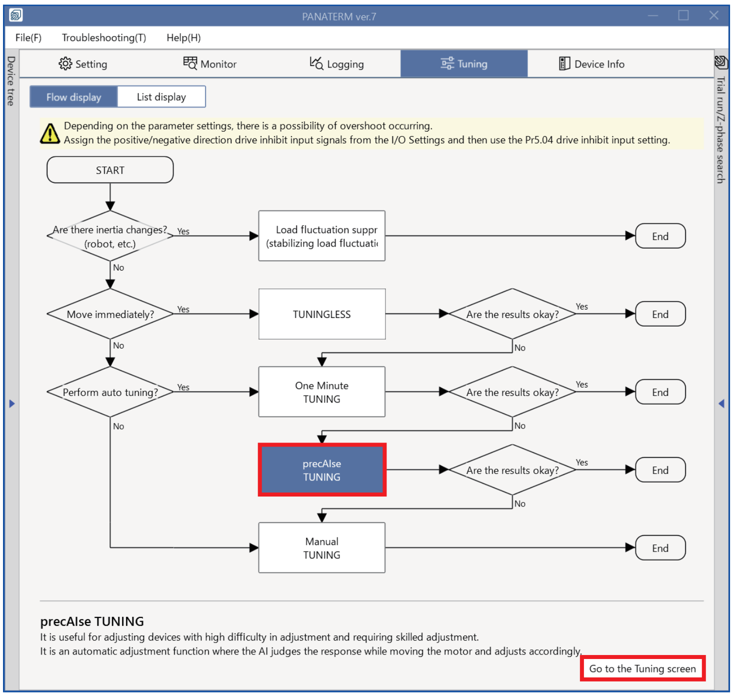
3.1.3.4.1 Starting the Tuning Function

<< Procedure >>

1. Check that Pr0.01 “Control mode setup” is set to position control mode for operational conditions.
2. Activate Set-up Support Software (PANATERM ver.7) .
3. Select one device that you want to tune in the device tree and click the “Tuning” tab.



4. In the “Tuning” tab screen, select “precAIse TUNING”, and click the [Go to the Tuning screen] button.

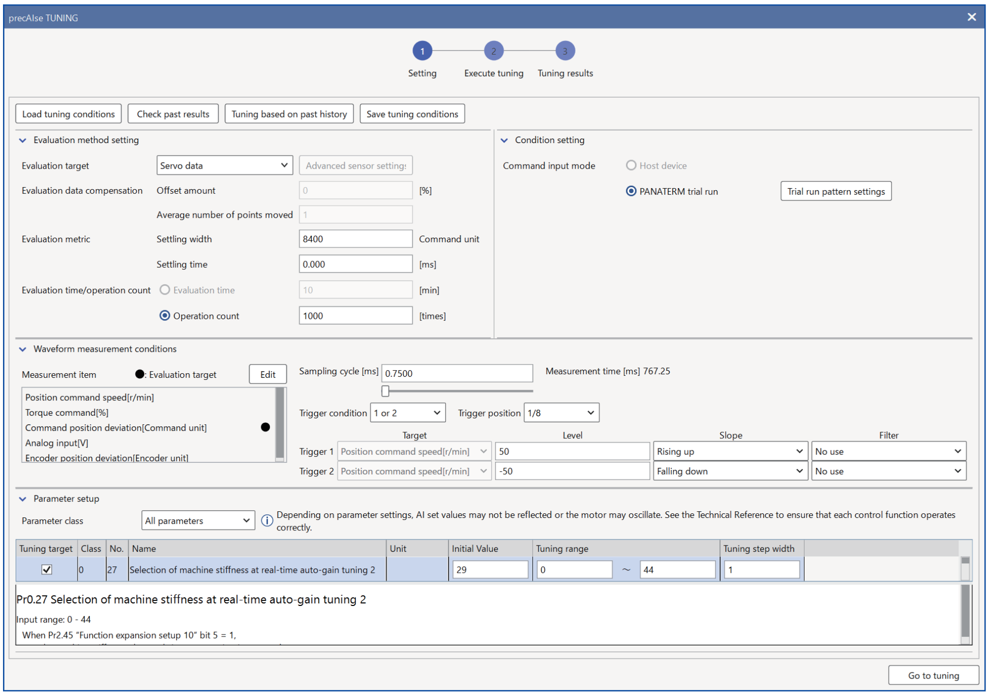


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

precAIse TUNING

It is useful for adjusting devices with high difficulty in adjustment and requiring skilled adjustment.
It is an automatic adjustment function where the AI judges the response while moving the motor and adjusts accordingly.

The “precAIse TUNING” settings screen is displayed.



Evaluation target: Servo data
Evaluation data compensation: Offset amount 0 [%]
Average number of points moved 1
Evaluation metric: Settling width 8400 Command unit
Settling time 0.000 [ms]
Evaluation time/operation count: ○ Evaluation time 10 [min]
● Operation count 1000 [times]

Command input mode: ○ Host device
● PANATERM trial run

Measurement item ●: Evaluation target
Position command speed[r/min]
Torque command[%]
Command position deviation[Command unit] ●
Analog input[V]
Encoder position deviation[Encoder unit]

Sampling cycle [ms] 0.7500
Measurement time [ms] 767.25
Trigger condition 1 or 2
Trigger position 1/8

	Target	Level	Slope	Filter
Trigger 1	Position command speed[r/min]	50	Rising up	No use
Trigger 2	Position command speed[r/min]	-50	Falling down	No use

Parameter class: All parameters

Depending on parameter settings, AI set values may not be reflected or the motor may oscillate. See the Technical Reference to ensure that each control function operates correctly.

Tuning target	Class	No.	Name	Unit	Initial Value	Tuning range			Tuning step width
☑	0	27	Selection of machine stiffness at real-time auto-gain tuning 2		29	0	~	44	1

Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2

Input range: 0 - 44

When Pr2.45 “Function expansion setup 10” bit 5 = 1,

3.1.3.4.2 Initial Settings

<< Procedure >>

1. Starts configuration of initial settings.
   - To set new initial settings

     Go to "Step 2".
   - To use the contents of a previously saved configuration file

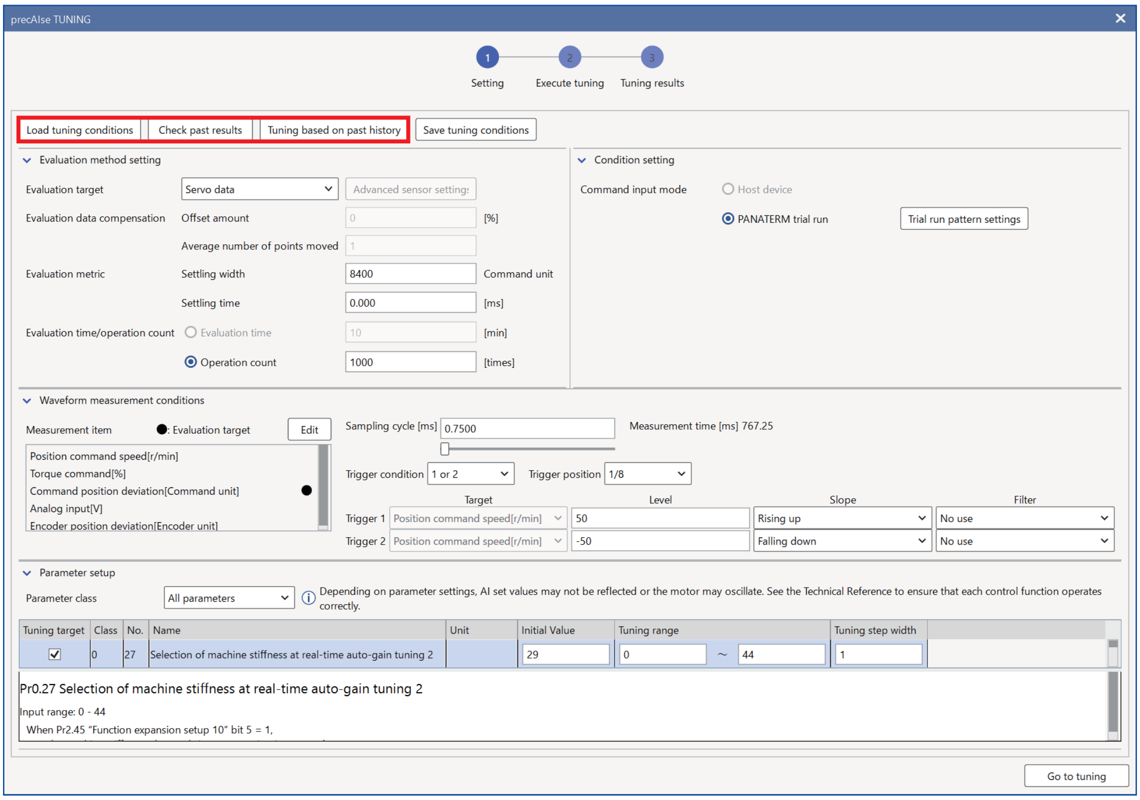
     Perform one of the following operations before proceeding to "Step 3".
     - To use the contents of a previously saved tuning condition setup file

       Click on the [Load tuning conditions] button to load that file.
     - To check previously saved tuning results

       Click on the [Check past results] button to load that file.
     - To start tuning based on previously saved tuning results

       Click on the [Tuning based on past history] button to load that file. If tuning is aborted due to a problem, tuning can be resumed using past history files saved up to that point.

precAIse TUNING Settings Screen



Evaluation method setting

Evaluation target: Servo data

Evaluation data compensation: Offset amount 0 [%]; Average number of points moved 1

Evaluation metric: Settling width 8400 Command unit; Settling time 0.000 [ms]

Evaluation time/operation count: ○ Evaluation time 10 [min]; ● Operation count 1000 [times]

Condition setting

Command input mode: ○ Host device; ● PANATERM trial run

Waveform measurement conditions

Measurement item ●: Evaluation target

Position command speed[r/min]
Torque command[%]
Command position deviation[Command unit] ●
Analog input[V]
Encoder position deviation[Encoder unit]

Sampling cycle [ms] 0.7500

Measurement time [ms] 767.25

Trigger condition 1 or 2

Trigger position 1/8

	Target	Level	Slope	Filter
Trigger 1	Position command speed[r/min]	50	Rising up	No use
Trigger 2	Position command speed[r/min]	-50	Falling down	No use

Parameter setup

Parameter class: All parameters

ⓘ Depending on parameter settings, AI set values may not be reflected or the motor may oscillate. See the Technical Reference to ensure that each control function operates correctly.

Tuning target	Class	No.	Name	Unit	Initial Value	Tuning range		Tuning step width
☑	0	27	Selection of machine stiffness at real-time auto-gain tuning 2		29	0 ~	44	1

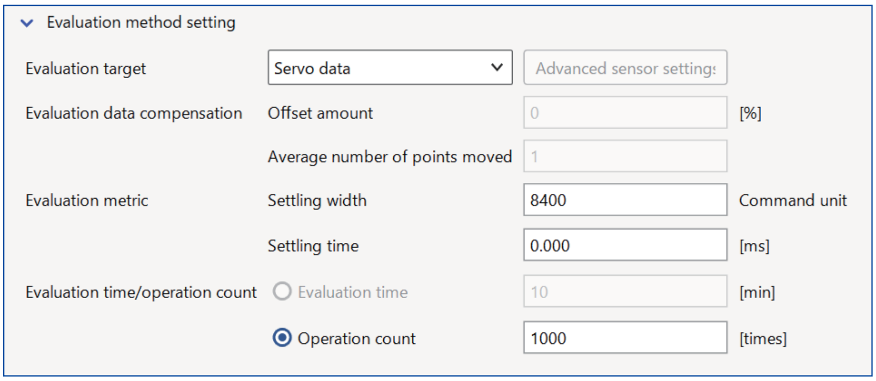
Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2

Input range: 0 - 44

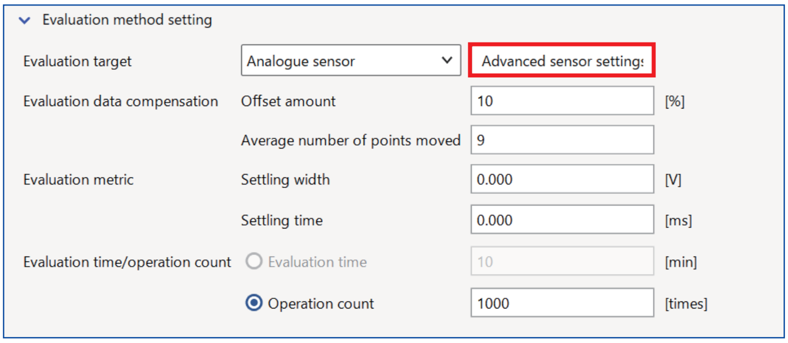
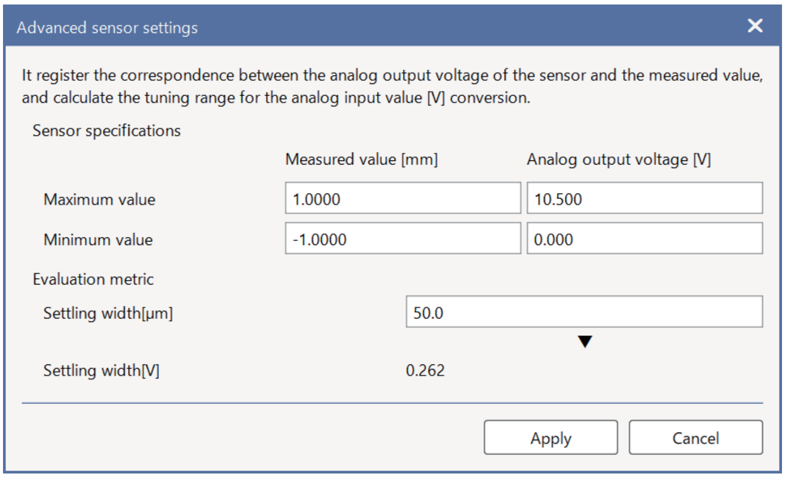
When Pr2.45 "Function expansion setup 10" bit 5 = 1,

2. To set new tuning conditions, set the following. After completing the settings, go to "Step 3".

Evaluation method setting

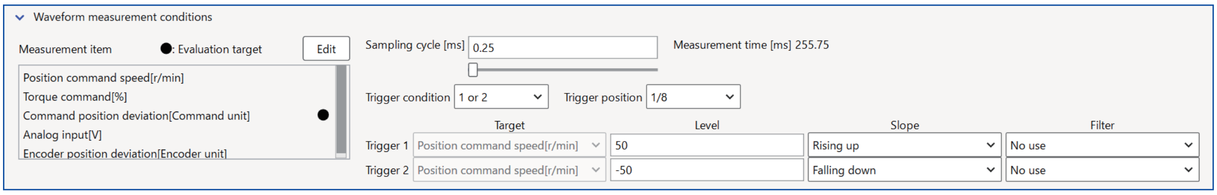

Evaluation method setting
Evaluation target: Servo data

Evaluation data compensation: Offset amount 0 [%]
Average number of points moved 1
Evaluation metric: Settling width 8400 Command unit
Settling time 0.000 [ms]
Evaluation time/operation count: ○ Evaluation time 10 [min]
● Operation count 1000 [times]

Item	Description
Evaluation target	Select data to be used for performance evaluation (servo data, analog sensors). ● is automatically assigned to the evaluation target in [Waveform measurement conditions] - [Measurement items]. When “Servo data” is selected, the target data is command position deviation. When “Analog sensor” is selected, the target data is the analog input. When “Analog sensor” is selected, click the [Advanced sensor settings] button and enter specifications from the “Advanced sensor settings” screen.  Evaluation method setting Evaluation target: Analogue sensor Evaluation data compensation: Offset amount 10 [%] Average number of points moved 9 Evaluation metric: Settling width 0.000 [V] Settling time 0.000 [ms] Evaluation time/operation count: ○ Evaluation time 10 [min] ● Operation count 1000 [times] **“Advanced Sensor Settings” Screen** Register the correspondence between the analog output voltage of the sensor and the measured value and input the settling width in µm to calculate the settling width with the analog sensor. Click the [Apply] button to apply the settling width on the settings screen.  Advanced sensor settings It register the correspondence between the analog output voltage of the sensor and the measured value, and calculate the tuning range for the analog input value [V] conversion. Sensor specifications Maximum value: Measured value [mm] 1.0000, Analog output voltage [V] 10.500 Minimum value: Measured value [mm] -1.0000, Analog output voltage [V] 0.000 Evaluation metric Settling width[µm] 50.0 Settling width[V] 0.262 **— Precautions —** ● When using analog sensors, configure Pr4.22, Pr4.23, Pr4.24, and Pr4.65 settings appropriately for normal waveform measurement.

Item	Description
Evaluation data compensation	This item can be set when “Analog sensor” is selected, and it sets the measurement data compensation value. ● Offset amount [%] Sets the percentage of data used for offset calculation relative to the entire measured setting time waveform data (for automatic calibration of analog sensor data). ● Average number of points moved Sets the number of movement averaging data points for measured waveform data.
Evaluation metric	Sets the target values for settling width and settling time.
Evaluation time/operation count	Sets the upper limit for the operation count or evaluation time. **— Precautions —** ● In the current version of Set-up Support Software (PANATERM ver.7) , only “operation count” can be selected. ● The actual operation count will be less than the set operation count due to the adjustment algorithm. The set upper limit value is displayed in the operation count [times] denominator on the Execute Tuning screen.

Waveform measurement conditions



Waveform measurement conditions

Measurement item ●: Evaluation target

Position command speed[r/min]
Torque command[%]
Command position deviation[Command unit] ●
Analog input[V]
Encoder position deviation[Encoder unit]

Sampling cycle [ms] 0.25

Measurement time [ms] 255.75

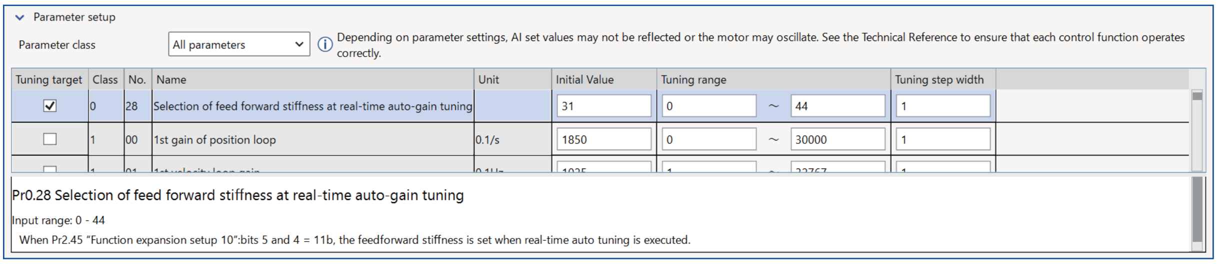
Trigger condition 1 or 2

Trigger position 1/8

	Target	Level	Slope	Filter
Trigger 1	Position command speed[r/min]	50	Rising up	No use
Trigger 2	Position command speed[r/min]	-50	Falling down	No use

Item	Description
Measurement item	This displays the measurement items. Measurement items can be added or deleted in the “Edit measurement items” dialog box that is displayed when the [Edit] button is clicked. For the editing method, see Set-up Support Software (PANATERM ver.7) Operating Manual. Default items cannot be deleted.
Sampling cycle, trigger-related setting items	See Set-up Support Software (PANATERM ver.7) Operating Manual. **— Precautions —** ● Set the sampling cycle so that the evaluation metric (settling time) can be determined within the measurement time.

Parameter setup



Parameter setup

Parameter class All parameters

Depending on parameter settings, AI set values may not be reflected or the motor may oscillate. See the Technical Reference to ensure that each control function operates correctly.

Tuning target	Class	No.	Name	Unit	Initial Value	Tuning range			Tuning step width
☑	0	28	Selection of feed forward stiffness at real-time auto-gain tuning		31	0	~	44	1
☐	1	00	1st gain of position loop	0.1/s	1850	0	~	30000	1

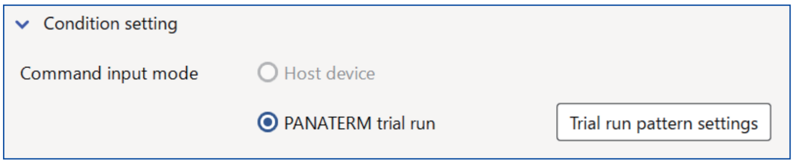
Pr0.28 Selection of feed forward stiffness at real-time auto-gain tuning

Input range: 0 - 44

When Pr2.45 “Function expansion setup 10”:bits 5 and 4 = 11b, the feedforward stiffness is set when real-time auto tuning is executed.

Item	Description
Parameter setup	Select the parameters to be tuned. The “Parameter class” drop-down list allows only “All parameters” to be selected. A list of parameters is displayed at the bottom of the screen. Select the parameter to be tuned by checking the “Tuning target” check box, and enter the “Initial value”, “Tuning range” and “Tuning step width” in the text boxes. **— Precautions —** ● At least one parameter should be set as a tuning target. ● Tuning can be performed without changing the setting values. Changing the tuning range, tuning target, or initial value may cause the motor to oscillate.

Condition setting

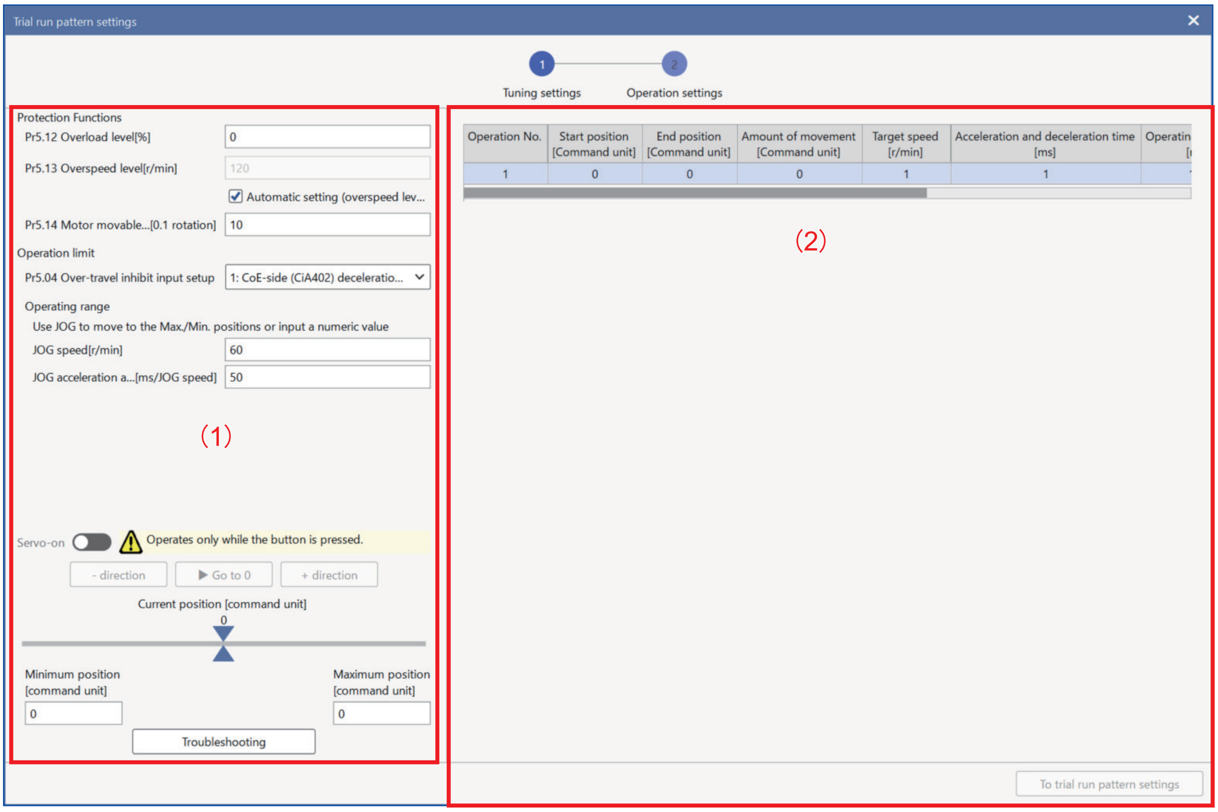


Condition setting

Command input mode: ○ Host device ● PANATERM trial run

Item	Description
Command input mode	Set the command generation means. **— Precautions —** ● In the current version of Set-up Support Software (PANATERM ver.7) , only “PANATERM trial run” can be selected. Configure the advanced settings from the [Trial run pattern settings] button.

Condition setting - Trial run pattern settings screen



Protection Functions

Pr5.12 Overload level[%]: 0

Pr5.13 Overspeed level[r/min]: 120

☑ Automatic setting (overspeed lev...

Pr5.14 Motor movable...[0.1 rotation]: 10

Operation limit

Pr5.04 Over-travel inhibit input setup: 1: CoE-side (CiA402) deceleratio...

Operating range

Use JOG to move to the Max./Min. positions or input a numeric value

JOG speed[r/min]: 60

JOG acceleration a...[ms/JOG speed]: 50

Servo-on

Operates only while the button is pressed.

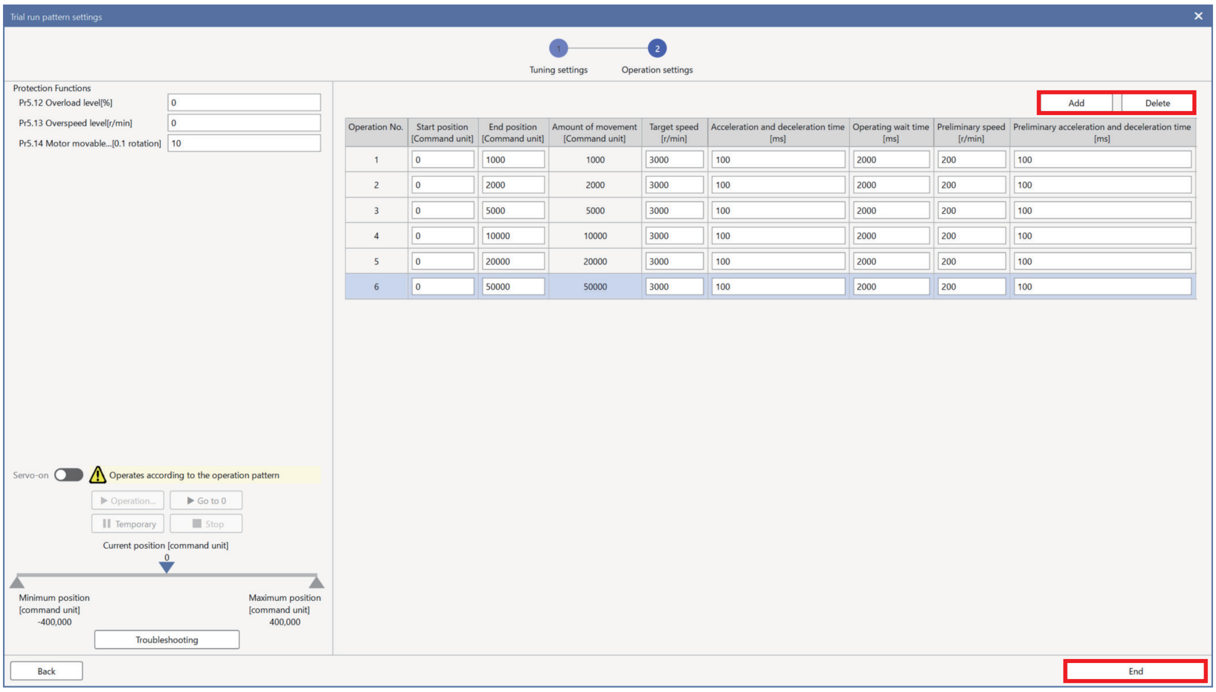
Current position [command unit]: 0

Minimum position [command unit]: 0

Maximum position [command unit]: 0

Operation No.	Start position [Command unit]	End position [Command unit]	Amount of movement [Command unit]	Target speed [r/min]	Acceleration and deceleration time [ms]	Operatin
1	0	0	0	1	1	

(1)	Set the protective function and operable range for trial run.
(2)	The parameters of the operation command for which the response is to be evaluated are displayed. To edit, click the [To trial run pattern settings] button at the bottom, which becomes active when the operating range is set in (1), and then click the button to display the screen (next figure).



Protection Functions

Pr5.12 Overload level[%]: 0

Pr5.13 Overspeed level[r/min]: 0

Pr5.14 Motor movable...[0.1 rotation]: 10

Operation No.	Start position [Command unit]	End position [Command unit]	Amount of movement [Command unit]	Target speed [r/min]	Acceleration and deceleration time [ms]	Operating wait time [ms]	Preliminary speed [r/min]	Preliminary acceleration and deceleration time [ms]
1	0	1000	1000	3000	100	2000	200	100
2	0	2000	2000	3000	100	2000	200	100
3	0	5000	5000	3000	100	2000	200	100
4	0	10000	10000	3000	100	2000	200	100
5	0	20000	20000	3000	100	2000	200	100
6	0	50000	50000	3000	100	2000	200	100

Operates according to the operation pattern

Current position [command unit]
0

Minimum position [command unit] -400,000

Maximum position [command unit] 400,000

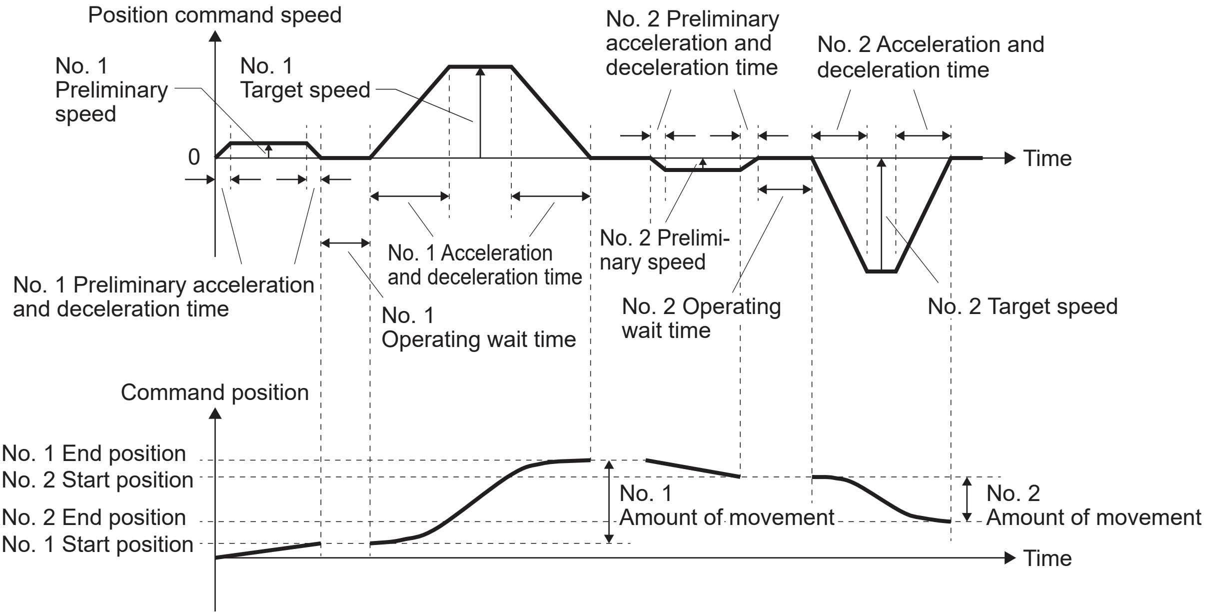
Different trial run patterns can be added or deleted by clicking the [Add] and [Delete] buttons. Please refer to the following example of a trial run pattern when setting.

The maximum number of trial run patterns that can be set is 100. The amount of movement can be automatically calculated by entering the start and end positions. When finishing configuring the settings, click the [End] button.

— Precautions —

- In all trial run patterns, the amount of movement must be greater than or equal to 1.

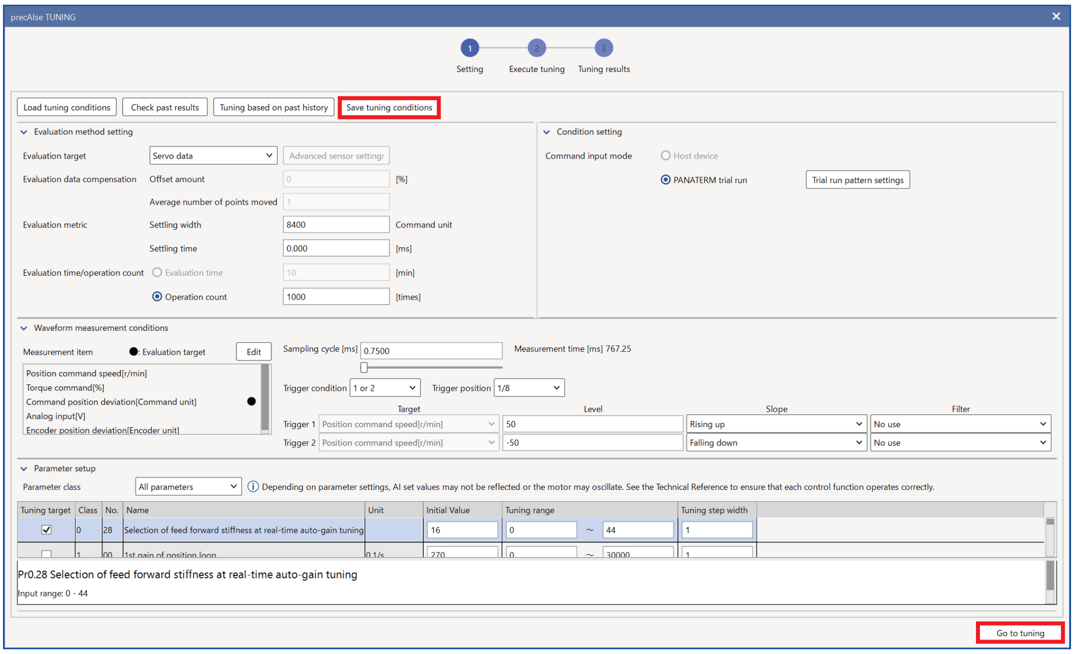
Example trial run pattern



Once finished configuring the settings for tuning conditions, go to "Step 3".

3. To save the settings configured in “Step 1” or “Step 2”, click the [Save tuning conditions] button. A save file dialog box opens. Set the folder to save to and the file name, and save the file.

After finishing the tuning condition setup, click the [Go to tuning] button in the lower right-hand corner of the screen.



Evaluation method setting

Evaluation target: Servo data

Evaluation data compensation: Offset amount 0 [%]; Average number of points moved 1

Evaluation metric: Settling width 8400 Command unit; Settling time 0.000 [ms]

Evaluation time/operation count: ○ Evaluation time 10 [min]; ● Operation count 1000 [times]

Condition setting

Command input mode: ○ Host device; ● PANATERM trial run

Waveform measurement conditions

Measurement item ●: Evaluation target

Position command speed[r/min]
Torque command[%]
Command position deviation[Command unit] ●
Analog input[V]
Encoder position deviation[Encoder unit]

Sampling cycle [ms] 0.7500

Measurement time [ms] 767.25

Trigger condition 1 or 2

Trigger position 1/8

	Target	Level	Slope	Filter
Trigger 1	Position command speed[r/min]	50	Rising up	No use
Trigger 2	Position command speed[r/min]	-50	Falling down	No use

Parameter setup

Parameter class: All parameters

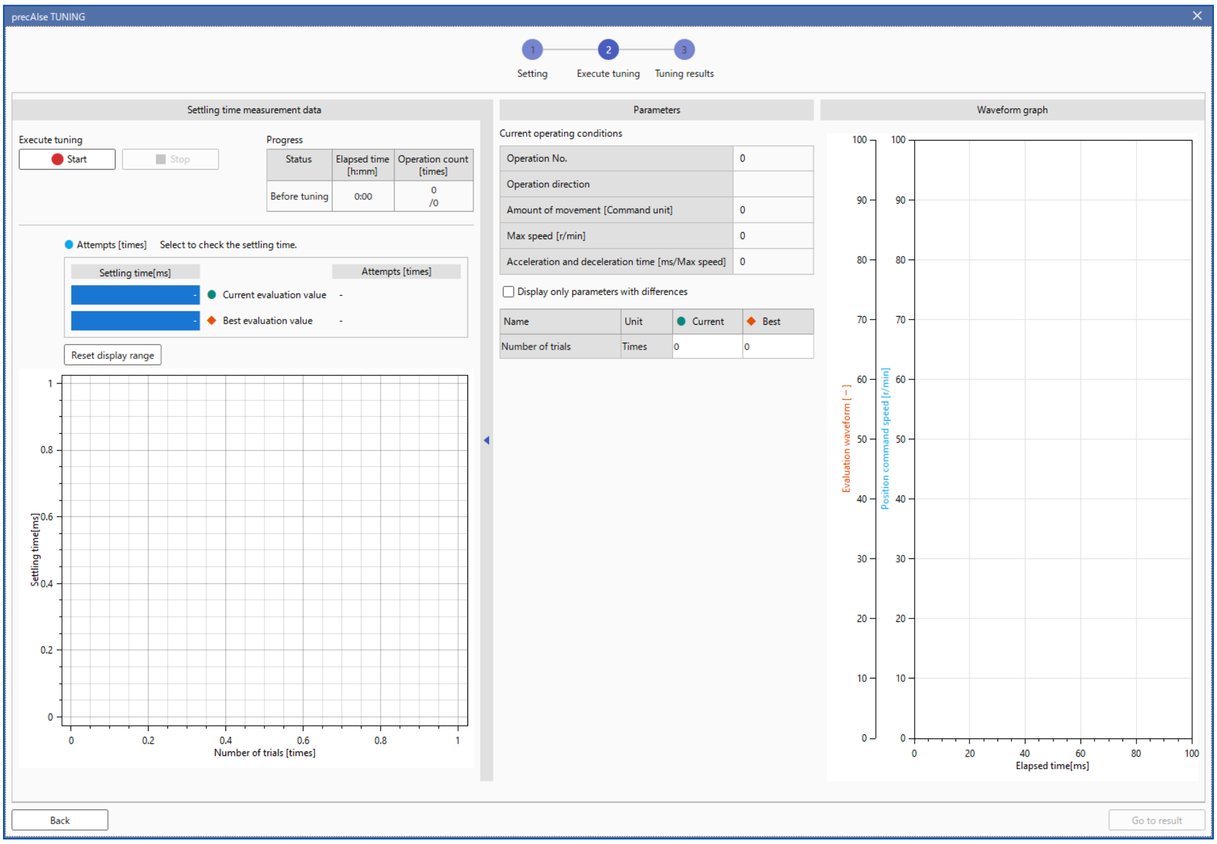
ⓘ Depending on parameter settings, AI set values may not be reflected or the motor may oscillate. See the Technical Reference to ensure that each control function operates correctly.

Tuning target	Class	No.	Name	Unit	Initial Value	Tuning range		Tuning step width
☑	0	28	Selection of feed forward stiffness at real-time auto-gain tuning		16	0	~ 44	1
☐	1	00	1st gain of position loop	0.1/s	270	0	~ 30000	1

Pr0.28 Selection of feed forward stiffness at real-time auto-gain tuning

Input range: 0 - 44

The screen switches to the Execute Tuning screen.



Status	Elapsed time [h:mm]	Operation count [times]
Before tuning	0:00	0 /0

● Current evaluation value -

◆ Best evaluation value -

Current operating conditions

Operation No.	0
Operation direction	
Amount of movement [Command unit]	0
Max speed [r/min]	0
Acceleration and deceleration time [ms/Max speed]	0

☐ Display only parameters with differences

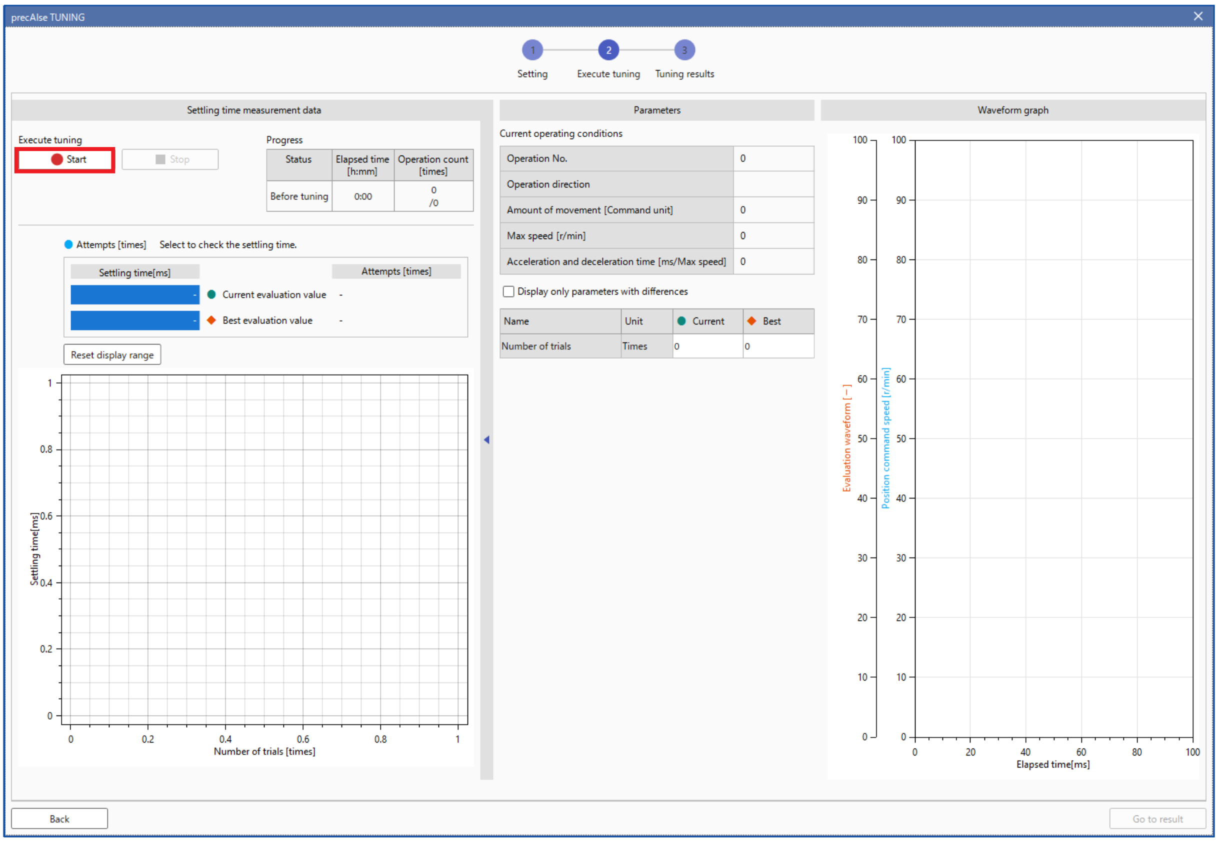
Name	Unit	● Current	◆ Best
Number of trials	Times	0	0

Go to *“3.1.3.4.3 Adjustment Operation”* .

3.1.3.4.3 Adjustment Operation

<< Procedure >>

1. Click the [Start] button on the Execute Tuning screen.



Progress

Status	Elapsed time [h:mm]	Operation count [times]
Before tuning	0:00	0 /0

● Current evaluation value -
◆ Best evaluation value -

Current operating conditions

Operation No.	0
Operation direction	
Amount of movement [Command unit]	0
Max speed [r/min]	0
Acceleration and deceleration time [ms/Max speed]	0

☐ Display only parameters with differences

Name	Unit	● Current	◆ Best
Number of trials	Times	0	0

The “Tuning start preparation dialog” dialog box is displayed.

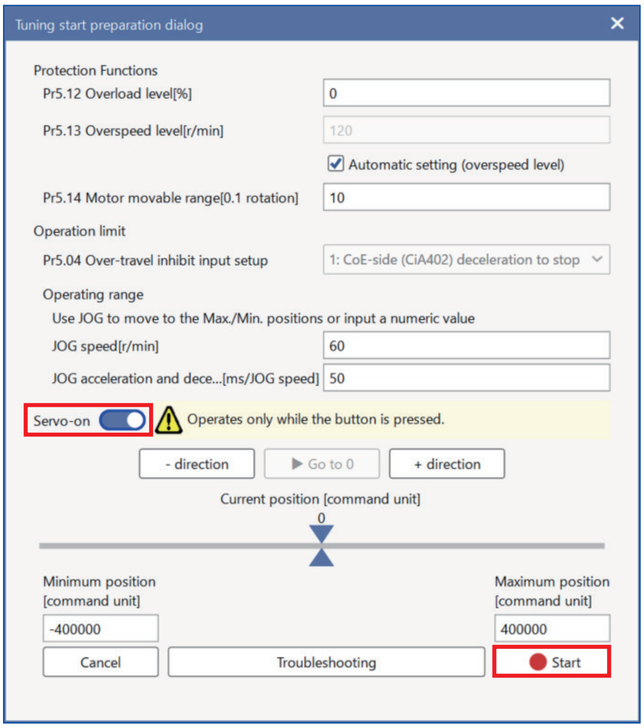
2. Perform servo-on, set the operating range of the device, and click the [Start] button.

   Once clicked, the “Tuning start preparation dialog” dialog box automatically closes and AI evaluates the motor command response and starts tuning the parameters.

   - If you are tuning repeatedly under the same conditions, please use PANATERM to align the motor position as much as possible when setting the servo to servo-on status.

     The precAIse TUNING function uses PANATERM and operates with the reference position (zero position) set as the motor position when the servo is set to servo-on status.

     If the reference position (zero position) deviates significantly in comparison to past tunings, an error may occur when tuning is in progress or the expected performance may not be achieved.



Tuning start preparation dialog

Protection Functions

Pr5.12 Overload level[%]: 0

Pr5.13 Overspeed level[r/min]: 120

☑ Automatic setting (overspeed level)

Pr5.14 Motor movable range[0.1 rotation]: 10

Operation limit

Pr5.04 Over-travel inhibit input setup: 1: CoE-side (CiA402) deceleration to stop

Operating range

Use JOG to move to the Max./Min. positions or input a numeric value

JOG speed[r/min]: 60

JOG acceleration and dece...[ms/JOG speed]: 50

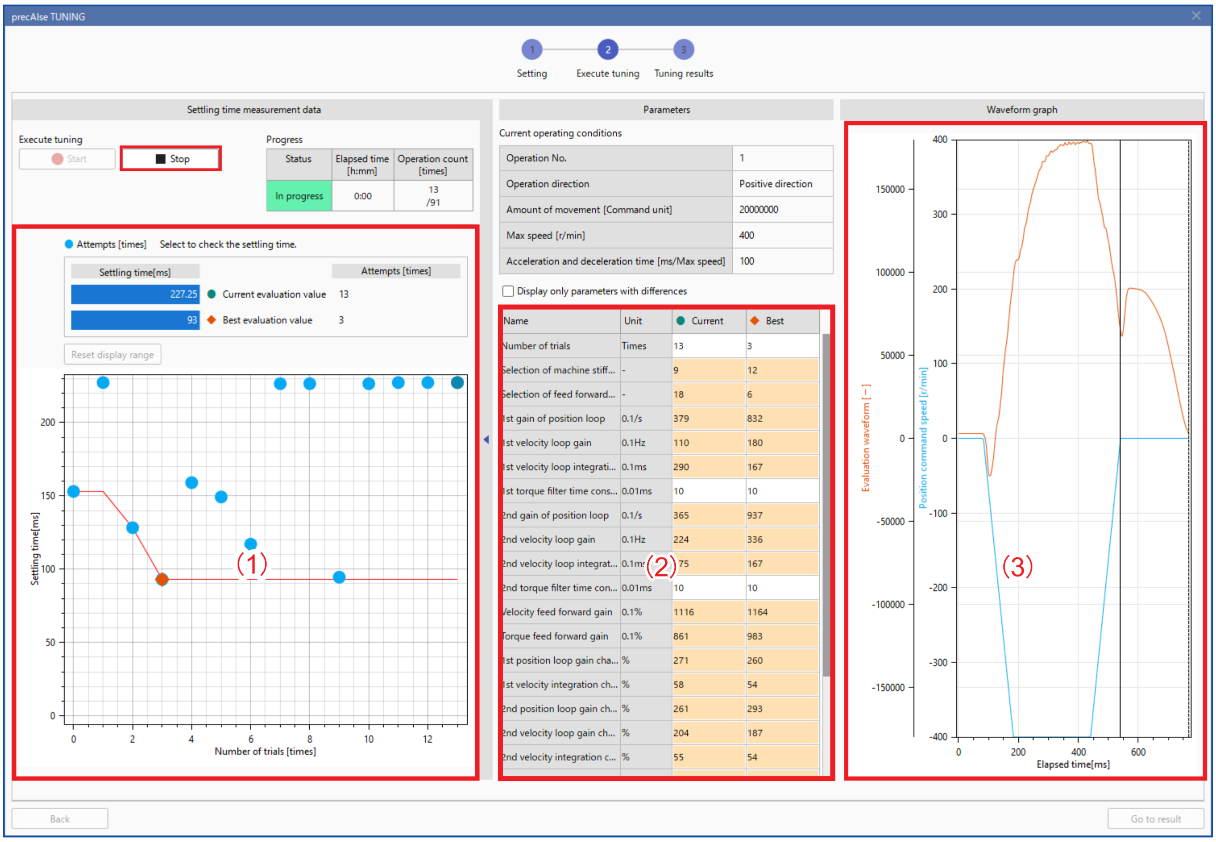
Servo-on ⚠ Operates only while the button is pressed.

Current position [command unit]: 0

Minimum position [command unit]: -400000

Maximum position [command unit]: 400000

3. If you wish to end parameter tuning, for example in an emergency, click the [Stop] button.



precAIse TUNING

Settling time measurement data

Execute tuning

Progress

Status	Elapsed time [h:mm]	Operation count [times]
In progress	0:00	13 /91

● Attempts [times] Select to check the settling time.

Settling time[ms]		Attempts [times]
227.25	● Current evaluation value	13
93	◆ Best evaluation value	3

Parameters

Current operating conditions

Operation No.	1
Operation direction	Positive direction
Amount of movement [Command unit]	20000000
Max speed [r/min]	400
Acceleration and deceleration time [ms/Max speed]	100

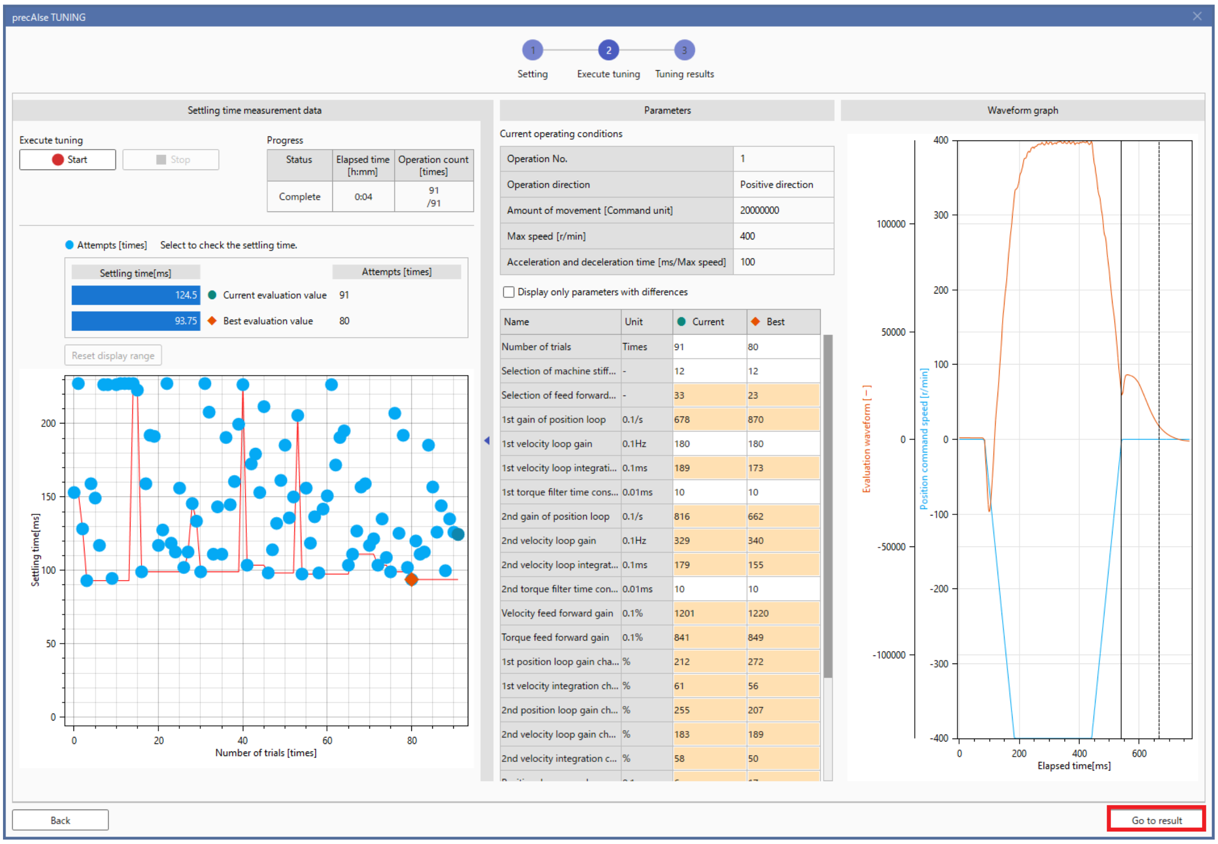
☐ Display only parameters with differences

Name	Unit	● Current	◆ Best
Number of trials	Times	13	3
Selection of machine stiff...	-	9	12
Selection of feed forward...	-	18	6
1st gain of position loop	0.1/s	379	832
1st velocity loop gain	0.1Hz	110	180
1st velocity loop integrati...	0.1ms	290	167
1st torque filter time cons...	0.01ms	10	10
2nd gain of position loop	0.1/s	365	937
2nd velocity loop gain	0.1Hz	224	336
2nd velocity loop integrat...	0.1ms	75	167
2nd torque filter time con...	0.01ms	10	10
Velocity feed forward gain	0.1%	1116	1164
Torque feed forward gain	0.1%	861	983
1st position loop gain cha...	%	271	260
1st velocity integration ch...	%	58	54
2nd position loop gain ch...	%	261	293
2nd velocity loop gain ch...	%	204	187
2nd velocity integration c...	%	55	54

You can check progress with “Progress status” and “Current operating conditions”. In addition, detailed data is displayed on three central images on the screen.

(1)	Settling time measurement data	The settling time transition in the adjustment process is displayed.
(2)	Parameters	The current parameters in the adjustment process and the parameters with the best results at that time are displayed.
(3)	Waveform graph	The current measurement data (time-series data) is displayed.

4. When the progress status displays “Complete”, click the [Go to result] button in the lower right-hand corner.



Progress

Status	Elapsed time [h:mm]	Operation count [times]
Complete	0:04	91 /91

Settling time[ms]		Attempts [times]
124.5	Current evaluation value	91
93.75	Best evaluation value	80

Current operating conditions

Operation No.	1
Operation direction	Positive direction
Amount of movement [Command unit]	20000000
Max speed [r/min]	400
Acceleration and deceleration time [ms/Max speed]	100

☐ Display only parameters with differences

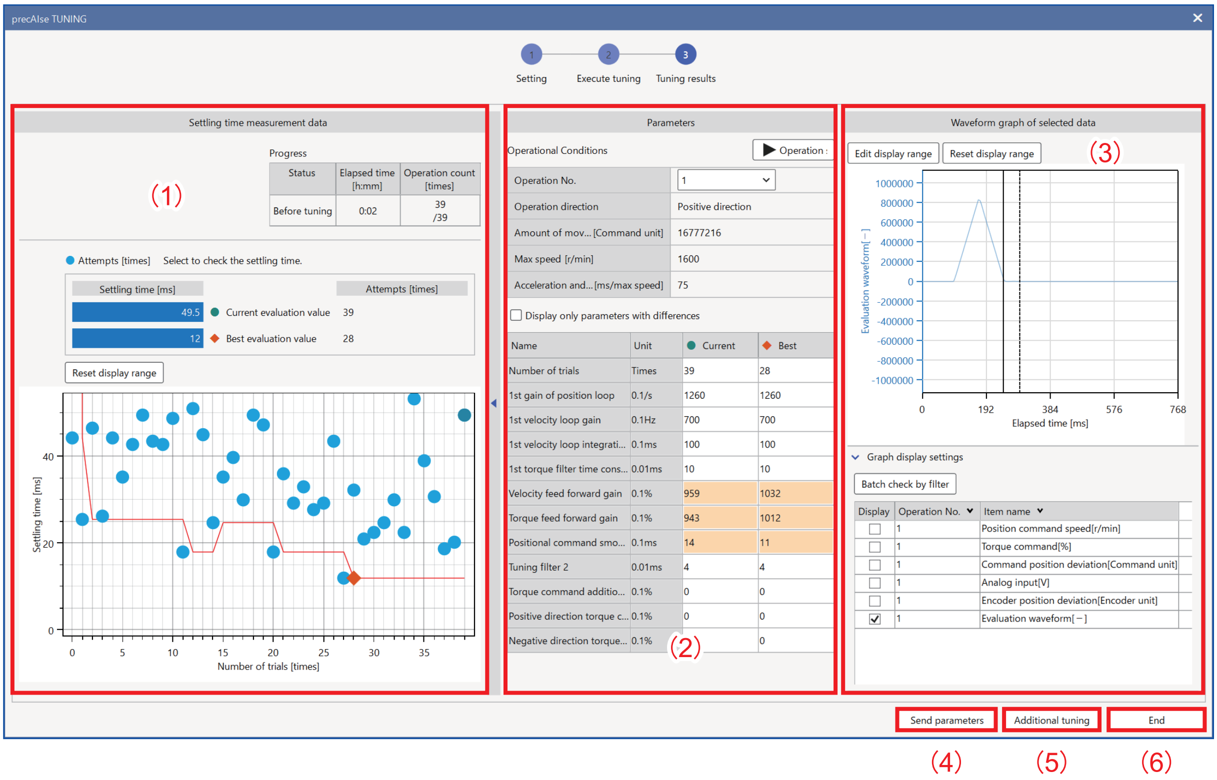
Name	Unit	● Current	◆ Best
Number of trials	Times	91	80
Selection of machine stiff...	-	12	12
Selection of feed forward...	-	33	23
1st gain of position loop	0.1/s	678	870
1st velocity loop gain	0.1Hz	180	180
1st velocity loop integrati...	0.1ms	189	173
1st torque filter time cons...	0.01ms	10	10
2nd gain of position loop	0.1/s	816	662
2nd velocity loop gain	0.1Hz	329	340
2nd velocity loop integrat...	0.1ms	179	155
2nd torque filter time con...	0.01ms	10	10
Velocity feed forward gain	0.1%	1201	1220
Torque feed forward gain	0.1%	841	849
1st position loop gain cha...	%	212	272
1st velocity integration ch...	%	61	56
2nd position loop gain ch...	%	255	207
2nd velocity loop gain ch...	%	183	189
2nd velocity integration c...	%	58	50

The tuning results screen is displayed.

3.1.3.4.4 Confirming Tuning Results, Ending precAIse TUNING

To check the tuning results and end precAIse TUNING, use the respective buttons listed in the table below.

precAIse TUNING Results Screen



Progress

Status	Elapsed time [h:mm]	Operation count [times]
Before tuning	0:02	39 /39

Settling time [ms]		Attempts [times]
49.5	Current evaluation value	39
12	Best evaluation value	28

Operational Conditions

Operation No.	1
Operation direction	Positive direction
Amount of mov... [Command unit]	16777216
Max speed [r/min]	1600
Acceleration and... [ms/max speed]	75

☐ Display only parameters with differences

Name	Unit	● Current	◆ Best
Number of trials	Times	39	28
1st gain of position loop	0.1/s	1260	1260
1st velocity loop gain	0.1Hz	700	700
1st velocity loop integrati...	0.1ms	100	100
1st torque filter time cons...	0.01ms	10	10
Velocity feed forward gain	0.1%	959	1032
Torque feed forward gain	0.1%	943	1012
Positional command smo...	0.1ms	14	11
Tuning filter 2	0.01ms	4	4
Torque command additio...	0.1%	0	0
Positive direction torque c...	0.1%	0	0
Negative direction torque...	0.1%	[illegible]	0

Display	Operation No.	Item name
☐	1	Position command speed[r/min]
☐	1	Torque command[%]
☐	1	Command position deviation[Command unit]
☐	1	Analog input[V]
☐	1	Encoder position deviation[Encoder unit]
☑	1	Evaluation waveform[–]

(1)	Settling time measurement data	The settling time transition in the adjustment process is displayed. Each dot represents an evaluation value (data result) measured after changing the parameter setup values. Red dot: Best evaluation value Blue dots: Other evaluation values Green dot: Selected evaluation value (displayed in [Current evaluation value] at the top of the screen)
(2)	Parameters	The parameters from the settling time measurement data determined to be the best in the adjustment process and the parameters for the selected settling time measurement data are displayed.
(3)	Waveform graph of selected data	The measurement data (time-series data) for the selected trial is displayed. When multiple operation commands are set in the operational conditions settings, measurement data (time-series data) for each operation command can be selected and superimposed on top of each other.
(4)	[Send parameters] button	Sets the parameters for the selected trial to the servo driver.
(5)	[Additional tuning] button	Click this button to continue tuning. Click the button to go to the settings screen.
(6)	[End] button	Save all results of the adjustment process and end precAIse TUNING.

3.2 Manual Tuning

Manual tuning is possible if gain adjustment has not be adequately performed using an automatic tuning function such as One Minute TUNING, or to ensure the best responsiveness and stability for individual loads. The user determines the response results when the parameters are changed, and performs tuning.

3.2.1 Manual TUNING

3.2.1.1 Function Overview

Use to further improve responsiveness and stability after auto tuning, for example. Make sure you have a thorough understanding of the characteristics of each control function before use.

Set-up Support Software (PANATERM ver.7) has a user interface that groups related parameters by control function for easy tuning.

3.2.1.2 Operational Conditions

Set-up Support Software (PANATERM ver.7) is used.

Depending on the parameters to be changed, power may need to be restored. If the power needs to be restored, a message is displayed. Follow the instructions in the message to restore the power.

3.2.1.3 Tuning Method

The tuning method with Manual TUNING for each control mode is described in this section.

- *“3.2.1.3.1 Tuning in Position Control Mode”*
- *“3.2.1.3.2 Tuning in Speed Control Mode”*
- *“3.2.1.3.3 Tuning in Torque Control Mode”*
- *“3.2.1.3.4 Tuning in Full-closed Control Mode”*

3.2.1.3.1 Tuning in Position Control Mode

This section describes the basic gain adjustment procedure when the gain switching function is not used in position control mode.

This section describes the adjustment procedure aimed at position control with high responsiveness and that uses the basic parameters of position loop gain, speed loop gain, speed integral time constant, and torque filter and notch filter parameters to suppress vibration.

For a block diagram on position control, see *“7.2.1 Position Control Mode Block Diagram”* .

Refer to the following procedure for reference when tuning.

<< Procedure >>

1. After tuning using an automatic tuning function, go to “Step 3”. When starting new tuning, configure initial settings for the parameters.

   Reset the following parameters to the initial values. For initial values, see *“7.1 Object Dictionary List”* .

   - Pr0.02 “Real-time auto-gain tuning setup”
   - Pr0.04 “Inertia ratio”
   - Pr1.00 “1st gain of position loop”
   - Pr1.01 “1st velocity loop gain”
   - Pr1.02 “1st velocity loop integration time constant”
   - Pr1.03 “1st filter of velocity detection”

- Pr1.04 “1st torque filter time constant”
- Pr1.14 “2nd gain setup”
- Pr2.00 “Adaptive filter mode setup”
- Pr2.01 “1st notch frequency”
- Pr2.02 “1st notch width selection”
- Pr2.03 “1st notch depth selection”
- Pr2.04 “2nd notch frequency”
- Pr2.05 “2nd notch width selection”
- Pr2.06 “2nd notch depth selection”
- Pr2.07 “3rd notch frequency”
- Pr2.08 “3rd notch width selection”
- Pr2.09 “3rd notch depth selection”
- Pr2.10 “4th notch frequency”
- Pr2.11 “4th notch width selection”
- Pr2.12 “4th notch depth selection”

2. Set the inertia ratio.

Set Pr0.04 “Inertia ratio” .

If the Pr0.04 “Inertia ratio” value is found with the real-time auto tuning function, use the Pr0.04 “Inertia ratio” set value as it is.

If the inertia ratio is found by load calculation or other means, enter the calculated value.

3. Check the motor operation.

Run the motor with Set-up Support Software (PANATERM ver.7) , etc., and check for any abnormalities in operation.

If no vibration or oscillation occurs at stop (servo lock) or during operation, go to “Step 4”.

If vibration or oscillation occurs, lower Pr1.01 “1st velocity loop gain” and Pr1.00 “1st gain of position loop” by about 50 [0.1 Hz] until vibration or oscillation no longer occurs.

4. Adjust the speed loop gain.

Raise Pr1.01 “1st velocity loop gain” by about 100 [0.1 Hz], and then raise Pr1.00 “1st gain of position loop” by the same amount.

Run the motor to check for vibration or oscillation, and if vibration or oscillation does not occur, proceed to “Step 5”.

If vibration or oscillation occurs, lower Pr1.01 “1st velocity loop gain” to about 80% of the current value and then lower Pr1.00 “1st gain of position loop” to the same value and proceed to “Step 5”.

— Precautions —

- Parameters should be changed when the motor is stopped.

5. Set the time constant of the torque filter.

- Refer to the following formula when setting Pr1.04 “1st torque filter time constant” .

  Torque filter cut-off frequency [Hz] × 4 ≥ speed loop gain [Hz]

- The torque filter cut-off frequency can be obtained using the following formula.

  Cut-off frequency [Hz] = 1/(2 π × Pr1.04 “1st torque filter time constant” [0.01 ms] × 0.00001)

If the operation sound is noticeable, increase Pr1.04 “1st torque filter time constant” by about 10 [0.01 ms].

To speed up the response, decrease Pr1.04 “1st torque filter time constant” by about 10 [0.01 ms] and increase Pr1.01 “1st velocity loop gain” .

If Pr0.04 “Inertia ratio” is set correctly, the value of Pr1.01 “1st velocity loop gain” is the speed loop gain [Hz].

6. Set 1st filter of velocity detection.

To speed up the response, decrease Pr1.03 “1st filter of velocity detection” and increase Pr1.01 “1st velocity loop gain” .

Normally use with Pr1.03 “1st filter of velocity detection” set to 0.

7. Set 1st gain of position loop.

Set Pr1.00 “1st gain of position loop” to a value of about Pr1.01 “1st velocity loop gain” ×1.5.

Run the motor and fine tune while checking the positioning settling time by Set-up Support Software (PANATERM ver.7) waveform measurement or other means.

To shorten the positioning settling time, go to “Step 8”, and if not, go to “Step 9”.

— Precautions —

- Increasing the value shortens the positioning settling time, but too large a value may cause vibration or oscillation. Take due care.

  If vibration or oscillation occurs, lower Pr1.00 “1st gain of position loop” to about 80% of the current level.
- Parameters should be changed when the motor is stopped.

8. Set the 1st velocity loop integration time constant.

Lower Pr1.02 “1st velocity loop integration time constant” from the initial value below according to the conditions.

The extent of lowering depends on the value of Pr1.02 “1st velocity loop integration time constant” [0.1 ms]. Refer to the conditions in the table below when lowering the value.

Initial value

1,500,000 / (2 π × Pr1.01 “1st velocity loop gain” [0.1 Hz])

Extent of lowering

Pr1.02 “1st velocity loop integration time constant” [0.1 ms] value	Extent of lowering
300 or more	100 at a time
150 to 299	50 at a time
Less than 150	10 at a time

To further shorten the positioning settling time, go back to “Step 4” and tune Pr1.01 “1st velocity loop gain” .

If vibration or oscillation occurs when Pr1.01 “1st velocity loop gain” is raised, configure the notch filter settings in “Step 9”, and then go back to “Step 4” and tune Pr1.01 “1st velocity loop gain” .

A smaller Pr1.02 “1st velocity loop integration time constant” value will bring the deviation during positioning settling time closer to 0 sooner, but may delay the time to first reach the settling width. In this case, the settling time may be improved by setting Pr1.07 “2nd velocity loop integration time constant” to 10,000 (disabled) during operation using the gain switching function.

9. Set the notch filter settings.

Measure the vibration frequency of the torque command using Set-up Support Software (PANATERM ver.7) waveform measurement, frequency response measurement, etc.

Take the following measures according to the measured vibration frequency.

Compare before and after the measures and continue to tune settings to raise Pr1.01 “1st velocity loop gain” more.

After the measures, vibration and oscillation, etc. may subside even if Pr1.01 “1st velocity loop gain” is raised. Go back to “Step 4” again to check.

Vibration frequency	Details of measures
1.5 kHz or more	Increase the set value for Pr1.04 “1st torque filter time constant” until the vibration is within the allowable range. The set value should be changed by increasing by 10% at a time. If Pr1.04 “1st torque filter time constant” is set too large, vibration at low frequencies may increase. In this case, lower Pr1.01 “1st velocity loop gain” .
600 Hz to 1.5 kHz	Set the vibration frequency to Pr2.01 “1st notch frequency” . Set a notch filter to suppress resonance peaks. If vibration is not reduced, fine tune the Pr2.01 “1st notch frequency” value. Resonance peaks can be measured using Set-up Support Software (PANATERM ver.7) frequency response measurement. If there are multiple resonance peaks, set the vibration frequency to Pr2.04 “2nd notch frequency” to Pr2.10 “4th notch frequency” . If the vibration is still 600 Hz or more, increase the set value for Pr1.04 “1st torque filter time constant” . The set value should be changed by increasing by 10% at a time.
400 to 600 Hz	Measure the resonance frequency using the frequency response measurement in Set-up Support Software (PANATERM ver.7) and set the resonance frequency in Pr2.01 “1st notch frequency” . After setting Pr2.01 “1st notch frequency” , measure the frequency response again and confirm that the resonance peak is reduced. If the resonance peak is not reduced, tune Pr2.01 “1st notch frequency” , Pr2.02 “1st notch width selection” , and Pr2.03 “1st notch depth selection” to lower the resonance peak. For vibrations with resonance peaks at low frequencies and frequencies lower than the anti-resonance frequency, make Pr1.01 “1st velocity loop gain” smaller. When the resonance frequency is within the range of about 350 to 450 Hz, raise Pr1.01 “1st velocity loop gain” and set a notch filter when vibration occurs. Vibration may be reduced.

If the vibration is not reduced by the measures taken, no further tuning is available. Disable the notch filter used for the measures taken and end tuning.

3.2.1.3.2 Tuning in Speed Control Mode

Tuning in speed control is almost the same as in *“3.2.1.3.1 Tuning in Position Control Mode”* . Tune parameters excluding the Pr1.00 “1st gain of position loop” setting in accordance with the *“3.2.1.3.1 Tuning in Position Control Mode”* procedure.

For speed control mode block diagram, see *“7.2.2 Speed Control Mode Block Diagram”* .

3.2.1.3.3 Tuning in Torque Control Mode

In torque control mode, the Obj.6080h:00h “Max motor speed” speed limit controls the rotational velocity of the motor so that it does not exceed the speed limit value.

For a block diagram on torque control, see *“7.2.3 Torque Control Mode Block Diagram”* .

Details on setting speed limit values are provided below.

- Setting speed limit values

  Set the speed limit value selection method in Pr3.17 “Selection of speed limit” .

  For this driver, set Pr3.17 “Selection of speed limit” = 2 (fixed) and set the speed limit value in Obj.6080h:00h “Max motor speed” .

  When Pr6.97 “Function expansion setup 3” :bit 12 “Speed limit priority function during torque control” =1, if Obj.6080h:00h “Max motor speed” is exceeded, the torque limit is disabled by Obj.60E0h:00h “Positive torque limit value” and Obj.60E1h:00h “Negative torque limit value” and the required torque is generated and controlled to stay below the speed limit value.

  To ensure stable operation even when there are speed limits, it is necessary to set parameters according to *“3.2.1.3.2 Tuning in Speed Control Mode”* .

If the speed limit value is too low, the speed loop gain is too low, or the speed loop integral time constant is set to 10,000 (disabled), the input to the torque limit part will be small and torque may not be produced as per the torque command.

3.2.1.3.4 Tuning in Full-closed Control Mode

In full-closed control, the same procedure as for *“3.2.1.3.1 Tuning in Position Control Mode”* can be used for tuning, except for the notes in Operating Instructions (Overall) “7.6.1 Full-closed Control Overview” (difference in command units, difference in command division/multiplication, etc.).

For a block diagram on full-closed control, see *“7.2.4 Full-closed Control Mode Block Diagram”* .

External scale ratio setup and hybrid deviation excess setup in the initial settings for full-closed control are detailed below.

- External scale ratio setup

  Use Pr3.24 “Numerator of external scale division” and Pr3.25 “Denominator of external scale division” to set the external scale ratio.

  Check the encoder pulse count per motor revolution and the external scale pulse count per motor revolution, and set Pr3.24 “Numerator of external scale division” and Pr3.25 “Denominator of external scale division” so that the following formula holds.

$$\text{External scale ratio} = \frac{\text{Pr3.24 } \boxed{134217728}}{\text{Pr3.25 } \boxed{100000}} = \frac{\text{Encoder pulse count per motor revolution [pulse]}}{\text{External scale pulse count per motor revolution [pulse]}}$$

  If this ratio is wrong, the difference between the position calculated based on the encoder pulse and the position calculated based on the external scale pulse becomes large over a long travel distance and Err25.0.0 “Hybrid deviation excess protection” is triggered.

  Setting Pr3.24 “Numerator of external scale division” to 0 automatically sets the encoder pulse count as the numerator.

- Hybrid deviation excess setup

  Set Pr3.28 “Hybrid deviation excess setup” to the minimum allowable difference between the motor (encoder) position and the load (external scale) position.

  In addition to the primary causes above, Err25.0.0 “Hybrid deviation excess protection” can also be caused by reverse connection of the external scale or loose connection between the motor and the load. Also check for these primary causes.

— Precautions —

- Input a command pulse value based on the feedback scale resolution.
- Set Pr3.28 “Hybrid deviation excess setup” to the appropriate value in command units to prevent damage to the machine due to an out-of-control motor caused by improper setting of parameters related to the external scale.
- An external scale ratio of 1/40 ≦ External scale ratio ≦ 20480 is recommended.

  Setting the external scale ratio to a smaller value than 50/position loop gain (Pr1.00, Pr1.05) even if the value is within the aforementioned range, may prevent control in single pulse units.

  Also, increasing the external scale ratio may increase operation sound.
- For a list scale manufacturers and product numbers that can be used for full-closed control, see the “AC Servo Partner Products” catalog.

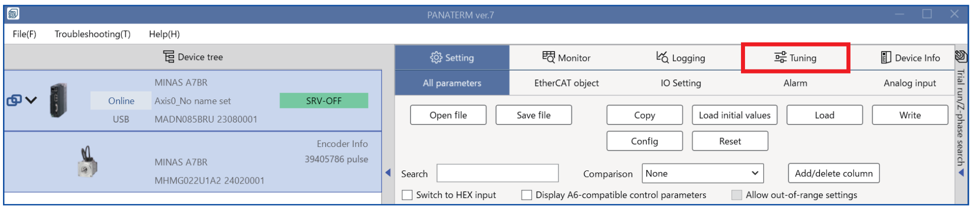
3.2.1.4 Manual TUNING Using Set-up Support Software (PANATERM ver.7)

3.2.1.4.1 How to Use

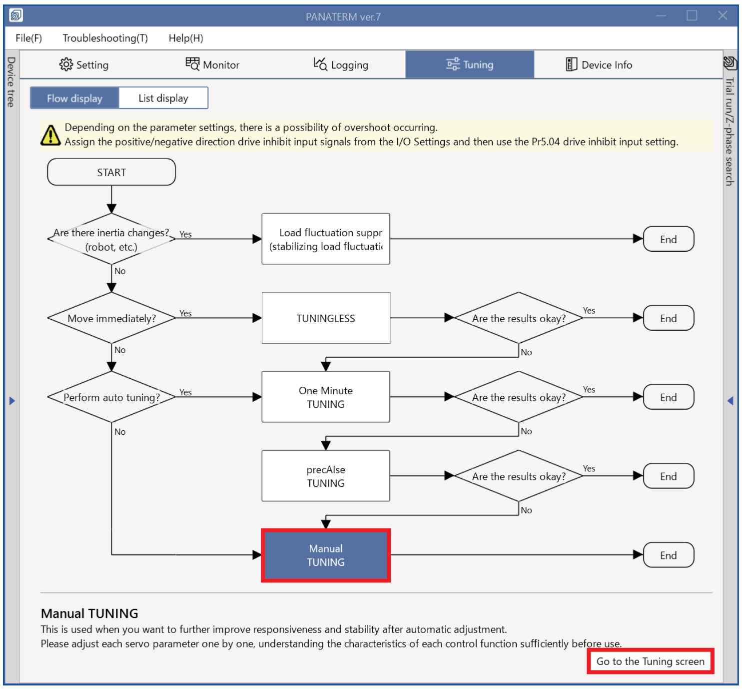
<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



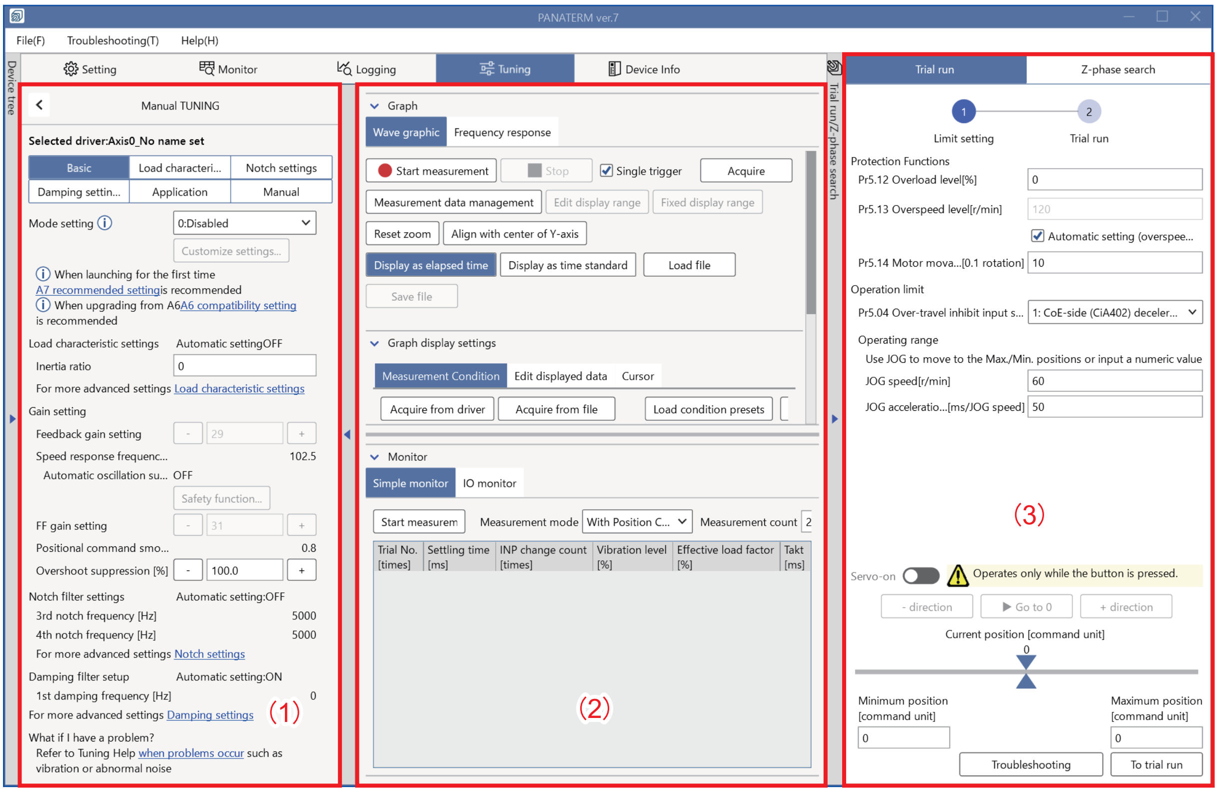
3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.



Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING
This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.



Selected driver:Axis0_No name set

Mode setting 0:Disabled

When launching for the first time
A7 recommended setting is recommended
When upgrading from A6 A6 compatibility setting
is recommended

Load characteristic settings Automatic settingOFF
Inertia ratio 0
For more advanced settings Load characteristic settings

Gain setting
Feedback gain setting 29
Speed response frequenc... 102.5
Automatic oscillation su... OFF
FF gain setting 31
Positional command smo... 0.8
Overshoot suppression [%] 100.0

Notch filter settings Automatic setting:OFF
3rd notch frequency [Hz] 5000
4th notch frequency [Hz] 5000
For more advanced settings Notch settings

Damping filter setup Automatic setting:ON
1st damping frequency [Hz] 0
For more advanced settings Damping settings

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

☑ Single trigger

Measurement mode With Position C...
Measurement count 2

Trial No. [times]	Settling time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%] 0
Pr5.13 Overspeed level[r/min] 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation] 10

Operation limit
Pr5.04 Over-travel inhibit input s... 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min] 60
JOG acceleratio...[ms/JOG speed] 50

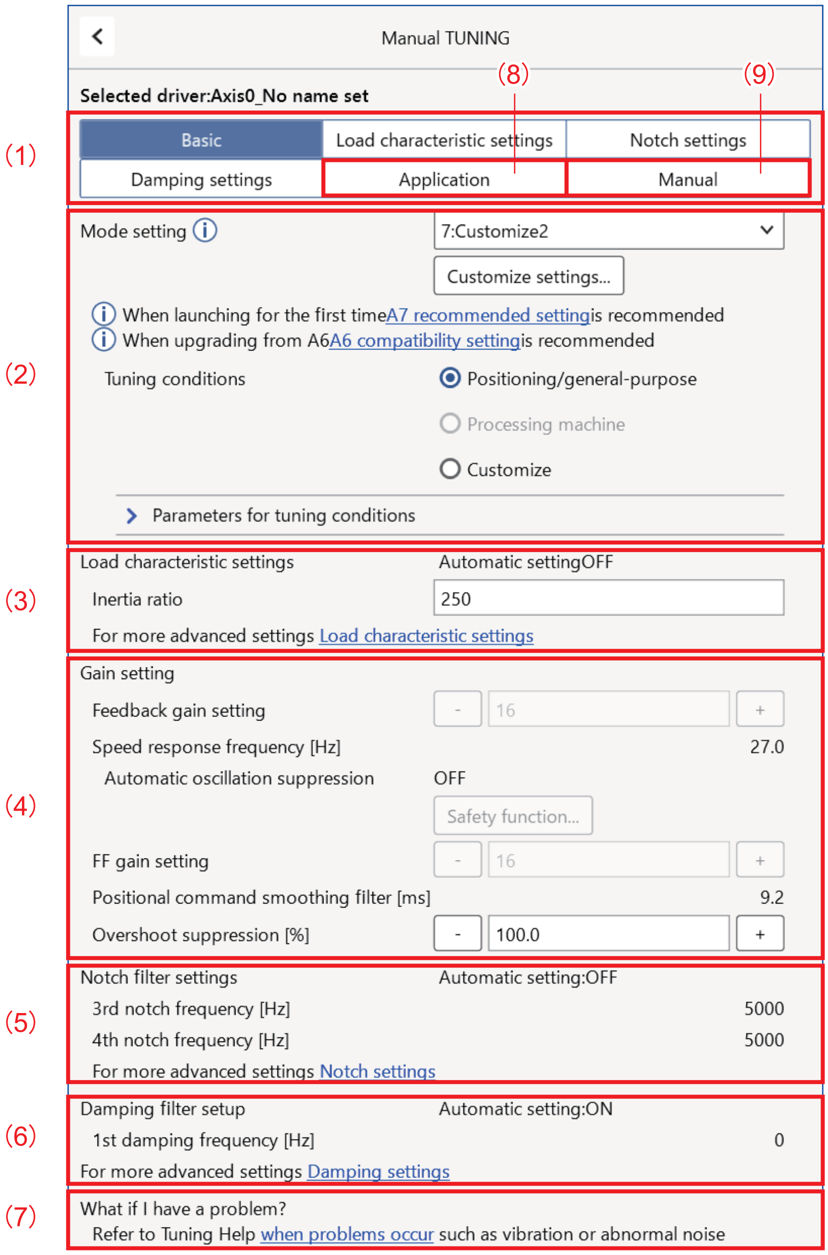
Servo-on
Operates only while the button is pressed.

Current position [command unit]
0

Minimum position [command unit] 0
Maximum position [command unit] 0

(1)	This is the main screen. This displays the parameter tuning screen.
(2)	This displays the waveform measurement and frequency response measurement screens.
(3)	This displays the trial run operation screen.

Each item on the main screen (left side of the screen) is described below.



Manual TUNING

Selected driver:Axis0_No name set

Mode setting: 7:Customize2

When launching for the first time A7 recommended setting is recommended

When upgrading from A6 A6 compatibility setting is recommended

Tuning conditions: ● Positioning/general-purpose ○ Processing machine ○ Customize

Parameters for tuning conditions

Load characteristic settings: Automatic setting OFF

Inertia ratio: 250

For more advanced settings Load characteristic settings

Gain setting

Feedback gain setting: 16

Speed response frequency [Hz]: 27.0

Automatic oscillation suppression: OFF

FF gain setting: 16

Positional command smoothing filter [ms]: 9.2

Overshoot suppression [%]: 100.0

Notch filter settings: Automatic setting:OFF

3rd notch frequency [Hz]: 5000

4th notch frequency [Hz]: 5000

For more advanced settings Notch settings

Damping filter setup: Automatic setting:ON

1st damping frequency [Hz]: 0

For more advanced settings Damping settings

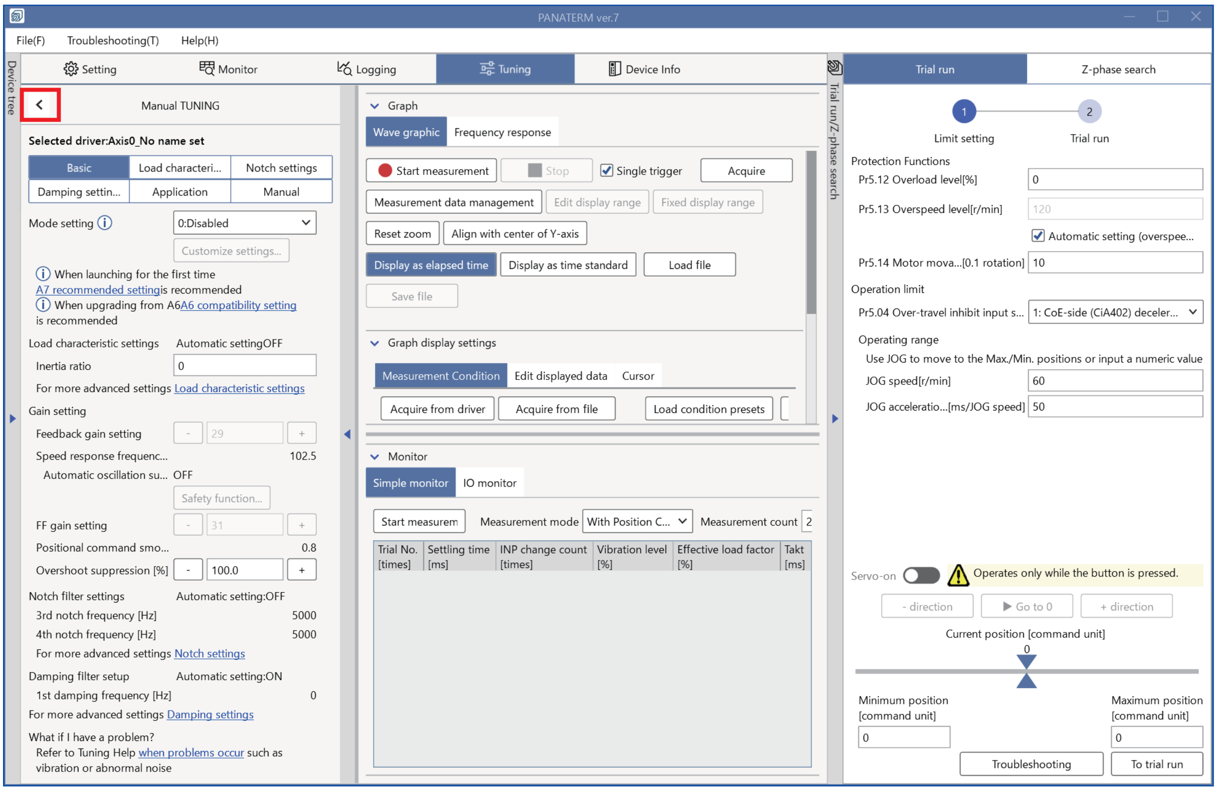
What if I have a problem?

Refer to Tuning Help when problems occur such as vibration and abnormal noise

For details on each item, see *"3.2.1.4.2 Main Screen Details"* .

	Reference	Description
(1)	*"Category Selection"*	Clicking the button toggles the content displayed on the main screen.
(2)	*"Mode Setting"*	Set Pr0.02 "Real-time auto-gain tuning setup" .
(3)	*"Load characteristic settings"*	Tune the parameters related to setting and estimating load characteristics.
(4)	*"Gain setting"*	Tune the parameters related to feedback and feedforward collectively or when overshoot occurs.
(5)	*"Notch settings"*	Tune the parameters related to the notch filter and torque filter.
(6)	*"Damping settings"*	Tune the parameters related to damping control, the model-type damping filter and position command filter function.
(7)	*"What if I have a problem?"*	A PDF file detailing the basics of tuning parameters and typical control challenges is displayed. Use this when issues are known, but corresponding tuning procedures are unknown.
(8)	*"Application"*	This section summarizes features not listed above.
(9)	*"Manual"*	Displays the parameters shown in "Basic", "Load characteristic settings", "Notch settings", "Damping settings", and "Apply" in list format.

4. To end the Manual TUNING function, click the [<] button in the upper left corner.



Selected driver:Axis0_No name set

Mode setting: 0:Disabled

When launching for the first time A7 recommended setting is recommended
When upgrading from A6 A6 compatibility setting is recommended

Load characteristic settings: Automatic setting OFF
Inertia ratio: 0
Feedback gain setting: 29
Speed response frequenc...: 102.5
Automatic oscillation su...: OFF
FF gain setting: 31
Positional command smo...: 0.8
Overshoot suppression [%]: 100.0
Notch filter settings: Automatic setting:OFF
3rd notch frequency [Hz]: 5000
4th notch frequency [Hz]: 5000
Damping filter setup: Automatic setting:ON
1st damping frequency [Hz]: 0

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode: With Position C...
Measurement count: 2

Trial No. [times]	Setting time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%]: 0
Pr5.13 Overspeed level[r/min]: 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation]: 10
Operation limit
Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...
Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min]: 60
JOG acceleratio...[ms/JOG speed]: 50
Servo-on: Operates only while the button is pressed.
Current position [command unit]: 0
Minimum position [command unit]: 0
Maximum position [command unit]: 0

The “Finish Manual TUNING” dialog box is displayed.

5. Check the tuning results, select “Retained” or “Disabled”, and then click the [End] button.

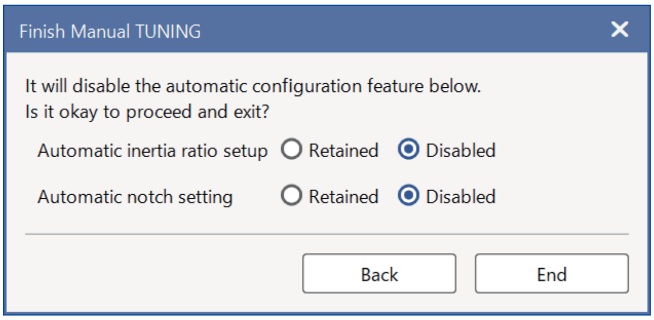
- To retain parameters related to inertia ratio and friction compensation

  “Disabled” automatic inertia ratio setup
- To retain parameters related to notch filter

  “Disabled” automatic notch setting

Selecting “Disabled” for both is recommended as this allows parameters to be fixed after tuning.

Enable the “Automatic inertia ratio setup” and “Automatic notch setting” automatic setting functions, and select “Retained” to keep the automatic setting functions enabled after tuning. (If “Retained” is selected after tuning with the automatic setting functions disabled, the parameters are the same as when “Disabled” is selected.)



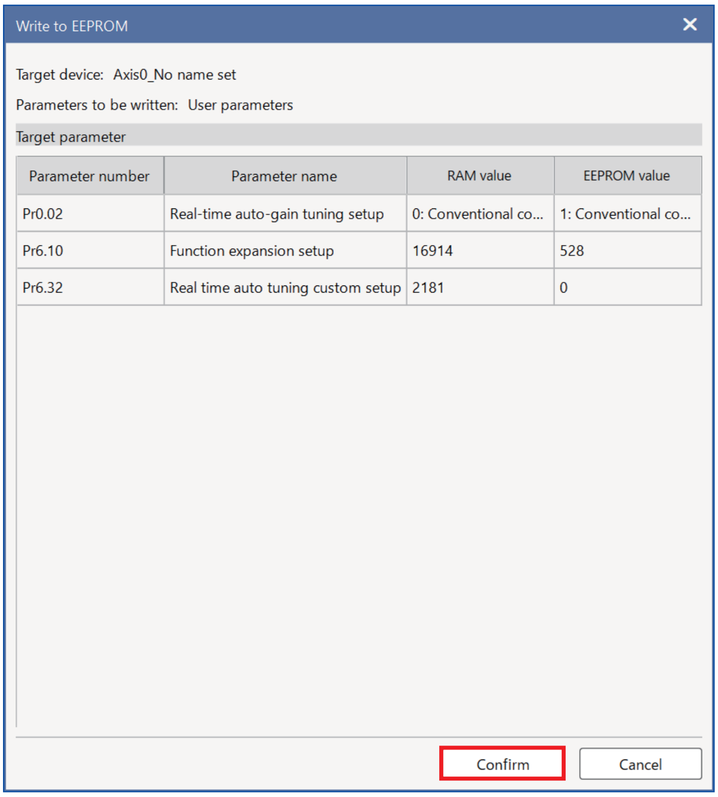
It will disable the automatic configuration feature below.
Is it okay to proceed and exit?

Automatic inertia ratio setup ○ Retained ● Disabled

Automatic notch setting ○ Retained ● Disabled

If there is a change to a parameter, the “Write to EEPROM” dialog box is displayed.

6. Click the [Confirm] button.



Target device: Axis0_No name set

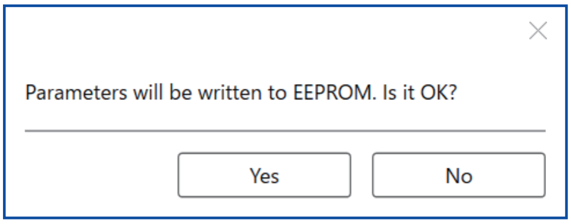
Parameters to be written: User parameters

Target parameter

Parameter number	Parameter name	RAM value	EEPROM value
Pr0.02	Real-time auto-gain tuning setup	0: Conventional co...	1: Conventional co...
Pr6.10	Function expansion setup	16914	528
Pr6.32	Real time auto tuning custom setup	2181	0

A confirmation dialog box is displayed asking if you want to write the parameters to EEPROM.

- To write the parameters to EEPROM, click the [Yes] button.
- To end tuning without writing the parameters to EEPROM, click the [No] button.

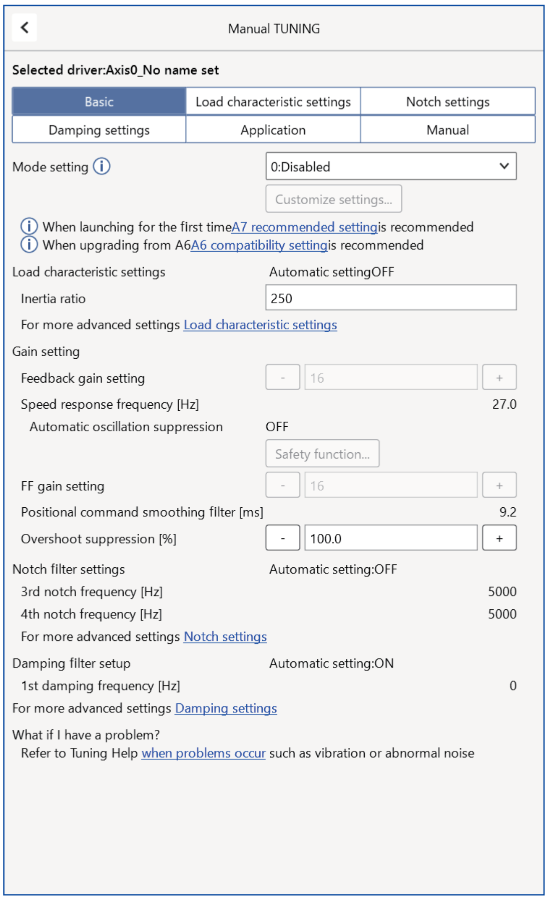


Parameters will be written to EEPROM. Is it OK?

Clicking the [Cancel] button ends tuning without writing the parameters to EEPROM.

3.2.1.4.2 Main Screen Details

This section describes each item on the main screen of the Manual TUNING screen.



Selected driver:Axis0_No name set

Mode setting: 0:Disabled

When launching for the first timeA7 recommended settingis recommended

When upgrading from A6A6 compatibility settingis recommended

Load characteristic settings: Automatic settingOFF

Inertia ratio: 250

For more advanced settings Load characteristic settings

Gain setting

Feedback gain setting: 16

Speed response frequency [Hz]: 27.0

Automatic oscillation suppression: OFF

FF gain setting: 16

Positional command smoothing filter [ms]: 9.2

Overshoot suppression [%]: 100.0

Notch filter settings: Automatic setting:OFF

3rd notch frequency [Hz]: 5000

4th notch frequency [Hz]: 5000

For more advanced settings Notch settings

Damping filter setup: Automatic setting:ON

1st damping frequency [Hz]: 0

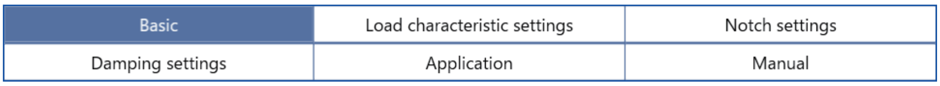
For more advanced settings Damping settings

What if I have a problem?

Refer to Tuning Help when problems occur such as vibration or abnormal noise

Category Selection

- Clicking the category selection button toggles the display content on the main screen.

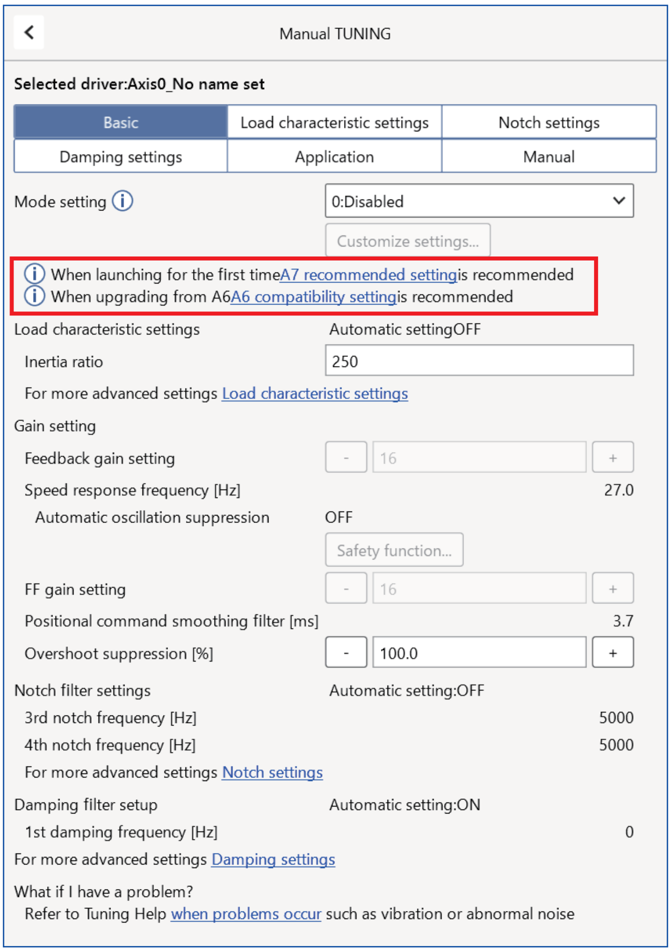


Item	Description
Basic	The first screen displayed is for tuning basic settings.
Load characteristic settings	Fine tune parameter details related to the inertia ratio and friction.
Notch settings	Fine tune the notch filter and torque filter parameters.
Damping settings	Fine tune the damping control, the model-type damping filter and position command filter function parameters.
Application	Tune parameters for functions other than those listed above, such as the gain switching function.
Manual	Tune parameters related to control in list format.

Mode Setting

- Set Pr0.02 “Real-time auto-gain tuning setup” .
- When “A7 recommended setting” is selected, “7 (Customize 2) ” is automatically set in “Mode setting”. When “A6 compatibility setting” is selected, the current “Mode setting” set value is retained.

- When “A7 recommended setting” or “A6 compatibility setting” is selected, parameters other than Pr0.02 “Real-time auto-gain tuning setup” are also set. For details, see the table below.



Selected driver:Axis0_No name set

Mode setting: 0:Disabled

When launching for the first timeA7 recommended settingis recommended
When upgrading from A6A6 compatibility settingis recommended

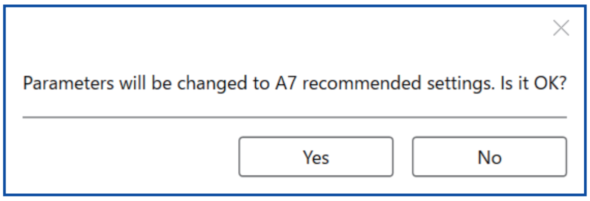
Load characteristic settings: Automatic settingOFF
Inertia ratio: 250
For more advanced settings Load characteristic settings

Gain setting
Feedback gain setting: 16
Speed response frequency [Hz]: 27.0
Automatic oscillation suppression: OFF
FF gain setting: 16
Positional command smoothing filter [ms]: 3.7
Overshoot suppression [%]: 100.0

Notch filter settings: Automatic setting:OFF
3rd notch frequency [Hz]: 5000
4th notch frequency [Hz]: 5000
For more advanced settings Notch settings

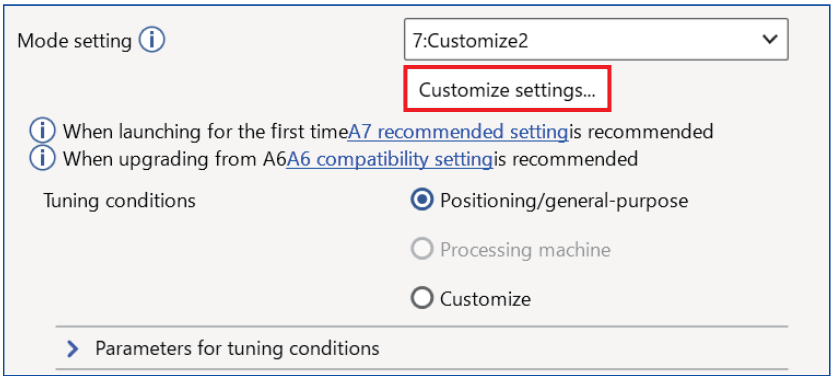
Damping filter setup: Automatic setting:ON
1st damping frequency [Hz]: 0
For more advanced settings Damping settings

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Item	Description
A7 recommended setting (blue text)	Sets Pr0.02 “Real-time auto-gain tuning setup” to setup value 7 (Customize 2). Sets Pr6.10 “Function expansion setup” and Pr2.45 “Function expansion setup 10” , etc. to A7 series recommended values. Allows finer tuning, such as 45-stage tables for real-time auto-tuning machine stiffness setup. Normally, this item should be selected when launching for the first time, for example. Click the [Yes] button when the dialog box for confirming the parameter change is displayed.  Parameters will be changed to A7 recommended settings. Is it OK?
A6 compatibility setting (blue text)	The current settings for Pr0.02 “Real-time auto-gain tuning setup” are retained. Sets Pr6.10 “Function expansion setup” and Pr2.45 “Function expansion setup 10” , etc. to settings used for the A6 series. Select this item if you need compatibility with the A6 series. Click the [Yes] button when the dialog box for confirming the parameter change is displayed.

- When “A7 recommended setting” is selected, “7: Customize2 ” is automatically input in “Mode setting” (set Pr0.02 = 7 (Customize2)).

  Clicking the [Customize settings...] button allows you to customize settings according to the application.

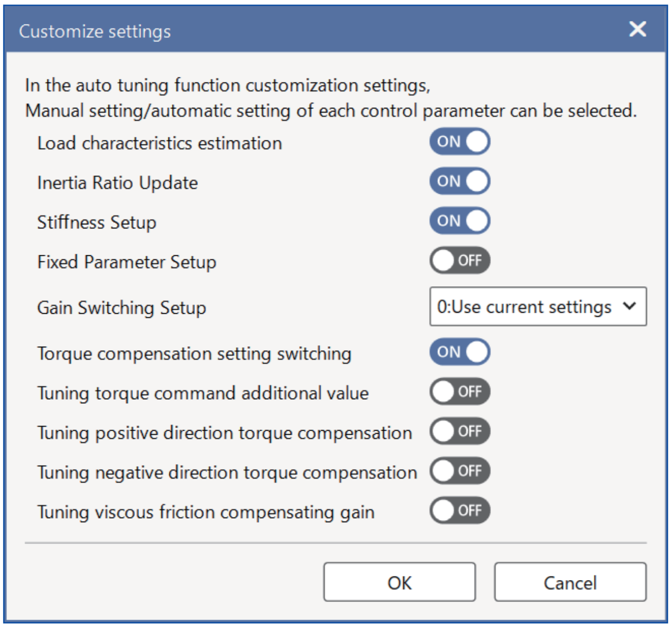

Mode setting: 7:Customize2

ⓘ When launching for the first timeA7 recommended settingis recommended

ⓘ When upgrading from A6A6 compatibility settingis recommended

Tuning conditions
● Positioning/general-purpose
○ Processing machine
○ Customize

Customize Settings Screen


Customize settings

In the auto tuning function customization settings,
Manual setting/automatic setting of each control parameter can be selected.

Load characteristics estimation: ON
Inertia Ratio Update: ON
Stiffness Setup: ON
Fixed Parameter Setup: OFF
Gain Switching Setup: 0:Use current settings
Torque compensation setting switching: ON
Tuning torque command additional value: OFF
Tuning positive direction torque compensation: OFF
Tuning negative direction torque compensation: OFF
Tuning viscous friction compensating gain: OFF

Item	Description
Load characteristics estimation	Set to enable or disable the load characteristics estimation function. ON: Enabled OFF: Disabled
Inertia ratio update	Set updates in load characteristic estimation results for Pr0.04 “Inertia ratio” . ON: Update with estimated value OFF: Current settings retained
Stiffness setup	Set to enable or disable the basic gain setting using Pr0.03 “Real-time auto-tuning machine stiffness setup” or Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2” . ON: Enabled OFF: Disabled
Fixed parameter setup	Set whether or not to change the parameters that become prescribed fixed values when Pr0.02 “Real-time auto-gain tuning setup” is enabled. ON: Change to fixed value OFF: Current settings retained
Gain switching setup	Select the method for setting parameters related to gain switching when Pr0.02 “Real-time auto-gain tuning setup” is enabled.

Item	Description
Torque compensation setting switching	Select settings for parameters related to friction torque compensation. ON: MINAS A7 Series recommended setting OFF: MINAS A6 Series compatibility setting ON is selected when “A7 recommended setting” is selected in mode setting, and OFF is selected when “A6 compatibility setting” is selected in mode setting.
Torque command additional value tuning	Select the method for setting the torque command additional value (Pr2.52 “Torque command additional value 2” or Pr6.07 “Torque command additional value”). ON: Automatic setting OFF: Manual setting
Positive direction torque compensation tuning	Select the method for settings the positive direction torque compensation value (Pr2.53 “Positive direction torque compensation value 2” or Pr6.08 “Positive direction torque compensation value”). ON: Automatic setting OFF: Manual setting
Negative direction torque compensation tuning	Select the method for setting the negative direction torque compensation value (Pr2.54 “Negative direction torque compensation value 2” or Pr6.09 “Negative direction torque compensation value”). ON: Automatic setting OFF: Manual setting
Viscous friction compensating gain adjustment	Select the method for setting Pr6.50 “Viscous friction compensating gain” . ON: Automatic setting OFF: Manual setting

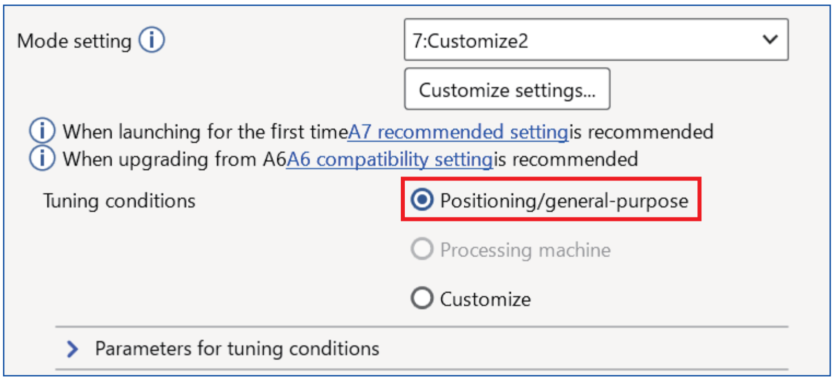
For details, see Pr6.32 “Real time auto tuning custom setup” below.

- *“4.1.1.4 Related Parameters”* of *“4.1.1 Real-time Auto Tuning (Two-degree-of-freedom Control Mode for Standard Type)”*
- *“4.1.3.4 Related Parameters”* of *“4.1.3 Real-time Auto Tuning (Two-degree-of-freedom Control Mode Disabled Type)”*

■ Tuning conditions

1 When “7: Customize 2” is selected, “Tuning conditions” are displayed. Normally, select “Positioning/general-purpose”.

When “Positioning/general-purpose” is selected, the basic gain parameter setting is used when Pr0.02 “Real-time auto-gain tuning setup” is enabled.



Mode setting: 7:Customize2

When launching for the first timeA7 recommended settingis recommended

When upgrading from A6A6 compatibility settingis recommended

Tuning conditions

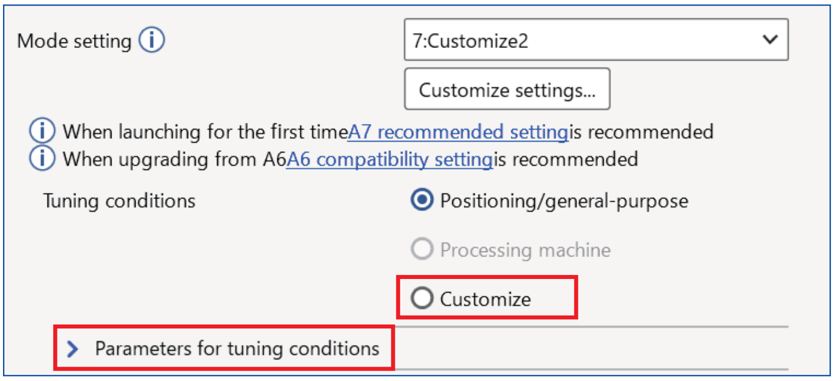
● Positioning/general-purpose

○ Processing machine

○ Customize

2 When “Customize” is selected for “Tuning conditions”, “Parameters for tuning conditions” is expanded. In “Parameters for tuning conditions” individual change ratios can be set for each basic gain parameter.

- For basic gain parameter settings, refer to the following.
  - *“4.1.1.4 Related Parameters”* of *“4.1.1 Real-time Auto Tuning (Two-degree-of-freedom Control Mode for Standard Type)”*
  - *“4.1.3.4 Related Parameters”* of *“4.1.3 Real-time Auto Tuning (Two-degree-of-freedom Control Mode Disabled Type)”*



Mode setting: 7:Customize2

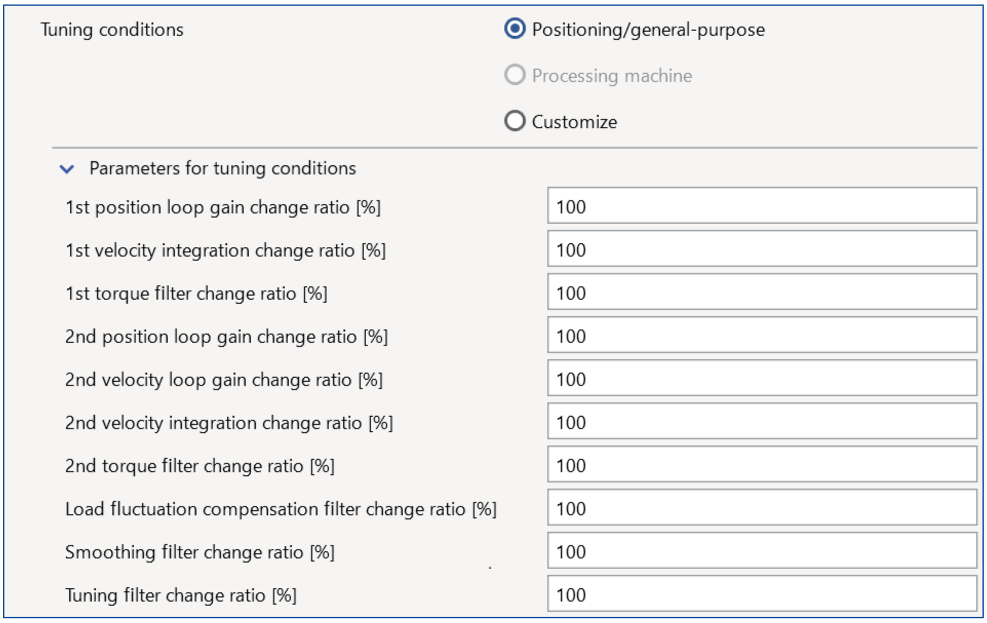
When launching for the first timeA7 recommended settingis recommended

When upgrading from A6A6 compatibility settingis recommended

Tuning conditions
- ● Positioning/general-purpose
- ○ Processing machine
- ○ Customize

› Parameters for tuning conditions

Customize Settings Screen



Tuning conditions
- ● Positioning/general-purpose
- ○ Processing machine
- ○ Customize

⌄ Parameters for tuning conditions

1st position loop gain change ratio [%]	100
1st velocity integration change ratio [%]	100
1st torque filter change ratio [%]	100
2nd position loop gain change ratio [%]	100
2nd velocity loop gain change ratio [%]	100
2nd velocity integration change ratio [%]	100
2nd torque filter change ratio [%]	100
Load fluctuation compensation filter change ratio [%]	100
Smoothing filter change ratio [%]	100
Tuning filter change ratio [%]	100

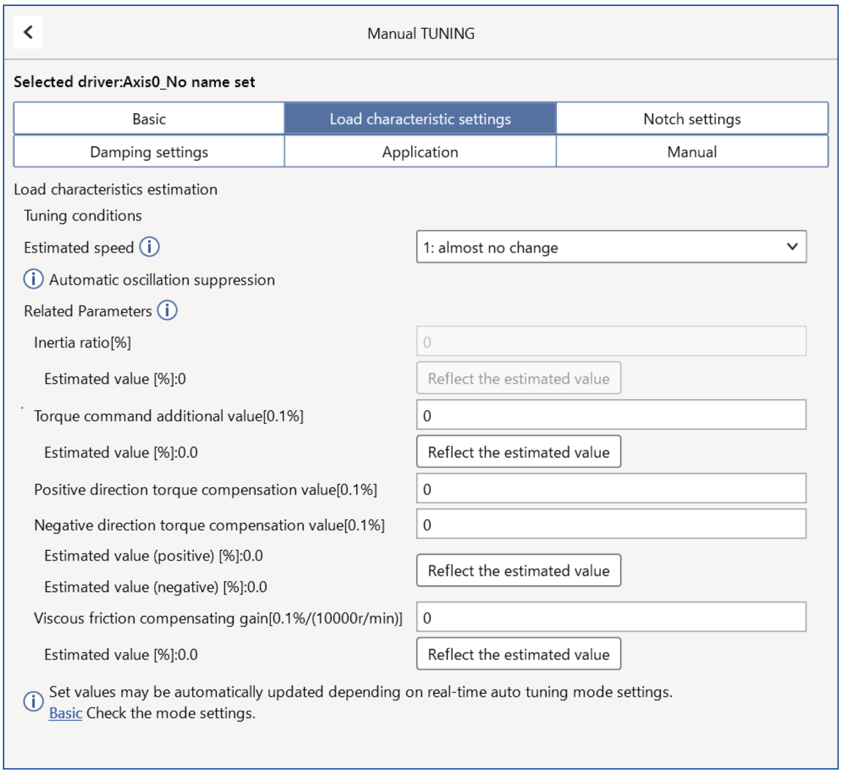
Load characteristic settings

- Parameter values related to setting and estimating load characteristics can be tuned manually.
- When “A7 recommended setting” is selected in *“Mode Setting”* , the inertia ratio is estimated and set automatically (Automatic setting: ON) in this mode.

  The current set value is displayed in “Inertia ratio”.

- To fine tune parameters related to load characteristics such as “Inertia ratio”, click “Load characteristics” in blue text, or click the [Load characteristic settings] button at the top. The main screen changes to the “Load characteristic settings” screen. To return to the “Basic” screen, click on the [Basic] button at the top.

“Load Characteristic Settings” Advanced Settings Screen



Selected driver:Axis0_No name set

Load characteristics estimation

Tuning conditions

Estimated speed: 1: almost no change

Automatic oscillation suppression

Related Parameters

Inertia ratio[%]: 0

Estimated value [%]:0

Torque command additional value[0.1%]: 0

Estimated value [%]:0.0

Positive direction torque compensation value[0.1%]: 0

Negative direction torque compensation value[0.1%]: 0

Estimated value (positive) [%]:0.0

Estimated value (negative) [%]:0.0

Viscous friction compensating gain[0.1%/(10000r/min)]: 0

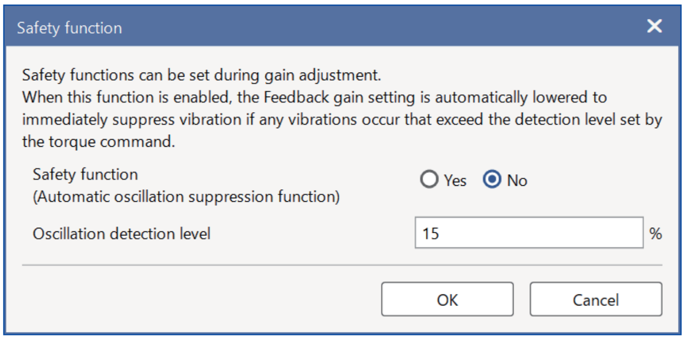
Estimated value [%]:0.0

Set values may be automatically updated depending on real-time auto tuning mode settings.
Basic Check the mode settings.

Item	Description
Estimation speed	Set the speed for load characteristics estimation. Normally, set the value to 3. Higher set values result in faster responses to changes in load characteristics, but they also increase variations in disturbance estimation.
Related parameters	Displays the setup values for each parameter currently set in the driver. Parameters with automatic setting selected are grayed out. Numerical values can be entered directly for parameters that do not have automatic settings selected. The estimated value under the parameter name indicates the load characteristic estimation result. When the estimated value is updated, the value displayed is also updated. When Pr0.02 “Real-time auto-gain tuning setup” is 0 (disabled), no value is displayed. Click the [Reflect the estimated value] button to reflect the estimated value of the target parameter in the set value.

Gain setting

- Tune the parameters related to feedback and feedforward collectively and tune the suppression level for when overshoot occurs.

Item	Description
FB gain setting	● Used when tuning feedback-related parameters collectively. ● This setting is linked to Pr0.03 “Real-time auto-tuning machine stiffness setup” or Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2” . ● To change the set value, click the [+] or [-] buttons, or enter the value directly. ● The larger the set value, the higher the command responsiveness and servo stiffness also increases, but vibration is more likely to occur. While checking the operation, increase the set value by increments of 1. **— Precautions —** ● Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b. • Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03 • Pr2.45: bits 5 to 4 = 10b : Pr0.27 • Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28 ● Even if the same value is set for both Pr0.03 “Real-time auto-tuning machine stiffness setup” and Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2” parameters, the values of the respective related parameters may be different. Refer to the basic gain parameter settings in *“4.1 Real-time Auto Tuning Function”* for the relationship between the set values and the corresponding related parameters. ● To set the safety function (for automatically lowering the set value to eliminate oscillation when tuning is in progress), click the [Safety function] button. “Enable (Yes)” or “Disable (No)” can be selected for the safety function. When enabled, the “Oscillation detection level” can be set. **“Feedback Gain Setting” - “Safety Function” Advanced Settings Screen**  Safety function Safety functions can be set during gain adjustment. When this function is enabled, the Feedback gain setting is automatically lowered to immediately suppress vibration if any vibrations occur that exceed the detection level set by the torque command. Safety function (Automatic oscillation suppression function) ○ Yes ● No Oscillation detection level 15 %
FF gain setting	● Used when tuning feedforward-related parameters collectively. ● This setting is linked to Pr0.28 “Selection of feed forward stiffness at real-time auto-gain tuning” . For details on set values and corresponding parameters, see *“4.1 Real-time Auto Tuning Function”* *“4.1.1.6 Basic Gain Parameter Setup Table”* . ● To change the set value, click the [+] or [-] buttons, or enter the value directly. ● Although speed responsiveness is higher the larger the set value, overshoot is more likely to occur. While checking the operation, increase the set value by increments of 1.
Overshoot suppression	● Used when overshoot occurs. ● To change the set value, click the [+] or [-] buttons, or enter the value directly. ● To suppress overshoot, adjust the value by decreasing it by about 5% from 100%. A smaller value suppresses overshoot, but delays response. ● This setting is linked to Pr1.10 “Velocity feed forward gain” .

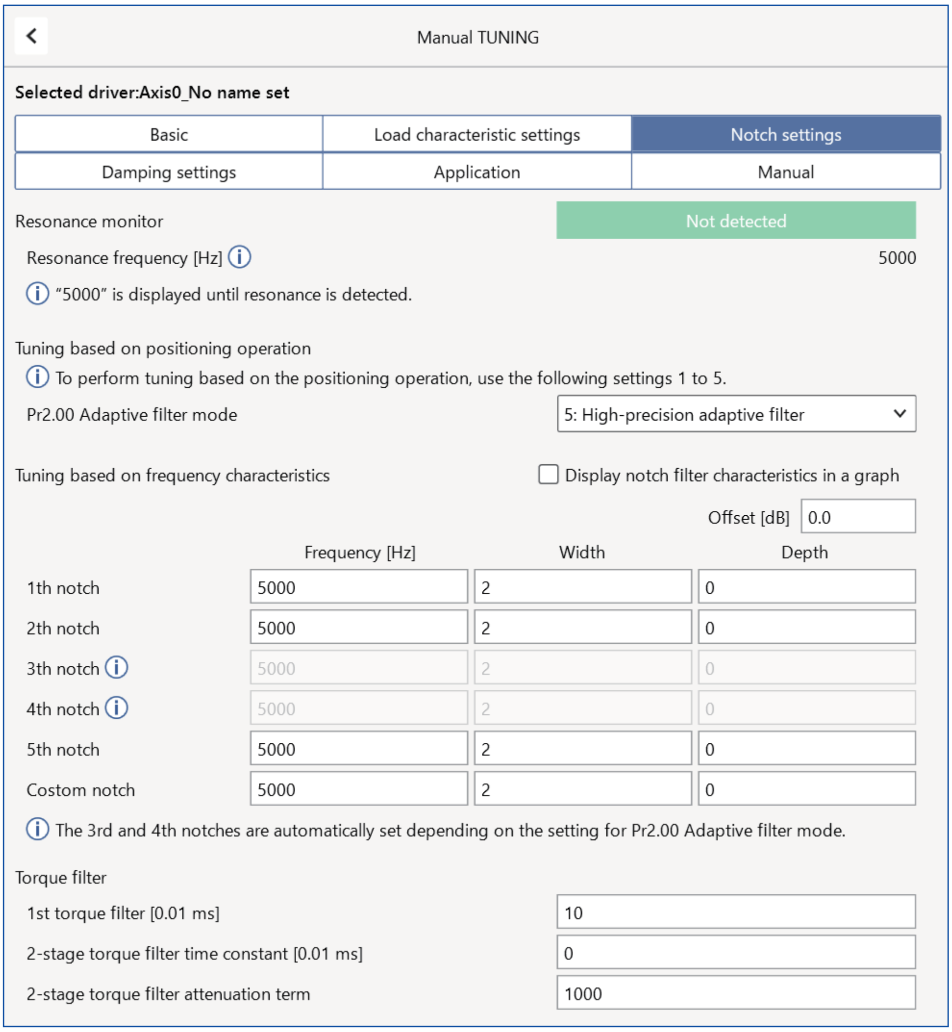
Notch settings

- Tune the parameters related to the notch filter and torque filter.
- When “A7 recommended setting” is selected in *“Mode Setting”* , the notch filters are set automatically in adaptive filter when the operation command is input in this mode (Pr2.00 = 5) (Automatic setting: ON). In this case, the notch frequencies set automatically are displayed in 3rd notch frequency and 4th notch frequency.

- To fine tune related parameters, click “Notch settings” in blue text, or click the [Notch settings] button at the top. The main screen changes to the “Notch Settings” screen.

  To return to the “Basic” screen, click on the [Basic] button at the top.

“Notch Settings” Advanced Settings Screen



Selected driver:Axis0_No name set

Resonance monitor: Not detected

Resonance frequency [Hz]: 5000

“5000” is displayed until resonance is detected.

Tuning based on positioning operation

To perform tuning based on the positioning operation, use the following settings 1 to 5.

Pr2.00 Adaptive filter mode: 5: High-precision adaptive filter

Tuning based on frequency characteristics

☐ Display notch filter characteristics in a graph

Offset [dB]: 0.0

	Frequency [Hz]	Width	Depth
1th notch	5000	2	0
2th notch	5000	2	0
3th notch	5000	2	0
4th notch	5000	2	0
5th notch	5000	2	0
Costom notch	5000	2	0

The 3rd and 4th notches are automatically set depending on the setting for Pr2.00 Adaptive filter mode.

Torque filter

1st torque filter [0.01 ms]: 10

2-stage torque filter time constant [0.01 ms]: 0

2-stage torque filter attenuation term: 1000

Item	Description
Resonance monitor	When Pr2.00 “Adaptive filter mode setup” is enabled, the resonance frequency is displayed if resonance is detected.
Pr2.00 Adaptive filter mode	When “A7 recommended setting” is selected in *“Mode Setting”* , “5: High-precision adaptive filter” settings are set, and the 3rd notch filter and 4th notch filter are automatically set. Use this setting if you are unfamiliar with notch filter tuning. To manually tune the 3rd notch filter and 4th notch filter, set “0: Disable adaptive filter”. For details on Pr2.00 “Adaptive filter mode setup” , see *“5.4 Adaptive Filter Function”* .
Display notch filter characteristics in a graph	When the check box is checked, the combined filter characteristics of the notch filter and torque filter are displayed when the frequency response graph is displayed on the center screen. Tuning can be performed while comparing with the frequency response measurement results. If the box is not checked, the filter characteristics are not displayed.
Offset	Entering a numerical value in Offset changes the display position of the filter characteristics.

Item	Description
1st notch 2nd notch 3rd notch 4th notch 5th notch Custom notch 1st torque filter 2-stage torque filter time constant 2-stage torque filter attenuation term	Allows advanced settings to be set for notch filter and torque filter parameters. Notch filter parameters set automatically in Pr2.00 “Adaptive filter mode setup” cannot be changed. When real-time auto-gain tuning setup is enabled, the torque filter parameters cannot be changed because the torque filter is set automatically. Custom notch functions the same as other notch filters. It can be used as a 6th notch filter.

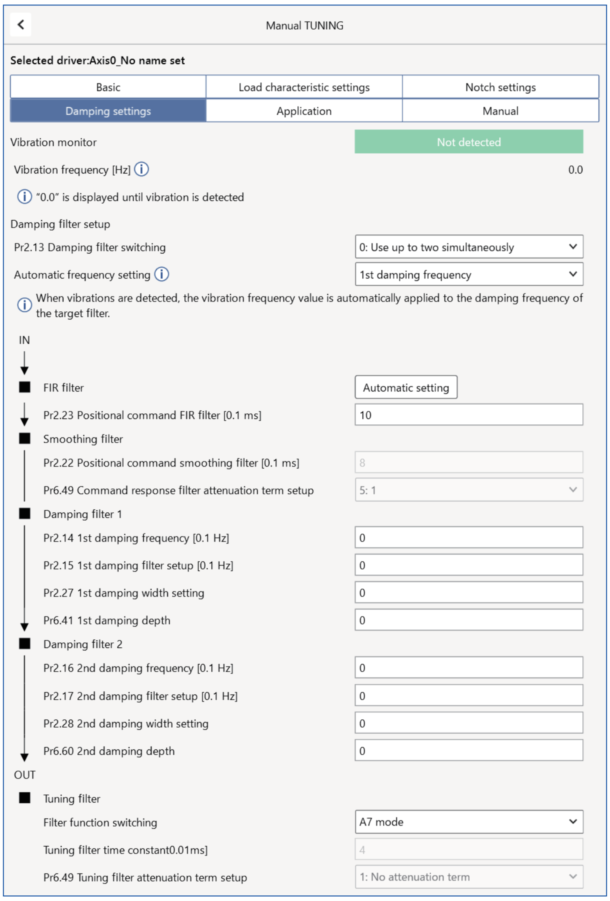
For details on functions, see *“5.3 Notch Filter Function”* , *“5.1 Torque Filter Function”* and *“5.2 2-stage Torque Filter Function”* .

Damping settings

- Parameters related to damping control, the model-type damping filter and position command filter function can be tuned.
- When “A7 recommended setting” is selected in *“Mode Setting”* , the damping control vibration frequency is estimated and set in damping frequency in this mode. The automatically set damping frequency is displayed.
- To manually tune related parameters, click “Damping settings” in blue text, or click the [Damping settings] button at the top. The main screen changes to the “Damping settings” screen. The screen displays the parameters of the filter used based on the Pr2.13 “Selection of damping filter switching” set value. To return to the “Basic” screen, click on the [Basic] button at the top.

“Damping Settings” Advanced Settings Screen

When Pr2.13 = 0



Selected driver:Axis0_No name set

Vibration monitor	Not detected
Vibration frequency [Hz]	0.0

“0.0” is displayed until vibration is detected

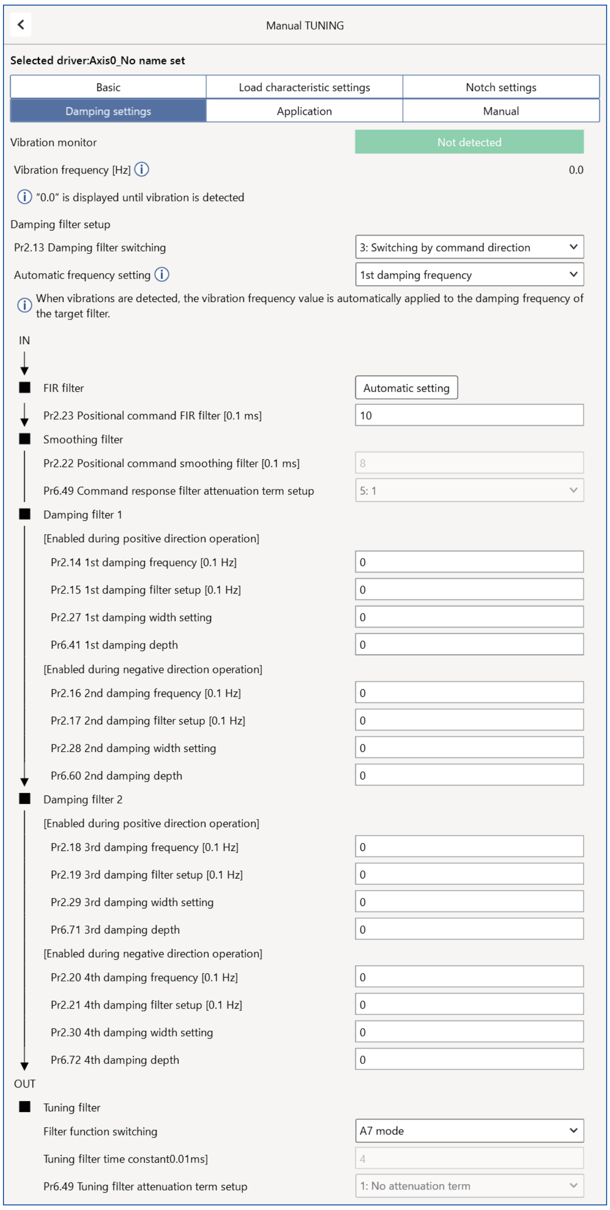
Damping filter setup

Pr2.13 Damping filter switching	0: Use up to two simultaneously
Automatic frequency setting	1st damping frequency

When vibrations are detected, the vibration frequency value is automatically applied to the damping frequency of the target filter.

FIR filter	Automatic setting
Pr2.23 Positional command FIR filter [0.1 ms]	10
Smoothing filter	
Pr2.22 Positional command smoothing filter [0.1 ms]	8
Pr6.49 Command response filter attenuation term setup	5: 1
Damping filter 1	
Pr2.14 1st damping frequency [0.1 Hz]	0
Pr2.15 1st damping filter setup [0.1 Hz]	0
Pr2.27 1st damping width setting	0
Pr6.41 1st damping depth	0
Damping filter 2	
Pr2.16 2nd damping frequency [0.1 Hz]	0
Pr2.17 2nd damping filter setup [0.1 Hz]	0
Pr2.28 2nd damping width setting	0
Pr6.60 2nd damping depth	0
Tuning filter	
Filter function switching	A7 mode
Tuning filter time constant0.01ms]	4
Pr6.49 Tuning filter attenuation term setup	1: No attenuation term

When Pr2.13 = 3



Selected driver:Axis0_No name set

Vibration monitor	Not detected
Vibration frequency [Hz]	0.0

“0.0” is displayed until vibration is detected

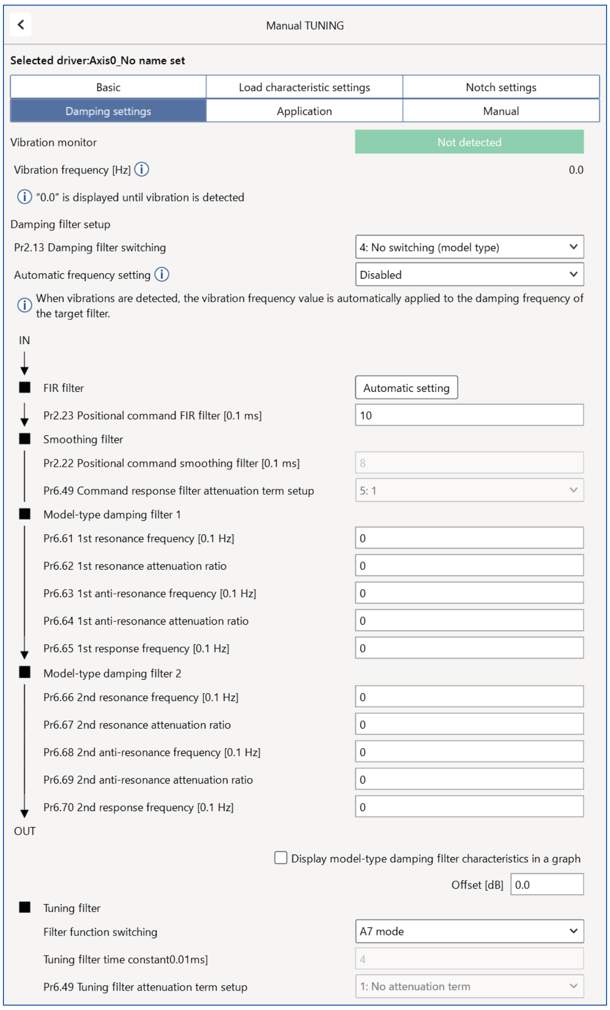
Damping filter setup

Pr2.13 Damping filter switching	3: Switching by command direction
Automatic frequency setting	1st damping frequency

When vibrations are detected, the vibration frequency value is automatically applied to the damping frequency of the target filter.

FIR filter	Automatic setting
Pr2.23 Positional command FIR filter [0.1 ms]	10
Smoothing filter	
Pr2.22 Positional command smoothing filter [0.1 ms]	8
Pr6.49 Command response filter attenuation term setup	5: 1
Damping filter 1	
[Enabled during positive direction operation]	
Pr2.14 1st damping frequency [0.1 Hz]	0
Pr2.15 1st damping filter setup [0.1 Hz]	0
Pr2.27 1st damping width setting	0
Pr6.41 1st damping depth	0
[Enabled during negative direction operation]	
Pr2.16 2nd damping frequency [0.1 Hz]	0
Pr2.17 2nd damping filter setup [0.1 Hz]	0
Pr2.28 2nd damping width setting	0
Pr6.60 2nd damping depth	0
Damping filter 2	
[Enabled during positive direction operation]	
Pr2.18 3rd damping frequency [0.1 Hz]	0
Pr2.19 3rd damping filter setup [0.1 Hz]	0
Pr2.29 3rd damping width setting	0
Pr6.71 3rd damping depth	0
[Enabled during negative direction operation]	
Pr2.20 4th damping frequency [0.1 Hz]	0
Pr2.21 4th damping filter setup [0.1 Hz]	0
Pr2.30 4th damping width setting	0
Pr6.72 4th damping depth	0
Tuning filter	
Filter function switching	A7 mode
Tuning filter time constant0.01ms]	4
Pr6.49 Tuning filter attenuation term setup	1: No attenuation term

When Pr2.13 = 4



Selected driver:Axis0_No name set

Vibration monitor: Not detected

Vibration frequency [Hz] ⓘ: 0.0

ⓘ "0.0" is displayed until vibration is detected

Damping filter setup

Pr2.13 Damping filter switching: 4: No switching (model type)

Automatic frequency setting ⓘ: Disabled

ⓘ When vibrations are detected, the vibration frequency value is automatically applied to the damping frequency of the target filter.

IN

■ FIR filter

Pr2.23 Positional command FIR filter [0.1 ms]: 10

■ Smoothing filter

Pr2.22 Positional command smoothing filter [0.1 ms]: 8

Pr6.49 Command response filter attenuation term setup: 5: 1

■ Model-type damping filter 1

Pr6.61 1st resonance frequency [0.1 Hz]: 0

Pr6.62 1st resonance attenuation ratio: 0

Pr6.63 1st anti-resonance frequency [0.1 Hz]: 0

Pr6.64 1st anti-resonance attenuation ratio: 0

Pr6.65 1st response frequency [0.1 Hz]: 0

■ Model-type damping filter 2

Pr6.66 2nd resonance frequency [0.1 Hz]: 0

Pr6.67 2nd resonance attenuation ratio: 0

Pr6.68 2nd anti-resonance frequency [0.1 Hz]: 0

Pr6.69 2nd anti-resonance attenuation ratio: 0

Pr6.70 2nd response frequency [0.1 Hz]: 0

OUT

☐ Display model-type damping filter characteristics in a graph

Offset [dB]: 0.0

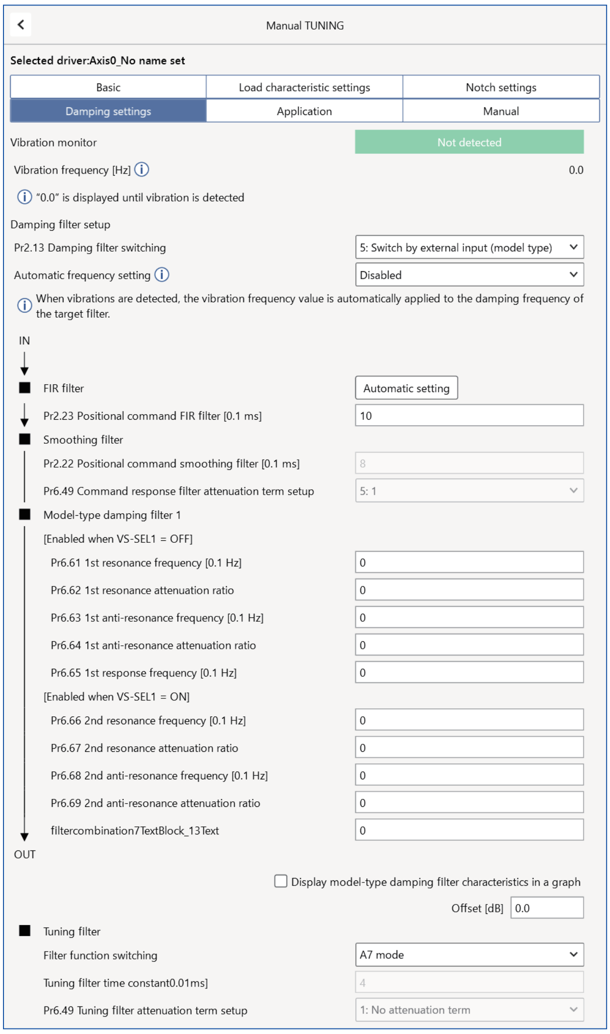
■ Tuning filter

Filter function switching: A7 mode

Tuning filter time constant0.01ms]: 4

Pr6.49 Tuning filter attenuation term setup: 1: No attenuation term

When Pr2.13 = 5



Selected driver:Axis0_No name set

Vibration monitor: Not detected

Vibration frequency [Hz] ⓘ: 0.0

ⓘ "0.0" is displayed until vibration is detected

Damping filter setup

Pr2.13 Damping filter switching: 5: Switch by external input (model type)

Automatic frequency setting ⓘ: Disabled

ⓘ When vibrations are detected, the vibration frequency value is automatically applied to the damping frequency of the target filter.

IN

■ FIR filter

Pr2.23 Positional command FIR filter [0.1 ms]: 10

■ Smoothing filter

Pr2.22 Positional command smoothing filter [0.1 ms]: 8

Pr6.49 Command response filter attenuation term setup: 5: 1

■ Model-type damping filter 1

[Enabled when VS-SEL1 = OFF]

Pr6.61 1st resonance frequency [0.1 Hz]: 0

Pr6.62 1st resonance attenuation ratio: 0

Pr6.63 1st anti-resonance frequency [0.1 Hz]: 0

Pr6.64 1st anti-resonance attenuation ratio: 0

Pr6.65 1st response frequency [0.1 Hz]: 0

[Enabled when VS-SEL1 = ON]

Pr6.66 2nd resonance frequency [0.1 Hz]: 0

Pr6.67 2nd resonance attenuation ratio: 0

Pr6.68 2nd anti-resonance frequency [0.1 Hz]: 0

Pr6.69 2nd anti-resonance attenuation ratio: 0

filtercombination7TextBlock_13Text: 0

OUT

☐ Display model-type damping filter characteristics in a graph

Offset [dB]: 0.0

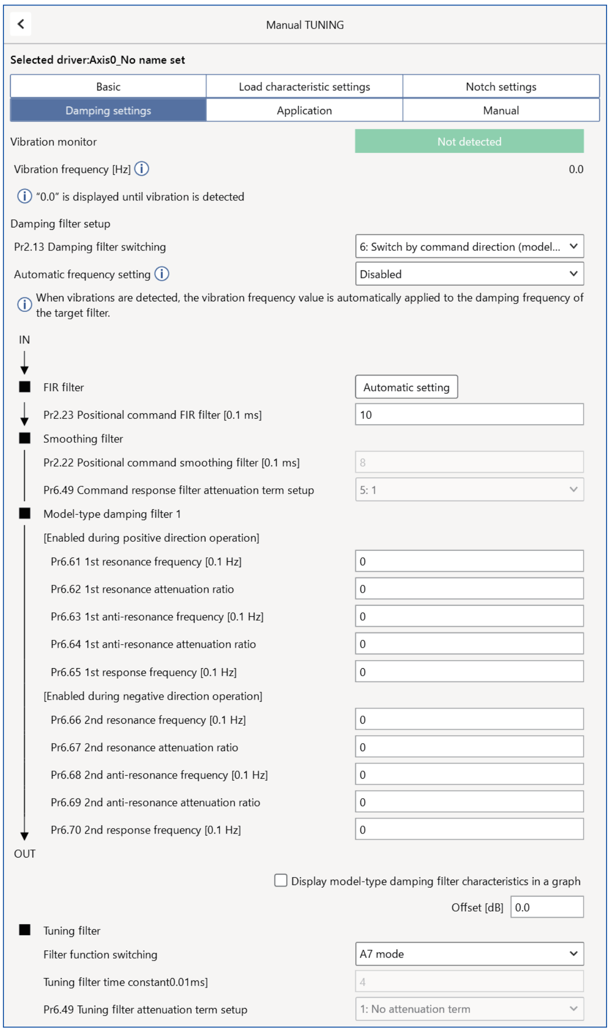
■ Tuning filter

Filter function switching: A7 mode

Tuning filter time constant0.01ms]: 4

Pr6.49 Tuning filter attenuation term setup: 1: No attenuation term

When Pr2.13 = 6



Selected driver:Axis0_No name set

Vibration monitor: Not detected

Vibration frequency [Hz]: 0.0

"0.0" is displayed until vibration is detected

Damping filter setup

Pr2.13 Damping filter switching: 6: Switch by command direction (model...

Automatic frequency setting: Disabled

When vibrations are detected, the vibration frequency value is automatically applied to the damping frequency of the target filter.

FIR filter

Pr2.23 Positional command FIR filter [0.1 ms]: 10

Smoothing filter

Pr2.22 Positional command smoothing filter [0.1 ms]: 8

Pr6.49 Command response filter attenuation term setup: 5: 1

Model-type damping filter 1

[Enabled during positive direction operation]

Pr6.61 1st resonance frequency [0.1 Hz]: 0

Pr6.62 1st resonance attenuation ratio: 0

Pr6.63 1st anti-resonance frequency [0.1 Hz]: 0

Pr6.64 1st anti-resonance attenuation ratio: 0

Pr6.65 1st response frequency [0.1 Hz]: 0

[Enabled during negative direction operation]

Pr6.66 2nd resonance frequency [0.1 Hz]: 0

Pr6.67 2nd resonance attenuation ratio: 0

Pr6.68 2nd anti-resonance frequency [0.1 Hz]: 0

Pr6.69 2nd anti-resonance attenuation ratio: 0

Pr6.70 2nd response frequency [0.1 Hz]: 0

☐ Display model-type damping filter characteristics in a graph

Offset [dB]: 0.0

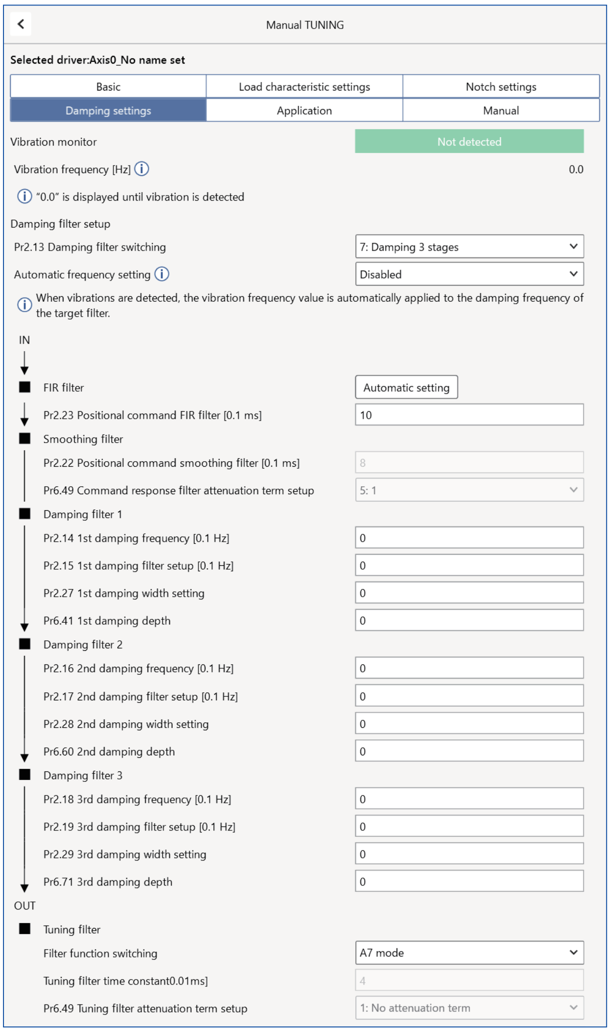
Tuning filter

Filter function switching: A7 mode

Tuning filter time constant0.01ms]: 4

Pr6.49 Tuning filter attenuation term setup: 1: No attenuation term

When Pr2.13 = 7



Selected driver:Axis0_No name set

Vibration monitor: Not detected

Vibration frequency [Hz]: 0.0

"0.0" is displayed until vibration is detected

Damping filter setup

Pr2.13 Damping filter switching: 7: Damping 3 stages

Automatic frequency setting: Disabled

When vibrations are detected, the vibration frequency value is automatically applied to the damping frequency of the target filter.

FIR filter

Pr2.23 Positional command FIR filter [0.1 ms]: 10

Smoothing filter

Pr2.22 Positional command smoothing filter [0.1 ms]: 8

Pr6.49 Command response filter attenuation term setup: 5: 1

Damping filter 1

Pr2.14 1st damping frequency [0.1 Hz]: 0

Pr2.15 1st damping filter setup [0.1 Hz]: 0

Pr2.27 1st damping width setting: 0

Pr6.41 1st damping depth: 0

Damping filter 2

Pr2.16 2nd damping frequency [0.1 Hz]: 0

Pr2.17 2nd damping filter setup [0.1 Hz]: 0

Pr2.28 2nd damping width setting: 0

Pr6.60 2nd damping depth: 0

Damping filter 3

Pr2.18 3rd damping frequency [0.1 Hz]: 0

Pr2.19 3rd damping filter setup [0.1 Hz]: 0

Pr2.29 3rd damping width setting: 0

Pr6.71 3rd damping depth: 0

Tuning filter

Filter function switching: A7 mode

Tuning filter time constant0.01ms]: 4

Pr6.49 Tuning filter attenuation term setup: 1: No attenuation term

For details on functions, see *"5.5 Damping Control Function"* and *"5.6 Model-type Damping Filter Function"* .

Item	Description
Vibration monitor	When automatic frequency setting of the damping filter is enabled, the vibration frequency is displayed if vibration is detected.
Pr2.13 Damping filter switching	Set Pr2.13 "Selection of damping filter switching" . The parameters of the filter used based on the set value are displayed. When automatic setting is enabled, the parameters for the damping filter selected for setup are set automatically.
Automatic frequency setting	Select the damping filter for which the damping frequency is automatically set. Each time vibration is detected, the frequency displayed on the vibration monitor is set to the damping frequency.
FIR filter	Sets the value for Pr2.23 "Positional command FIR filter" . Clicking the [Automatic setting] button calculates and automatically sets the appropriate parameters. For details on functions, see *"5.7 Position Command Filter Function"* .
Smoothing filter	When the two-degree-of-freedom control mode for standard type is set and real-time auto tuning is enabled, the parameters are automatically set to the command response filter settings. Otherwise, parameters can be set manually. If synchronization of multiple axes is required, such as for a processing machine, set Pr2.22 "Positional command smoothing filter" to the same value for all axes. For details on functions, see *"5.7 Position Command Filter Function"* .

Item	Description
Damping filter 1 Damping filter 2 Damping filter 3 Damping filter 4 Model type damping filter 1 Model type damping filter 2	Parameters for damping filters that are not identified for automatic setting can be set manually. For details on functions, see *"5.5 Damping Control Function"* and *"5.6 Model-type Damping Filter Function"* .
Tuning filter	In the case of filter function switching, when "A7 recommended setting" is selected in *"Mode Setting"* , "A7 mode" is automatically set, and when "A6 compatibility setting" is selected, "Backward compatible" is automatically set. Changes are not required. When the two-degree-of-freedom control mode is enabled and real-time auto tuning is enabled, the tuning filter time constant is automatically set. Otherwise, parameters can be set manually.
Display model-type damping filter characteristics in a graph	This is displayed when Pr2.13 "Selection of damping filter switching" is between 4 and 6, using a model-type damping filter. Use to support tuning of model-type damping filters. When the check box is checked, the model-type damping filter characteristics are displayed on the frequency characteristic screen in the center of the "Manual TUNING" screen. Use with torque speed characteristics displayed. For details of the model-type damping filter function, see *"5.6 Model-type Damping Filter Function"* .
Offset	Entering a numerical value in Offset changes the display position of the filter characteristics.

What if I have a problem?

- Clicking on "When problems occur" in blue text displays a PDF file detailing the basics of tuning parameters and typical control challenges.

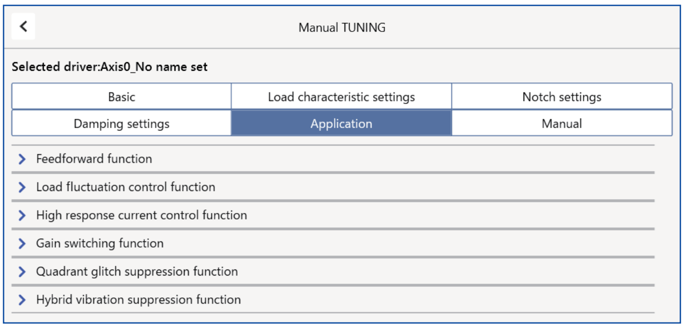
  Use this when issues are known, but corresponding tuning procedures are unknown.

  The PDF file is displayed in a separate window. Manual TUNING is possible while viewing the displayed contents.

Application

- This section summarizes functions not described previously.

- The main screen changes to the “Application” screen where the names of various functions are displayed. To return to the “Basic” screen, click on the [Basic] button at the top.



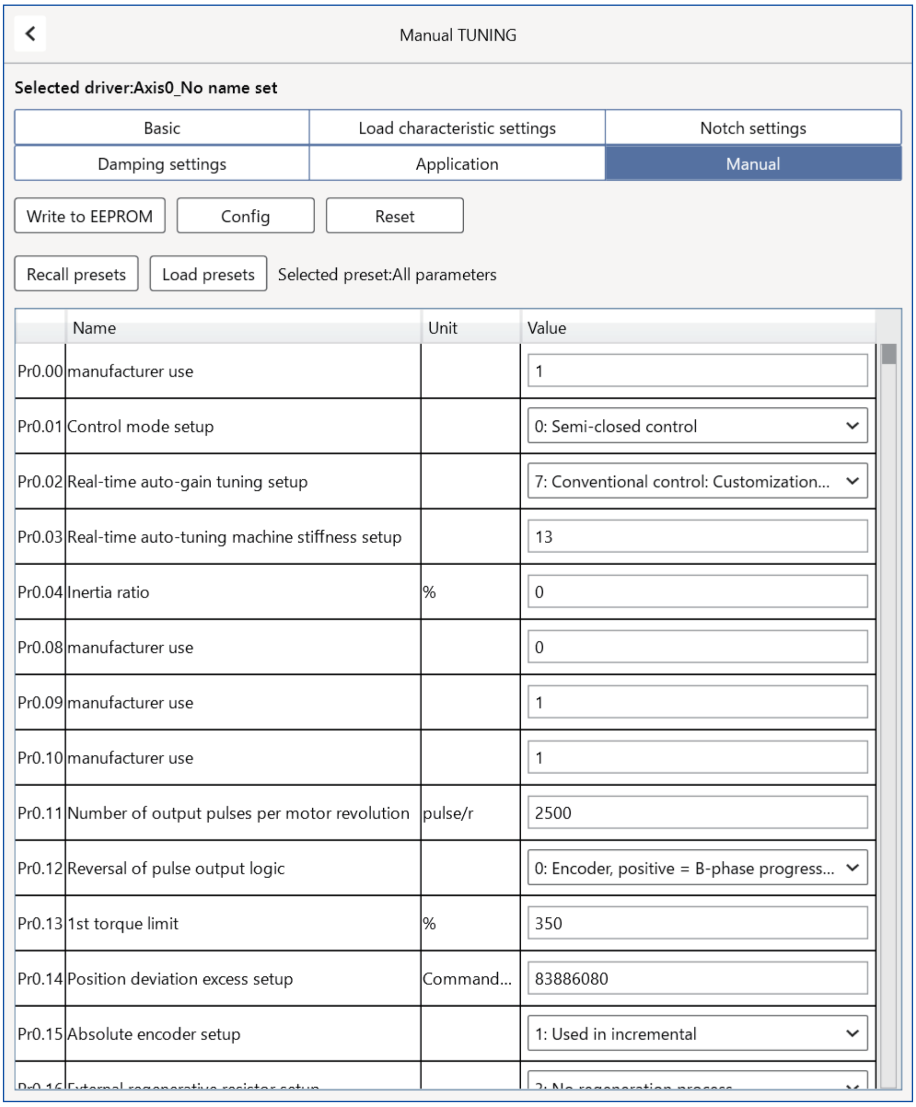
Click “>” to the left of each function name to display the related parameters and enable setup.

For details on each function and related parameters, please refer to the relevant items.

- *“4.4 Feedforward Function”*
- *“4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)”*
- *“4.8 High Response Current Control Function”*
- *“4.2 Gain Switching Function”*
- *“4.3 3rd Gain Switching Function”*
- *“4.9 Quadrant Glitch Suppression Function”*
- *“5.9 Hybrid Vibration Suppression Function”*

Manual

- Displays the parameters shown in “Basic”, “Load characteristic settings”, “Notch settings”, “Damping settings”, and “Apply” in list format.



Selected driver:Axis0_No name set

Selected preset:All parameters

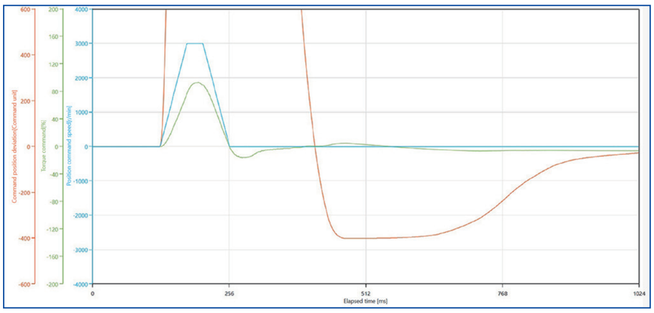
	Name	Unit	Value
Pr0.00	manufacturer use		1
Pr0.01	Control mode setup		0: Semi-closed control
Pr0.02	Real-time auto-gain tuning setup		7: Conventional control: Customization...
Pr0.03	Real-time auto-tuning machine stiffness setup		13
Pr0.04	Inertia ratio	%	0
Pr0.08	manufacturer use		0
Pr0.09	manufacturer use		1
Pr0.10	manufacturer use		1
Pr0.11	Number of output pulses per motor revolution	pulse/r	2500
Pr0.12	Reversal of pulse output logic		0: Encoder, positive = B-phase progress...
Pr0.13	1st torque limit	%	350
Pr0.14	Position deviation excess setup	Command...	83886080
Pr0.15	Absolute encoder setup		1: Used in incremental
Pr0.16	External regenerative resistor setup		3: No regeneration process

3.2.1.4.3 Tuning Procedure When Starting a New Tuning Session

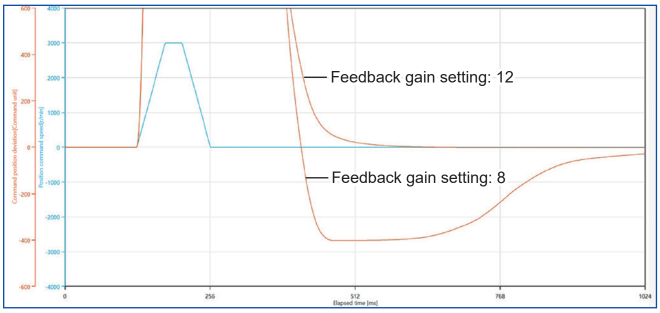
The basic tuning procedure is described when “A7 recommended setting” is selected in the mode setting as an example.

<< Procedure >>

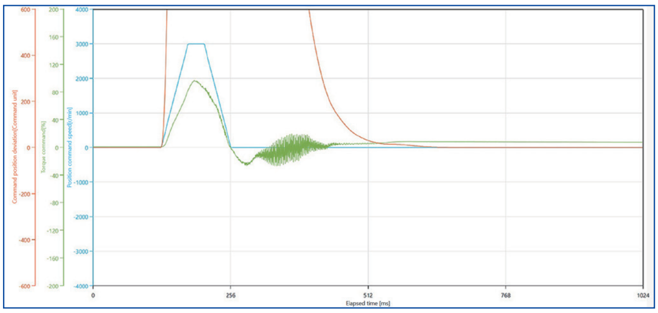
1. Run the motor and check the position deviation response.



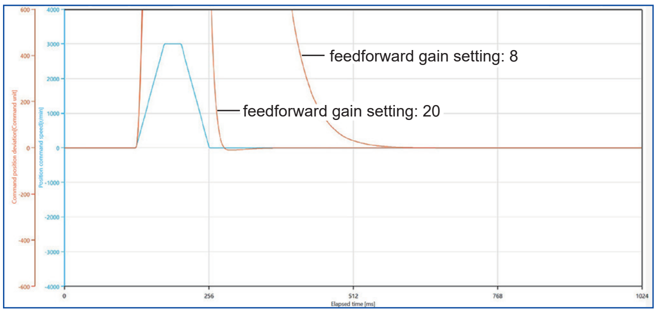
2. To reduce overshoot, increase the “Feedback gain setting” by increments of 1.



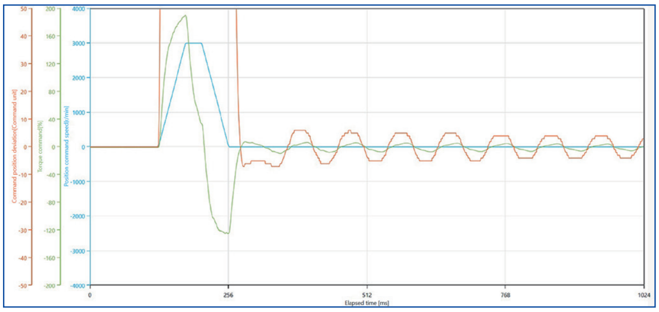
3. If the “Feedback gain setting” is set too high, oscillation may occur. In this case, set the filter properly in “Notch filter settings”. For the tuning procedure, see *“5.3 Notch Filter Function”* .



4. Once the overshoot is reduced to a satisfactory level, increase the “FF gain setting” by increments of 1.



5. If the position deviation residual vibration is large, set the filter properly in “Damping filter settings”. For the tuning procedure, see *“5.5 Damping Control Function”* .



6. If you experience any trouble during the process, click “When problems occur” in blue text and refer to the tuning advice that is displayed. Check the *“3.2.1.4.4 Tuning Procedure When Control Challenges Are Identified”* table for the main contents.

3.2.1.4.4 Tuning Procedure When Control Challenges Are Identified

<< Procedure >>

1. Click on “When problems occur” in blue text on the “Basic” screen under “What if I have a problem?”.

2. A PDF file detailing the basics of tuning parameters and typical control challenges is displayed. Use this when issues are known, but corresponding tuning procedures are unknown.

   For details on each control function, refer to the relevant sections in this document.

Issues during re-adjustment	Corresponding control function references
Shortening the settling time.	*"4.1 Real-time Auto Tuning Function"* *"5.7 Position Command Filter Function"*
Reducing overshoot/undershoot.	*"4.1 Real-time Auto Tuning Function"* *"4.3 3rd Gain Switching Function"* *"4.4 Feedforward Function"* *"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)"* *"4.8 High Response Current Control Function"*
Reducing abnormal noise and oscillation.	*"5.3 Notch Filter Function"* *"5.7 Position Command Filter Function"*
Reducing vibration just before stopping.	*"5.5 Damping Control Function"* *"5.6 Model-type Damping Filter Function"*
I want to reduce uneven operation and deviation during operation.	*"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)"* *"4.8 High Response Current Control Function"*
Preventing falling on the vertical axis after servo-on.	*"4.5 Friction Torque Compensation Function"*
Suppressing quadrant glitches when velocity is inverted for processing machines, etc.	*"4.9 Quadrant Glitch Suppression Function"*
Ensuring own axis is not moved when other axes are moved.	*"4.1 Real-time Auto Tuning Function"* *"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)"* *"4.8 High Response Current Control Function"*
Reducing vibration when gain is increased in full-closed control.	*"5.9 Hybrid Vibration Suppression Function"*

3.2.2 Load Fluctuation Suppression Tuning (Stabilizing Load Fluctuation Applications)

3.2.2.1 Function Overview

In devices where load inertia fluctuates, vibration may occur due to the effect of load inertia fluctuations. This function reduces this vibration and improves stability. Set-up Support Software (PANATERM ver.7) has a dedicated screen for tuning the parameters of this function.

3.2.2.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control, speed control, and full-closed control

Under the following conditions, the effect of the load fluctuation control function may not be seen.

Item	Conditions that obstruct the effectiveness of the load fluctuation control function
Load	● Low stiffness (antiresonance points exists in the low frequency range of 10 Hz or less) ● Looseness, backlash, etc. are present and the load non-linearity is strong

3.2.2.3 Tuning Procedure

For the tuning procedure using Set-up Support Software (PANATERM ver.7) , see *“4.7.4.2 When Set-up Support Software (PANATERM ver.7) Is Used”* in *“4.7 Load Fluctuation Control Function (Load Fluctuation Stabilization Applications)”* .

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4.1 Real-time Auto Tuning Function

This function estimates machine load characteristics in real time and uses those results to automatically perform basic gain setting and load characteristic compensation.

There are the following three types of real-time auto tuning, which can be switched by setting parameters.

Control type	Description
Two-degree-of-freedom control mode for standard type	This mode is suitable for positioning control. Load characteristic measurement, 3rd gain switching and viscous friction compensation can be enabled.
Two-degree-of-freedom control mode for synchronization type	This mode is suitable for controlling multiple loci such as with multijoint robots, etc. This type differs from the two-degree-of-freedom control mode for standard type in that the command response can be set individually and unbalanced load (gravity) compensation can be disabled.
Two-degree-of-freedom control mode disabled type	Two-degree-of-freedom control mode is disabled.

4.1.1 Real-time Auto Tuning (Two-degree-of-freedom Control Mode for Standard Type)

4.1.1.1 Function Overview

This control mode is suitable for positioning control where the moving locus is not important. It is effective for individually tuning operation acceleration and disturbance suppression. This is a standard control mode, and normally the two-degree-of-freedom control mode for standard type should be used.

Set Pr6.47 “Function expansion setup 2” :bit 0 “Two-degree-of-freedom control mode” = 1 (enabled) and bit 3 “Two-degree-of-freedom control real-time auto tuning selection” = 0 (standard type) to set this type.

4.1.1.2 Operation Mode

In real-time auto tuning (two-degree-of-freedom control mode for standard type), the operation mode can be changed according to Pr0.02 “Real-time auto-gain tuning setup” . In each operation mode, automatic inertia ratio updates, basic gain setting, unbalanced load compensation, and friction compensation can be enabled or disabled.

In all modes of operation, operation acceleration and disturbance suppression can be tuned individually.

When Pr0.02 = 7, automatic inertia ratio updates, basic gain setting, unbalanced load compensation, and friction compensation can be enabled or disabled individually. Select Pr0.02 = 7 (set value 7) to optimize each function according to device characteristics.

Details on Pr0.02 “Real-time auto-gain tuning setup”

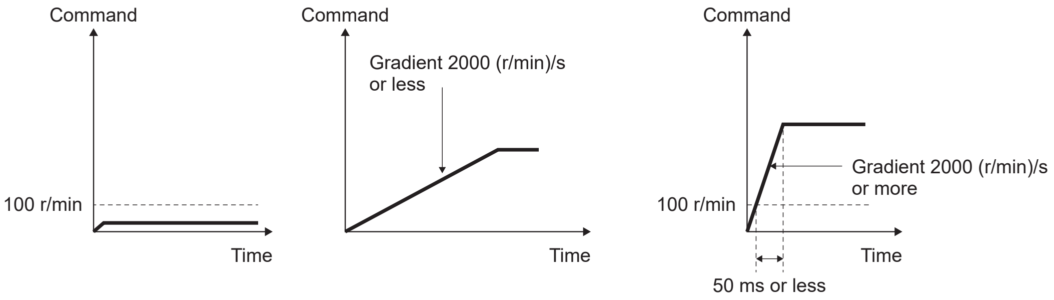
Setup value	Operation mode	Description
0	Disabled	The real-time auto tuning function is disabled.
1	Standard response mode	This is an operation mode with an emphasis on stability. Unbalanced load compensation and friction compensation are not performed, and gain switching is not used.
2	High response mode 1	This is a positioning-focused operation mode. Use for devices such as low-friction ball screw driven devices that do not have unbalanced load on the horizontal axis.
3	High response mode 2	In addition to high response mode 1, this mode suppresses variation in positioning settling times using unbalanced load compensation, such as for a vertical axis, as well as via application of 3rd gain.
4	High response mode 3	In addition to high response mode 2, this mode shortens the positioning settling time with a belt mechanical shaft with high friction, etc. In terms of speed control, this mode is the same as high response mode 2. The Pr2.53 “Positive direction torque compensation value 2” , Pr2.54 “Negative direction torque compensation value 2” , and Pr6.50 “Viscous friction compensating gain” parameter values are updated, but are not reflected in the operation.

Setup value	Operation mode	Description
5	Load characteristic measurement	The basic gain setting and friction compensation setting are not changed, only load characteristic estimation is performed. Used in combination with Set-up Support Software (PANATERM ver.7) .
6	Customize 1	The real-time auto tuning function is disabled in two-degree-of-freedom control mode for standard type.
7	Customize 2	The combination of real-time auto tuning functions can be customized for each application by configuring advanced settings in Pr6.32 “Real time auto tuning custom setup” . A change ratio can be set for the basic gain setting. Therefore, this mode should normally be selected. Some functions are not available depending on the control mode. For details, see *“Details on Pr6.32 “Real time auto tuning custom setup” ”* .

4.1.1.3 Operational Conditions

Item	Operational Conditions
Control mode	● Position control, speed control, and full-closed control ● Pr6.47:bit 0 = 1 and bit 3 = 0 (standard type)

Real-time auto tuning may not work normally under the following conditions. In such cases, change the load conditions, operation pattern, or manually set the related parameters.

Item	Conditions that obstruct the operation of real-time auto tuning
Load	● When load inertia is small or large compared to the rotor inertia of the servo motor (less than 3× or 20× or more) ● When load inertia fluctuates ● When machine stiffness is extremely low ● When non-linear characteristics exist, such as looseness due to backlash
Operation patterns	● When used continuously at low speeds of less than 100 r/min ● When acceleration and deceleration are gentle, less than 2000 r/min in 1 s ● When the speed is more than 100 r/min and the acceleration and deceleration condition of more than 2000 r/min in 1 s does not continue for more than 50 ms **Example of an operation pattern that obstructs function operation**  ● When the acceleration and deceleration torque is small compared to the unbalanced load and viscous friction torque

4.1.1.4 Related Parameters

4.1.1.4.1 Parameters That Control the Operation of This Function

—: N/A

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
0	02	B	Real-time auto-gain tuning setup	0 to 7	—	Sets the real-time auto tuning operation mode. Normally, select setting value 7.
0	03	B	Real-time auto-tuning machine stiffness setup	0 to 31	—	Sets responsiveness when real-time auto tuning is enabled. Higher settings result in higher speed responsiveness and servo stiffness, but make it more likely that vibration will occur. Values should be changed from low to high with a close eye on operation. Enabled with Pr2.45 “Function expansion setup 10” : bit 5 = 0 (32 stiffness settings).
0	27	B	Selection of machine stiffness at real-time auto-gain tuning 2	0 to 44	—	Sets responsiveness when real-time auto tuning is enabled. Higher settings result in higher speed responsiveness and servo stiffness, but make it more likely that vibration will occur. Values should be changed from low to high with a close eye on operation. Allows finer gain adjustment than Pr0.03. Enabled with Pr2.45 “Function expansion setup 10” : bit 5 = 1 (45 stiffness settings).
0	28	B	Selection of feed forward stiffness at real-time auto-gain tuning	0 to 44	—	Sets responsiveness when real-time auto tuning is enabled. Higher settings result in higher speed responsiveness, but make it more likely that overshoot will occur. Values should be changed from low to high with a close eye on operation. Enabled with Pr2.45 “Function expansion setup 10” : bits 5 to 4 = 11b.
2	74	A	Tuning auto tuning application selection	-32768 to 32767	—	For Pr0.02 = 7 (Customize 2), any change ratio can be set for the basic gain setting to fit the application when the set value = 3. 0: Positioning 3: Customize
6	10	B	Function expansion setup	-32768 to 32767	—	bit 14: Load fluctuation suppression function automatic tuning 0: Disabled 1: Enabled
6	31	B	Real time auto tuning estimation speed	0 to 3	—	Sets load characteristics estimated speed when real-time auto-tuning is enabled. Higher settings result in faster responses to changes in load characteristics, but they also increase variations in disturbance estimation. Estimation results are saved in EEPROM every 30 minutes regardless of the load characteristic estimated speed setting. When automatic vibration detection is enabled from Setup Support Software (PANATERM ver.7) , this setting will be ignored and the setting value will be set to 3.

Setup value	Mode	Description
0	Does not change	Stops load characteristics estimation.
1	Changes very little	Estimates changes in load characteristics in minutes.
2	Changes slowly	Estimates changes in load characteristics in seconds.
3	Changes precipitously	Fastest estimation of changes in load characteristics.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	32	B	Real time auto tuning custom setup	-32768 to 32767	—	Makes advanced settings for the automatic adjustment function when the Pr0.02 = 7 (Customize 2) is selected as an operation mode for real-time auto tuning.

*1 For attributes, see *"7.1 Object Dictionary List"* .

■ Details on Pr6.32 "Real time auto tuning custom setup"

<table>
<tr><th>bit</th><th>Name</th><th>Description</th></tr>
<tr><td>1 to 0</td><td>Load characteristics estimation</td><td>Set to enable or disable the load characteristics estimation function.
0: Disabled
1: Enabled
— Precautions —
● When this setting is disabled, the target parameters are not updated from the current settings even if bit 3 to 2 "Inertia Ratio Update" , bit 6 to 4 "Torque compensation" , and bit 15 to 12 "Individual torque compensation settings" are set to enable updates.
● To enable load characteristic estimation, set Pr6.31 "Real time auto tuning estimation speed" to a value other than 0 (no change).</td></tr>
<tr><td>3 to 2</td><td>Inertia Ratio Update</td><td>Set updates in load characteristic estimation results for Pr0.04 "Inertia ratio" .
0: Disabled
1: Enabled
— Precautions —
● To enable inertia ratio updates, set bit 1 to 0 "Load characteristics estimation" to 1 (enabled). If both are not enabled, the inertia ratio will not be updated.</td></tr>
<tr><td>6 to 4</td><td>Torque compensation (*1)</td><td>Set updates in load characteristic estimation results for Pr2.52 "Torque command additional value 2" , Pr2.53 "Positive direction torque compensation value 2" , Pr2.54 "Negative direction torque compensation value 2" and Pr6.50 "Viscous friction compensating gain" .
<table>
<tr><th>Setup value</th><th>Mode</th><th>Description</th></tr>
<tr><td>0</td><td>Use current settings</td><td>Uses current settings.</td></tr>
<tr><td>1</td><td>Disable torque compensation</td><td>Clear Pr2.52, Pr2.53, Pr2.54, and Pr6.50 to 0.</td></tr>
<tr><td>2</td><td>Vertical axis mode</td><td>Update Pr2.52 and clear Pr2.53, Pr2.54 and Pr6.50 to 0.</td></tr>
<tr><td>3</td><td>Friction compensation (weak)</td><td>Update Pr2.52 and set weak compensation for Pr2.53, Pr2.54, and Pr6.50.</td></tr>
<tr><td>4</td><td>Friction compensation (medium)</td><td>Update Pr2.52 and set medium compensation for Pr2.53, Pr2.54, and Pr6.50.</td></tr>
<tr><td>5</td><td>Friction compensation (strong)</td><td>Update Pr2.52 and set strong compensation for Pr2.53, Pr2.54 and Pr6.50.</td></tr>
</table>
— Precautions —
● Change the parameters to be used depending on the values set in Pr2.45 "Function expansion setup 10" :bit 2 "Friction torque compensation parameter selection" . The initial value is Pr2.45: bit 2 = 1.
• Pr2.45: bit 2=0 : Pr6.07, Pr6.08, Pr6.09
• Pr2.45: bit 2=1 : Pr2.52, Pr2.53, Pr2.54</td></tr>
</table>

<table>
<tr><th>bit</th><th>Name</th><th>Description</th></tr>
<tr><td>7</td><td>Stiffness Setup (*2)</td><td>Set to enable or disable the basic gain setting using Pr0.03 “Real-time auto-tuning machine stiffness setup” , Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2” or Pr0.28 “Selection of feed forward stiffness at real-time auto-gain tuning” .
0: Disabled
1: Enabled
— Precautions —
● Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.
• Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
• Pr2.45: bits 5 to 4 = 10b : Pr0.27
• Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28</td></tr>
<tr><td>8</td><td>Fixed Parameter Setup (*2)</td><td>Set whether or not to change parameters that become fixed values when real-time auto tuning is enabled.
For details, see the table <i>“Values Set When Real-Time Auto Tuning is Enabled (Pr0.02 = 1 to 4, 7)”</i> in <i>“4.1.1.4.3 Parameters Changed By This Function”</i> .
0: Use current settings
1: Set to fixed values</td></tr>
<tr><td>10 to 9</td><td>Gain Switching Setup (*2)</td><td>Select the method for setting parameters related to gain switching when real-time auto tuning is enabled.
0: Use current settings
1: Gain switching disabled
2: Gain switching enabled</td></tr>
<tr><td>11</td><td>Torque compensation setting switching</td><td>Select whether to enable bits 6 to 4 or bits 15 to 12 for torque compensation.
0: Enable bits 6 to 4
1: Enable bits 15 to 12</td></tr>
<tr><td>15 to 12</td><td>Individual torque compensation settings (*1)</td><td>Select whether to use or update the current setting for the corresponding parameters when bit 11 “Torque compensation setting switching” = 1.
0: Use current settings
1: Update
<table><tr><th></th><th>bit 15</th><th>bit 14</th><th>bit 13</th><th>bit 12</th></tr><tr><td>When Pr2.45:bit 2 = 1</td><td>Pr6.50</td><td>Pr2.54</td><td>Pr2.53</td><td>Pr2.52</td></tr><tr><td>When Pr2.45:bit 2 = 0</td><td>Pr6.50</td><td>Pr6.09</td><td>Pr6.08</td><td>Pr6.07</td></tr></table></td></tr>
</table>

*1 To set to enable updates to torque compensation, set bit 1 to 0 “Load characteristics estimation” and bit 3 to 2 “Inertia Ratio Update” to 1 (enabled). Updates are not applied with update settings for torque compensation only.

*2 To set this set value to a value other than 0, set bit 3 to 2 “Inertia Ratio Update” to 1 (enabled). Whether or not inertia ratio update is enabled at this time can be set with bit 1 to 0 “Load characteristics estimation” .

— Precautions —

- These parameters must be set in bit units. Operation cannot be guaranteed with incorrect settings. Using Set-up Support Software (PANATERM ver.7) is recommended for changing parameter setup values.
- Do not change these parameters during motor operation. Actually updating of parameters takes place when the motor stops after the load characteristic measurement results are confirmed.

Notes

- Calculating Pr6.32 set value from values in bit units

  When configuring each setting to a value other than 0, use the following procedure to calculate the set value for Pr6.32.

  1 Confirm the least significant bit for each setting.

(Example) The least significant bit of the torque compensation function is 4

2 Multiply 2 to the power of (LSB) by the set value.

(Example) If bit 6 to 4 “Torque compensation” = 3 (friction compensation (weak)), then $2^4 \times 3$.

3 For each setting, calculate “1” and “2” and then add them all together to obtain the set value for Pr6.32.

(Example) When load characteristic measurement = enabled, inertia ratio update = enabled, torque compensation = friction compensation (weak), stiffness setting = enabled, fixed parameters = set to fixed values, gain switching setup = enabled

$2^0\times1 + 2^2\times1 + 2^4\times3 + 2^7\times1 + 2^8\times1 + 2^9\times2 = 1461$

4.1.1.4.2 Parameters to Switch the Parameters Used by This Function to Minas A6 Series-Compatible Specification

In real-time auto tuning, the parameters used in real-time auto tuning can be switched to MINAS A6 Series-compatible specification parameters by setting Pr2.45 “Function expansion setup 10” .

- Parameters related to stiffness, unbalanced load and friction compensation and tuning filters
- Calculation method when updating torque filter time constant and some parameters for load fluctuation compensation (Pr6.73 “Load estimation filter” and Pr6.76 “Load estimation count”)

Item	Parameters for switching to MINAS A6 Series-compatible specification	Initial value (*1)
Stiffness	Can be changed with Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” .	bits 5 to 4 = 11b
Unbalanced load/ friction compensation	Can be changed with Pr2.45 “Function expansion setup 10” :bit 2 “Friction torque compensation parameter selection” .	bit 2 = 1
Torque filter time constant	Determined by the value of Pr2.45 “Function expansion setup 10” :bit 1 to 0 “Two-degree-of-freedom control function setting” .	bits 1 to 0 = 01b
Load fluctuation compensation	Determined by the value of Pr2.45 “Function expansion setup 10” :bit 3 “Load fluctuation suppression function automatic calculation” .	bit 3 = 1

*1 Normally used with initial values.

—: N/A

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	38	B	Filter function switching	-32768 to 32767	—	Select a tuning filter. Normally, set to bit 1 = 1. bit 1: Tuning filter 2 0: Use Pr6.48 “Tuning filter” (MINAS A6 Series-compatible specification) 1: Use Pr2.46 “Tuning filter 2” (MINAS A7 Series specification)
2	45	B	Function expansion setup 10	-2147483648 to 2147483647	—	Sets various functions. bit 1 to 0: Two-degree-of-freedom control function setting bit 2: Friction torque compensation parameter selection bit 3: Load fluctuation suppression function automatic calculation bit 5 to 4: Stiffness setting resolution, individual FB/FF setting switching bit 31 to 6: Unused

*1 For attributes, see *“7.1 Object Dictionary List”* .

■ Details on Pr2.45 “Function expansion setup 10”

—: N/A

bit	Name	Description	Initial value
1 to 0	Two-degree-of-freedom control function setting	00b: Two-degree-of-freedom control (MINAS A6 Series-compatible specification) 01b: Two-degree-of-freedom control (MINAS A7 Series specification) 10b: Manufacturer use 11b: Manufacturer use	01b
2	Friction torque compensation parameter selection	0: MINAS A6 Series-compatible specification settings Unbalanced load compensation value: Use Pr6.07 Dynamic friction compensation value: Use Pr6.08, Pr6.09 1: MINAS A7 Series specification settings Unbalanced load compensation value: Use Pr2.52 Dynamic friction compensation value: Use Pr2.53, Pr2.54	1
3	Load fluctuation suppression function automatic calculation	0: Conventional setting (MINAS A6 Series specification) 1: The following parameters are automatically calculated. Pr6.73 “Load estimation filter” Pr6.76 “Load estimation count”	1
5 to 4	Stiffness setting resolution, individual FB/FF setting switching	00b: 32 stiffness settings, FB/FF common setting (MINAS A6 Series-compatible specification) Use Pr0.03 01b: Same as 00b 10b: 45 stiffness settings, FB/FF common setting (MINAS A7 Series specification) Use Pr0.27 11b: 45 stiffness settings, individual FB/FF settings (MINAS A7 Series specification) Use Pr0.27 and Pr0.28	11b
31 to 6	Not used	—	—

4.1.1.4.3 Parameters Changed By This Function

■ Parameters updated using estimated values for load characteristics

When Pr0.02 “Real-time auto-gain tuning setup” is 1 to 4, real-time auto tuning updates the parameters in the table below using the estimated value for load characteristics.

When Pr0.02 “Real-time auto-gain tuning setup” is 7, the parameters in the table below are updated using the estimated value for load characteristics estimates based on the contents of Pr6.32 “Real time auto tuning custom setup” .

Target parameter (*1)		Conditions for update (*2)
Pr2.45:bit 2 = 1	Pr2.45:bit 2 = 0	
Pr0.04 “Inertia ratio”		When inertia ratio update is enabled (Pr0.02 = 1 to 4, 7)
Pr2.52 “Torque command additional value 2”	Pr6.07 “Torque command additional value”	When vertical axis mode or friction compensation mode is enabled (Pr0.02 = 3, 4, 7)
Pr2.53 “Positive direction torque compensation value 2”	Pr6.08 “Positive direction torque compensation value”	When friction compensation mode is enabled (Pr0.02 = 4, 7)
Pr2.54 “Negative direction torque compensation value 2”	Pr6.09 “Negative direction torque compensation value”	When friction compensation mode is enabled (Pr0.02 = 4, 7)

Target parameter [*1]		Conditions for update [*2]
Pr2.45:bit 2 = 1	Pr2.45:bit 2 = 0	
Pr6.50 “Viscous friction compensating gain”		When viscous friction compensation mode is enabled (Pr0.02 = 4, 7)

*1 Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 2 “Friction torque compensation parameter selection” . The initial value is Pr2.45: bit 2 = 1.

*2 When Pr0.02 = 7, each parameter update can be set with Pr6.32 “Real time auto tuning custom setup” .

■ Basic gain setting parameters updated according to machine stiffness settings

Real-time auto tuning updates the basic gain setting parameters according to the parameter settings below when Pr0.02 “Real-time auto-gain tuning setup” is 1 to 4 or 7. For details, see *“4.1.1.6 Basic Gain Parameter Setup Table”* .

- Pr0.03 “Real-time auto-tuning machine stiffness setup”
- Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2”
- Pr0.28 “Selection of feed forward stiffness at real-time auto-gain tuning”

Notes

- Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.
  - Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
  - Pr2.45: bits 5 to 4 = 10b : Pr0.27
  - Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

Basic gain setting

Target parameter	Conditions for update according to stiffness [*1]
Pr1.00 “1st gain of position loop” Pr1.01 “1st velocity loop gain” Pr1.02 “1st velocity loop integration time constant” Pr1.04 “1st torque filter time constant” Pr1.05 “2nd gain of position loop” Pr1.06 “2nd velocity loop gain” Pr1.07 “2nd velocity loop integration time constant” Pr1.09 “2nd torque filter time constant”	● When stiffness setup is enabled (Pr0.02 = 1 to 4, 7)
Pr2.22 “Positional command smoothing filter”	● When stiffness setup is enabled (Pr0.02 = 1 to 4, 7) ● In speed control, the first order lag filter is fixed.
Pr2.46 “Tuning filter 2”	● Pr2.38 “Filter function switching” :bit 1 “Tuning filter 2” = 1 (enabled) When stiffness setup is enabled (Pr0.02 = 1 to 4, 7)
Pr6.48 “Tuning filter”	● Pr2.38 “Filter function switching” :bit 1 “Tuning filter 2” = 0 (disabled) When stiffness setup is enabled (Pr0.02 = 1 to 4, 7) ● In speed control, the first order lag filter is fixed.
Pr6.49 “Command response/tuning filter attenuation term”	● Set to (Pr0.02 = 1 to 4, 7) or 15 when real-time auto tuning is enabled.

*1 When Pr0.02 = 7, each parameter update can be set with Pr6.32 “Real time auto tuning custom setup” .

When Pr0.02 = 7 (Customize 2) and Pr2.74 “Tuning auto tuning application selection” = 3, any change ratio can be set for the values in the Basic Gain Parameter Settings Table.

Target parameter	Basic gain parameter setting in stiffness setup values when gain change ratio is enabled
Pr1.106 “1st position loop gain change ratio”	● Sets the change ratio for Pr1.00 “1st gain of position loop” ● When this setup value is 0, this is set to 100%.
Pr1.107 “1st velocity integration change ratio”	● Sets the change ratio for Pr1.02 “1st velocity loop integration time constant” ● When this setup value is 0, this is set to 100%.
Pr1.108 “1st torque filter change ratio”	● Sets the change ratio for Pr1.04 “1st torque filter time constant”
Pr1.109 “2nd position loop gain change ratio”	● Sets the change ratio for Pr1.05 “2nd gain of position loop” ● When this setup value is 0, this is set to 100%.
Pr1.110 “2nd velocity loop gain change ratio”	● Sets the change ratio for Pr1.06 “2nd velocity loop gain” ● When this setup value is 0, this is set to 100%.
Pr1.111 “2nd velocity integration change ratio”	● Sets the change ratio for Pr1.07 “2nd velocity loop integration time constant” ● When this setup value is 0, this is set to 100%.
Pr1.112 “2nd torque filter change ratio”	● Sets the change ratio for Pr1.09 “2nd torque filter time constant”
Pr1.113 “Load fluctuation compensation filter change ratio”	● Sets the change ratio for Pr6.24 “Load change compensation filter” ● When this setup value is 0, this is set to 100%.
Pr1.114 “Smoothing filter change ratio”	● Sets the change ratio for Pr2.22 “Positional command smoothing filter” (*1)
Pr1.115 “Tuning filter change ratio”	● Sets the change ratio for Pr6.48 “Tuning filter”

*1 The “High response modes 1 to 3” column in the Basic Gain Parameter Settings Table is used for Pr2.22 values. For details, see *“4.1.1.6 Basic Gain Parameter Setup Table”* .

■ Parameters set based on Fixed Parameter Setup

For real-time auto tuning, set the parameters in the table below in any of the following cases.

- When Pr0.02 “Real-time auto-gain tuning setup” is 1 to 4
- When Pr0.02 “Real-time auto-gain tuning setup” is 7 and Pr6.32 “Real time auto tuning custom setup” :bit 8 “Fixed Parameter Setup” is 1

Target parameter	Value to set (Pr0.02 = 1 to 4, 7) when real-time auto tuning is enabled
Pr1.03 “1st filter of velocity detection”	Set to 0
Pr1.08 “2nd filter of velocity detection”	Set to 0
Pr1.10 “Velocity feed forward gain”	Set to 1000
Pr1.11 “Velocity feed forward filter”	Set to 0
Pr1.12 “Torque feed forward gain”	Set to 1000
Pr1.13 “Torque feed forward filter”	Set to 0
Pr6.10 “Function expansion setup”	Set bit 4 “Current response improvement” to 1 (enabled)

■ Parameters set based on Gain Switching Setup

For real-time auto tuning, set the parameters in the table below in any of the following cases.

- When Pr0.02 “Real-time auto-gain tuning setup” is 1 to 4
- When Pr0.02 “Real-time auto-gain tuning setup” is 7 and Pr6.32 “Real time auto tuning custom setup” :bit 10 to 9 “Gain Switching Setup” is 1

Target parameter	Value to be set				
	Pr0.02 = 1	Pr0.02 = 2	Pr0.02 = 3	Pr0.02 = 4	Pr0.02 = 7
Pr1.14 “2nd gain setup”	Set to 1				
Pr1.15 “Mode of position control switching”	Set to 0	Set to 7			

<table>
<tr><th rowspan="2">Target parameter</th><th colspan="5">Value to be set</th></tr>
<tr><th>Pr0.02 = 1</th><th>Pr0.02 = 2</th><th>Pr0.02 = 3</th><th>Pr0.02 = 4</th><th>Pr0.02 = 7</th></tr>
<tr><td>Pr1.16 “Delay time of position control switching”</td><td colspan="5">Set to 10</td></tr>
<tr><td>Pr1.17 “Level of position control switching”</td><td colspan="5">Set to 0</td></tr>
<tr><td>Pr1.18 “Hysteresis at position control switching”</td><td colspan="5">Set to 0</td></tr>
<tr><td>Pr1.19 “Position gain switching time”</td><td colspan="5">Set to 10</td></tr>
<tr><td>Pr1.20 “Mode of velocity control switching”</td><td colspan="5">Set to 0</td></tr>
<tr><td>Pr1.21 “Delay time of velocity control switching”</td><td colspan="5">Set to 0</td></tr>
<tr><td>Pr1.22 “Level of velocity control switching”</td><td colspan="5">Set to 0</td></tr>
<tr><td>Pr1.23 “Hysteresis at velocity control switching”</td><td colspan="5">Set to 0</td></tr>
<tr><td>Pr1.24 “Mode of torque control switching”</td><td colspan="5">Set to 0</td></tr>
<tr><td>Pr1.25 “Delay time of torque control switching”</td><td colspan="5">Set to 0</td></tr>
<tr><td>Pr1.26 “Level of torque control switching”</td><td colspan="5">Set to 0</td></tr>
<tr><td>Pr1.27 “Hysteresis at torque control switching”</td><td colspan="5">Set to 0</td></tr>
<tr><td>Pr6.05 “Position 3rd gain valid time”</td><td colspan="2">Set to 0 (disabled)</td><td colspan="3">Set to “Pr2.22 × 20”
(However, the maximum value is limited to 10000.)</td></tr>
<tr><td>Pr6.06 “Position 3rd gain scale factor”</td><td colspan="2">Set to 100 (100%)</td><td colspan="3">Set to 200 (200%)</td></tr>
</table>

■ Parameters set based on Load fluctuation suppression function automatic tuning

When Pr0.02 “Real-time auto-gain tuning setup” is between 1 to 4 or 7, set the following parameters according to Pr6.10 “Function expansion setup” :bit 14 “Load fluctuation suppression function automatic tuning” .

<table>
<tr><th rowspan="2">Target parameter</th><th rowspan="2">Condition</th><th colspan="2">Value to be set</th></tr>
<tr><th>Pr6.10:bit 14 = 1</th><th>Pr6.10:bit 14 = 0</th></tr>
<tr><td>Pr6.10 “Function expansion setup”</td><td>When stiffness setup is enabled</td><td>bit 1 “Load fluctuation control function” = 1 (enabled)</td><td>bit 1 “Load fluctuation control function” = 0 (disabled)</td></tr>
<tr><td>Pr6.23 “Load change compensation gain”</td><td>When stiffness setup is enabled</td><td>Set to 90 (90%)</td><td>Set to 0</td></tr>
<tr><td>Pr6.24 “Load change compensation filter”</td><td>When stiffness setup is enabled</td><td>Updates to set value according to stiffness</td><td>Retain value</td></tr>
<tr><td rowspan="2">Pr6.73 “Load estimation filter”</td><td>When stiffness setup is enabled and Pr2.45 “Function expansion setup 10” :bit 3 = 0</td><td>Set to 13</td><td>Set to 0</td></tr>
<tr><td>When stiffness setup is enabled and Pr2.45 “Function expansion setup 10” :bit 3 = 1</td><td colspan="2">Set automatically</td></tr>
<tr><td>Pr6.74 “Torque compensation frequency 1”</td><td colspan="3">Set to 0 regardless of the value of Pr6.10:bit 14.</td></tr>
<tr><td>Pr6.75 “Torque compensation frequency 2”</td><td colspan="3">Set to 0 regardless of the value of Pr6.10:bit 14.</td></tr>
<tr><td rowspan="2">Pr6.76 “Load estimation count”</td><td>When stiffness setup is enabled and Pr2.45 “Function expansion setup 10” :bit 3 = 0</td><td>Set to 4</td><td>Set to 0</td></tr>
<tr><td>When stiffness setup is enabled and Pr2.45 “Function expansion setup 10” :bit 3 = 1</td><td colspan="2">Automatically set according to stiffness</td></tr>
</table>

4.1.1.5 How to Use

- When Pr0.02 “Real-time auto-gain tuning setup” is set to 1 to 4 or 7, real-time auto tuning is enabled. The parameter values used for tuning are automatically set according to the parameter settings below.
  - Pr0.03 “Real-time auto-tuning machine stiffness setup”
  - Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2”
  - Pr0.28 “Selection of feed forward stiffness at real-time auto-gain tuning”
  - Pr6.10 “Function expansion setup” :bit 14 “Load fluctuation suppression function automatic tuning”
- Input the operation command after approximately 100 ms have elapsed since servo-on.
- Pr0.04 “Inertia ratio” changes when load characteristics estimation is complete. Pr2.52 “Torque command additional value 2” , Pr2.53 “Positive direction torque compensation value 2” , and Pr2.54 “Negative direction torque compensation value 2” also change depending on the mode setting (see *“Supplement”*).
- Increasing the setup values of the following parameters will increase the responsiveness of the motor. While checking the positioning settling time and vibration state, increase the setup values by increments of 1 and tune to the optimal values.
  - Pr0.03 “Real-time auto-tuning machine stiffness setup”
  - Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2”
  - Pr0.28 “Selection of feed forward stiffness at real-time auto-gain tuning”
- Setting Pr0.02 “Real-time auto-gain tuning setup” to 0 disables real-time auto tuning. Automatic estimation of Pr0.04 “Inertia ratio” stops, but the inertia ratio value at the time of estimation stopping is retained. If the value of the inertia ratio is clearly abnormal, set a reasonable value manually.

Notes

- Pr2.52, Pr2.53 and Pr2.54

  Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 2 “Friction torque compensation parameter selection” . The initial value is Pr2.45: bit 2 = 1.
  - Pr2.45: bit 2=0 : Pr6.07, Pr6.08, Pr6.09
  - Pr2.45: bit 2=1 : Pr2.52, Pr2.53, Pr2.54
- Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.
  - Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
  - Pr2.45: bits 5 to 4 = 10b : Pr0.27
  - Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

— Precautions —

- When real-time auto tuning is enabled, the response to estimated values after power-up to completion of load characteristic estimation may be faster regardless of the set value for Pr6.31 “Real time auto tuning estimation speed” .
- Immediately after power-up, there is not enough operation data effective for load characteristic estimation, meaning estimated values may be abnormal and operation instable due to disturbance, etc. Once tuning is finished, we recommended that real-time auto tuning is set to disabled (Pr0.02 “Real-time auto-gain tuning setup” = 0).
- Until load characteristic estimation results stabilize, abnormal noise or oscillation may occur.

  For example, if abnormal noise or oscillation occurs immediately after the first servo-on after activation or when the Pr0.03 “Real-time auto-tuning machine stiffness setup” set value is increased, it is not abnormal for the operation to stabilize immediately. After abnormal noise or oscillation occurs ,Pr0.04

"Inertia ratio" , Pr2.52 "Torque command additional value 2" , Pr2.53 "Positive direction torque compensation value 2" , or Pr2.54 "Negative direction torque compensation value 2" may change to extreme values. Take the following measures. The following measures should also be taken if abnormal noise or oscillation occurs frequently.

1. Lower the set value for Pr0.03 "Real-time auto-tuning machine stiffness setup" or Pr0.27 "Selection of machine stiffness at real-time auto-gain tuning 2" .
2. Set Pr0.02 "Real-time auto-gain tuning setup" to 0 to disable real-time auto tuning.
3. Set Pr0.04 "Inertia ratio" to the value calculated on the device and set Pr2.52 "Torque command additional value 2" , Pr2.53 "Positive direction torque compensation value 2" , and Pr2.54 "Negative direction torque compensation value 2" to 0 (see *"Supplement"*).
4. After setting Pr6.10 "Function expansion setup" :bit 14 = 0, set bit 1 = 0 to disable the load fluctuation control function.

- The Pr0.04 "Inertia ratio" , Pr2.52 "Torque command additional value 2" , Pr2.53 "Positive direction torque compensation value 2" , and Pr2.54 "Negative direction torque compensation value 2" (see *"Supplement"*) values, which are the results of real-time auto gain tuning, are automatically written to and saved in EEPROM every 30 minutes. When power is restored, auto tuning is performed using the saved EEPROM values as the initial values. If turning OFF the power without 30 minutes having elapsed since values were automatically saved in EEPROM, manually write the latest real-time auto gain tuning results to EEPROM before turning OFF the power.
- Since control gain is updated when the motor stops, changes to Pr0.03 "Real-time auto-tuning machine stiffness setup" , Pr0.27 "Selection of machine stiffness at real-time auto-gain tuning 2" , and Pr0.28 "Selection of feed forward stiffness at real-time auto-gain tuning" settings are not reflected if the motor does not stop (if the gain is extremely low or if a command is continuously given in one direction).

  Before changing any of the above three parameters related to stiffness setup, stop the motor once to make sure that the stiffness setup has been reflected. Depending on the stiffness setup reflected after the motor is stopped, abnormal noise or oscillation may occur.
- In torque control of two-degree-of-freedom control mode, when real-time auto tuning is enabled, torque feedforward is disabled (equivalent to Pr1.12 = 0) regardless of the Pr1.12 "Torque feed forward gain" set value. Operation continues with torque feedforward disabled until the next operation is performed.
  - Set Pr1.12 "Torque feed forward gain" to a value other than the current parameter (1000) after switching real-time auto tuning from enabled to disabled.
- The following are linked in the Set-up Support Software (PANATERM ver.7) Manual TUNING screen.
  - Feedback gain setting: Pr0.03 "Real-time auto-tuning machine stiffness setup" or Pr0.27 "Selection of machine stiffness at real-time auto-gain tuning 2"
  - FF gain setting: Pr0.28 "Selection of feed forward stiffness at real-time auto-gain tuning"

Notes

- Pr2.52, Pr2.53 and Pr2.54

  Change the parameters to be used depending on the values set in Pr2.45 "Function expansion setup 10" :bit 2 "Friction torque compensation parameter selection" . The initial value is Pr2.45: bit 2 = 1.
  - Pr2.45: bit 2=0 : Pr6.07, Pr6.08, Pr6.09
  - Pr2.45: bit 2=1 : Pr2.52, Pr2.53, Pr2.54
- Change the parameters to be used depending on the values set in Pr2.45 "Function expansion setup 10" :bit 5 to 4 "Stiffness setting resolution, individual FB/FF setting switching" . The initial value is Pr2.45: bits 5 to 4 = 11b.
  - Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03

- Pr2.45: bits 5 to 4 = 10b : Pr0.27
- Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

4.1.1.6 Basic Gain Parameter Setup Table

—: None

Stiffness (*1)		1st gain/2nd gain				Command response		Tuning filter	Load fluctuation suppression
Pr0.03 (*1)	Pr0.27 Pr0.28 (*1)	Pr1.00 Pr1.05	Pr1.01 Pr1.06	Pr1.02 Pr1.07	Pr1.04 Pr1.09 (*2)	Pr2.22		Pr6.48 (*3)	Pr6.24
		Position [0.1 s^{-1}]	Speed [0.1 Hz]	Speed integration [0.1 ms]	Torque [0.01 ms]	Time constant [0.1 ms]		Time constant [0.1 ms]	Load change compensation filter [0.01 ms]
						Standard response mode	High response modes 1 to 3		
0	0	20	15	3700	1500	1919	764	155	2500
1	1	25	20	2800	1100	1487	595	115	2500
2	2	30	25	2200	900	1214	486	94	2500
3	3	40	30	1900	800	960	384	84	2500
4	4	45	35	1600	600	838	335	64	2500
5	5	55	45	1200	500	668	267	54	2500
6	6	75	60	900	400	496	198	44	2500
7	7	95	75	700	300	394	158	34	2120
8	8	115	90	600	300	327	131	34	1770
9	9	140	110	500	200	268	107	24	1450
10	10	175	140	400	200	212	85	23	1140
—	11	250	160	350	163	170	68	19	1000
11	12	320	180	310	126	139	55	16	880
—	13	355	200	280	114	125	49	14	795
12	14	390	220	250	103	113	45	13	720
—	15	435	245	225	93	101	40	12	650
13	16	480	270	210	84	92	37	11	590
—	17	535	300	190	74	82	33	10	535
14	18	630	350	160	65	71	28	9	450
15	19	720	400	140	57	62	25	8	400
—	20	810	450	125	51	55	22	7	355
16	21	900	500	120	45	50	20	7	320
—	22	990	550	110	41	45	18	6	290
17	23	1080	600	110	38	41	17	6	270
—	24	1170	650	105	35	37	15	5	250
—	25	1260	700	100	32	35	14	5	235
18	26	1350	750	90	30	33	13	5	210
—	27	1490	825	85	27	30	12	5	190
19	28	1620	900	80	25	28	11	5	180
—	29	1850	1025	70	22	24	10	4	160

Stiffness (*1)		1st gain/2nd gain				Command response		Tuning filter	Load fluctuation suppression
Pr0.03 (*1)	Pr0.27 Pr0.28 (*1)	Pr1.00 Pr1.05	Pr1.01 Pr1.06	Pr1.02 Pr1.07	Pr1.04 Pr1.09 (*2)	Pr2.22		Pr6.48 (*3)	Pr6.24
		Position [0.1 s^{-1}]	Speed [0.1 Hz]	Speed integration [0.1 ms]	Torque [0.01 ms]	Time constant [0.1 ms]		Time constant [0.1 ms]	Load change compensation filter [0.01 ms]
						Standard response mode	High response modes 1 to 3		
20	30	2060	1150	70	20	22	9	4	140
—	31	2260	1260	65	18	20	8	4	130
21	32	2510	1400	60	16	18	7	4	110
—	33	2780	1550	55	14	16	6	3	100
22	34	3050	1700	50	13	15	6	3	90
—	35	3410	1900	45	12	13	5	3	80
23	36	3770	2100	40	11	12	5	3	80
24	37	4490	2500	40	9	10	4	3	60
25	38	5000	2800	35	8	9	4	2	60
26	39	5600	3100	30	7	8	3	2	50
27	40	6100	3400	30	7	7	3	2	50
28	41	6600	3700	25	6	7	3	2	40
29	42	7200	4000	25	6	6	2	2	40
30	43	8100	4500	20	5	6	2	2	40
31	44	9000	5000	20	5	5	2	2	40

*1 Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.

- Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
- Pr2.45: bits 5 to 4 = 10b : Pr0.27
- Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

In the initial settings, only Pr2.22 is set according to Pr0.28 in the basic gain parameter setup table.

*2 The values in the table are used only when Pr2.45 “Function expansion setup 10” :bit 1 to 0 = 0.

*3 Pr6.48 “Tuning filter” may be +1 depending on the combination of servo driver and motor. Also, Pr6.48 is not used because Pr2.38 “Filter function switching” :bit 1 “Tuning filter 2” =1 (enabled) in the initial settings. The Pr2.46 “Tuning filter 2” value is set automatically when real-time auto tuning is enabled.

4.1.2 Real-time Auto Tuning (Two-degree-of-freedom Control Mode for Synchronization Type)

4.1.2.1 Function Overview

The two-degree-of-freedom control mode for synchronization type is suitable for controlling multiple loci such as with multijoint robots, because the command response setting for each axis can be set to the same value.

Set Pr6.47 “Function expansion setup 2” :bit 0 “Two-degree-of-freedom control mode” = 1 (enabled) and bit 3 “Two-degree-of-freedom control real-time auto tuning selection” = 1 (synchronization type) to set this type.

4.1.2.2 Operation Mode

In real-time auto tuning (two-degree-of-freedom control mode for synchronization type), the operation mode can be changed according to Pr0.02 “Real-time auto-gain tuning setup” . In each operation mode, automatic inertia ratio updates, basic gain setting, dynamic friction compensation, and viscous friction compensation can be enabled or disabled. An operation mode (Pr0.02 = 6) is also available for applications where load inertia fluctuates, such as multijoint robots.

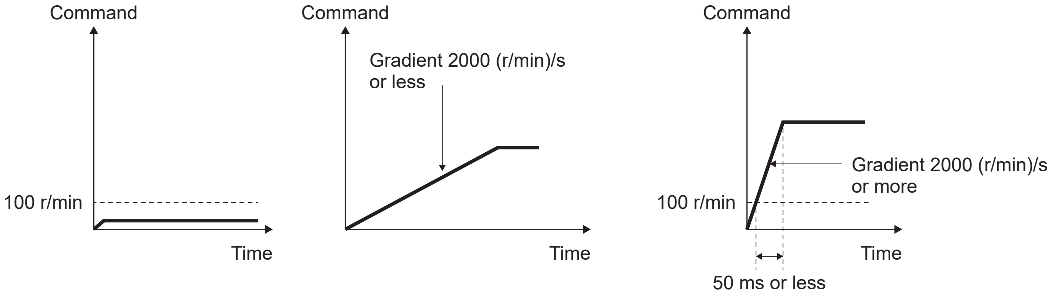
Details on Pr0.02 “Real-time auto-gain tuning setup”

Setup value	Operation mode	Description
0	Disabled	The real-time auto tuning function is disabled.
1	Synchronization	This mode is for synchronous control. The settings for unbalanced load compensation and friction compensation are not changed. The command response filter is retained. Use this mode first. If you have any issues, try a different mode.
2	Synchronous friction compensation	In addition to synchronous mode, dynamic friction compensation and viscous friction compensation are applied. Use this mode for loads with high friction.
3	Stiffness setup	Only the gain and filter settings corresponding to the stiffness table are updated without changing the settings for inertia ratio estimation, unbalanced load compensation or friction compensation. For loads with significant inertia change, use this mode after inertia ratio estimation in the synchronous mode, etc.
4	Load characteristics update	Of the load characteristics, only the inertia ratio, dynamic friction compensation and viscous friction compensation are updated. Gain and filter settings retain their current values.
5	Load characteristic measurement	The basic gain setting and friction compensation setting are not changed, only load characteristic estimation is performed. Used in combination with Set-up Support Software (PANATERM ver.7) .
6	Load fluctuation support mode	Use this mode for robust tuning against load fluctuations.
7	Disabled	The real-time auto tuning function is disabled for the two-degree-of-freedom control mode for synchronization type.

4.1.2.3 Operational Conditions

Item	Operational Conditions
Control mode	● Position control ● Pr6.47:bit 0 = 1 and bit 3 = 1 (synchronization type)

Real-time auto tuning may not work normally under the following conditions. In such cases, change the load conditions, operation pattern, or refer to the manual TUNING function description and manually set the related parameters.

Item	Conditions that obstruct the operation of real-time auto tuning
Load	● When load inertia is small or large compared to the rotor inertia of the servo motor (less than 3× or 20× or more) ● When load inertia fluctuates ● When machine stiffness is extremely low ● When non-linear characteristics exist, such as looseness due to backlash
Operation patterns	● When used continuously at low speeds of less than 100 r/min ● When acceleration and deceleration are gentle, less than 2000 r/min in 1 s ● When the speed is more than 100 r/min and the acceleration and deceleration condition of more than 2000 r/min in 1 s does not continue for more than 50 ms **Example of an operation pattern that obstructs function operation**  ● When the acceleration and deceleration torque is small compared to the unbalanced load and viscous friction torque

4.1.2.4 Related Parameters

4.1.2.4.1 Parameters That Control the Operation of This Function

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
0	02	B	Real-time auto-gain tuning setup	0 to 7	—	Sets the real-time auto tuning operation mode.
0	03	B	Real-time auto-tuning machine stiffness setup	0 to 31	—	Sets responsiveness when real-time auto tuning is enabled. Higher settings result in higher speed responsiveness and servo stiffness, but make it more likely that vibration will occur. Values should be changed from low to high with a close eye on operation. Enabled with Pr2.45 “Function expansion setup 10” : bit 5 = 0 (32 stiffness settings).
0	27	B	Selection of machine stiffness at real-time auto-gain tuning 2	0 to 44	—	Sets responsiveness when real-time auto tuning is enabled. Higher settings result in higher speed responsiveness and servo stiffness, but make it more likely that vibration will occur. Values should be changed from low to high with a close eye on operation. Allows finer gain adjustment than Pr0.03. Enabled with Pr2.45 “Function expansion setup 10” : bit 5 = 1 (45 stiffness settings).
0	28	B	Selection of feed forward stiffness at real-time auto-gain tuning	0 to 44	—	Cannot be used with two-degree-of-freedom control mode for synchronization type.

<table>
<tr><th>Class</th><th>No.</th><th>Attribute (*1)</th><th>Parameter name</th><th>Setting range</th><th>Unit</th><th>Function</th></tr>
<tr><td>2</td><td>74</td><td>A</td><td>Tuning auto tuning application selection</td><td>-32768 to 32767</td><td>—</td><td>Cannot be used with two-degree-of-freedom control mode for synchronization type.</td></tr>
<tr><td>6</td><td>10</td><td>B</td><td>Function expansion setup</td><td>-32768 to 32767</td><td>—</td><td>bit 14: Load fluctuation suppression function automatic tuning
0: Disabled
1: Enabled</td></tr>
<tr><td>6</td><td>31</td><td>B</td><td>Real time auto tuning estimation speed</td><td>0 to 3</td><td>—</td><td>Sets load characteristics estimated speed when real-time auto-tuning is enabled. Higher settings result in faster responses to changes in load characteristics, but they also increase variations in disturbance estimation.
Estimation results are saved in EEPROM every 30 minutes regardless of the load characteristic estimated speed setting.
When automatic vibration detection is enabled from Setup Support Software (PANATERM ver.7) , this setting will be ignored and the setting value will be set to 3.</td></tr>
<tr><td colspan="7">
<table>
<tr><th>Setup value</th><th>Mode</th><th>Description</th></tr>
<tr><td>0</td><td>Does not change</td><td>Stops load characteristics estimation.</td></tr>
<tr><td>1</td><td>Changes very little</td><td>Estimates changes in load characteristics in minutes.</td></tr>
<tr><td>2</td><td>Changes slowly</td><td>Estimates changes in load characteristics in seconds.</td></tr>
<tr><td>3</td><td>Changes precipitously</td><td>Fastest estimation of changes in load characteristics.</td></tr>
</table>
</td></tr>
<tr><td>6</td><td>32</td><td>B</td><td>Real time auto tuning custom setup</td><td>-32768 to 32767</td><td>—</td><td>Cannot be used with two-degree-of-freedom control mode for synchronization type.
Use with the setup value at 0.</td></tr>
</table>

*1 For attributes, see *“7.1 Object Dictionary List”* .

4.1.2.4.2 Parameters to Switch the Parameters Used by This Function to Minas A6 Series-Compatible Specification

In real-time auto tuning, the parameters used in real-time auto tuning can be switched to MINAS A6 Series-compatible specification parameters by setting Pr2.45 “Function expansion setup 10” .

- Parameters related to stiffness, unbalanced load and friction compensation and tuning filters
- Calculation method when updating torque filter time constant and some parameters for load fluctuation compensation (Pr6.73 “Load estimation filter” and Pr6.76 “Load estimation count”)

Item	Parameters for switching to MINAS A6 Series-compatible specification	Initial value (*1)
Stiffness	Can be changed with Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” .	bits 5 to 4 = 11b
Unbalanced load/friction compensation	Can be changed with Pr2.45 “Function expansion setup 10” :bit 2 “Friction torque compensation parameter selection” .	bit 2 = 1
Tuning filter	Can be changed with Pr2.38 “Filter function switching” :bit 1 “Tuning filter 2” .	bit 1 = 1
Torque filter time constant	Determined by the value of Pr2.45 “Function expansion setup 10” :bit 1 to 0 “Two-degree-of-freedom control function setting” .	bits 1 to 0 = 01b
Load fluctuation compensation	Determined by the value of Pr2.45 “Function expansion setup 10” :bit 3 “Load fluctuation suppression function automatic calculation” .	bit 3 = 1

*1 Normally used with initial values.

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	38	B	Filter function switching	-32768 to 32767	—	Select a tuning filter. Normally, set to bit 1 = 1. bit 1: Tuning filter 2 0: Use Pr6.48 “Tuning filter” (MINAS A6 Series-compatible specification) 1: Use Pr2.46 “Tuning filter 2” (MINAS A7 Series specification)
2	45	B	Function expansion setup 10	-2147483648 to 2147483647	—	Sets various functions. bit 1 to 0: Two-degree-of-freedom control function setting bit 2: Friction torque compensation parameter selection bit 3: Load fluctuation suppression function automatic calculation bit 5 to 4: Stiffness setting resolution, individual FB/FF setting switching bit 31 to 6: Unused

*1 For attributes, see *“7.1 Object Dictionary List”* .

■ Details on Pr2.45 “Function expansion setup 10”

—: N/A

bit	Name	Description	Initial value
1 to 0	Two-degree-of-freedom control function setting	00b: Two-degree-of-freedom control (MINAS A6 Series-compatible specification) 01b: Two-degree-of-freedom control (MINAS A7 Series specification) 10b: Manufacturer use 11b: Manufacturer use	01b
2	Friction torque compensation parameter selection	0: MINAS A6 Series-compatible specification settings Unbalanced load compensation value: Use Pr6.07 Dynamic friction compensation value: Use Pr6.08, Pr6.09 1: MINAS A7 Series specification settings Unbalanced load compensation value: Use Pr2.52 Dynamic friction compensation value: Use Pr2.53, Pr2.54	1
3	Load fluctuation suppression function automatic calculation	0: Conventional setting (MINAS A6 Series specification) 1: The following parameters are automatically calculated. Pr6.73 “Load estimation filter” Pr6.76 “Load estimation count”	1
5 to 4	Stiffness setting resolution, individual FB/FF setting switching	00b: 32 stiffness settings, FB/FF common setting (MINAS A6 Series-compatible specification) Use Pr0.03 01b: Same as 00b 10b: 45 stiffness settings, FB/FF common setting (MINAS A7 Series specification) Use Pr0.27 11b: 45 stiffness settings, individual FB/FF settings (MINAS A7 Series specification) Use Pr0.27 and Pr0.28	11b
31 to 6	Not used	—	—

4.1.2.4.3 Parameters Changed By This Function

■ Parameters updated using estimated values for load characteristics

Real-time auto tuning updates the parameters in the table below using the estimated value for load characteristics based on the Pr0.02 "Real-time auto-gain tuning setup" setting.

Target parameter (*1)		Conditions for update
Pr2.45:bit 2 = 1	Pr2.45:bit 2 = 0	
Pr0.04 "Inertia ratio"		When in synchronous mode (Pr0.02 = 1), synchronous friction compensation mode (Pr0.02 = 2), or load characteristics update mode (Pr0.02 = 4). However, in load fluctuation support mode (Pr0.02 = 6), the value is fixed at 100.
Pr2.52 "Torque command additional value 2"	Pr6.07 "Torque command additional value"	When in synchronous friction compensation mode (Pr0.02 = 2) or load characteristics update mode (Pr0.02 = 4)
Pr2.53 "Positive direction torque compensation value 2"	Pr6.08 "Positive direction torque compensation value"	
Pr2.54 "Negative direction torque compensation value 2"	Pr6.09 "Negative direction torque compensation value"	
Pr6.50 "Viscous friction compensating gain"		

*1 Change the parameters to be used depending on Pr2.45 "Function expansion setup 10" and bit 2 "Friction torque compensation parameter selection" set values. The initial setting is Pr2.45:bit 2 = 1.

■ Basic gain setting parameters updated according to machine stiffness settings

Real-time auto tuning updates the basic gain setting parameters according to the parameter settings below. For details, see *"4.1.2.6 Basic Gain Parameter Setup Table"* .

- Pr0.03 "Real-time auto-tuning machine stiffness setup"
- Pr0.27 "Selection of machine stiffness at real-time auto-gain tuning 2"

Notes

- Change the parameters to be used depending on the values set in Pr2.45 "Function expansion setup 10" :bit 5 to 4 "Stiffness setting resolution, individual FB/FF setting switching" . The initial value is Pr2.45: bits 5 to 4 = 11b.
  - Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
  - Pr2.45: bits 5 to 4 = 10b : Pr0.27
  - Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

  Pr0.28 is disabled.

Basic gain setting

Target parameter	Conditions for update according to stiffness
Pr1.00 "1st gain of position loop" Pr1.01 "1st velocity loop gain" Pr1.02 "1st velocity loop integration time constant" Pr1.04 "1st torque filter time constant" Pr1.05 "2nd gain of position loop" Pr1.06 "2nd velocity loop gain" Pr1.07 "2nd velocity loop integration time constant" Pr1.09 "2nd torque filter time constant"	● When in synchronous mode, synchronous friction compensation mode, stiffness setting mode, or load fluctuation support mode (Pr0.02 = 1 to 3, or 6)

Target parameter	Conditions for update according to stiffness
Pr2.46 “Tuning filter 2”	● Pr2.38 “Filter function switching” :bit 1 “Tuning filter 2” = 1 (enabled) When in synchronous mode, synchronous friction compensation mode, stiffness setting mode, or load fluctuation support mode (Pr0.02 = 1 to 3, or 6)
Pr6.48 “Tuning filter”	● Pr2.38 “Filter function switching” :bit 1 “Tuning filter 2” = 0 (disabled) When in synchronous mode, synchronous friction compensation mode, stiffness setting mode, or load fluctuation support mode (Pr0.02 = 1 to 3, or 6)
Pr6.49 “Command response/tuning filter attenuation term”	● Set the tens place to 1 and keep the ones place unchanged when in synchronous mode, synchronous friction compensation mode, stiffness setting mode, or load fluctuation support mode (Pr0.02 = 1 to 3, or 6).

■ Parameters set according to Pr0.02 “Real-time auto-gain tuning setup” settings

Real-time auto tuning sets the following parameters according to the Pr0.02 “Real-time auto-gain tuning setup” settings.

Target parameter	Values to set when in synchronous mode, synchronous friction compensation mode, stiffness setting mode, or load fluctuation support mode (Pr0.02 = 1 to 3, or 6)
Pr1.03 “1st filter of velocity detection”	Set to 0
Pr1.08 “2nd filter of velocity detection”	Set to 0
Pr1.10 “Velocity feed forward gain”	Set to 1000 (100%)
Pr1.11 “Velocity feed forward filter”	Set to 0 (disabled)
Pr1.12 “Torque feed forward gain”	Set to 1000 (100%)
Pr1.13 “Torque feed forward filter”	Set to 0 (disabled)
Pr1.14 “2nd gain setup”	Set to 1
Pr1.15 “Mode of position control switching”	Set to 0
Pr1.16 “Delay time of position control switching”	Set to 10 (1.0 ms).
Pr1.17 “Level of position control switching”	Set to 0
Pr1.18 “Hysteresis at position control switching”	Set to 0
Pr1.19 “Position gain switching time”	Set to 10 (1.0 ms).
Pr1.20 “Mode of velocity control switching”	Set to 0
Pr1.21 “Delay time of velocity control switching”	Set to 0
Pr1.22 “Level of velocity control switching”	Set to 0
Pr1.23 “Hysteresis at velocity control switching”	Set to 0
Pr1.24 “Mode of torque control switching”	Set to 0
Pr1.25 “Delay time of torque control switching”	Set to 0
Pr1.26 “Level of torque control switching”	Set to 0
Pr1.27 “Hysteresis at torque control switching”	Set to 0
Pr6.10 “Function expansion setup”	Set bit 4 “Current response improvement” to 1 (enabled)

■ Parameters set based on Load fluctuation suppression function automatic tuning

When Pr0.02 “Real-time auto-gain tuning setup” is 1 to 4, set the following parameters according to Pr6.10 “Function expansion setup” :bit 14 “Load fluctuation suppression function automatic tuning” .

Target parameter	Condition	Value to be set	
		Pr6.10:bit 14 = 1	Pr6.10:bit 14 = 0
Pr6.10 "Function expansion setup"	When stiffness setup is enabled	bit 1 "Load fluctuation control function" = 1 (enabled)	bit 1 "Load fluctuation control function" = 0 (disabled)
Pr6.23 "Load change compensation gain"	When stiffness setup is enabled	Set to 90 (90%)	Set to 0
Pr6.24 "Load change compensation filter"	When stiffness setup is enabled	Updates to set value according to stiffness	Retain value
Pr6.73 "Load estimation filter"	When stiffness setup is enabled and Pr2.45 "Function expansion setup 10" :bit 3 = 0	Set to 13	Set to 0
	When stiffness setup is enabled and Pr2.45 "Function expansion setup 10" :bit 3 = 1	Set automatically	
Pr6.74 "Torque compensation frequency 1"	Set to 0 regardless of the value of Pr6.10:bit 14.		
Pr6.75 "Torque compensation frequency 2"	Set to 0 regardless of the value of Pr6.10:bit 14.		
Pr6.76 "Load estimation count"	When stiffness setup is enabled and Pr2.45 "Function expansion setup 10" :bit 3 = 0	Set to 4	Set to 0
	When stiffness setup is enabled and Pr2.45 "Function expansion setup 10" :bit 3 = 1	Automatically set according to stiffness	

When Pr0.02 "Real-time auto-gain tuning setup" is set to 6 (load fluctuation support mode), the settings change to those shown in the table below.

Target parameter	Value to be set
Pr6.10 "Function expansion setup"	The load fluctuation control function is always enabled (bit 1 = 1, bit 2 = 1)
Pr6.23 "Load change compensation gain"	Set to 100%
Pr6.24 "Load change compensation filter"	Updates to set value according to stiffness
Pr6.73 "Load estimation filter"	Set to 13 (0.13 ms).
Pr6.74 "Torque compensation frequency 1"	Updates to set value according to stiffness
Pr6.75 "Torque compensation frequency 2"	Updates to set value according to stiffness
Pr6.76 "Load estimation count"	Set to 4

4.1.2.5 How to Use

- When Pr0.02 "Real-time auto-gain tuning setup" is set to 1 to 3 or 6, real-time auto tuning is enabled. The parameter values used for tuning are automatically set according to the parameter settings below.
  - Pr0.03 "Real-time auto-tuning machine stiffness setup"
  - Pr0.27 "Selection of machine stiffness at real-time auto-gain tuning 2"
  - Pr6.10 "Function expansion setup" :bit 14 "Load fluctuation suppression function automatic tuning"
- Input the operation command after approximately 100 ms have elapsed since servo-on.
- Pr0.04 "Inertia ratio" changes when load characteristics estimation is complete. Pr2.52 "Torque command additional value 2" , Pr2.53 "Positive direction torque compensation value 2" , and Pr2.54 "Negative direction torque compensation value 2" also change depending on the mode setting (see *"Supplement"*).
- Increasing the set value of either of the following parameters will increase motor responsiveness. While checking the positioning settling time and vibration state, increase the setup values by increments of 1 and tune to the optimal values.
  - Pr0.03 "Real-time auto-tuning machine stiffness setup"

  - Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2”
- Setting Pr0.02 “Real-time auto-gain tuning setup” to 0 disables real-time auto tuning. Automatic estimation of Pr0.04 “Inertia ratio” stops, but the inertia ratio value at the time of estimation stopping is retained. If the value of the inertia ratio is clearly abnormal, set a reasonable value manually.

Notes

- Pr2.52, Pr2.53 and Pr2.54

  Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 2 “Friction torque compensation parameter selection” . The initial value is Pr2.45: bit 2 = 1.
  - Pr2.45: bit 2=0 : Pr6.07, Pr6.08, Pr6.09
  - Pr2.45: bit 2=1 : Pr2.52, Pr2.53, Pr2.54
- Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.
  - Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
  - Pr2.45: bits 5 to 4 = 10b : Pr0.27
  - Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

  Pr0.28 is disabled.

— Precautions —

- When real-time auto tuning is enabled, the response to estimated values after power-up to completion of load characteristic estimation may be faster regardless of the set value for Pr6.31 “Real time auto tuning estimation speed” .
- Immediately after power-up, there is not enough operation data effective for load characteristic estimation, meaning estimated values may be abnormal and operation instable due to disturbance, etc. Once tuning is finished, we recommended that real-time auto tuning is set to disabled (Pr0.02 “Real-time auto-gain tuning setup” = 0).
- Until load characteristic estimation results stabilize, abnormal noise or oscillation may occur.

  For example, if abnormal noise or oscillation occurs immediately after the first servo-on after activation or when the Pr0.03 “Real-time auto-tuning machine stiffness setup” set value is increased, it is not abnormal for the operation to stabilize immediately. After abnormal noise or oscillation occurs ,Pr0.04 “Inertia ratio” , Pr2.52 “Torque command additional value 2” , Pr2.53 “Positive direction torque compensation value 2” , or Pr2.54 “Negative direction torque compensation value 2” may change to extreme values. Take the following measures. The following measures should also be taken if abnormal noise or oscillation occurs frequently.

  1. Lower the set value for Pr0.03 “Real-time auto-tuning machine stiffness setup” or Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2” .
  2. Set Pr0.02 “Real-time auto-gain tuning setup” to 0 to disable real-time auto tuning.
  3. Set Pr0.04 “Inertia ratio” to the value calculated on the device and set Pr2.52 “Torque command additional value 2” , Pr2.53 “Positive direction torque compensation value 2” , and Pr2.54 “Negative direction torque compensation value 2” to 0 (see *“Supplement”*).
  4. After setting Pr6.10 “Function expansion setup” :bit 14 = 0, set bit 1 = 0 to disable the load fluctuation control function.
- The Pr0.04 “Inertia ratio” , Pr2.52 “Torque command additional value 2” , Pr2.53 “Positive direction torque compensation value 2” , and Pr2.54 “Negative direction torque compensation value 2” (see *“Supplement”*) values, which are the results of real-time auto gain tuning, are automatically written to and saved in EEPROM every 30 minutes. When power is restored, auto tuning is performed using the saved EEPROM values as the initial values. If turning OFF the power without 30 minutes having

elapsed since values were automatically saved in EEPROM, manually write the latest real-time auto gain tuning results to EEPROM before turning OFF the power.

- Since control gain is updated when the motor stops, changes to Pr0.03 “Real-time auto-tuning machine stiffness setup” or Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2” settings are not reflected if the motor does not stop (if the gain is extremely low or if a command is continuously given in one direction).

  Before changing any of the above parameters related to stiffness setup, stop the motor once to make sure that the stiffness setup has been reflected. Depending on the stiffness setup reflected after the motor is stopped, abnormal noise or oscillation may occur.
- In torque control of two-degree-of-freedom control mode, when real-time auto tuning is enabled, torque feedforward is disabled (equivalent to Pr1.12 = 0) regardless of the Pr1.12 “Torque feed forward gain” set value. Operation continues with torque feedforward disabled until the next operation is performed.
  - Set Pr1.12 “Torque feed forward gain” to a value other than the current parameter (1000) after switching real-time auto tuning from enabled to disabled.
- The following are linked in the Set-up Support Software (PANATERM ver.7) Manual TUNING screen.
  - Feedback gain setting: Pr0.03 “Real-time auto-tuning machine stiffness setup” or Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2”

Notes

- Pr2.52, Pr2.53 and Pr2.54

  Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 2 “Friction torque compensation parameter selection” . The initial value is Pr2.45: bit 2 = 1.
  - Pr2.45: bit 2=0 : Pr6.07, Pr6.08, Pr6.09
  - Pr2.45: bit 2=1 : Pr2.52, Pr2.53, Pr2.54
- Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.
  - Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
  - Pr2.45: bits 5 to 4 = 10b : Pr0.27
  - Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

  Pr0.28 is disabled.

4.1.2.6 Basic Gain Parameter Setup Table

—: None

Stiffness		1st gain/2nd gain				Tuning filter	For load fluctuation control function	Only in load fluctuation support mode (Pr0.02 = 6)			
Pr0.03 (*1)	Pr0.27 (*1)	Pr1.00 Pr1.05	Pr1.01 Pr1.06	Pr1.02 Pr1.07	Pr1.04 Pr1.09 (*2)	Pr6.48 (*3)	Pr6.24	Pr1.00 Pr1.05	Pr6.24	Pr6.74	Pr6.75
		Position [0.1 s^{-1}]	Speed [0.1 Hz]	Speed integration [0.1 ms]	Torque [0.01 ms]	Time constant [0.1 ms]	Load change compensation filter [0.01 ms]	Load fluctuation position loop gain [0.1 s^{-1}]	Load change compensation filter [0.01 ms]	Torque compensation frequency L [0.1 Hz]	Torque compensation frequency H [0.1 Hz]
0	0	20	15	3700	1500	155	2500	15	1330	25	10
1	1	25	20	2800	1100	115	2500	20	990	34	10
2	2	30	25	2200	900	94	2500	25	800	42	12
3	3	40	30	1900	800	84	2500	30	660	51	15
4	4	45	35	1600	600	64	2500	35	570	59	17
5	5	55	45	1200	500	54	2500	45	440	76	22
6	6	75	60	900	400	44	2500	60	330	104	30
7	7	95	75	700	300	34	2120	75	270	129	37
8	8	115	90	600	300	34	1770	90	220	153	44
9	9	140	110	500	200	24	1450	110	180	184	53
10	10	175	140	400	200	23	1140	140	140	231	66
—	11	250	160	350	163	19	1000	160	120	264	75
11	12	320	180	310	126	16	880	180	110	290	83
—	13	355	200	280	114	14	795	200	100	322	92
12	14	390	220	250	103	13	720	220	90	346	99
—	15	435	245	225	93	12	650	245	80	385	110
13	16	480	270	210	84	11	590	270	70	413	118
—	17	535	300	190	74	10	535	300	65	458	131
14	18	630	350	160	65	9	450	350	60	512	146
15	19	720	400	140	57	8	400	400	50	570	163
—	20	810	450	125	51	7	355	450	45	641	183
16	21	900	500	120	45	7	320	500	40	678	194
—	22	990	550	110	41	6	290	550	40	678	194
17	23	1080	600	110	38	6	270	600	40	678	194
—	24	1170	650	105	35	5	250	650	40	678	194
—	25	1260	700	100	32	5	235	700	40	678	194
18	26	1350	750	90	30	5	210	750	40	678	194
—	27	1490	825	85	27	5	190	825	40	678	194
19	28	1620	900	80	25	5	180	900	40	678	194
—	29	1850	1025	70	22	4	160	1025	40	678	194
20	30	2060	1150	70	20	4	140	1150	40	678	194

Stiffness		1st gain/2nd gain				Tuning filter	For load fluctuation control function	Only in load fluctuation support mode (Pr0.02 = 6)			
Pr0.03 (*1)	Pr0.27 (*1)	Pr1.00 Pr1.05	Pr1.01 Pr1.06	Pr1.02 Pr1.07	Pr1.04 Pr1.09 (*2)	Pr6.48 (*3)	Pr6.24	Pr1.00 Pr1.05	Pr6.24	Pr6.74	Pr6.75
		Position [0.1 s^{-1}]	Speed [0.1 Hz]	Speed integration [0.1 ms]	Torque [0.01 ms]	Time constant [0.1 ms]	Load change compensation filter [0.01 ms]	Load fluctuation position loop gain [0.1 s^{-1}]	Load change compensation filter [0.01 ms]	Torque compensation frequency L [0.1 Hz]	Torque compensation frequency H [0.1 Hz]
—	31	2260	1260	65	18	4	130	1260	40	678	194
21	32	2510	1400	60	16	4	110	1400	40	678	194
—	33	2780	1550	55	14	3	100	1550	40	678	194
22	34	3050	1700	50	13	3	90	1700	40	678	194
—	35	3410	1900	45	12	3	80	1900	40	678	194
23	36	3770	2100	40	11	3	80	2100	40	678	194
24	37	4490	2500	40	9	3	60	2500	40	678	194
25	38	5000	2800	35	8	2	60	2800	40	678	194
26	39	5600	3100	30	7	2	50	3100	40	678	194
27	40	6100	3400	30	7	2	50	3400	40	678	194
28	41	6600	3700	25	6	2	40	3700	40	678	194
29	42	7200	4000	25	6	2	40	4000	40	678	194
30	43	8100	4500	20	5	2	40	4500	40	678	194
31	44	9000	5000	20	5	2	40	5000	40	678	194

*1 Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.

- Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
- Pr2.45: bits 5 to 4 = 10b : Pr0.27
- Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

Pr0.28 is disabled for synchronization type.

*2 The values in the table are used only when Pr2.45 “Function expansion setup 10” :bit 1 to 0 = 0.

*3 Pr6.48 “Tuning filter” may be +1 depending on the combination of servo driver and motor. Also, Pr6.48 is not used because Pr2.38 “Filter function switching” :bit 1 “Tuning filter 2” =1 (enabled) in the initial settings. The Pr2.46 “Tuning filter 2” value is set automatically when real-time auto tuning is enabled.

4.1.3 Real-time Auto Tuning (Two-degree-of-freedom Control Mode Disabled Type)

4.1.3.1 Function Overview

This is a type of real-time auto tuning function without two-degree-of-freedom control. Set Pr6.47 “Function expansion setup 2” :bit 0 “Two-degree-of-freedom control mode” = 0 (disabled) to set this type.

4.1.3.2 Operation Mode

In real-time auto tuning (two-degree-of-freedom control mode disabled type), the operation mode can be changed according to Pr0.02 “Real-time auto-gain tuning setup” . In each operation mode, automatic inertia ratio updates, basic gain setting, unbalanced load compensation, and friction compensation can be enabled or disabled. Also, when Pr0.02 = 7, automatic inertia ratio updates, basic gain setting, unbalanced load compensation, and friction compensation can be enabled or disabled individually. Select Pr0.02 = 7 (set value 7) to optimize each function according to device characteristics.

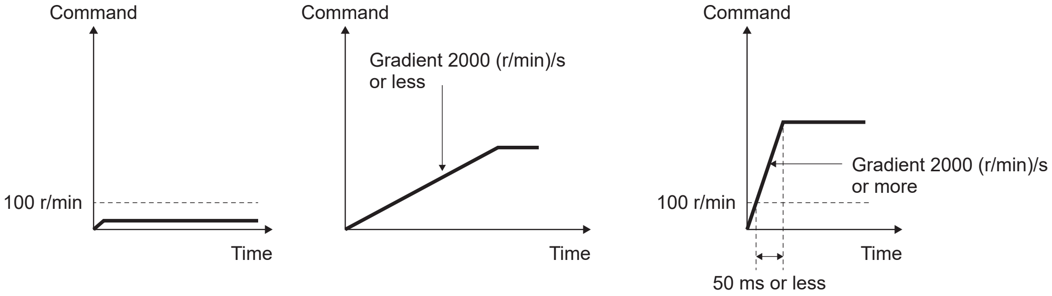
Details on Pr0.02 “Real-time auto-gain tuning setup”

Setup value	Operation mode	Description
0	Disabled	The real-time auto tuning function is disabled.
1	Standard	This is a mode with an emphasis on stability. Unbalanced load compensation and friction compensation are not performed, and gain switching is not used.
2	Positioning	This is a positioning-focused mode. Use for devices such as low-friction ball screw driven devices that do not have unbalanced load on the horizontal axis. In terms of speed control and torque control, this mode is the same as standard mode.
3	Vertical axis	In addition to positioning mode, this mode suppresses variation in positioning settling time using unbalanced load compensation, such as a vertical axis. In terms of torque control, this mode is the same as standard mode.
4	Friction compensation	In addition to the vertical axis mode, this mode shortens the positioning settling time with a belt mechanical shaft with high friction, etc. In terms of speed control, this mode is the same as vertical axis mode. In terms of torque control, this mode is the same as standard mode.
5	Load characteristic measurement	The basic gain setting and friction compensation setting are not changed, only load characteristic estimation is performed. Used in combination with Set-up Support Software (PANATERM ver.7) .
6	Customize 1	Although two-degree-of-freedom control mode disabled type has the same function as Customize 2 (Pr0.02 = 7), the change ratio cannot be set for the basic gain setting.
7	Customize 2	The combination of real-time auto tuning functions can be customized for each application by configuring advanced settings in Pr6.32 “Real time auto tuning custom setup” . A change ratio can be set for the basic gain setting. Some functions are not available depending on the control mode. See *“Details on Pr6.32 “Real time auto tuning custom setup” ”* .

4.1.3.3 Operational Conditions

Item	Operational Conditions
Control mode	● Position control, speed control, and full-closed control ● Pr6.47:bit 0 = 0 (disabled)

Real-time auto tuning may not work normally under the following conditions. In such cases, change the load conditions, operation pattern, or refer to the manual TUNING function description and manually set the related parameters.

Item	Conditions that obstruct the operation of real-time auto tuning
Load	● When load inertia is small or large compared to the rotor inertia of the servo motor (less than 3× or 20× or more) ● When load inertia fluctuates ● When machine stiffness is extremely low ● When non-linear characteristics exist, such as looseness due to backlash
Operation patterns	● When used continuously at low speeds of less than 100 r/min ● When acceleration and deceleration are gentle, less than 2000 r/min in 1 s ● When the speed is more than 100 r/min and the acceleration and deceleration condition of more than 2000 r/min in 1 s does not continue for more than 50 ms **Example of an operation pattern that obstructs function operation**  ● When the acceleration and deceleration torque is small compared to the unbalanced load and viscous friction torque

4.1.3.4 Related Parameters

4.1.3.4.1 Parameters That Control the Operation of This Function

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
0	02	B	Real-time auto-gain tuning setup	0 to 7	—	Sets the real-time auto tuning operation mode.
0	03	B	Real-time auto-tuning machine stiffness setup	0 to 31	—	Sets responsiveness when real-time auto tuning is enabled. Higher settings result in higher speed responsiveness and servo stiffness, but make it more likely that vibration will occur. Values should be changed from low to high with a close eye on operation. Enabled with Pr2.45 “Function expansion setup 10” : bit 5 = 0 (32 stiffness settings).
0	27	B	Selection of machine stiffness at real-time auto-gain tuning 2	0 to 44	—	Sets responsiveness when real-time auto tuning is enabled. Higher settings result in higher speed responsiveness and servo stiffness, but make it more likely that vibration will occur. Values should be changed from low to high with a close eye on operation. Allows finer gain adjustment than Pr0.03. Enabled with Pr2.45 “Function expansion setup 10” : bit 5 = 1 (45 stiffness settings).
0	28	B	Selection of feed forward stiffness at real-time auto-gain tuning	0 to 44	—	Cannot be used when two-degree-of-freedom control mode is disabled.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	74	A	Tuning auto tuning application selection	-32768 to 32767	—	For Pr0.02 = 7 (Customize 2), any change ratio can be set for the basic gain setting to fit the application when the set value = 3. 0: Positioning 3: Customize
6	10	B	Function expansion setup	-32768 to 32767	—	bit 14: Load fluctuation suppression function automatic tuning 0: Disabled 1: Enabled
6	31	B	Real time auto tuning estimation speed	0 to 3	—	Sets load characteristics estimated speed when real-time auto-tuning is enabled. Higher settings result in faster responses to changes in load characteristics, but they also increase variations in disturbance estimation. Estimation results are saved in EEPROM every 30 minutes regardless of the load characteristic estimated speed setting. When automatic vibration detection is enabled from Setup Support Software (PANATERM ver.7) , this setting will be ignored and the setting value will be set to 3.

Setup value	Mode	Description
0	Does not change	Stops load characteristics estimation.
1	Changes very little	Estimates changes in load characteristics in minutes.
2	Changes slowly	Estimates changes in load characteristics in seconds.
3	Changes precipitously	Fastest estimation of changes in load characteristics.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	32	B	Real time auto tuning custom setup	-32768 to 32767	—	Makes advanced settings for the automatic adjustment function when the Pr0.02 = 7 (Customize 2) is selected as an operation mode for real-time auto tuning.

*1 For attributes, see *“7.1 Object Dictionary List”* .

■ Details on Pr6.32 “Real time auto tuning custom setup”

bit	Mode	Description
1 to 0	Load characteristics estimation	Set to enable or disable the load characteristics estimation function. 0: Disabled 1: Enabled **— Precautions —** ● When this setting is disabled, the target parameters are not updated from the current settings even if bit 3 to 2 “Inertia Ratio Update” , bit 6 to 4 “Torque compensation” , and bit 15 to 12 “Individual torque compensation settings” are set to enable updates. ● To enable load characteristic estimation, set Pr6.31 “Real time auto tuning estimation speed” to a value other than 0 (no change).
3 to 2	Inertia ratio update	Set updates in load characteristic estimation results for Pr0.04 “Inertia ratio” . 0: Disabled 1: Enabled **— Precautions —** ● To enable inertia ratio updates, set bit 1 to 0 “Load characteristics estimation” to 1 (enabled). If both are not enabled, the inertia ratio will not be updated.

<table>
<tr><th>bit</th><th>Mode</th><th>Description</th></tr>
<tr><td>6 to 4</td><td>Torque compensation (*1)</td><td>Set updates in load characteristic estimation results for Pr2.52 “Torque command additional value 2” , Pr2.53 “Positive direction torque compensation value 2” , Pr2.54 “Negative direction torque compensation value 2” and Pr6.50 “Viscous friction compensating gain” .
<table>
<tr><th>Setup value</th><th>Mode</th><th>Description</th></tr>
<tr><td>0</td><td>Use current settings</td><td>Uses current settings.</td></tr>
<tr><td>1</td><td>Disable torque compensation</td><td>Clear Pr2.52, Pr2.53, Pr2.54, and Pr6.50 to 0.</td></tr>
<tr><td>2</td><td>Vertical axis mode</td><td>Update Pr2.52 and clear Pr2.53, Pr2.54 and Pr6.50 to 0.</td></tr>
<tr><td>3</td><td>Friction compensation (weak)</td><td>Update Pr2.52 and set weak compensation for Pr2.53, Pr2.54, and Pr6.50.</td></tr>
<tr><td>4</td><td>Friction compensation (medium)</td><td>Update Pr2.52 and set medium compensation for Pr2.53, Pr2.54, and Pr6.50.</td></tr>
<tr><td>5</td><td>Friction compensation (strong)</td><td>Update Pr2.52 and set strong compensation for Pr2.53, Pr2.54 and Pr6.50.</td></tr>
</table>
— Precautions —
● Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 2 “Friction torque compensation parameter selection” . The initial value is Pr2.45: bit 2 = 1.
• Pr2.45: bit 2=0 : Pr6.07, Pr6.08, Pr6.09
• Pr2.45: bit 2=1 : Pr2.52, Pr2.53, Pr2.54</td></tr>
<tr><td>7</td><td>Stiffness setup (*2)</td><td>Set to enable or disable the basic gain setting using Pr0.03 “Real-time auto-tuning machine stiffness setup” , Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2” or Pr0.28 “Selection of feed forward stiffness at real-time auto-gain tuning” .
0: Disabled
1: Enabled
— Precautions —
● Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.
• Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
• Pr2.45: bits 5 to 4 = 10b : Pr0.27
• Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28
Pr0.28 is disabled.</td></tr>
<tr><td>8</td><td>Fixed parameter setup (*2)</td><td>Set whether or not to change parameters that become fixed values when real-time auto tuning is enabled.
For details, see the table <i>“Values Set When Real-Time Auto Tuning is Enabled (Pr0.02 = 1 to 4, 6, 7)”</i> in <i>“4.1.3.4.3 Parameters Changed By This Function”</i> .
0: Use current settings
1: Set to fixed values</td></tr>
<tr><td>10 to 9</td><td>Gain switching setup (*2)</td><td>Select the method for setting parameters related to gain switching when real-time auto tuning is enabled.
0: Use current settings
1: Gain switching disabled
2: Gain switching enabled</td></tr>
<tr><td>11</td><td>Torque compensation setting switching</td><td>Select whether to enable bits 6 to 4 or bits 15 to 12 for torque compensation.
0: Enable bits 6 to 4
1: Enable bits 15 to 12</td></tr>
</table>

<table>
<tr><th>bit</th><th>Mode</th><th>Description</th></tr>
<tr><td>15 to 12</td><td>Individual torque compensation settings [*1]</td><td>Select whether to use or update the current setting for the corresponding parameters when bit 11 “Torque compensation setting switching” = 1.
0: Use current settings
1: Update
<table>
<tr><th></th><th>bit 15</th><th>bit 14</th><th>bit 13</th><th>bit 12</th></tr>
<tr><td>When Pr2.45:bit 2 = 1</td><td>Pr6.50</td><td>Pr2.54</td><td>Pr2.53</td><td>Pr2.52</td></tr>
<tr><td>When Pr2.45:bit 2 = 0</td><td>Pr6.50</td><td>Pr6.09</td><td>Pr6.08</td><td>Pr6.07</td></tr>
</table>
</td></tr>
</table>

*1 To set to enable updates to torque compensation, set bit 1 to 0 “Load characteristics estimation” and bit 3 to 2 “Inertia Ratio Update” to 1 (enabled). Updates are not applied with update settings for torque compensation only.

*2 To set this set value to a value other than 0, set bit 3 to 2 “Inertia Ratio Update” to 1 (enabled). Whether or not inertia ratio update is enabled at this time can be set with bit 1 to 0 “Load characteristics estimation” .

— Precautions —

- These parameters must be set in bit units. Operation cannot be guaranteed with incorrect settings. Using Set-up Support Software (PANATERM ver.7) is recommended for changing parameter setup values.
- Do not change these parameters during motor operation. Actually updating of parameters takes place when the motor stops after the load characteristic measurement results are confirmed.

Notes

- Calculating Pr6.32 set value from values in bit units

  When configuring each setting to a value other than 0, use the following procedure to calculate the set value for Pr6.32.

  1 Confirm the least significant bit for each setting.

  (Example) The least significant bit of the torque compensation function is 4

  2 Multiply 2 to the power of (LSB) by the set value.

  (Example) If bit 6 to 4 “Torque compensation” = 3 (friction compensation (weak)), then $2^4 \times 3$.

  3 For each setting, calculate “1” and “2” and then add them all together to obtain the set value for Pr6.32.

  (Example) When load characteristic measurement = enabled, inertia ratio update = enabled, torque compensation = friction compensation (weak), stiffness setting = enabled, fixed parameters = set to fixed values, gain switching setup = enabled

  $2^0\times1 + 2^2\times1 + 2^4\times3 + 2^7\times1 + 2^8\times1 + 2^9\times2 = 1461$

4.1.3.4.2 Parameters to Switch the Parameters Used by This Function to Minas A6 Series-Compatible Specification

In real-time auto tuning, the parameters used in real-time auto tuning can be switched to MINAS A6 Series-compatible specification parameters by setting Pr2.45 “Function expansion setup 10” .

- Parameters related to stiffness, unbalanced load and friction compensation and tuning filters
- Calculation method when updating torque filter time constant and some parameters for load fluctuation compensation (Pr6.73 “Load estimation filter” and Pr6.76 “Load estimation count”)

Item	Parameters for switching to MINAS A6 Series-compatible specification	Initial value [*1]
Stiffness	Can be changed with Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” .	bits 5 to 4 = 11b

Item	Parameters for switching to MINAS A6 Series-compatible specification	Initial value (*1)
Unbalanced load/friction compensation	Can be changed with Pr2.45 “Function expansion setup 10” :bit 2 “Friction torque compensation parameter selection” .	bit 2 = 1
Tuning filter	Can be changed with Pr2.38 “Filter function switching” :bit 1 “Tuning filter 2” .	bit 1 = 1
Torque filter time constant	Determined by the value of Pr2.45 “Function expansion setup 10” :bit 1 to 0 “Two-degree-of-freedom control function setting” .	bits 1 to 0 = 01b
Load fluctuation compensation	Determined by the value of Pr2.45 “Function expansion setup 10” :bit 3 “Load fluctuation suppression function automatic calculation” .	bit 3 = 1

*1 Normally used with initial values.

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	38	B	Filter function switching	-32768 to 32767	—	Select a tuning filter. Normally, set to bit 1 = 1. bit 1: Tuning filter 2 0: Use Pr6.48 “Tuning filter” (MINAS A6 Series-compatible specification) 1: Use Pr2.46 “Tuning filter 2” (MINAS A7 Series specification)
2	45	B	Function expansion setup 10	-2147483648 to 2147483647	—	Sets various functions. bit 1 to 0: Two-degree-of-freedom control function setting bit 2: Friction torque compensation parameter selection bit 3: Load fluctuation suppression function automatic calculation bit 5 to 4: Stiffness setting resolution, individual FB/FF setting switching bit 31 to 6: Unused

*1 For attributes, see *“7.1 Object Dictionary List”* .

■ Details on Pr2.45 “Function expansion setup 10”

—: N/A

bit	Name	Description	Initial value
1 to 0	Two-degree-of-freedom control function setting	00b: Two-degree-of-freedom control (MINAS A6 Series-compatible specification) 01b: Two-degree-of-freedom control (MINAS A7 Series specification) 10b: Manufacturer use 11b: Manufacturer use	01b
2	Friction torque compensation parameter selection	0: MINAS A6 Series-compatible specification settings Unbalanced load compensation value: Use Pr6.07 Dynamic friction compensation value: Use Pr6.08, Pr6.09 1: MINAS A7 Series specification settings Unbalanced load compensation value: Use Pr2.52 Dynamic friction compensation value: Use Pr2.53, Pr2.54	1
3	Load fluctuation suppression function automatic calculation	0: Conventional setting (MINAS A6 Series specification) 1: The following parameters are automatically calculated. Pr6.73 “Load estimation filter” Pr6.76 “Load estimation count”	1

bit	Name	Description	Initial value
5 to 4	Stiffness setting resolution, individual FB/FF setting switching	00b: 32 stiffness settings, FB/FF common setting (MINAS A6 Series-compatible specification) Use Pr0.03 01b: Same as 00b 10b: 45 stiffness settings, FB/FF common setting (MINAS A7 Series specification) Use Pr0.27 11b: 45 stiffness settings, individual FB/FF settings (MINAS A7 Series specification) Use Pr0.27 and Pr0.28	11b
31 to 6	Not used	—	—

4.1.3.4.3 Parameters Changed By This Function

■ Parameters updated using estimated values for load characteristics

When Pr0.02 “Real-time auto-gain tuning setup” is 1 to 4, real-time auto tuning updates the parameters in the table below using the estimated value for load characteristics.

When Pr0.02 “Real-time auto-gain tuning setup” is 6 or 7, the parameters in the table below are updated using the estimated value for load characteristics estimates based on the contents of Pr6.32 “Real time auto tuning custom setup” .

Target parameter (*1)		Conditions for update
Pr2.45:bit 2 = 1	Pr2.45:bit 2 = 0	
Pr0.04 “Inertia ratio”		When inertia ratio update is enabled (Pr0.02 = 1 to 4, 6, 7)
Pr2.52 “Torque command additional value 2”	Pr6.07 “Torque command additional value”	When vertical axis mode or friction compensation mode is enabled (Pr0.02 = 3, 4, 6, 7)
Pr2.53 “Positive direction torque compensation value 2”	Pr6.08 “Positive direction torque compensation value”	When friction compensation mode is enabled (Pr0.02 = 4, 6, 7)
Pr2.54 “Negative direction torque compensation value 2”	Pr6.09 “Negative direction torque compensation value”	When friction compensation mode is enabled (Pr0.02 = 4, 6, 7)
Pr6.50 “Viscous friction compensating gain”		When Pr0.02 = 6, 7 (customize mode) with viscous friction compensation enabled

*1 Change the parameters to be used depending on Pr2.45 “Function expansion setup 10” and bit 2 “Friction torque compensation parameter selection” set values. The initial setting is Pr2.45:bit 2 = 1.

■ Basic gain setting parameters updated according to machine stiffness settings

Real-time auto tuning updates the basic gain setting parameters according to the parameter settings below when Pr0.02 “Real-time auto-gain tuning setup” is 1 to 4, 6, or 7. For details, see *“4.1.3.6 Basic Gain Parameter Setup Table”* .

- Pr0.03 “Real-time auto-tuning machine stiffness setup”
- Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2”

Notes

- Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.
  - Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
  - Pr2.45: bits 5 to 4 = 10b : Pr0.27
  - Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

  Pr0.28 is disabled.

Basic gain setting

Target parameter	Conditions for update according to stiffness
Pr1.00 “1st gain of position loop” Pr1.01 “1st velocity loop gain” Pr1.02 “1st velocity loop integration time constant” Pr1.04 “1st torque filter time constant” Pr1.05 “2nd gain of position loop” Pr1.06 “2nd velocity loop gain” Pr1.07 “2nd velocity loop integration time constant” Pr1.09 “2nd torque filter time constant”	● When stiffness setup is enabled (Pr0.02 = 1 to 4, 7)

When Pr0.02 = 7 (Customize 2) and Pr2.74 “Tuning auto tuning application selection” = 3, any change ratio can be set for the values in the Basic Gain Parameter Settings Table.

Target parameter	Basic gain parameter setting in stiffness setup values when gain change ratio is enabled
Pr1.106 “1st position loop gain change ratio”	● Sets the change ratio for Pr1.00 “1st gain of position loop” ● When this setup value is 0, this is set to 100 %.
Pr1.107 “1st velocity integration change ratio”	● Sets the change ratio for Pr1.02 “1st velocity loop integration time constant” ● When this setup value is 0, this is set to 100 %.
Pr1.108 “1st torque filter change ratio”	● Sets the change ratio for Pr1.04 “1st torque filter time constant”
Pr1.109 “2nd position loop gain change ratio”	● Sets the change ratio for Pr1.05 “2nd gain of position loop” ● When this setup value is 0, this is set to 100 %.
Pr1.110 “2nd velocity loop gain change ratio”	● Sets the change ratio for Pr1.06 “2nd velocity loop gain” ● When this setup value is 0, this is set to 100 %.
Pr1.111 “2nd velocity integration change ratio”	● Sets the change ratio for Pr1.07 “2nd velocity loop integration time constant” ● When this setup value is 0, this is set to 100 %.
Pr1.112 “2nd torque filter change ratio”	● Sets the change ratio for Pr1.09 “2nd torque filter time constant”
Pr1.113 “Load fluctuation compensation filter change ratio”	● Sets the change ratio for Pr6.24 “Load change compensation filter” (time constant) ● When this setup value is 0, this is set to 100 %.
Pr1.114 “Smoothing filter change ratio”	● Cannot be used with two-degree-of-freedom control mode disabled type.
Pr1.115 “Tuning filter change ratio”	● Cannot be used with two-degree-of-freedom control mode disabled type.

■ Parameters set based on Fixed Parameter Setup

For real-time auto tuning, set the parameters in the table below in any of the following cases.

- When Pr0.02 “Real-time auto-gain tuning setup” is 1 to 4
- When Pr0.02 “Real-time auto-gain tuning setup” is 6 or 7 and Pr6.32 “Real time auto tuning custom setup” :bit 8 “Fixed Parameter Setup” is 1

Target parameter	Value set to (Pr0.02 = 1 to 4, 6, 7) when real-time auto tuning is enabled
Pr1.03 “1st filter of velocity detection”	Set to 0
Pr1.08 “2nd filter of velocity detection”	Set to 0
Pr1.10 “Velocity feed forward gain”	Set to 300
Pr1.11 “Velocity feed forward filter”	Set to 50
Pr1.12 “Torque feed forward gain”	Set to 0
Pr1.13 “Torque feed forward filter”	Set to 0

■ Parameters set based on Gain Switching Setup

For real-time auto tuning, set the parameters in the table below in any of the following cases.

- When Pr0.02 “Real-time auto-gain tuning setup” is 1 to 4
- When Pr0.02 “Real-time auto-gain tuning setup” is 6 or 7 and Pr6.32 “Real time auto tuning custom setup” :bit 10 to 9 “Gain Switching Setup” is 1

Target parameter	Value to be set					
	Pr0.02 = 1	Pr0.02 = 2	Pr0.02 = 3	Pr0.02 = 4	Pr0.02 = 6	Pr0.02 = 7
Pr1.14 “2nd gain setup”	Set to 1					
Pr1.15 “Mode of position control switching”	Set to 0	Set to 10				
Pr1.16 “Delay time of position control switching”	Set to 50 (5 ms).					
Pr1.17 “Level of position control switching”	Set to 50					
Pr1.18 “Hysteresis at position control switching”	Set to 33					
Pr1.19 “Position gain switching time”	Set to 33 (3.3 ms).					
Pr1.20 “Mode of velocity control switching”	Set to 0					
Pr1.21 “Delay time of velocity control switching”	Set to 0					
Pr1.22 “Level of velocity control switching”	Set to 0					
Pr1.23 “Hysteresis at velocity control switching”	Set to 0					
Pr1.24 “Mode of torque control switching”	Set to 0					
Pr1.25 “Delay time of torque control switching”	Set to 0					
Pr1.26 “Level of torque control switching”	Set to 0					
Pr1.27 “Hysteresis at torque control switching”	Set to 0					

■ Parameters set based on Load fluctuation suppression function automatic tuning

When Pr0.02 “Real-time auto-gain tuning setup” is 1 to 4, 6, or 7, set the following parameters according to Pr6.10 “Function expansion setup” :bit 14 “Load fluctuation suppression function automatic tuning” .

Target parameter	Condition	Value to be set	
		Pr6.10:bit 14 = 1	Pr6.10:bit 14 = 0
Pr6.10 “Function expansion setup”	When stiffness setup is enabled	bit 1 “Load fluctuation control function” = 1 (enabled)	bit 1 “Load fluctuation control function” = 0 (disabled)
Pr6.23 “Load change compensation gain”	When stiffness setup is enabled	Set to 90 (90%)	Set to 0
Pr6.24 “Load change compensation filter”	When stiffness setup is enabled	Updates to set value according to stiffness	Retain value
Pr6.73 “Load estimation filter”	When stiffness setup is enabled and Pr2.45 “Function expansion setup 10” :bit 3 = 0	Set to 13	Set to 0
	When stiffness setup is enabled and Pr2.45 “Function expansion setup 10” :bit 3 = 1	Set automatically	
Pr6.74 “Torque compensation frequency 1”	Set to 0 regardless of the value of Pr6.10:bit 14.		
Pr6.75 “Torque compensation frequency 2”	Set to 0 regardless of the value of Pr6.10:bit 14.		
Pr6.76 “Load estimation count”	When stiffness setup is enabled and Pr2.45 “Function expansion setup 10” :bit 3 = 0	Set to 4	Set to 0

Target parameter	Condition	Value to be set	
		Pr6.10:bit 14 = 1	Pr6.10:bit 14 = 0
Pr6.76 “Load estimation count”	When stiffness setup is enabled and Pr2.45 “Function expansion setup 10” :bit 3 = 1	Automatically set according to stiffness	

4.1.3.5 How to Use

- When Pr0.02 “Real-time auto-gain tuning setup” is set to 1 to 4, 6 or 7, real-time auto tuning is enabled. The parameter values used for tuning are automatically set according to the parameter settings below.
  - Pr0.03 “Real-time auto-tuning machine stiffness setup”
  - Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2”
  - Pr6.10 “Function expansion setup” :bit 14 “Load fluctuation suppression function automatic tuning”
- Input the operation command after approximately 100 ms have elapsed since servo-on.
- Pr0.04 “Inertia ratio” changes when load characteristics estimation is complete. Pr2.52 “Torque command additional value 2” , Pr2.53 “Positive direction torque compensation value 2” , and Pr2.54 “Negative direction torque compensation value 2” also change depending on the mode setting (see *“Supplement”*).
- Increasing the set value of either of the following parameters will increase motor responsiveness. While checking the positioning settling time and vibration state, increase the setup values by increments of 1 and tune to the optimal values.
  - Pr0.03 “Real-time auto-tuning machine stiffness setup”
  - Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2”
- Setting Pr0.02 “Real-time auto-gain tuning setup” to 0 disables real-time auto tuning. Automatic estimation of Pr0.04 “Inertia ratio” stops, but the inertia ratio value at the time of estimation stopping is retained. If the value of the inertia ratio is clearly abnormal, set a reasonable value manually.

Notes

- Pr2.52, Pr2.53 and Pr2.54

  Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 2 “Friction torque compensation parameter selection” . The initial value is Pr2.45: bit 2 = 1.
  - Pr2.45: bit 2=0 : Pr6.07, Pr6.08, Pr6.09
  - Pr2.45: bit 2=1 : Pr2.52, Pr2.53, Pr2.54
- Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.
  - Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
  - Pr2.45: bits 5 to 4 = 10b : Pr0.27
  - Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

  Pr0.28 is disabled.

— Precautions —

- When real-time auto tuning is enabled, the response to estimated values after power-up to completion of load characteristic estimation may be faster regardless of the set value for Pr6.31 “Real time auto tuning estimation speed” .
- Immediately after power-up, there is not enough operation data effective for load characteristic estimation, meaning estimated values may be abnormal and operation instable due to disturbance, etc. Once tuning is finished, we recommended that real-time auto tuning is set to disabled (Pr0.02 “Real-time auto-gain tuning setup” = 0).

- Until load characteristic estimation results stabilize, abnormal noise or oscillation may occur. For example, if abnormal noise or oscillation occurs immediately after the first servo-on after activation or when the Pr0.03 “Real-time auto-tuning machine stiffness setup” set value is increased, it is not abnormal for the operation to stabilize immediately. After abnormal noise or oscillation occurs ,Pr0.04 “Inertia ratio” , Pr2.52 “Torque command additional value 2” , Pr2.53 “Positive direction torque compensation value 2” , or Pr2.54 “Negative direction torque compensation value 2” may change to extreme values. Take the following measures. The following measures should also be taken if abnormal noise or oscillation occurs frequently.
  1. Lower the set value for Pr0.03 “Real-time auto-tuning machine stiffness setup” or Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2” .
  2. Set Pr0.02 “Real-time auto-gain tuning setup” to 0 to disable real-time auto tuning.
  3. Set Pr0.04 “Inertia ratio” to the value calculated on the device and set Pr2.52 “Torque command additional value 2” , Pr2.53 “Positive direction torque compensation value 2” , and Pr2.54 “Negative direction torque compensation value 2” to 0 (see *“Supplement”*).
  4. After setting Pr6.10 “Function expansion setup” :bit 14 = 0, set bit 1 = 0 to disable the load fluctuation control function.
- The Pr0.04 “Inertia ratio” , Pr2.52 “Torque command additional value 2” , Pr2.53 “Positive direction torque compensation value 2” , and Pr2.54 “Negative direction torque compensation value 2” (see *“Supplement”*) values, which are the results of real-time auto gain tuning, are automatically written to and saved in EEPROM every 30 minutes. When power is restored, auto tuning is performed using the saved EEPROM values as the initial values. If turning OFF the power without 30 minutes having elapsed since values were automatically saved in EEPROM, manually write the latest real-time auto gain tuning results to EEPROM before turning OFF the power.
- Since control gain is updated when the motor stops, changes to Pr0.03 “Real-time auto-tuning machine stiffness setup” or Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2” settings are not reflected if the motor does not stop (if the gain is extremely low or if a command is continuously given in one direction).

  Before changing any of the above parameters related to stiffness setup, stop the motor once to make sure that the stiffness setup has been reflected. Depending on the stiffness setup reflected after the motor is stopped, abnormal noise or oscillation may occur.
- The following are linked in the Set-up Support Software (PANATERM ver.7) Manual TUNING screen.
  - Feedback gain setting: Pr0.03 “Real-time auto-tuning machine stiffness setup” or Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2”

Notes

- Pr2.52, Pr2.53 and Pr2.54

  Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 2 “Friction torque compensation parameter selection” . The initial value is Pr2.45: bit 2 = 1.
  - Pr2.45: bit 2=0 : Pr6.07, Pr6.08, Pr6.09
  - Pr2.45: bit 2=1 : Pr2.52, Pr2.53, Pr2.54
- Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.
  - Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
  - Pr2.45: bits 5 to 4 = 10b : Pr0.27
  - Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

  Pr0.28 is disabled.

4.1.3.6 Basic Gain Parameter Setup Table

—: None

Stiffness		1st gain				2nd gain				For load fluctuation control function
Pr0.03 (*1)	Pr0.27 (*1)	Pr1.00	Pr1.01	Pr1.02	Pr1.04 (*2)	Pr1.05	Pr1.06	Pr1.07 (*3)	Pr1.09 (*2)	Pr6.24
		Position [0.1 s^{-1}]	Speed [0.1 Hz]	Speed integration [0.1 ms]	Torque [0.01 ms]	Position [0.1 s^{-1}]	Speed [0.1 Hz]	Speed integration [0.1 ms]	Torque [0.01 ms]	Load change compensation filter [0.01 ms]
0	0	20	15	3700	1500	25	15	10000	1500	2500
1	1	25	20	2800	1100	30	20	10000	1100	2500
2	2	30	25	2200	900	40	25	10000	900	2500
3	3	40	30	1900	800	45	30	10000	800	2500
4	4	45	35	1600	600	55	35	10000	600	2500
5	5	55	45	1200	500	70	45	10000	500	2500
6	6	75	60	900	400	95	60	10000	400	2500
7	7	95	75	700	300	120	75	10000	300	2120
8	8	115	90	600	300	140	90	10000	300	1770
9	9	140	110	500	200	175	110	10000	200	1450
10	10	175	140	400	200	220	140	10000	200	1140
—	11	250	160	350	163	300	160	10000	163	1000
11	12	320	180	310	126	380	180	10000	126	880
—	13	355	200	280	114	425	200	10000	114	795
12	14	390	220	250	103	460	220	10000	103	720
—	15	435	245	225	93	515	245	10000	93	650
13	16	480	270	210	84	570	270	10000	84	590
—	17	535	300	190	74	635	300	10000	74	535
14	18	630	350	160	65	730	350	10000	65	450
15	19	720	400	140	57	840	400	10000	57	400
—	20	810	450	125	51	945	450	10000	51	355
16	21	900	500	120	45	1050	500	10000	45	320
—	22	990	550	110	41	1160	550	10000	41	290
17	23	1080	600	110	38	1260	600	10000	38	270
—	24	1170	650	105	35	1370	650	10000	35	250
—	25	1260	700	100	32	1480	700	10000	32	235
18	26	1350	750	90	30	1570	750	10000	30	210
—	27	1490	825	85	27	1730	825	10000	27	190
19	28	1620	900	80	25	1880	900	10000	25	180
—	29	1850	1025	70	22	2150	1025	10000	22	160
20	30	2060	1150	70	20	2410	1150	10000	20	140
—	31	2260	1260	65	18	2640	1260	10000	18	130
21	32	2510	1400	60	16	2930	1400	10000	16	110
—	33	2780	1550	55	14	3250	1550	10000	14	100
22	34	3050	1700	50	13	3560	1700	10000	13	90

Stiffness		1st gain				2nd gain				For load fluctuation control function
Pr0.03 (*1)	Pr0.27 (*1)	Pr1.00	Pr1.01	Pr1.02	Pr1.04 (*2)	Pr1.05	Pr1.06	Pr1.07 (*3)	Pr1.09 (*2)	Pr6.24
		Position [0.1 s^{-1}]	Speed [0.1 Hz]	Speed integration [0.1 ms]	Torque [0.01 ms]	Position [0.1 s^{-1}]	Speed [0.1 Hz]	Speed integration [0.1 ms]	Torque [0.01 ms]	Load change compensation filter [0.01 ms]
—	35	3410	1900	45	12	3980	1900	10000	12	80
23	36	3770	2100	40	11	4400	2100	10000	11	80
24	37	4490	2500	40	9	5240	2500	10000	9	60
25	38	5000	2800	35	8	5900	2800	10000	8	60
26	39	5600	3100	30	7	6500	3100	10000	7	50
27	40	6100	3400	30	7	7100	3400	10000	7	50
28	41	6600	3700	25	6	7700	3700	10000	6	40
29	42	7200	4000	25	6	8400	4000	10000	6	40
30	43	8100	4500	20	5	9400	4500	10000	5	40
31	44	9000	5000	20	5	10500	5000	10000	5	40

*1 Change the parameters to be used depending on the values set in Pr2.45 “Function expansion setup 10” :bit 5 to 4 “Stiffness setting resolution, individual FB/FF setting switching” . The initial value is Pr2.45: bits 5 to 4 = 11b.

- Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03
- Pr2.45: bits 5 to 4 = 10b : Pr0.27
- Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28

Pr0.28 is disabled.

*2 The values in the table are used only when Pr2.45 “Function expansion setup 10” :bit 1 to 0 = 0.

*3 For vertical axis mode or friction compensation mode (Pr0.02 “Real-time auto-gain tuning setup” = 3, 4), Pr1.07 “2nd velocity loop integration time constant” is 9999 (retained) until estimation of load characteristics is complete.

4.2 Gain Switching Function

4.2.1 Function Overview

This function optimizes control based on the operating state of the servo driver by changing settings such as applied gain types and setting conditions based on command inputs such as torque commands and speed commands.

Gain switching is expected to have the following effects:

- Reduce gain when stopped (servo lock) to suppress vibration
- Increase the gain when stopped (settling time) to shorten the settling time
- Increase the gain during operation to improve command tracking
- Switch gain using external signal based on the device status

4.2.2 Operational Conditions

Item	Operational Conditions
Control mode	● All control modes

4.2.3 Related Parameters

The parameters that can be switched vary depending on the control mode.

■ Common

—: N/A

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
1	14	B	2nd gain setup	0 to 1	—	Set when performing optimum tuning using the gain switching function. 0: Disabled (Fixes 1st gain) 1: Enabled (Enables gain switching between 1st gain and 2nd gain)

*1 For attributes, see *“7.1 Object Dictionary List”* .

■ Position control mode, full-closed control mode

—: N/A

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
1	15	B	Mode of position control switching	0 to 10	—	Sets the trigger condition for gain switching during position control and full-closed control. (Setup value): (switching condition) 0: 1st gain fixed 1: 2nd gain fixed 2: Manufacturer use (setting is prohibited) 3: Torque command 4: Disabled (1st gain fixed) 5: Speed command 6: Position deviation 7: With position command 8: Positioning not completed 9: Actual speed 10: With position command + actual speed
1	16	B	Delay time of position control switching	0 to 10000	0.1 ms	Sets the time from trigger detection to actual gain switching when switching from 2nd gain to 1st gain during position control and full-closed control when Pr1.15 “Mode of position control switching” is 3, or 5 to 10.
1	17	B	Level of position control switching	0 to 20000	Depends on the mode	Sets triggering level during position control and full-closed control when Pr1.15 “Mode of position control switching” is 3, 5, 6, 9, or 10. Units vary with switching mode setting. ● Set the level equal to or higher than the hysteresis.
1	18	B	Hysteresis at position control switching	0 to 20000	Depends on the mode	Sets triggering hysteresis during position control and full-closed control when Pr1.15 “Mode of position control switching” is 3, 5, 6, 9, or 10. Units vary with switching mode setting. ● When the level is less than the hysteresis, the hysteresis is re-set internally so that it is equal to the level.
1	19	B	Position gain switching time	0 to 10000	0.1 ms	Sudden increases in position loop gain can be suppressed during position control and full-closed control if there is a large difference between Pr1.00 “1st gain of position loop” and Pr1.05 “2nd gain of position loop” . If the position loop gain increases, gain will change over the set time.

*1 For attributes, see *“7.1 Object Dictionary List”* .

The target parameters referred to in the above description in terms of 1st gain and 2nd gain are as follows.

- 1st gain
  - Pr1.00 “1st gain of position loop”
  - Pr1.01 “1st velocity loop gain”
  - Pr1.02 “1st velocity loop integration time constant”
  - Pr1.03 “1st filter of velocity detection”
  - Pr1.04 “1st torque filter time constant”
- 2nd gain

- Pr1.05 “2nd gain of position loop”
- Pr1.06 “2nd velocity loop gain”
- Pr1.07 “2nd velocity loop integration time constant”
- Pr1.08 “2nd filter of velocity detection”
- Pr1.09 “2nd torque filter time constant”

■ Speed control modes

―: N/A

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
1	20	B	Mode of velocity control switching	0 to 5	―	Sets gain switching trigger conditions during velocity control. (Setup value): (switching condition) 0: 1st gain fixed 1: 2nd gain fixed 2: Manufacturer use (setting is prohibited) 3: Torque command 4: Speed command variation 5: Speed command
1	21	B	Delay time of velocity control switching	0 to 10000	0.1 ms	Sets the time from trigger detection to actual gain switching when switching from 2nd gain to 1st gain during velocity control when Pr1.20 “Mode of velocity control switching” is 3 to 5.
1	22	B	Level of velocity control switching	0 to 20000	Depends on the mode	Sets triggering level during velocity control when Pr1.20 “Mode of velocity control switching” is 3 to 5. Units vary with switching mode setting. ● Set the level equal to or higher than the hysteresis.
1	23	B	Hysteresis at velocity control switching	0 to 20000	Depends on the mode	Sets triggering hysteresis during velocity control when Pr1.20 “Mode of velocity control switching” is 3 to 5. Units vary with switching mode setting. ● When the level is less than the hysteresis, the hysteresis is re-set internally so that it is equal to the level.

*1 For attributes, see *“7.1 Object Dictionary List”* .

The target parameters referred to in the above description in terms of 1st gain and 2nd gain are as follows.

- 1st gain
  - Pr1.01 “1st velocity loop gain”
  - Pr1.02 “1st velocity loop integration time constant”
  - Pr1.03 “1st filter of velocity detection”
  - Pr1.04 “1st torque filter time constant”
- 2nd gain
  - Pr1.06 “2nd velocity loop gain”
  - Pr1.07 “2nd velocity loop integration time constant”
  - Pr1.08 “2nd filter of velocity detection”
  - Pr1.09 “2nd torque filter time constant”

■ Torque control modes

—: N/A

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
1	24	B	Mode of torque control switching	0 to 3	—	Sets gain switching trigger conditions during torque control. (Setup value): (switching condition) 0: 1st gain fixed 1: 2nd gain fixed 2: Manufacturer use (setting is prohibited) 3: Torque command
1	25	B	Delay time of torque control switching	0 to 10000	0.1 ms	Sets the time from trigger detection to actual gain switching when switching from 2nd gain to 1st gain during torque control when Pr1.24 “Mode of torque control switching” is 3.
1	26	B	Level of torque control switching	0 to 20000	Depends on the mode	Sets triggering level during torque control when Pr1.24 “Mode of torque control switching” is 3. Units vary with switching mode setting. ● Set the level equal to or higher than the hysteresis.
1	27	B	Hysteresis at torque control switching	0 to 20000	Depends on the mode	Sets triggering hysteresis during torque control when Pr1.24 “Mode of torque control switching” is 3. Units vary with switching mode setting. ● When the level is less than the hysteresis, the hysteresis is re-set internally so that it is equal to the level.

*1 For attributes, see *“7.1 Object Dictionary List”* .

The target parameters referred to in the above description in terms of 1st gain and 2nd gain are as follows.

- 1st gain
  - Pr1.01 “1st velocity loop gain”
  - Pr1.02 “1st velocity loop integration time constant”
  - Pr1.03 “1st filter of velocity detection”
  - Pr1.04 “1st torque filter time constant”
- 2nd gain
  - Pr1.06 “2nd velocity loop gain”
  - Pr1.07 “2nd velocity loop integration time constant”
  - Pr1.08 “2nd filter of velocity detection”
  - Pr1.09 “2nd torque filter time constant”

■ Each control switching mode and gain switching details

The gain switching method differs depending on the set values for Pr1.15 “Mode of position control switching” , Pr1.20 “Mode of velocity control switching” , and Pr1.24 “Mode of torque control switching” . Check 0, 1, 3, 5 to 10 for mode of position control switching, 0, 1, 3 to 5 for mode of velocity control switching, and 0, 1 and 3 for mode of torque control switching.

○: Enabled ×: Disabled

Control switching mode setting values	Switching condition	Gain switching details	Control mode			
			Position	Full-closed	Speed	Torque
0	1st gain fixed	Fixed to 1st gain (Pr1.00 to Pr1.04)	○	○	○	○
1	2nd gain fixed	Fixed to 2nd gain (Pr1.05 to Pr1.09)	○	○	○	○
2	Manufacturer use (setting is prohibited)	Do not set.	×	×	×	×
3	Torque command magnitude	Switches to 2nd gain if previously the absolute value of the torque command exceeded (level + hysteresis) [%] in 1st gain. Returns to 1st gain if previously the absolute value of the torque command remained below (level - hysteresis) [%] for the delay time in 2nd gain.	○	○	○	○
4	Large amount of speed command variation	Switches to 2nd gain if previously the absolute value of speed command variation exceeded (level + hysteresis) [10 r/min/s] in 1st gain. Returns to 1st gain if previously the absolute value of speed command variation remained below (level - hysteresis) [10 r/min/s] for the delay time in 2nd gain. **Notes** ● Except with speed control, the 1st gain is fixed.	×	×	○	×
5	Speed command magnitude	Switches to 2nd gain if previously the absolute value of the speed command exceeded (level + hysteresis) [r/min] in 1st gain. Returns to 1st gain if previously the absolute value of the speed command remained below (level - hysteresis) [r/min] for the delay time in 2nd gain.	○	○	○	×
6	Position deviation magnitude	Switches to 2nd gain if previously the absolute value of position deviation exceeded (level + hysteresis) [pulse] in 1st gain. Returns to 1st gain if previously the absolute value of position deviation remained below (level - hysteresis) [pulse] for the delay time in 2nd gain. **Notes** ● Level and hysteresis units [pulse] are set by encoder resolution for position control and by feedback scale resolution for full-closed control. The position deviation in this description refers to the deviation between the internal command position after the filter and the actual position, regardless of the set value for Pr7.23 “Communication function extended setup 2” :bit 14.	○	○	×	×
7	With position command	Switches to 2nd gain if previously the position command was not 0 in 1st gain. Returns to 1st gain if previously the position command remained 0 for the delay time in 2nd gain.	○	○	×	×
8	Positioning not completed	Switches to 2nd gain if previously positioning was not completed in 1st gain. Returns to 1st gain if previously the positioning completed state continued for the delay time in 2nd gain.	○	○	×	×
9	Actual Speed - Large	Shifts to 2nd gain when the actual speed absolute value exceeds (level + hysteresis) [r/min] in the previous 1st gain. Returns to 1st gain when the actual speed absolute value remains (level - hysteresis) [r/min] or less for the delay time in the previous 2nd gain.	○	○	×	×

Control switching mode setting values	Switching condition	Gain switching details	Control mode			
			Position	Full-closed	Speed	Torque
10	With Position Command + Actual Speed	Switches to 2nd gain if previously the position command was not 0 in 1st gain. Returns to 1st gain when position command remains at 0 for the delay time and the actual speed absolute value is (level - hysteresis) [r/min] or less in the previous 2nd gain.	○	○	×	×

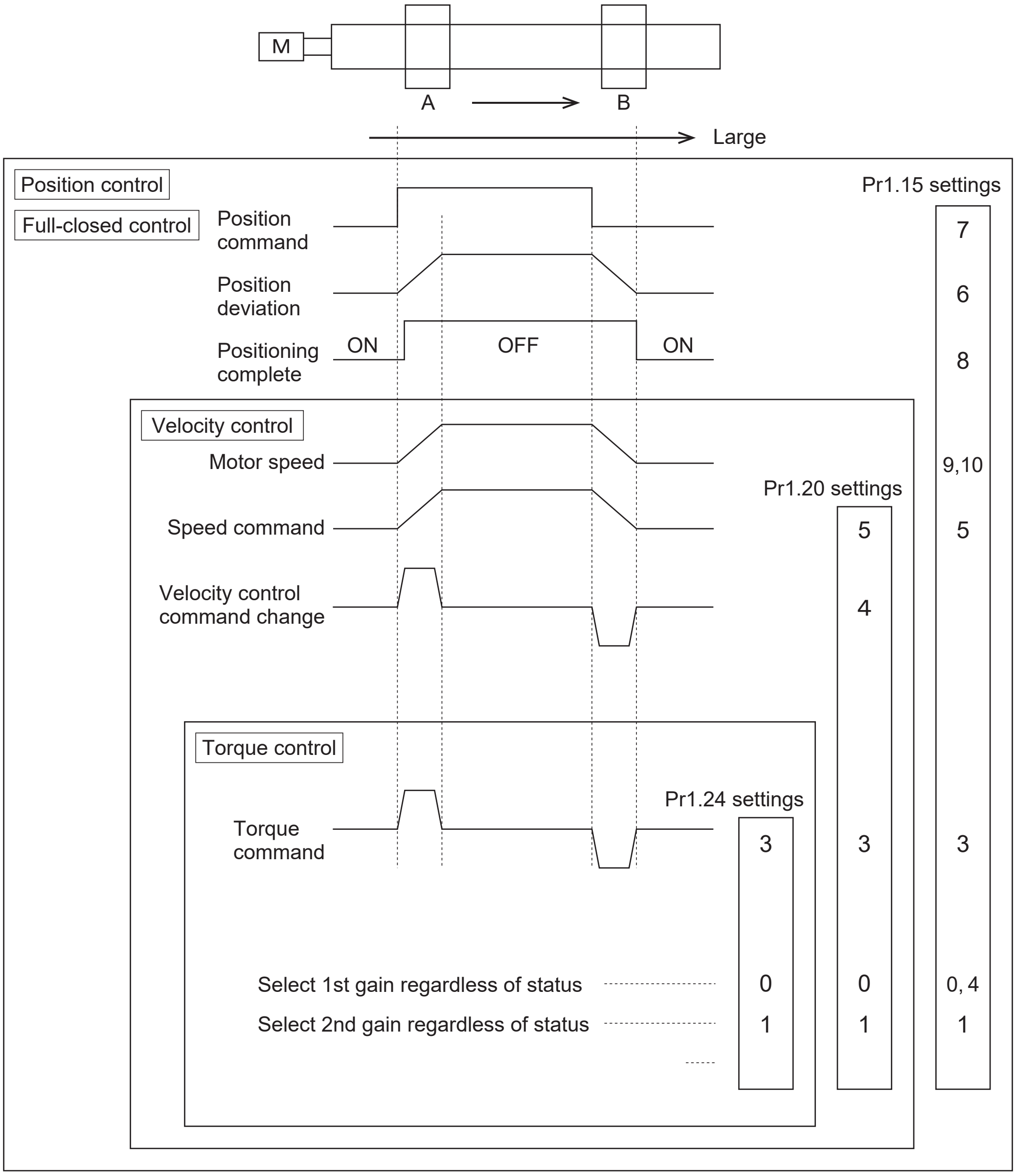
4.2.4 How to Use

4.2.4.1 For Manual Setting

After setting the gain switching mode for each control mode used, enable the gain switching function (Pr1.14 “2nd gain setup” = 1). Change the related parameters for each control mode.

4.2.4.1.1 Example of Gain Switching Function Use

Assume that when the load moves from position A to position B, the internal state of the servo driver changes as shown in the figure below. This section describes how to set the related parameters when using the gain switching function under such conditions.



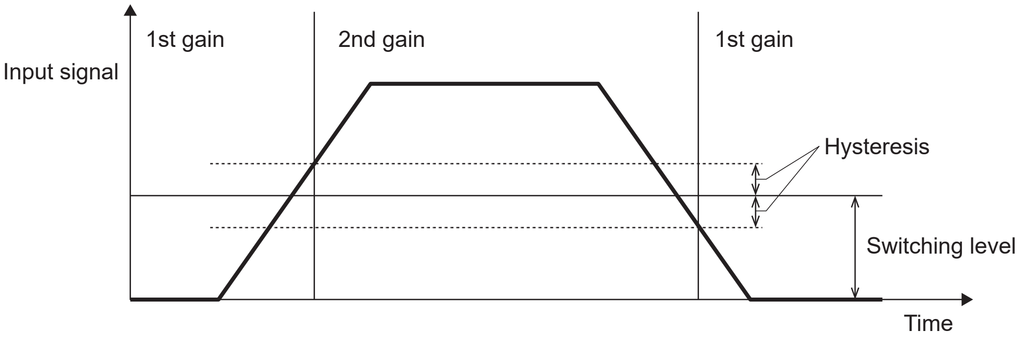
<< Procedure >>

1. The following parameters are used to set the conditions for switching gain.

- Pr1.15 “Mode of position control switching”
- Pr1.20 “Mode of velocity control switching”
- Pr1.24 “Mode of torque control switching”

2. Set the switching level and hysteresis according to the gain switching conditions.

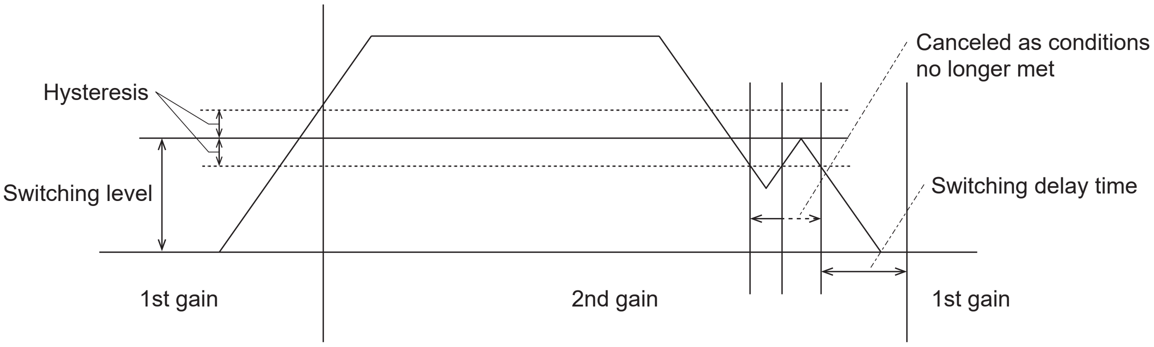
   When there is a small fluctuation such as noise in the input signal change based on the Pr1.15 “Mode of position control switching” , Pr1.20 “Mode of velocity control switching” , and Pr1.24 “Mode of torque control switching” settings, set the hysteresis to a value greater than the fluctuation range to prevent unnecessary gain switching from occurring continuously and to enable smooth gain switching.



3. Set the switching time.

   The switching time sets the delay time from trigger detection to actual gain switching when switching from 2nd gain to 1st gain.

   2nd gain switches to 1st gain when the input signal exceeds the set switching level and hysteresis continuously for a set switching time or longer.



4. Set the position gain switching time.

   The following parameters are switched instantly during gain switching.

   - 1st gain
     - Pr1.00 “1st gain of position loop”
     - Pr1.01 “1st velocity loop gain”
     - Pr1.02 “1st velocity loop integration time constant”
     - Pr1.04 “1st torque filter time constant”
   - 2nd gain
     - Pr1.05 “2nd gain of position loop”
     - Pr1.06 “2nd velocity loop gain”
     - Pr1.07 “2nd velocity loop integration time constant”
     - Pr1.09 “2nd torque filter time constant”

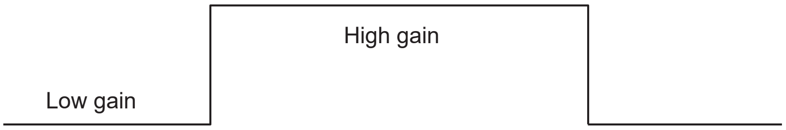
   Position loop gain can be switched gradually and stepwise to avoid problems caused by sudden changes to high gain.

   In this case, the number of steps is “position gain switching time / resolution 62.5 μs”. If there is a fraction instead of a multiple of 62.5, the number of steps is rounded down.

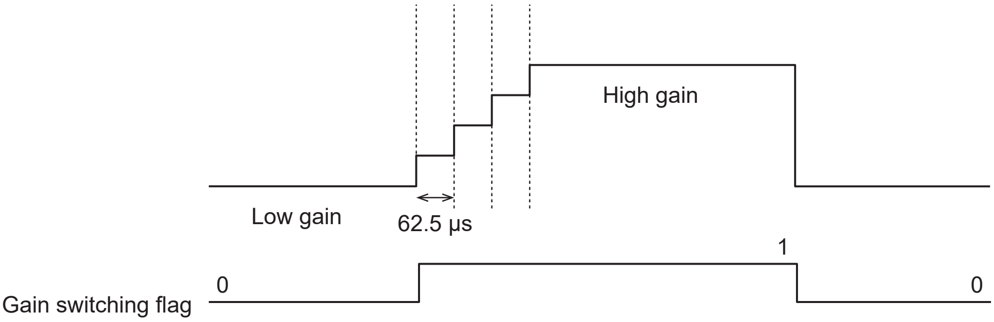
When Pr1.19 “Position gain switching time” is 2 in the figure below, the set time is 0.2 ms. Therefore, 0.2 ms / 62.5 μs = 3.2, which is a rise of 3 steps. (Actual switching time is 62.5 μs × 3 = 250 μs = 187.5 μs)

*The gain switching flag changes at the moment of switching from low gain.

When Pr1.19 “Position gain switching time” is 0



When Pr1.19 “Position gain switching time” is 2



4.2.4.1.2 Example Tuning Procedure for Vibration Suppression

The following is an example tuning procedure for suppressing vibration by lowering the gain after settling due to high position deviation vibration after positioning settling during position control.

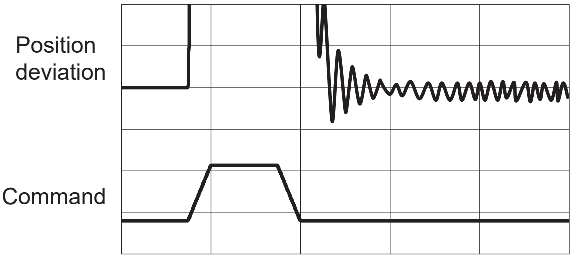
<< Procedure >>

1. Set Pr1.15 “Mode of position control switching” to 7 or 10.
2. Set Pr1.16 “Delay time of position control switching” = 50, Pr1.17 “Level of position control switching” = 50, Pr1.18 “Hysteresis at position control switching” = 33, Pr1.19 “Position gain switching time” = 33.
3. Lower Pr1.00 “1st gain of position loop” and Pr1.01 “1st velocity loop gain” by the same ratio.

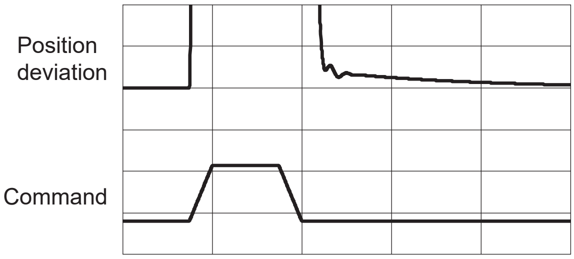
   Raise Pr1.04 “1st torque filter time constant” by the same ratio. Tune Pr1.02 “1st velocity loop integration time constant” so that vibration is suppressed.
4. To change the timing of vibration suppression, tune Pr1.16 “Delay time of position control switching” , Pr1.17 “Level of position control switching” , and Pr1.18 “Hysteresis at position control switching” .

   At this time, tune so that Pr1.18 “Hysteresis at position control switching” ≦ Pr1.17 “Level of position control switching” .

Example of waveform before tuning



Example of waveform after tuning

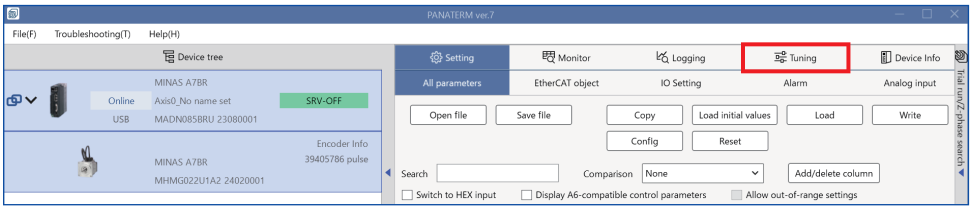


4.2.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

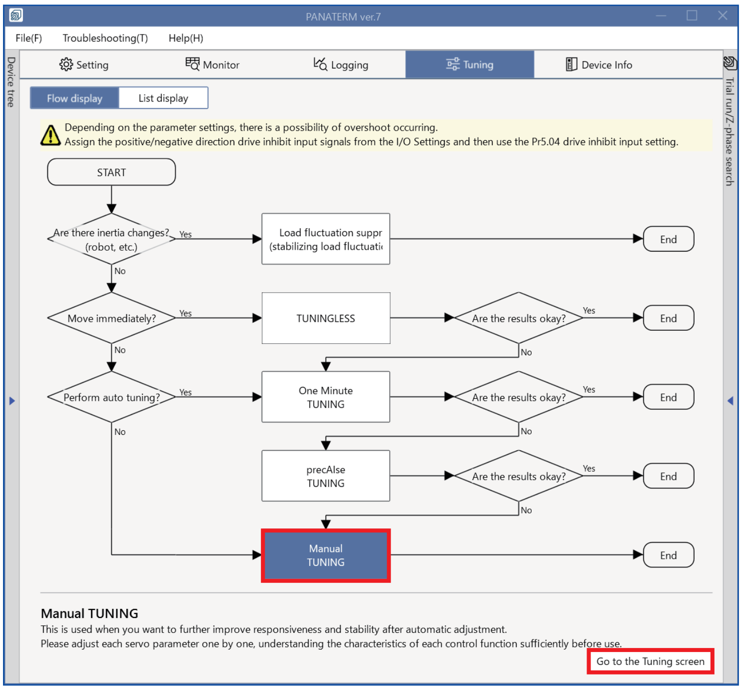
<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.

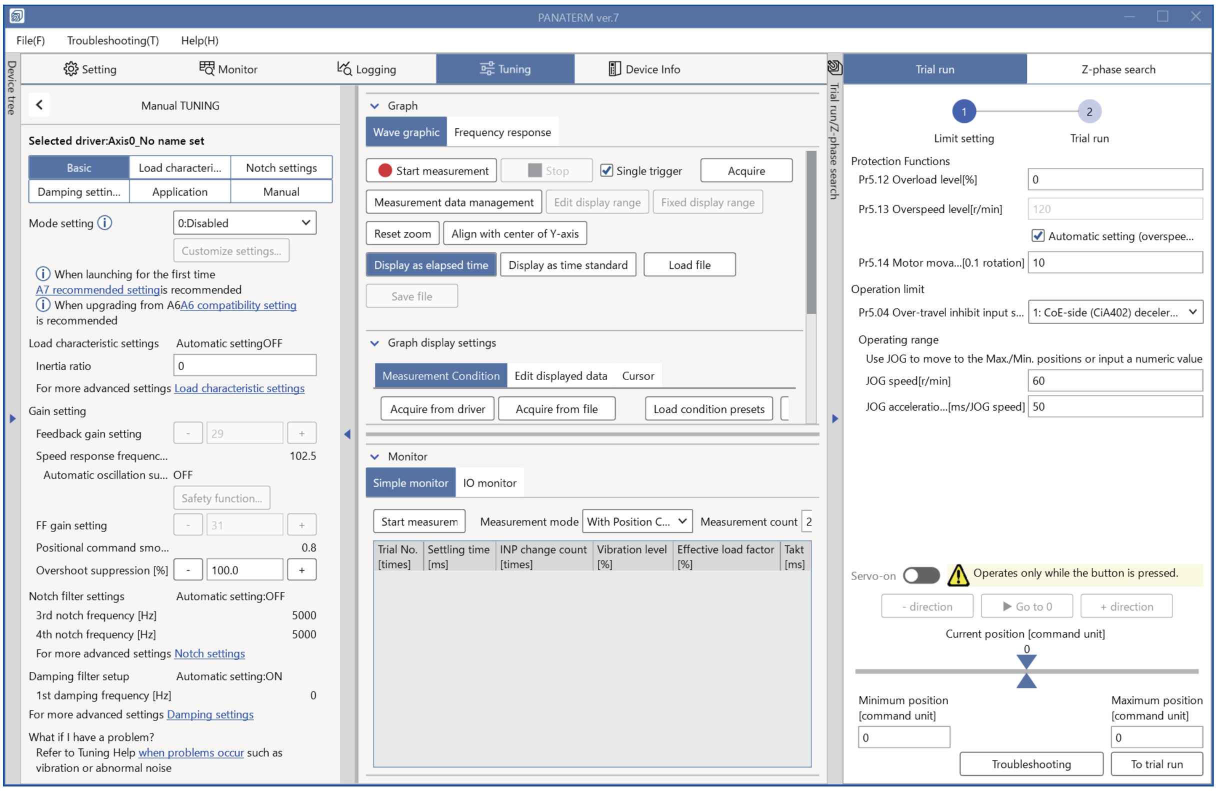


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING

This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.



Selected driver:Axis0_No name set

Mode setting: 0:Disabled

When launching for the first time A7 recommended setting is recommended
When upgrading from A6 A6 compatibility setting is recommended

Load characteristic settings Automatic setting OFF
Inertia ratio 0
For more advanced settings Load characteristic settings

Gain setting
Feedback gain setting 29
Speed response frequenc... 102.5
Automatic oscillation su... OFF
FF gain setting 31
Positional command smo... 0.8
Overshoot suppression [%] 100.0

Notch filter settings Automatic setting:OFF
3rd notch frequency [Hz] 5000
4th notch frequency [Hz] 5000
For more advanced settings Notch settings

Damping filter setup Automatic setting:ON
1st damping frequency [Hz] 0
For more advanced settings Damping settings

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode With Position C...
Measurement count 2

Trial No. [times]	Settling time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%] 0
Pr5.13 Overspeed level[r/min] 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation] 10

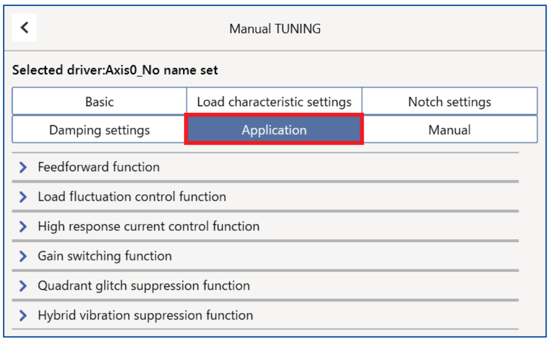
Operation limit
Pr5.04 Over-travel inhibit input s... 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min] 60
JOG acceleratio...[ms/JOG speed] 50

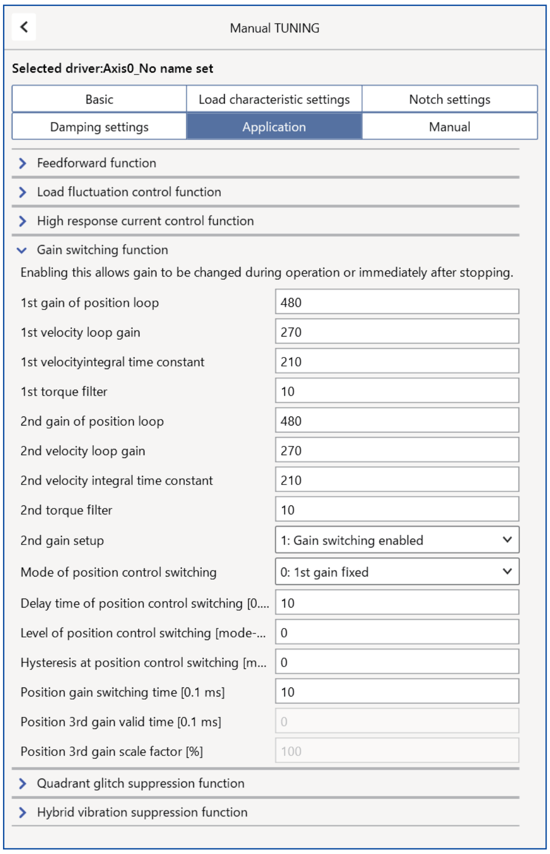
Servo-on Operates only while the button is pressed.

Current position [command unit] 0
Minimum position [command unit] 0
Maximum position [command unit] 0

4. Click the [Application] button.



5. Click on "˃" of "> Gain switching function" to expand "Gain switching function".



Enabling this allows gain to be changed during operation or immediately after stopping.

1st gain of position loop	480
1st velocity loop gain	270
1st velocityintegral time constant	210
1st torque filter	10
2nd gain of position loop	480
2nd velocity loop gain	270
2nd velocity integral time constant	210
2nd torque filter	10
2nd gain setup	1: Gain switching enabled
Mode of position control switching	0: 1st gain fixed
Delay time of position control switching [0....	10
Level of position control switching [mode-...	0
Hysteresis at position control switching [m...	0
Position gain switching time [0.1 ms]	10
Position 3rd gain valid time [0.1 ms]	0
Position 3rd gain scale factor [%]	100

6. After setting the "Mode of position control switching", select "1: Gain switching enabled" from the "2nd gain setup" drop-down list. Change the related parameters.

— Precautions —

- In the current version of Set-up Support Software (PANATERM ver.7) , the parameter setup screen for gain switching supports only position control and full-closed control. To set the gain switching parameters for speed control and torque control, click the [Manual] button.

4.3 3rd Gain Switching Function

4.3.1 Function Overview

In addition to the normal gain switching function (see *"4.2 Gain Switching Function"*), this function sets the gain just before stopping as the 3rd gain.

The positioning settling time can be shortened by setting the gain just before stopping higher for a fixed period of time.

4.3.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control and full-closed control

4.3.3 Related Parameters

—: N/A

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
1	14	B	2nd gain setup	0 to 1	—	Set when performing optimum tuning using the gain switching function. 0: Disabled (Fixes 1st gain) 1: Enabled (Enables gain switching between 1st gain and 2nd gain)
1	15	B	Mode of position control switching	0 to 10	—	Sets the trigger condition for gain switching during position control and full-closed control. (Setup value): (switching condition) 0: 1st gain fixed 1: 2nd gain fixed 2: Manufacturer use (setting is prohibited) 3: Torque command 4: Disabled (1st gain fixed) 5: Speed command 6: Position deviation 7: With position command 8: Positioning not completed 9: Actual speed 10: With position command + actual speed
6	05	B	Position 3rd gain valid time	0 to 10000	0.1 ms	Sets time for 3rd gain to be enabled.
6	06	B	Position 3rd gain scale factor	50 to 1000	%	Sets the scale factor of the 3rd gain with respect to the 1st gain. 3rd gain = 1st gain × Pr6.06/100

*1 For attributes, see *"7.1 Object Dictionary List"* .

4.3.4 How to Use

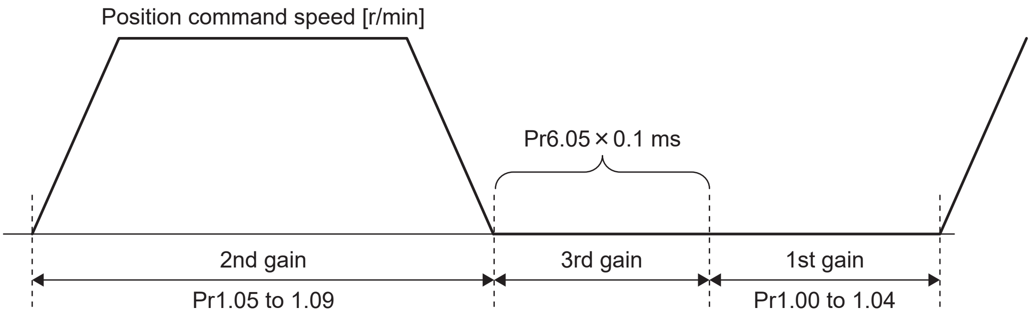
4.3.4.1 For Manual Setting

Set the time for applying 3rd gain to Pr6.05 “Position 3rd gain valid time” when the normal gain switching function operates normally (Pr1.14 “2nd gain setup” = 1 and Pr1.15 “Mode of position control switching” = 3, with gain switching occurring at 5 to 10). Set the scale factor of the 3rd gain with respect to the 1st gain in Pr6.06 “Position 3rd gain scale factor” .

- If 3rd gain is not used, set Pr6.05 “Position 3rd gain valid time” = 0 and Pr6.06 “Position 3rd gain scale factor” = 100.
- In the 3rd gain section, the position loop gain and speed loop gain become 3rd gain, and 1st gain settings are applied to the speed loop integral time constant, speed detection filter and torque filter time constant parameters.
- If 2nd gain switching conditions are satisfied in the 3rd gain section, the gain is switched to 2nd gain.
- When switching from 2nd gain to 3rd gain, Pr1.19 “Position gain switching time” is applied.

  Note that a 3rd gain section is also generated when the gain is switched from 2nd gain to the 1st gain due to a parameter change, etc.

  (Example) Gain transition when Pr1.15 “Mode of position control switching” = 7 (with position command)



[3rd gain section]
Position loop gain = Pr1.00 × Pr6.06/100
Speed loop gain = Pr1.01 × Pr6.06/100
The 1st gain value is used as is for the speed loop integration time constant, speed detection filter, and torque filter time constant.

— Precautions —

- If Pr6.06 “Position 3rd gain scale factor” is raised too high, oscillation may occur.

4.3.4.1.1 Example Tuning Procedure for Overshoot/Undershoot Suppression

The following is an example procedure for suppressing overshoot/undershoot by increasing the gain near settling due to large overshoot/undershoot at positioning settling during position control.

<< Procedure >>

1. Determine the section to be suppressed while observing amounts of overshoot/undershoot.
2. Set the value determined by “Step 1” to Pr6.05 “Position 3rd gain valid time” .
3. Increase Pr6.06 “Position 3rd gain scale factor” by increments of 10 from 100 within the range of oscillation does not occur.
4. If the overshoot/undershoot suppression is ineffective, try tuning Pr6.05 “Position 3rd gain valid time” and Pr6.06 “Position 3rd gain scale factor” to a setting at which overshoot/undershoot is suppressed.

5. If still ineffective after executing “Step 4”, try finding the optimal setting values, including for 1st gain and 2nd gain.

4.3.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

Refer to *“4.2 Gain Switching Function”* *“4.2.4.2 When Set-up Support Software (PANATERM ver.7) Is Used”* .

4.4 Feedforward Function

4.4.1 Function Overview

This function performs compensation to minimize the effect of delay caused by feedback control on the command value before the effect is apparent.

- The speed feedforward function generates a speed feedforward value by adding a speed control command calculated from the internal position command to the speed command from the position control processing part. The use of this speed feedforward value results in less position deviation while operating at a constant speed compared to with feedback control alone, thus increasing the responsiveness of position control.
- The torque feedforward function generates a torque feedforward value by adding the torque command calculated from the speed control command to the torque command from the speed control processing part. The use of this torque feedforward value results in position deviation of close to 0 at constant acceleration and deceleration, thus increasing the responsiveness of speed control.
- In addition to this function, feedforward values can also be set and sent using EtherCAT communication. With EtherCAT communication, the speed feedforward value can be set with Obj.60B1h:00h “Velocity offset” and the torque feedforward value with Obj.60B2h:00h “Torque offset” . Each feedforward value given by EtherCAT communication is added to each internally calculated feedforward value according to the parameter setup of this function. For details, see Operating Instructions (Overall) “6.6.5 Position Control Function (pp, csp, ip, hm)” , “6.6.6 Velocity Control Function (pv, csv)” and “6.6.7 Torque Control Function (tq, cst)” .

4.4.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control, speed control, and full-closed control ● In speed control, only the torque feedforward function works

- Each feedforward that can be set using EtherCAT communication supports the control modes listed below.

○: Enabled ×: Disabled

Index	csp	pp	hm	csv	pv	cst	tq
Obj.60B1h:00h “Velocity offset”	○	○	○	○	○	×	×
Obj.60B2h:00h “Torque offset”	○	○	○	○	○	○	○

— Precautions —

- If the control mode is switched during motor operation from a control mode other than torque control mode to torque control mode, feedforward may operate even though torque control is in progress.

4.4.3 Related Parameters

—: N/A

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
1	10	B	Velocity feed forward gain	0 to 4000	0.1%	Multiply the velocity control command calculated according to the internal position command by the ratio of this parameter and add the result to the speed command resulting from the position control process.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
1	11	B	Velocity feed forward filter	0 to 6400	0.01 ms	Sets the time constant of first order lag filter which affects the input of velocity feedforward. Disabled when the set value is 0 to 3. Invalid during two-degree-of-freedom control mode.
1	12	B	Torque feed forward gain	0 to 2000	0.1%	Multiply the torque command calculated according to the velocity control command by the ratio of this parameter and add the result to the torque command resulting from the velocity control process.
1	13	B	Torque feed forward filter	0 to 6400	0.01 ms	Set the time constant of first order lag filter which affects the input of torque feedforward. Disabled when the set value is 0 to 3.

*1 For attributes, see *"7.1 Object Dictionary List"* .

4.4.4 How to Use

4.4.4.1 For Manual Setting

In the initial setting, two-degree-of-freedom control mode is set to enabled, and both Pr1.10 "Velocity feed forward gain" and Pr1.12 "Torque feed forward gain" are set to 100%.

This setting does not usually require tuning, as this value obtains the highest responsiveness if Pr0.04 "Inertia ratio" is set correctly.

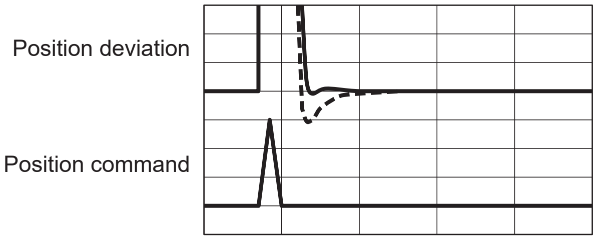
However, the value can be tuned to suppress overshoot during positioning.

Setting Pr1.10 "Velocity feed forward gain" lower suppresses position deviation overshoot during positioning. Reduce the set value by increments of 50 from 1000. Tune to the optimal value, as too small a value may increase the settling time.

On the Manual TUNING screen for Set-up Support Software (PANATERM ver.7) , Pr1.10 "Velocity feed forward gain" is linked to "Overshoot Suppression".

Image of overshoot suppression

Position deviation - Dotted line: before suppression, Solid line: after suppression

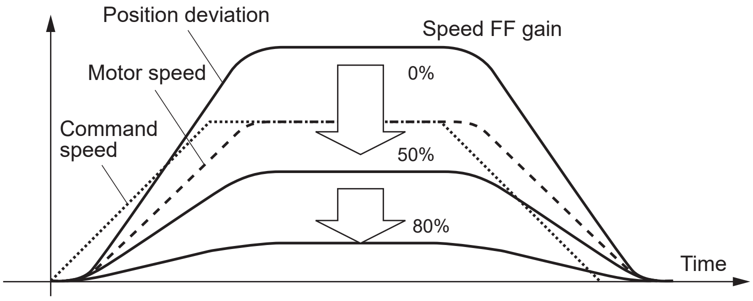


If setting Pr1.10 "Velocity feed forward gain" or Pr1.12 "Torque feed forward gain" anything other than 100%, see *"Tuning speed feedforward"* and *"Tuning torque feedforward"* below.

■ Tuning speed feedforward

With Pr1.11 "Velocity feed forward filter" set to about 50 (0.5 ms), position deviation in the constant speed range can be reduced by gradually increasing Pr1.10 "Velocity feed forward gain" .

If the speed feedforward gain is set to 100%, the calculated position deviation becomes zero, but large overshoot occurs during acceleration and deceleration. Tune the value of Pr1.10 “Velocity feed forward gain” while observing the overshoot response.



Position deviation during operation at a constant speed reduces as the velocity feed forward gain is increased.

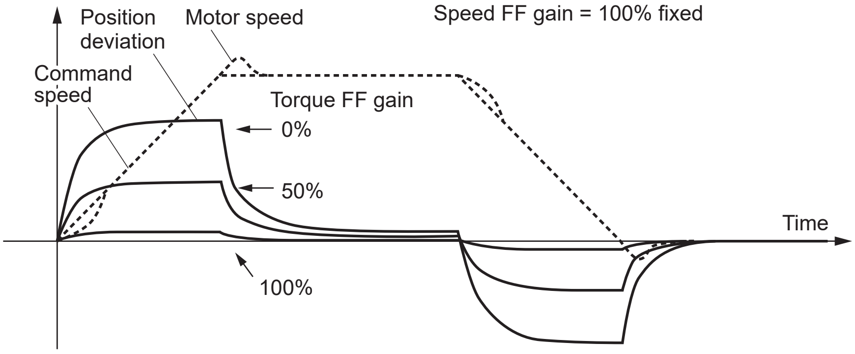
If the position command input updating cycle is longer than the servo driver control cycle, or if the input command frequency is not uniform, operation sound may become louder when speed feedforward is enabled.

In this case, apply a position command filter (1st order lag or FIR smoothing) or set a higher value for the speed feedforward filter.

■ Tuning torque feedforward

When using torque feedforward, the inertia ratio must be set correctly. Just use the estimated value from when real-time auto tuning was executed, or set Pr0.04 “Inertia ratio” to the inertia ratio that can be calculated from the mechanical specifications.

Next, with Pr1.13 “Torque feed forward filter” set to about 50 (0.5 ms), position deviation during constant acceleration and deceleration can be brought close to 0 by gradually increasing Pr1.12 “Torque feed forward gain” . Position deviation can be reduced to almost zero over the entire operating range when driving in a trapezoidal speed pattern under ideal conditions in which torque feedforward gain is set to 100% and disturbance torque is not an issue. Tune the value of Pr1.12 “Torque feed forward gain” while observing the position deviation response.



Position deviation during operation at a constant acceleration reduces as the torque feed forward gain is increased.

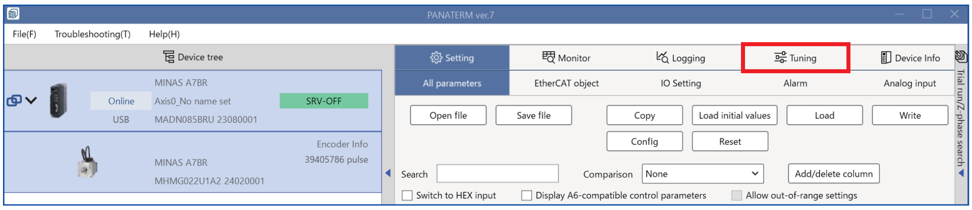
If the position command input updating cycle is longer than the servo driver control cycle, or if the input command frequency is not uniform, operation sound may become louder when speed feedforward is enabled. In this case, apply a position command filter (1st order lag or FIR smoothing) or set a higher value for the speed feedforward filter. Although operation sound decreases when the torque feedforward filter time constant is increased, the position deviation at the point of acceleration change also increases. Tune Pr1.13 “Torque feed forward filter” while observing the position deviation response.

4.4.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

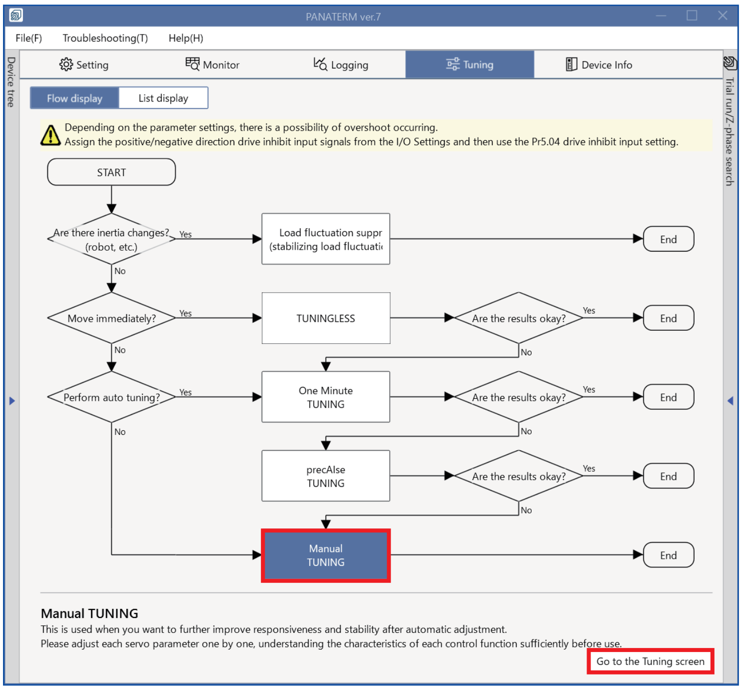
<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.

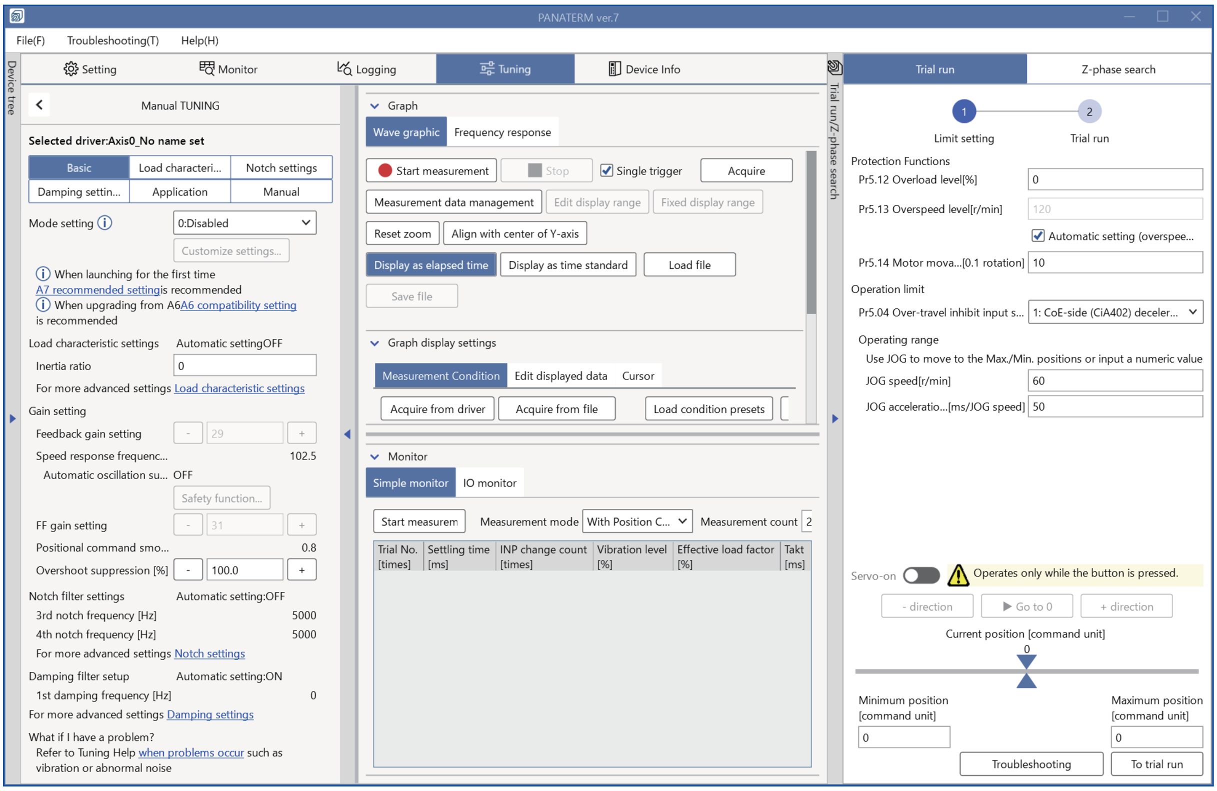


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING

This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.



Selected driver:Axis0_No name set

Mode setting: 0:Disabled

When launching for the first time
A7 recommended settingis recommended
When upgrading from A6A6 compatibility setting
is recommended

Load characteristic settings Automatic settingOFF
Inertia ratio 0
For more advanced settings Load characteristic settings

Gain setting
Feedback gain setting 29
Speed response frequenc... 102.5
Automatic oscillation su... OFF
FF gain setting 31
Positional command smo... 0.8
Overshoot suppression [%] 100.0

Notch filter settings Automatic setting:OFF
3rd notch frequency [Hz] 5000
4th notch frequency [Hz] 5000
For more advanced settings Notch settings

Damping filter setup Automatic setting:ON
1st damping frequency [Hz] 0
For more advanced settings Damping settings

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode With Position C... Measurement count 2

Trial No. [times]	Settling time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%] 0
Pr5.13 Overspeed level[r/min] 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation] 10

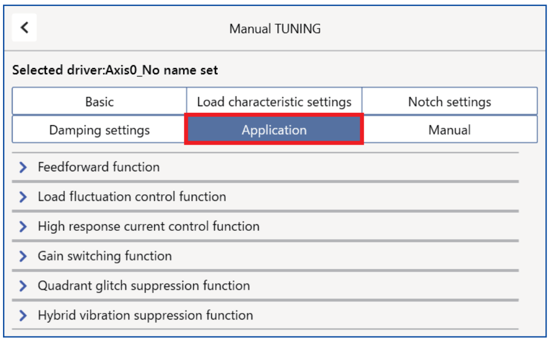
Operation limit
Pr5.04 Over-travel inhibit input s... 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min] 60
JOG acceleratio...[ms/JOG speed] 50

Operates only while the button is pressed.

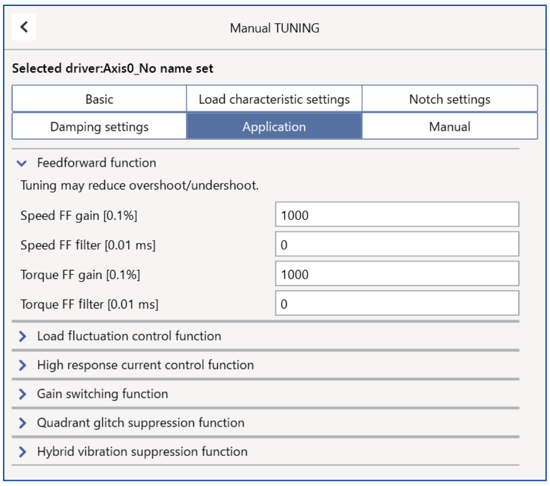
Current position [command unit] 0
Minimum position [command unit] 0
Maximum position [command unit] 0

4. Click the [Application] button.



Selected driver:Axis0_No name set

5. Click on “>” of “> Feedforward function” to expand “Feedforward Function”.



Selected driver:Axis0_No name set

Tuning may reduce overshoot/undershoot.

Speed FF gain [0.1%]	1000
Speed FF filter [0.01 ms]	0
Torque FF gain [0.1%]	1000
Torque FF filter [0.01 ms]	0

6. For details on tuning each parameter, see *“4.4.4.1 For Manual Setting”* .

4.5 Friction Torque Compensation Function

4.5.1 Function Overview

This function reduces the effect of mechanical system friction and improves responsiveness.

The following three types of friction torque compensation are possible.

Unbalanced load compensation

A constant offset value is always added to the torque command to provide friction compensation.

In situations such as when a constant unbalanced load torque is continuously applied to the motor due to gravity on a vertical axis, a torque command value is added to reduce the variation in the positioning operation caused by the direction of movement.

Dynamic friction compensation

Performs friction compensation by adding a compensation value based on positive-direction and negative-direction position commands to the torque command.

For loads that require high dynamic friction torque due to radial loads, such as a belt mechanical shaft, setting friction torque for each parameter in each rotational direction can reduce positioning settling times that are worsened or varied due to dynamic friction.

Viscous friction compensation

A compensation value proportional to the command speed is added to the torque command to provide friction compensation.

Setting a torque command value for viscous load can reduce response delay during acceleration.

4.5.2 Operational Conditions

<table>
<tr><th>Item</th><th colspan="2">Operational Conditions</th></tr>
<tr><td rowspan="5">Control mode</td><td colspan="2">● Possible modes of operation depend on the type of friction torque compensation.</td></tr>
<tr><td>Compensation description</td><td>Operable modes</td></tr>
<tr><td>Unbalanced load compensation</td><td>Position control mode, speed control mode, full-closed control mode</td></tr>
<tr><td>Dynamic friction compensation</td><td>Position control mode, full-closed control mode</td></tr>
<tr><td>Viscous friction compensation</td><td>When two-degree-of-freedom control mode is enabled in position control mode, speed control mode, or full-close control mode</td></tr>
</table>

4.5.3 Related Parameters

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	45	B	Function expansion setup 10	-2147483648 to 2147483647	—	bit 2: Friction torque compensation parameter selection 0: Use Pr6.07, Pr6.08, Pr6.09 1: Use Pr2.52, Pr2.53, Pr2.54
2	52	B	Torque command additional value 2	-1000 to 1000	0.1%	Sets the offset torque to be added to the torque command when Pr2.45: bit 2 “Friction torque compensation parameter selection” = 1.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	53	B	Positive direction torque compensation value 2	-1000 to 1000	0.1%	Sets the value to be added to the torque command during positive direction operation when Pr2.45: bit 2 “Friction torque compensation parameter selection” = 1.
2	54	B	Negative direction torque compensation value 2	-1000 to 1000	0.1%	Sets the value to be added to the torque command during negative direction operation when Pr2.45: bit 2 “Friction torque compensation parameter selection” = 1.
6	07	B	Torque command additional value	-100 to 100	%	Sets the offset torque to be added to the torque command when Pr2.45: bit 2 “Friction torque compensation parameter selection” = 0.
6	08	B	Positive direction torque compensation value	-100 to 100	%	Sets the value to be added to the torque command during positive direction operation when Pr2.45: bit 2 “Friction torque compensation parameter selection” = 0.
6	09	B	Negative direction torque compensation value	-100 to 100	%	Sets the value to be added to the torque command during negative direction operation when Pr2.45: bit 2 “Friction torque compensation parameter selection” = 0.
6	50	B	Viscous friction compensating gain	0 to 10000	0.1 %/ (10000 r /min)	When the two-degree-of-freedom control mode is enabled, the product of the command speed and the setup value is used as the viscous friction torque compensation and the torque command is added to the torque. ● Setting the value of the viscous friction coefficient estimation of real-time auto tuning can improve the encoder position deviation of the settling area.

*1 For attributes, see *“7.1 Object Dictionary List”* .

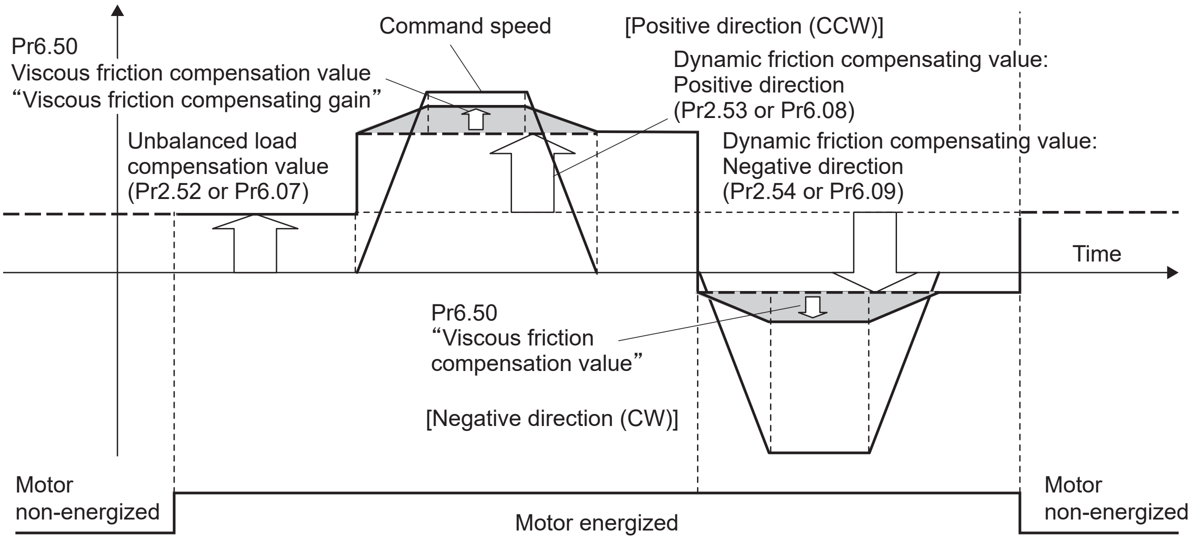
4.5.4 How to Use

Friction torque compensation is added according to the direction and speed of the input position command as shown in the figure below.

Friction torque compensation is the sum of the following three values.

- Unbalanced load compensation value set by the torque command additional value that is always constantly added
- Dynamic friction compensation value set by the positive direction torque compensation value or negative direction torque compensation value, which is added according to the command speed and direction input last
- Viscous friction compensating value added according to command speed

Command speed and direction are reset at power-up and when the motor is not energized.



— Precautions —

- Although it is possible to use both unbalanced load compensation and dynamic friction compensation in combination or individually, note that the following restrictions will apply depending on the control mode switching or servo-on status.
  - Change the parameters to be used depending on the values set in Pr2.45 "Function expansion setup 10" :bit 2 "Friction torque compensation parameter selection" . The initial value is Pr2.45: bit 2 = 1.
    - Pr2.45: bit 2=0 : Pr6.07, Pr6.08, Pr6.09
    - Pr2.45: bit 2=1 : Pr2.52, Pr2.53, Pr2.54
  - During torque control:

    Unbalanced load compensation and dynamic friction compensation are set to 0 regardless of the parameter settings.
  - During speed control and servo-off:

    Unbalanced load compensation is enabled according to Pr2.52 "Torque command additional value 2" and Pr6.07 "Torque command additional value" . Dynamic friction compensation is set to 0 regardless of the parameter setting.
  - During servo-on in position control or full-closed control:

    Until the first position command is received, the previous unbalanced load compensation and dynamic friction compensation values are retained.

    Once a position command is received, unbalanced load compensation updates according to the settings for Pr2.52 "Torque command additional value 2" and Pr6.07 "Torque command additional value" .

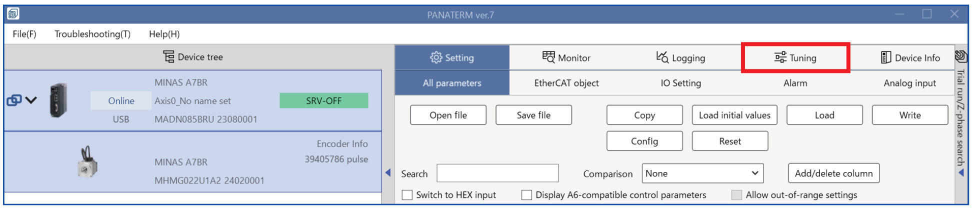
    Depending on the command direction, the dynamic friction compensation value is updated according to the positive direction (Pr2.53 "Positive direction torque compensation value 2" , Pr6.08 "Positive direction torque compensation value") or negative direction (Pr2.54 "Negative direction torque compensation value 2" , Pr6.09 "Negative direction torque compensation value") settings.

4.5.4.1 When Set-up Support Software (PANATERM ver.7) Is Used

<< Procedure >>

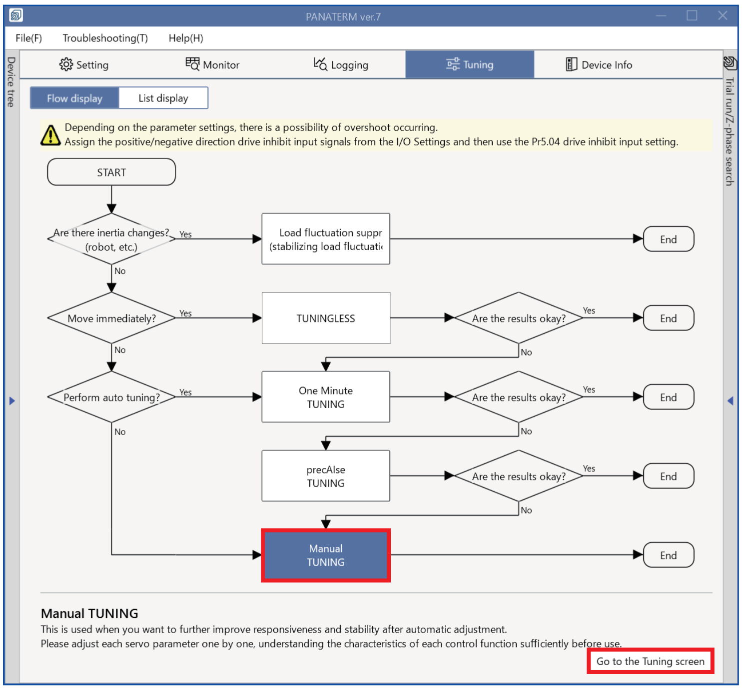
1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



MINAS A7BR
Online Axis0_No name set SRV-OFF
USB MADN085BRU 23080001
Encoder Info 39405786 pulse
MINAS A7BR
MHMG022U1A2 24020001

3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.

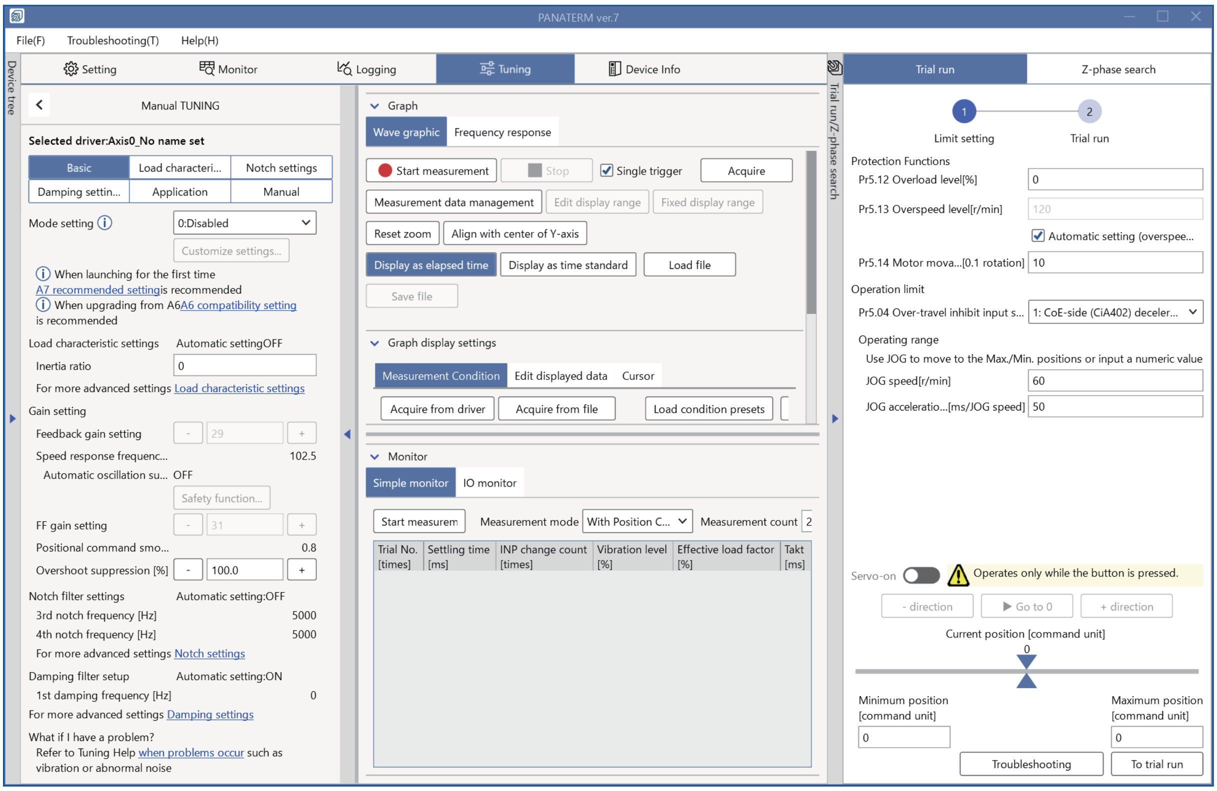


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING

This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.



Selected driver:Axis0_No name set

Mode setting 0:Disabled

When launching for the first time A7 recommended setting is recommended
When upgrading from A6 A6 compatibility setting is recommended

Load characteristic settings Automatic settingOFF
Inertia ratio 0
For more advanced settings Load characteristic settings

Gain setting
Feedback gain setting 29
Speed response frequenc... 102.5
Automatic oscillation su... OFF
FF gain setting 31
Positional command smo... 0.8
Overshoot suppression [%] 100.0

Notch filter settings Automatic setting:OFF
3rd notch frequency [Hz] 5000
4th notch frequency [Hz] 5000
For more advanced settings Notch settings

Damping filter setup Automatic setting:ON
1st damping frequency [Hz] 0
For more advanced settings Damping settings

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode With Position C... Measurement count 2

Trial No. [times]	Settling time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%] 0
Pr5.13 Overspeed level[r/min] 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation] 10

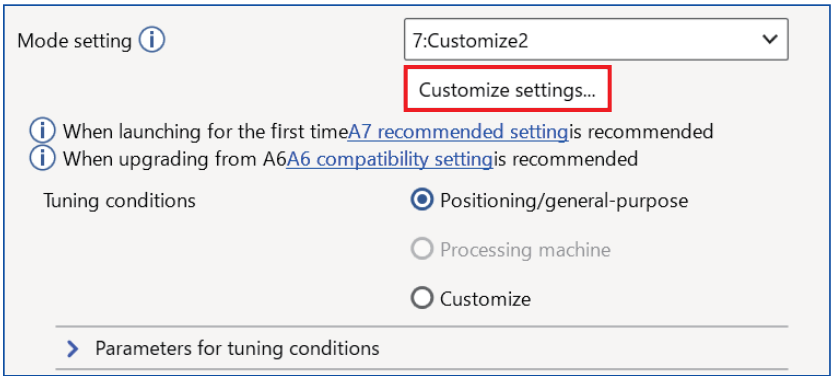
Operation limit
Pr5.04 Over-travel inhibit input s... 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min] 60
JOG acceleratio...[ms/JOG speed] 50

Servo-on
Operates only while the button is pressed.

Current position [command unit] 0
Minimum position [command unit] 0
Maximum position [command unit] 0

4. Select “Mode setting” from the drop-down list. Select “7: Customize 2” and click the [Customize settings] button.



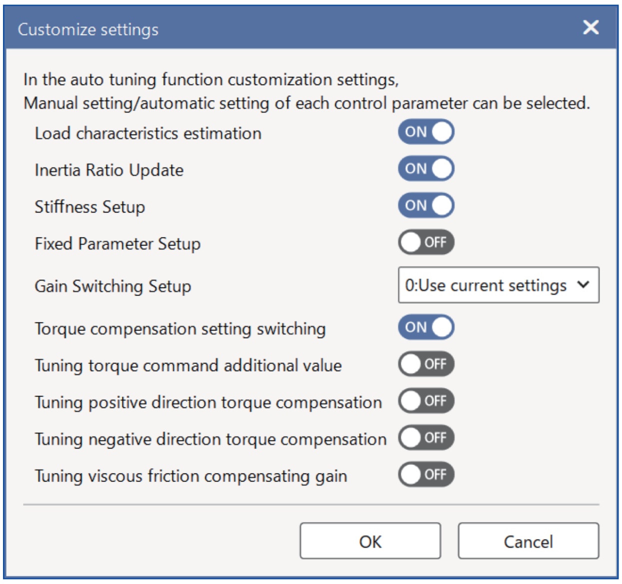
Mode setting ⓘ: 7:Customize2

ⓘ When launching for the first timeA7 recommended settingis recommended

ⓘ When upgrading from A6A6 compatibility settingis recommended

Tuning conditions:
- ● Positioning/general-purpose
- ○ Processing machine
- ○ Customize

- To set automatically, go to “Step 5”.
- To set manually, go to “Step 6” to “Step 7”.



Customize settings

In the auto tuning function customization settings,
Manual setting/automatic setting of each control parameter can be selected.

Load characteristics estimation: ON
Inertia Ratio Update: ON
Stiffness Setup: ON
Fixed Parameter Setup: OFF
Gain Switching Setup: 0:Use current settings
Torque compensation setting switching: ON
Tuning torque command additional value: OFF
Tuning positive direction torque compensation: OFF
Tuning negative direction torque compensation: OFF
Tuning viscous friction compensating gain: OFF

5. To set automatically, set all of the following items to “ON” (automatic).

- “Torque compensation setting switching” (A7 recommended setting)
- “Torque command additional value tuning”
- “Positive direction torque compensation tuning”
- “Negative direction torque compensation tuning”
- “Viscous friction compensating gain adjustment”

When setup is complete, close the screen with the [OK] button.

To finish without changing any settings, close the screen with the [Cancel] button.

Once the motor has operated for a while, estimated values for each parameter are calculated and set.

6. To set manually, set all of the following items to “OFF” (manual) and manually set the values calculated from the actual measured data.

- “Tuning torque command additional value”
- “Tuning positive direction torque compensation”
- “Tuning negative direction torque compensation”
- “Viscous friction compensating gain adjustment”

When setup is complete, close the screen with the [OK] button.

To finish without changing any settings, close the screen with the [Cancel] button.

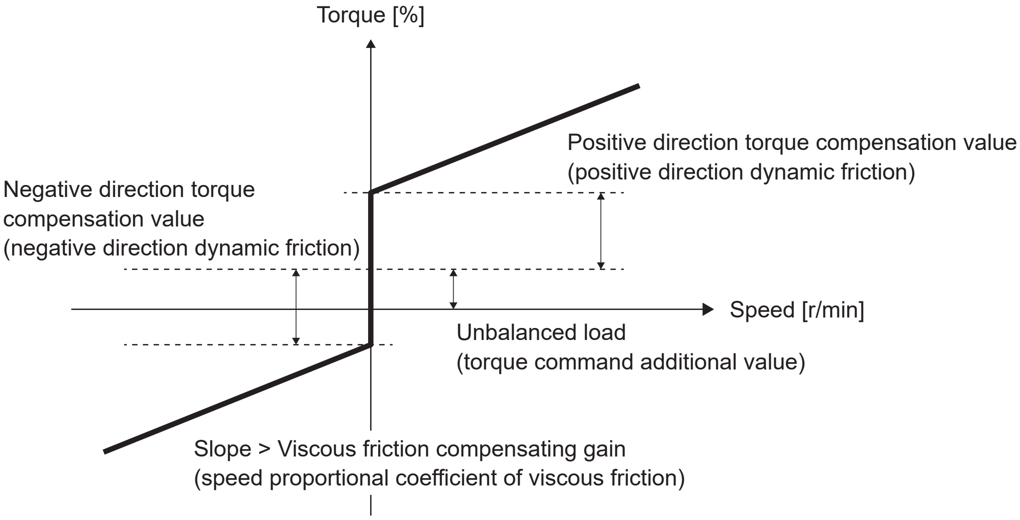
Set values for each parameter. Use the following procedure to calculate the values.

6-1 Drive the motor with an operation command that includes constant speed and use the waveform measurement function of Set-up Support Software (PANATERM ver.7) to measure the torque in the constant speed section. Measure the torque multiple times by changing this constant speed value.

6-2 Based on these measurement results, create a graph that combines speed and torque and calculate the value of each parameter.

The unit [%] of torque is a percentage of the motor rated torque.

The viscous friction compensation gain is calculated by calculating the inclination of the graph and the torque at 10000 r/min.



7. Click the [Load characteristic settings] button to display the “Load characteristic settings” screen. Set the values calculated by “Step 6”.

4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)

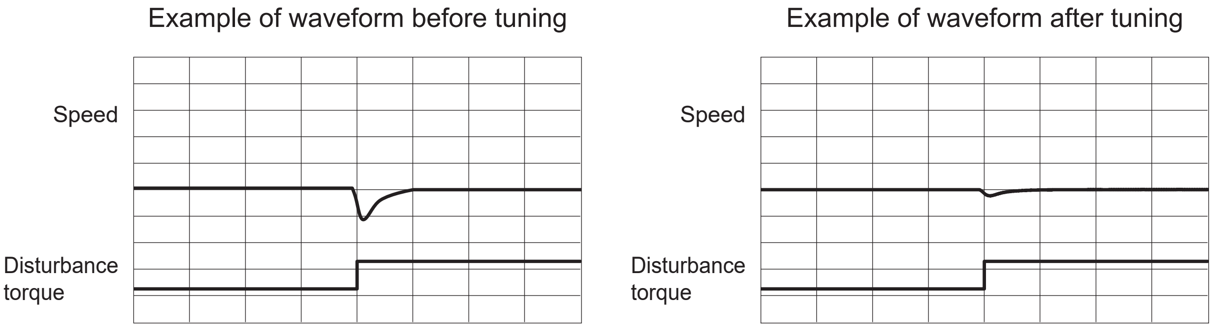
There are the following two types of load fluctuation control functions.

- Disturbance suppression applications
- Load fluctuation stabilization applications

This section describes "Disturbance Suppression Applications".

4.6.1 Function Overview

In devices with which disturbance torque is applied, velocity change may occur due to the disturbance torque. This function reduces this velocity change and improves stability. An overshoot/undershoot suppression effect may also be obtained during positioning.



4.6.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control, speed control, and full-closed control

Under the following conditions, the effect of the load fluctuation control function may not be seen.

Item	Conditions that obstruct the effectiveness of the load fluctuation control function
Load	● Low stiffness (antiresonance points exists in the low frequency range of 10 Hz or less) ● Looseness, backlash, etc. are present and the load non-linearity is strong

4.6.3 Related Parameters

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	45	A	Function expansion setup 10	-2147483648 to 2147483647	—	Sets automatic calculation of parameters for load fluctuation suppression. bit 3: Load fluctuation suppression function automatic calculation 0: Conventional setting (MINAS A6 Series specification) 1: The following parameters are automatically calculated Pr6.73 "Load estimation filter" Pr6.76 "Load estimation count"

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	10	B	Function expansion setup	-32768 to 32767	—	Sets the load fluctuation suppression function. bit 1: Load fluctuation control function 0: Disabled 1: Enabled bit 2: Load fluctuation stabilization setting 0: Disabled 1: Enabled bit 14: Load fluctuation suppression function automatic tuning 0: Disabled 1: Enabled **Notes** ● Depending on the settings for two-degree-of-freedom control and real-time auto tuning, bit 1 may be set automatically according to the setting for bit 14.
6	23	B	Load change compensation gain	-100 to 100	%	Sets compensation gain with respect to load fluctuation.
6	24	B	Load change compensation filter	10 to 2500	0.01 ms	Sets filter time constant with respect to load fluctuation. Disabled when the set value is 0 to 3.
6	73	B	Load estimation filter	0 to 2500	0.01 ms	Sets filter time constant for load estimation. Disabled when the set value is 0 to 3.
6	74	B	Torque compensation frequency 1	0 to 5000	0.1 Hz	Sets filter frequency 1 with respect to velocity control output. Torque compensation is valid when the relationship between Pr6.74 “Torque compensation frequency 1” and Pr6.75 “Torque compensation frequency 2” is within the range of the following formula. 1.0 Hz ≤ Pr6.75 ＜ Pr6.74 ≤ (Pr6.75 × 32)
6	75	B	Torque compensation frequency 2	0 to 5000	0.1 Hz	Sets filter frequency 2 with respect to velocity control output. Torque compensation is valid when the relationship between Pr6.74 “Torque compensation frequency 1” and Pr6.75 “Torque compensation frequency 2” is within the range of the following formula. 1.0 Hz ≤ Pr6.75 ＜ Pr6.74 ≤ (Pr6.75 × 32)
6	76	B	Load estimation count	0 to 8	—	Sets count relating to load estimation.

*1 For attributes, see *“7.1 Object Dictionary List”* .

4.6.4 How to Use

4.6.4.1 For Manual Setting

<< Procedure >>

1. Operate the motor with Pr0.02 “Real-time auto-gain tuning setup” enabled and the load fluctuation control function disabled (Pr6.10 bit 1 = 0). Increase the stiffness settings (Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2” , Pr0.03 “Real-time auto-tuning machine stiffness setup”) by increments of 1 to the largest possible values.

2. After setting the load fluctuation suppression function automatic setting to enable (Pr6.10 “Function expansion setup” :bit 14 = 1), operate the motor to check the disturbance suppression effect.

   — Precautions —

   - To enable or disable load fluctuation suppression function automatic setting, turn the servo off once.
   - If this change causes the motor to oscillate or make abnormal noises, go back to “Step 1”, reduce the servo stiffness by one or two steps, and repeat the procedure thereafter.

3. If the disturbance suppression effect is insufficient and further tuning is required, perform the following operations.

   - Set Pr0.02 “Real-time auto-gain tuning setup” = 0 (disabled).
   - Set Pr6.10 “Function expansion setup” :bit 14 = 0 to enable load fluctuation suppression function automatic tuning.
   - Reduce the set value for Pr6.24 “Load change compensation filter” . The set value should be changed by decreasing by 10% at a time.

     By reducing the filter setting within the range where abnormal noise and torque command fluctuations are not noticeable, disturbance suppression performance is improved, resulting in smaller motor speed fluctuation and encoder position deviation. During positioning, the following effects may be obtained.

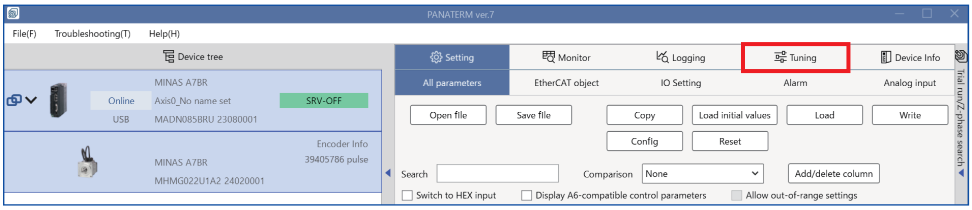
     - Overshoot/undershoot suppression
     - Velocity fluctuation suppression during constant speed control
     - Improved disturbance suppression performance
   - If high frequency (1 kHz or higher) abnormal noise is generated, increase Pr6.76 “Load estimation count” by increments of 1. Set an appropriate value as too large a value may result in unstable control.
   - If low frequency (10 Hz or less) vibration is generated, after stopping, for example, decrease Pr6.23 “Load change compensation gain” by increments of 5.
   - Pr6.73 “Load estimation filter” does not normally need to be changed, but may be fine-tuned to an optimal point between 0.00 and 0.20 ms.

4.6.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

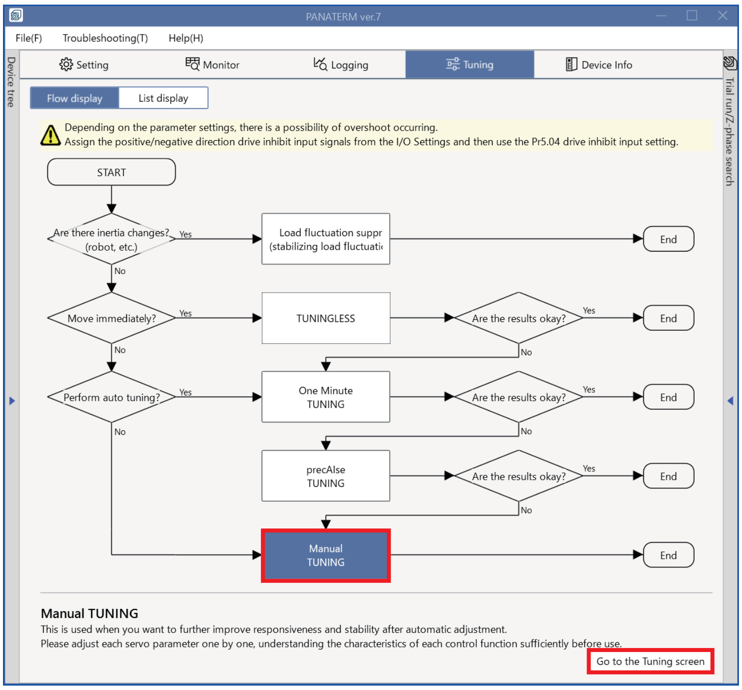
<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



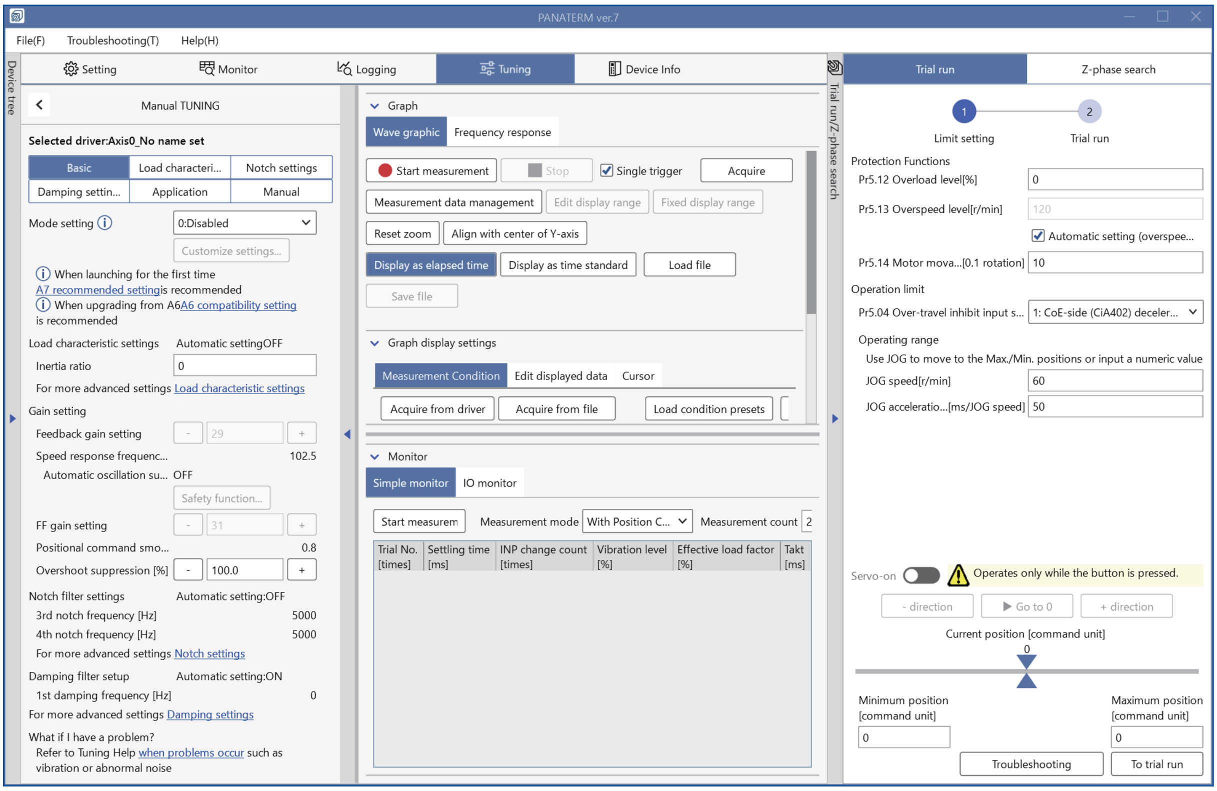
3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.



Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING
This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.



Selected driver:Axis0_No name set

Mode setting 0:Disabled

When launching for the first time
A7 recommended settingis recommended
When upgrading from A6A6 compatibility setting
is recommended

Load characteristic settings Automatic settingOFF
Inertia ratio 0
For more advanced settings Load characteristic settings
Gain setting
Feedback gain setting 29
Speed response frequenc... 102.5
Automatic oscillation su... OFF
FF gain setting 31
Positional command smo... 0.8
Overshoot suppression [%] 100.0
Notch filter settings Automatic setting:OFF
3rd notch frequency [Hz] 5000
4th notch frequency [Hz] 5000
For more advanced settings Notch settings
Damping filter setup Automatic setting:ON
1st damping frequency [Hz] 0
For more advanced settings Damping settings
What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

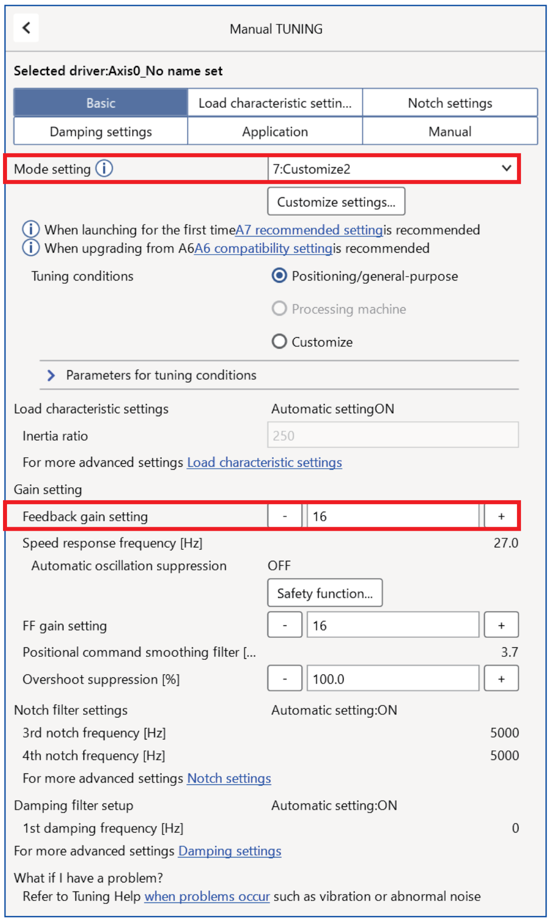
Measurement mode With Position C... Measurement count 2

Protection Functions
Pr5.12 Overload level[%] 0
Pr5.13 Overspeed level[r/min] 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation] 10
Operation limit
Pr5.04 Over-travel inhibit input s... 1: CoE-side (CiA402) deceler...
Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min] 60
JOG acceleratio...[ms/JOG speed] 50

Operates only while the button is pressed.

Current position [command unit] 0
Minimum position [command unit] 0
Maximum position [command unit] 0

4. After changing “Mode setting” to a mode that enables real-time auto tuning, operate the motor. Increase the “Feedback gain setting” by increments of 1 and set as large a value as possible.



Selected driver:Axis0_No name set

Mode setting: 7:Customize2

When launching for the first timeA7 recommended settingis recommended

When upgrading from A6A6 compatibility settingis recommended

Tuning conditions
- ● Positioning/general-purpose
- ○ Processing machine
- ○ Customize

Parameters for tuning conditions

Load characteristic settings: Automatic settingON

Inertia ratio: 250

For more advanced settings Load characteristic settings

Gain setting

Feedback gain setting: 16

Speed response frequency [Hz]: 27.0

Automatic oscillation suppression: OFF

FF gain setting: 16

Positional command smoothing filter [...: 3.7

Overshoot suppression [%]: 100.0

Notch filter settings: Automatic setting:ON

3rd notch frequency [Hz]: 5000

4th notch frequency [Hz]: 5000

For more advanced settings Notch settings

Damping filter setup: Automatic setting:ON

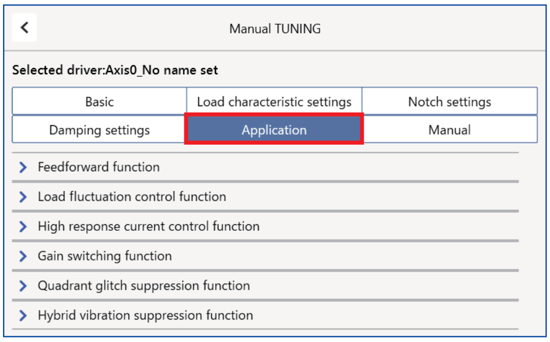
1st damping frequency [Hz]: 0

For more advanced settings Damping settings

What if I have a problem?

Refer to Tuning Help when problems occur such as vibration or abnormal noise

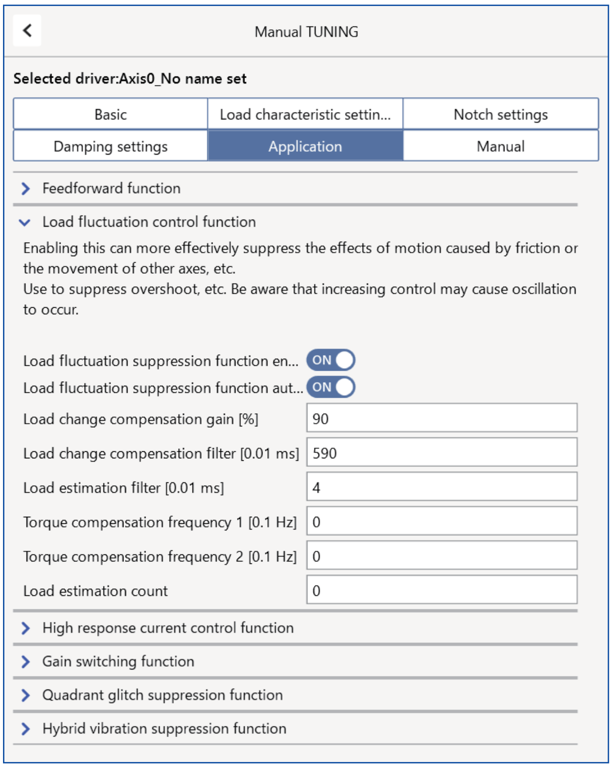
5. Click the [Application] button.



Selected driver:Axis0_No name set

- Feedforward function
- Load fluctuation control function
- High response current control function
- Gain switching function
- Quadrant glitch suppression function
- Hybrid vibration suppression function

6. Click “>” of “> Load fluctuation control function” to expand “Load fluctuation control function”.



Selected driver:Axis0_No name set

Load fluctuation control function

Enabling this can more effectively suppress the effects of motion caused by friction or the movement of other axes, etc.
Use to suppress overshoot, etc. Be aware that increasing control may cause oscillation to occur.

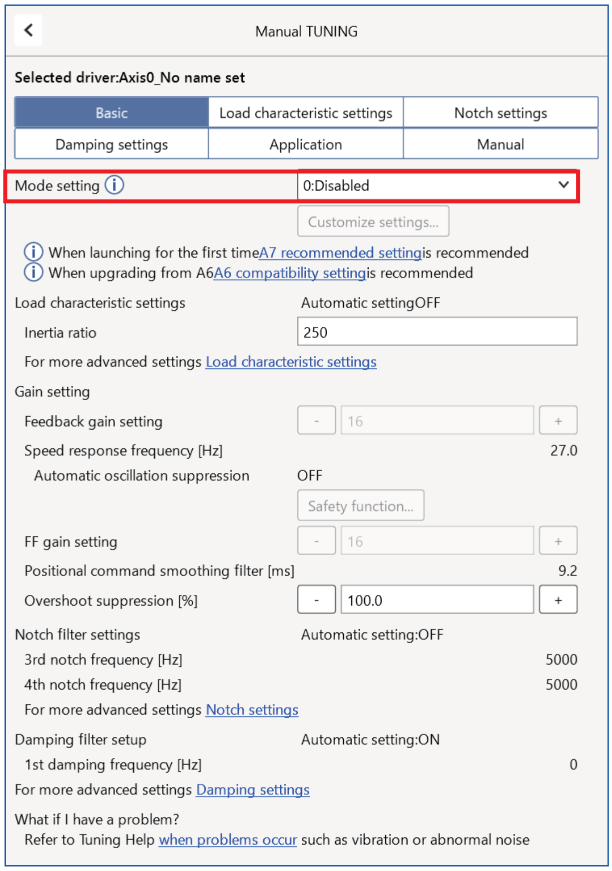
Load fluctuation suppression function en...	ON
Load fluctuation suppression function aut...	ON
Load change compensation gain [%]	90
Load change compensation filter [0.01 ms]	590
Load estimation filter [0.01 ms]	4
Torque compensation frequency 1 [0.1 Hz]	0
Torque compensation frequency 2 [0.1 Hz]	0
Load estimation count	0

7. After setting “Load fluctuation suppression function automatic tuning” to ON, operate the motor to check the disturbance suppression effect.

— Precautions —

- When switching “Load fluctuation suppression function automatic tuning” from OFF to ON, turn the servo off once.
- If the motor oscillates or makes an abnormal noise after this tuning, click the [Basic] button to return to the “Manual TUNING” screen. After lowering the feedback gain setting by one or two steps on the “Manual TUNING” screen, run the motor again to check the disturbance suppression effect.
- Changing the feedback gain setting changes several parameters, including the speed loop gain. Save previous parameters if necessary.

8. If the disturbance suppression effect is insufficient and further tuning is required, perform the following operations.
    - Click the [Basic] button and set “Mode setting” to “0: disabled”.



Selected driver:Axis0_No name set

Mode setting: 0:Disabled

When launching for the first timeA7 recommended settingis recommended

When upgrading from A6A6 compatibility settingis recommended

Load characteristic settings: Automatic settingOFF

Inertia ratio: 250

For more advanced settings Load characteristic settings

Gain setting

Feedback gain setting: 16

Speed response frequency [Hz]: 27.0

Automatic oscillation suppression: OFF

FF gain setting: 16

Positional command smoothing filter [ms]: 9.2

Overshoot suppression [%]: 100.0

Notch filter settings: Automatic setting:OFF

3rd notch frequency [Hz]: 5000

4th notch frequency [Hz]: 5000

For more advanced settings Notch settings

Damping filter setup: Automatic setting:ON

1st damping frequency [Hz]: 0

For more advanced settings Damping settings

What if I have a problem?

Refer to Tuning Help when problems occur such as vibration or abnormal noise

- After clicking on the [Application] button, click “>” of “Load fluctuation control function” to expand “Load fluctuation control function”.
- After setting “Load fluctuation suppression function automatic tuning” to OFF, set Load change compensation filter as small as possible. The set value should be changed by decreasing by 10% at a time.
- If high frequency (1 kHz or higher) abnormal noise is generated, increase Load estimation count by increments of 1. Set an appropriate value, as too large a value may result in unstable control.
- If low frequency (10 Hz or less) vibration is generated, after stopping, for example, decrease Load change compensation gain by increments of 5.
- Load estimation filter does not normally need to be changed, but may be fine-tuned to an optimal point between 0.00 and 0.20 ms.

4.7 Load Fluctuation Control Function (Load Fluctuation Stabilization Applications)

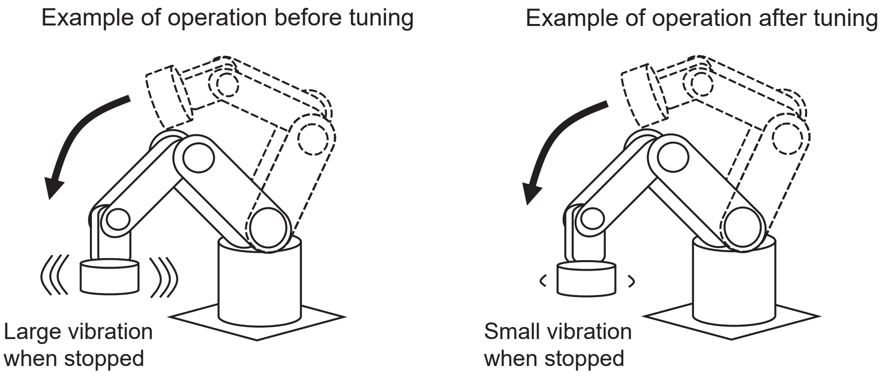
There are the following two types of load fluctuation control functions.

- Disturbance suppression applications
- Load fluctuation stabilization applications

This section describes “Load Fluctuation Stabilization Applications”.

4.7.1 Function Overview

In devices where load inertia fluctuates, vibration may occur due to the effect of load inertia fluctuations. This function reduces this vibration and improves stability.



4.7.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control, speed control, and full-closed control

Under the following conditions, the effect of the load fluctuation control function may not be seen.

Item	Conditions that obstruct the effectiveness of the load fluctuation control function
Load	● Low stiffness (antiresonance points exists in the low frequency range of 10 Hz or less) ● Looseness, backlash, etc. are present and the load non-linearity is strong

4.7.3 Related Parameters

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	45	A	Function expansion setup 10	-2147483648 to 2147483647	—	Sets automatic calculation of parameters for load fluctuation suppression. bit 3: Load fluctuation suppression function automatic calculation 0: Conventional setting (MINAS A6 Series specification) 1: The following parameters are automatically calculated Pr6.73 “Load estimation filter” Pr6.76 “Load estimation count”
6	10	B	Function expansion setup	-32768 to 32767	—	Sets the load fluctuation suppression function. bit 1: Load fluctuation control function 0: Disabled 1: Enabled bit 2: Load fluctuation stabilization setting 0: Disabled 1: Enabled bit 14: Load fluctuation suppression function automatic tuning 0: Disabled 1: Enabled **Notes** ● Depending on the settings for two-degree-of-freedom control and real-time auto tuning, bit 1 may be set automatically according to the setting for bit 14.
6	23	B	Load change compensation gain	-100 to 100	%	Sets compensation gain with respect to load fluctuation.
6	24	B	Load change compensation filter	10 to 2500	0.01 ms	Sets filter time constant with respect to load fluctuation. Disabled when the set value is 0 to 3.
6	73	B	Load estimation filter	0 to 2500	0.01 ms	Sets filter time constant for load estimation. Disabled when the set value is 0 to 3.
6	74	B	Torque compensation frequency 1	0 to 5000	0.1 Hz	Sets filter frequency 1 with respect to velocity control output. Torque compensation is valid when the relationship between Pr6.74 “Torque compensation frequency 1” and Pr6.75 “Torque compensation frequency 2” is within the range of the following formula. 1.0 Hz ≤ Pr6.75 ＜ Pr6.74 ≤ (Pr6.75 × 32)
6	75	B	Torque compensation frequency 2	0 to 5000	0.1 Hz	Sets filter frequency 2 with respect to velocity control output. Torque compensation is valid when the relationship between Pr6.74 “Torque compensation frequency 1” and Pr6.75 “Torque compensation frequency 2” is within the range of the following formula. 1.0 Hz ≤ Pr6.75 ＜ Pr6.74 ≤ (Pr6.75 × 32)

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	76	B	Load estimation count	0 to 8	—	Sets count relating to load estimation.

*1 For attributes, see *"7.1 Object Dictionary List"* .

4.7.4 How to Use

4.7.4.1 For Manual Setting

<< Procedure >>

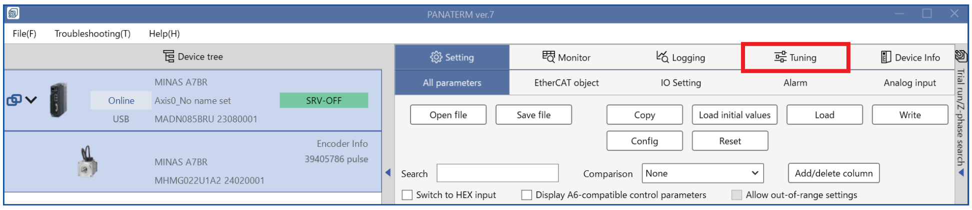
1. Set to two-degree-of-freedom position control mode (synchronization type) (Pr0.01 “Control mode setup” = 0, Pr6.47 “Function expansion setup 2” :bit 0 = 1 bit 3 = 1), and then turn on control power.
2. Set Pr2.22 “Positional command smoothing filter” to 10.0 ms.
3. Set real-time auto tuning to load fluctuation support mode (Pr0.02 “Real-time auto-gain tuning setup” = 6) (this sets Pr6.10 “Function expansion setup” :bit 1 and bit 2 to 1) and operate the motor in a pattern that generates as large a load fluctuation as possible in this state.
4. Increase the stiffness settings (Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2” , Pr0.03 “Real-time auto-tuning machine stiffness setup”) by increments of 1 to the largest possible values.
5. While checking the motor response, change the Pr2.22 “Positional command smoothing filter” value to a small value and set so that the motor response vibration is smaller.

   If locus control for multiple axes is required, tune Pr2.22 “Positional command smoothing filter” for all axes, changing them to the same value.

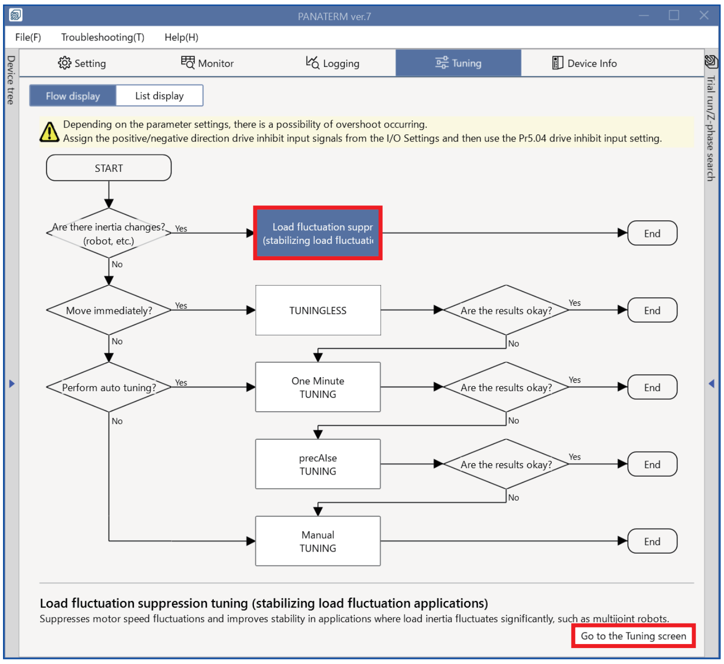
4.7.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .
2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Load fluctuation suppression tuning (Load fluctuation stabilization applications)”, and click the [Go to the Tuning screen] button.

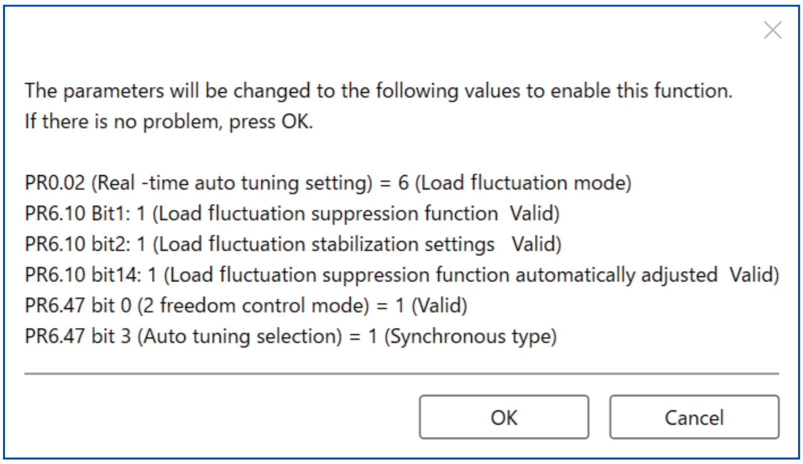


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Load fluctuation suppression tuning (stabilizing load fluctuation applications)
Suppresses motor speed fluctuations and improves stability in applications where load inertia fluctuates significantly, such as multijoint robots.

A dialog box for enabling the load fluctuation control function is displayed.

4. Check the contents, and click the [OK] button or [Cancel] button.

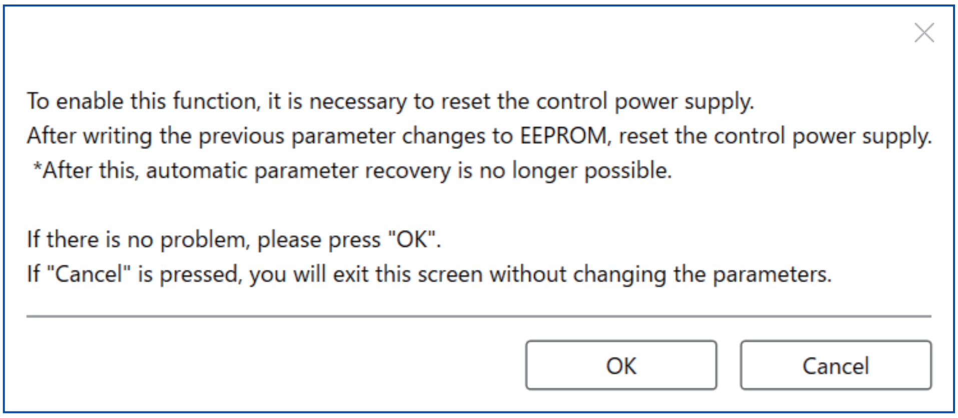


The parameters will be changed to the following values to enable this function.
If there is no problem, press OK.

PR0.02 (Real -time auto tuning setting) = 6 (Load fluctuation mode)
PR6.10 Bit1: 1 (Load fluctuation suppression function Valid)
PR6.10 bit2: 1 (Load fluctuation stabilization settings Valid)
PR6.10 bit14: 1 (Load fluctuation suppression function automatically adjusted Valid)
PR6.47 bit 0 (2 freedom control mode) = 1 (Valid)
PR6.47 bit 3 (Auto tuning selection) = 1 (Synchronous type)

— Precautions —

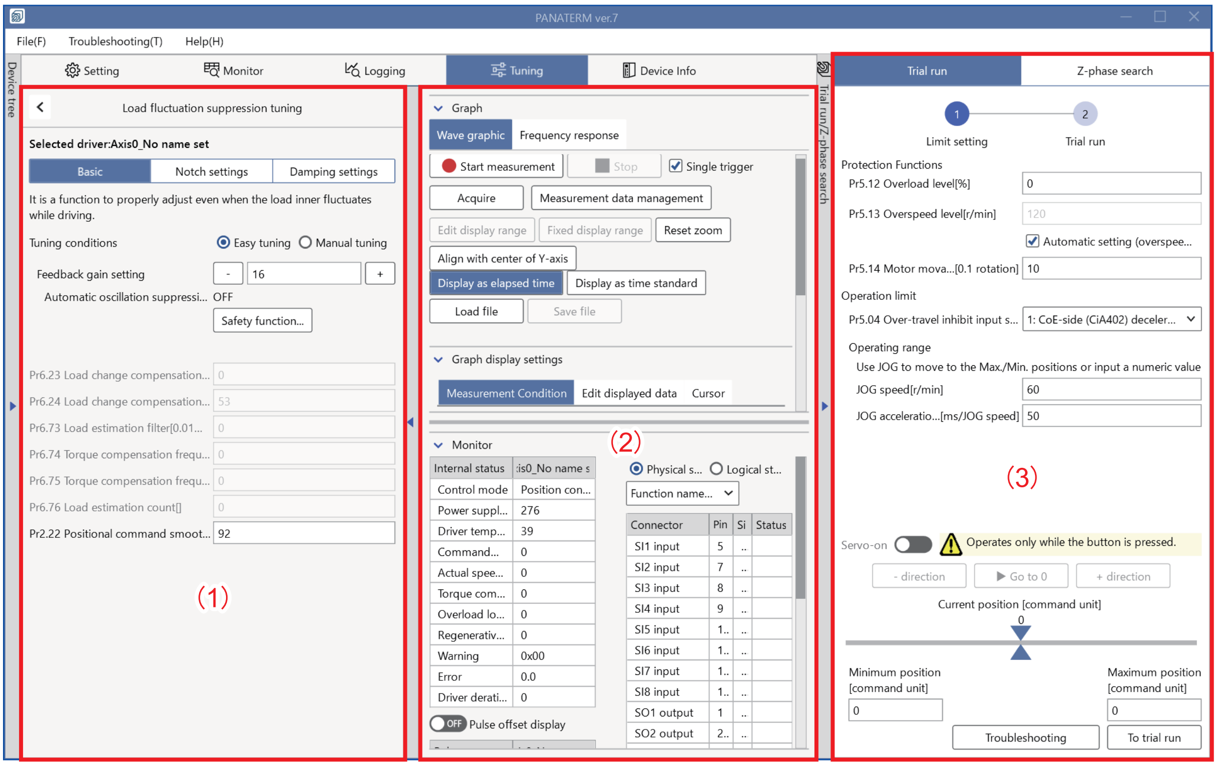
- If the power needs to be restored, the following dialog box is displayed.
  Check the contents, and click the [OK] button or [Cancel] button.



To enable this function, it is necessary to reset the control power supply.
After writing the previous parameter changes to EEPROM, reset the control power supply.
*After this, automatic parameter recovery is no longer possible.

If there is no problem, please press "OK".
If "Cancel" is pressed, you will exit this screen without changing the parameters.

The load fluctuation suppression tuning screen is displayed.



Selected driver:Axis0_No name set

It is a function to properly adjust even when the load inner fluctuates while driving.

Tuning conditions ● Easy tuning ○ Manual tuning

Feedback gain setting 16

Automatic oscillation suppressi... OFF

Pr6.23 Load change compensation...	0
Pr6.24 Load change compensation...	53
Pr6.73 Load estimation filter[0.01...	0
Pr6.74 Torque compensation frequ...	0
Pr6.75 Torque compensation frequ...	0
Pr6.76 Load estimation count[]	0
Pr2.22 Positional command smoot...	92

Internal status	:is0_No name s
Control mode	Position con...
Power suppl...	276
Driver temp...	39
Command...	0
Actual spee...	0
Torque com...	0
Overload lo...	0
Regenerativ...	0
Warning	0x00
Error	0.0
Driver derati...	0

Connector	Pin	Si	Status
SI1 input	5	..	
SI2 input	7	..	
SI3 input	8	..	
SI4 input	9	..	
SI5 input	1..	..	
SI6 input	1..	..	
SI7 input	1..	..	
SI8 input	1..	..	
SO1 output	1	..	
SO2 output	2..	..	

Protection Functions

Pr5.12 Overload level[%]	0
Pr5.13 Overspeed level[r/min]	120

☑ Automatic setting (overspee...

Pr5.14 Motor mova...[0.1 rotation]	10

Operation limit

Pr5.04 Over-travel inhibit input s...	1: CoE-side (CiA402) deceler...

Operating range

Use JOG to move to the Max./Min. positions or input a numeric value

JOG speed[r/min]	60
JOG acceleratio...[ms/JOG speed]	50

Operates only while the button is pressed.

Current position [command unit] 0

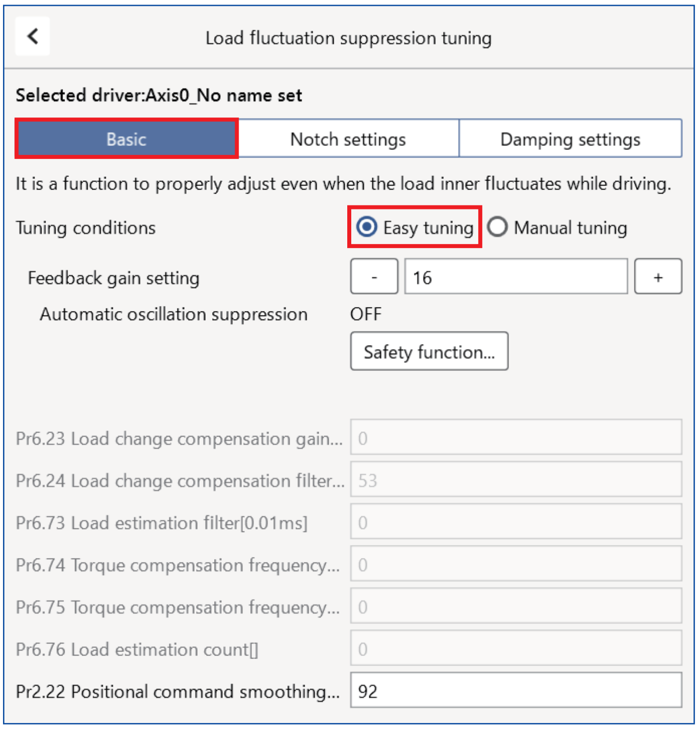
Minimum position [command unit] 0

Maximum position [command unit] 0

(1)	This is the main screen. This displays the parameter tuning screen.
(2)	This displays the waveform measurement and frequency response measurement screens.
(3)	This displays the trial run operation screen.

The following describes tuning with focus on the operations on the main screen (left side of the screen).

5. Click the [Basic] button and then select “Easy tuning” for the tuning condition.



Selected driver:Axis0_No name set

It is a function to properly adjust even when the load inner fluctuates while driving.

Tuning conditions ● Easy tuning ○ Manual tuning

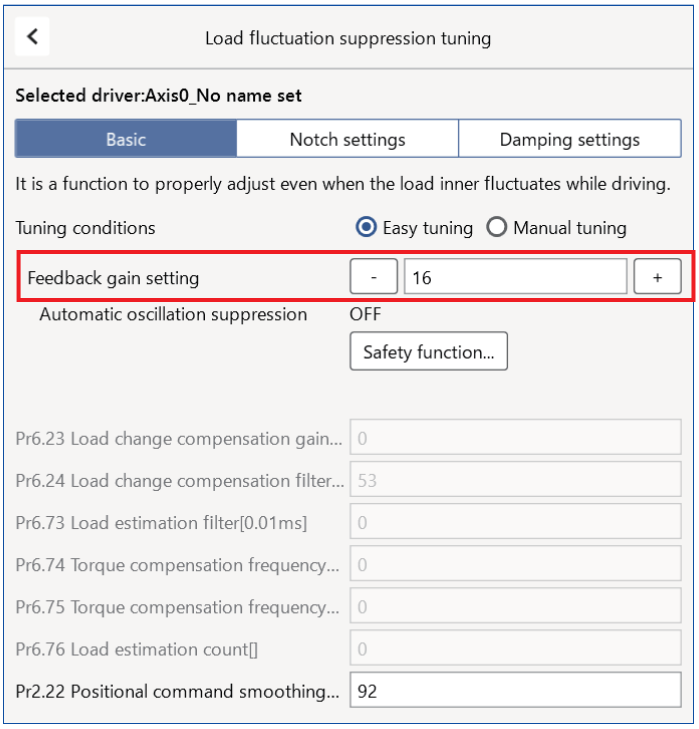
Feedback gain setting 16

Automatic oscillation suppression OFF

Pr6.23 Load change compensation gain...	0
Pr6.24 Load change compensation filter...	53
Pr6.73 Load estimation filter[0.01ms]	0
Pr6.74 Torque compensation frequency...	0
Pr6.75 Torque compensation frequency...	0
Pr6.76 Load estimation count[]	0
Pr2.22 Positional command smoothing...	92

6. In order to generate as large a load fluctuation as possible, the motor is operated in multiple patterns using the trial run function or via commands from the host device.

7. Check the motor operation by waveform measurement while gradually changing the feedback gain setting to a higher value. Tune so that motor response vibration is reduced in any operation pattern. If “Easy tuning” does not satisfy the response performance, proceed to “Step 8”.



Selected driver:Axis0_No name set

It is a function to properly adjust even when the load inner fluctuates while driving.

Tuning conditions ● Easy tuning ○ Manual tuning

Feedback gain setting 16

Automatic oscillation suppression OFF

Pr6.23 Load change compensation gain... 0

Pr6.24 Load change compensation filter... 53

Pr6.73 Load estimation filter[0.01ms] 0

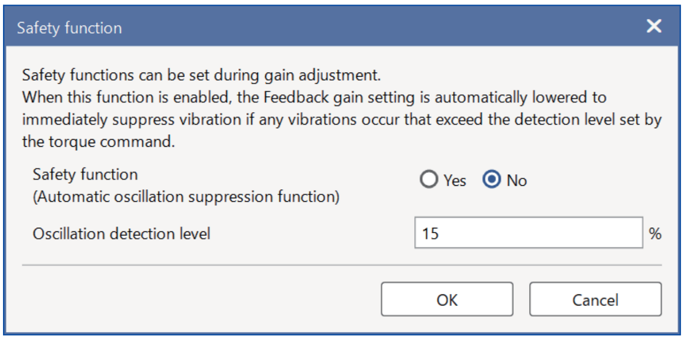
Pr6.74 Torque compensation frequency... 0

Pr6.75 Torque compensation frequency... 0

Pr6.76 Load estimation count[] 0

Pr2.22 Positional command smoothing... 92

A safety function (for automatically lowering the set value to eliminate oscillation when tuning is in progress) can be set. To set, click the [Safety function] button. The “Safety function” dialog box is displayed. “Enable (Yes)” or “Disable (No)” can be selected for the safety function. When enabled, the “Oscillation detection level” can be set.



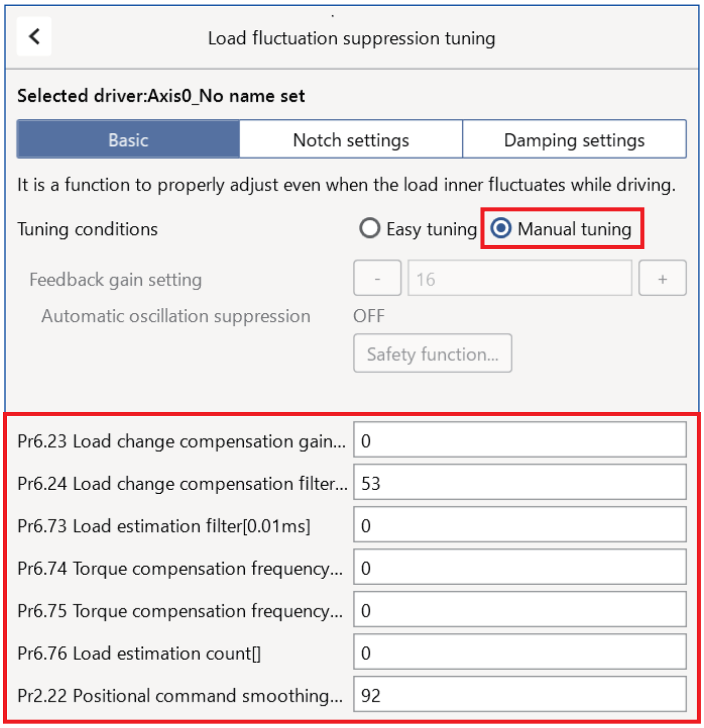
Safety functions can be set during gain adjustment.
When this function is enabled, the Feedback gain setting is automatically lowered to immediately suppress vibration if any vibrations occur that exceed the detection level set by the torque command.

Safety function (Automatic oscillation suppression function) ○ Yes ● No

Oscillation detection level 15 %

8. Select “Manual tuning” for the tuning condition.

The parameters at the bottom of the screen can now be changed. Tune these parameters.



Selected driver:Axis0_No name set

It is a function to properly adjust even when the load inner fluctuates while driving.

Tuning conditions ○ Easy tuning ● Manual tuning

Feedback gain setting - 16 +

Automatic oscillation suppression OFF

Pr6.23 Load change compensation gain...	0
Pr6.24 Load change compensation filter...	53
Pr6.73 Load estimation filter[0.01ms]	0
Pr6.74 Torque compensation frequency...	0
Pr6.75 Torque compensation frequency...	0
Pr6.76 Load estimation count[]	0
Pr2.22 Positional command smoothing...	92

Lower the set value for Pr2.22 “Positional command smoothing filter” while checking the motor response. The set value should be changed by decreasing by 10% at a time to decrease motor response vibration.

- If locus control for multiple axes is required, tune Pr2.22 “Positional command smoothing filter” for all axes, changing them to the same value.
- If high frequency (1 kHz or higher) abnormal noise is generated, increase Pr6.76 “Load estimation count” by increments of 1.
- If low frequency (10 Hz or less) vibration is generated, after stopping, for example, decrease Pr6.23 “Load change compensation gain” by increments of 5.
- Pr6.73 “Load estimation filter” does not normally need to be changed, but may be fine-tuned to an optimal point between 0.00 and 0.20 ms.

Notes

- If sounds or vibrations of specific frequencies occur in the high frequency range when tuning is in progress, these may be suppressed by tuning the notch filter. Select the [Notch settings] button at the top of the main screen and tune the notch filter parameters. For details, see *“5.3 Notch Filter Function”* .
- Residual vibration that occurs at the moving part tip or the overall device when tuning is in progress may be suppressed by tuning the damping filter or model-type damping filter. Select the [Damping settings] button at the top of the main screen and tune the damping filter and model-type damping filter parameters. For details, see *“5.5 Damping Control Function”* and *“5.6 Model-type Damping Filter Function”* .

4.8 High Response Current Control Function

4.8.1 Function Overview

This function improves the responsiveness of the current controller by changing the current response setting to a value greater than the initial value in order to improve the current control responsiveness when operating at low current, such as with a processing machine. Improved current response may provide the following effects during positioning

- Overshoot/undershoot suppression
- Velocity fluctuation suppression during constant speed control
- Improved disturbance suppression performance

Changing the current response setting to a value smaller than the initial value enables this to also be used for suppressing fine vibration when stopped.

4.8.2 Operational Conditions

Item	Operational Conditions
Control mode	● All control modes

4.8.3 Related Parameters

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	11	B	Current loop gain response setup	10 to 300	%	Tunes the current response with the current response default as 100%.
6	121	B	Current feed forward response setup	0 to 300	%	Tunes the current feedforward response with the current feedforward response default as 100%.

*1 For attributes, see *“7.1 Object Dictionary List”* .

— Precautions —

- Setting Pr6.11 “Current loop gain response setup” and Pr6.121 “Current feed forward response setup” to values greater than 100% of the initial values can cause vibration and noise. As with tuning of the position control part and speed control part, tune to the appropriate values according to the operating status of the applicable device.
- Changing Pr6.11 “Current loop gain response setup” and Pr6.121 “Current feed forward response setup” to values smaller than 100% of the initial values reduces the responsiveness of the current control part.
- Although the maximum value in the setting range for Pr6.11 “Current loop gain response setup” and Pr6.121 “Current feed forward response setup” is 300%, the maximum value capable of being set will depend on the motor and may be less than 300%. The set value is limited by the maximum value that can be set for the motor (Pr6.11 and Pr6.121 are different limit values, even though they are for one motor). Check the parameters after input.
- The parameter name for Pr6.11 is “Current response setting” for the MINAS A6B Series, but was changed to “Current loop gain response setup” from the MINAS A7B Series.

  If the value is 100% or higher, the responsiveness is the same as for the MINAS A6BSeries. If the value is 99% or less, set Pr6.121 “Current feed forward response setup” to 0% to obtain responsiveness equivalent to the MINAS A6B Series.

4.8.4 How to Use

4.8.4.1 For Manual Setting

- To improve current responsiveness

  Set Pr6.11 “Current loop gain response setup” and Pr6.121 “Current feed forward response setup” to values greater than 100% within the range where no noise or vibration is generated, while observing the operating status of the applicable equipment. The set value should be changed by increasing by 30% at a time.

- To suppress fine vibration when stopped

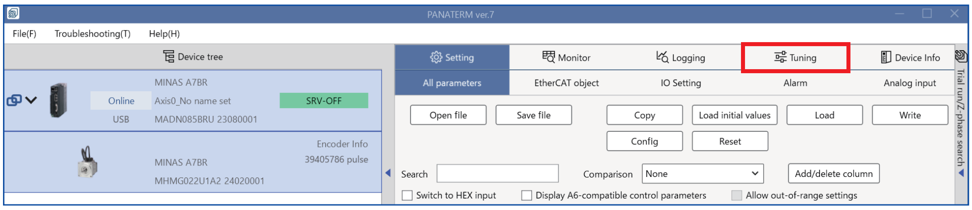
  Set Pr6.11 “Current loop gain response setup” to less than 100% while observing the operating status of the applicable device. The set value should be changed by decreasing by 10% at a time. If the value is set too low, control may become unstable. Set the value within the range that does not cause problems in actual operation.

4.8.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

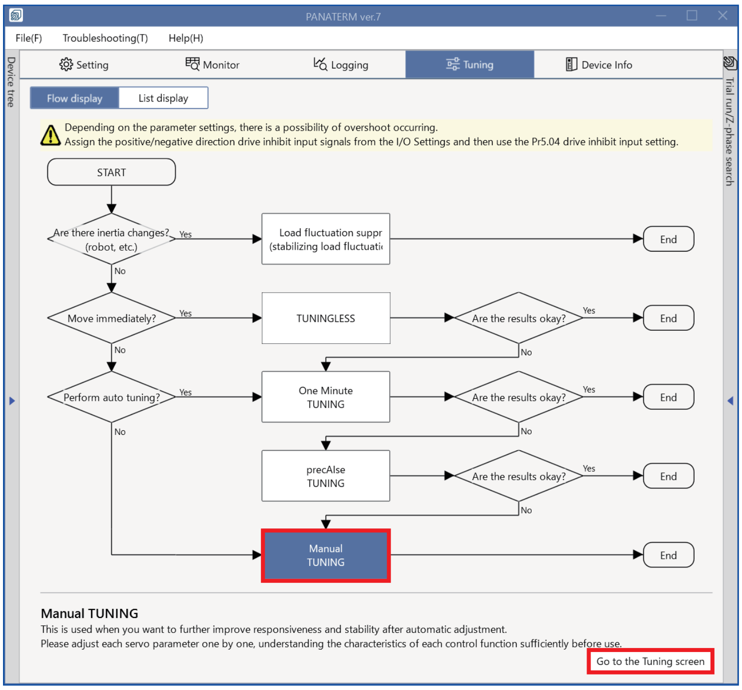
<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.

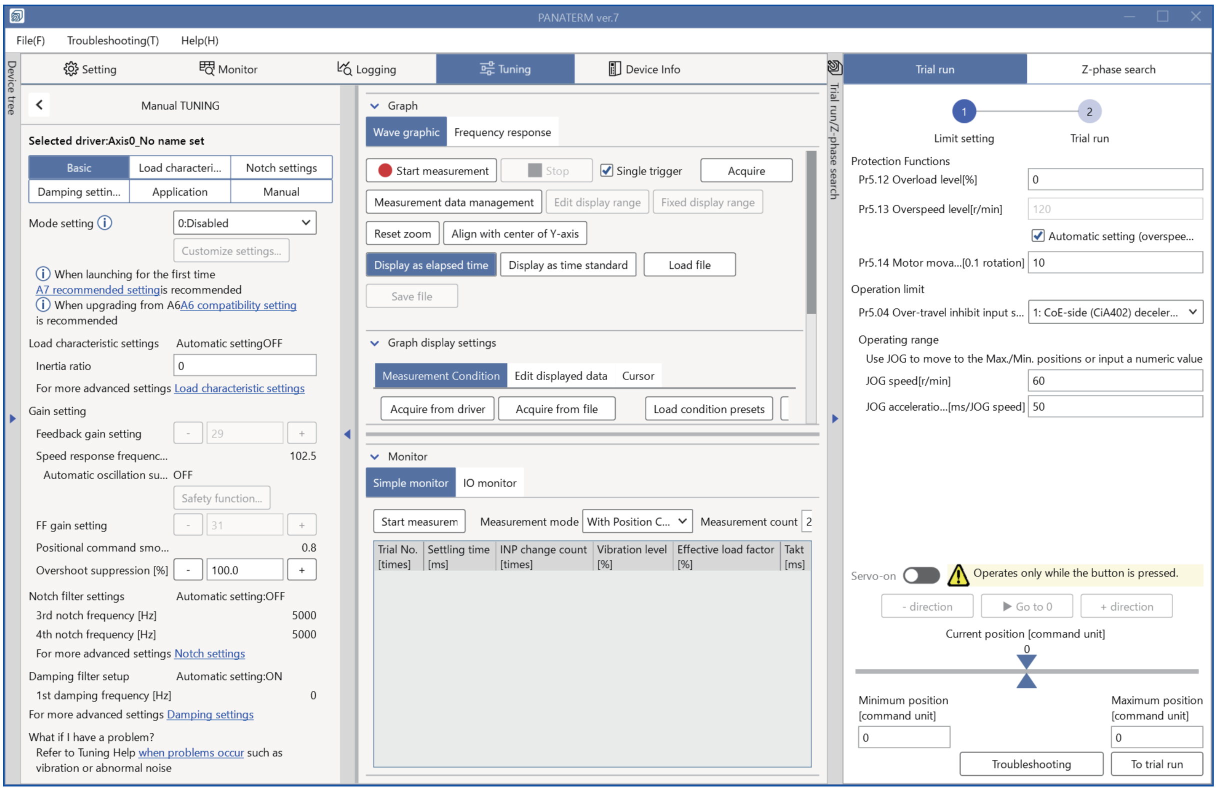


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING

This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.



Selected driver:Axis0_No name set

Mode setting: 0:Disabled

When launching for the first time A7 recommended setting is recommended
When upgrading from A6 A6 compatibility setting is recommended

Load characteristic settings: Automatic settingOFF
Inertia ratio: 0
For more advanced settings Load characteristic settings

Gain setting
Feedback gain setting: 29
Speed response frequenc...: 102.5
Automatic oscillation su...: OFF
FF gain setting: 31
Positional command smo...: 0.8
Overshoot suppression [%]: 100.0

Notch filter settings: Automatic setting:OFF
3rd notch frequency [Hz]: 5000
4th notch frequency [Hz]: 5000
For more advanced settings Notch settings

Damping filter setup: Automatic setting:ON
1st damping frequency [Hz]: 0
For more advanced settings Damping settings

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode: With Position C...
Measurement count: 2

Trial No. [times]	Settling time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%]: 0
Pr5.13 Overspeed level[r/min]: 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation]: 10

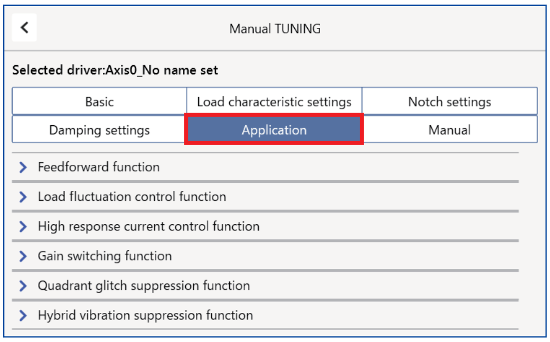
Operation limit
Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min]: 60
JOG acceleratio...[ms/JOG speed]: 50

Operates only while the button is pressed.

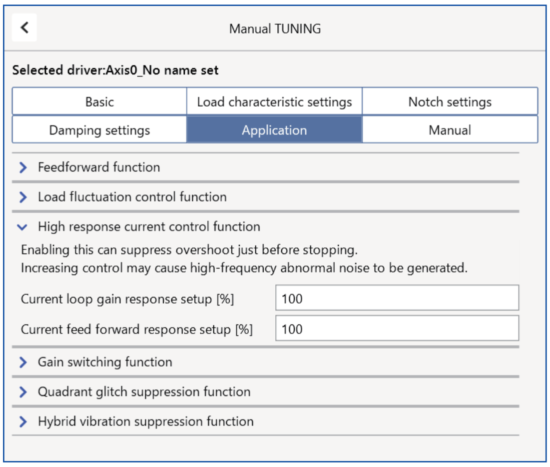
Current position [command unit]: 0
Minimum position [command unit]: 0
Maximum position [command unit]: 0

4. Click the [Application] button.



Selected driver:Axis0_No name set

5. Click on “>” of “> High response current control function” to expand “High response current control function”.



Selected driver:Axis0_No name set

Enabling this can suppress overshoot just before stopping.
Increasing control may cause high-frequency abnormal noise to be generated.

Current loop gain response setup [%] 100

Current feed forward response setup [%] 100

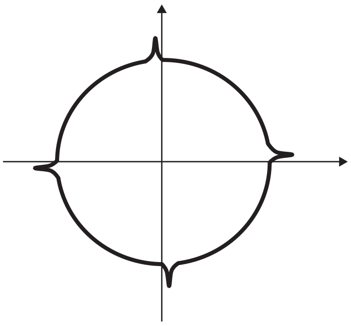
6. For details on tuning each parameter, see *“4.8.4.1 For Manual Setting”* .

4.9 Quadrant Glitch Suppression Function

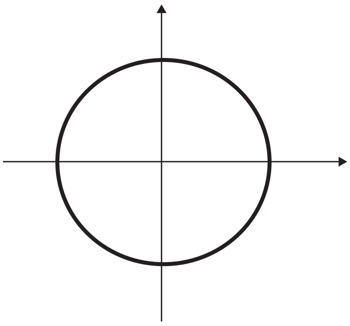
4.9.1 Function Overview

This function suppresses quadrant glitches that occur when drawing an arc with two or more axes. Although the load fluctuation control function (disturbance suppression applications) can be used to suppress load fluctuations, this function can be used to further suppress fluctuations when levels are still unsatisfactory.

Example of waveform before tuning



Example of waveform after tuning



4.9.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control and full-closed control

Under the following conditions, the quadrant glitch suppression function may not be effective.

Item	Conditions that obstruct the effectiveness of the quadrant glitch suppression function
Load	● Low stiffness (antiresonance points exists in the low frequency range of 10 Hz or less) ● Looseness, backlash, etc. are present and the load non-linearity is strong ● When the operation pattern changes

4.9.3 Related Parameters

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
5	45	B	Quadrant glitch positive-direction compensation value	-1000 to 1000	0.1%	Sets the compensation value to be added to the torque command when the position command is in positive direction when the quadrant glitch compensation function is enabled.
5	46	B	Quadrant glitch negative-direction compensation value	-1000 to 1000	0.1%	Sets the compensation value to be added to the torque command when the position command is in negative direction when the quadrant glitch compensation function is enabled.
5	47	B	Quadrant glitch compensation delay time	0 to 1000	ms	Sets the delay time until the compensation value is switched when the initial position command is input or after reversing the position command when the quadrant glitch compensation function is enabled.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
5	48	B	Quadrant glitch compensation filter setting L	0 to 6400	0.01 ms	Sets the time constant of the low-pass filter applied to the torque command compensation value when the quadrant glitch compensation function is enabled. Disabled when the set value is 0 to 3.
5	49	B	Quadrant glitch compensation filter setting H	0 to 10000	0.1 ms	Sets the time constant of the high pass filter applied to the torque command compensation value when the quadrant glitch compensation function is enabled.
6	47	R	Function expansion setup 2	-32768 to 32767	—	bit 14: Quadrant glitch compensation function Enables and disables the quadrant glitch compensation function. 0: Disabled 1: Enabled
6	97	B	Function expansion setup 3	-2147483648 to 2147483647	—	bit 0: Quadrant glitch compensation HPF clear Enables and disables expansion of the quadrant glitch compensation function. 0: Disabled 1: Enabled To set the compensation amount of quadrant glitch by inversion direction when the direction of the velocity has changed, set to 1.

*1 For attributes, see *“7.1 Object Dictionary List”* .

4.9.4 How to Use

4.9.4.1 For Manual Setting

<< Procedure >>

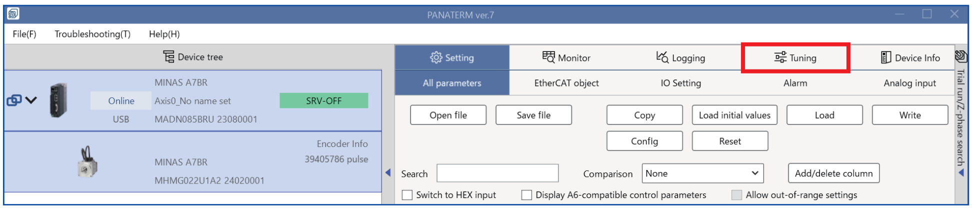
1. Set the quadrant glitch suppression function to enable (Pr6.47:bit 14 = 1), and then turn the control power back on.
2. Set the following parameters to their initial settings.
   Pr5.47 “Quadrant glitch compensation delay time” = 0
   Pr5.48 “Quadrant glitch compensation filter setting L” = Pr1.04 “1st torque filter time constant”
   Pr5.49 “Quadrant glitch compensation filter setting H” = 0
3. Fine tune Pr5.45 “Quadrant glitch positive-direction compensation value” and Pr5.46 “Quadrant glitch negative-direction compensation value” for each axis while measuring the size of the quadrant glitch.
   - If quadrant glitch occurs later than the movement direction inversion timing, configure the following settings.
     1 Change Pr5.47 “Quadrant glitch compensation delay time” and Pr5.48 “Quadrant glitch compensation filter setting L” .
   - Use the following procedure to set the amount of quadrant glitch compensation for each direction when reversing the direction of movement.
     1 Set Pr6.97 “Function expansion setup 3” :bit 0 “Quadrant glitch compensation HPF clear” to 1.
     2 Set Pr5.45 “Quadrant glitch positive-direction compensation value” , Pr5.46 “Quadrant glitch negative-direction compensation value” .
     3 Tune the Pr5.49 “Quadrant glitch compensation filter setting H” value.

4.9.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

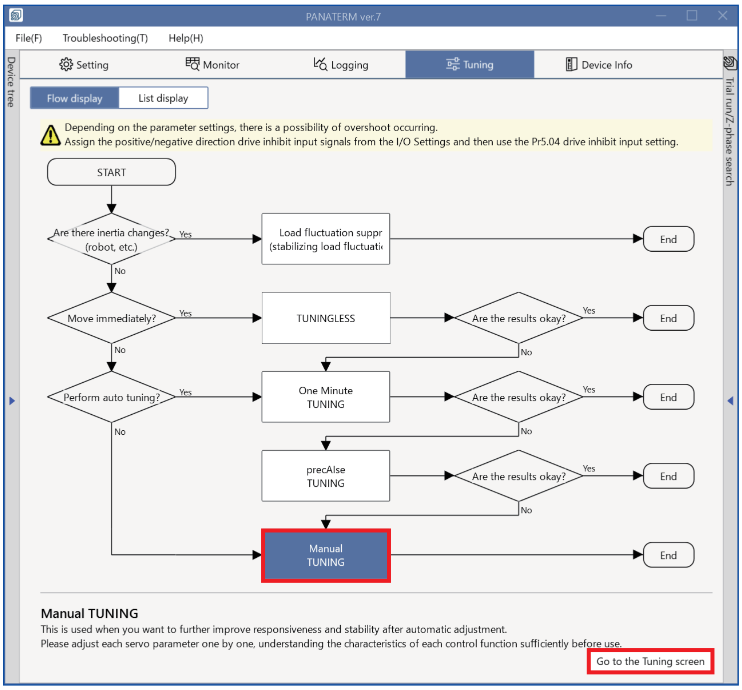
<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.

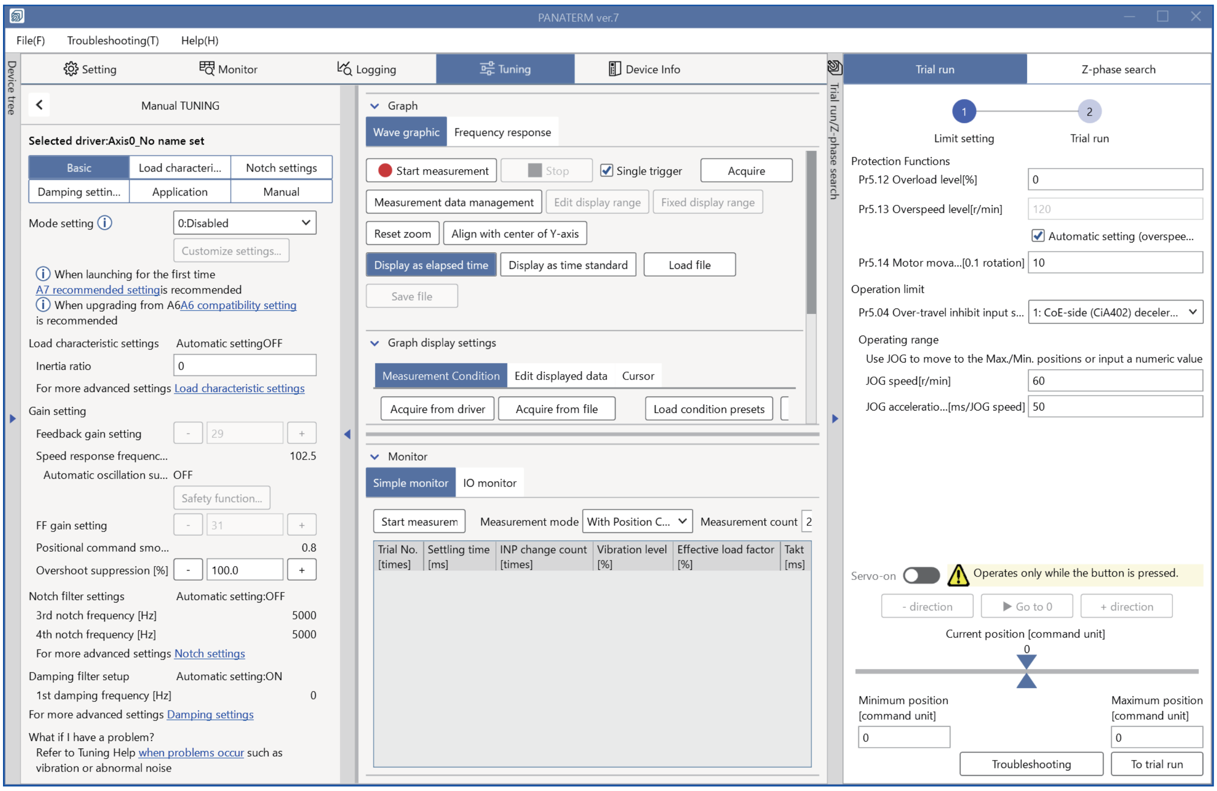


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING

This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.



Selected driver:Axis0_No name set

Mode setting: 0:Disabled

When launching for the first time
A7 recommended settingis recommended
When upgrading from A6A6 compatibility setting
is recommended

Load characteristic settings Automatic settingOFF
Inertia ratio: 0
For more advanced settings Load characteristic settings

Gain setting
Feedback gain setting: 29
Speed response frequenc... 102.5
Automatic oscillation su... OFF
FF gain setting: 31
Positional command smo... 0.8
Overshoot suppression [%]: 100.0

Notch filter settings Automatic setting:OFF
3rd notch frequency [Hz] 5000
4th notch frequency [Hz] 5000
For more advanced settings Notch settings

Damping filter setup Automatic setting:ON
1st damping frequency [Hz] 0
For more advanced settings Damping settings

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode: With Position C...
Measurement count: 2

Trial No. [times]	Settling time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%]: 0
Pr5.13 Overspeed level[r/min]: 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation]: 10

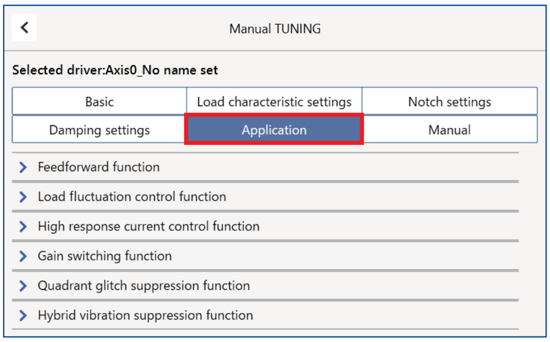
Operation limit
Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min]: 60
JOG acceleratio...[ms/JOG speed]: 50

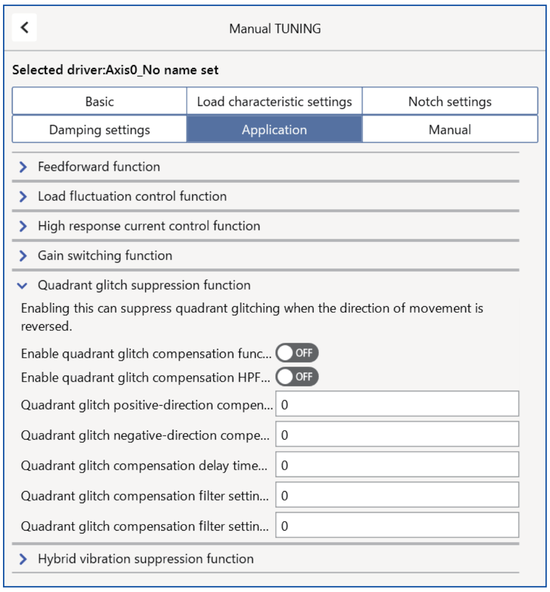
Operates only while the button is pressed.

Current position [command unit]: 0
Minimum position [command unit]: 0
Maximum position [command unit]: 0

4. Click the [Application] button.



5. Click on “>” of “> Quadrant glitch suppression function” to expand “Quadrant glitch suppression function”.



Enabling this can suppress quadrant glitching when the direction of movement is reversed.

Enable quadrant glitch compensation func... OFF
Enable quadrant glitch compensation HPF... OFF
Quadrant glitch positive-direction compen... 0
Quadrant glitch negative-direction compe... 0
Quadrant glitch compensation delay time... 0
Quadrant glitch compensation filter settin... 0
Quadrant glitch compensation filter settin... 0

6. Turn “Enable quadrant glitch compensation function” to ON. Power must be restored. In the message dialog box displayed, click the [OK] button to restore the power.

7. Set related parameters to the following values.

- Quadrant glitch compensation delay time = 0
- Quadrant glitch compensation filter setting L = Pr1.04 “1st torque filter time constant”
- Quadrant glitch compensation filter setting H = 0

8. Fine tune Quadrant glitch positive-direction compensation value and Quadrant glitch negative-direction compensation value for each axis while measuring the size of the quadrant glitch.

- If quadrant glitch occurs later than the movement direction inversion timing, configure the following settings.
  1. Set Quadrant glitch compensation delay time, Quadrant glitch compensation filter setting L.
- Use the following procedure to set the amount of quadrant glitch compensation for each direction when reversing the direction of movement.
  1. Turn on “Quadrant glitch compensation HPF clear enabled”.
  2. Set Quadrant glitch positive-direction compensation value, Quadrant glitch negative-direction compensation value.
  3. Set Quadrant glitch compensation filter setting H.

4.10 Backlash Compensation Function

4.10.1 Function Overview

When driving a device with backlash (mechanical gap in the drive system), the amount of movement commanded by the host device will differ from the actual amount of movement of the mechanical axis. The backlash compensation function adds a backlash compensation value to the host device position command and drives the motor axis by the command to which the compensation value has been added, thereby matching the amount of movement commanded by the host device with the actual amount of movement of the mechanical axis.

4.10.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control

— Precautions —

- Although the backlash compensation function is disabled when switching from position control to speed or torque control, the backlash compensation state is retained. After switching to position control again, movement resumes from the backlash compensation state in the previous position control.

4.10.3 Related Parameters

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	97	B	Function expansion setup 3	-2147483648 to 2147483647	—	bit 6: Switches position information during backlash correction 0: Obj.6064h:00h “Position actual value” = Obj.6063h:00h “Position actual internal value” - Pr7.05 1: Obj.6064h:00h “Position actual value” = Obj.6063h:00h “Position actual internal value” *Obj.6064h is the command unit, Obj.6063h, Pr7.05 is the Pulse unit, and conversion by electronic gear is included in the above formula.
7	04	B	Backlash compensation enable	0 to 7	—	bits 1 to 0: Enable or disable backlash compensation and select the direction of operation during compensation 00b: Disabled 01b: Compensates during the first positive direction operation after servo-on 10b: Compensates during the first negative direction operation after servo-on 11b: Manufacturer use bit 2: Expand backlash compensation retention conditions 0: Conventional specifications (A6B specification) 1: Expanded specification
7	05	B	Backlash compensation value	-1073741824 to 1073741823	pulse	Sets the backlash (mechanical clearance in the drive system) compensation amount during position control.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
7	06	B	Time constant for backlash compensation	0 to 6400	0.01 ms	Sets the backlash (mechanical clearance in the drive system) compensation time constant during position control. Disabled when the set value is 0 to 3.
7	18	B	Backlash compensation value holding range	0 to 2147483647	Command unit	Sets dead zone for backlash compensation when turned from servo-off to servo-on. When this setup value is 0, this function is disabled. This parameter does not depend on Pr7.04:bit 2 setup.

*1 For attributes, see *“7.1 Object Dictionary List”* .

— Precautions —

- Do not change Pr7.04 “Backlash compensation enable” :bit 2 or Pr7.05 “Backlash compensation value” and Pr7.06 “Time constant for backlash compensation” while the motor is running or during command transfer. If changes are made while the motor is running or during command transfer, changes will be applied at uncertain times.
- The actual motor position is shifted by the backlash compensation value from the motor position information read via EtherCAT communication. (When Pr6.97 “Function expansion setup 3” :bit 6 = 0)
- Do not latch position information, initialize position information, or switch control modes when the backlash compensation output is not fully transferred (cases other than when “the backlash compensation output set value is 0 or Pr7.05 “Backlash compensation value” ”). Also, be sure to change backlash compensation-related parameters during servo-off.
- Pr7.05 “Backlash compensation value” and Pr7.06 “Time constant for backlash compensation” should not exceed the command limit value (the threshold at which Err27.4.☐ “Position command error protection” occurs). When Err27.4.☐ “Position command error protection” occurs, increase Pr7.06 “Time constant for backlash compensation” to a larger value.
- If the device moving part is moved by external force during servo-off, or if the servo is turned off during backlash compensation value transfer, the backlash compensation value is shifted. Run homing again.
- If the following conditions are met, Obj.6063h:00h “Position actual internal value” = Obj.60FCh:00h “Position demand internal value” = Pr7.05 “Backlash compensation value” .
  - At the time of homing operation.
  - Backlash compensation is enabled.
  - The homing return operation direction (the final command speed and direction output) is the backlash compensation enable direction.
  - At Pr6.97 “Function expansion setup 3” :bit 6 = 0.
- When the motor is run with the backlash compensation function enabled with Pr6.97 “Function expansion setup 3” :bit 6 = 0,Obj.60FCh:00h “Position demand internal value” = Obj.6062h:00h “Position demand value” + Pr7.05 “Backlash compensation value” .

■ Details of Pr7.04:bit 1 to 0

Enables or disables backlash compensation and sets the direction of operation during compensation.

Pr7.04 “Backlash compensation enable” :bit 1 to 0 reflects changes at servo-on timing.

Pr7.04:bit 1 to 0	Pr7.05 value	
	Positive	Negative
01b	Positive direction compensation setting during positive direction operation	Negative direction compensation setting during positive direction operation
10b	Positive direction compensation setting during negative direction operation	Negative direction compensation setting during negative direction operation

■ Details of Pr7.04:bit 2

The conditions under which the backlash compensation state is cleared depends on the setting of Pr7.04 “Backlash compensation enable” :bit 2 “Expand backlash compensation retention conditions”.

- When Pr7.04 “Backlash compensation enable” :bit 2 = 0

  When turned to the servo-off state with backlash compensated, the backlash compensation value is cleared by presetting command position information inside the servo driver using motor position information, including the backlash compensation value.

  When turned back to servo-on, the first backlash compensation operation after servo-on is performed.

- When Pr7.04 “Backlash compensation enable” :bit 2 = 1

  Even in servo-of state, the backlash compensation value is not cleared and the backlash compensation state is retained. When turned back to servo-on, the motor can be run from the backlash compensation state when in the previous servo-on state.

— Precautions —

- During servo-off, make sure that the positional relationship between the device moving part and the motor is maintained. If the positional relationship is not maintained, depending on the Pr7.06 “Time constant for backlash compensation” setting, abnormal noise or oscillation may occur during motor operation after the next servo-on.

Pr7.04:bit 2	Conditions under which the backlash compensation state is cleared
0 (Conventional specifications)	● When in servo-off state ● When ESM state becomes Init state ● When Obj.6040h:00h “Controlword” is mapped to PDO, when not in OP state ● When an alarm is triggered ● In Safe Torque Off (STO) state ● When position deviation is cleared ● When the servo driver side decelerates to a stop due to an over-travel inhibit input
1 (Expanded specification)	● When ESM state becomes Init state

4.10.4 How to Use

■ When compensating in the positive direction during positive direction operation

(Condition)

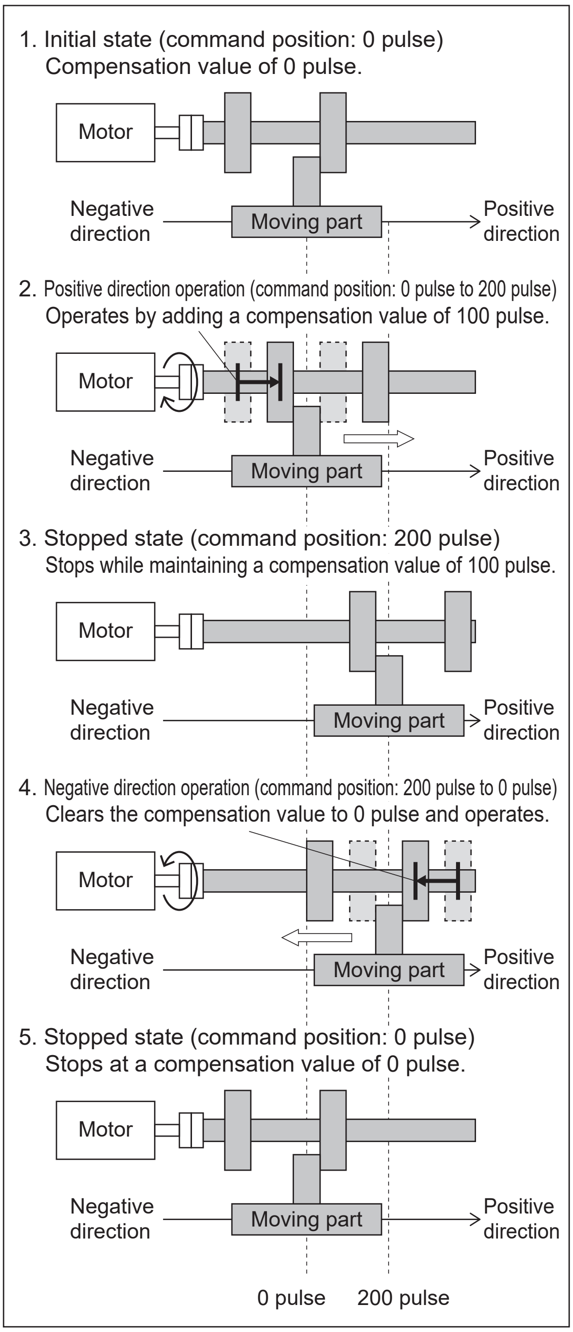
- Pr7.04 “Backlash compensation enable” = 1

  bit 1 to 0 = 01b (compensation during positive direction operation)

- Pr7.05 “Backlash compensation value” = 100 pulse
- Pr7.06 “Time constant for backlash compensation” = 0 ms

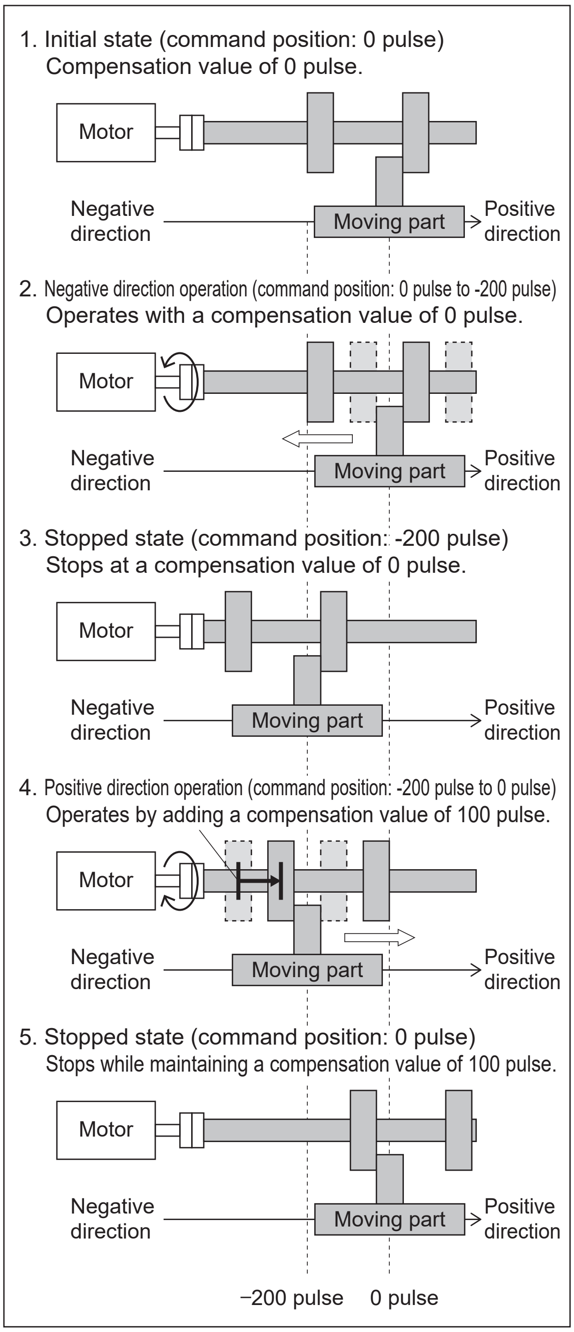
- Electronic gear ratio: 1/1

■ When switching from positive direction operation to negative direction operation



1. Initial state (command position: 0 pulse)
   Compensation value of 0 pulse.
2. Positive direction operation (command position: 0 pulse to 200 pulse)
   Operates by adding a compensation value of 100 pulse.
3. Stopped state (command position: 200 pulse)
   Stops while maintaining a compensation value of 100 pulse.
4. Negative direction operation (command position: 200 pulse to 0 pulse)
   Clears the compensation value to 0 pulse and operates.
5. Stopped state (command position: 0 pulse)
   Stops at a compensation value of 0 pulse.

■ When switching from negative direction operation to positive direction operation



1. Initial state (command position: 0 pulse)
   Compensation value of 0 pulse.
2. Negative direction operation (command position: 0 pulse to -200 pulse)
   Operates with a compensation value of 0 pulse.
3. Stopped state (command position: -200 pulse)
   Stops at a compensation value of 0 pulse.
4. Positive direction operation (command position: -200 pulse to 0 pulse)
   Operates by adding a compensation value of 100 pulse.
5. Stopped state (command position: 0 pulse)
   Stops while maintaining a compensation value of 100 pulse.

— Precautions —

- When the backlash compensation state is cleared to 0, such as when the power is turned on or when at servo-off, position the device so that the device moving part is positioned against the backlash compensation direction as the initial state of the device. If this initial state is not set correctly, displacement may occur.
- Depending on the Pr7.06 “Time constant for backlash compensation” setting, abnormal noise or oscillation may occur while the motor is running.

■ When a dead zone is set

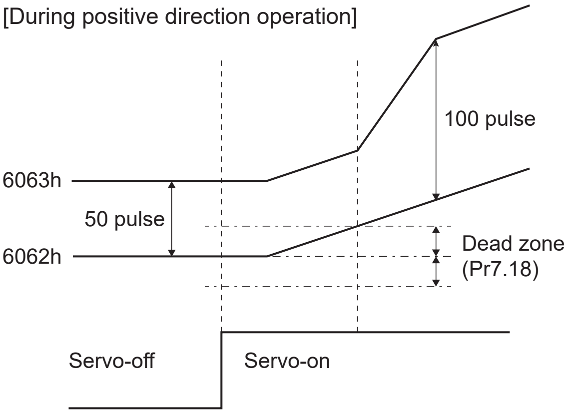
To prevent backlash compensation from working in an unintended direction due to an Obj.607Ah:00h “Target position” communication delay on the Main Device side, a position dead zone can be set for the backlash compensation state update after servo-on using Pr7.18 “Backlash compensation value holding range” .

(Condition)

- Pr6.97 “Function expansion setup 3” :bit 6 “Switches position information during backlash correction” = 0
- Pr7.04 “Backlash compensation enable” = 5
  bit 1 to 0 = 01b (compensation during positive direction operation)
  bit 2 = 1 (Compensation state retained during servo-off)
- Pr7.05 “Backlash compensation value” = 100 pulse
- Pr7.06 “Time constant for backlash compensation” = Any
- Pr7.18 “Backlash compensation value holding range” = 50
- Electronic gear ratio: 1/1

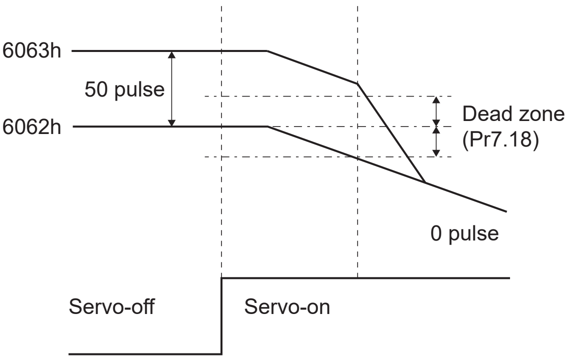
(Example) When the backlash compensation value is retained 50 pulses in the positive direction during servo-off

[During positive direction operation]



If the relative position (*1) after servo-on is within the dead zone,
the backlash compensation value of 50 pulse is maintained.
If the dead zone in the positive direction is exceeded,
the compensation value is 100 pulse.

[During negative direction operation]



If the relative position (*1) after servo-on is within the dead zone,
the backlash compensation value of 50 pulse is maintained.
If the dead zone in the negative direction is exceeded,
the compensation value becomes 0 pulse.

*1 Relative position after servo-on = Obj.6062h during servo-on - Obj.6062h just before servo-on

If homing (other than Methods 35 and 37) accompanying motor operation is executed when the relative position “(*1)” after servo-on is within the dead zone, the dead zone status is released, the backlash compensation status is updated, and homing operation is performed.

When homing not accompanying motor operation (Methods 35 and 37) is executed, and homing is performed with the dead zone state not released.

■ First backlash compensation action after servo-on

After servo-on, compensation is applied to the position command when first moved in the direction set above (the direction set by Pr7.04 “Backlash compensation enable” and Pr7.05 “Backlash compensation value”). If the operation is reversed before that time, no compensation is applied.

Furthermore, when the first operation is performed in the opposite direction after backlash compensation, compensation is applied in that direction.

Once backlash compensation is applied, new compensation is not applied as long as the operation is repeated in the same direction.

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5.1 Torque Filter Function

5.1.1 Function Overview

By setting a torque filter, this function suppresses sounds and vibrations in the high frequency range that may occur when gain is increased.

5.1.2 Operational Conditions

Item	Operational Conditions
Control mode	● All control modes

5.1.3 Related Parameters

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
1	04	B	1st torque filter time constant	0 to 2500	0.01 ms	Sets the time constant of the 1st torque filter. Disabled when the set value is 0 to 3.
1	09	B	2nd torque filter time constant	0 to 2500	0.01 ms	Sets the time constant of the 2nd torque filter. Disabled when the set value is 0 to 3.

*1 For attributes, see *"7.1 Object Dictionary List"* .

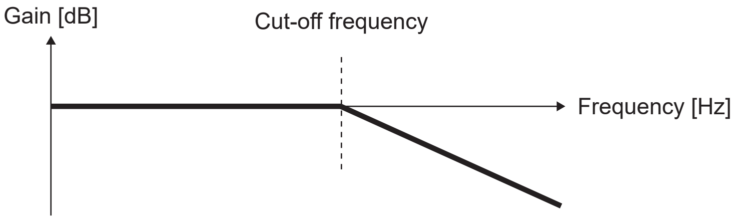
The two types of torque filter are 1st torque filter and 2nd torque filter.

See *"4.2 Gain Switching Function"* for details on the use of both torque filters.

The torque filter cut-off frequency can be obtained using the following formula.

Cut-off frequency [Hz] fc = 1/(2 π × parameter setup value × 0.00001)

Torque filter frequency response



5.1.4 How to Use

5.1.4.1 For Manual Setting

If there is noticeable noise during operation, increase Pr1.04 "1st torque filter time constant" . The set value should be changed by increasing by 10% at a time. The larger the set value, the stronger the effect of the filter.

However, if set too large, control may become unstable and vibration may occur. Therefore, when increasing the set value, tune it while maintaining balance with other parameters (especially Pr1.01 "1st velocity loop gain").

— Precautions —

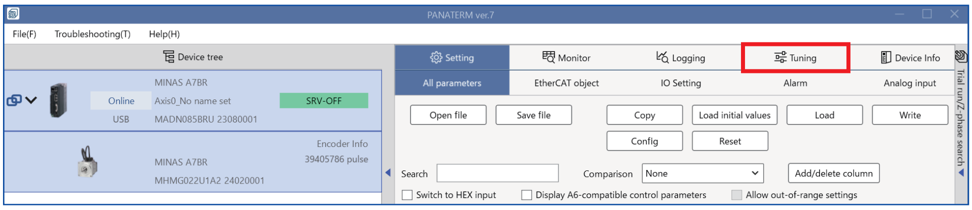
- If Pr0.02 “Real-time auto-gain tuning setup” is not 0 (disabled), the related parameters are set automatically and cannot be set manually. If you want to set the parameters manually, set Pr0.02 “Real-time auto-gain tuning setup” to 0 (disabled) before setting.

5.1.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

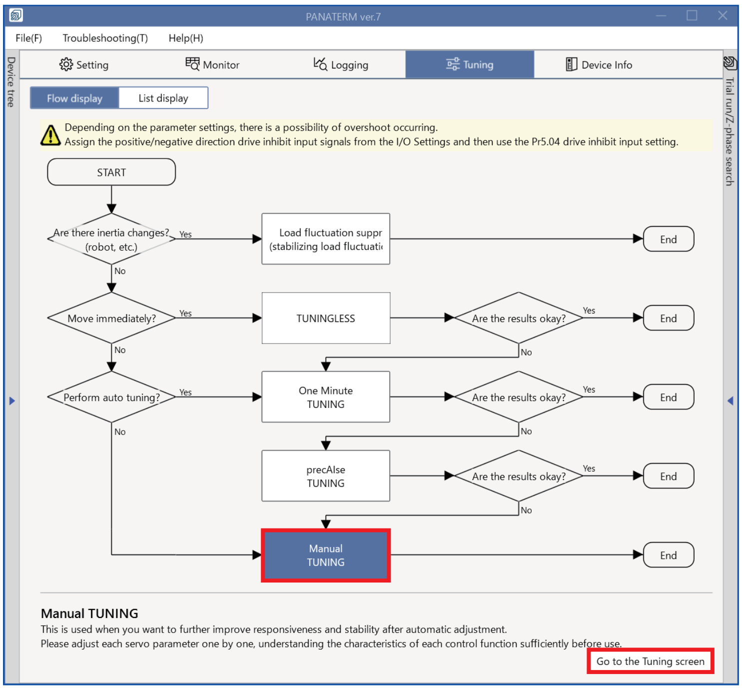
<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.



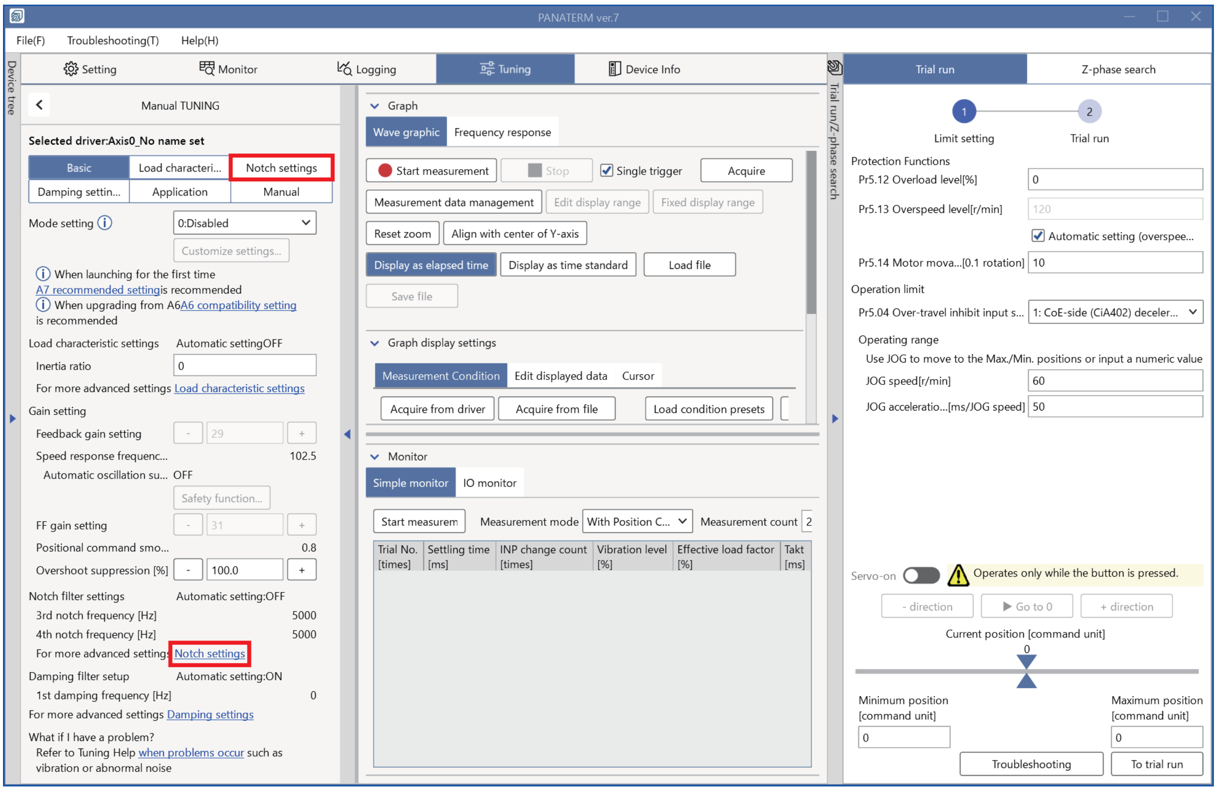
Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING

This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.

4. Click on the [Notch settings] button or “Notch settings” in blue text.



Selected driver:Axis0_No name set

Mode setting: 0:Disabled

When launching for the first time A7 recommended settingis recommended

When upgrading from A6A6 compatibility setting is recommended

Load characteristic settings: Automatic settingOFF

Inertia ratio: 0

For more advanced settings Load characteristic settings

Gain setting

Feedback gain setting: 29

Speed response frequenc...: 102.5

Automatic oscillation su...: OFF

FF gain setting: 31

Positional command smo...: 0.8

Overshoot suppression [%]: 100.0

Notch filter settings: Automatic setting:OFF

3rd notch frequency [Hz]: 5000

4th notch frequency [Hz]: 5000

For more advanced settings Notch settings

Damping filter setup: Automatic setting:ON

1st damping frequency [Hz]: 0

For more advanced settings Damping settings

What if I have a problem?

Refer to Tuning Help when problems occur such as vibration or abnormal noise

Start measurem | Measurement mode: With Position C... | Measurement count: 2

Trial No. [times]	Settling time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions

Pr5.12 Overload level[%]: 0

Pr5.13 Overspeed level[r/min]: 120

☑ Automatic setting (overspee...

Pr5.14 Motor mova...[0.1 rotation]: 10

Operation limit

Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

Operating range

Use JOG to move to the Max./Min. positions or input a numeric value

JOG speed[r/min]: 60

JOG acceleratio...[ms/JOG speed]: 50

Servo-on ○ Operates only while the button is pressed.

- direction | ▶ Go to 0 | + direction

Current position [command unit]: 0

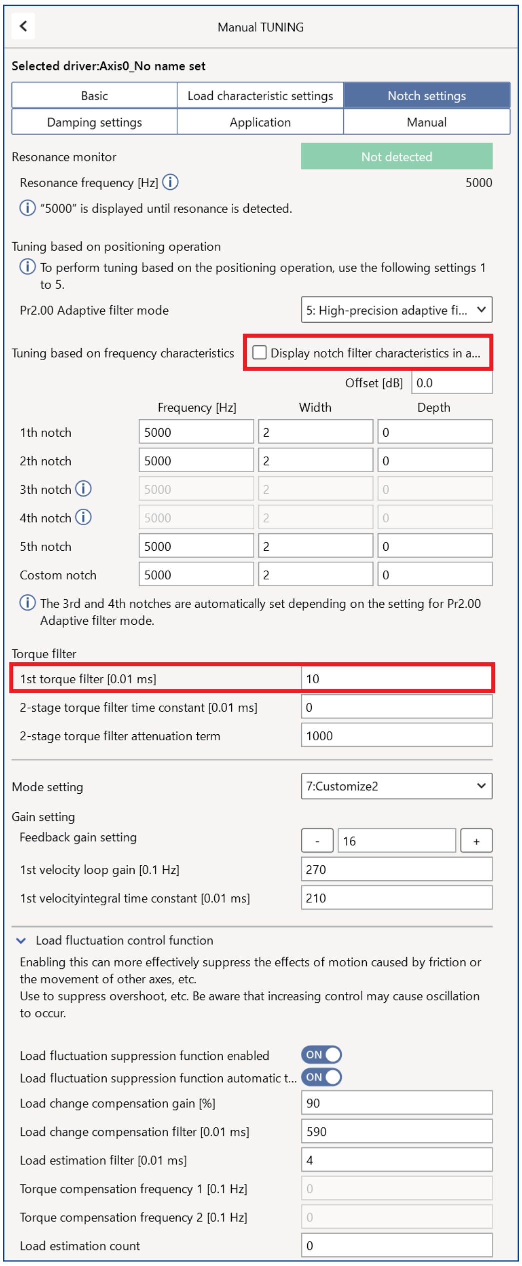
Minimum position [command unit]: 0

Maximum position [command unit]: 0

The advanced notch settings screen is displayed.

5. Tune the “1st torque filter”. For details on parameter tuning, see *“5.1.4.1 For Manual Setting”* .

When the “Display notch filter characteristics in a graph” check box is checked, the frequency response of the torque filter set here and the frequency response of the notch filter set separately as parameters are displayed on the frequency response graph.



Selected driver:Axis0_No name set

Resonance monitor: Not detected

Resonance frequency [Hz]: 5000

“5000” is displayed until resonance is detected.

Tuning based on positioning operation

To perform tuning based on the positioning operation, use the following settings 1 to 5.

Pr2.00 Adaptive filter mode: 5: High-precision adaptive fi...

Tuning based on frequency characteristics: ☐ Display notch filter characteristics in a...

Offset [dB]: 0.0

	Frequency [Hz]	Width	Depth
1th notch	5000	2	0
2th notch	5000	2	0
3th notch	5000	2	0
4th notch	5000	2	0
5th notch	5000	2	0
Costom notch	5000	2	0

The 3rd and 4th notches are automatically set depending on the setting for Pr2.00 Adaptive filter mode.

Torque filter

1st torque filter [0.01 ms]	10
2-stage torque filter time constant [0.01 ms]	0
2-stage torque filter attenuation term	1000

Mode setting: 7:Customize2

Gain setting

Feedback gain setting	16
1st velocity loop gain [0.1 Hz]	270
1st velocityintegral time constant [0.01 ms]	210

Load fluctuation control function

Enabling this can more effectively suppress the effects of motion caused by friction or the movement of other axes, etc.
Use to suppress overshoot, etc. Be aware that increasing control may cause oscillation to occur.

Load fluctuation suppression function enabled	ON
Load fluctuation suppression function automatic t...	ON
Load change compensation gain [%]	90
Load change compensation filter [0.01 ms]	590
Load estimation filter [0.01 ms]	4
Torque compensation frequency 1 [0.1 Hz]	0
Torque compensation frequency 2 [0.1 Hz]	0
Load estimation count	0

5.2 2-stage Torque Filter Function

5.2.1 Function Overview

This function sets a 2-stage torque filter to suppress high-frequency vibration components that cannot be suppressed by the *"5.1 Torque Filter Function"* torque filter alone.

5.2.2 Operational Conditions

Item	Operational Conditions
Control mode	● All control modes

5.2.3 Related Parameters

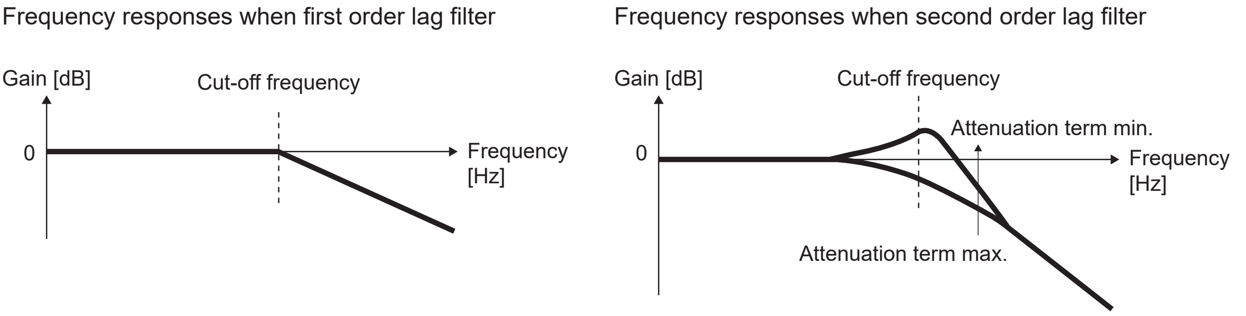
Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	42	B	2-stage torque filter time constant	0 to 2500	0.01 ms	Sets the 2-stage torque filter time constant. ● When Pr6.43 = 0 to 49 0 to 3: 2-stage torque filter disabled 4 to 2500: Setting value [×0.01 ms] ● When Pr6.43 = 50 to 1000 0: 2-stage torque filter disabled 1 to 3: 4 [×0.01 ms] 4 to 159: Setting value [×0.01 ms] 159 to 2500: 159 [×0.01 ms]
6	43	B	2-stage torque filter attenuation term	0 to 1000	—	Sets the 2-stage torque filter attenuation term. ● 0 to 49: Operates as the first order lag filter. ● 50 to 1000: Operates as the second order lag filter. With a setting value of 1000, becomes a second order lag filter with $\zeta = 1.0$. The smaller the setting value, the more it vibrates. Normally use with a setting value of 1000.

*1 For attributes, see *"7.1 Object Dictionary List"* .

The torque filter cut-off frequency of the 2-stage torque filter can be obtained using the following formula.

Cut-off frequency [Hz] fc = 1/(2 π × parameter setup value × 0.00001)

2-stage torque filter characteristics figure



5.2.4 How to Use

5.2.4.1 For Manual Setting

If there is noticeable noise during operation, increase Pr6.42 “2-stage torque filter time constant” . The set value should be changed by increasing by 10% at a time. The larger the set value, the stronger the effect of the filter.

If set too large, control may become unstable and vibration may occur. Therefore, when increasing the set value, tune it while maintaining balance with other parameters (especially Pr1.01 “1st velocity loop gain”).

Pr6.43 “2-stage torque filter attenuation term” is normally used with a set value of 1000.

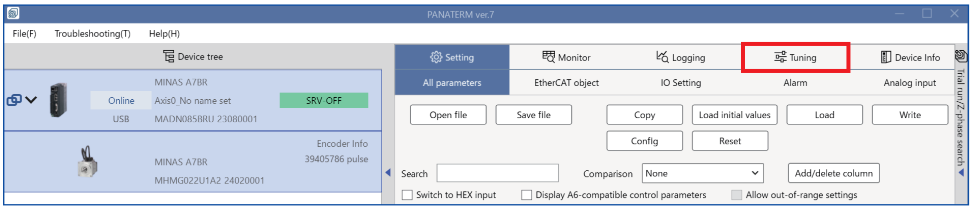
— Precautions —

- If Pr6.42 “2-stage torque filter time constant” is set too large, control may become unstable and vibration may occur.
- Changing Pr6.43 “2-stage torque filter attenuation term” during operation may cause vibration. Stop operation before making changes.

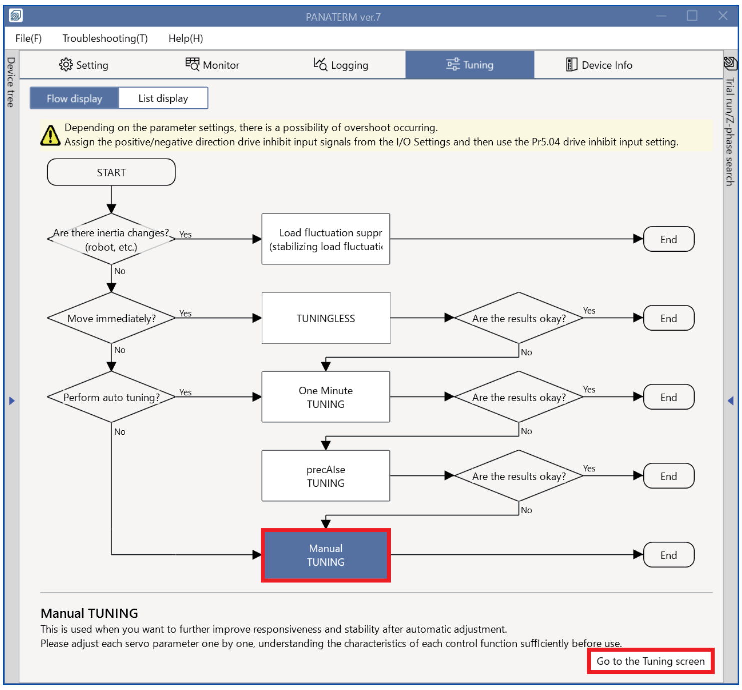
5.2.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .
2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.



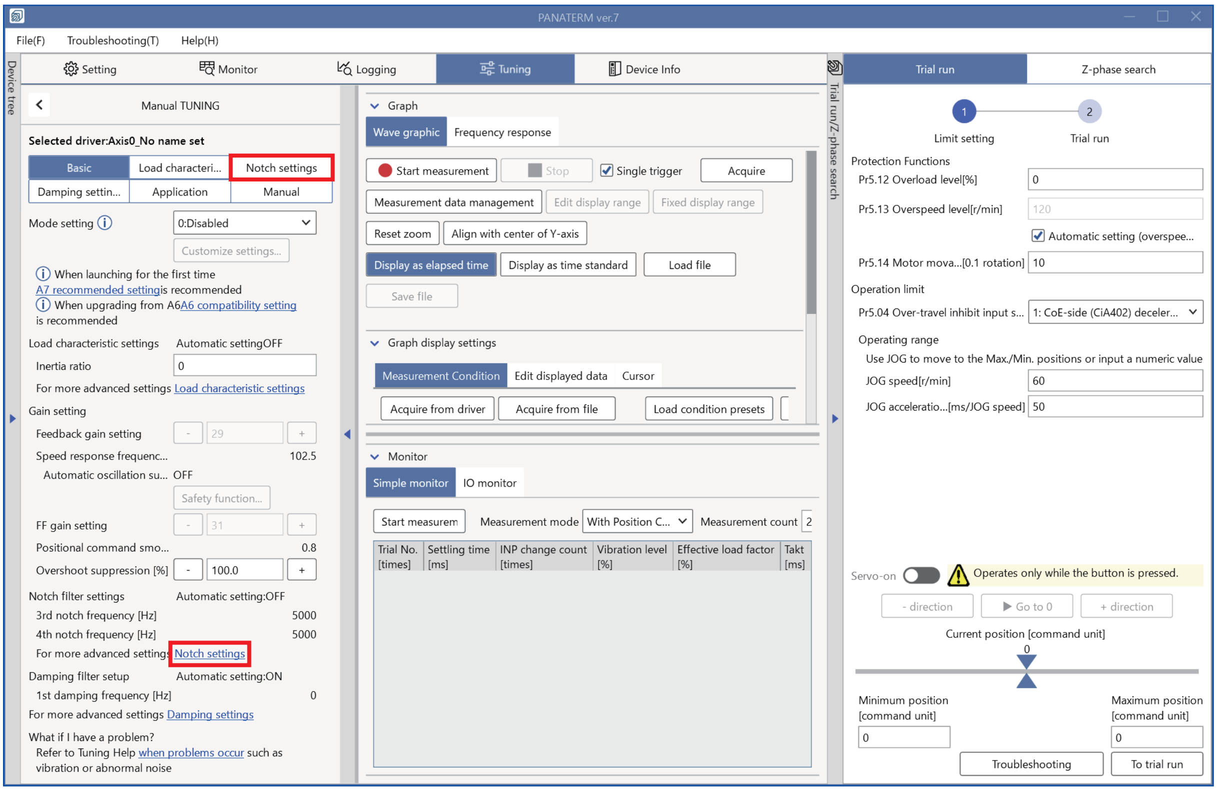
Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING

This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.

4. Click on the [Notch settings] button or “Notch settings” in blue text.



Selected driver:Axis0_No name set

Mode setting 0:Disabled

When launching for the first time
A7 recommended settingis recommended
When upgrading from A6A6 compatibility setting
is recommended

Load characteristic settings Automatic settingOFF
Inertia ratio 0
For more advanced settings Load characteristic settings

Gain setting
Feedback gain setting 29
Speed response frequenc... 102.5
Automatic oscillation su... OFF
FF gain setting 31
Positional command smo... 0.8
Overshoot suppression [%] 100.0

Notch filter settings Automatic setting:OFF
3rd notch frequency [Hz] 5000
4th notch frequency [Hz] 5000
For more advanced settings Notch settings

Damping filter setup Automatic setting:ON
1st damping frequency [Hz] 0
For more advanced settings Damping settings

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode With Position C...
Measurement count 2

Trial No. [times]	Setting time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%] 0
Pr5.13 Overspeed level[r/min] 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation] 10

Operation limit
Pr5.04 Over-travel inhibit input s... 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min] 60
JOG acceleratio...[ms/JOG speed] 50

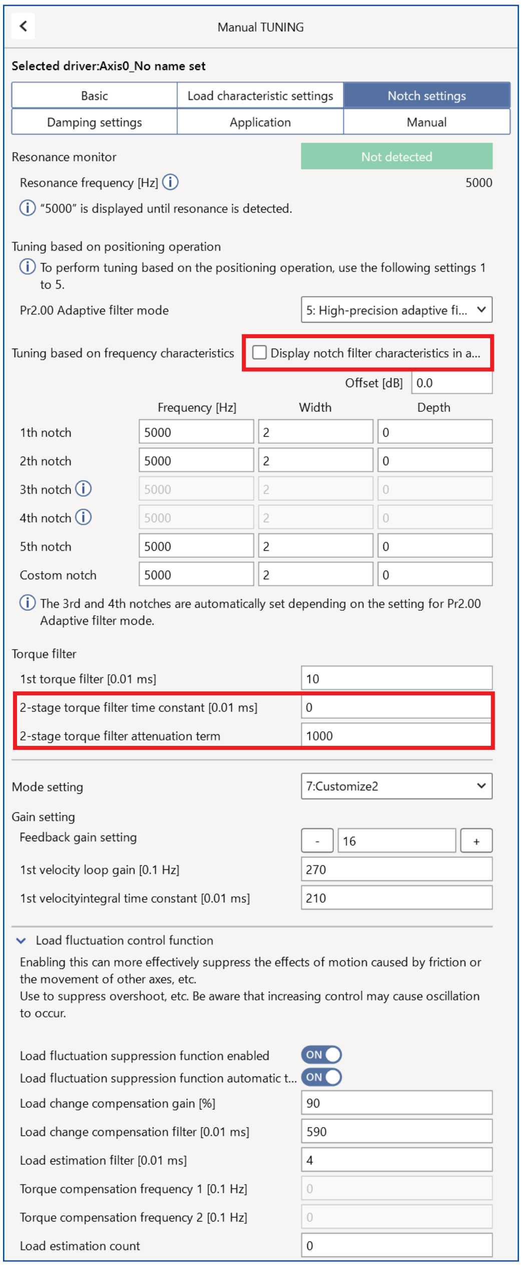
Servo-on
Operates only while the button is pressed.

Current position [command unit] 0
Minimum position [command unit] 0
Maximum position [command unit] 0

The advanced notch settings screen is displayed.

5. Tune the “2-stage torque filter time constant”. For details on parameter tuning, see *“5.2.4.1 For Manual Setting”* .

When the “Display notch filter characteristics in a graph” check box is checked, the frequency response of the torque filter set here and the frequency response of the notch filter set separately as parameters are displayed on the frequency response graph.



Manual TUNING

Selected driver:Axis0_No name set

Resonance monitor: Not detected

Resonance frequency [Hz] ⓘ 5000

ⓘ "5000" is displayed until resonance is detected.

Tuning based on positioning operation

ⓘ To perform tuning based on the positioning operation, use the following settings 1 to 5.

Pr2.00 Adaptive filter mode: 5: High-precision adaptive fi...

Tuning based on frequency characteristics ☐ Display notch filter characteristics in a...

Offset [dB] 0.0

	Frequency [Hz]	Width	Depth
1th notch	5000	2	0
2th notch	5000	2	0
3th notch ⓘ	5000	2	0
4th notch ⓘ	5000	2	0
5th notch	5000	2	0
Costom notch	5000	2	0

ⓘ The 3rd and 4th notches are automatically set depending on the setting for Pr2.00 Adaptive filter mode.

Torque filter

1st torque filter [0.01 ms]: 10

2-stage torque filter time constant [0.01 ms]: 0

2-stage torque filter attenuation term: 1000

Mode setting: 7:Customize2

Gain setting

Feedback gain setting: - 16 +

1st velocity loop gain [0.1 Hz]: 270

1st velocityintegral time constant [0.01 ms]: 210

Load fluctuation control function

Enabling this can more effectively suppress the effects of motion caused by friction or the movement of other axes, etc.
Use to suppress overshoot, etc. Be aware that increasing control may cause oscillation to occur.

Load fluctuation suppression function enabled: ON

Load fluctuation suppression function automatic t...: ON

Load change compensation gain [%]: 90

Load change compensation filter [0.01 ms]: 590

Load estimation filter [0.01 ms]: 4

Torque compensation frequency 1 [0.1 Hz]: 0

Torque compensation frequency 2 [0.1 Hz]: 0

Load estimation count: 0

5.3 Notch Filter Function

5.3.1 Function Overview

When the gain is increased, sounds and vibrations of specific frequencies in the high frequency range may occur. This function suppresses sound and vibration at specific frequencies in the high frequency range by setting a notch filter. Up to six notch filters (1st to 5th notch filters and a custom notch filter) can be set simultaneously for different vibration frequencies.

5.3.2 Operational Conditions

Item	Operational Conditions
Control mode	● All control modes

5.3.3 Related Parameters

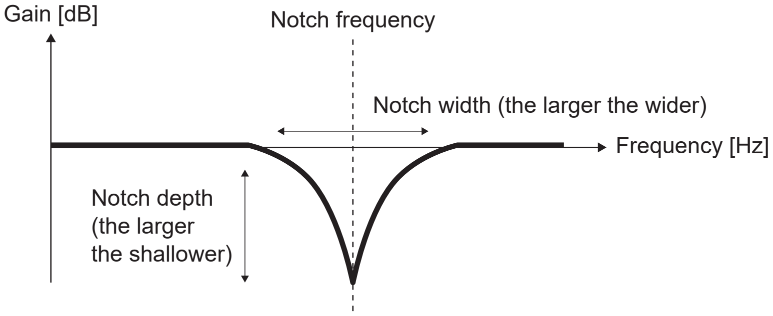
Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	01	B	1st notch frequency	10 to 5000	Hz	Sets 1st notch filter center frequency. A setup value of 5000 disables the notch filter.
2	02	B	1st notch width selection	0 to 20	–	Sets 1st notch filter frequency width.
2	03	B	1st notch depth selection	0 to 99	–	Sets depth in 1st notch filter center frequency.
2	04	B	2nd notch frequency	10 to 5000	Hz	Sets 2nd notch filter center frequency. A setup value of 5000 disables the notch filter.
2	05	B	2nd notch width selection	0 to 20	–	Sets 2nd notch filter frequency width.
2	06	B	2nd notch depth selection	0 to 99	–	Sets depth in 2nd notch filter center frequency.
2	07	B	3rd notch frequency	10 to 5000	Hz	Sets 3rd notch filter center frequency. A setup value of 5000 disables the notch filter. The parameter value is set automatically when the adaptive filter function is used.
2	08	B	3rd notch width selection	0 to 20	–	Sets 3rd notch filter frequency width. The parameter value is set automatically when the adaptive filter function is used.
2	09	B	3rd notch depth selection	0 to 99	–	Sets depth in 3rd notch filter center frequency. The parameter value is set automatically when the adaptive filter function is used.
2	10	B	4th notch frequency	10 to 5000	Hz	Sets 4th notch filter center frequency. A setup value of 5000 disables the notch filter. The parameter value is set automatically when the adaptive filter function is used.
2	11	B	4th notch width selection	0 to 20	–	Sets 4th notch filter frequency width. The parameter value is set automatically when the adaptive filter function is used.
2	12	B	4th notch depth selection	0 to 99	–	Sets depth in 4th notch filter center frequency. The parameter value is set automatically when the adaptive filter function is used.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	24	B	5th notch frequency	10 to 5000	Hz	Sets 5th notch filter center frequency. A setup value of 5000 disables the notch filter.
2	25	B	5th notch width selection	0 to 20	—	Sets 5th notch filter frequency width.
2	26	B	5th notch depth selection	0 to 99	—	Sets depth in 5th notch filter center frequency.
2	39	B	Custom notch compensation coefficient	0 to 1000	0.01	Sets the custom notch compensation coefficient. A set value of 100 or less disables compensation. Normally, leave it at the initial value.
2	40	B	Custom notch compensation frequency 1	0 to 10000	0.1 Hz	Sets custom notch compensation frequency 1. A setup value of 0 disables compensation. Normally, leave it at the initial value.
2	41	B	Custom notch compensation frequency 2	0 to 10000	0.1 Hz	Sets custom notch compensation frequency 2. A setup value of 0 disables compensation. Normally, leave it at the initial value.
2	42	B	Custom notch frequency	10 to 5000	Hz	Sets the notch frequency of the custom notch filter. A setup value of 5000 disables the custom notch filter.
2	43	B	Custom notch width	0 to 20	—	Sets the notch width of the custom notch filter.
2	44	B	Custom notch depth	0 to 99	—	Sets the notch depth of the custom notch filter.

*1 For attributes, see *“7.1 Object Dictionary List”* .

■ Notch filter set values

Notch filter frequency response



Notch frequency

The frequency at which the most gain is attenuated.

Notch depth

The input/output ratio (attenuation rate) for the notch frequency.

The notch depth values corresponding to the set values are shown in the table below.

For the input in notch frequency, a set value of 0 is complete cutoff and a set value of 100 is complete pass.

Notch width

The frequency bandwidth in which the attenuation ratio is -3 dB when the notch depth set value is 0 (complete cutoff).

This is expressed as a ratio to the notch frequency.

The notch width values for the set values are shown in the table below.

Relation between notch depth set value and notch depth

Notch depth set value Pr2.03, Pr2.06, Pr2.09, Pr2.12, Pr2.26, Pr2.44	Notch depth (ratio)	Notch depth ([dB] display)
0	0.00	-∞
1	0.01	-40.0
2	0.02	-34.0
3	0.03	-30.5
4	0.04	-28.0
5	0.05	-26.0
6	0.06	-24.4
7	0.07	-23.1
8	0.08	-21.9
9	0.09	-20.9
10	0.10	-20.0
15	0.15	-16.5
20	0.20	-14.0
25	0.25	-12.0
30	0.30	-10.5
35	0.35	-9.1
40	0.40	-8.0
45	0.45	-6.9
50	0.50	-6.0
60	0.60	-4.4
70	0.70	-3.1
80	0.80	-1.9
90	0.90	-0.9
100	1.00	0.0

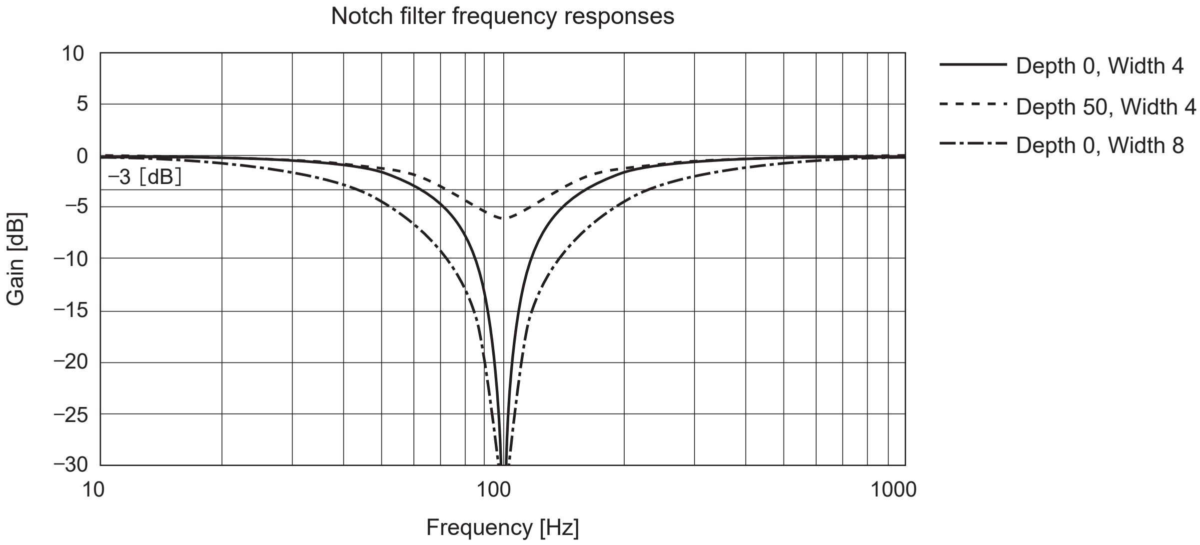
Relation between notch width set value and notch width

Notch width set value Pr2.02, Pr2.05, Pr2.08, Pr2.11, Pr2.25, Pr2.43	Notch width
0	0.25
1	0.3
2	0.35
3	0.42
4	0.5
5	0.59
6	0.71
7	0.84
8	1.00
9	1.19
10	1.41
11	1.68
12	2.00
13	2.38
14	2.83
15	3.36
16	4.00
17	4.76
18	5.66
19	6.73
20	8.00

Example of notch filter characteristics

The following is an example of the change in characteristics when the notch frequency setting is fixed and the notch depth and notch width settings are changed.

(Example) For a notch frequency of 100 Hz



— Precautions —

- If the notch filter parameters are not set normally, noise and vibration may increase.
- Using more notch filters may cause unstable control and vibration.
- If the notch filter frequency is too low, control may become unstable and vibration may occur.
- Note that when adaptive filter is enabled, parameters of either or both the 3rd notch filter and 4th notch filter cannot be set manually, but are automatically set (overwritten) by adaptive operation. For details, see *“5.4 Adaptive Filter Function”* .

5.3.4 How to Use

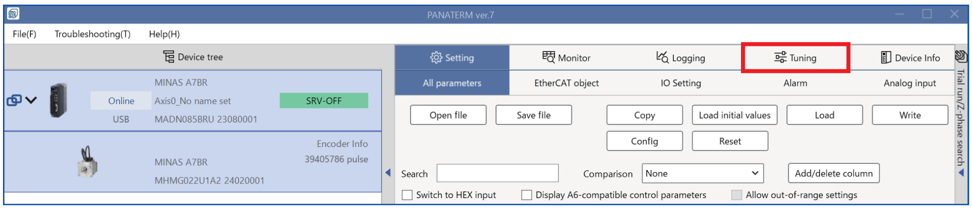
5.3.4.1 For Manual Setting

Tune using an adaptive filter. For details, see *“5.4 Adaptive Filter Function”* .

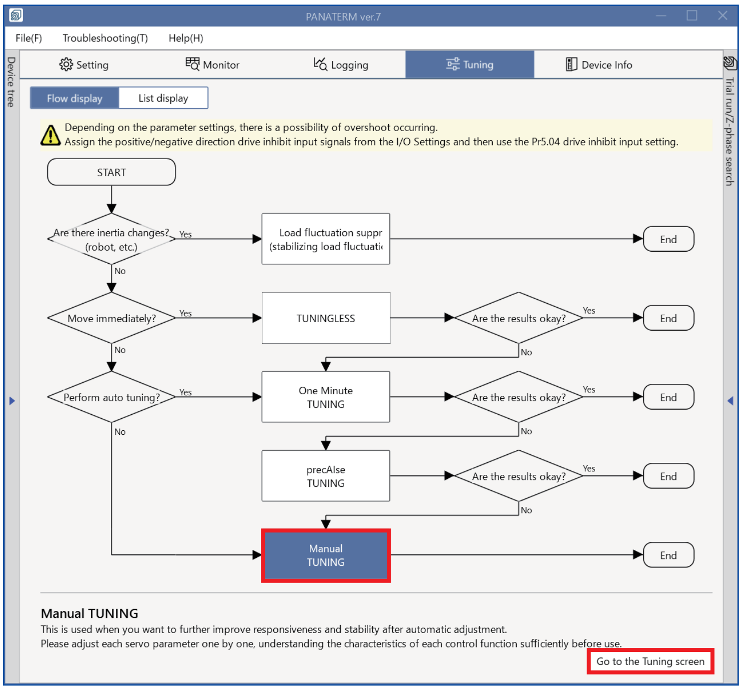
5.3.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .
2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.

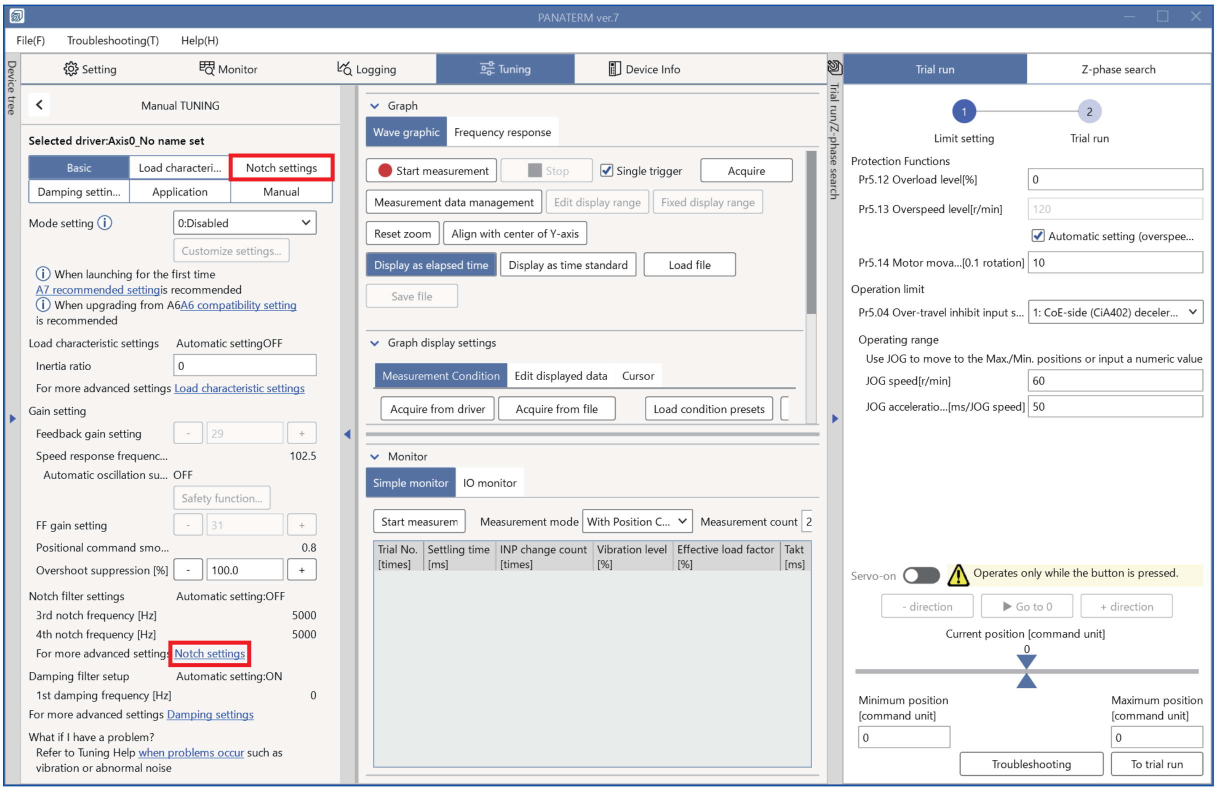


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING
This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.

4. Click on the [Notch settings] button or “Notch settings” in blue text.



Selected driver:Axis0_No name set
Mode setting: 0:Disabled
When launching for the first time A7 recommended setting is recommended
When upgrading from A6 A6 compatibility setting is recommended
Load characteristic settings: Automatic settingOFF
Inertia ratio: 0
For more advanced settings Load characteristic settings
Gain setting
Feedback gain setting: 29
Speed response frequenc...: 102.5
Automatic oscillation su...: OFF
FF gain setting: 31
Positional command smo...: 0.8
Overshoot suppression [%]: 100.0
Notch filter settings: Automatic setting:OFF
3rd notch frequency [Hz]: 5000
4th notch frequency [Hz]: 5000
For more advanced settings Notch settings
Damping filter setup: Automatic setting:ON
1st damping frequency [Hz]: 0
For more advanced settings Damping settings
What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode: With Position C...
Measurement count: 2

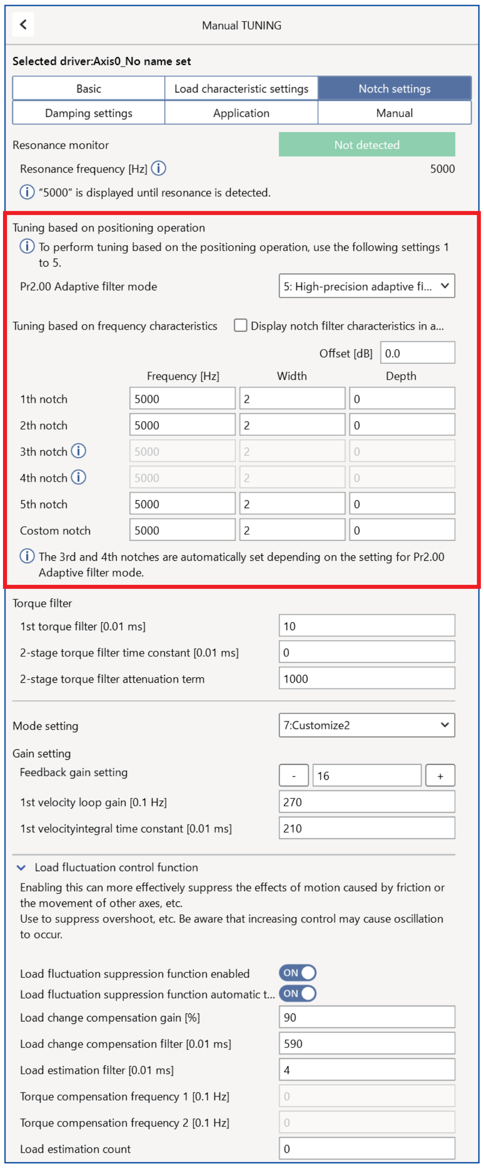
Trial No. [times]	Settling time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%]: 0
Pr5.13 Overspeed level[r/min]: 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation]: 10
Operation limit
Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...
Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min]: 60
JOG acceleratio...[ms/JOG speed]: 50
Operates only while the button is pressed.
Current position [command unit]: 0
Minimum position [command unit]: 0
Maximum position [command unit]: 0

The advanced notch settings screen is displayed.

5. Set “Tuning based on positioning operation” or “Tuning based on frequency characteristics”.

Settings can be configured from either menu, but usually settings are configured using “Tuning based on positioning operation”.



Selected driver:Axis0_No name set

Resonance monitor: Not detected

Resonance frequency [Hz]: 5000

"5000" is displayed until resonance is detected.

Tuning based on positioning operation

To perform tuning based on the positioning operation, use the following settings 1 to 5.

Pr2.00 Adaptive filter mode: 5: High-precision adaptive fi...

Tuning based on frequency characteristics ☐ Display notch filter characteristics in a...

Offset [dB]: 0.0

	Frequency [Hz]	Width	Depth
1th notch	5000	2	0
2th notch	5000	2	0
3th notch	5000	2	0
4th notch	5000	2	0
5th notch	5000	2	0
Costom notch	5000	2	0

The 3rd and 4th notches are automatically set depending on the setting for Pr2.00 Adaptive filter mode.

Torque filter

1st torque filter [0.01 ms]: 10

2-stage torque filter time constant [0.01 ms]: 0

2-stage torque filter attenuation term: 1000

Mode setting: 7:Customize2

Gain setting

Feedback gain setting: 16

1st velocity loop gain [0.1 Hz]: 270

1st velocityintegral time constant [0.01 ms]: 210

Load fluctuation control function

Enabling this can more effectively suppress the effects of motion caused by friction or the movement of other axes, etc.
Use to suppress overshoot, etc. Be aware that increasing control may cause oscillation to occur.

Load fluctuation suppression function enabled: ON

Load fluctuation suppression function automatic t...: ON

Load change compensation gain [%]: 90

Load change compensation filter [0.01 ms]: 590

Load estimation filter [0.01 ms]: 4

Torque compensation frequency 1 [0.1 Hz]: 0

Torque compensation frequency 2 [0.1 Hz]: 0

Load estimation count: 0

- To set with "Tuning based on positioning operation"

  Up to two adaptive filters can be used for auto tuning.

  For details, see *"5.4 Adaptive Filter Function"* .

- To set with "Tuning based on frequency characteristics"

  Make the following preparations.

  - Measure frequency response. For details, see *"6.2 Frequency Response Measurement"* .
  - Turn the servo off.

  Set according to the following procedure.

  1. Read the resonance frequency (the frequency with the highest gain peak) from the measurement results and set that frequency as the notch frequency.
  2. Check the "Display notch filter characteristics in a graph" check box. The notch filter characteristics configured are displayed on the graph screen (frequency response).
  3. Tune the notch width and notch depth settings so that the resonance shape in the measurement results is inverted vertically compared to the shape of the notch filter.

— Precautions —

- Noise and vibration may not be suppressed if the lowest notch frequency is lower than the Pr1.01 "1st velocity loop gain" setting frequency or close to the Pr1.01 "1st velocity loop gain" setting frequency.

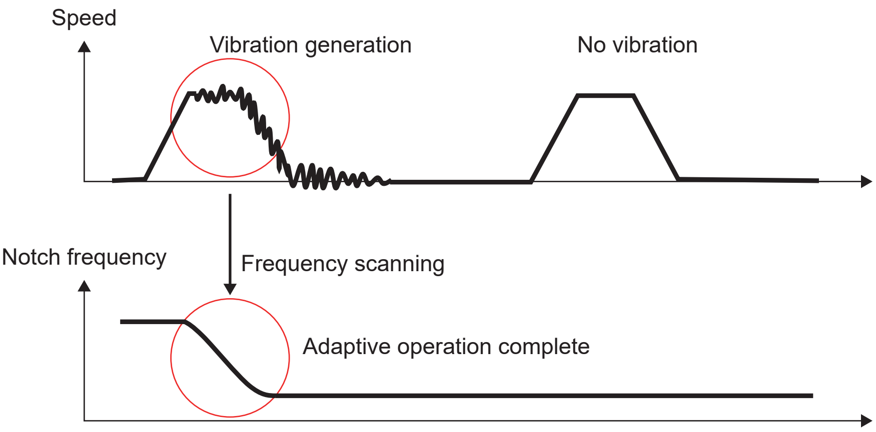
When this happens, click the [Basic] button to return to the “Manual TUNING” screen, lower the feedback gain setting, and then tune the notch filter.

5.4 Adaptive Filter Function

5.4.1 Function Overview

This function auto tunes parameters related to notch filters by estimating the resonance frequency from vibration components that appear due to motor speed during actual operation. Up to two notch filters (3rd notch filter and 4th notch filter) can be tuned automatically.

Adaptive filter operation image



5.4.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control, speed control, and full-closed control

Under the following conditions, adaptive filters may not work normally. In such cases, set the notch filters manually to suppress resonance.

Item	Conditions that obstruct the operation of adaptive filters
Resonance	● Resonance frequency is less than three times the speed response frequency [Hz] ● When the resonance peak is low or the control gain is low and the effect is not apparent in the motor speed ● When there are three or more resonance points
Load	● When motor speed fluctuations with high-frequency components occur due to non-linear characteristics such as backlash
Command pattern	● When acceleration and deceleration are 30000 r/min or more every second
Other	● In the event of sudden disturbances such as a collision

5.4.3 Related Parameters

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	00	B	Adaptive filter mode setup	0 to 6	—	Sets adaptive filter operation mode. When changing modes, temporarily set this parameter to 0 (adaptive filter disabled) or 4 (adaptation results cleared). Then set this parameter to the next value to be changed. 0: Disable adaptive filter Adaptive filter is disabled. Maintains current values of parameters related to 3rd and 4th notch filters. 1: Enable one adaptive filter One adaptive filter is enabled. Updates parameters related to 3rd notch filter according to adaptation results. 2: Enable two adaptive filters Two adaptive filters are enabled. Updates parameter related to 3rd and 4th notch filters according to adaptation results. 3: Resonance frequency measurement mode Measures resonance frequency. Measurement results can be checked using the Set-up Support Software (PANATERM ver.7) . Retains current values of parameters related to 3rd and 4th notch filters. 4: Clear adaptation results Clears adaptation results by disabling parameters related to 3rd and 4th notch filters. 5: High-precision adaptive filter Two adaptive filters are enabled. Updates parameter related to 3rd and 4th notch filters according to adaptation results. Adaption performance is improved using setting value 2. Set this setting value when two adaptive filters are used. 6: Manufacturer use (setting is prohibited) Do not use this setting value.

*1 For attributes, see *“7.1 Object Dictionary List”* .

The following parameters are set automatically when adaptive filter is enabled.

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	07	B	3rd notch frequency	10 to 5000	Hz	The 1st resonance frequency estimated by the adaptive filter is automatically set. Is set to 5000 when the resonance point cannot be found.
2	08	B	3rd notch width selection	0 to 20	—	Set automatically when adaptive filter is enabled.
2	09	B	3rd notch depth selection	0 to 99	—	Set automatically when adaptive filter is enabled.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	10	B	4th notch frequency	10 to 5000	Hz	The 2nd resonance frequency estimated by the adaptive filter is automatically set. Is set to 5000 when the resonance point cannot be found.
2	11	B	4th notch width selection	0 to 20	—	Set automatically when two adaptive filters are enabled or a high-precision adaptive filter is used.
2	12	B	4th notch depth selection	0 to 99	—	Set automatically when two adaptive filters are enabled or a high-precision adaptive filter is used.

*1 For attributes, see *"7.1 Object Dictionary List"* .

5.4.4 How to Use

5.4.4.1 For Manual Setting

<< Procedure >>

1. When Pr2.07 "3rd notch frequency" and Pr2.10 "4th notch frequency" are set to a value other than 5000 (disabled), set Pr2.00 "Adaptive filter mode setup" = 4 and initialize 3rd notch frequency and 4th notch frequency.

   Then, set Pr2.00 "Adaptive filter mode setup" to 1, 2, or 5 to enable the adaptive filter (5 is recommended).

2. Run the motor in actual operation. When the effect of the resonance point is apparent in the motor speed, the parameters of one or both of the 3rd notch filter and 4th notch filter are automatically set, depending on the number of adaptive filters.

— Precautions —

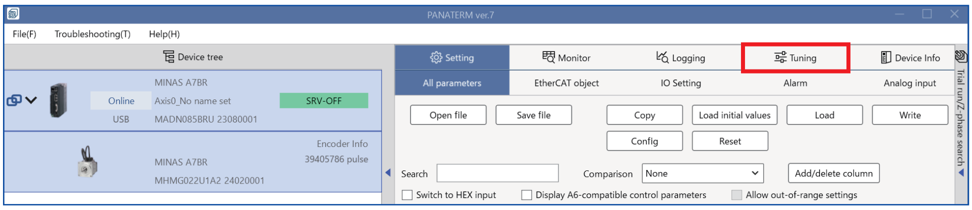
- Abnormal noise or oscillation may occur until the adaptive filter stabilizes, such as immediately after the first servo-on after activating the motor, or when the stiffness setting is increased when real-time auto tuning is enabled. However, if oscillation or continuous abnormal noise for three or more reciprocating operations occur frequently, take the following measures.
  1 Write the parameters to EEPROM once in normal operation.
  2 Lower the set value for Pr0.27 "Selection of machine stiffness at real-time auto-gain tuning 2" or Pr0.03 "Real-time auto-tuning machine stiffness setup" .
  3 Set Pr2.00 "Adaptive filter mode setup" to 0 to disable the adaptive filter.
  4 Manually set the notch filter.
- After an abnormal noise or oscillation occurs, the 3rd notch filter and 4th notch filter settings may have changed to extreme values. When this happens, disable the adaptive filter once using the procedure "1" to "3" above. Then, enable the adaptive filter again (set Pr2.00 "Adaptive filter mode setup" to either 1, 2, or 5 (5 is recommended)).
- Pr2.07 "3rd notch frequency" and Pr2.10 "4th notch frequency" are written to EEPROM every 30 minutes. When power is restored, the adaptive filter starts processing with this data as the initial values.
- Depending on the Pr2.00 "Adaptive filter mode setup" set value, parameters of one or both of the 3rd notch filter and 4th notch filter are automatically set. Note that these parameters are automatically updated.

5.4.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

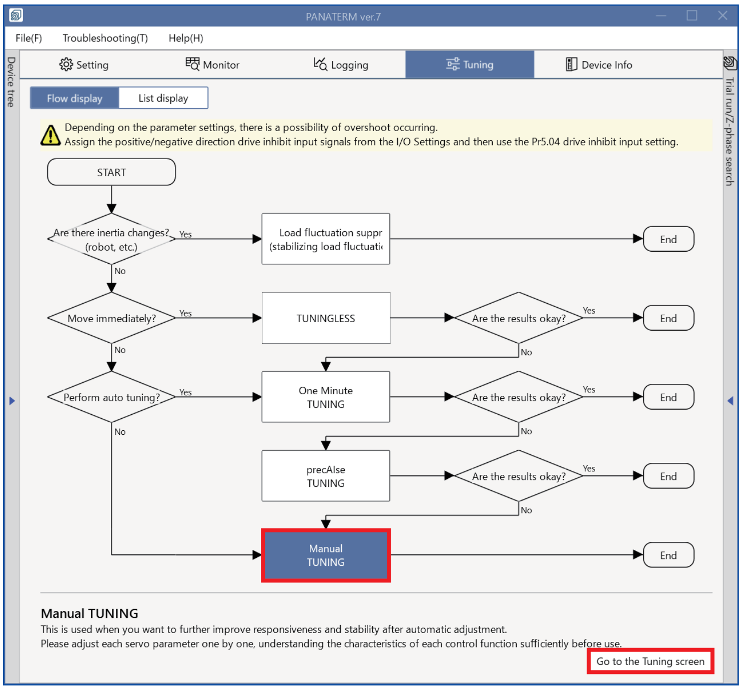
<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.



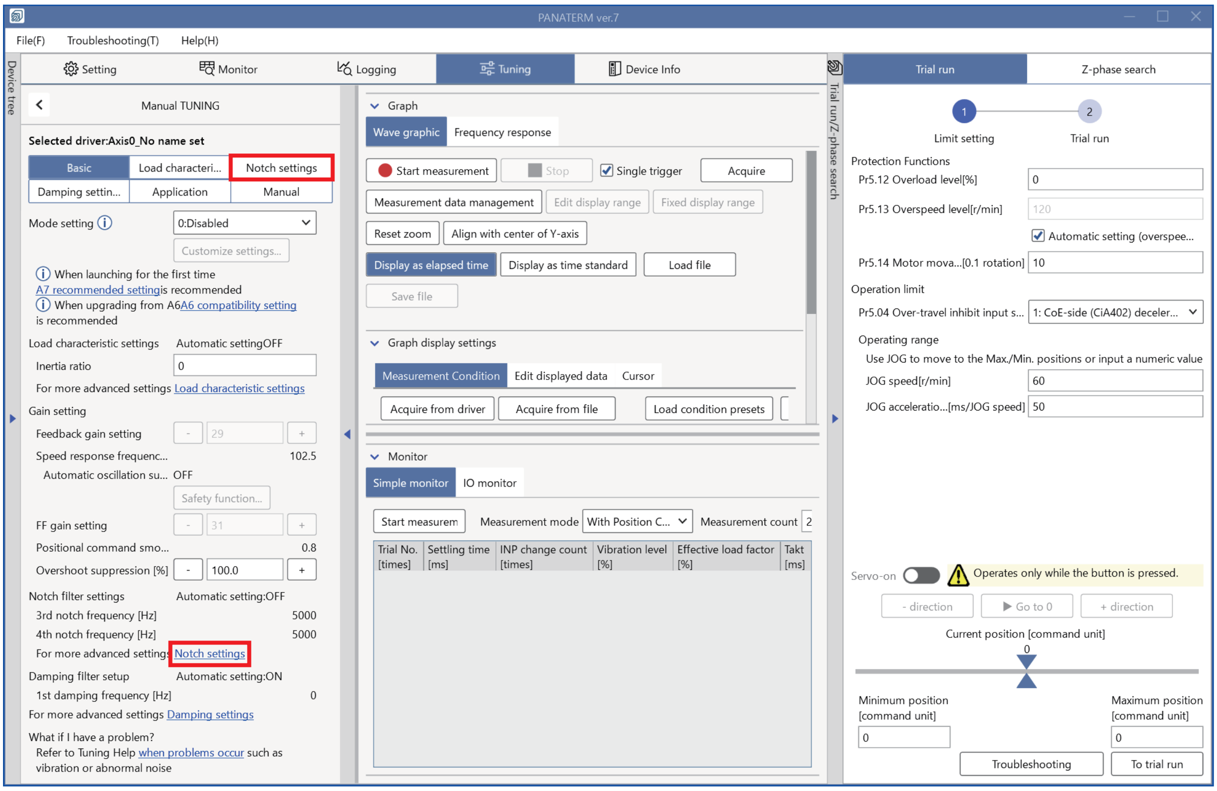
Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING

This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.

4. Click on the [Notch settings] button or “Notch settings” in blue text.



Selected driver:Axis0_No name set

Mode setting: 0:Disabled

When launching for the first time A7 recommended settingis recommended

When upgrading from A6A6 compatibility setting is recommended

Load characteristic settings: Automatic settingOFF
Inertia ratio: 0
For more advanced settings Load characteristic settings

Gain setting
Feedback gain setting: 29
Speed response frequenc...: 102.5
Automatic oscillation su...: OFF
FF gain setting: 31
Positional command smo...: 0.8
Overshoot suppression [%]: 100.0

Notch filter settings: Automatic setting:OFF
3rd notch frequency [Hz]: 5000
4th notch frequency [Hz]: 5000
For more advanced settings Notch settings

Damping filter setup: Automatic setting:ON
1st damping frequency [Hz]: 0
For more advanced settings Damping settings

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode: With Position C...
Measurement count: 2

Trial No. [times]	Settling time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%]: 0
Pr5.13 Overspeed level[r/min]: 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation]: 10

Operation limit
Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

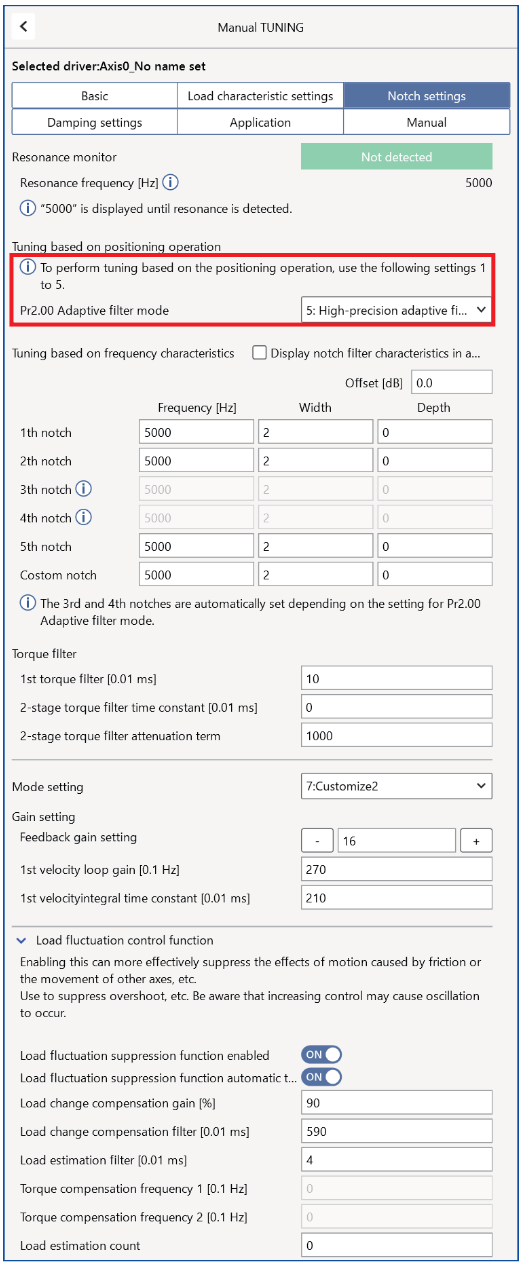
Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min]: 60
JOG acceleratio...[ms/JOG speed]: 50

Current position [command unit]: 0
Minimum position [command unit]: 0
Maximum position [command unit]: 0

The advanced notch settings screen is displayed.

5. In “Pr2.00 Adaptive filter mode” select “4: Clear adaptive results” from the drop-down list to initialize the 3rd notch and 4th notch.

   Next, select either “1: One adaptive filter enabled”, “2: Two adaptive filters enabled” or “5: High-precision adaptive filter” to enable the adaptive filter (“5: High-precision adaptive filter” is recommended).



Selected driver:Axis0_No name set

Resonance monitor: Not detected

Resonance frequency [Hz] ⓘ 5000

ⓘ “5000” is displayed until resonance is detected.

Tuning based on positioning operation

ⓘ To perform tuning based on the positioning operation, use the following settings 1 to 5.

Pr2.00 Adaptive filter mode: 5: High-precision adaptive fi...

Tuning based on frequency characteristics ☐ Display notch filter characteristics in a...

Offset [dB] 0.0

	Frequency [Hz]	Width	Depth
1th notch	5000	2	0
2th notch	5000	2	0
3th notch ⓘ	5000	2	0
4th notch ⓘ	5000	2	0
5th notch	5000	2	0
Costom notch	5000	2	0

ⓘ The 3rd and 4th notches are automatically set depending on the setting for Pr2.00 Adaptive filter mode.

Torque filter

1st torque filter [0.01 ms]	10
2-stage torque filter time constant [0.01 ms]	0
2-stage torque filter attenuation term	1000

Mode setting: 7:Customize2

Gain setting

Feedback gain setting	- 16 +
1st velocity loop gain [0.1 Hz]	270
1st velocityintegral time constant [0.01 ms]	210

Load fluctuation control function

Enabling this can more effectively suppress the effects of motion caused by friction or the movement of other axes, etc.
Use to suppress overshoot, etc. Be aware that increasing control may cause oscillation to occur.

Load fluctuation suppression function enabled	ON
Load fluctuation suppression function automatic t...	ON
Load change compensation gain [%]	90
Load change compensation filter [0.01 ms]	590
Load estimation filter [0.01 ms]	4
Torque compensation frequency 1 [0.1 Hz]	0
Torque compensation frequency 2 [0.1 Hz]	0
Load estimation count	0

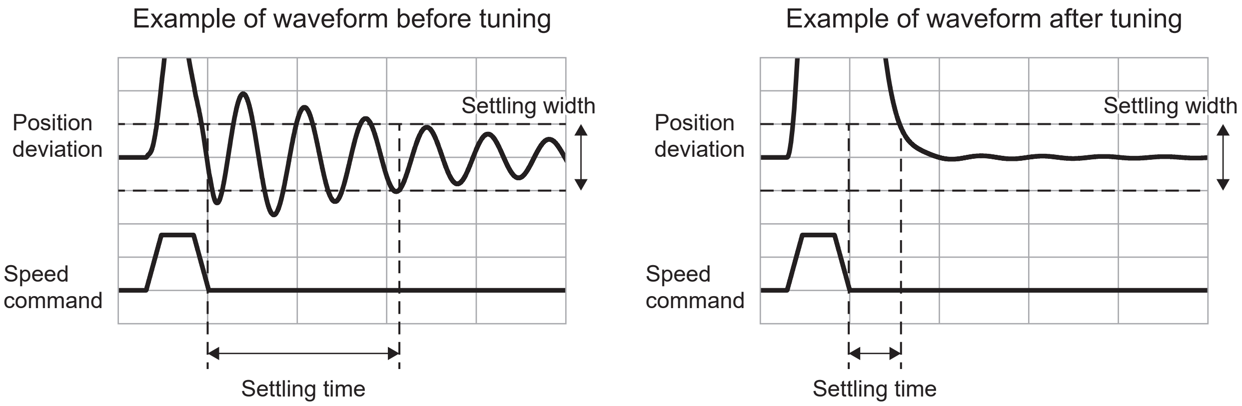
6. Click the [Basic] button to return to the “Manual TUNING” screen. Check that automatic setting is turned ON for the notch filter.

7. Operate the motor. When the effect of the resonance point is apparent in the motor speed, the parameters of one or both of the 3rd notch filter and 4th notch filter are automatically set, depending on the number of adaptive filters.

5.5 Damping Control Function

5.5.1 Function Overview

This function reduces residual vibration of approximately 100 Hz or less that occurs at the moving part tip or the overall device during positioning operation by setting a damping filter. Positioning settling time can be shortened by reducing residual vibration. Up to three of the four damping filters can be used simultaneously.



5.5.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control and full-closed control

Under the following conditions, damping control may not work normally, and its effects may not be seen.

Item	Conditions that obstruct the operation of damping control
Load conditions	● When vibration is excited by primary causes other than commands (external forces, etc.) ● When the ratio of resonance frequency to antiresonance frequency is large ● When the vibration frequency is outside the range of 0.5 to 300.0 Hz

5.5.3 Related Parameters

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	13	B	Selection of damping filter switching	0 to 7	—	Sets the switching method of the four filters used for damping control. For details, see “Pr2.13 “Selection of damping filter switching” details” below.
2	14	B	1st damping frequency	0 to 3000	0.1 Hz	Sets the 1st control frequency of damping control that suppresses the vibration at load edge. Measure the frequency of vibration at load edge and set it in units of 0.1 Hz. The valid frequency range for the setting is 0.5 to 300.0 Hz. Disabled if the setting value is set to 0 to 4.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	15	B	1st damping filter setup	0 to 1500	0.1 Hz	When the 1st damping frequency is set to enabled, set it smaller if torque saturation occurs, and set it larger to speed up operation. Use 0 under normal conditions. The setting value is capped by the corresponding damping frequency, or (3000-damping frequency), whichever is smaller.
6	41	B	1st damping depth	0 to 1000	—	Sets the depth for the 1st damping frequency. Setting value 0 is the deepest, and the larger the setting value, the shallower the depth. The deeper the depth, the better the damping effect, but the greater the delay. As the depth decreases, the delay decreases, but the damping effect also decreases. Use the parameter to make fine adjustments to the damping effect and delay.
2	27	B	1st damping width setting	0 to 1000	—	Sets width for the 1st control frequency. The valid range of setting is 10 to 1000, and 0 to 9 works as setup value 100. Within the effective range, the larger the value, the wider the width, improving the robustness against changes in vibration.
2	16	B	2nd damping frequency	0 to 3000	0.1 Hz	Sets the 2nd control frequency of damping control that suppresses the vibration at load edge. Measure the frequency of vibration at load edge and set it in units of 0.1 Hz. The valid frequency range for the setting is 0.5 to 300.0 Hz. Disabled if the setting value is set to 0 to 4.
2	17	B	2nd damping filter setup	0 to 1500	0.1 Hz	When the 2nd damping frequency is set to enabled, set it smaller if torque saturation occurs, and set it larger to speed up operation. Use 0 under normal conditions. The setting value is capped by the corresponding damping frequency, or (3000-damping frequency), whichever is smaller.
6	60	B	2nd damping depth	0 to 1000	—	Sets the depth for the 2nd damping frequency. Setting value 0 is the deepest, and the larger the setting value, the shallower the depth. The deeper the depth, the better the damping effect, but the greater the delay. As the depth decreases, the delay decreases, but the damping effect also decreases. Use the parameter to make fine adjustments to the damping effect and delay.
2	28	B	2nd damping width setting	0 to 1000	—	Sets width for the 2nd control frequency. The valid range of setting is 10 to 1000, and 0 to 9 works as setup value 100. Within the effective range, the larger the value, the wider the width, improving the robustness against changes in vibration.
2	18	B	3rd damping frequency	0 to 3000	0.1 Hz	Sets the 3rd control frequency of damping control that suppresses the vibration at load edge. Measure the frequency of vibration at load edge and set it in units of 0.1 Hz. The valid frequency range for the setting is 0.5 to 300.0 Hz. Disabled if the setting value is set to 0 to 4.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	19	B	3rd damping filter setup	0 to 1500	0.1 Hz	When the 3rd damping frequency is set to enabled, set it smaller if torque saturation occurs, and set it larger to speed up operation. Use 0 under normal conditions. The setting value is capped by the corresponding damping frequency, or (3000-damping frequency), whichever is smaller.
6	71	B	3rd damping depth	0 to 1000	—	Sets the depth for the 3rd damping frequency. Setting value 0 is the deepest, and the larger the setting value, the shallower the depth. The deeper the depth, the better the damping effect, but the greater the delay. As the depth decreases, the delay decreases, but the damping effect also decreases. Use the parameter to make fine adjustments to the damping effect and delay.
2	29	B	3rd damping width setting	0 to 1000	—	Sets width for the 3rd control frequency. The valid range of setting is 10 to 1000, and 0 to 9 works as setup value 100. Within the effective range, the larger the value, the wider the width, improving the robustness against changes in vibration.
2	20	B	4th damping frequency	0 to 3000	0.1 Hz	Sets the 4th control frequency of damping control that suppresses the vibration at load edge. Measure the frequency of vibration at load edge and set it in units of 0.1 Hz. The valid frequency range for the setting is 0.5 to 300.0 Hz. Disabled if the setting value is set to 0 to 4.
2	21	B	4th damping filter setup	0 to 1500	0.1 Hz	When the 4th damping frequency is set to enabled, set it smaller if torque saturation occurs, and set it larger to speed up operation. Use 0 under normal conditions. The setting value is capped by the corresponding damping frequency, or (3000-damping frequency), whichever is smaller.
6	72	B	4th damping depth	0 to 1000	—	Sets the depth for the 4th damping frequency. Setting value 0 is the deepest, and the larger the setting value, the shallower the depth. The deeper the depth, the better the damping effect, but the greater the delay. As the depth decreases, the delay decreases, but the damping effect also decreases. Use the parameter to make fine adjustments to the damping effect and delay.
2	30	B	4th damping width setting	0 to 1000	—	Sets width for the 4th control frequency. The valid range of setting is 10 to 1000, and 0 to 9 works as setup value 100. Within the effective range, the larger the value, the wider the width, improving the robustness against changes in vibration.
2	50	B	Detection start vibration count	0 to 100	—	This parameter is related to automatic frequency settings for damping control, and sets the number of vibrations for the position deviation that starts the vibration frequency detection process after the command is completed.
2	51	B	Detected vibration amplitude	0 to 134217728	Command unit	This parameter is related to automatic frequency settings for damping control, and sets the vibration amplitude for the position deviation detected as vibrations after the command is completed. If 0, the parameters are set automatically inside the driver.

*1 For attributes, see *“7.1 Object Dictionary List”* .

■ Pr2.13 “Selection of damping filter switching” details

<table>
<tr><th>Setup value</th><th>Description</th></tr>
<tr><td>0</td><td>Each damping control filter can be enabled or disabled as follows.
<table>
<tr><th>Setup value</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td>0</td><td>Enabled</td><td>Enabled</td><td>Disabled</td><td>Disabled</td></tr>
</table></td></tr>
<tr><td>1 to 2</td><td>Manufacturer use (setting is prohibited)</td></tr>
<tr><td>3</td><td>Depending on the direction of the position command, each damping control filter is switched between enabled and disabled as follows.
<table>
<tr><th>Setup value</th><th>Position command direction</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td rowspan="2">3</td><td>Positive direction</td><td>Enabled</td><td>Disabled</td><td>Enabled</td><td>Disabled</td></tr>
<tr><td>Negative direction</td><td>Disabled</td><td>Enabled</td><td>Disabled</td><td>Enabled</td></tr>
</table></td></tr>
<tr><td>4 to 6</td><td>Depending on the control mode, each damping control filter is switched between enabled and disabled as follows.
<p>Position Control (Two-degree-of-freedom Control Mode Enabled)</p>
<table>
<tr><th>Setup value</th><th>Position command direction</th><th>1st model-type damping control</th><th>2nd model-type damping control</th></tr>
<tr><td>4</td><td>—</td><td>Enabled</td><td>Enabled</td></tr>
<tr><td>5</td><td>—</td><td colspan="2">Manufacturer use (setting is prohibited)</td></tr>
<tr><td rowspan="2">6</td><td>Positive direction</td><td>Enabled</td><td>Disabled</td></tr>
<tr><td>Negative direction</td><td>Disabled</td><td>Enabled</td></tr>
</table>
<p>Position Control (Two-degree-of-freedom Control Mode Disabled)</p>
<table>
<tr><th>Setup value</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td>4</td><td>Enabled</td><td>Enabled</td><td>Enabled</td><td>Disabled</td></tr>
<tr><td>5, 6</td><td>Enabled</td><td>Enabled</td><td>Disabled</td><td>Disabled</td></tr>
</table>
<p>Full-closed Control</p>
<table>
<tr><th>Setup value</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td>4 to 6</td><td>Enabled</td><td>Enabled</td><td>Disabled</td><td>Disabled</td></tr>
</table></td></tr>
<tr><td>7</td><td>Depending on the control mode, each damping control filter is switched between enabled and disabled as follows.
<p>Position Control (Two-degree-of-freedom Control Mode Enabled), Full-closed Control</p>
<table>
<tr><th>Setup value</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td>7</td><td>Enabled</td><td>Enabled</td><td>Enabled</td><td>Disabled</td></tr>
</table>
<p>Position Control (Two-degree-of-freedom Control Mode Disabled)</p>
<table>
<tr><th>Setup value</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td>7</td><td>Enabled</td><td>Enabled</td><td>Disabled</td><td>Disabled</td></tr>
</table></td></tr>
</table>

5.5.4 How to Use

5.5.4.1 For Manual Setting

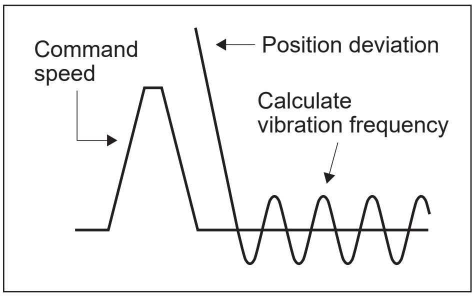
Depending on the Pr2.13 “Selection of damping filter switching” setting, the damping filters that can be used may be limited. Check before tuning.

<< Procedure >>

1. Tune the damping frequency (Pr2.14, Pr2.16, Pr2.18, Pr2.20).

   Measure the vibration frequency at the tip of the device. If the tip vibration can be measured directly with a laser displacement meter or similar instrument, the vibration frequency is read from the measured waveform in 0.1 Hz increments and set for each parameter.

   If there is no measuring instrument, the frequency is read from the residual vibration of the position deviation measured by the vibration frequency monitor using Set-up Support Software (PANATERM ver.7) or the waveform measurement function, and then set for each parameter.



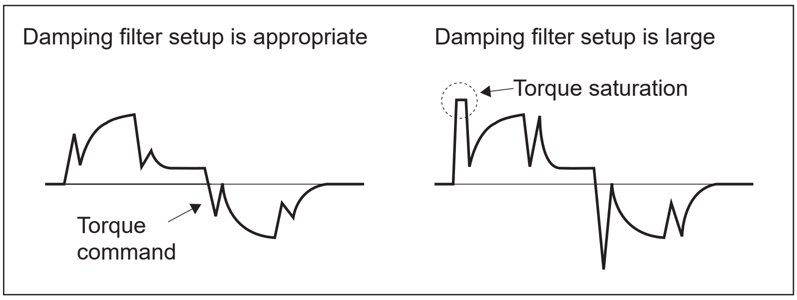
2. Tune the damping filter settings (Pr2.15, Pr2.17, Pr2.19, Pr2.21).

   Initially, set each parameter to 0 to check the position deviation waveform and torque waveform during operation.

   To shorten the settling time, gradually increase the damping filter setting from 0. The amount of change in the set value per change is approximately 10% of the damping frequency. If increased too much, torque saturation (hitting the torque limit) occurs as shown in the figure below, causing vibration suppression to be ineffective. Tune within the range where torque saturation does not occur under actual operating conditions.

   Note that the damping filter setting is limited by the following equation.

   10.0 Hz - Damping frequency $\leq$ Damping filter setting $\leq$ Damping frequency



3. Tune the damping depth settings (Pr6.41, Pr6.60, Pr6.71, Pr6.72) and damping width settings (Pr2.27, Pr2.28, Pr2.29, Pr2.30).

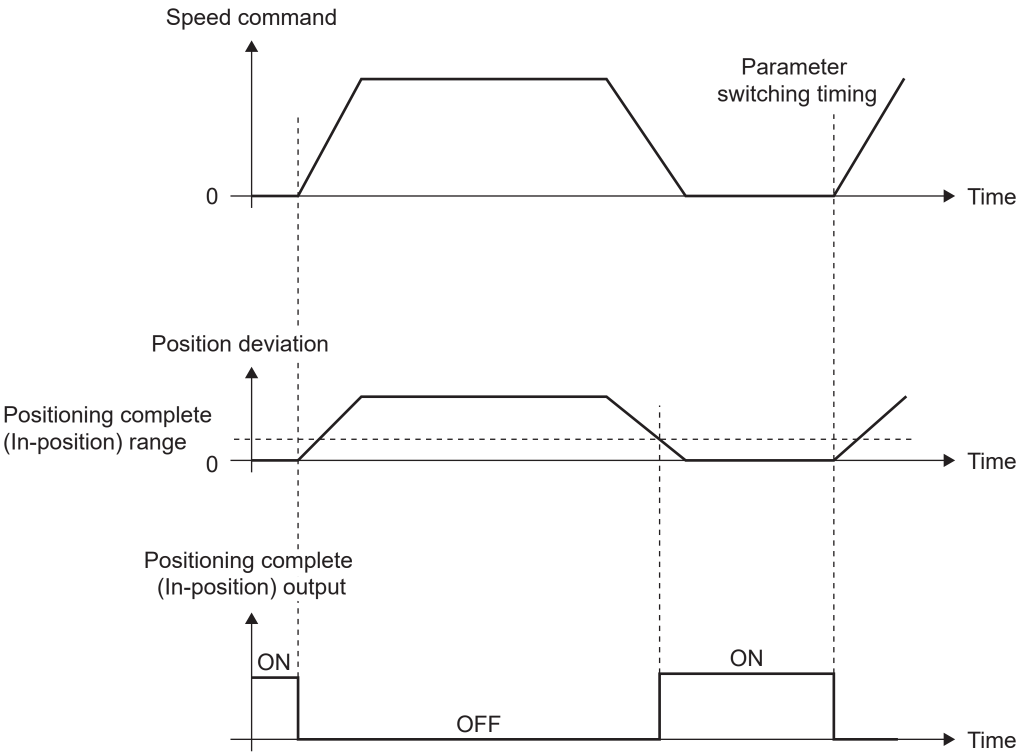
   Initially, set each parameter to 0 to check for tip vibration or residual vibration in the position deviation waveform.

   To further increase the effectiveness of vibration suppression, gradually increase the damping depth setting from 0 (make it shallower). The amount of change in the set value per change is approximately 50.

To reduce delays in command responses, set a smaller (narrower) damping width setting. To track fluctuations in vibration frequency, increase (widen) the damping width setting. The amount of change in the set value per change is approximately 20 for each.

— Precautions —

- Parameter switching when changing damping filter-related parameter settings



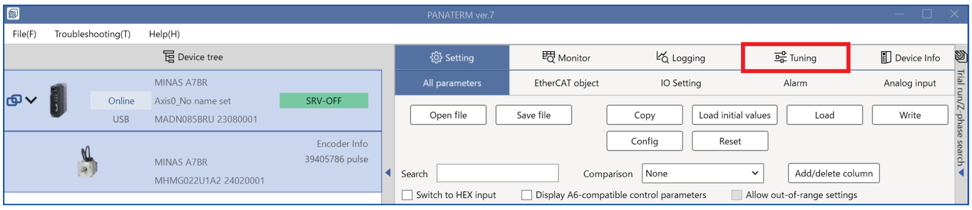
- If damping filter-related parameters (damping frequency, damping filter setup, damping depth and damping width settings) are changed during command input, parameter switching occurs at the rising up of the command (before position command filter) from 0 during positioning complete (In-position) output.
- When the positioning complete (in-position) range is set to a large value, a large accumulated pulse (the area obtained by integrating the difference between the position command before the filter and the position command after the filter over time) may remain in the filter during parameter switching. In particular, if the setting is changed to increase damping frequency or disable the filter, the motor may temporarily run at a higher speed than the original command speed because the accumulated pulses are transferred rapidly when switching occurs. Take due care.
- After changing the parameter settings of the filter during velocity control or torque control, the setting will not change even if the control mode is changed to position control.

5.5.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.

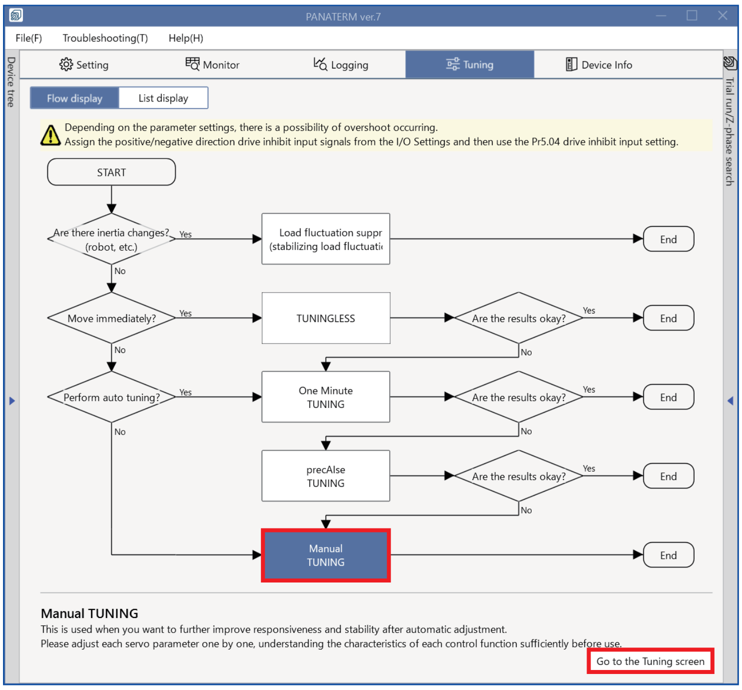


MINAS A7BR
Online Axis0_No name set SRV-OFF
USB MADN085BRU 23080001
Encoder Info
39405786 pulse
MINAS A7BR
MHMG022U1A2 24020001

Comparison: None

☐ Switch to HEX input ☐ Display A6-compatible control parameters ☐ Allow out-of-range settings

3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.



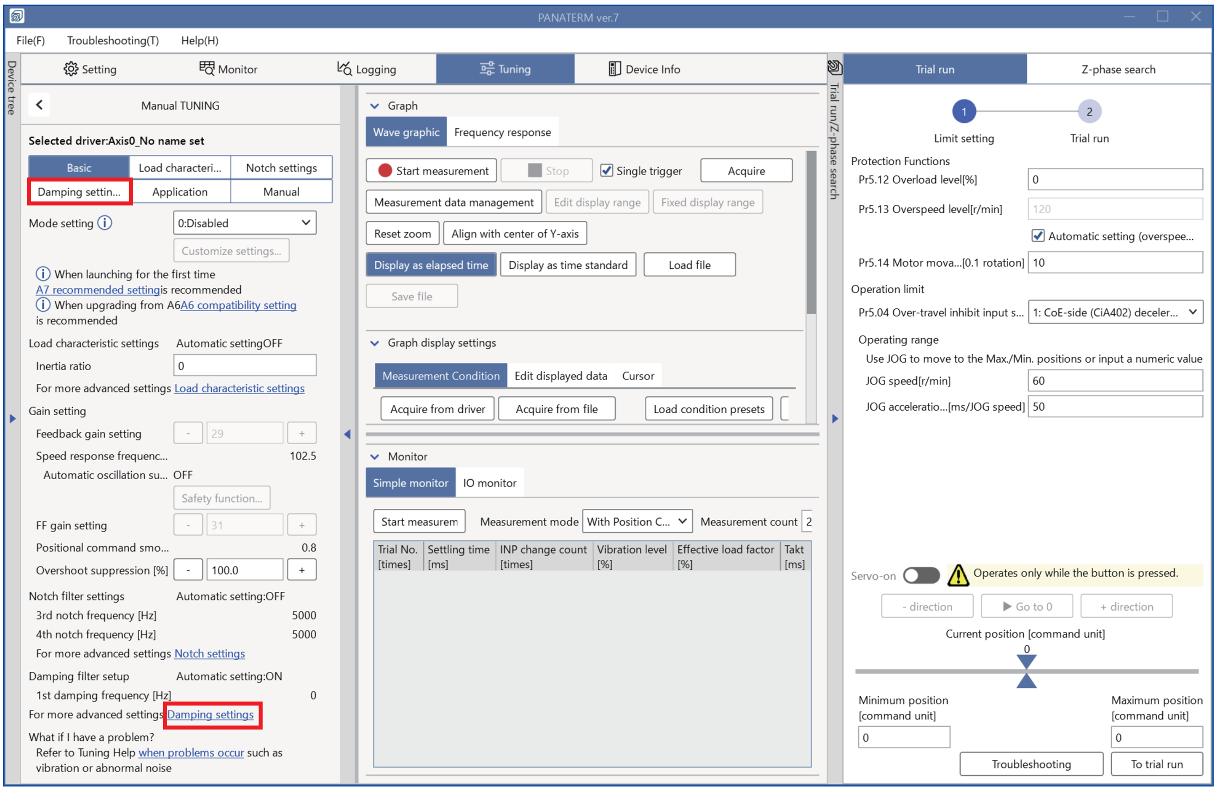
Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING

This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.

4. Click on the [Damping settings] button or “Damping settings” in blue text.



Selected driver:Axis0_No name set

Mode setting: 0:Disabled

When launching for the first time A7 recommended setting is recommended
When upgrading from A6 A6 compatibility setting is recommended

Load characteristic settings: Automatic settingOFF
Inertia ratio: 0
For more advanced settings Load characteristic settings

Gain setting
Feedback gain setting: 29
Speed response frequenc...: 102.5
Automatic oscillation su...: OFF
FF gain setting: 31
Positional command smo...: 0.8
Overshoot suppression [%]: 100.0

Notch filter settings: Automatic setting:OFF
3rd notch frequency [Hz]: 5000
4th notch frequency [Hz]: 5000
For more advanced settings Notch settings

Damping filter setup: Automatic setting:ON
1st damping frequency [Hz]: 0
For more advanced settings Damping settings

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode: With Position C...
Measurement count: 2

Trial No. [times]	Setting time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%]: 0
Pr5.13 Overspeed level[r/min]: 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation]: 10

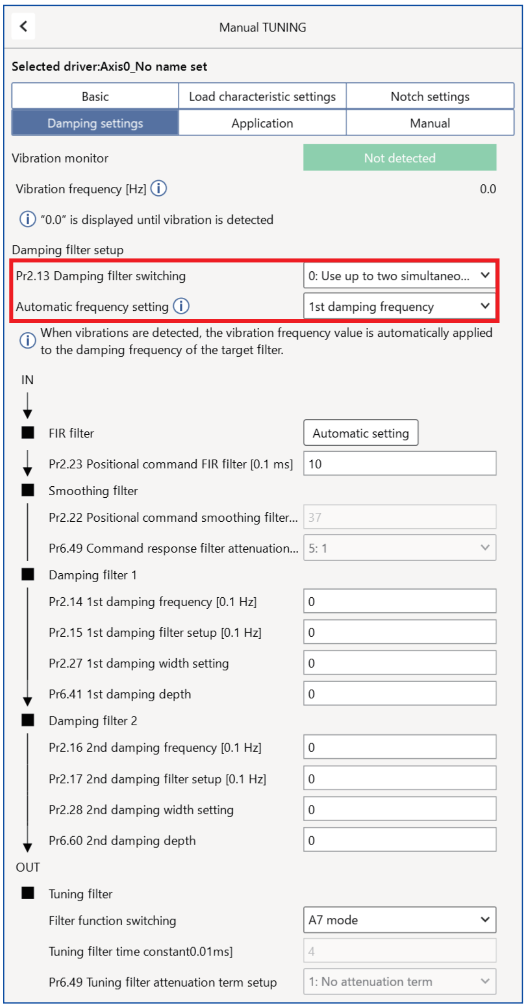
Operation limit
Pr5.04 Over-travel inhibit input s...: 1: CoE-side (CiA402) deceler...

Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min]: 60
JOG acceleratio...[ms/JOG speed]: 50

Operates only while the button is pressed.

Current position [command unit]: 0
Minimum position [command unit]: 0
Maximum position [command unit]: 0

The advanced damping settings screen is displayed.



Selected driver:Axis0_No name set

Vibration monitor: Not detected

Vibration frequency [Hz]: 0.0

"0.0" is displayed until vibration is detected

Damping filter setup

Pr2.13 Damping filter switching: 0: Use up to two simultaneo...

Automatic frequency setting: 1st damping frequency

When vibrations are detected, the vibration frequency value is automatically applied to the damping frequency of the target filter.

FIR filter: Automatic setting

Pr2.23 Positional command FIR filter [0.1 ms]: 10

Smoothing filter

Pr2.22 Positional command smoothing filter...: 37

Pr6.49 Command response filter attenuation...: 5: 1

Damping filter 1

Pr2.14 1st damping frequency [0.1 Hz]: 0

Pr2.15 1st damping filter setup [0.1 Hz]: 0

Pr2.27 1st damping width setting: 0

Pr6.41 1st damping depth: 0

Damping filter 2

Pr2.16 2nd damping frequency [0.1 Hz]: 0

Pr2.17 2nd damping filter setup [0.1 Hz]: 0

Pr2.28 2nd damping width setting: 0

Pr6.60 2nd damping depth: 0

Tuning filter

Filter function switching: A7 mode

Tuning filter time constant0.01ms]: 4

Pr6.49 Tuning filter attenuation term setup: 1: No attenuation term

— Precautions —

- The parameters displayed vary depending on the set value for "Pr2.13 Damping filter switching".

5. Select "Pr2.13 Damping filter switching" from the drop-down list. For details, see *"5.5.3 Related Parameters"* .

— Precautions —

- Only damping filter parameters that can be used are displayed.

6. Select "Automatic frequency setting" from the drop-down list.

The choices displayed depend on the "Pr2.13 Damping filter switching" setting.

Automatic frequency setting	Description
Disabled	None of the damping frequencies are set automatically.
1st damping frequency 2nd damping frequency 3rd damping frequency 4th damping frequency	When vibrations are detected, the vibration frequency value is automatically applied to the damping frequency of the target filter.

7. If not setting the damping frequency automatically with "Automatic frequency setting", set "Automatic frequency setting" to "Disabled" and set manually.

For details on parameter settings, see *“5.5.4.1 For Manual Setting”* .

5.5.4.3 Error Troubleshooting

- When Err24.0.0 “Position deviation excess protection” occurs

  Tuning related parameters may cause the position deviation excess setup value to deviate from the appropriate value.

  Review the set value using the formula for calculating the position deviation excess setup value shown in Operating Instructions (Overall) “7.2.9 Before Gain Tuning Protection Function Setup” .

5.6 Model-type Damping Filter Function

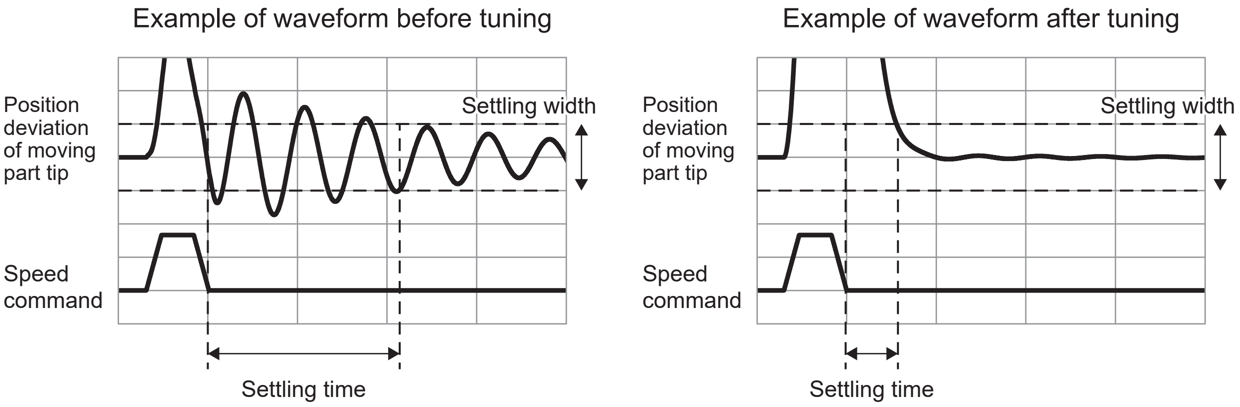
5.6.1 Function Overview

This function reduces residual vibration of approximately 100 Hz or less that occurs at the moving part tip of the device during positioning operation by setting a model-type damping filter. Positioning settling time can be shortened by reducing residual vibration.

The model-type damping filter eliminates both resonance frequency components and antiresonance frequency components while increasing the effectiveness of conventional damping filters to achieve smooth torque commands and improve the damping effect.

By removing the antiresonance frequency components and resonance frequency components, the responsiveness of the command response filter can be increased and the settling time can be reduced.

However, to measure antiresonance frequency components and resonance frequency components, it is necessary to perform frequency characteristics analysis to set optimal parameter values, since vibration components cannot be acquired from position sensors, as is the case with conventional damping filters. (For details of conventional damping filters, see *“5.5 Damping Control Function”* .)



5.6.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control and two-degree-of-freedom control mode enabled
Other	● Set-up Support Software (PANATERM ver.7) is required.

Under the following conditions, the model-type damping filter may not work normally, and its effects may not be seen.

Item	Conditions that obstruct the operation of model-type damping filters
Load conditions	● When vibration is excited by primary causes other than commands (external forces, etc.) ● When the resonance frequency and antiresonance frequency are not between 5.0 and 300.0 Hz

If the parameter settings are as follows, the filter operates as a conventional damping filter (see *“5.5 Damping Control Function”*).

Item	Conditions for operating as a conventional damping filter
Parameter set-up	● When the resonance frequency and antiresonance frequency do not have the following relationship 5.0 Hz ≤ antiresonance frequency < resonance frequency ≤ 300.0 Hz ● When the response frequency and antiresonance frequency do not have the following relationship 5.0 Hz ≤ antiresonance frequency ≤ response frequency ≤ antiresonance frequency × 4 ≤ 300.0 Hz ● When Pr2.13 “Selection of damping filter switching” is set to 4, both the 1st and 2nd model-type damping filters are enabled, and the ratio of the 1st and 2nd response frequencies and antiresonance frequencies multiplied exceeds 8 (in this case, only the 2nd model-type damping filter is a conventional type damping filter)

When operating as a conventional damping filter, the following three types of parameters of antiresonance frequency, anti-resonance damping ratio, and response frequency, are used as the damping frequency, damping depth and damping filter setting, respectively.

To completely disable this function, all five parameters (resonance frequency, resonance damping ratio, antiresonance frequency, anti-resonance damping ratio, response frequency) must be set to 0.

Pr6.61 “1st resonance frequency” , Pr6.66 “2nd resonance frequency”

Pr6.62 “1st resonance attenuation ratio” , Pr6.67 “2nd resonance attenuation ratio”

Pr6.63 “1st anti-resonance frequency” , Pr6.68 “2nd anti-resonance frequency”

Pr6.64 “1st anti-resonance attenuation ratio” , Pr6.69 “2nd anti-resonance attenuation ratio”

Pr6.65 “1st response frequency” , Pr6.70 “2nd response frequency”

5.6.3 Related Parameters

—: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	13	B	Selection of damping filter switching	0 to 7	—	Sets the switching method of the four filters used for damping control. For details, see “Pr2.13 “Selection of damping filter switching” details” below.
6	61	B	1st resonance frequency	0 to 3000	0.1 Hz	Sets model-type damping filter load resonance frequency.
6	62	B	1st resonance attenuation ratio	0 to 1000	—	Sets the model-type damping filter load resonance damping ratio. The damping ratio can be set as the setup value multiplied by 0.001. A setting value of 1000 results in an attenuation of 1 (no peak). The smaller the setting value, the smaller the damping ratio (higher resonance peak).
6	63	B	1st anti-resonance frequency	0 to 3000	0.1 Hz	Sets the model-type damping filter load anti-resonance frequency.
6	64	B	1st anti-resonance attenuation ratio	0 to 1000	—	Sets the model-type damping filter load anti-resonance damping ratio. The damping ratio can be set as the setup value multiplied by 0.001. A setting value of 1000 results in an attenuation of 1 (no peak). The smaller the setting value, the smaller the damping ratio (higher resonance peak).
6	65	B	1st response frequency	0 to 3000	0.1 Hz	Sets the model-type damping filter load response frequency.
6	66	B	2nd resonance frequency	0 to 3000	0.1 Hz	Sets the model-type damping filter load 2nd resonance frequency.
6	67	B	2nd resonance attenuation ratio	0 to 1000	—	Sets the model-type damping filter load 2nd resonance attenuation ratio. The damping ratio can be set as the setup value multiplied by 0.001. A setting value of 1000 results in an attenuation of 1 (no peak). The smaller the setting value, the smaller the damping ratio (higher resonance peak).
6	68	B	2nd anti-resonance frequency	0 to 3000	0.1 Hz	Sets the model-type damping filter load 2nd anti-resonance frequency.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	69	B	2nd anti-resonance attenuation ratio	0 to 1000	–	Sets the model-type damping filter load 2nd anti-resonance attenuation ratio The damping ratio can be set as the setup value multiplied by 0.001. A setting value of 1000 results in an attenuation of 1 (no peak). The smaller the setting value, the smaller the damping ratio (higher resonance peak).
6	70	B	2nd response frequency	0 to 3000	0.1 Hz	Sets the model-type damping filter load 2nd response frequency. The unit is 0.1 Hz.

*1 For attributes, see *"7.1 Object Dictionary List"* .

■ Pr2.13 "Selection of damping filter switching" details

<table>
<tr><th>Setup value</th><th>Description</th></tr>
<tr><td>0</td><td>Each damping control filter can be enabled or disabled as follows.
<table>
<tr><th>Setup value</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td>0</td><td>Enabled</td><td>Enabled</td><td>Disabled</td><td>Disabled</td></tr>
</table></td></tr>
<tr><td>1 to 2</td><td>Manufacturer use (setting is prohibited)</td></tr>
<tr><td>3</td><td>Depending on the direction of the position command, each damping control filter is switched between enabled and disabled as follows.
<table>
<tr><th>Setup value</th><th>Position command direction</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td rowspan="2">3</td><td>Positive direction</td><td>Enabled</td><td>Disabled</td><td>Enabled</td><td>Disabled</td></tr>
<tr><td>Negative direction</td><td>Disabled</td><td>Enabled</td><td>Disabled</td><td>Enabled</td></tr>
</table></td></tr>
<tr><td>4 to 6</td><td>Depending on the control mode, each damping control filter is switched between enabled and disabled as follows.
<p>Position Control (Two-degree-of-freedom Control Mode Enabled)</p>
<table>
<tr><th>Setup value</th><th>Position command direction</th><th>1st model-type damping control</th><th>2nd model-type damping control</th></tr>
<tr><td>4</td><td>–</td><td>Enabled</td><td>Enabled</td></tr>
<tr><td>5</td><td>–</td><td colspan="2">Manufacturer use (setting is prohibited)</td></tr>
<tr><td rowspan="2">6</td><td>Positive direction</td><td>Enabled</td><td>Disabled</td></tr>
<tr><td>Negative direction</td><td>Disabled</td><td>Enabled</td></tr>
</table>
<p>Position Control (Two-degree-of-freedom Control Mode Disabled)</p>
<table>
<tr><th>Setup value</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td>4</td><td>Enabled</td><td>Enabled</td><td>Enabled</td><td>Disabled</td></tr>
<tr><td>5, 6</td><td>Enabled</td><td>Enabled</td><td>Disabled</td><td>Disabled</td></tr>
</table>
<p>Full-closed Control</p>
<table>
<tr><th>Setup value</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td>4 to 6</td><td>Enabled</td><td>Enabled</td><td>Disabled</td><td>Disabled</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Setup value</th><th>Description</th></tr>
<tr><td>7</td><td>Depending on the control mode, each damping control filter is switched between enabled and disabled as follows.
Position Control (Two-degree-of-freedom Control Mode Enabled), Full-closed Control
<table>
<tr><th>Setup value</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td>7</td><td>Enabled</td><td>Enabled</td><td>Enabled</td><td>Disabled</td></tr>
</table>
Position Control (Two-degree-of-freedom Control Mode Disabled)
<table>
<tr><th>Setup value</th><th>1st damping</th><th>2nd damping</th><th>3rd damping</th><th>4th damping</th></tr>
<tr><td>7</td><td>Enabled</td><td>Enabled</td><td>Disabled</td><td>Disabled</td></tr>
</table>
</td></tr>
</table>

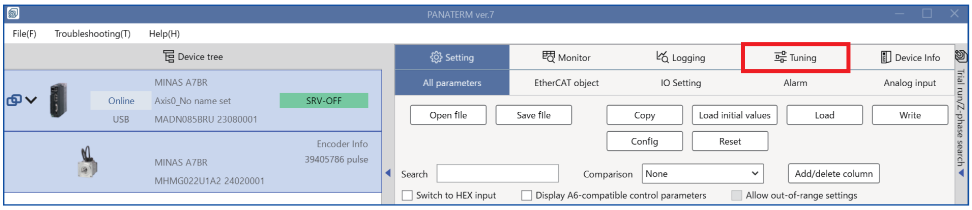
5.6.4 How to Use

Manual setting is not possible. Use Set-up Support Software (PANATERM ver.7) .

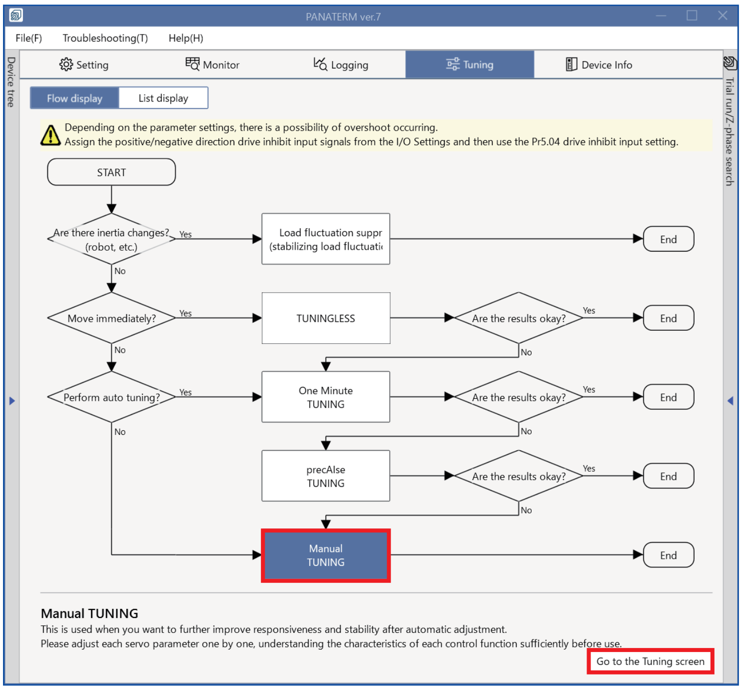
5.6.4.1 When Set-up Support Software (PANATERM ver.7) Is Used

<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .
2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.

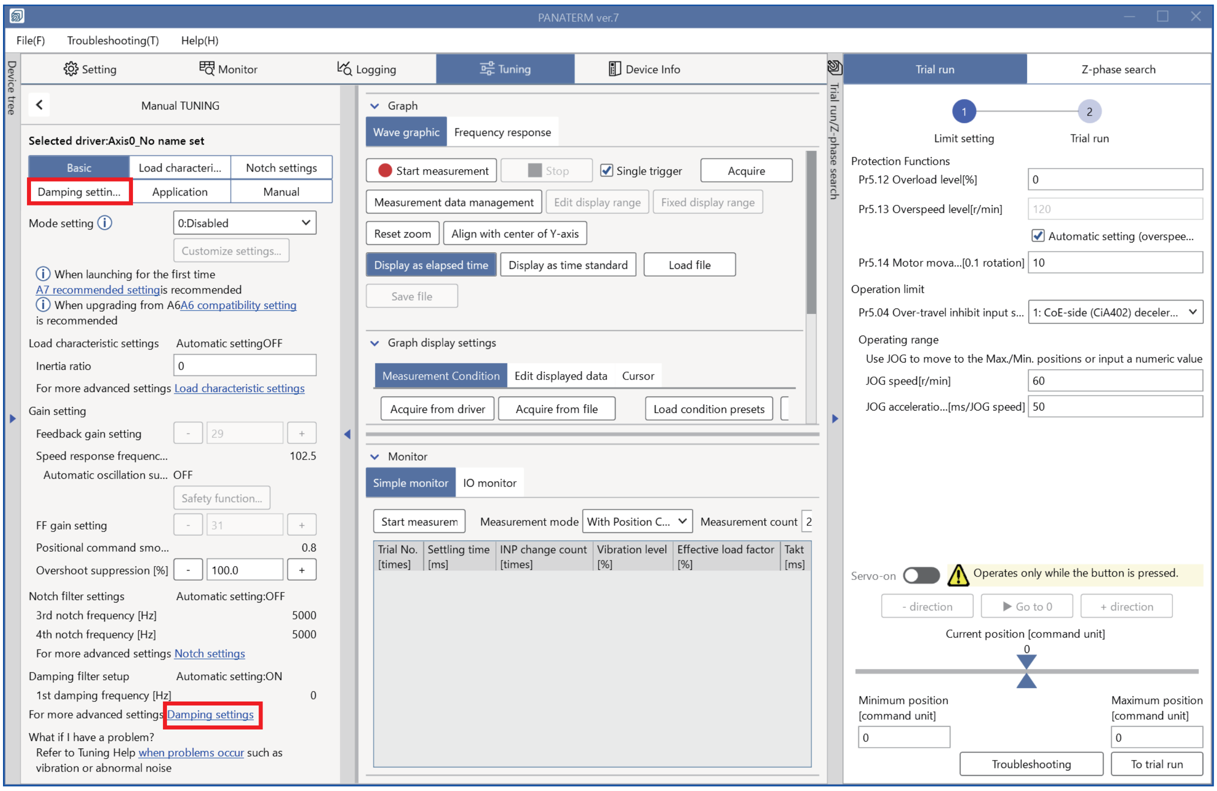


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING
This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.

4. Click on the [Damping settings] button or “Damping settings” in blue text.



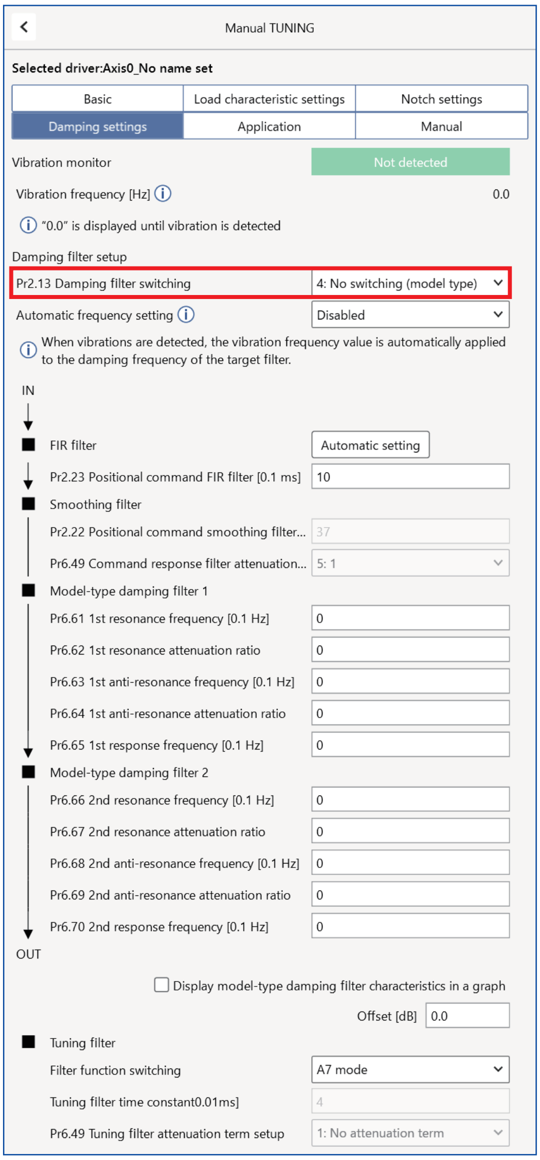
Selected driver:Axis0_No name set
Mode setting 0:Disabled
When launching for the first time
A7 recommended setting is recommended
When upgrading from A6A6 compatibility setting is recommended
Load characteristic settings Automatic settingOFF
Inertia ratio 0
For more advanced settings Load characteristic settings
Gain setting
Feedback gain setting 29
Speed response frequenc... 102.5
Automatic oscillation su... OFF
FF gain setting 31
Positional command smo... 0.8
Overshoot suppression [%] 100.0
Notch filter settings Automatic setting:OFF
3rd notch frequency [Hz] 5000
4th notch frequency [Hz] 5000
For more advanced settings Notch settings
Damping filter setup Automatic setting:ON
1st damping frequency [Hz] 0
For more advanced settings Damping settings
What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode With Position C...
Measurement count 2

Trial No. [times]	Settling time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%] 0
Pr5.13 Overspeed level[r/min] 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation] 10
Operation limit
Pr5.04 Over-travel inhibit input s... 1: CoE-side (CiA402) deceler...
Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min] 60
JOG acceleratio...[ms/JOG speed] 50
Operates only while the button is pressed.
Current position [command unit] 0
Minimum position [command unit] 0
Maximum position [command unit] 0

The advanced damping settings screen is displayed.



Selected driver:Axis0_No name set

Vibration monitor: Not detected

Vibration frequency [Hz]: 0.0

"0.0" is displayed until vibration is detected

Damping filter setup

Pr2.13 Damping filter switching: 4: No switching (model type)

Automatic frequency setting: Disabled

When vibrations are detected, the vibration frequency value is automatically applied to the damping frequency of the target filter.

FIR filter

Pr2.23 Positional command FIR filter [0.1 ms]: 10

Smoothing filter

Pr2.22 Positional command smoothing filter...: 37

Pr6.49 Command response filter attenuation...: 5: 1

Model-type damping filter 1

Pr6.61 1st resonance frequency [0.1 Hz]: 0

Pr6.62 1st resonance attenuation ratio: 0

Pr6.63 1st anti-resonance frequency [0.1 Hz]: 0

Pr6.64 1st anti-resonance attenuation ratio: 0

Pr6.65 1st response frequency [0.1 Hz]: 0

Model-type damping filter 2

Pr6.66 2nd resonance frequency [0.1 Hz]: 0

Pr6.67 2nd resonance attenuation ratio: 0

Pr6.68 2nd anti-resonance frequency [0.1 Hz]: 0

Pr6.69 2nd anti-resonance attenuation ratio: 0

Pr6.70 2nd response frequency [0.1 Hz]: 0

☐ Display model-type damping filter characteristics in a graph

Offset [dB]: 0.0

Tuning filter

Filter function switching: A7 mode

Tuning filter time constant0.01ms]: 4

Pr6.49 Tuning filter attenuation term setup: 1: No attenuation term

— Precautions —

- The parameters displayed vary depending on the set value for “Pr2.13 Damping filter switching”.

5. Select “Pr2.13 Damping filter switching” from the drop-down list. For details, see *“5.6.3 Related Parameters”* .

— Precautions —

- Only parameters for model-type damping filter that can be used are displayed.

6. Frequency response is measured using the torque speed mode of the frequency response measurement function. For details, see *“6.2 Frequency Response Measurement”* .

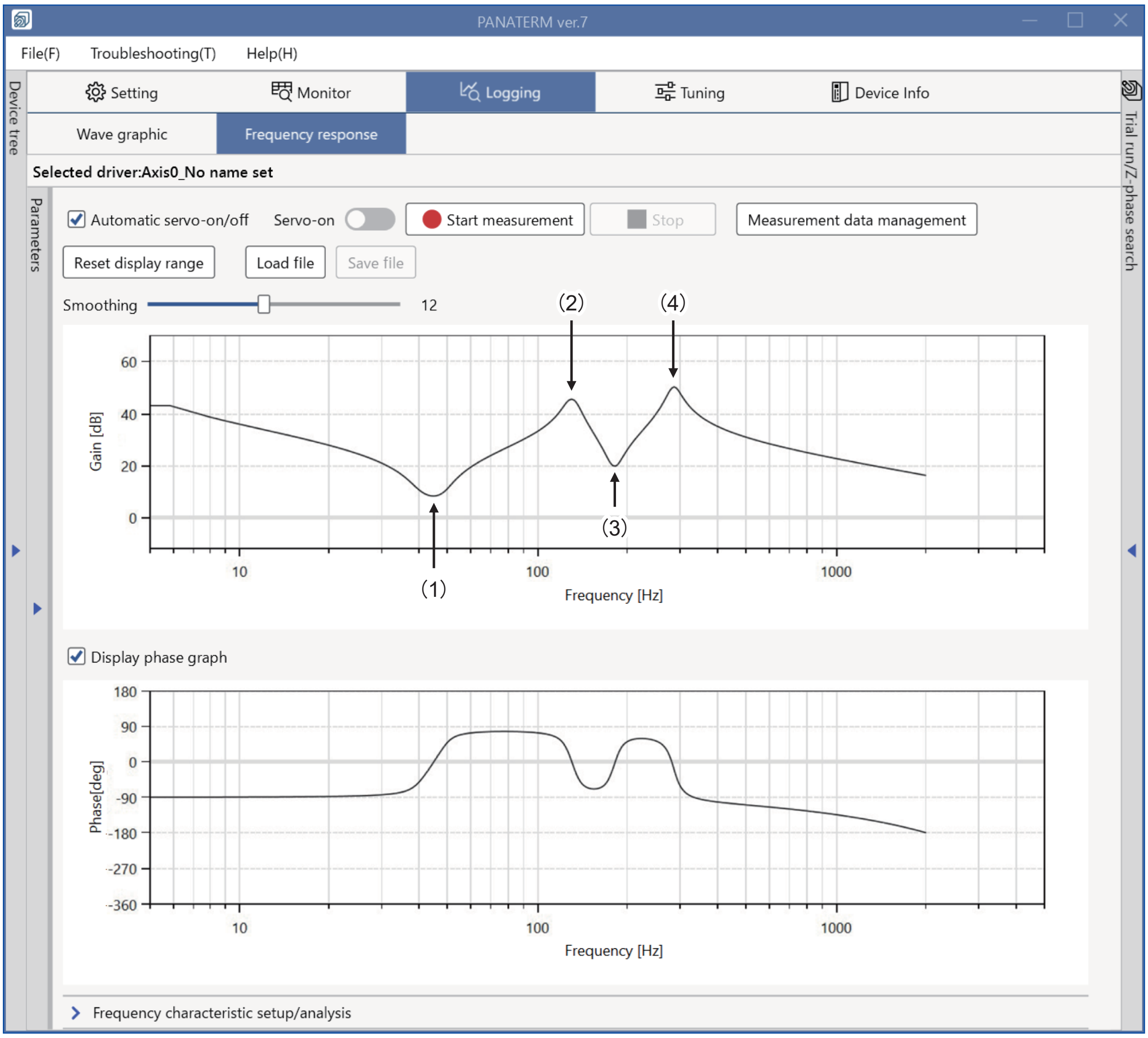
7. Read a maximum of two each of large peaks and troughs for gain from the measurement results, and set Pr6.61 “1st resonance frequency” , Pr6.63 “1st anti-resonance frequency” , Pr6.66 “2nd resonance frequency” , and Pr6.68 “2nd anti-resonance frequency” .

   An example of measurement with a belt device is shown below. Ignoring small resonances, the resonance frequencies that are peaks of the gain, as well as the antiresonance frequencies that are troughs of the gain, are as follows.

   1st resonance frequency = 130 Hz ((2) in the figure below), 1st anti-resonance frequency = 44 Hz ((1) in the figure below)

   2nd resonance frequency = 285 Hz ((4) in the figure below), 2nd anti-resonance frequency = 180 Hz ((3) in the figure below)

Example of frequency response measurement results



Selected driver:Axis0_No name set

8. For the 1st and 2nd resonance damping ratios and anti-resonance damping ratios, set the initial value to 50 (0.050).

   Check the “Display model-type damping filter characteristics in a graph” check box to display the model-type damping filter characteristics based on the set parameter.

   The validity of the set parameters can be checked by comparing them with the measurement results for frequency response.

9. Set response frequency to the same value as antiresonance frequency.

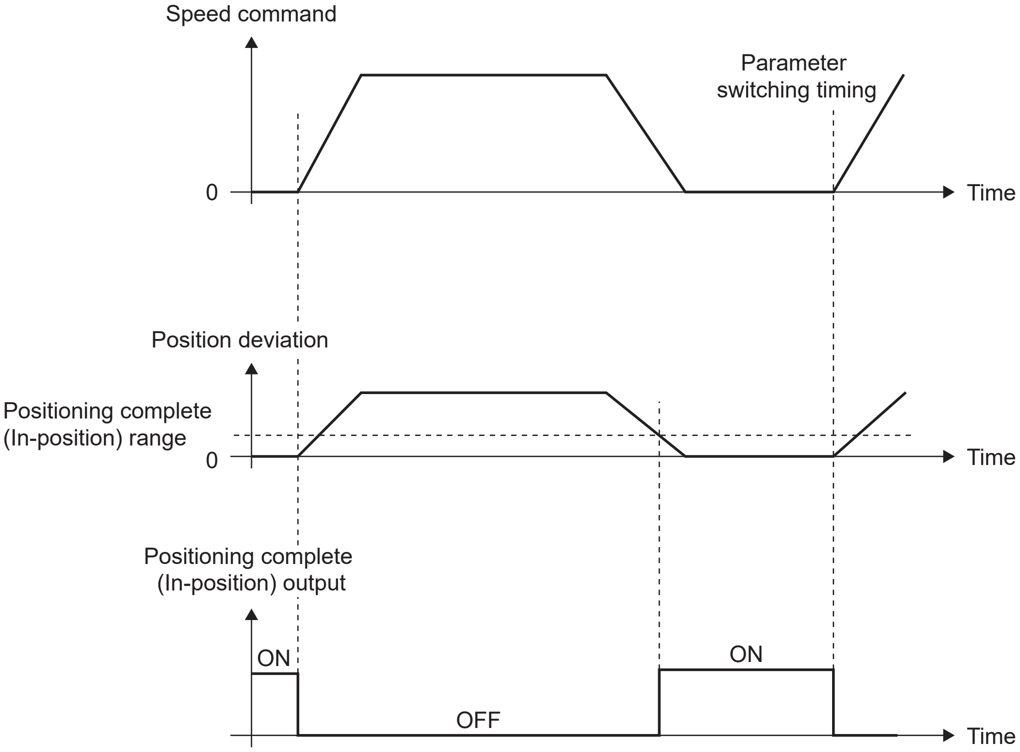
10. Run the motor to check for tip vibration or residual vibration in the position deviation waveform. Then, fine tune the parameters in the following order to reduce vibration components.

- Pr6.63 “1st anti-resonance frequency” > Pr6.64 “1st anti-resonance attenuation ratio” > Pr6.61 “1st resonance frequency” > Pr6.62 “1st resonance attenuation ratio”
- Pr6.68 “2nd anti-resonance frequency” > Pr6.69 “2nd anti-resonance attenuation ratio” > Pr6.66 “2nd resonance frequency” > Pr6.67 “2nd resonance attenuation ratio”

11. Find the setting with the lowest vibration and increase the response frequency setting. Although higher frequencies result in less control delay caused by the model-type damping filter, they also result in gradual decreases in damping effectiveness. This makes it important to find a balanced setting. Note that, according to the specifications of the model-type damping filter, the response frequency setting should be less than four times the antiresonance frequency.

— Precautions —

- Parameter switching when changing model-type damping filter-related parameter settings



- If the model-type damping filter-related parameters (resonance frequency, resonance damping ratio, antiresonance frequency, anti-resonance damping ratio, and response frequency) are changed during command input, parameter switching occurs at the rising up of the command (before position command filter) from 0 during positioning complete (in-position) output.
- When the positioning complete (in-position) range is set to a large value, a large accumulated pulse (the area obtained by integrating the difference between the position command before the filter and the position command after the filter over time) may remain in the filter during parameter switching. In particular, if the setting is changed to increase the antiresonance frequency or disable the filter, the motor may temporarily run at a higher speed than the original command speed because the accumulated pulses are transferred rapidly when switching occurs. Take due care.
- After changing the parameter settings of the filter during velocity control or torque control, the setting will not change even if the control mode is changed to position control.

5.6.4.2 Error Troubleshooting

- When Err24.0.0 “Position deviation excess protection” occurs

  Tuning related parameters may cause the position deviation excess setup value to deviate from the appropriate value.

  Review the set value using the formula for calculating the position deviation excess setup value shown in Operating Instructions (Overall) “7.2.9 Before Gain Tuning Protection Function Setup” .

5.7 Position Command Filter Function

5.7.1 Function Overview

A function that applies a positional command smoothing filter to a position command to gently accelerate or decelerate the motor. This is expected to suppress vibration and velocity change caused by the command resolution and command updating cycle roughness.

5.7.2 Operational Conditions

Item	Operational Conditions
Control mode	● Position control, speed control, and full-closed control

5.7.3 Related Parameters

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	22	B	Positional command smoothing filter	0 to 10000	0.1 ms	When two-degree-of-freedom control mode is enabled: Functions as a command response filter and sets the filter time constant. When two-degree-of-freedom control mode is disabled: Sets the time constant of the first order lag filter for the position command.
2	23	B	Positional command FIR filter	0 to 10000	0.1 ms	Sets the average movement time for the position command.
6	49	B	Command response/tuning filter attenuation term	0 to 99	–	Sets the “command response filter” and “tuning filter” attenuation terms in the two-degree-of-freedom control. ● Sets each filter in decimal notation. Ones: Command response filter Tens: Tuning filter <Target digit setting values> 0 to 4: No attenuation terms (operates as first order lag filter) 5 to 9: Attenuation term ζ is 1.0, 0.86, 0.71, 0.50, 0.35, in that order (operates as second order lag filter) ＜ Example of this parameter setup ＞ To set the command response filter to ζ = 1.0 and the tuning filter to ζ = 0.71, set the setting value to 75 (ones = 5 (ζ = 1.0), tens = 7 (ζ = 0.71)). Note that Pr2.22 “Positional command smoothing filter” is applied to the command response filter time constant.

*1 For attributes, see *“7.1 Object Dictionary List”* .

— Precautions —

- Changing the damping control-related parameters changes the recommended setting value for position deviation excess protection.

  As a result, the set value for position deviation may be too small to cause an unexpected error, or the set value may be too large to detect. Review the set values.

5.7.4 How to Use

■ Details on Pr2.22 "Positional command smoothing filter"

Setting the time constant of the command response filter

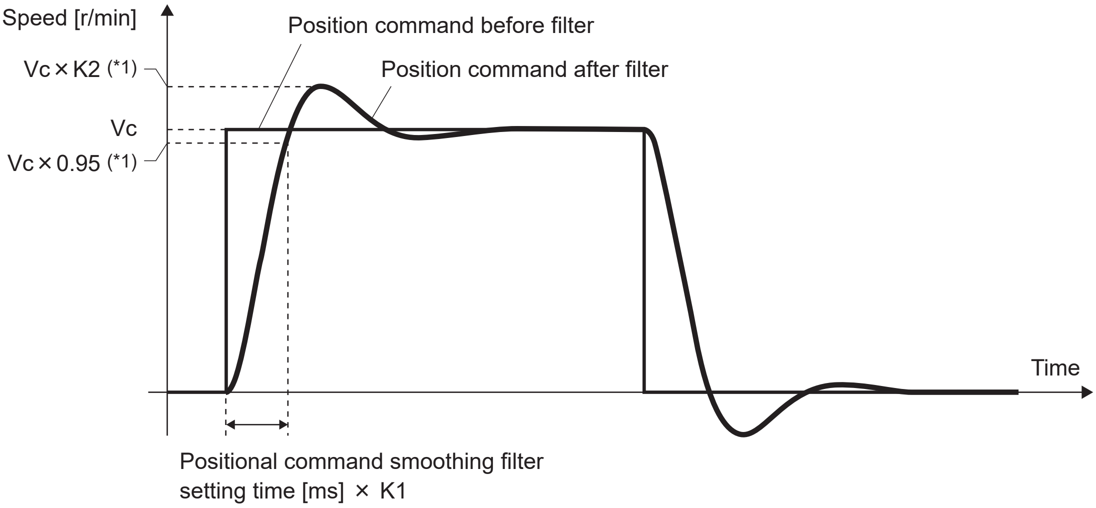
Set the time constant of the "command response filter" when two-degree-of-freedom control mode is enabled.

In the following cases, set the time constant of the first order lag filter or the second order lag filter based on the set value for the ones place of Pr6.49, "Command response filter attenuation term setup".

- When two-degree-of-freedom control mode is enabled, and the set value for the ones place of Pr6.49, "Command response filter attenuation term setup", is 5 to 9

Normally, the ones place of Pr6.49, "Command response filter attenuation term setup", should be set to 5.

The figure below shows a waveform after filtering for the target speed Vc square wave command using a second-order lag filter.

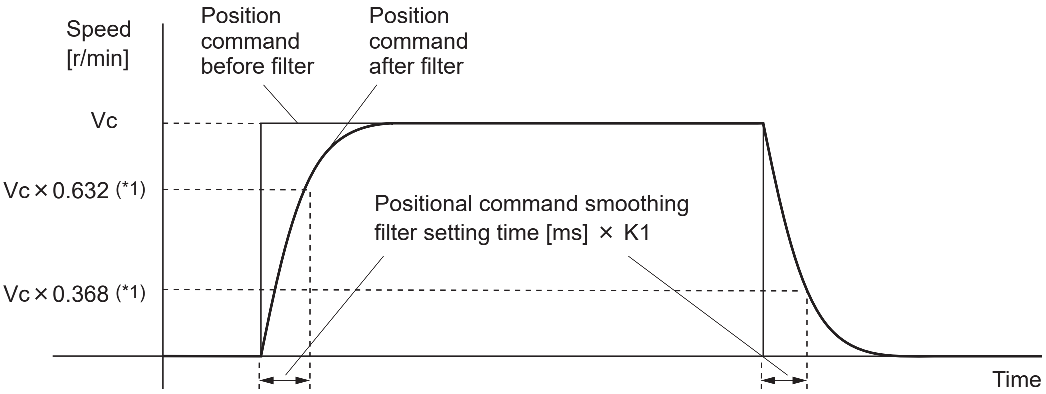


Ones place of Pr6.49	Attenuation term value	K1	K2
5	1.0	4.7	1.00
6	0.86	3.8	1.01
7	0.71	2.9	1.04
8	0.5	2.3	1.16
9	0.35	2.0	1.31

Setting the time constant of the first order lag filter

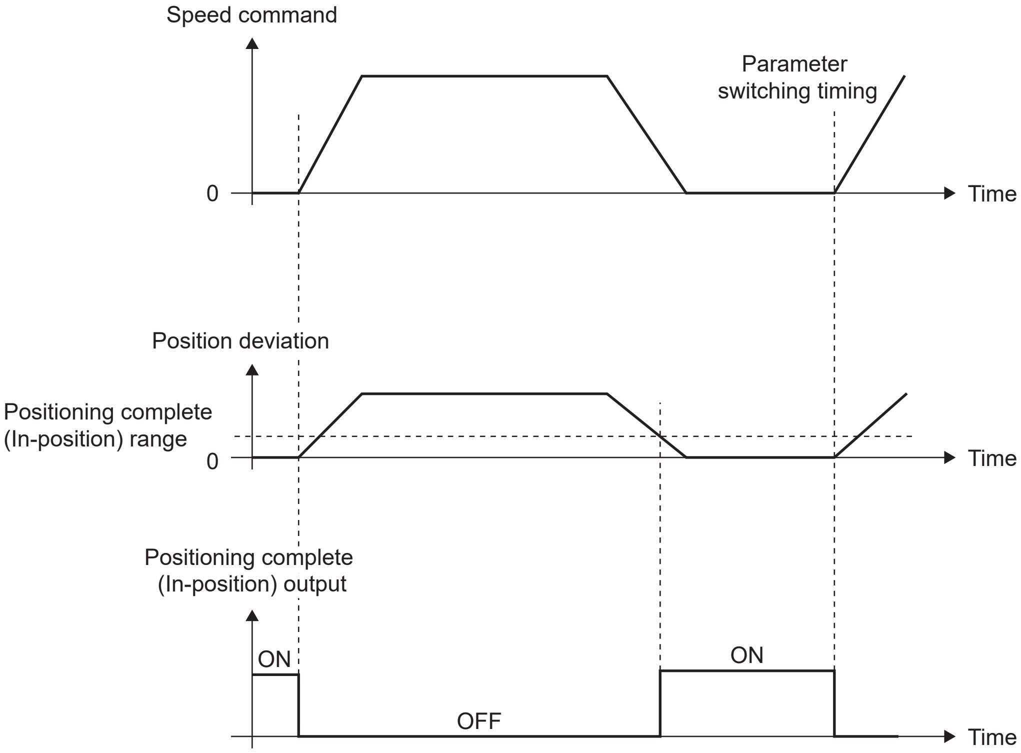
Sets the time constant of the first order lag filter for the target speed Vc square wave command in the following cases.

- When two-degree-of-freedom control mode is disabled
- When two-degree-of-freedom control mode is enabled and the set value for the ones place of Pr6.49, "Command response filter attenuation term setup", is 0 to 4



*1 The actual filter time constant is (set value × 0.1 ms) with a relative error of up to 0.2% above 20 ms, and the error increases to a maximum of 0.4 ms until 100 ms.

*2 Parameter switching when changing Pr2.22 “Positional command smoothing filter” settings



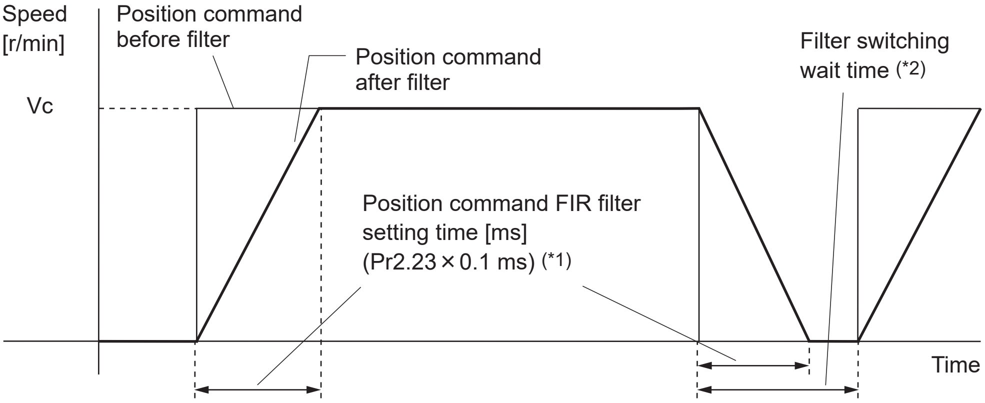
- If the positional command smoothing filter-related parameters (Pr2.22 “Positional command smoothing filter” , Pr6.49 “Command response/tuning filter attenuation term”) are changed during command input, parameter switching occurs at the rising up of the command (before position command filter) from 0 during positioning complete (in-position) output.
- When the positioning complete (in-position) range is set to a large value, a large accumulated pulse (the area obtained by integrating the difference between the position command before the filter and the position command after the filter over time) may remain in the filter during parameter switching. In particular, if the setting is changed to reduce the positional command smoothing filter value or disable the filter, the motor may temporarily run at a higher speed than the original command speed because the accumulated pulses are transferred rapidly when switching occurs. Take due care.
- After changing the parameter settings of the filter during velocity control or torque control, the setting will not change even if the control mode is changed to position control.

*3 There is a delay between when the set value for Pr2.22 “Positional command smoothing filter” is changed and when it is applied to the internal calculation. Therefore, if the switching of “*2” occurs during that delay period, the change may be put on hold.

■ Details on Pr2.23 “Positional command FIR filter”

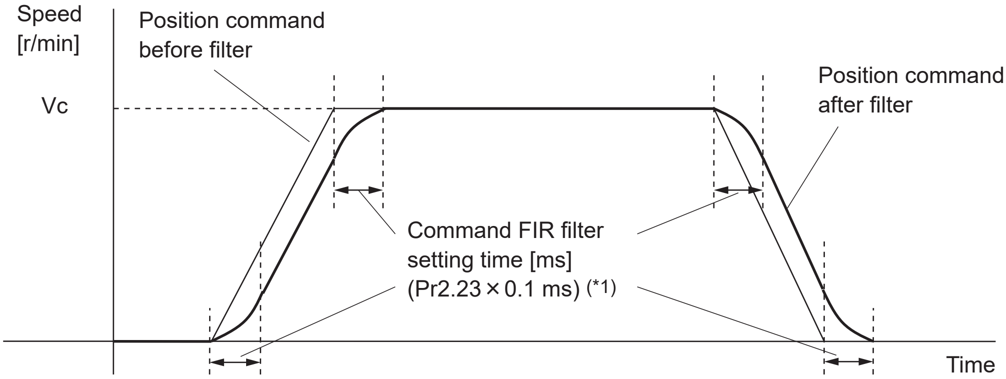
For square wave commands

Sets the time to reach Vc for the target speed Vc square wave command. (See figure below)



For trapezoidal wave commands

If the position command is a trapezoidal wave, the waveform after passing through the filter will be an S-curve.



*1 The actual average movement time has an absolute error of up to 0.2 ms for time periods of less than 10 ms and a relative error of up to 1.6% for time periods of 10 ms or more, with respect to (set value × 0.1 ms).

*2 If the setting for Pr2.23 “Positional command FIR filter” is changed during command input, parameter switching will take place when the amount time remaining until the next command pulse is received exceeds the filter switch waiting time. The filter switching waiting time is (set value × 0.1 ms + 0.25 ms) for a set value of 10 ms or less and (set value × 0.1 ms × 1.05) for 10 ms or more.

*3 There is a delay between when the set value for Pr2.23 “Positional command FIR filter” is changed and when it is applied to the internal calculation. Therefore, if the switching of “2” occurs during that delay period, the change may be put on hold.

5.7.4.1 For Manual Setting

<< Procedure >>

1. Tuning “FIR filter”

Tune Pr2.23 “Positional command FIR filter” to suppress vibration and velocity change caused by infrequent command updating cycles.

Tune the value of Pr2.23 “Positional command FIR filter” to a value greater than or equal to the command updating cycle.

2. Tuning “Smoothing filter”

Increase the set value of Pr2.22 “Positional command smoothing filter” to suppress vibration and velocity changes caused by command resolution. The set value should be changed by increasing by 10% at a time.

- If the beginning of the movement is vibratory, increasing the Pr2.22 “Positional command smoothing filter” set value results in a smoother movement, but with a longer command time. Tune to the optimal value.
- The ones place of Pr6.49 “Command response/tuning filter attenuation term” “Command response filter attenuation term setup” does not require tuning.
- When two-degree-of-freedom control mode is enabled, this functions as the command response filter. The smaller the set value, the smaller the delay caused by the filter, and thus the higher the command responsiveness.

— Precautions —

- Pr2.22 “Positional command smoothing filter” cannot be changed manually because it is automatically set based on the Pr0.28 “Selection of feed forward stiffness at real-time auto-gain tuning” set value when the auto tuning function is enabled in the two-degree-of-freedom control mode for standard type settings. If you want to change the parameters manually, set Pr0.02 “Real-time auto-gain tuning setup” to 0 (disabled) before changing. For details of the relationship between Pr0.28 “Selection of feed forward stiffness at real-time auto-gain tuning” and Pr2.22 “Positional command smoothing filter” , see *“4.1.1.6 Basic Gain Parameter Setup Table”* .

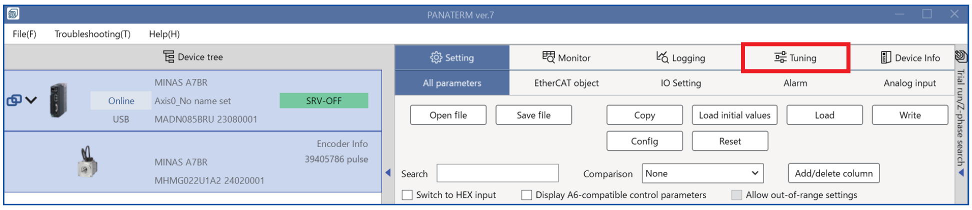
5.7.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

For manual setting, see “Step 5” onward.

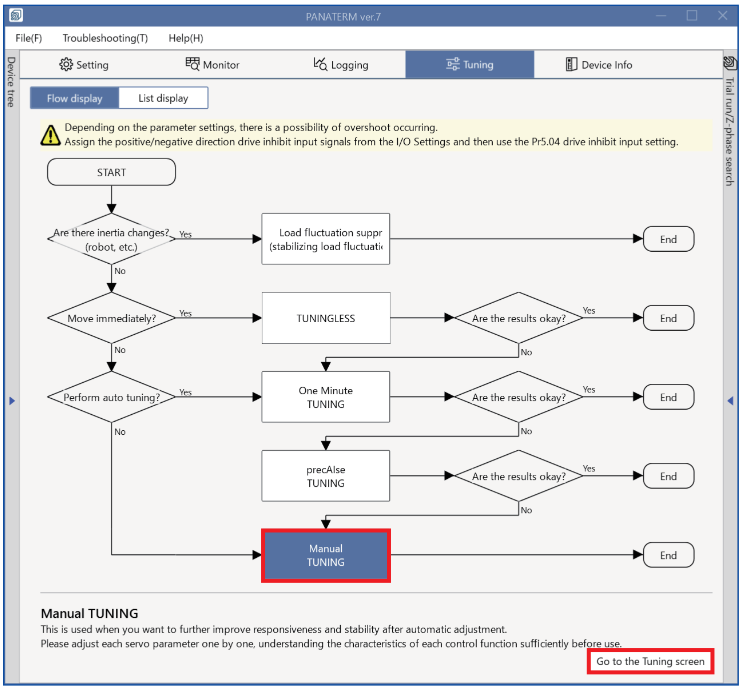
<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.

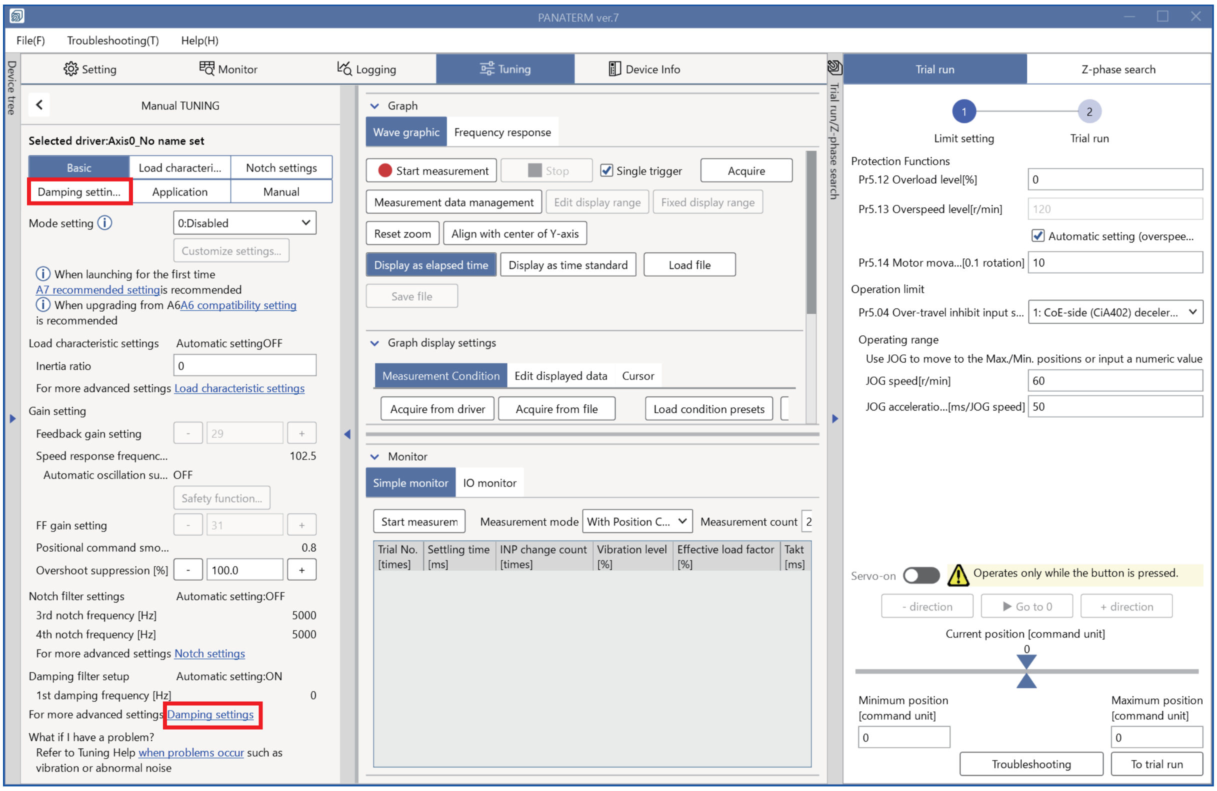


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING
This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.

4. Click on the [Damping settings] button or “Damping settings” in blue text.



Selected driver:Axis0_No name set
Mode setting 0:Disabled
When launching for the first time
A7 recommended setting is recommended
When upgrading from A6 A6 compatibility setting is recommended
Load characteristic settings Automatic settingOFF
Inertia ratio 0
For more advanced settings Load characteristic settings
Gain setting
Feedback gain setting 29
Speed response frequenc... 102.5
Automatic oscillation su... OFF
FF gain setting 31
Positional command smo... 0.8
Overshoot suppression [%] 100.0
Notch filter settings Automatic setting:OFF
3rd notch frequency [Hz] 5000
4th notch frequency [Hz] 5000
For more advanced settings Notch settings
Damping filter setup Automatic setting:ON
1st damping frequency [Hz] 0
For more advanced settings Damping settings
What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

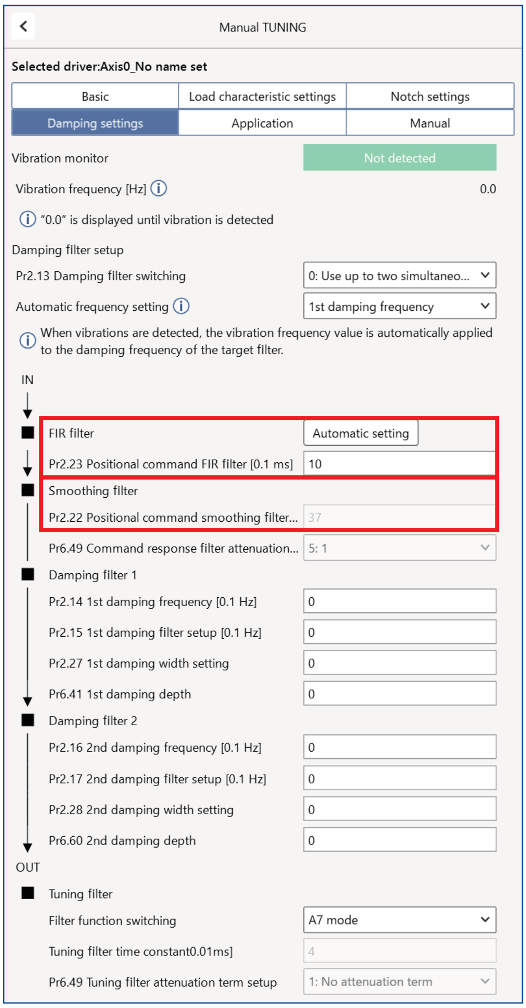
Measurement mode With Position C...
Measurement count 2

Trial No. [times]	Setting time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%] 0
Pr5.13 Overspeed level[r/min] 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation] 10
Operation limit
Pr5.04 Over-travel inhibit input s... 1: CoE-side (CiA402) deceler...
Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min] 60
JOG acceleratio...[ms/JOG speed] 50
Operates only while the button is pressed.
Current position [command unit] 0
Minimum position [command unit] 0
Maximum position [command unit] 0

The advanced damping settings screen is displayed.

5. Tune the Pr2.23 Positional command FIR filter and the Pr2.22 Positional command smoothing filter.



Selected driver:Axis0_No name set

Vibration monitor: Not detected

Vibration frequency [Hz]: 0.0

"0.0" is displayed until vibration is detected

Damping filter setup

Pr2.13 Damping filter switching: 0: Use up to two simultaneo...

Automatic frequency setting: 1st damping frequency

When vibrations are detected, the vibration frequency value is automatically applied to the damping frequency of the target filter.

IN

FIR filter

Pr2.23 Positional command FIR filter [0.1 ms]: 10

Smoothing filter

Pr2.22 Positional command smoothing filter...: 37

Pr6.49 Command response filter attenuation...: 5: 1

Damping filter 1

Pr2.14 1st damping frequency [0.1 Hz]: 0

Pr2.15 1st damping filter setup [0.1 Hz]: 0

Pr2.27 1st damping width setting: 0

Pr6.41 1st damping depth: 0

Damping filter 2

Pr2.16 2nd damping frequency [0.1 Hz]: 0

Pr2.17 2nd damping filter setup [0.1 Hz]: 0

Pr2.28 2nd damping width setting: 0

Pr6.60 2nd damping depth: 0

OUT

Tuning filter

Filter function switching: A7 mode

Tuning filter time constant0.01ms]: 4

Pr6.49 Tuning filter attenuation term setup: 1: No attenuation term

- Tuning "FIR filter"

  Tune Pr2.23 "Positional command FIR filter" to suppress vibration and velocity change caused by infrequent command updating cycles.

  - To set automatically

    Click the [Auto tuning] button. The Pr2.23 "Positional command FIR filter" value is automatically set based on the command updating cycle setting and communication cycle setting.

  - To set manually

    See *"5.7.4.1 For Manual Setting"* .

- Tuning "Smoothing filter"

  Tune Pr2.22 "Positional command smoothing filter" to suppress vibration and velocity change caused by command resolution.

  - See *"5.7.4.1 For Manual Setting"* .

5.7.4.3 Error Troubleshooting

- When Err24.0.0 "Position deviation excess protection" occurs

  Tuning related parameters may cause the position deviation excess setup value to deviate from the appropriate value.

  Review the set value using the formula for calculating the position deviation excess setup value shown in Operating Instructions (Overall) "7.2.9 Before Gain Tuning Protection Function Setup" .

5.8 Speed Command Acceleration/Deceleration Setting Function

5.8.1 Function Overview

This function performs speed control by applying a speed command for which acceleration and deceleration have been tuned inside the servo driver with respect to the speed command input from the host device. Smooth acceleration and deceleration is possible when stepwise speed commands are input.

To reduce shock caused by acceleration changes, the S-curve acceleration/deceleration function can be used to suppress vibration by reducing the change in acceleration at the start and end of acceleration.

5.8.2 Operational Conditions

Item	Operational Conditions
Control mode	● Speed control

5.8.3 Related Parameters

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
3	12	B	Acceleration time setup	0 to 10000	ms/ (1000 r/ min)	Sets the acceleration time for acceleration processing with respect to speed command input.
3	13	B	Deceleration time setup	0 to 10000	ms/ (1000 r/ min)	Sets the deceleration time for deceleration processing with respect to speed command input.
3	14	B	Sigmoid acceleration / deceleration time setup	0 to 1000	ms	Sets the S-curve time for acceleration/deceleration processing with respect to speed command input.

*1 For attributes, see *"7.1 Object Dictionary List"* .

— Precautions —

- Do not use Pr3.12 "Acceleration time setup" and Pr3.13 "Deceleration time setup" if a position loop is configured outside the servo driver. Use all of the above settings with the value set to 0.

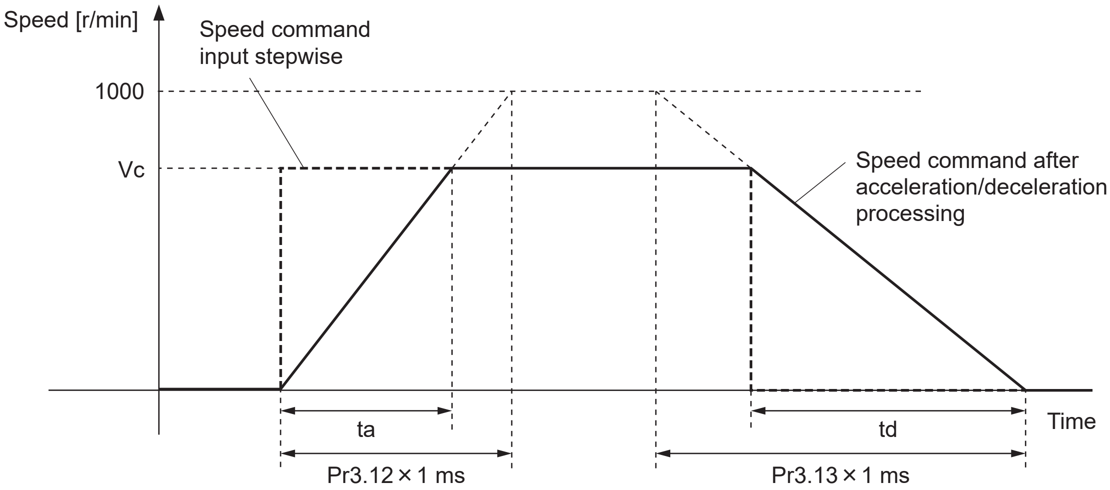
5.8.4 How to Use

■ Pr3.12 "Acceleration time setup" , Pr3.13 "Deceleration time setup"

When a stepwise speed command is input, these parameters set the time it takes for the speed command to reach 1000 r/min in Pr3.12 "Acceleration time setup" . They also set the time it takes for the speed command to reach 0 r/min from 1000 r/min in Pr3.13 "Deceleration time setup" . The time required for acceleration and deceleration can be calculated by the following formula, assuming the target value of the speed command is Vc [r/min].

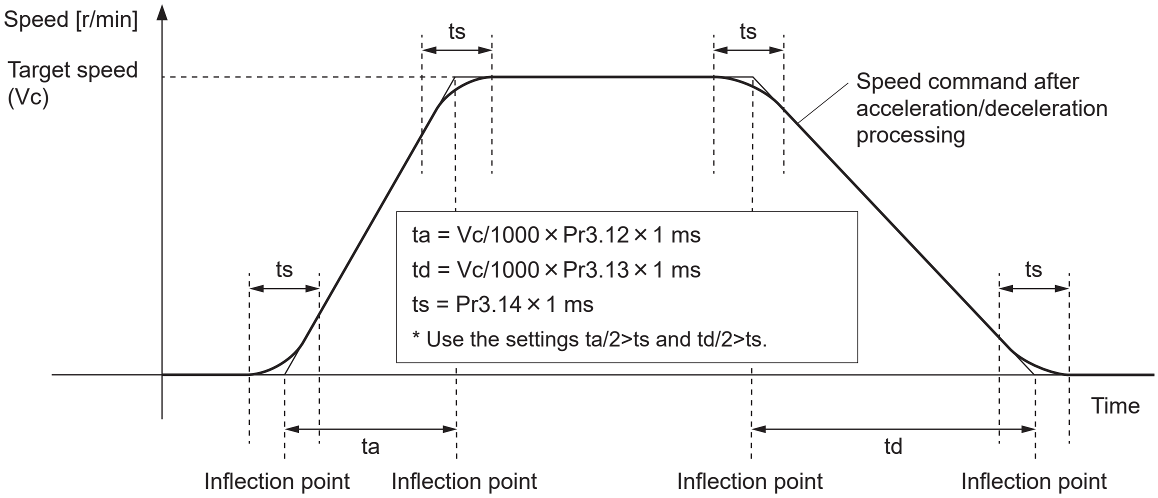
Acceleration time (ta) [ms] = Vc/1000 × Pr3.12 × 1 ms

Deceleration time (td) [ms] = Vc/1000 × Pr3.13 × 1 ms



■ Pr3.14 "Sigmoid acceleration / deceleration time setup"

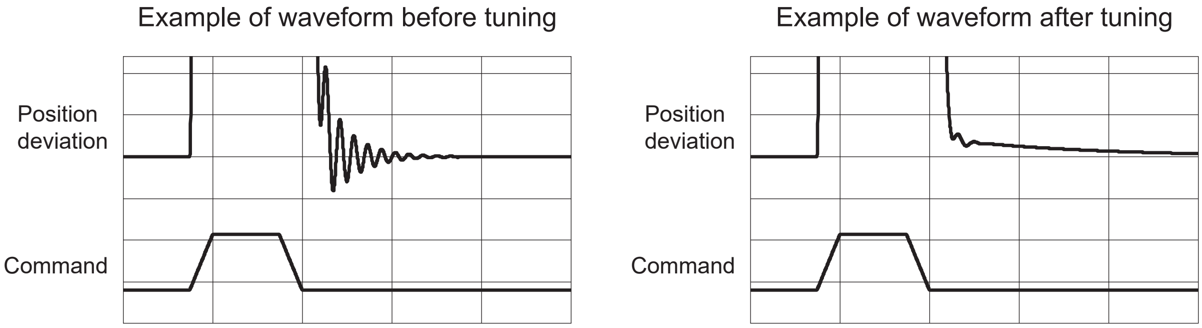
Sets the time of the S-curve part in the time width with the inflection point during acceleration and deceleration at the center and with respect to the acceleration and deceleration time set by Pr3.12 "Acceleration time setup" and Pr3.13 "Deceleration time setup" .



5.9 Hybrid Vibration Suppression Function

5.9.1 Function Overview

This function suppresses vibration caused by the amount of torsion between the motor and the load in full-closed control mode.



5.9.2 Operational Conditions

Item	Operational conditions
Control mode	● Full-closed control

Under the following conditions, the effects of the hybrid vibration suppression function may not be seen.

Item	Conditions that obstruct operation of the hybrid vibration suppression function
Load conditions	● Looseness, backlash, etc. are present and the load non-linearity is strong

5.9.3 Related Parameters

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	34	B	Hybrid vibration suppression gain	0 to 30000	0.1 s^{-1}	Sets hybrid vibration suppression gain. Normally set to the same value as the position loop gain, and then fine-tune as necessary.
6	35	B	Hybrid vibration suppression filter	0 to 32000	0.01 ms	Sets the hybrid vibration suppression filter. Disabled when the set value is 0 to 3.

*1 For attributes, see *"7.1 Object Dictionary List"* .

5.9.4 How to Use

5.9.4.1 For Manual Setting

<< Procedure >>

1. Set Pr6.34 "Hybrid vibration suppression gain" to the same setting as the position loop gain (Pr1.00 "1st gain of position loop" or Pr1.05 "2nd gain of position loop").

2. Set the Pr6.35 “Hybrid vibration suppression filter” [ms] value using the vibration cycle confirmed when this function is unused. This can be obtained with the following equation:

   Pr6.35 “Hybrid vibration suppression filter” [Ms] value = vibration cycle/(2 π)

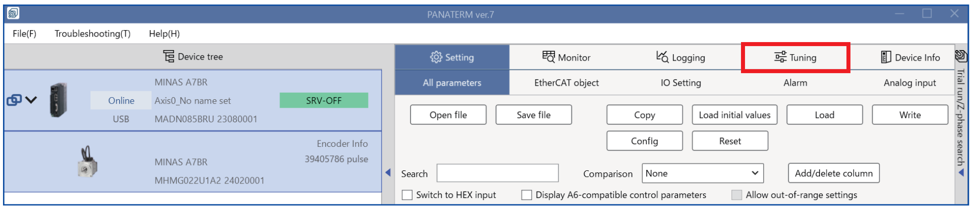
3. While driving in full-closed control, gradually increase the Pr6.35 “Hybrid vibration suppression filter” set value to check the change in response. The set value should be changed by increasing by 10% at a time. If the response seems to improve, tune Pr6.34 “Hybrid vibration suppression gain” and Pr6.35 “Hybrid vibration suppression filter” to find the combination that provides the best response.

5.9.4.2 When Set-up Support Software (PANATERM ver.7) Is Used

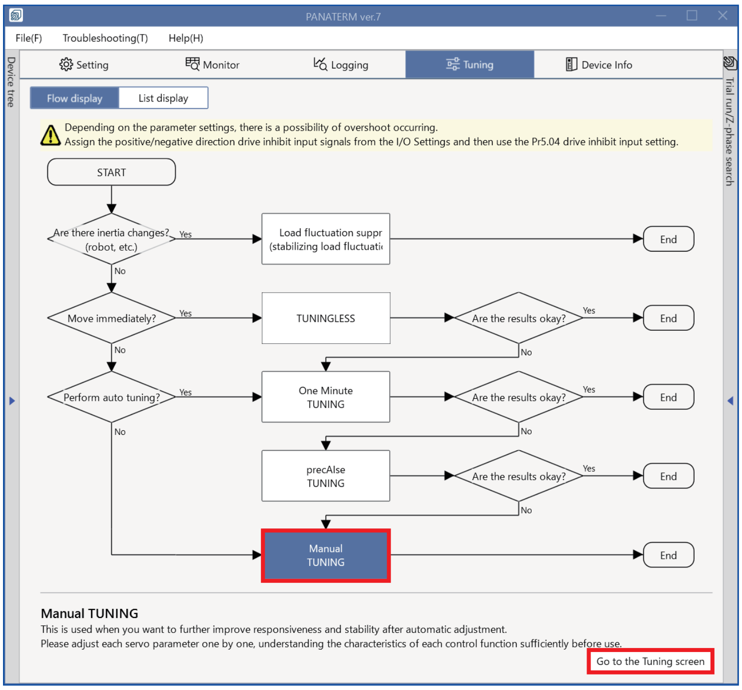
<< Procedure >>

1. Activate Set-up Support Software (PANATERM ver.7) .

2. Select one device that you want to tune in the device tree and click the “Tuning” tab.



3. In the “Tuning” tab screen, select “Manual TUNING”, and click the [Go to the Tuning screen] button.

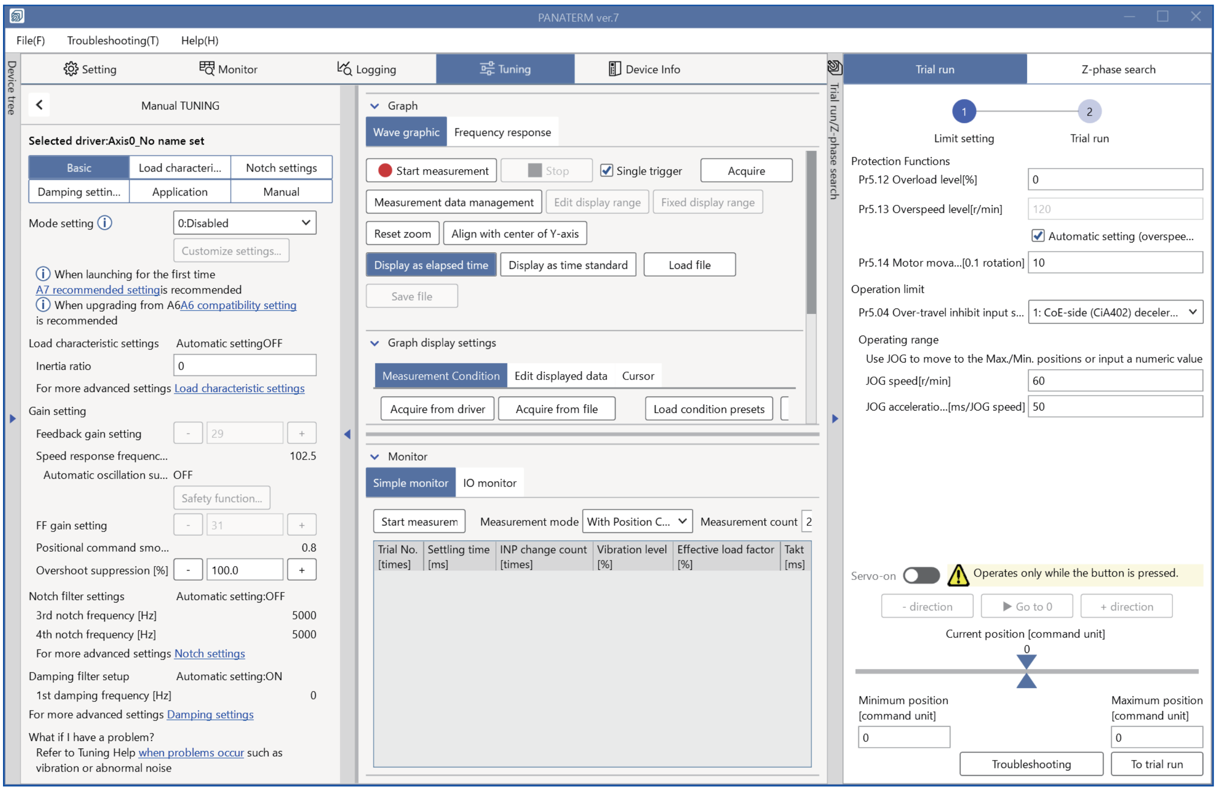


Depending on the parameter settings, there is a possibility of overshoot occurring.
Assign the positive/negative direction drive inhibit input signals from the I/O Settings and then use the Pr5.04 drive inhibit input setting.

Manual TUNING

This is used when you want to further improve responsiveness and stability after automatic adjustment.
Please adjust each servo parameter one by one, understanding the characteristics of each control function sufficiently before use.

The “Manual TUNING” settings screen is displayed.



Selected driver:Axis0_No name set

Mode setting 0:Disabled

When launching for the first time
A7 recommended settingis recommended
When upgrading from A6A6 compatibility setting
is recommended

Load characteristic settings Automatic settingOFF
Inertia ratio 0
For more advanced settings Load characteristic settings

Gain setting
Feedback gain setting 29
Speed response frequenc... 102.5
Automatic oscillation su... OFF
FF gain setting 31
Positional command smo... 0.8
Overshoot suppression [%] 100.0

Notch filter settings Automatic setting:OFF
3rd notch frequency [Hz] 5000
4th notch frequency [Hz] 5000
For more advanced settings Notch settings

Damping filter setup Automatic setting:ON
1st damping frequency [Hz] 0
For more advanced settings Damping settings

What if I have a problem?
Refer to Tuning Help when problems occur such as vibration or abnormal noise

Measurement mode With Position C...
Measurement count 2

Trial No. [times]	Settling time [ms]	INP change count [times]	Vibration level [%]	Effective load factor [%]	Takt [ms]

Protection Functions
Pr5.12 Overload level[%] 0
Pr5.13 Overspeed level[r/min] 120
☑ Automatic setting (overspee...
Pr5.14 Motor mova...[0.1 rotation] 10

Operation limit
Pr5.04 Over-travel inhibit input s... 1: CoE-side (CiA402) deceler...

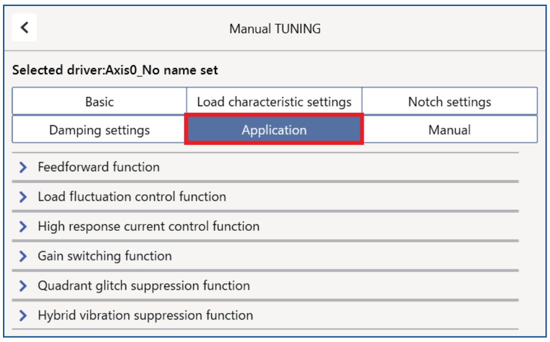
Operating range
Use JOG to move to the Max./Min. positions or input a numeric value
JOG speed[r/min] 60
JOG acceleratio...[ms/JOG speed] 50

Operates only while the button is pressed.

Current position [command unit] 0

Minimum position [command unit] 0
Maximum position [command unit] 0

4. Click the [Application] button.

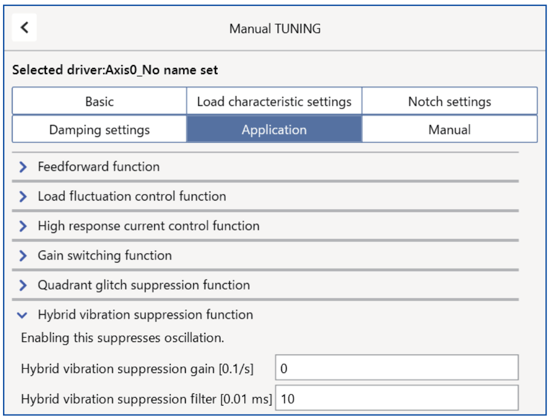

Manual TUNING

Selected driver:Axis0_No name set

Basic	Load characteristic settings	Notch settings
Damping settings	Application	Manual

- Feedforward function
- Load fluctuation control function
- High response current control function
- Gain switching function
- Quadrant glitch suppression function
- Hybrid vibration suppression function

5. Click on "›" of "› Hybrid vibration suppression function" to expand "Hybrid vibration suppression function".


Manual TUNING

Selected driver:Axis0_No name set

Basic	Load characteristic settings	Notch settings
Damping settings	Application	Manual

- Feedforward function
- Load fluctuation control function
- High response current control function
- Gain switching function
- Quadrant glitch suppression function
- Hybrid vibration suppression function

Enabling this suppresses oscillation.

Hybrid vibration suppression gain [0.1/s]	0
Hybrid vibration suppression filter [0.01 ms]	10

6. For details on tuning each parameter, see *"5.9.4.1 For Manual Setting"* .

6 Functions to Assist Tuning

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6.1 Waveform Measurement

6.1.1 Function Overview

This function uses Set-up Support Software (PANATERM ver.7) .

This function draws up data stored inside drivers and motors into Set-up Support Software (PANATERM ver.7) as time-series data and displays it as waveform graphs.

Waveform graphs can also be displayed within the tuning function screens, such as One Minute TUNING, precAIse TUNING, and Manual TUNING, and can be used to check response during tuning.

6.1.2 Purpose of Use

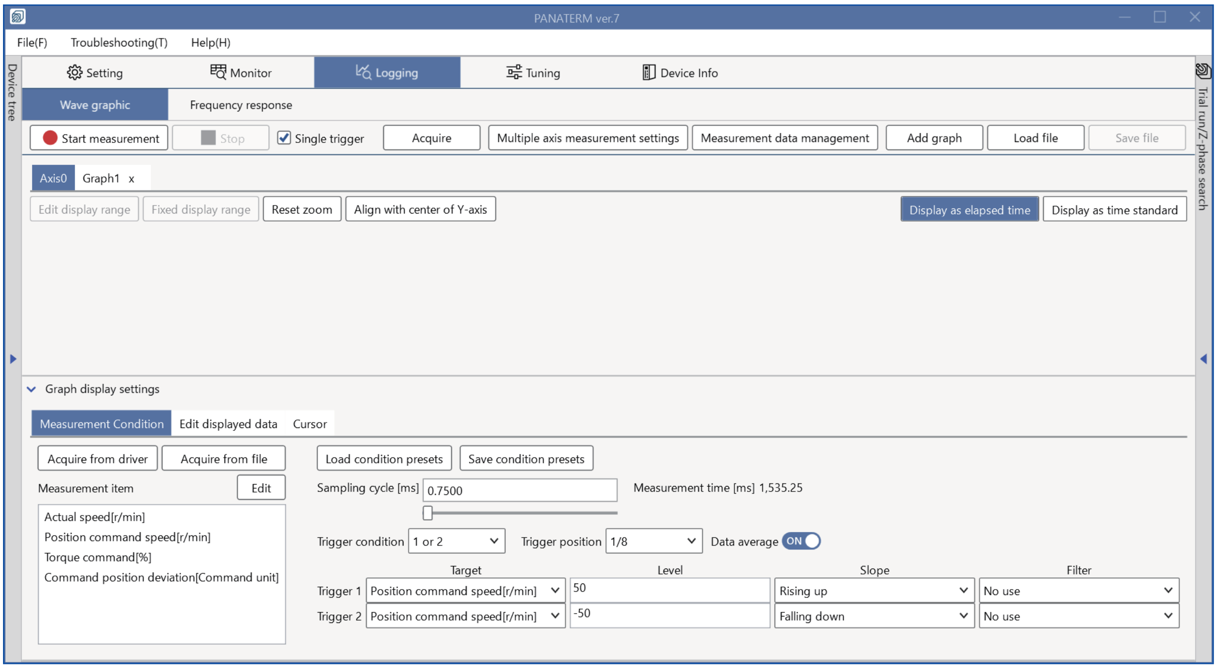
An example of waveform measurement usage is shown below.

- Checking responsiveness with One Minute TUNING and precAIse TUNING
- Checking the amplitude and frequency of residual vibration for the settling waveform during damping control tuning
- Checking the overshoot amount for the settling waveform when tuning the feedforward function, etc.

6.1.3 Measurement Procedure

<< Procedure >>

1. Select **Logging**>**Wave graphic** in Set-up Support Software (PANATERM ver.7) to open the main screen.



☑ Single trigger

Measurement item:
Actual speed[r/min]
Position command speed[r/min]
Torque command[%]
Command position deviation[Command unit]

Sampling cycle [ms] 0.7500

Measurement time [ms] 1,535.25

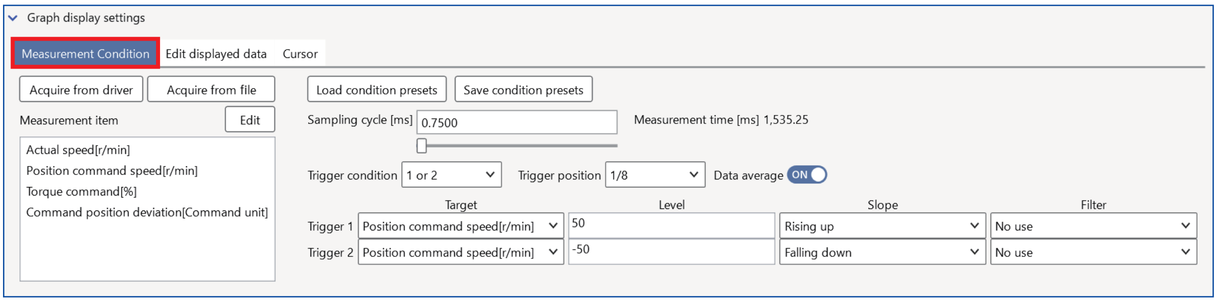
Trigger condition 1 or 2

Trigger position 1/8

Data average ON

	Target	Level	Slope	Filter
Trigger 1	Position command speed[r/min]	50	Rising up	No use
Trigger 2	Position command speed[r/min]	-50	Falling down	No use

2. In “Measurement condition” of “Graph display settings”, set the measurement items, measurement conditions, sampling cycle, and trigger.



Measurement item
- Actual speed[r/min]
- Position command speed[r/min]
- Torque command[%]
- Command position deviation[Command unit]

Sampling cycle [ms] 0.7500

Measurement time [ms] 1,535.25

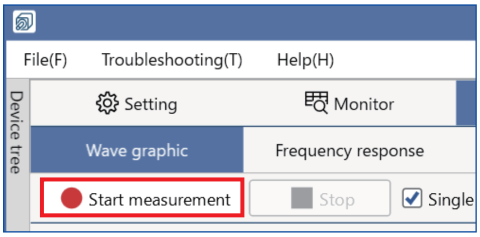
Trigger condition 1 or 2

Trigger position 1/8

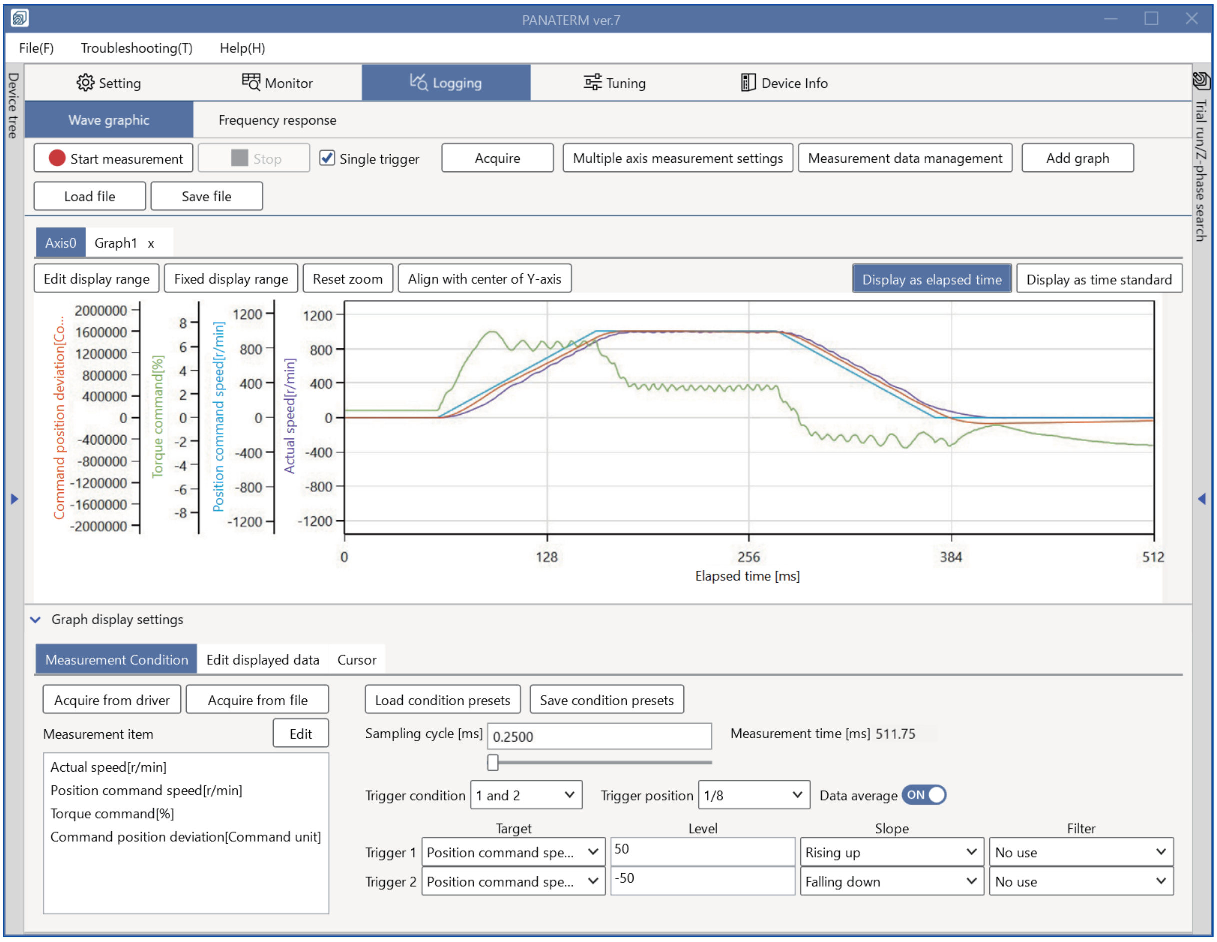
Data average ON

	Target	Level	Slope	Filter
Trigger 1	Position command speed[r/min]	50	Rising up	No use
Trigger 2	Position command speed[r/min]	-50	Falling down	No use

3. Click the [Start measurement] button.



The measurement results are displayed.



Measurement item
- Actual speed[r/min]
- Position command speed[r/min]
- Torque command[%]
- Command position deviation[Command unit]

Sampling cycle [ms] 0.2500

Measurement time [ms] 511.75

Trigger condition 1 and 2

Trigger position 1/8

Data average ON

	Target	Level	Slope	Filter
Trigger 1	Position command spe...	50	Rising up	No use
Trigger 2	Position command spe...	-50	Falling down	No use

6.1.4 Method of Use

■ Checking settling time

See Set-up Support Software (PANATERM ver.7) Operating Manual “10.1.14 Measure the Fixed Time from the Measurement Data” .

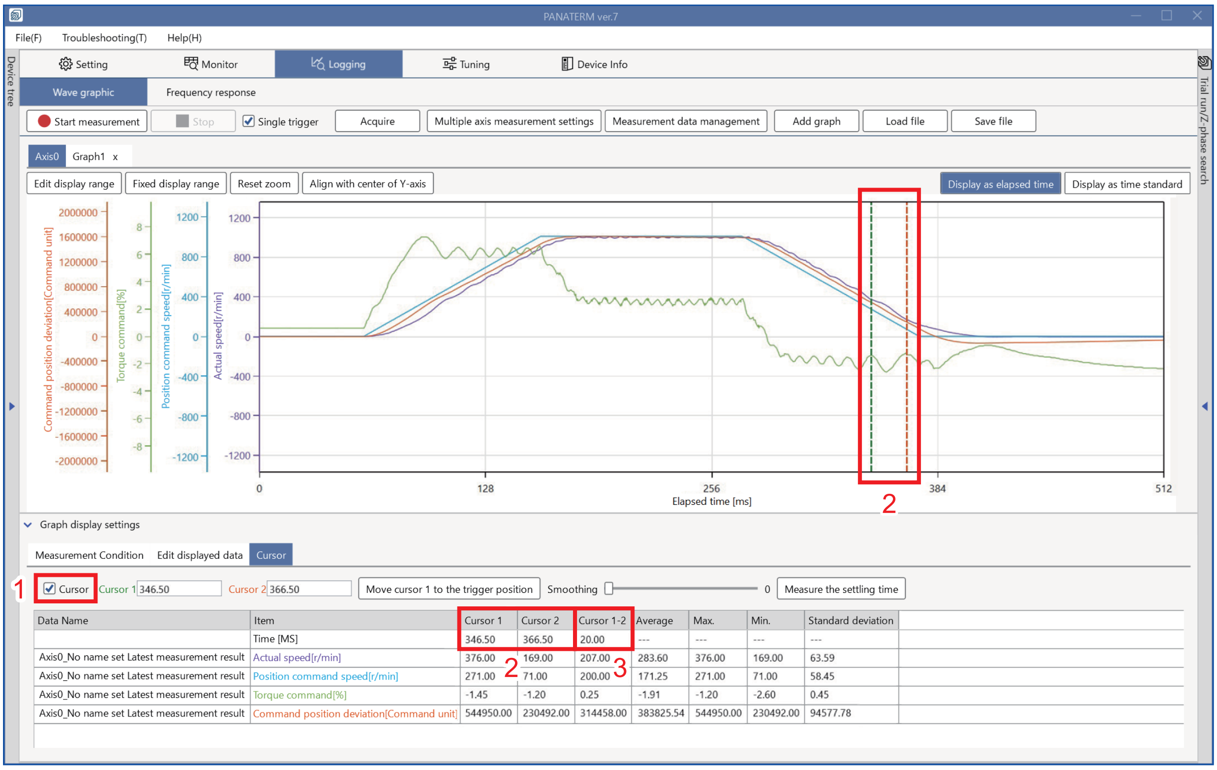
■ Checking vibration frequency

1 Check the “Cursor” check box in “Graph display settings” to display the cursor.

2 Drag Cursor 1 (green dotted line) or Cursor 2 (red dotted line) on the graph with the mouse to move it to the desired position. You can also enter a numerical value in the numeric field at the bottom of the screen to move the cursor to that position. Set Cursor 1 to match the peak position of the vibration waveform, and set Cursor 2 to match the peak one cycle after Cursor 1.

3 The time (in seconds) can be calculated from the difference between the times displayed in Cursors 1-2 for the item “Time”, and the frequency can be found from the inverse.

For example, if the difference in time between Cursor 1 and Cursor 2 is 20 ms (0.02 sec), the frequency can be calculated as 1/0.02 sec = 50 Hz.



☑ Cursor Cursor 1 346.50 Cursor 2 366.50

Data Name	Item	Cursor 1	Cursor 2	Cursor 1-2	Average	Max.	Min.	Standard deviation
	Time [MS]	346.50	366.50	20.00	---	---	---	---
Axis0_No name set Latest measurement result	Actual speed[r/min]	376.00	169.00	207.00	283.60	376.00	169.00	63.59
Axis0_No name set Latest measurement result	Position command speed[r/min]	271.00	71.00	200.00	171.25	271.00	71.00	58.45
Axis0_No name set Latest measurement result	Torque command[%]	-1.45	-1.20	0.25	-1.91	-1.20	-2.60	0.45
Axis0_No name set Latest measurement result	Command position deviation[Command unit]	544950.00	230492.00	314458.00	383825.54	544950.00	230492.00	94577.78

6.2 Frequency Response Measurement

6.2.1 Function Overview

This function uses Set-up Support Software (PANATERM ver.7) .

Operate the motor to measure the frequency response including the load and display the Bode diagram.

From the measurement results, the resonance point can be identified, benchmarks for filter setting values decided, and the stability of the feedback control system determined.

The measurement results can also be saved to a file.

— Precautions —

- The speed of the motor changes rapidly during measurement. Take necessary safety precautions.
- Perform the measurement with the servo ready to be turned off immediately in case of unexpected operation of the motor or other hazards.
- Do not use this function if there is a possibility that the device could be damaged by violent movement of the motor.
- Setting a large offset may cause movement limits to be exceeded. Take due care.
- Initially, start measurement with the gain as low as possible.
- Frequency response measurement results may vary greatly or show incorrect values due to device characteristics or measurement conditions. Use the measurement results of this function as a reference for gain adjustment.
- Servo parameters during measurement are fixed to 1st gain.
- In measurement modes other than torque speed (normal), the measurement results include the effects of various torque filters and various notch filters.

6.2.2 Types of Measurement Modes

Measurement mode	Function overview	Application
Speed closed loop characteristics	Measures the characteristics of the speed feedback control system, including mechanical characteristics. Measures in speed control mode.	Checks the stability of the speed feedback control system when parameter tuning is in progress or has finished.
Torque speed (normal)	Measures mechanical characteristics. Takes measurements without applying a control to prevent the falling of moving parts due to gravity.	Used to determine the resonance frequency and resonance strength of a device where gravity is not applied to moving parts, and to obtain a guide for set values of various filters.
Torque speed (vertical)	Measures mechanical characteristics. Measurements are taken while applying a control to prevent the falling of moving parts due to gravity.	Used to determine the resonance frequency and resonance strength of a device where gravity is applied to moving parts, and to obtain a guide for set values of various filters.
Position loop characteristics	Measures the characteristics of the position feedback control system, including mechanical characteristics. Measures in position control mode.	Used to check the disturbance suppression of the position feedback control system when parameter tuning is in progress or has finished.

6.2.3 Changes from measurements using A6 Series drivers

Measurement mode	Change
Speed closed loop characteristics	● Since the operation mode corresponds to “Pr6.47:bit 0 “Two-degree-of-freedom control mode” = 0 (disabled)” during measurement operation, “Pr6.47:bit 0” does not require switching before measurement in Set-up Support Software (PANATERM ver.7) . ● Measurement results unaffected by the feedforward system can be obtained regardless of the set value of the parameter “Pr6.47:bit 0 “Two-degree-of-freedom control mode” ” (0 = disabled, 1 = enabled) at the time of measurement.
Torque speed (normal)	● Because torque commands are applied as noise signals after various filters, mechanical characteristics unaffected by various filters can be obtained. This means that the various torque filters and various notch filters do not need to be disabled during measurement in Set-up Support Software (PANATERM ver.7) . ● Although the Set-up Support Software (PANATERM ver.6) formerly displayed gain with the same scaling as speed closed loop characteristics by offsetting the gain, this function has been deleted.
Torque speed (vertical)	● The load fluctuation control function is disabled during measurement. ● Torque commands are applied as noise signals after the various filters. ● Although the Set-up Support Software (PANATERM ver.6) formerly displayed gain with the same scaling as speed closed loop characteristics by offsetting the gain, this function has been deleted.
Position loop characteristics	● Torque commands are applied as noise signals after the various filters. ● Although the Set-up Support Software (PANATERM ver.6) formerly displayed gain with the same scaling as speed closed loop characteristics by offsetting the gain, this function has been deleted.

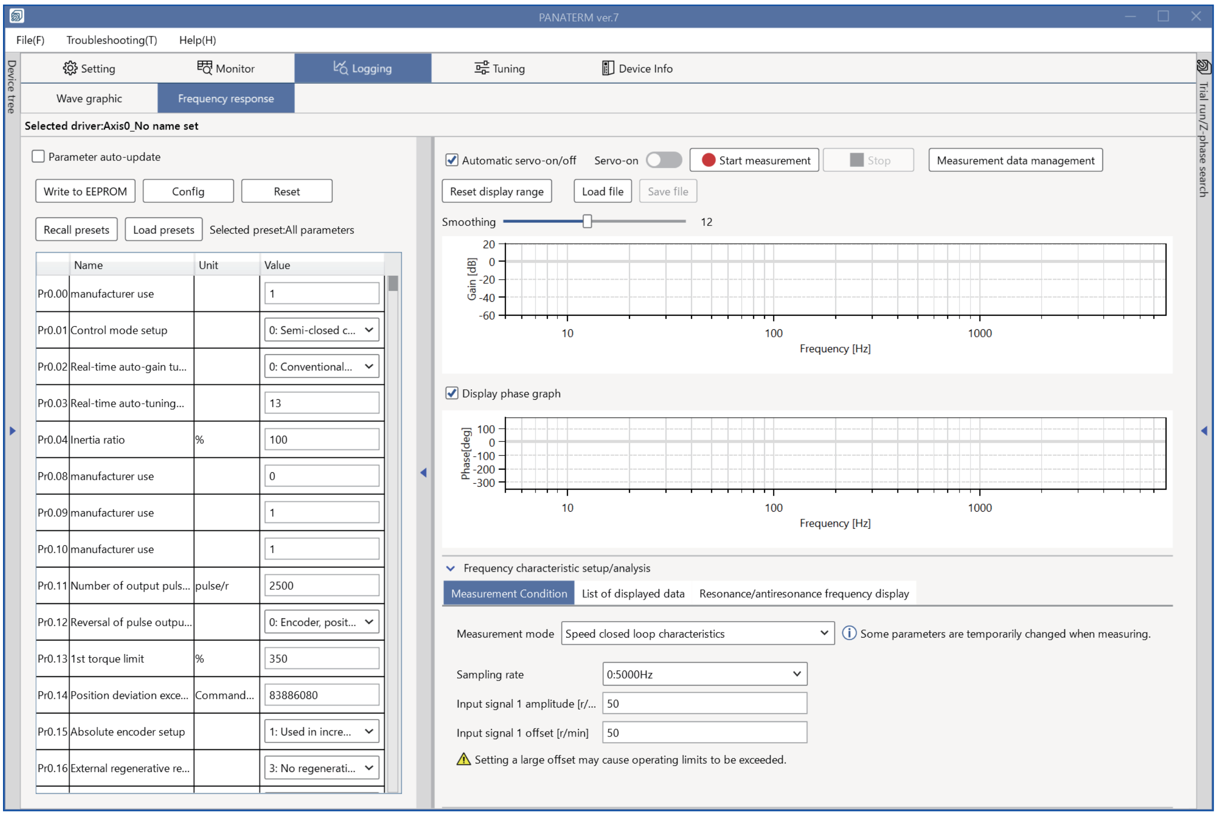
6.2.4 Restrictions

The waveform graphic function cannot be used at the same time.

6.2.5 Measurement Procedure

<< Procedure >>

1. Select **Logging**>**Frequency response** in Set-up Support Software (PANATERM ver.7) to open the main screen.



Selected driver:Axis0_No name set

☐ Parameter auto-update

Selected preset:All parameters

	Name	Unit	Value
Pr0.00	manufacturer use		1
Pr0.01	Control mode setup		0: Semi-closed c...
Pr0.02	Real-time auto-gain tu...		0: Conventional...
Pr0.03	Real-time auto-tuning...		13
Pr0.04	Inertia ratio	%	100
Pr0.08	manufacturer use		0
Pr0.09	manufacturer use		1
Pr0.10	manufacturer use		1
Pr0.11	Number of output puls...	pulse/r	2500
Pr0.12	Reversal of pulse outpu...		0: Encoder, posit...
Pr0.13	1st torque limit	%	350
Pr0.14	Position deviation exce...	Command...	83886080
Pr0.15	Absolute encoder setup		1: Used in incre...
Pr0.16	External regenerative re...		3: No regenerati...

☑ Automatic servo-on/off

Smoothing 12

☑ Display phase graph

Measurement mode: Speed closed loop characteristics

ⓘ Some parameters are temporarily changed when measuring.

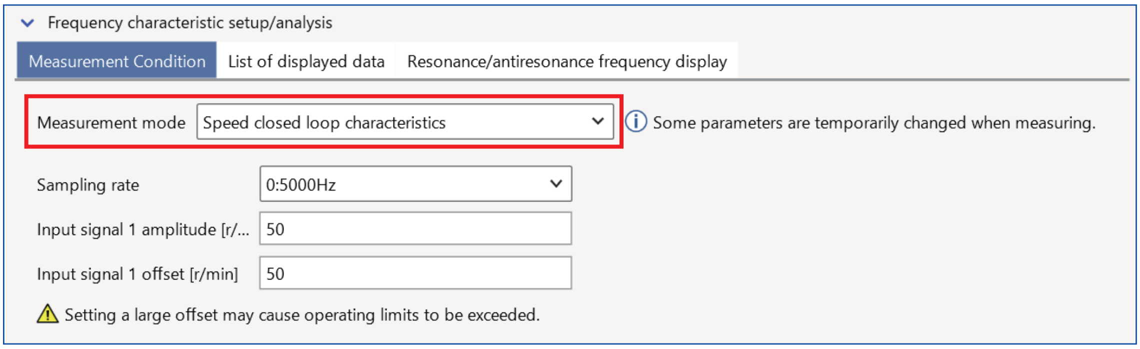
Sampling rate: 0:5000Hz

Input signal 1 amplitude [r/...: 50

Input signal 1 offset [r/min]: 50

⚠ Setting a large offset may cause operating limits to be exceeded.

2. Select the desired measurement mode from the “Measurement mode” drop-down list.



Measurement mode: Speed closed loop characteristics

ⓘ Some parameters are temporarily changed when measuring.

Sampling rate: 0:5000Hz

Input signal 1 amplitude [r/...: 50

Input signal 1 offset [r/min]: 50

⚠ Setting a large offset may cause operating limits to be exceeded.

Check the precautions for the selected measurement mode.

Measurement mode	Precautions
Speed closed loop characteristics	When an offset speed is entered, the load moves. (See details in “Step 5”) Therefore, if the movable range of the device is narrow, the moving part may collide with the mechanical end.
Torque speed (normal)	Do not use in devices with a Z axis that may cause the mechanism to fall when in servo-on. For such devices, use torque speed (vertical).
Torque speed (vertical)	Before measurement, change Pr1.01 “1st velocity loop gain” to a value lower than the frequency bandwidth you wish to check. Furthermore, Pr1.02 “1st velocity loop integration time constant” should also be tuned by referencing *“4.1.1.6 Basic Gain Parameter Setup Table”* of *“4.1 Real-time Auto Tuning Function”* . Technically, the measurement results include the effects of various torque filters and various notch filters. Disabling the aforementioned filters can remove their effects, but there is a risk of oscillation if the various filters are disabled when the Pr1.01 “1st velocity loop gain” value is large.

3. Select “Sampling rate” from the drop-down list.

The respective upper limits of the frequency range that can be checked are displayed.

- When the upper limit of the frequency range that can be checked is high

  Although measuring accuracy in the low frequency band is reduced, a wide range of frequency response can be checked. Measurement time is reduced.

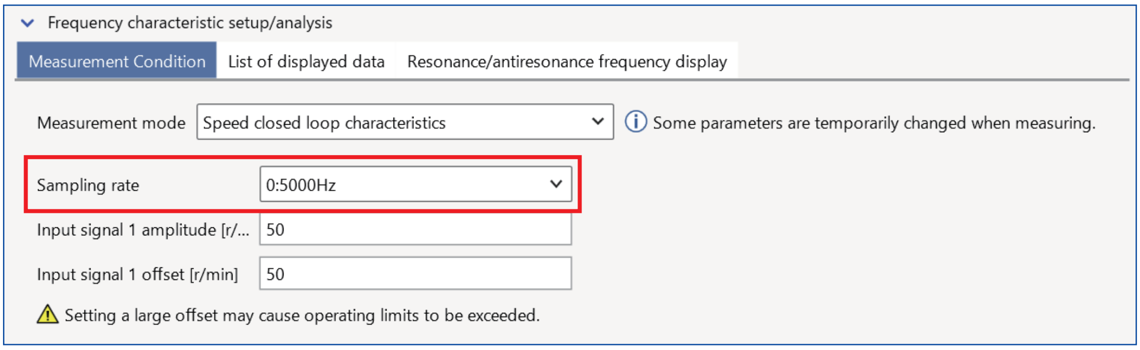
- When the upper limit of the frequency range that can be checked is low

  The frequency range that can be checked is narrower, but measuring accuracy in the low frequency band is improved. Measurement time is longer.

Select the sampling rate to include the frequency range you want to view with high accuracy.

If you are unsure of which frequency range you want to view with high accuracy, first measure the frequency response with “0:5000 Hz”, which can measure the widest range of frequency response, and then select the optimal sampling rate based on those measurement results.

When the sampling rate is other than “0:5000 Hz”, folding due to aliasing may occur.



Measurement mode: Speed closed loop characteristics

ⓘ Some parameters are temporarily changed when measuring.

Sampling rate: 0:5000Hz

Input signal 1 amplitude [r/...: 50

Input signal 1 offset [r/min]: 50

⚠ Setting a large offset may cause operating limits to be exceeded.

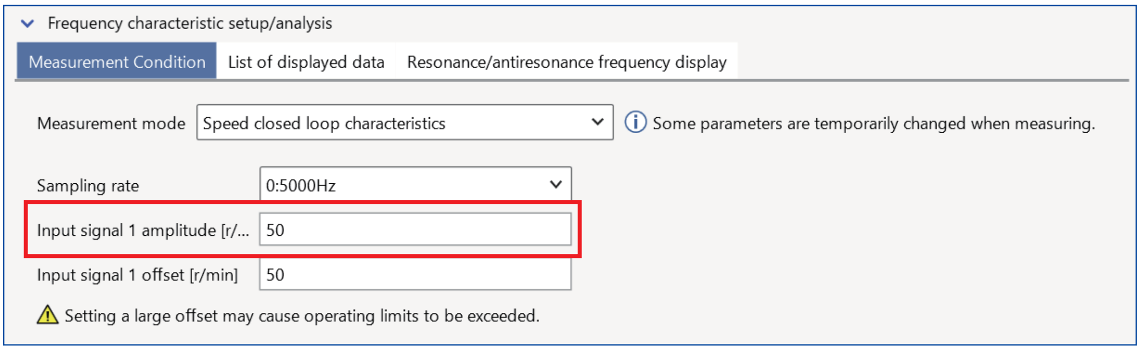
4. Set the amplitude of the noise waveform to be applied to the speed or torque command in “Input signal 1 amplitude”.

See table *“Amplitude and offset setting ranges”* below for the range that can be set for amplitude.

Increasing the amplitude improves measuring accuracy, but too large an amplitude results in torque saturation and reduced accuracy. Start from a small value and gradually increase it as you observe the measurement results.

The torque command units [%] set for torque speed (normal), torque speed (vertical), and position loop characteristics are ratios of the motor rated torque at 100%.

We recommend confirming that amplitude is 50% for torque speed (normal), torque speed (vertical), and position loop characteristics, and that amplitude is 50 r/min for speed closed loop characteristics.



Measurement mode: Speed closed loop characteristics

Some parameters are temporarily changed when measuring.

Sampling rate: 0:5000Hz

Input signal 1 amplitude [r/...: 50

Input signal 1 offset [r/min]: 50

⚠ Setting a large offset may cause operating limits to be exceeded.

5. Set the offset value of the noise waveform to be applied to the speed command to “Input signal 1 offset”.

   See table *“Amplitude and offset setting ranges”* below for the range that can be set for offset.

   During speed closed loop characteristics measurement, the motor operates with the set offset as the average speed command. Polarity is + for positive directions and - for negative directions. Good measurement results are obtained when the offset is greater than the set value for amplitude and the motor always rotates in one direction. (For example, if input signal 1 amplitude is 50 r/min, set input signal 1 offset [r/min] to 50 r/min.)

   However, note that if the working range of the device mechanism is narrow, the movement limits may be exceeded.

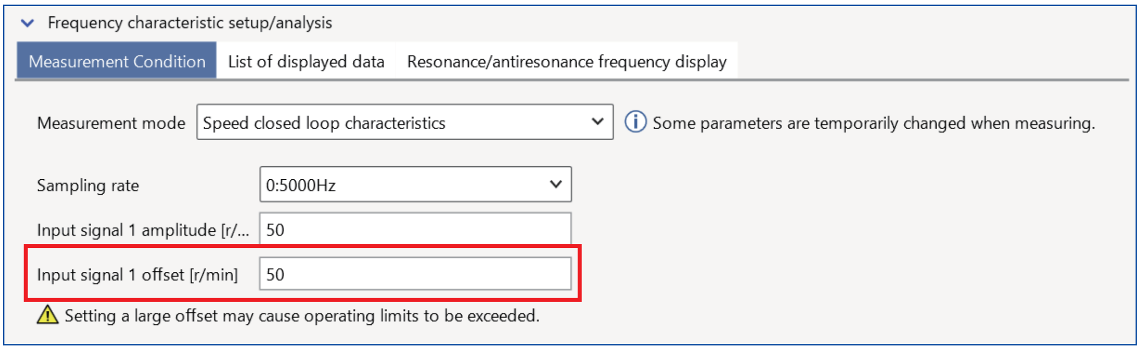
   The approximate amount of motor rotation during measuring operation can be determined by the following equation. Before starting a measurement, always make sure that the movement limits of the device mechanism are not exceeded.

   Approximate amount of rotation [r] = offset [r/min] × 0.017 × (sampling rate + 1)

Amplitude and offset setting ranges

—: N/A

Measurement mode	Amplitude setting range	Offset setting range
Speed closed loop characteristics	1 r/min to rated speed [r/min]	- rated speed [r/min] to rated speed [r/min]
Torque speed (normal)	1 to 100%	—
Torque speed (vertical)	1 to 100%	—
Position loop characteristics	1 to 100%	—



Measurement mode: Speed closed loop characteristics

Some parameters are temporarily changed when measuring.

Sampling rate: 0:5000Hz

Input signal 1 amplitude [r/...: 50

Input signal 1 offset [r/min]: 50

Setting a large offset may cause operating limits to be exceeded.

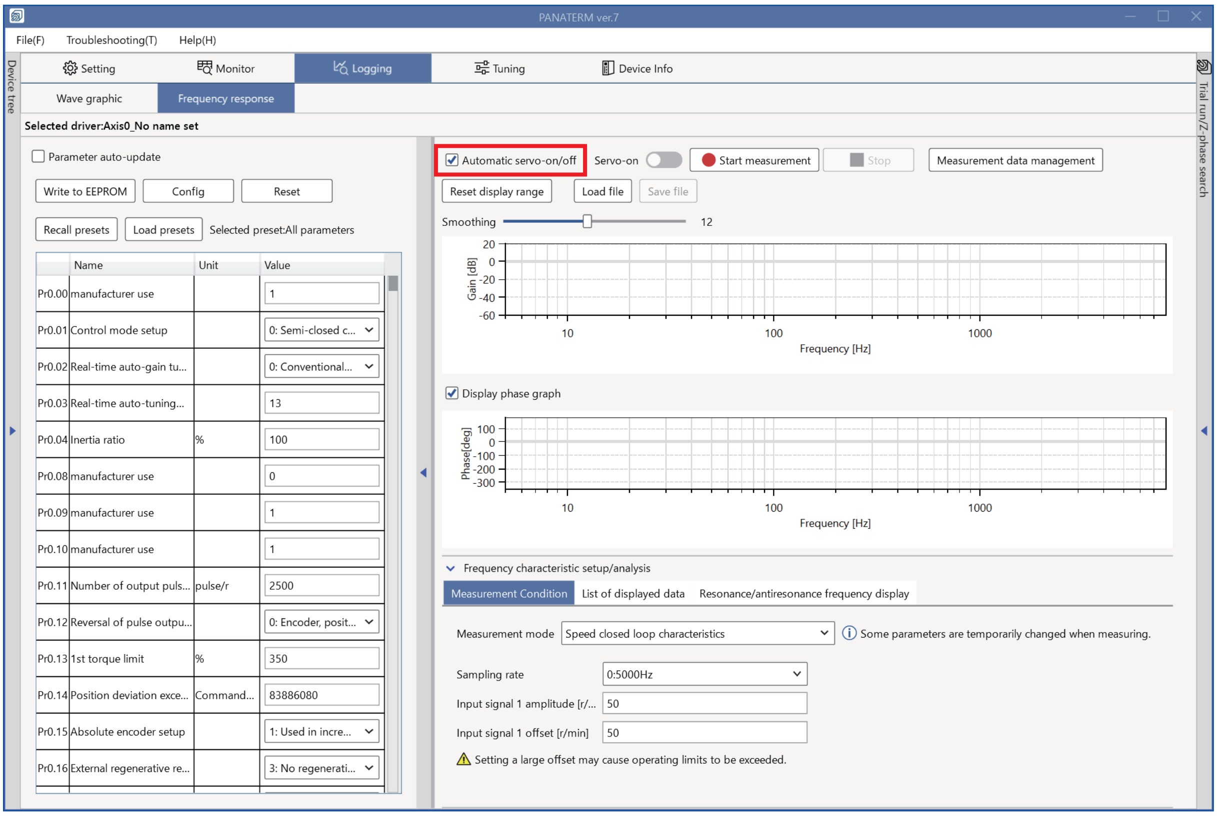
6. Check the “Automatic servo-on/off” check box to automatically servo-on at the start of measurement.

- Do not check the box when measuring in servo-on state by external input.

  After servo-on by external input, go to “Step 7”.

- Uncheck the box if the brake release operation is performed by a host device in a network.

  After servo-on, release the brake from the host device and go to “Step 7”.



Selected driver:Axis0_No name set

☐ Parameter auto-update

Selected preset:All parameters

	Name	Unit	Value
Pr0.00	manufacturer use		1
Pr0.01	Control mode setup		0: Semi-closed c...
Pr0.02	Real-time auto-gain tu...		0: Conventional...
Pr0.03	Real-time auto-tuning...		13
Pr0.04	Inertia ratio	%	100
Pr0.08	manufacturer use		0
Pr0.09	manufacturer use		1
Pr0.10	manufacturer use		1
Pr0.11	Number of output puls...	pulse/r	2500
Pr0.12	Reversal of pulse outpu...		0: Encoder, posit...
Pr0.13	1st torque limit	%	350
Pr0.14	Position deviation exce...	Command...	83886080
Pr0.15	Absolute encoder setup		1: Used in incre...
Pr0.16	External regenerative re...		3: No regenerati...

☑ Automatic servo-on/off

Smoothing 12

☑ Display phase graph

Measurement mode: Speed closed loop characteristics

ⓘ Some parameters are temporarily changed when measuring.

Sampling rate: 0:5000Hz

Input signal 1 amplitude [r/...: 50

Input signal 1 offset [r/min]: 50

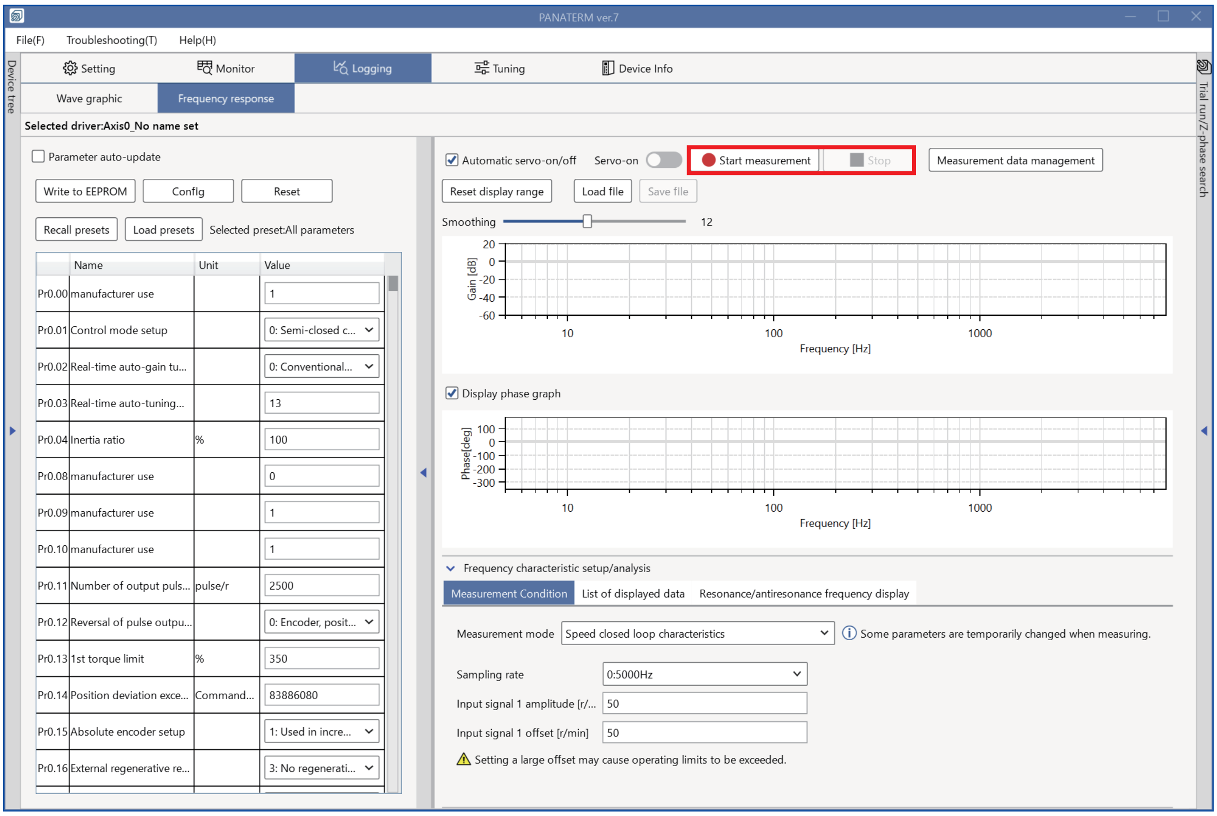
⚠ Setting a large offset may cause operating limits to be exceeded.

7. Click the [Start measurement] button to execute measurement.

A “buzzing” noise may be heard during operation. This noise is caused by the operation of motor excitation by the noise signal and does not indicate a problem.

To stop in an emergency, click the [Stop] button.

Depending on the parameter values for the safety function or protection function systems, a measurement error may occur. If an error occurs, see the table below.



Selected driver:Axis0_No name set

☐ Parameter auto-update

Selected preset:All parameters

☑ Automatic servo-on/off

Smoothing 12

☑ Display phase graph

	Name	Unit	Value
Pr0.00	manufacturer use		1
Pr0.01	Control mode setup		0: Semi-closed c...
Pr0.02	Real-time auto-gain tu...		0: Conventional...
Pr0.03	Real-time auto-tuning...		13
Pr0.04	Inertia ratio	%	100
Pr0.08	manufacturer use		0
Pr0.09	manufacturer use		1
Pr0.10	manufacturer use		1
Pr0.11	Number of output puls...	pulse/r	2500
Pr0.12	Reversal of pulse outpu...		0: Encoder, posit...
Pr0.13	1st torque limit	%	350
Pr0.14	Position deviation exce...	Command...	83886080
Pr0.15	Absolute encoder setup		1: Used in incre...
Pr0.16	External regenerative re...		3: No regenerati...

Measurement mode: Speed closed loop characteristics

ⓘ Some parameters are temporarily changed when measuring.

Sampling rate: 0:5000Hz

Input signal 1 amplitude [r/...: 50

Input signal 1 offset [r/min]: 50

⚠ Setting a large offset may cause operating limits to be exceeded.

Measurement error troubleshooting

Error	Solution
After the measurement, a “Torque saturated. Lower the amplitude and measure again” pop-up dialog appeared. An alarm is not triggered.	Set the amplitude to a smaller value and measure again. If possible, the torque limit determined by Pr5.21 “Selection of torque limit” should be set to a value large enough for the amplitude of the measurement condition. If there are no special constraints, the initial values are recommended for the relevant torque limit-related parameters.
An “Alarm triggered during measurement” pop-up dialog appeared. An Err16.0 alarm was triggered.	After clearing the alarm, set the amplitude to a smaller value and measure again. Also, if possible, change Pr5.12 “Motor overload level setup” to a larger value. If there are no special constraints, the initial values are recommended.
An “Alarm triggered during measurement” pop-up dialog appeared. An Err26.0 alarm was triggered.	After clearing the alarm, set the amplitude to a smaller value and measure again. This error always occurs when the speed closed loop characteristics are measured and the speed set for offset in the measurement conditions is greater than the speed set by Pr5.13 “Over-speed level setup” . Make sure the offset speed is set smaller. Also, if possible, change Pr5.13 “Over-speed level setup” to a larger value. If there are no special constraints, the initial values are recommended.
An “Alarm triggered during measurement” pop-up dialog appeared. An Err26.1 alarm was triggered.	After clearing the alarm, set the amplitude to a smaller value and measure again. This error always occurs when the speed closed loop characteristics are measured and the speed set for offset in the measurement conditions is greater than the speed set by Pr6.15 “2nd overspeed level setting” . Make sure the offset speed is set smaller. Also, if possible, change Pr6.15 “2nd overspeed level setting” to a larger value. If there are no special constraints, the initial values are recommended.

Error	Solution
An "Alarm triggered during measurement" pop-up dialog appeared. Alarms other than the above alarms were triggered.	Take the specified measures for handling each alarm. Measure again after clearing the alarm.

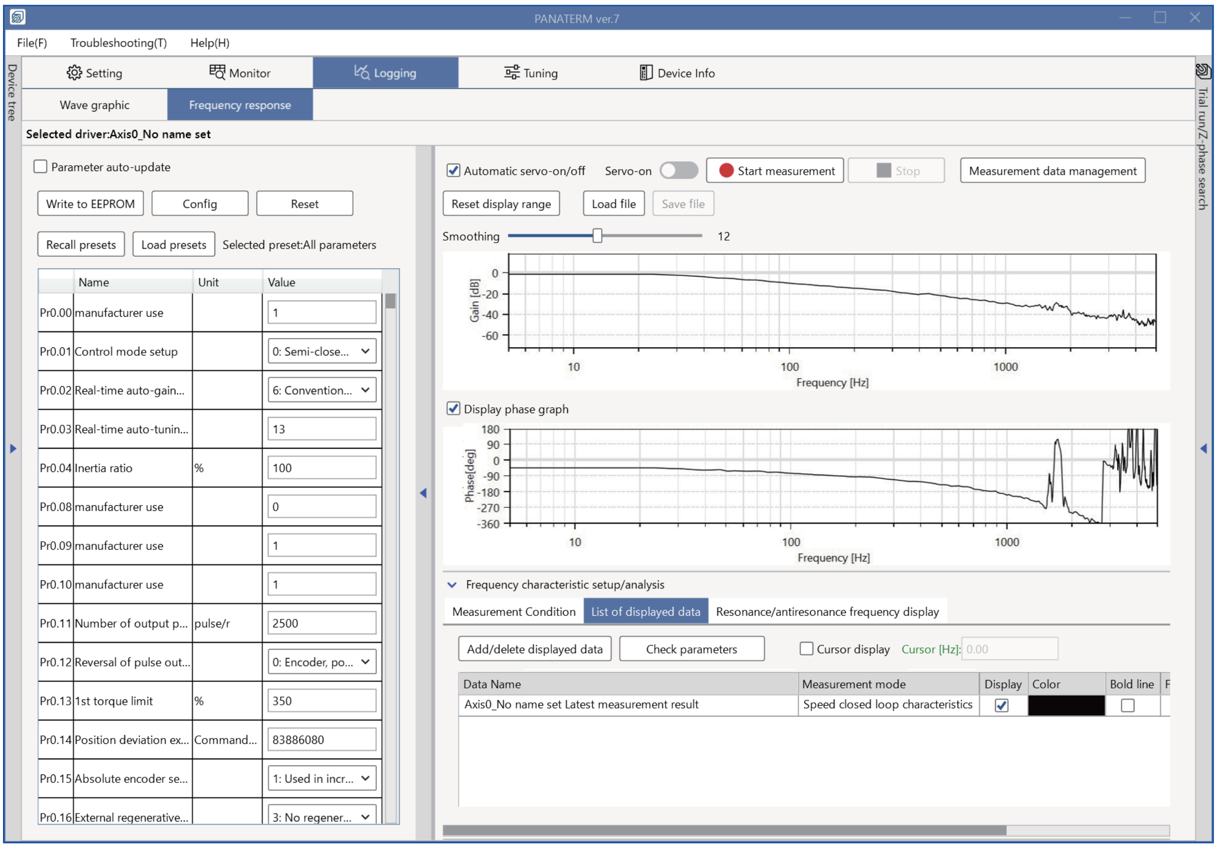
8. After measurement is completed, the gain and phase are displayed on the main screen.

For detailed instructions on how to operate the graph area of the main screen, see Set-up Support Software (PANATERM ver.7) Operating Manual.

Also, if parameters were changed manually prior to measurement, such as torque speed (vertical), do not forget to restore the relevant parameters once the measurement of frequency response is complete.

If the servo-on is performed manually with "Step 6", the waveform is displayed on the main screen after servo-off.

If the brake is operated by a host device, apply the brake before servo-off.



Selected driver:Axis0_No name set

☐ Parameter auto-update

Selected preset:All parameters

	Name	Unit	Value
Pr0.00	manufacturer use		1
Pr0.01	Control mode setup		0: Semi-close...
Pr0.02	Real-time auto-gain...		6: Convention...
Pr0.03	Real-time auto-tunin...		13
Pr0.04	Inertia ratio	%	100
Pr0.08	manufacturer use		0
Pr0.09	manufacturer use		1
Pr0.10	manufacturer use		1
Pr0.11	Number of output p...	pulse/r	2500
Pr0.12	Reversal of pulse out...		0: Encoder, po...
Pr0.13	1st torque limit	%	350
Pr0.14	Position deviation ex...	Command...	83886080
Pr0.15	Absolute encoder se...		1: Used in incr...
Pr0.16	External regenerative...		3: No regener...

☑ Automatic servo-on/off

Smoothing 12

☑ Display phase graph

☐ Cursor display Cursor [Hz]: 0.00

Data Name	Measurement mode	Display	Color	Bold line	F
Axis0_No name set Latest measurement result	Speed closed loop characteristics	☑	■	☐	

6.2.6 Method of Use

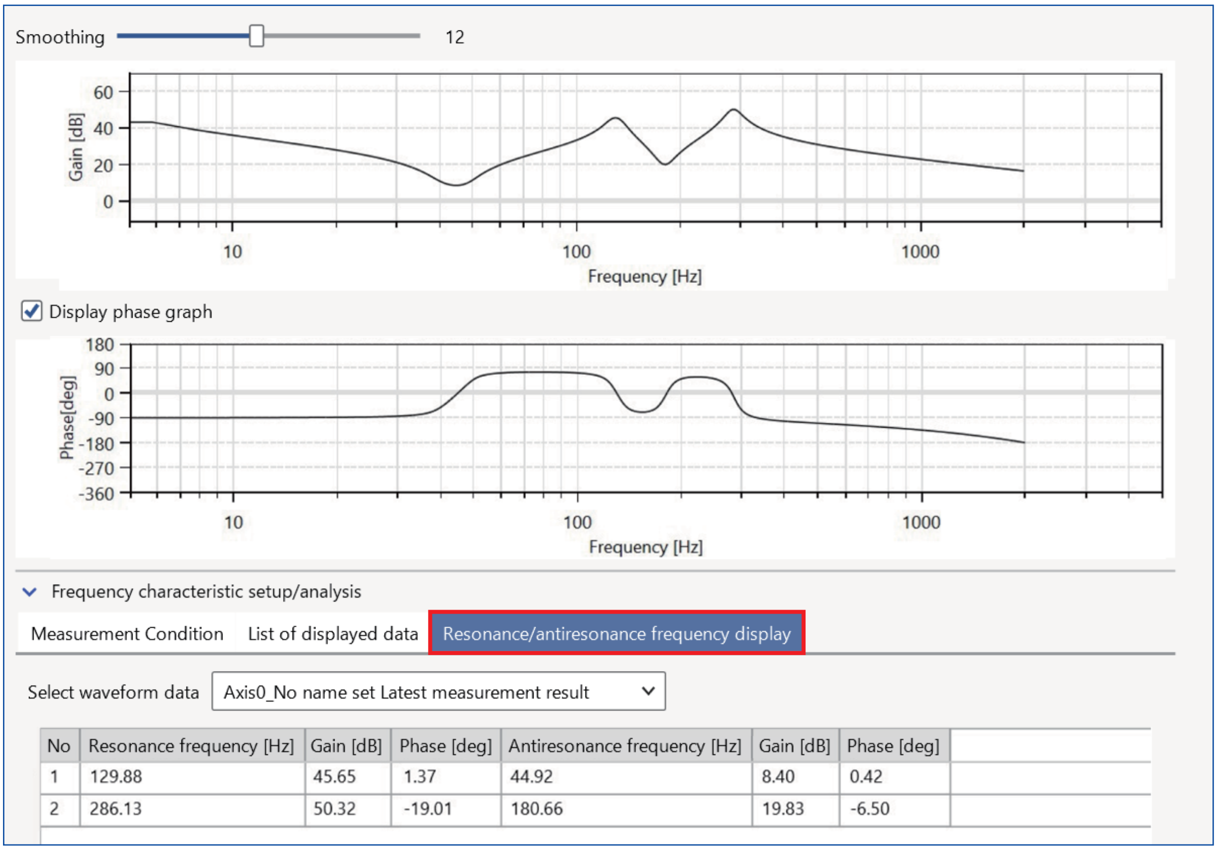
■ Understanding mechanical resonance and using it as reference for the set values of various filters

1 Measure "Torque speed (normal)" or "Torque speed (vertical)" according to *"6.2.5 Measurement Procedure"* .

2 Select the "Resonance/antiresonance frequency display" tab on the screen to view the resonance frequency and antiresonance frequency.

The figure below is an example of "Torque speed (normal)".

For an example of filter settings using these, see *"5.6 Model-type Damping Filter Function"* .



Smoothing 12

☑ Display phase graph

Select waveform data: Axis0_No name set Latest measurement result

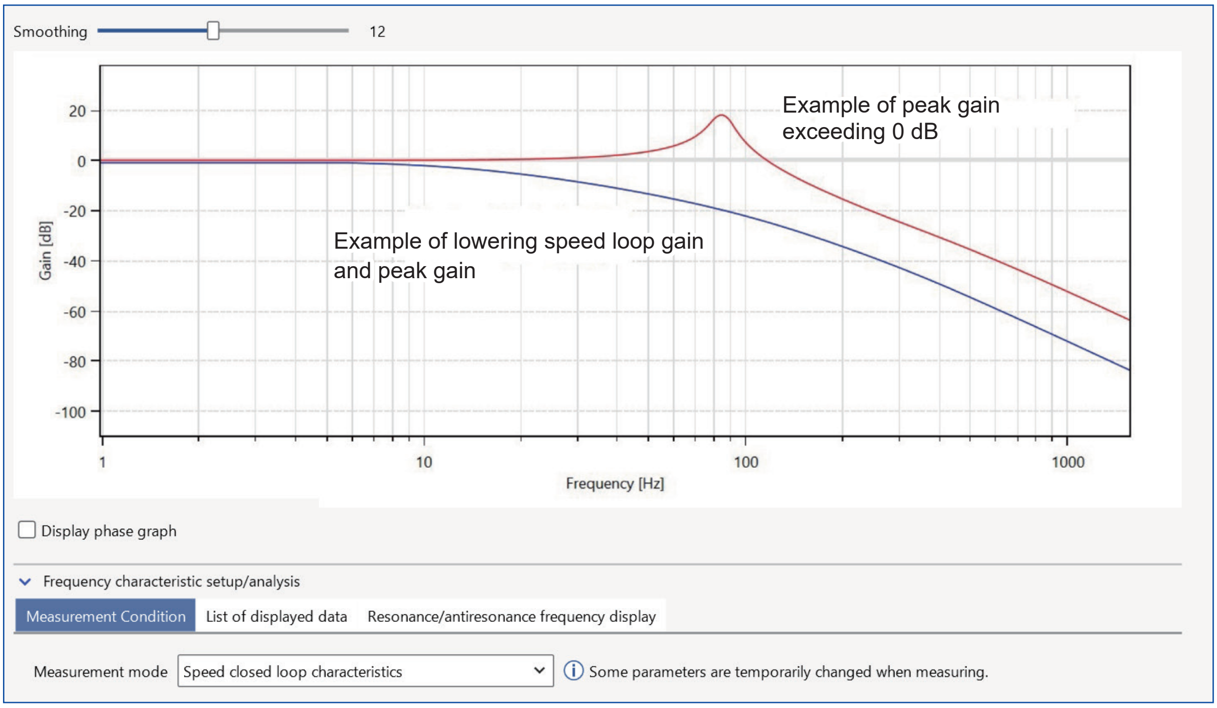
No	Resonance frequency [Hz]	Gain [dB]	Phase [deg]	Antiresonance frequency [Hz]	Gain [dB]	Phase [deg]
1	129.88	45.65	1.37	44.92	8.40	0.42
2	286.13	50.32	-19.01	180.66	19.83	-6.50

■ Checking the stability of the feedback control system when parameter tuning is in progress or has finished

1 Measure “Speed closed loop characteristics” according to *“6.2.5 Measurement Procedure”* .

2 Check if the peak gain exceeds 0 dB. If this value is exceeded, oscillation may occur. Basically, the lower the stiffness value of the feedback control system, the lower the peak gain. If a device has high friction, oscillation may not occur even though the value is above 0 dB.

For details on how to tune parameters, see *“3.2.1 Manual TUNING”* .



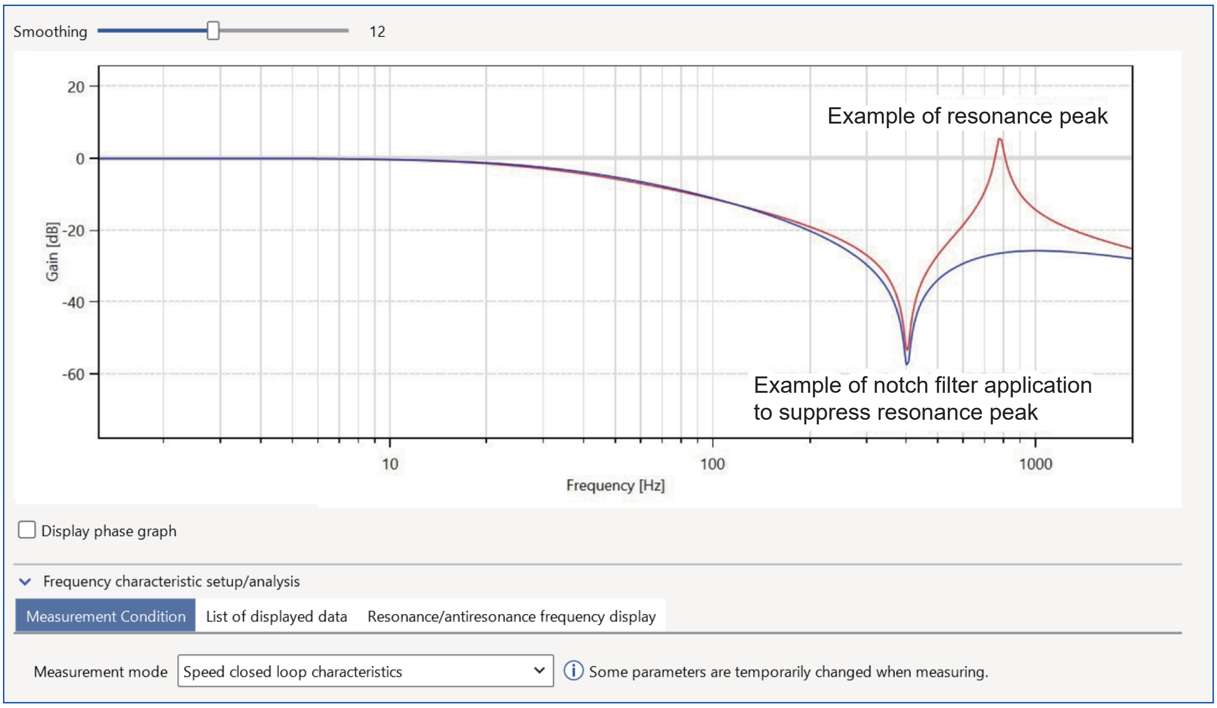
Smoothing 12

☐ Display phase graph

Measurement mode: Speed closed loop characteristics

ⓘ Some parameters are temporarily changed when measuring.

Resonance peaks from mechanical resonance may also be measured. When doing so, it may be possible to increase the stiffness by setting a notch filter to suppress the resonance peak. For information on how to set notch filters, see *“5.3 Notch Filter Function”* .



Example of resonance peak

Example of notch filter application to suppress resonance peak

Measurement mode: Speed closed loop characteristics

Some parameters are temporarily changed when measuring.

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7.1 Object Dictionary List

For how to view the Object Dictionary List, see Operating Instructions (Overall) “6.1 How to Read the Object Table” .
For details on abbreviations used for document names, see *“1.2 Related Documents”* .

7.1.1 CoE Communication Area (1000h to 1FFFh)

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
1000h	00h	Device type	–	0 to 4294967295	–	U32	ro	No	ALL	No	X	OI_O
1001h	00h	Error register	–	0 to 255	–	U8	ro	No	ALL	No	X	–
		● bit 4: Generation of an alarm defined by AL status code										OI_O
		● bit 7: Generation of an alarm not defined by AL status code										
1008h	00h	Manufacturer device name	–	–	–	VS	ro	No	ALL	No	X	OI_O
1009h	00h	Manufacturer hardware version	–	–	–	VS	ro	No	ALL	No	X	
100Ah	00h	Manufacturer software version	–	–	–	VS	ro	No	ALL	No	X	
1010h	–	Store parameters	–	–	–	–	–	–	–	–	–	OI_O
	00h	Number of entries	–	0 to 255	–	U8	ro	No	ALL	No	X	
	01h	Save all parameters	–	0 to 4294967295	1	U32	rw	No	ALL	No	A	
1018h	–	Identity object	–	–	–	–	–	–	–	–	–	OI_O
	00h	Number of entries	–	0 to 255	–	U8	ro	No	ALL	No	X	
	01h	Vendor ID	–	0 to 4294967295	–	U32	ro	No	ALL	No	X	
	02h	Product code	–	0 to 4294967295	–	U32	ro	No	ALL	No	X	
	03h	Revision number	–	0 to 4294967295	–	U32	ro	No	ALL	No	X	
	04h	Serial number	–	0 to 4294967295	–	U32	ro	No	ALL	No	X	
10F3h	–	Diagnosis history	–	–	–	–	–	–	–	–	–	OI_O
	00h	Number of entries	–	0 to 255	–	U8	ro	No	ALL	No	X	
	01h	Maximum messages	–	0 to 255	–	U8	ro	No	ALL	No	X	
	02h	Newest message	–	0 to 255	–	U8	ro	No	ALL	No	X	
	03h	Newest acknowledged message	–	0 to 255	0	U8	rw	No	ALL	No	A	
	04h	New messages available	–	0 to 1	–	BOOL	ro	No	ALL	No	X	
	05h	Flags	–	0 to 65535	39	U16	rw	No	ALL	Yes	A	–
		● bit 0: Emergency message execution permission										OI_O
		● bit 5: Diagnosis message clearing information										
	06h	Diagnosis message 1	–	–	–	OS	ro	No	ALL	No	X	OI_O
	⋮											
	23h	Diagnosis message 30	–	–	–	OS	ro	No	ALL	No	X	
1600h	–	Receive PDO mapping 1	–	–	–	–	–	–	–	–	–	OI_O
	00h	Number of entries	–	0 to 32	4	U8	rw	No	ALL	Yes	S	
	01h	1st receive PDO mapped	–	0 to 4294967295	1614807056	U32	rw	No	ALL	Yes	S	
	02h	2nd receive PDO mapped	–	0 to 4294967295	1616904200	U32	rw	No	ALL	Yes	S	
	03h	3rd receive PDO mapped	–	0 to 4294967295	1618608160	U32	rw	No	ALL	Yes	S	
	04h	4th receive PDO mapped	–	0 to 4294967295	1622671376	U32	rw	No	ALL	Yes	S	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
1600h	05h	5th receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	OI_O
	06h	6th receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
	07h	7th receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
	08h	8th receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
	⋮											
	20h	32nd receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
1601h	—	Receive PDO mapping 2	—	—	—	—	—	—	—	—	—	
	00h	Number of entries	—	0 to 32	7	U8	rw	No	ALL	Yes	S	
	01h	1st receive PDO mapped	—	0 to 4294967295	1614807056	U32	rw	No	ALL	Yes	S	
	02h	2nd receive PDO mapped	—	0 to 4294967295	1616904200	U32	rw	No	ALL	Yes	S	
	03h	3rd receive PDO mapped	—	0 to 4294967295	1618018320	U32	rw	No	ALL	Yes	S	
	04h	4th receive PDO mapped	—	0 to 4294967295	1618608160	U32	rw	No	ALL	Yes	S	
	05h	5th receive PDO mapped	—	0 to 4294967295	1619001376	U32	rw	No	ALL	Yes	S	
	06h	6th receive PDO mapped	—	0 to 4294967295	1622671376	U32	rw	No	ALL	Yes	S	
	07h	7th receive PDO mapped	—	0 to 4294967295	1627324448	U32	rw	No	ALL	Yes	S	
	08h	8th receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
	⋮											
	20h	32nd receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
1602h	—	Receive PDO mapping 3	—	—	—	—	—	—	—	—	—	
	00h	Number of entries	—	0 to 32	6	U8	rw	No	ALL	Yes	S	
	01h	1st receive PDO mapped	—	0 to 4294967295	1614807056	U32	rw	No	ALL	Yes	S	
	02h	2nd receive PDO mapped	—	0 to 4294967295	1616904200	U32	rw	No	ALL	Yes	S	
	03h	3rd receive PDO mapped	—	0 to 4294967295	1618083856	U32	rw	No	ALL	Yes	S	
	04h	4th receive PDO mapped	—	0 to 4294967295	1618608160	U32	rw	No	ALL	Yes	S	
	05h	5th receive PDO mapped	—	0 to 4294967295	1622671376	U32	rw	No	ALL	Yes	S	
	06h	6th receive PDO mapped	—	0 to 4294967295	1627324448	U32	rw	No	ALL	Yes	S	
	07h	7th receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
	08h	8th receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
	⋮											
	20h	32nd receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
1603h	—	Receive PDO mapping 4	—	—	—	—	—	—	—	—	—	
	00h	Number of entries	—	0 to 32	8	U8	rw	No	ALL	Yes	S	
	01h	1st receive PDO mapped	—	0 to 4294967295	1614807056	U32	rw	No	ALL	Yes	S	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
1603h	02h	2nd receive PDO mapped	—	0 to 4294967295	1616904200	U32	rw	No	ALL	Yes	S	OI_O
	03h	3rd receive PDO mapped	—	0 to 4294967295	1618018320	U32	rw	No	ALL	Yes	S	
	04h	4th receive PDO mapped	—	0 to 4294967295	1618083856	U32	rw	No	ALL	Yes	S	
	05h	5th receive PDO mapped	—	0 to 4294967295	1618608160	U32	rw	No	ALL	Yes	S	
	06h	6th receive PDO mapped	—	0 to 4294967295	1619001376	U32	rw	No	ALL	Yes	S	
	07h	7th receive PDO mapped	—	0 to 4294967295	1622671376	U32	rw	No	ALL	Yes	S	
	08h	8th receive PDO mapped	—	0 to 4294967295	1627324448	U32	rw	No	ALL	Yes	S	
	09h	9th receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
	⋮											
	20h	32nd receive PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
1A00h	—	Transmit PDO mapping 1	—	—	—	—	—	—	—	—	—	
	00h	Number of entries	—	0 to 32	8	U8	rw	No	ALL	Yes	S	
	01h	1st transmit PDO mapped	—	0 to 4294967295	1614741520	U32	rw	No	ALL	Yes	S	
	02h	2nd transmit PDO mapped	—	0 to 4294967295	1614872592	U32	rw	No	ALL	Yes	S	
	03h	3rd transmit PDO mapped	—	0 to 4294967295	1616969736	U32	rw	No	ALL	Yes	S	
	04h	4th transmit PDO mapped	—	0 to 4294967295	1617166368	U32	rw	No	ALL	Yes	S	
	05h	5th transmit PDO mapped	—	0 to 4294967295	1622736912	U32	rw	No	ALL	Yes	S	
	06h	6th transmit PDO mapped	—	0 to 4294967295	1622802464	U32	rw	No	ALL	Yes	S	
	07h	7th transmit PDO mapped	—	0 to 4294967295	1626603552	U32	rw	No	ALL	Yes	S	
	08h	8th transmit PDO mapped	—	0 to 4294967295	1627193376	U32	rw	No	ALL	Yes	S	
	09h	9th transmit PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
	⋮											
	20h	32nd transmit PDO mapped	—	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
1A01h	—	Transmit PDO mapping 2	—	—	—	—	—	—	—	—	—	
	00h	Number of entries	—	0 to 32	9	U8	rw	No	ALL	Yes	S	
	01h	1st transmit PDO mapped	—	0 to 4294967295	1614741520	U32	rw	No	ALL	Yes	S	
	02h	2nd transmit PDO mapped	—	0 to 4294967295	1614872592	U32	rw	No	ALL	Yes	S	
	03h	3rd transmit PDO mapped	—	0 to 4294967295	1616969736	U32	rw	No	ALL	Yes	S	
	04h	4th transmit PDO mapped	—	0 to 4294967295	1617166368	U32	rw	No	ALL	Yes	S	
	05h	5th transmit PDO mapped	—	0 to 4294967295	1617690656	U32	rw	No	ALL	Yes	S	
	06h	6th transmit PDO mapped	—	0 to 4294967295	1618411536	U32	rw	No	ALL	Yes	S	
	07h	7th transmit PDO mapped	—	0 to 4294967295	1622736912	U32	rw	No	ALL	Yes	S	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
1A01h	08h	8th transmit PDO mapped	–	0 to 4294967295	1622802464	U32	rw	No	ALL	Yes	S	OI_O
	09h	9th transmit PDO mapped	–	0 to 4294967295	1627193376	U32	rw	No	ALL	Yes	S	
	0Ah	10th transmit PDO mapped	–	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
	⋮											
	20h	32nd transmit PDO mapped	–	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
1A02h	–	Transmit PDO mapping 3	–	–	–	–	–	–	–	–	–	
	00h	Number of entries	–	0 to 32	9	U8	rw	No	ALL	Yes	S	
	01h	1st transmit PDO mapped	–	0 to 4294967295	1614741520	U32	rw	No	ALL	Yes	S	
	02h	2nd transmit PDO mapped	–	0 to 4294967295	1614872592	U32	rw	No	ALL	Yes	S	
	03h	3rd transmit PDO mapped	–	0 to 4294967295	1616969736	U32	rw	No	ALL	Yes	S	
	04h	4th transmit PDO mapped	–	0 to 4294967295	1617166368	U32	rw	No	ALL	Yes	S	
	05h	5th transmit PDO mapped	–	0 to 4294967295	1617690656	U32	rw	No	ALL	Yes	S	
	06h	6th transmit PDO mapped	–	0 to 4294967295	1618411536	U32	rw	No	ALL	Yes	S	
	07h	7th transmit PDO mapped	–	0 to 4294967295	1622736912	U32	rw	No	ALL	Yes	S	
	08h	8th transmit PDO mapped	–	0 to 4294967295	1622802464	U32	rw	No	ALL	Yes	S	
	09h	9th transmit PDO mapped	–	0 to 4294967295	1627193376	U32	rw	No	ALL	Yes	S	
	0Ah	10th transmit PDO mapped	–	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
	⋮											
	20h	32nd transmit PDO mapped	–	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
1A03h	–	Transmit PDO mapping 4	–	–	–	–	–	–	–	–	–	
	00h	Number of entries	–	0 to 32	9	U8	rw	No	ALL	Yes	S	
	01h	1st transmit PDO mapped	–	0 to 4294967295	1614741520	U32	rw	No	ALL	Yes	S	
	02h	2nd transmit PDO mapped	–	0 to 4294967295	1614872592	U32	rw	No	ALL	Yes	S	
	03h	3rd transmit PDO mapped	–	0 to 4294967295	1616969736	U32	rw	No	ALL	Yes	S	
	04h	4th transmit PDO mapped	–	0 to 4294967295	1617166368	U32	rw	No	ALL	Yes	S	
	05h	5th transmit PDO mapped	–	0 to 4294967295	1617690656	U32	rw	No	ALL	Yes	S	
	06h	6th transmit PDO mapped	–	0 to 4294967295	1618411536	U32	rw	No	ALL	Yes	S	
	07h	7th transmit PDO mapped	–	0 to 4294967295	1622736912	U32	rw	No	ALL	Yes	S	
	08h	8th transmit PDO mapped	–	0 to 4294967295	1622802464	U32	rw	No	ALL	Yes	S	
	09h	9th transmit PDO mapped	–	0 to 4294967295	1627193376	U32	rw	No	ALL	Yes	S	
	0Ah	10th transmit PDO mapped	–	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	
	⋮											
	20h	32nd transmit PDO mapped	–	0 to 4294967295	0	U32	rw	No	ALL	Yes	S	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
1C00h	—	Sync manager communication type	—	—	—	—	—	—	—	—	—	OI_O
	00h	Number of used sync manager channels	—	0 to 255	—	U8	ro	No	ALL	No	X	
	01h	Communication type sync manager 0	—	0 to 4	—	U8	ro	No	ALL	No	X	
	02h	Communication type sync manager 1	—	0 to 4	—	U8	ro	No	ALL	No	X	
	03h	Communication type sync manager 2	—	0 to 4	—	U8	ro	No	ALL	No	X	
	04h	Communication type sync manager 3	—	0 to 4	—	U8	ro	No	ALL	No	X	
1C12h	—	Sync manager channel 2	—	—	—	—	—	—	—	—	—	OI_O
	00h	Number of assigned PDOs	—	0 to 4	1	U8	rw	No	ALL	Yes	S	
	01h	PDO mapping object index of assigned RxPDO 1	—	1600h to 1603h	5632	U16	rw	No	ALL	Yes	S	
	02h	PDO mapping object index of assigned RxPDO 2	—	1600h to 1603h	5633	U16	rw	No	ALL	Yes	S	
	03h	PDO mapping object index of assigned RxPDO 3	—	1600h to 1603h	5634	U16	rw	No	ALL	Yes	S	
	04h	PDO mapping object index of assigned RxPDO 4	—	1600h to 1603h	5635	U16	rw	No	ALL	Yes	S	
1C13h	—	Sync manager channel 3	—	—	—	—	—	—	—	—	—	
	00h	Number of assigned PDOs	—	0 to 4	1	U8	rw	No	ALL	Yes	S	
	01h	PDO mapping object index of assigned TxPDO 1	—	1A00h to 1A03h	6656	U16	rw	No	ALL	Yes	S	
	02h	PDO mapping object index of assigned TxPDO 2	—	1A00h to 1A03h	6657	U16	rw	No	ALL	Yes	S	
	03h	PDO mapping object index of assigned TxPDO 3	—	1A00h to 1A03h	6658	U16	rw	No	ALL	Yes	S	
	04h	PDO mapping object index of assigned TxPDO 4	—	1A00h to 1A03h	6659	U16	rw	No	ALL	Yes	S	
1C32h	—	Sync manager 2 synchronization	—	—	—	—	—	—	—	—	—	OI_O
	00h	Number of sub-objects	—	0 to 255	—	U8	ro	No	ALL	No	X	
	01h	Sync mode	—	0 to 65535	2	U16	rw	No	ALL	Yes	S	
	02h	Cycle time	ns	0 to 4294967295	1000000	U32	rw	No	ALL	Yes	S	
	03h	Shift time	ns	0 to 4294967295	—	U32	ro	No	ALL	No	X	
	04h	Sync modes supported	—	0 to 65535	—	U16	ro	No	ALL	No	X	—
		● bit 0: FreeRun mode support										OI_O
		● bit 1: SM Synchronous mode support										OI_O
		● bits 4 to 2: DC synchronous mode support										OI_O
		● bits 6 to 5: Output shift support										OI_O
	05h	Minimum cycle time	ns	0 to 4294967295	—	U32	ro	No	ALL	No	X	OI_O
	06h	Calc and copy time	ns	0 to 4294967295	—	U32	ro	No	ALL	No	X	
	08h	Command	—	0 to 65535	—	U16	ro	No	ALL	No	X	
	09h	Delay time	ns	0 to 4294967295	—	U32	ro	No	ALL	No	X	
	0Ah	Sync0 cycle time	ns	0 to 4294967295	—	U32	ro	No	ALL	No	X	
	0Bh	SM-event missed	—	0 to 65535	—	U16	ro	No	ALL	No	X	
	0Ch	Cycle time too small	—	0 to 65535	—	U16	ro	No	ALL	No	X	
	0Dh	Shift time too short	—	0 to 65535	—	U16	ro	No	ALL	No	X	
	0Eh	RxPDO toggle failed	—	0 to 65535	—	U16	ro	No	ALL	No	X	
	20h	Sync error	—	0 to 1	—	BOOL	ro	No	ALL	No	X	
1C33h	—	Sync manager 3 synchronization	—	—	—	—	—	—	—	—	—	
	00h	Number of sub-objects	—	0 to 255	—	U8	ro	No	ALL	No	X	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
1C33h	01h	Sync mode	–	0 to 65535	2	U16	rw	No	ALL	Yes	S	OI_O
	02h	Cycle time	ns	0 to 4294967295	–	U32	ro	No	ALL	No	X	
	03h	Shift time	ns	0 to 4294967295	0	U32	rw	No	ALL	No	S	
	04h	Sync modes supported	–	0 to 65535	–	U16	ro	No	ALL	No	X	–
		● bit 0: FreeRun mode support										OI_O
		● bit 1: SM Synchronous mode support										OI_O
		● bits 4 to 2: DC synchronous mode support										OI_O
		● bits 6 to 5: Output Shift Support Input Shift Support										OI_O
	05h	Minimum cycle time	ns	0 to 4294967295	–	U32	ro	No	ALL	No	X	OI_O
	06h	Calc and copy time	ns	0 to 4294967295	–	U32	ro	No	ALL	No	X	
	08h	Command	–	0 to 65535	–	U16	ro	No	ALL	No	X	
	09h	Delay time	ns	0 to 4294967295	–	U32	ro	No	ALL	No	X	
	0Ah	Sync0 cycle time	ns	0 to 4294967295	–	U32	ro	No	ALL	No	X	
	0Bh	SM-event missed	–	0 to 65535	–	U16	ro	No	ALL	No	X	
	0Ch	Cycle time too small	–	0 to 65535	–	U16	ro	No	ALL	No	X	
	0Dh	Shift time too short	–	0 to 65535	–	U16	ro	No	ALL	No	X	
	0Eh	RxPDO toggle failed	–	0 to 65535	–	U16	ro	No	ALL	No	X	
	20h	Sync error	–	0 to 1	–	BOOL	ro	No	ALL	No	X	

7.1.2 Servo Parameter Area (3000h to 3FFFh)

For correspondence between parameter numbers and object numbers, see Operating Instructions (Overall) “6.4 Servo Parameter Area (3000h to 3FFFh) Details” .

7.1.2.1 Class 0: Basic Settings

—: N/A

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3000h	00h	Reserved	—	—	1	I16	—	—	—	—	—	—
3001h	00h	Control mode setup	—	0 to 6	0	I16	rw	No	ALL	Yes	R	OI_O
3002h	00h	Real-time auto-gain tuning setup	—	0 to 7	1	I16	rw	No	ALL	Yes	B	*“4.1.1.4”* *“4.1.2.4”* *“4.1.3.4”*
3003h	00h	Real-time auto-tuning machine stiffness setup	—	0 to 31	Sizes A, B: 13 Sizes C, D: 11 (13) (*3)	I16	rw	No	ALL	Yes	B	
3004h	00h	Inertia ratio	%	0 to 100000	250	I32	rw	No	ALL	Yes	B	*“7.5”*
3008h	00h	Reserved	—	—	0	I32	—	—	—	—	—	—
3009h	00h	Reserved	—	—	1	I32	—	—	—	—	—	
3010h	00h	Reserved	—	—	1	I32	—	—	—	—	—	
3011h	00h	Number of output pulses per motor revolution	pulse/r	1 to 33554432	2500	I32	rw	No	ALL	Yes	R	OI_O
3012h	00h	Reversal of pulse output logic	—	0 to 3	0	I16	rw	No	ALL	Yes	R	
3013h	00h	1st torque limit	%	0 to 500	500 (*2)	I16	rw	No	ALL	Yes	B	OI_O
3014h	00h	Position deviation excess setup	Command unit	0 to 1073741824	83886080	I32	rw	No	csp pp hm ip	Yes	A	OI_O
3015h	00h	Absolute encoder setup	—	0 to 4	1	I16	rw	No	csp (S) pp (S) hm (S) ip (S) csv (S) pv (S) cst (S) tq (S)	Yes	C	OI_O
3016h	00h	External regenerative resistor setup	—	0 to 3	Sizes A, B: 3 Sizes C, D: 0	I16	rw	No	ALL	Yes	C	OI_O
3017h	00h	Selection of load factor for external regenerative resistor	—	0 to 4	0	I16	rw	No	ALL	Yes	C	
3018h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3022h	00h	Sensor feedback control mode setup (*1)	—	0 to 1	0	I16	rw	No	csp	Yes	R	OI_O
3027h	00h	Selection of machine stiffness at real-time auto-gain tuning 2	—	0 to 44	Sizes A, B: 16 Sizes C, D: 12 (16) (*3)	I16	rw	No	ALL	Yes	B	*“4.1.1.4”* *“4.1.2.4”* *“4.1.3.4”*
3028h	00h	Selection of feed forward stiffness at real-time auto-gain tuning	—	0 to 44	Sizes A, B: 16 Sizes C, D: 12 (16) (*3)	I16	rw	No	ALL	Yes	B	

*1 Cannot be used with the standard type or multi-function type. Do not change the factory default value.

*2 Factory default values vary depending on the servo driver and motor combination.

For details, see Operating Instructions (Overall) “8.1 Torque Limit Switching Function” .

*3 Values in parentheses are initial values for models with an instantaneous maximum current (peak value) of less than 24 A.

7.1.2.2 Class 1: Gain Adjustment

—: N/A

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3100h	00h	1st gain of position loop	0.1 s^{-1}	0 to 30000	Sizes A, B: 480 Sizes C, D: 320 (480) (*1)	I16	rw	No	csp pp hm ip	Yes	B	*“4.1.1.4”* *“4.1.2.4”* *“4.1.3.4”*
3101h	00h	1st velocity loop gain	0.1 Hz	1 to 32767	Sizes A, B: 270 Sizes C, D: 180 (270) (*1)	I16	rw	No	ALL	Yes	B	
3102h	00h	1st velocity loop integration time constant	0.1 ms	1 to 10000	Sizes A, B: 210 Sizes C, D: 310 (210) (*1)	I16	rw	No	ALL	Yes	B	
3103h	00h	1st filter of velocity detection	—	0 to 5	0	I16	rw	No	ALL	Yes	B	
3104h	00h	1st torque filter time constant	0.01 ms	0 to 2500	Sizes A, B: 84 Sizes C, D: 126 (84) (*1)	I16	rw	No	ALL	Yes	B	*“5.1.3”*
3105h	00h	2nd gain of position loop	0.1 s^{-1}	0 to 30000	Sizes A, B: 480 Sizes C, D: 320 (480) (*1)	I16	rw	No	csp pp hm ip	Yes	B	*“7.5”*
3106h	00h	2nd velocity loop gain	0.1 Hz	1 to 32767	Sizes A, B: 270 Sizes C, D: 180 (270) (*1)	I16	rw	No	ALL	Yes	B	
3107h	00h	2nd velocity loop integration time constant	0.1 ms	1 to 10000	Sizes A, B: 210 Sizes C, D: 310 (210) (*1)	I16	rw	No	ALL	Yes	B	
3108h	00h	2nd filter of velocity detection	—	0 to 5	0	I16	rw	No	ALL	Yes	B	
3109h	00h	2nd torque filter time constant	0.01 ms	0 to 2500	Sizes A, B: 84 Sizes C, D: 126 (84) (*1)	I16	rw	No	ALL	Yes	B	*“5.1.3”*
3110h	00h	Velocity feed forward gain	0.1%	0 to 4000	1000	I16	rw	No	csp pp hm ip	Yes	B	*“4.4.3”*
3111h	00h	Velocity feed forward filter	0.01 ms	0 to 6400	0	I16	rw	No	csp pp hm ip	Yes	B	
3112h	00h	Torque feed forward gain	0.1%	0 to 2000	1000	I16	rw	No	ALL	Yes	B	
3113h	00h	Torque feed forward filter	0.01 ms	0 to 6400	0	I16	rw	No	ALL	Yes	B	
3114h	00h	2nd gain setup	—	0 to 1	1	I16	rw	No	ALL	Yes	B	*“4.2.3”* *“4.3.3”*
3115h	00h	Mode of position control switching	—	0 to 10	0	I16	rw	No	csp pp hm ip	Yes	B	
3116h	00h	Delay time of position control switching	0.1 ms	0 to 10000	10	I16	rw	No	csp pp hm ip	Yes	B	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3117h	00h	Level of position control switching	—	0 to 20000	0	I16	rw	No	csp pp hm ip	Yes	B	*"4.2.3"*
3118h	00h	Hysteresis at position control switching	—	0 to 20000	0	I16	rw	No	csp pp hm ip	Yes	B	
3119h	00h	Position gain switching time	0.1 ms	0 to 10000	10	I16	rw	No	csp pp hm ip	Yes	B	
3120h	00h	Mode of velocity control switching	—	0 to 5	0	I16	rw	No	csv pv	Yes	B	
3121h	00h	Delay time of velocity control switching	0.1 ms	0 to 10000	0	I16	rw	No	csv pv	Yes	B	
3122h	00h	Level of velocity control switching	—	0 to 20000	0	I16	rw	No	csv pv	Yes	B	
3123h	00h	Hysteresis at velocity control switching	—	0 to 20000	0	I16	rw	No	csv pv	Yes	B	
3124h	00h	Mode of torque control switching	—	0 to 3	0	I16	rw	No	cst tq	Yes	B	
3125h	00h	Delay time of torque control switching	0.1 ms	0 to 10000	0	I16	rw	No	cst tq	Yes	B	
3126h	00h	Level of torque control switching	—	0 to 20000	0	I16	rw	No	cst tq	Yes	B	
3127h	00h	Hysteresis at torque control switching	—	0 to 20000	0	I16	rw	No	cst tq	Yes	B	
3128h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
		⁞										
3178h	00h	Reserved	—	—	0	I16	—	—	—	—	—	
31A6h	00h	1st position loop gain change ratio	%	0 to 300	100	I16	rw	No	ALL	Yes	B	*"7.5"*
31A7h	00h	1st velocity integration change ratio	%	0 to 300	100	I16	rw	No	ALL	Yes	B	
31A8h	00h	1st torque filter change ratio	%	0 to 300	100	I16	rw	No	ALL	Yes	B	
31A9h	00h	2nd position loop gain change ratio	%	0 to 300	100	I16	rw	No	ALL	Yes	B	
31B0h	00h	2nd velocity loop gain change ratio	%	0 to 300	100	I16	rw	No	ALL	Yes	B	
31B1h	00h	2nd velocity integration change ratio	%	0 to 300	100	I16	rw	No	ALL	Yes	B	
31B2h	00h	2nd torque filter change ratio	%	0 to 300	100	I16	rw	No	ALL	Yes	B	
31B3h	00h	Load fluctuation compensation filter change ratio	%	0 to 300	100	I16	rw	No	ALL	Yes	B	
31B4h	00h	Smoothing filter change ratio	%	0 to 300	100	I16	rw	No	ALL	Yes	B	
31B5h	00h	Tuning filter change ratio	%	0 to 300	100	I16	rw	No	ALL	Yes	B	

*1 Values in parentheses are initial values for models with an instantaneous maximum current (peak value) of less than 24 A.

7.1.2.3 Class 2: Vibration Suppression

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3200h	00h	Adaptive filter mode setup	–	0 to 6	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	*"5.4.3"*
3201h	00h	1st notch frequency	Hz	10 to 5000	5000	I16	rw	No	ALL	Yes	B	*"5.3.3"*
3202h	00h	1st notch width selection	–	0 to 20	2	I16	rw	No	ALL	Yes	B	
3203h	00h	1st notch depth selection	–	0 to 99	0	I16	rw	No	ALL	Yes	B	
3204h	00h	2nd notch frequency	Hz	10 to 5000	5000	I16	rw	No	ALL	Yes	B	
3205h	00h	2nd notch width selection	–	0 to 20	2	I16	rw	No	ALL	Yes	B	
3206h	00h	2nd notch depth selection	–	0 to 99	0	I16	rw	No	ALL	Yes	B	
3207h	00h	3rd notch frequency	Hz	10 to 5000	5000	I16	rw	No	ALL	Yes	B	*"5.3.3"* *"5.4.3"*
3208h	00h	3rd notch width selection	–	0 to 20	2	I16	rw	No	ALL	Yes	B	
3209h	00h	3rd notch depth selection	–	0 to 99	0	I16	rw	No	ALL	Yes	B	
3210h	00h	4th notch frequency	Hz	10 to 5000	5000	I16	rw	No	ALL	Yes	B	
3211h	00h	4th notch width selection	–	0 to 20	2	I16	rw	No	ALL	Yes	B	
3212h	00h	4th notch depth selection	–	0 to 99	0	I16	rw	No	ALL	Yes	B	
3213h	00h	Selection of damping filter switching	–	0 to 7	0	I16	rw	No	csp pp hm ip	Yes	B	*"5.5.3"* *"5.6.3"*
3214h	00h	1st damping frequency	0.1 Hz	0 to 3000	0	I16	rw	No	csp pp hm ip	Yes	B	*"5.5.3"*
3215h	00h	1st damping filter setup	0.1 Hz	0 to 1500	0	I16	rw	No	csp pp hm ip	Yes	B	
3216h	00h	2nd damping frequency	0.1 Hz	0 to 3000	0	I16	rw	No	csp pp hm ip	Yes	B	
3217h	00h	2nd damping filter setup	0.1 Hz	0 to 1500	0	I16	rw	No	csp pp hm ip	Yes	B	
3218h	00h	3rd damping frequency	0.1 Hz	0 to 3000	0	I16	rw	No	csp pp hm ip	Yes	B	
3219h	00h	3rd damping filter setup	0.1 Hz	0 to 1500	0	I16	rw	No	csp pp hm ip	Yes	B	
3220h	00h	4th damping frequency	0.1 Hz	0 to 3000	0	I16	rw	No	csp pp hm ip	Yes	B	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3221h	00h	4th damping filter setup	0.1 Hz	0 to 1500	0	I16	rw	No	csp pp hm ip	Yes	B	*“5.5.3”*
3222h	00h	Positional command smoothing filter	0.1 ms	0 to 10000	Sizes A, B: 92 Sizes C, D: 139 (92) (*1)	I16	rw	No	csp pp hm ip csv pv	Yes	B	*“5.7.3”* OI_O
3223h	00h	Positional command FIR filter	0.1 ms	0 to 10000	10	I16	rw	No	csp pp hm ip	Yes	B	*“5.7.3”*
3224h	00h	5th notch frequency	Hz	10 to 5000	5000	I16	rw	No	ALL	Yes	B	*“5.3.3”*
3225h	00h	5th notch width selection	–	0 to 20	2	I16	rw	No	ALL	Yes	B	
3226h	00h	5th notch depth selection	–	0 to 99	0	I16	rw	No	ALL	Yes	B	
3227h	00h	1st damping width setting	–	0 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	*“5.5.3”*
3228h	00h	2nd damping width setting	–	0 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	
3229h	00h	3rd damping width setting	–	0 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	
3230h	00h	4th damping width setting	–	0 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	
3231h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
		⋮										
3237h	00h	Reserved	–	–	0	I16	–	–	–	–	–	
3238h	00h	Filter function switching	–	-32768 to 32767	3	I16	rw	No	ALL	Yes	B	–
		● bit 0: Custom notch filter										OI_O
		● bit 1: Tuning filter 2										*“4.1.1.4”* *“4.1.2.4”* *“4.1.3.4”* OI_O
3239h	00h	Custom notch compensation coefficient	0.01	0 to 1000	0	I16	rw	No	ALL	Yes	B	OI_O *“5.3.3”*
3240h	00h	Custom notch compensation frequency1	0.1 Hz	0 to 10000	0	I16	rw	No	ALL	Yes	B	
3241h	00h	Custom notch compensation frequency2	0.1 Hz	0 to 10000	0	I16	rw	No	ALL	Yes	B	
3242h	00h	Custom notch frequency	Hz	10 to 5000	5000	I16	rw	No	ALL	Yes	B	
3243h	00h	Custom notch width	–	0 to 20	2	I16	rw	No	ALL	Yes	B	
3244h	00h	Custom notch depth	–	0 to 99	0	I16	rw	No	ALL	Yes	B	
3245h	00h	Function expansion setup 10	–	-2147483648 to 2147483647	61	I32	rw	No	ALL	Yes	B	–
		● bit 1 to 0: Two-degree-of-freedom control function setting										*“4.1.1.4”* *“4.1.2.4”* *“4.1.3.4”* OI_O
		● bit 2: Friction torque compensation parameter selection										*“7.5”*

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3245h	00h	• bit 3: Load fluctuation suppression function automatic calculation										*"4.1.1.4"* *"4.1.2.4"* *"4.1.3.4"* *"4.6.3"* *"4.7.3"*
		• bit 5 to 4: Stiffness setting resolution, individual FB/FF setting switching										*"4.1.1.4"* *"4.1.2.4"* *"4.1.3.4"*
3246h	00h	Tuning filter 2	0.01 ms	0 to 20000	Size A: 110 Size B: 120 Sizes C, D: 170 (120) (*1)	I16	rw	No	csp pp hm ip	Yes	B	OI_O
3250h	00h	Detection start vibration count	—	0 to 100	3	I16	rw	No	csp pp	Yes	B	*"5.5.3"*
3251h	00h	Detected vibration amplitude	Command unit	0 to 134217728	0	I32	rw	No	csp pp	Yes	B	
3252h	00h	Torque command additional value 2	0.1%	-1000 to 1000	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	*"4.5.3"*
3253h	00h	Positive direction torque compensation value 2	0.1%	-1000 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	
3254h	00h	Negative direction torque compensation value 2	0.1%	-1000 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	
3261h	00h	Target settling time	ms	0 to 32767	0	I16	rw	No	ALL	Yes	A	*"7.5"*
3262h	00h	Settling time count condition	—	0 to 1	0	I16	rw	No	ALL	Yes	A	
3263h	00h	Allowable overshoot amount	%	0 to 500	100	I16	rw	No	ALL	Yes	A	
3264h	00h	Tuning amount of movement	Command unit	0 to 2147483647	0	I32	rw	No	ALL	Yes	A	
3265h	00h	Tuning max speed	r/min	0 to 20000	0	I16	rw	No	ALL	Yes	A	
3266h	00h	Tuning acceleration and deceleration time	ms	0 to 5000	0	I16	rw	No	ALL	Yes	A	
3267h	00h	Tuning wait time	ms	0 to 10000	2000	I16	rw	No	ALL	Yes	A	
3268h	00h	Tuning operating range upper limit	Command unit	0 to 1073741823	8388608	I32	rw	No	ALL	Yes	A	
3269h	00h	Tuning operating range lower limit	Command unit	-1073741824 to 0	-8388608	I32	rw	No	ALL	Yes	A	
3270h	00h	Tuning overspeed level setting	r/min	0 to 20000	0	I16	rw	No	ALL	Yes	A	
3271h	00h	Tuning torque limit	%	0 to 500	0	I16	rw	No	ALL	Yes	A	
3272h	00h	Tuning start RTAT machine stiffness setting	—	0 to 44	8	I16	rw	No	ALL	Yes	A	
3273h	00h	Tuning stability margin	%	0 to 100	80	I16	rw	No	ALL	Yes	A	
3274h	00h	Tuning auto tuning application selection	—	-32768 to 32767	0	I16	rw	No	ALL	Yes	A	*"4.1.1.4"* *"4.1.2.4"* *"4.1.3.4"*
3275h	00h	Tuning step selection	—	-32768 to 32767	3	I16	rw	No	ALL	Yes	A	—
		• bit 0: Advance operation										*"7.5"*
		• bit 1: Homing operation										
3276h	00h	Tuning target function selection	—	-32768 to 32767	1009	I16	rw	No	ALL	Yes	A	—

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3276h	00h	● bit 0: Inertia ratio										*“7.5”*
		● bit 1: Unbalanced load compensation (default disabled)										
		● bit 2: Dynamic friction compensation (default disabled)										
		● bit 3: Viscous friction compensation (default disabled)										
		● bit 4: RTAT machine stiffness setting (position and speed gains, speed integration time constant, torque filter)										
		● bit 5: RTAT feedforward control section stiffness setting (smoothing filter time constant)										
		● bit 6: Notch filter										
		● bit 7: 1st damping filter										
		● bit 8: 2nd damping filter										
		● bit 9: Load fluctuation control function										
3277h	00h	Tuning start position	Command unit	-1073741824 to 1073741823	0	I32	rw	No	ALL	Yes	A	*“7.5”*
3278h	00h	Tuning vibration automatic suppression effective level	%	0 to 100	15	I16	rw	No	ALL	Yes	A	
3279h	00h	Tuning JOG test run command speed	r/min	0 to 500	60	I16	rw	No	ALL	Yes	A	
3280h	00h	Tuning JOG test run acceleration and deceleration time	ms	0 to 5000	50	I16	rw	No	ALL	Yes	A	

*1 Values in parentheses are initial values for models with an instantaneous maximum current (peak value) of less than 24 A.

7.1.2.4 Class 3: Velocity/Torque Control/Full-closed Control

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3304h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
⋮												
3307h	00h	Reserved	—	—	0	I16	—	—	—	—	—	
3312h	00h	Acceleration time setup	ms/ (1000 r/min)	0 to 10000	0	I16	rw	No	csv pv	Yes	B	*“5.8.3”*
3313h	00h	Deceleration time setup	ms/ (1000 r/min)	0 to 10000	0	I16	rw	No	csv pv	Yes	B	
3314h	00h	Sigmoid acceleration / deceleration time setup	ms	0 to 1000	0	I16	rw	No	csv pv	Yes	B	
3317h	00h	Selection of speed limit	—	2	2	I16	rw	No	cst tq	Yes	B	OI_O
3321h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3322h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3323h	00h	External scale selection	—	0 to 2	0	I16	rw	No	ALL	Yes	R	OI_O
3324h	00h	Numerator of external scale division	—	0 to 134217728	0	I32	rw	No	csp (F) pp (F) hm (F) ip (F)	Yes	R	OI_O
3325h	00h	Denominator of external scale division	—	1 to 134217728	10000	I32	rw	No	csp (F) pp (F) hm (F) ip (F)	Yes	R	
3326h	00h	Reversal of direction of external scale	—	0 to 3	0	I16	rw	No	ALL	Yes	R	OI_O
3327h	00h	External scale Z phase disconnection detection disable	—	0 to 1	0	I16	rw	No	ALL	Yes	R	OI_O
3328h	00h	Hybrid deviation excess setup	Command unit	1 to 134217728	16000	I32	rw	No	csp (F) pp (F) hm (F) ip (F)	Yes	C	OI_O
3329h	00h	Hybrid deviation clear setup	Rotation	0 to 100	0	I16	rw	No	csp (F) pp (F) hm (F) ip (F)	Yes	C	
3333h (*1)	00h	Analog input gain	Command unit/mV	0 to 30000	0	I16	rw	No	csp	Yes	B	OI_O
3334h (*1)	00h	Analog input polarity	—	0 to 1	0	I16	rw	No	csp	Yes	B	
3335h (*1)	00h	Analog input integration time constant	0.01 ms	0 to 100000	0	I32	rw	No	csp	Yes	B	
3336h (*1)	00h	Analog input integration limit	Command unit/mV	0 to 2147483647	0	I32	rw	No	csp	Yes	B	

*1 Cannot be used with the standard type or multi-function type. Do not change the factory default value.

7.1.2.5 Class 4: I/O Monitor Settings

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3400h	00h	SI1 input selection	—	0 to 16777215	3289650	I32	rw	No	ALL	Yes	C	OI_O
3401h	00h	SI2 input selection	—	0 to 16777215	8487297	I32	rw	No	ALL	Yes	C	
3402h	00h	SI3 input selection	—	0 to 16777215	8553090	I32	rw	No	ALL	Yes	C	
3403h	00h	SI4 input selection	—	0 to 16777215	2236962	I32	rw	No	ALL	Yes	C	
3404h	00h	SI5 input selection	—	0 to 16777215	2105376	I32	rw	No	ALL	Yes	C	
3405h	00h	SI6 input selection	—	0 to 16777215	2171169	I32	rw	No	ALL	Yes	C	
3406h	00h	SI7 input selection	—	0 to 16777215	3158064	I32	rw	No	ALL	Yes	C	
3407h	00h	SI8 input selection	—	0 to 16777215	3223857	I32	rw	No	ALL	Yes	C	
3410h	00h	SO1 output selection	—	0 to 16777215	197379	I32	rw	No	ALL	Yes	C	OI_O
3411h	00h	SO2 output selection	—	0 to 16777215	1052688	I32	rw	No	ALL	Yes	C	
3412h	00h	SO3 output selection	—	0 to 16777215	65793	I32	rw	No	ALL	Yes	C	
3416h	00h	Type of analog monitor 1	—	0 to 35	0	I16	rw	No	ALL	Yes	A	OI_O
3417h	00h	Analog monitor 1 output gain	—	0 to 214748364	0	I32	rw	No	ALL	Yes	A	
3418h	00h	Type of analog monitor 2	—	0 to 35	4	I16	rw	No	ALL	Yes	A	
3419h	00h	Analog monitor 2 output gain	—	0 to 214748364	0	I32	rw	No	ALL	Yes	A	
3421h	00h	Analog monitor output setup	—	0 to 2	0	I16	rw	No	ALL	Yes	A	
3422h (*1)	00h	Analog input (AIN) offset setting	0.375 mV	-26666 to 26666	0	I16	rw	No	ALL	Yes	B	OI_O
3423h (*1)	00h	Analog input (AIN) filter setting	0.01 ms	0 to 6400	0	I16	rw	No	ALL	Yes	B	
3424h (*1)	00h	Analog input (AIN) excessive setting	0.1 V	0 to 100	0	I16	rw	No	ALL	Yes	B	
3431h	00h	Positioning complete (In-position) range	Command unit	0 to 2097152	8400	I32	rw	No	csp pp hm ip	Yes	A	*“7.5”* OI_O
3432h	00h	Positioning complete (In-position) output setup	—	0 to 10	0	I16	rw	No	csp pp hm ip	Yes	A	OI_O
3433h	00h	INP hold time	ms	0 to 30000	0	I16	rw	No	csp pp hm ip	Yes	A	
3434h	00h	Zero-speed	r/min	10 to 20000	50	I16	rw	No	ALL	Yes	A	OI_O
3435h	00h	Speed coincidence range	r/min	10 to 20000	50	I16	rw	No	csv pv cst tq	Yes	A	OI_O
3436h	00h	At-speed (Speed arrival)	r/min	10 to 20000	1000	I16	rw	No	csv pv cst tq	Yes	A	OI_O
3437h	00h	Mechanical brake action at stalling setup	ms	0 to 10000	0	I16	rw	No	ALL	Yes	B	OI_O
3438h	00h	Mechanical brake action at running setup	ms	0 to 32000	0	I16	rw	No	ALL	Yes	B	OI_O
3439h	00h	Brake release speed setup	r/min	30 to 3000	30	I16	rw	No	ALL	Yes	B	OI_O
3440h	00h	Selection of alarm output 1	—	0 to 32767	0	I16	rw	No	ALL	Yes	A	OI_O
3441h	00h	Selection of alarm output 2	—	0 to 32767	0	I16	rw	No	ALL	Yes	A	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3442h	00h	Positioning complete (In-position) range 2	Command unit	0 to 2097152	8400	I32	rw	No	csp pp hm ip	Yes	A	OI_O
3444h	00h	Position comparison output pulse width setting	0.1 ms	0 to 32767	0	I16	rw	No	ALL	Yes	R	OI_O
3445h	00h	Position comparison output polarity selection	—	0 to 7	0	I16	rw	No	ALL	Yes	R	—
		• bit 0: Polarity for SO1 (general-purpose output) or OCMP1 (encoder/position comparison output terminal)										OI_O
		• bit 1: Polarity for SO2 (general-purpose output) or OCMP2 (encoder/position comparison output terminal)										
		• bit 2: Polarity for SO3 (general-purpose output) or OCMP3 (encoder/position comparison output terminal)										
3447h	00h	Pulse output selection	—	0 to 1	0	I16	rw	No	ALL	Yes	R	OI_O
3448h	00h	Position comparison value 1	Command unit	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	A	OI_O
3449h	00h	Position comparison value 2	Command unit	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	A	
3450h	00h	Position comparison value 3	Command unit	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	A	
3451h	00h	Position comparison value 4	Command unit	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	A	
3452h	00h	Position comparison value 5	Command unit	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	A	
3453h	00h	Position comparison value 6	Command unit	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	A	
3454h	00h	Position comparison value 7	Command unit	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	A	
3455h	00h	Position comparison value 8	Command unit	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	A	
3456h	00h	Position comparison output delay compensation amount	0.1 μs	-32768 to 32767	0	I16	rw	No	ALL	Yes	R	
3457h	00h	Position comparison output assignment setting	—	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	R	—
		• bit 3 to 0: Position comparison 1										OI_O
		• bit 7 to 4: Position comparison 2										
		• bit 11 to 8: Position comparison 3										
		• bit 15 to 12: Position comparison 4										
		• bit 19 to 16: Position comparison 5										
		• bit 23 to 20: Position comparison 6										
		• bit 27 to 24: Position comparison 7										
		• bit 31 to 28: Position comparison 8										
3463h	00h	Reserved	—	—	5242884	I32	—	—	—	—	—	—
3464h	00h	Reserved	—	—	64	I32	—	—	—	—	—	—

*1 Cannot be used with the standard type or multi-function type. Do not change the factory default value.

7.1.2.6 Class 5: Enhancing Settings

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3503h	00h	Denominator of pulse output division	–	0 to 134217728	0	I32	rw	No	ALL	Yes	R	OI_O
3504h	00h	Over-travel inhibit input setup	–	0 to 2	1	I16	rw	No	ALL	Yes	C	OI_O
3505h	00h	Sequence at over-travel inhibit	–	0 to 2	0	I16	rw	No	ALL	Yes	C	OI_O
3506h	00h	Sequence at Servo-Off	–	0 to 9	0	I16	rw	No	ALL	Yes	B	OI_O
3507h	00h	Sequence upon main power off	–	0 to 9	0	I16	rw	No	ALL	Yes	B	OI_O
3508h	00h	L/V trip selection upon main power off	–	0 to 3	0	I16	rw	No	ALL	Yes	B	–
		● bit 0: Operation selection with main power supply OFF										OI_O
		● bit 1: Main power off warning condition detection time										
3509h	00h	Detection time of main power off	ms	20 to 2000	2000	I16	rw	No	ALL	Yes	C	OI_O
3510h	00h	Sequence at alarm	–	0 to 7	0	I16	rw	No	ALL	Yes	B	OI_O
3511h	00h	Torque setup for emergency stop	%	0 to 500	0	I16	rw	No	ALL	Yes	B	OI_O
3512h	00h	Motor over-load level setup	%	0 to 500	0	I16	rw	No	ALL	Yes	A	OI_O
3513h	00h	Over-speed level setup	r/min	0 to 20000	0	I16	rw	No	ALL	Yes	B	OI_O
3514h	00h	Motor working range setup	0.1 rotation	0 to 1000	10	I16	rw	No	csp pp hm ip	Yes	A	OI_O
3515h	00h	Control input signal reading setup	–	0 to 3	0	I16	rw	No	ALL	Yes	C	OI_O
3516h	00h	Reserved	–	–	1	I16	–	–	–	–	–	–
3520h	00h	Position setup unit select	–	0 to 1	0	I16	rw	No	csp pp hm ip	Yes	C	OI_O
3521h	00h	Selection of torque limit	–	0 to 5	1	I16	rw	No	ALL	Yes	B	OI_O
3522h	00h	2nd torque limit	%	0 to 500	500 (*1)	I16	rw	No	csp pp hm ip csv pv	Yes	B	
3525h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
3526h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
3529h	00h	Reserved	–	–	2	I16	–	–	–	–	–	–
3531h	00h	USB axis address	–	0 to 127	1	I16	rw	No	ALL	Yes	C	PT_OM
3533h	00h	Pulse regenerative output limit setup	–	0 to 1	0	I16	rw	No	ALL	Yes	C	OI_O
3534h	00h	Reserved	–	–	4	I16	–	–	–	–	–	–
3536h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
3545h	00h	Quadrant glitch positive-direction compensation value	0.1%	-1000 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	*“4.9.3”*
3546h	00h	Quadrant glitch negative-direction compensation value	0.1%	-1000 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	
3547h	00h	Quadrant glitch compensation delay time	ms	0 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3548h	00h	Quadrant glitch compensation filter setting L	0.01 ms	0 to 6400	0	I16	rw	No	csp pp hm ip	Yes	B	*“4.9.3”*
3549h	00h	Quadrant glitch compensation filter setting H	0.1 ms	0 to 10000	0	I16	rw	No	csp pp hm ip	Yes	B	
3550h	00h	Reserved	—	—	0	I32	—	—	—	—	—	—
⋮												
3555h	00h	Reserved	—	—	0	I32	—	—	—	—	—	
3556h	00h	Slow stop deceleration time setting	ms/ (1000 r/min)	0 to 10000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S) csv (S) pv (S) cst (S) tq (S)	Yes	B	OI_O
3557h	00h	Slow stop S-shape acceleration and deceleration setting	ms	0 to 1000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S) csv (S) pv (S) cst (S) tq (S)	Yes	B	
3566h	00h	Deterioration diagnosis convergence judgment time	0.1 s	0 to 10000	0	I16	rw	No	ALL	Yes	A	OI_O
3567h	00h	Deterioration diagnosis inertia ratio upper limit	%	0 to 10000	0	I16	rw	No	ALL	Yes	A	
3568h	00h	Deterioration diagnosis inertia ratio lower limit	%	0 to 10000	0	I16	rw	No	ALL	Yes	A	
3569h	00h	Deterioration diagnosis unbalanced load upper limit	0.1%	-1000 to 1000	0	I16	rw	No	ALL	Yes	A	
3570h	00h	Deterioration diagnosis unbalanced load lower limit	0.1%	-1000 to 1000	0	I16	rw	No	ALL	Yes	A	
3571h	00h	Deterioration diagnosis dynamic friction upper limit	0.1%	-1000 to 1000	0	I16	rw	No	ALL	Yes	A	
3572h	00h	Deterioration diagnosis dynamic friction lower limit	0.1%	-1000 to 1000	0	I16	rw	No	ALL	Yes	A	
3573h	00h	Deterioration diagnosis viscous friction upper limit	0.1%/ (10000 r/min)	0 to 10000	0	I16	rw	No	ALL	Yes	A	
3574h	00h	Deterioration diagnosis viscous friction lower limit	0.1%/ (10000 r/min)	0 to 10000	0	I16	rw	No	ALL	Yes	A	
3575h	00h	Deterioration diagnosis velocity setting	r/min	-20000 to 20000	0	I16	rw	No	ALL	Yes	A	
3576h	00h	Deterioration diagnosis torque average time	ms	0 to 10000	0	I16	rw	No	ALL	Yes	A	
3577h	00h	Deterioration diagnosis torque upper limit	0.1%	-1000 to 1000	0	I16	rw	No	ALL	Yes	A	
3578h	00h	Deterioration diagnosis torque lower limit	0.1%	-1000 to 1000	0	I16	rw	No	ALL	Yes	A	
3595h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
35B0h	00h	Driver derating factor	%	0 to 100	100	I16	rw	No	ALL	Yes	A	OI_O
35B2h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—

*1 Factory default values vary depending on the servo driver and motor combination.

For details, see Operating Instructions (Overall) “8.1 Torque Limit Switching Function” .

7.1.2.7 Class 6: Special Settings

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3602h	00h	Speed deviation excess setup	r/min	0 to 20000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S)	Yes	A	OI_O
3603h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3605h	00h	Position 3rd gain valid time	0.1 ms	0 to 10000	0	I16	rw	No	csp pp hm ip	Yes	B	*“4.3.3”*
3606h	00h	Position 3rd gain scale factor	%	50 to 1000	100	I16	rw	No	csp pp hm ip	Yes	B	
3607h	00h	Torque command additional value	%	-100 to 100	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	*“4.5.3”*
3608h	00h	Positive direction torque compensation value	%	-100 to 100	0	I16	rw	No	csp pp hm ip	Yes	B	
3609h	00h	Negative direction torque compensation value	%	-100 to 100	0	I16	rw	No	csp pp hm ip	Yes	B	
3610h	00h	Function expansion setup	—	-32768 to 32767	528	I16	rw	No	ALL	Yes	B	—
		● bit 1: Load fluctuation control function										*“4.6.3”* *“4.7.3”*
		● bit 2: Load fluctuation stabilization setting										
		● bit 4: Current response improvement										*“7.5”*
		● bit 10: Fall prevention function during an alarm										OI_O
		● bit 11: Encoder overheat error protection detection										OI_O
		● bit 14: Load fluctuation suppression function automatic tuning										*“4.1.1.4”* *“4.1.2.4”* *“4.1.3.4”* *“4.6.3”* *“4.7.3”*
		● bit 15: Slow stop function										OI_O
3611h	00h	Current loop gain response setup	%	10 to 300	100	I16	rw	No	ALL	Yes	B	*“4.8.3”*
3614h	00h	Emergency stop time at alarm	ms	0 to 1000	200	I16	rw	No	ALL	Yes	B	OI_O
3615h	00h	2nd over-speed level setup	r/min	0 to 20000	0	I16	rw	No	ALL	Yes	B	OI_O
3618h	00h	Power-up wait time	100 ms	0 to 100	0	I16	rw	No	ALL	Yes	R	OI_O
3619h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3620h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3621h	00h	Reserved	—	—	0	I32	—	—	—	—	—	—
3622h	00h	AB phase external scale pulse outputting method selection	—	0 to 1	0	I16	rw	No	csp (F) pp (F) hm (F) ip (F)	Yes	R	OI_O

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3623h	00h	Load change compensation gain	%	-100 to 100	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	*"4.6.3"* *"4.7.3"*
3624h	00h	Load change compensation filter	0.01 ms	10 to 2500	53	I16	rw	No	csp pp hm ip csv pv	Yes	B	
3626h	00h	Reserved	—	—	0	I32	—	—	—	—	—	—
3627h	00h	Warning latch state setup	—	0 to 3	3	I16	rw	No	ALL	Yes	C	—
		● bit 0: Expanded warnings										OI_O
		● bit 1: General warnings										
3630h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3631h	00h	Real time auto tuning estimation speed	—	0 to 3	1	I16	rw	No	ALL	Yes	B	*"4.1.1.4"* *"4.1.2.4"* *"4.1.3.4"*
3632h	00h	Real time auto tuning custom set-up	—	-32768 to 32767	0	I16	rw	No	ALL	Yes	B	—
		● bit 1 to 0: Load characteristics estimation										*"4.1.1.4"* *"4.1.2.4"* *"4.1.3.4"*
		● bit 3 to 2: Inertia Ratio Update										
		● bit 6 to 4: Torque compensation										
		● bit 7: Stiffness Setup										
		● bit 8: Fixed Parameter Setup										
		● bit 10 to 9: Gain Switching Setup										
		● bit 11: Torque compensation setting switching										
		● bit 15 to 12: Individual torque compensation settings										
3634h	00h	Hybrid vibration suppression gain	$0.1\ s^{-1}$	0 to 30000	0	I16	rw	No	csp (F) pp (F) hm (F) ip (F)	Yes	B	*"5.9.3"*
3635h	00h	Hybrid vibration suppression filter	0.01 ms	0 to 32000	10	I16	rw	No	csp (F) pp (F) hm (F) ip (F)	Yes	B	
3636h	00h	Dynamic brake operation input setup	—	0 to 1	0	I16	rw	No	ALL	Yes	R	OI_O
3637h	00h	Oscillation detecting level	0.1%	0 to 1000	0	I16	rw	No	ALL	Yes	B	OI_O
3638h	00h	Warning mask setup	—	-32768 to 32767	4	I16	rw	No	ALL	Yes	C	
3639h	00h	Warning mask setup 2	—	-32768 to 32767	0	I16	rw	No	ALL	Yes	C	
3641h	00h	1st damping depth	—	0 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	*"5.5.3"*
3642h	00h	2-stage torque filter time constant	0.01 ms	0 to 2500	0	I16	rw	No	ALL	Yes	B	*"5.2.3"*
3643h	00h	2-stage torque filter attenuation term	—	0 to 1000	1000	I16	rw	No	ALL	Yes	B	
3647h	00h	Function expansion setup 2	—	-32768 to 32767	1	I16	rw	No	ALL	Yes	R	—
		● bit 0: Two-degree-of-freedom control mode										*"7.5"* OI_O
		● bit 2: Encoder communication error/warning judgment setup										OI_O

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3647h	00h	● bit 3: Two-degree-of-freedom control real-time auto tuning selection										*“7.5”* OI_O
		● bit 14: Quadrant glitch compensation function										*“4.9.3”*
3648h	00h	Tuning filter	0.1 ms	0 to 2000	Size A: 11 Size B: 12 Sizes C, D: 17 (12) (*1)	I16	rw	No	csp pp hm ip csv pv	Yes	B	OI_O
3649h	00h	Command/tuning filter damping	—	0 to 99	15	I16	rw	No	csp pp hm ip	Yes	B	*“5.7.3”* OI_O
3650h	00h	Viscous friction compensating gain	0.1%/ (10000 r/min)	0 to 10000	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	*“4.5.3”* OI_O
3651h	00h	Wait time for emergency stop	ms	0 to 10000	0	I16	rw	No	ALL	Yes	B	OI_O
3652h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
⋮												
3654h	00h	Reserved	—	—	0	I16	—	—	—	—	—	
3657h	00h	Torque saturation error protection detection time	ms	0 to 5000	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	OI_O
3658h	00h	Reserved	—	—	0	I32	—	—	—	—	—	—
3659h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3660h	00h	2nd damping depth	—	0 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	*“5.5.3”*
3661h	00h	1st resonance frequency	0.1 Hz	0 to 3000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S)	Yes	B	*“5.6.3”*
3662h	00h	1st resonance attenuation ratio	—	0 to 1000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S)	Yes	B	
3663h	00h	1st anti-resonance frequency	0.1 Hz	0 to 3000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S)	Yes	B	
3664h	00h	1st anti-resonance attenuation ratio	—	0 to 1000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S)	Yes	B	
3665h	00h	1st response frequency	0.1 Hz	0 to 3000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S)	Yes	B	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3666h	00h	2nd resonance frequency	0.1 Hz	0 to 3000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S)	Yes	B	*“5.6.3”*
3667h	00h	2nd resonance attenuation ratio	—	0 to 1000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S)	Yes	B	
3668h	00h	2nd anti-resonance frequency	0.1 Hz	0 to 3000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S)	Yes	B	
3669h	00h	2nd anti-resonance attenuation ratio	—	0 to 1000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S)	Yes	B	
3670h	00h	2nd response frequency	0.1 Hz	0 to 3000	0	I16	rw	No	csp (S) pp (S) hm (S) ip (S)	Yes	B	
3671h	00h	3rd damping depth	—	0 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	*“5.5.3”*
3672h	00h	4th damping depth	—	0 to 1000	0	I16	rw	No	csp pp hm ip	Yes	B	
3673h	00h	Load estimation filter	0.01 ms	0 to 2500	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	*“4.6.3”* *“4.7.3”*
3674h	00h	Torque compensation frequency 1	0.1 Hz	0 to 5000	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	
3675h	00h	Torque compensation frequency 2	0.1 Hz	0 to 5000	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	
3676h	00h	Load estimation count	—	0 to 8	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	
3685h	00h	Retracting operation condition setting	—	-32768 to 32767	0	I16	rw	No	ALL	Yes	C	—
		● bits 3 to 0: Non-communication settings										OI_O
		● bits 7 to 4: Communication-related setting										
		● bits 9 to 8: Judgment condition for stopping retracting operation										
3686h	00h	Retracting operation alarm setting	—	0 to 7	0	I16	rw	No	ALL	Yes	C	—

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3686h	00h	● bit 0: Err87.1.0 “Retracting operation completion (I/O)”										OI_O
		● bit 1: Err87.2.0 “Retracting operation completion (communication)”										
		● bit 2: Err87.3.0 “Retracting operation error”										
3687h	00h	Reserved	–	–	0	I32	–	–	–	–	–	–
3688h	00h	Absolute encoder multi-turn data upper-limit value	–	0 to 65534	0	I32	rw	No	ALL	Yes	C	OI_O
3695h	00h	Motor over-load warning detection level	%	0 to 114	0	I16	rw	No	ALL	Yes	A	OI_O
3696h	00h	Motor over-load warning release level	%	0 to 114	0	I16	rw	No	ALL	Yes	A	
3697h	00h	Function expansion setup 3	–	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	B	–
		● bit 0: Quadrant glitch compensation HPF clear										*“4.9.3”*
		● bit 1: Deterioration Diagnosis Warning Function										OI_O
		● bit 2: Motor movable range error protection expansion										OI_O
		● bit 3: Selection of external scale single-turn data monitor										OI_O
		● bit 6: Switches position information during backlash correction										*“4.10.3”*
		● bit 8: Target control mode extension of Obj.607Fh:00h “Max profile velocity”										OI_O
		● bit 11: External scale position latch during semi-closed control										OI_O
		● bit 12: Speed limit priority function during torque control										OI_O
		● bit 13: Touch probe latch completion status toggle output enabled										OI_O
		● bit 14: Over-travel inhibit warning										OI_O
		● bit 27: Alarm display switch setting										OI_O
3698h	00h	Function expansion setup 4	–	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	R	–
		● bit 3: Effective bit expansion for multi-turn data										OI_O
		● bit 8: Control mode switch function expansion										OI_O
		● bit 10: Selection of external scale single-turn data output format										OI_O
		● bit 21: Expand conditions for canceling over-travel inhibit										OI_O
36A0h	00h	Reserved	–	–	4000	I16	–	–	–	–	–	–
36A1h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
36A2h	00h	Over-travel inhibit release level setup	Command unit	0 to 2147483647	0	I32	rw	No	csp	Yes	B	OI_O
36A4h	00h	Open-phase monitoring setup	–	0 to 3	0	I16	rw	No	ALL	Yes	B	OI_O
36A6h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
36C1h	00h	Current feed forward response setup	%	0 to 300	100	I16	rw	No	ALL	Yes	B	*“4.8.3”*
36C5h	00h	Reserved	–	–	0	I32	–	–	–	–	–	–
36C6h	00h	Warning2 mask setup	–	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	C	OI_O
36C7h	00h	Warning3 mask setup	–	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	C	

*1 Values in parentheses are initial values for models with an instantaneous maximum current (peak value) of less than 24 A.

7.1.2.8 Class 7: Special Settings 2

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3700h	00h	Display on LED	—	0 to 32767	0	I16	rw	No	ALL	Yes	A	TR_FS
3701h	00h	Display time setup upon power-up	100 ms	0 to 1000	0	I16	rw	No	ALL	Yes	R	
3703h	00h	Output setup during torque limit	—	0 to 1	0	I16	rw	No	cst tq	Yes	A	OI_O
3704h	00h	Backlash compensation enable	—	0 to 7	0	I16	rw	No	csp pp hm ip	Yes	B	—
		● bits 1 to 0: Enable or disable backlash compensation and select the direction of operation during compensation										*“4.10.3”*
		● bit 2: Expand backlash compensation retention conditions										
3705h	00h	Backlash compensation value	pulse	-1073741824 to 1073741823	0	I32	rw	No	csp pp hm ip	Yes	B	*“4.10.3”*
3706h	00h	Constant for backlash compensation	0.01 ms	0 to 6400	0	I16	rw	No	csp pp hm ip	Yes	B	
3707h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3708h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3709h	00h	Correction time of latch delay 1	25 ns	-2000 to 2000	360	I16	rw	No	ALL	Yes	B	OI_O
3710h	00h	Reserved	—	—	3	I16	—	—	—	—	—	—
3711h	00h	Reserved	—	—	0	I32	—	—	—	—	—	—
		⋮										
3713h	00h	Reserved	—	—	0	I32	—	—	—	—	—	
3714h	00h	Main power off warning detection time	ms	0 to 2000	0	I16	rw	No	ALL	Yes	C	OI_O
3715h	00h	Reserved	—	—	0	I32	—	—	—	—	—	—
3716h	00h	Torque saturation error protection frequency	Incidences	0 to 30000	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	OI_O
3718h	00h	Backlash compensation value holding range	Command unit	0 to 2147483647	0	I32	rw	No	csp pp hm ip	Yes	B	*“4.10.3”*
3722h	00h	Communication function extended setup 1	—	-32768 to 32767	0	I16	rw	No	ALL	Yes	R	—
		● bit 4: External scale position information monitoring function setting for semi-closed control										OI_O
		● bit 5: Command position change saturation function selection										OI_O
		● bit 6: Homing return velocity limit enabled										OI_O
		● bit 7: Over-travel inhibit input detection setting during Z-phase homing return operation										
		● bit 11: LINK establishment mode selection										OI_O
3723h	00h	Communication function extended setup 2	—	-32768 to 32767	16384	I16	rw	No	ALL	Yes	B	—
		● bit 14: Position deviation [command unit] output setup										OI_O
3724h	00h	Communication function extended setup 3	—	-32768 to 32767	14352	I16	rw	No	ALL	Yes	C	—
		● bit 0: EX-OUT1 output status setting at the time of communication interrupted after EtherCAT communication is established										OI_O

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3724h	00h	● bit 5: Latch position detection delay compensation function switching										OI_O
		● bit 7: TFF clear ON/OFF selection from host device										OI_O
		● bit 11: Condition setting for Obj.6041h: bit 12 “drive follows command value”										OI_O
3739h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3740h	00h	Station Alias setup (high)	—	0 to 255	0	I16	rw	No	ALL	Yes	R	OI_O
3741h	00h	Station Alias selection	—	0 to 2	1	I16	rw	No	ALL	Yes	R	
3742h	00h	Maximum continuation communication error	—	-32768 to 32767	-30584	I16	rw	No	ALL	Yes	R	—
		● bits 3 to 0: Err80.7.0 detection threshold										OI_O
3743h	00h	Lost link detection time	ms	0 to 32767	0	I16	rw	No	ALL	Yes	R	OI_O
3744h	00h	Software version	—	-2147483648 to 2147483647	16908546	I32	ro	No	ALL	Yes	X	OI_O
3779h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3780h	00h	Communication function extended setup 8	—	-32768 to 32767	2048	I16	rw	No	ALL	Yes	C	—
		● bit 6: Obj.6041h:00h “Statusword” : bit 12 Expansion setup for “homing attained”										OI_O
3787h	00h	Communication function extended setup 5	—	-32768 to 32767	3072	I16	rw	No	ALL	Yes	C	—
3792h	00h	Correction time of latch delay 2	25 ns	-2000 to 2000	0	I16	rw	No	ALL	Yes	B	OI_O
3793h	00h	Homing return speed limit value	r/min	0 to 20000	0	I16	rw	No	hm	Yes	C	OI_O
3799h	00h	Communication function extended setup 6	—	-32768 to 32767	0	I16	rw	No	ALL	Yes	B	—
		● bit 0: Enable/disable FFT execution while EtherCAT communication is established										OI_O
		● bit 3: Command pulse accumulated value [command unit] output setting										OI_O
37A0h	00h	Reserved	—	—	0	I32	—	—	—	—	—	—
⁝												
37A4h	00h	Reserved	—	—	0	I32	—	—	—	—	—	
37A8h	00h	Reserved	—	—	7	I16	—	—	—	—	—	—
37A9h	00h	Reserved	—	—	1	I16	—	—	—	—	—	—
37B0h	00h	Communication function extended setup 7	—	-2147483648 to 2147483647	384	I32	rw	No	ALL	Yes	B	—
		● bit 7: Err80.7.0 detection function expansion										OI_O
		● bit 8: Err80.3.0 detection function expansion										OI_O
		● bit 12: ERR Indicator off specification expansion										OI_O
37B3h	00h	Torque offset filter	0.01 ms	0 to 6400	0	I16	rw	No	csp pp hm ip csv pv	Yes	B	OI_O
37B7h	00h	Reserved	—	-2147483648～2147483647	0	I32	—	—	—	—	—	—
37C0h	00h	Absolute scale offset1	Rotation (multi-turn data), or pulse (external scale upper 32 bits)	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	R	OI_O
37C1h	00h	Absolute scale offset2	pulse (single-turn data), or pulse (external scale lower 32 bits)	-2147483648 to 2147483647	0	I32	rw	No	ALL	Yes	R	OI_O
37C7h	00h	Reserved	—	—	0	I32	—	—	—	—	—	—

7.1.2.9 Class 8: Special Settings 3

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3800h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3801h	00h	Profile linear acceleration constant	10,000 command units/s^2	1 to 429496	1	I32	rw	No	ALL	Yes	B	OI_O
3802h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3803h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3804h	00h	Profile linear deceleration constant	10,000 command units/s^2	1 to 429496	1	I32	rw	No	ALL	Yes	B	OI_O
3805h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3810h	00h	Reserved	—	—	0	I32	—	—	—	—	—	—
3812h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—
3813h	00h	Reserved	—	—	0	I32	—	—	—	—	—	—
⋮												
3815h	00h	Reserved	—	—	0	I32	—	—	—	—	—	
3817h	00h	Relative movement of retracting operation	Command unit	-2147483647 to 2147483647	0	I32	rw	No	ALL	Yes	B	OI_O
3818h	00h	Retracting operation speed	Command unit/s	0 to 2147483647	0	I32	rw	No	ALL	Yes	B	
3819h	00h	Reserved	—	—	0	I16	—	—	—	—	—	—

7.1.2.10 Class 9: Linear Relationship

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3901h	00h	Feedback scale resolution / Number of scale pulses per rotation	pulse	0 to 536870912	0	I32	rw	No	ALL	Yes	R	OI_O

7.1.2.11 Class 10: Special Settings 4

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3A00h	00h	Reserved	–	–	–	I16	–	–	–	–	–	–
3A01h	00h	Reserved	–	0～4	0	I16	–	–	–	–	–	–

7.1.2.12 Class 11: Manufacturer Use

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
3B00h	00h	Reserved	–	–	1	I16	–	–	–	–	–	–
3B01h	00h	Reserved	–	–	503578880	I32	–	–	–	–	–	–
3B02h	00h	Reserved	–	–	658185	I32	–	–	–	–	–	–
3B03h	00h	Reserved	–	–	-1	I32	–	–	–	–	–	–
⋮												
3B06h	00h	Reserved	–	–	-1	I32	–	–	–	–	–	
3B07h	00h	Reserved	–	–	16	I16	–	–	–	–	–	–
3B08h	00h	Reserved	–	–	6	I16	–	–	–	–	–	–
3B09h	00h	Reserved	–	–	1	I16	–	–	–	–	–	–
3B10h	00h	Reserved	–	–	129	I16	–	–	–	–	–	–
3B11h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
3B12h	00h	Reserved	–	–	0	I32	–	–	–	–	–	–
3B13h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
3B14h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
3B15h	00h	Reserved	–	–	0	I32	–	–	–	–	–	–
3B16h	00h	Reserved	–	–	255	I16	–	–	–	–	–	–
3B17h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
3B18h	00h	Reserved	–	–	0	I32	–	–	–	–	–	–
3B19h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
3B20h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
3B21h	00h	Reserved	–	–	0	I32	–	–	–	–	–	–
3B22h	00h	Reserved	–	–	0	I16	–	–	–	–	–	–
3B23h	00h	Reserved	–	–	0	I32	–	–	–	–	–	–
⋮												
3B26h	00h	Reserved	–	–	0	I32	–	–	–	–	–	

7.1.3 User-specific Area (4000h to 4FFFh)

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
4304h	00h	Touch probe function expansion setup	—	0 to 65535	0	U16	rw	RxPDO	ALL	Yes	B	—
		● bit 0: Touch probe 1 External scale position latch Z-phase switching in semi-closed control										OI_O
		● bit 1: Touch probe 1 Change storage location of external scale feedback position in semi-closed control										
		● bit 8: Touch probe 2 External scale position latch Z-phase switching in semi-closed control										
		● bit 9: Touch probe 2 Change storage location of external scale feedback position in semi-closed control										
4308h	00h	History number	—	0 to 3	0	U8	rw	No	ALL	No	A	OI_O
430Eh	—	Timestamp reference time	—	—	—	—	—	—	—	—	—	
	00h	Number of entries	—	2	—	U8	ro	No	ALL	No	X	
	01h	Timestamp reference time setting 1	ns	0 to 4294967295	0	U32	rw	No	ALL	No	A	
	02h	Timestamp reference time setting 2	ns	0 to 4294967295	0	U32	rw	No	ALL	No	A	
4310h	00h	Alarm main no	—	0 to 127	0	U8	rw	No	ALL	No	A	
4311h	00h	Reserved	—	—	—	U8	—	—	—	—	—	—
4312h	00h	Velocity control loop torque limit	0.1%	0 to 65535	0	U16	rw	RxPDO	ALL	No	A	OI_O
4314h (*1)	00h	Analog input internal offset	mV	-32768 to 32767	0	I16	rw	RxPDO	ALL	Yes	A	OI_O
4315h (*1)	00h	Analog input deviation limit	mV	0 to 65535	0	U16	rw	RxPDO	ALL	Yes	A	
4316h (*1)	—	Analog input voltage setup	—	—	—	—	—	—	—	—	—	
	00h	Number of entries	—	1	—	U8	ro	No	csp	No	X	
	01h	Analog input voltage dead zone	mV	0 to 65535	0	U16	rw	RxPDO	ALL	Yes	B	
4317h	00h	Alarm sub no	—	0 to 127	0	U8	rw	No	ALL	No	A	OI_O
4320h (*5)	00h	Analog monitor output 1	—	-32768 to 32767	0	I16	rw	RxPDO	ALL	No	A	—
4321h (*5)	00h	Analog monitor output 2	—	-32768 to 32767	0	I16	rw	RxPDO	ALL	No	A	—
4351h (*5)	00h	Analog input function	—	0 to 65535	0	U16	rw	RxPDO	csp	Yes	B	—
		● bit 0: Displacement control function switch										OI_O
		● bit 1: Position command latch switch										
4C00h (*1)	—	Analog servo parameters	—	—	—	—	—	—	—	—	—	OI_O
	00h	Number of entries	—	7	—	U8	ro	No	csp	No	B	
	01h	Analog input gain	Command unit/mV	0 to 30000	0	I16	rw	No	csp	Yes	B	
	02h	Analog input polarity	—	0 to 1	0	I16	rw	No	csp	Yes	B	
	03h	Analog input integration time constant	0.01 ms	0 to 100000	0	I32	rw	No	csp	Yes	B	
	04h	Analog input integration limit	Command unit	0 to 2147483647	0	I32	rw	No	csp	Yes	B	
	05h	Analog input (AIN) offset setting	0.375 mV	-26666 to 26666	0	I16	rw	No	ALL	Yes	B	
	06h	Analog input (AIN) filter setting	0.01 ms	0 to 6400	0	I16	rw	No	ALL	Yes	B	
	07h	Analog input (AIN) excessive setting	0.1 V	0 to 100	0	I16	rw	No	ALL	Yes	B	
4D00h	—	Special function start	—	—	—	—	—	—	—	—	—	OI_O
	00h	Number of entries	—	3	—	U8	ro	No	ALL	No	X	
	01h	Special function start flag 1	—	0 to 4294967295	0	U32	rw	No	ALL	No	B	—

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
4D00h	01h	● bit 9: Special function start trigger										OI_O
	02h	Special function start flag 2	—	0 to 4294967295	0	U32	rw	No	ALL	No	B	
	03h	Reserved	—	—	0	U32	rw	—	—	—	—	—
4D01h	00h	Special function setting 9	—	0 to 65535	0	U16	rw	No	ALL	No	B	OI_O
4D0Eh	—	Expansion warning flags	—	—	—	—	—	—	—	—	—	OI_O
	00h	Number of entries	—	3	—	U8	ro	No	ALL	No	X	
	01h	Expansion warning flags 1	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	02h	Expansion warning flags 2	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	03h	Expansion warning flags 3	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4D0Fh	00h	Reserved	—	—	—	U16	—	—	—	—	—	—
4D10h	—	External scale ID	—	—	—	—	—	—	—	—	—	OI_O
	00h	Number of entries	—	2	—	U8	ro	No	ALL	No	X	
	01h	External scale vendor ID	—	—	—	VS	ro	No	ALL	No	X	
	02h	External scale model ID	—	—	—	VS	ro	No	ALL	No	X	
4D11h	—	Reserved	—	—	—	—	—	—	—	—	—	—
	00h	Number of entries	—	13	—	U8	—	—	—	—	—	—
	01h	Reserved 1	—	—	—	U32	—	—	—	—	—	—
	⋮											
	0Dh	Reserved 13	—	—	—	U32	—	—	—	—	—	
4D12h	00h	Motor serial number	—	—	—	VS	ro	No	ALL	No	X	OI_O
4D13h	00h	Reserved	—	—	—	VS	—	—	—	—	—	—
4D14h	00h	Reserved	—	—	—	VS	—	—	—	—	—	—
4D15h	00h	Drive serial number	—	—	—	VS	ro	No	ALL	No	X	OI_O
4D29h	00h	Over load factor	0.1%	0 to 65535	—	U16	ro	TxPDO	ALL	No	X	OI_O
4D35h	—	Reserved	—	—	—	—	—	—	—	—	—	—
	00h	Number of entries	—	2	—	U8	—	—	—	—	—	—
	01h	Reserved 1	—	—	—	U16	—	—	—	—	—	—
	02h	Reserved 2	—	—	—	U16	—	—	—	—	—	—
4D36h	—	Reserved	—	—	—	—	—	—	—	—	—	—
	00h	Number of entries	—	2	—	U8	—	—	—	—	—	—
	01h	Reserved 1	—	—	—	U16	—	—	—	—	—	—
	02h	Reserved 2	—	—	—	U16	—	—	—	—	—	—
4D51h (*2)	00h	Analog input status	—	0 to 65535	—	U16	ro	TxPDO	csp	No	X	OI_O
4D52h	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4D53h	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4D54h	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4D55h	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4D57h	00h	Driver derating monitor	%	0 to 65535	—	U16	ro	TxPDO	ALL	No	X	OI_O
4DA0h (*3)	—	Alarm accessory information	—	—	—	—	—	—	—	—	—	—
	00h	Number of entries	—	71	—	U8	ro	No	ALL	No	X	OI_O
	01h	History number echo	—	0 to 3	—	U8	ro	No	ALL	No	X	
	02h	Alarm code	—	0 to 4294967295	—	U32	ro	No	ALL	No	X	
	03h	Control mode	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
4DA0h (*3)	04h	Motor speed	r/min	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	OI_O
	05h	Positional command velocity	r/min	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	06h	Velocity control command	r/min	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	07h	Torque command	0.05%	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	08h	Position command deviation	Command unit	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	09h	Position actual internal value	pulse	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	0Ah	Reserved 10	–	–	–	I32	–	–	–	–	–	–
	0Bh	Input port (logic signal)	–	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	OI_O
	0Ch	Output port (logic signal)	–	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	0Dh	Analog input	–	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	0Eh	Reserved 14	–	–	–	I32	–	–	–	–	–	–
	0Fh	Reserved 15	–	–	–	I32	–	–	–	–	–	–
	10h	Overload ratio	0.2 %	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	OI_O
	11h	Regenerative load ratio	%	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	12h	Voltage across PN	V	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	13h	Temperature of amplifier	°C	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	14h	Warning flags	–	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	15h	Inertia ratio	%	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	16h	Reserved 22	–	–	–	I32	–	–	–	–	–	–
	⁝											
	18h	Reserved 24	–	–	–	I32	–	–	–	–	–	
	19h	Temperature of encoder	°C	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	OI_O
	1Ah	Reserved 26	–	–	–	I32	–	–	–	–	–	–
	⁝											
	1Ch	Reserved 28	–	–	–	I32	–	–	–	–	–	
	1Dh	U-phase current detection value	–	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	OI_O
	1Eh	W-phase current detection value	–	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	1Fh	Reserved 31	–	–	–	I32	–	–	–	–	–	–
	20h	Reserved 32	–	–	–	I32	–	–	–	–	–	–
	21h	Encoder single-turn data	–	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	OI_O
	22h	Encoder communication error count (accumulated)	Incidences	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	23h	External scale communication data error count (accumulated)	Incidences	-2147483648 to 2147483647	–	I32	ro	No	ALL	No	X	
	24h	Reserved 36	–	–	–	I32	–	–	–	–	–	–
	25h	Alarm occurrence time on timestamp standard (Lower)	ns	0 to 4294967295	–	U32	ro	No	ALL	No	X	OI_O

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
4DA0h (*3)	26h	Alarm occurrence time on timestamp standard (Higher)	ns	0 to 4294967295	—	U32	ro	No	ALL	No	X	OI_O
	27h	Alarm occurrence time on power on time	0.5 h	0 to 4294967295	—	U32	ro	No	ALL	No	X	
	28h	Alarm occurrence time on power on time (detail)	62.5 μs	0 to 4294967295	—	U32	ro	No	ALL	No	X	
	29h	Reserved 41	—	—	—	U32	—	—	—	—	—	—
	2Ah	Alarm code (extended)	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	OI_O
	2Bh	Warning flags1	—	0 to 4294967295	—	U32	ro	No	ALL	No	X	
	2Ch	Warning flags2	—	0 to 4294967295	—	U32	ro	No	ALL	No	X	
	2Dh	Warning flags3	—	0 to 4294967295	—	U32	ro	No	ALL	No	X	
	2Eh	Reserved 46	—	0 to 4294967295	—	U32	ro	No	ALL	No	X	—
	⋮											
	3Dh	Reserved 61	—	0 to 4294967295	—	U32	ro	No	ALL	No	X	
	3Eh	Reserved 62	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	⋮											
	47h	Reserved 71	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4DB0h	—	Reserved	—	—	—	—	—	—	—	—	—	—
	00h	Number of entries	—	8	—	U8	—	—	—	—	—	—
	02h	Reserved 2	—	—	—	U32	—	—	—	—	—	—
	08h	Reserved 8	—	—	—	U32	—	—	—	—	—	—
4F01h	00h	Following error actual value (after filtering)	Command unit	-2147483648 to 2147483647	—	I32	ro	TxPDO	pp hm csp	No	X	OI_O
4F03h (*2)	00h	Analog input internal voltage	mV	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4F04h	00h	Position command internal value (after filtering)	Command unit	-2147483648 to 2147483647	—	I32	ro	TxPDO	pp hm csp	No	X	OI_O
4F0Bh	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4F0Ch	00h	Velocity command value (after filtering)	r/min	-2147483648 to 2147483647	—	I32	ro	TxPDO	pp hm csp	No	X	OI_O
4F0Dh	00h	External scale position	pulse (External scale)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4F11h	00h	Regenerative load ratio	%	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4F21h	00h	Logical input signal	—	0 to 4294967295	—	U32	ro	TxPDO	ALL	No	X	OI_O
4F22h	00h	Logical output signal	—	0 to 4294967295	—	U32	ro	TxPDO	ALL	No	X	
4F23h	00h	Logical input signal (expansion portion)	—	0 to 4294967295	—	U32	ro	TxPDO	ALL	No	X	
4F24h	00h	Reserved	—	—	—	U32	—	—	—	—	—	—
4F25h	00h	Physical input signal	—	0 to 4294967295	—	U32	ro	TxPDO	ALL	No	X	OI_O
4F26h	00h	Physical output signal	—	0 to 4294967295	—	U32	ro	TxPDO	ALL	No	X	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
4F31h	00h	Inertia ratio	%	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4F32h	00h	Motor automatic identification	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	OI_O
4F33h	00h	Cause of motor no work	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F34h	00h	Warning flags	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F36h	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4F37h	—	Multiple alarm/warning information	—	—	—	—	—	—	—	—	—	OI_O
	00h	Number of entries	—	35	—	U8	ro	No	ALL	No	X	
	01h	Multiple alarm information 1	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	02h	Multiple alarm information 2	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	03h	Multiple alarm information 3	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	04h	Multiple alarm information 4	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	05h	Reserved 5	—	—	—	I32	—	—	—	—	—	—
				⋮								
	0Fh	Reserved 15	—	—	—	I32	—	—	—	—	—	
	10h	Multiple sub alarm information	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	OI_O
	11h	Multiple warning information 1	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	12h	Multiple warning information 2	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	13h	Multiple warning information 3	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	14h	Reserved 20	—	—	—	I32	—	—	—	—	—	—
				⋮								
	1Fh	Reserved 31	—	—	—	I32	—	—	—	—	—	
	20h	Multiple alarm cause information 1	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	OI_O
	21h	Multiple alarm cause information 2	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	22h	Multiple alarm cause information 3	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
	23h	Multiple alarm cause information 4	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F41h	—	Motor encoder data	—	—	—	—	—	—	—	—	—	OI_O
	00h	Number of entries	—	2	—	U8	ro	No	ALL	No	X	
	01h	Mechanical angle (Single-turn data)	pulse	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	
	02h	Multi-turn data	Rotation	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	
4F42h	00h	Electrical angle	0.0879°	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F44h	00h	Encoder status	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	OI_O
4F46h	00h	Reserved	—	—	—	U16	—	—	—	—	—	—
4F48h	00h	External scale pulse total	pulse (External scale)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4F49h	00h	External scale absolute position	pulse (External scale)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
4F4Ah	00h	External scale position deviation	pulse (External scale)	-2147483648 to 2147483647	—	I32	ro	TxPDO	pp hm csp	No	X	OI_O
4F4Bh	00h	Touch probe external scale 1 positive edge	pulse (External scale)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4F4Ch	00h	Touch probe external scale 1 negative edge	pulse (External scale)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	
4F4Dh	00h	Touch probe external scale 2 positive edge	pulse (External scale)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	
4F4Eh	00h	Touch probe external scale 2 negative edge	pulse (External scale)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	
4F4Fh (*2)	00h	Analog input value	Command unit	-2147483648 to 2147483647	—	I32	ro	TxPDO	csp	No	X	OI_O
4F51h	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4F53h	00h	Reserved	—	—	—	U32	—	—	—	—	—	—
4F61h	00h	Power on cumulative time	30 minutes	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4F62h	00h	Temperature of amplifier	°C	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F63h	00h	Temperature of encoder	°C	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F64h	00h	Inrush resistance relay operating count	Incidences	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F65h	00h	Dynamic brake operating count	Incidences	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F66h	00h	Fan operating time	30 minutes	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F67h	00h	Fan life expectancy	0.1%	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F68h	00h	Capacitor life expectancy	0.1%	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F6Ah	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4F6Bh	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4F6Ch	00h	Motor power consumption	W	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	OI_O
4F6Dh	00h	Amount of motor power consumption	Wh	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F6Eh	00h	Cumulative value of motor power consumption	Wh	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F72h	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4F73h	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4F74h	00h	Reserved	—	—	—	U16	—	—	—	—	—	—
4F77h	00h	Lost link error count	Incidences	0 to 65535	—	U16	ro	No	ALL	No	X	OI_O
4F78h	00h	Synchronization signal error count	Incidences	0 to 65535	—	U16	ro	No	ALL	No	X	
4F81h	00h	Encoder communication error count (accumulated)	Incidences	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4F82h	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4F83h	00h	External scale communication error count (accumulated)	Incidences	0 to 65535	—	U16	ro	TxPDO	ALL	No	X	OI_O
4F84h	00h	External scale communication data error count (accumulated)	Incidences	0 to 65535	—	U16	ro	TxPDO	ALL	No	X	
4F85h	00h	Reserved	—	—	—	I32	—	—	—	—	—	—

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
4F86h	00h	Hybrid deviation	Command unit	-2147483648 to 2147483647	—	I32	ro	TxPDO	pp hm csp	No	X	OI_O
4F87h	00h	External scale data (Higher)	pulse (External scale)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4F88h	00h	External scale data (Lower)	pulse (External scale)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	
4F89h	00h	External scale status	—	0 to 65535	—	U16	ro	TxPDO	ALL	No	X	OI_O
4F8Ah	00h	External scale Z phase counter	—	0 to 65535	—	U16	ro	No	ALL	No	X	
4F8Ch	00h	External scale single-turn data	pulse	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	
4F91h (*4)	00h	Estimation accuracy of magnetic pole position	Degrees	0 to 180	—	U8	ro	TxPDO	ALL	No	X	
4F92h (*4)	00h	Execution time of estimation of magnetic pole position	ms	0 to 65535	—	U16	ro	TxPDO	ALL	No	X	
4F93h (*4)	00h	Maximum travel distance to plus direction when estimating magnetic pole position	pulse (Feedback scale unit)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	
4F94h (*4)	00h	Maximum travel distance to minus direction when estimating magnetic pole position	pulse (Feedback scale unit)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	
4FA1h	00h	Velocity command value	r/min	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4FA4h	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4FA5h	00h	Velocity internal position command	r/min	-2147483648 to 2147483647	—	I32	ro	TxPDO	pp hm csp	No	X	OI_O
4FA6h	00h	Velocity error actual value	r/min	-2147483648 to 2147483647	—	I32	ro	TxPDO	pp hm csp	No	X	
4FA7h	00h	External scale position (Applied polarity)	pulse (External scale)	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4FA8h	00h	Positive direction torque limit value	0.05%	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4FA9h	00h	Negative direction torque limit value	0.05%	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	
4FABh	00h	Gain switching flag	—	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
4FACh	00h	Reserved	—	—	—	I32	—	—	—	—	—	—
4FAFh	00h	Estimated position for seamless mode change	Command unit	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	—
4FB1h	00h	Deterioration diagnosis state	—	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	OI_O
4FB2h	00h	Deterioration diagnosis torque command average value	0.1%	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4FB3h	00h	Deterioration diagnosis torque command standard value	0.1%	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4FB4h	00h	Deterioration diagnosis inertia ratio estimate value	%	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4FB5h	00h	Deterioration diagnosis offset load estimate value	0.1%	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4FB6h	00h	Deterioration diagnosis dynamic friction estimate value	0.1%	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4FB7h	00h	Deterioration diagnosis viscous friction estimate value	0.1%/ (10000 r/min)	-2147483648 to 2147483647	—	I32	ro	No	ALL	No	X	
4FC2h (*2)	00h	Analog input voltage	mV	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
4FF5h	00h	Reserved	–	–	–	I32	–	TxPDO	–	–	–	–
4FF6h	00h	Reserved	–	–	–	I32	–	–	–	–	–	–
4FF7h	–	Reserved	–	–	–	–	–	–	–	–	–	–
	00h	Number of entries	–	2	–	U8	ro	No	ALL	No	X	–
	01h	Reserved 1	–	–	–	I32	–	–	–	–	–	–
	02h	Reserved 2	–	–	–	I32	–	–	–	–	–	–
4FF8h	–	Reserved	–	–	–	–	–	–	–	–	–	–
	00h	Number of entries	–	2	–	U8	ro	No	ALL	No	X	–
	01h	Reserved 1	–	–	–	I32	–	–	–	–	–	–
	02h	Reserved 2	–	–	–	I32	–	–	–	–	–	–
4FFDh	00h	Reserved	–	–	–	I32	–	–	–	–	–	–
4FFFh	00h	Target position echo	Command unit	-2147483648 to 2147483647	–	I32	ro	TxPDO	ALL	No	X	OI_O

*1 Cannot be used with the standard type or multi-function type. Do not change the factory default value.

*2 Cannot be used with the standard type or multi-function type.

*3 Obj.4DA0h: “Alarm accessory information” is not compatible with PDO.

Each sub-index of Obj.4DA0h is read by SDO, so synchronism cannot be guaranteed.

*4 Cannot be used with the standard type, multi-function type, or application specialized type.

*5 Cannot be used with the standard type or multi-function type. Do not change the initial value.

7.1.4 Drive Profile Area (6000h to 6FFFh)

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
6007h	00h	Abort connection option code	–	0 to 3	1	I16	rw	No	ALL	Yes	A	OI_O
603Fh	00h	Error code	–	0 to 65535	–	U16	ro	TxPDO	ALL	No	X	OI_O TR_CS
6040h	00h	Controlword	–	0 to 65535	0	U16	rw	RxPDO	ALL	No	A	OI_O
		● bit 0: switch on										OI_O
		● bit 1: enable voltage										
		● bit 2: quick stop										
		● bit 3: enable operation										
		● bit 4: operation mode specific (control mode dependent bit)										OI_O
		● bit 5: operation mode specific (control mode dependent bit)										OI_O
		● bit 6: operation mode specific (control mode dependent bit)										
		● bit 7: fault reset										OI_O
		● bit 8: halt										
		● bit 9: operation mode specific (control mode dependent bit)										OI_O
6041h	00h	Statusword	–	0 to 65535	–	U16	ro	TxPDO	ALL	No	X	OI_O
		● bit 0: ready to switch on										OI_O
		● bit 1: switched on										
		● bit 2: operation enabled										
		● bit 3: fault										
		● bit 4: voltage enabled										
		● bit 5: quick stop										
		● bit 6: switch on disabled										
		● bit 7: warning										
		● bit 9: remote										
		● bit 10: operation mode specific (control mode dependent bit)										OI_O
		● bit 11: internal limit active										OI_O
		● bit 12: operation mode specific (control mode dependent bit)										OI_O
		● bit 13: operation mode specific (control mode dependent bit)										OI_O
605Ah	00h	Quick stop option code	–	-2 to 7	2	I16	rw	No	ALL	Yes	A	OI_O
605Bh	00h	Shutdown option code	–	0 to 1	1	I16	rw	No	ALL	Yes	A	OI_O
605Ch	00h	Disable operation option code	–	0 to 1	1	I16	rw	No	ALL	Yes	A	OI_O
605Dh	00h	Halt option code	–	-1 to 3	1	I16	rw	No	ALL	Yes	A	OI_O
605Eh	00h	Fault reaction option code	–	0 to 2	2	I16	rw	No	ALL	Yes	A	OI_O
6060h	00h	Modes of operation	–	-128 to 127	0	I8	rw	RxPDO	ALL	Yes	A	OI_O
6061h	00h	Modes of operation display	–	-128 to 127	–	I8	ro	TxPDO	ALL	No	X	OI_O
6062h	00h	Position demand value	Command unit	-2147483648 to 2147483647	–	I32	ro	TxPDO	pp hm ip csp	No	X	OI_O
6063h	00h	Position actual internal value	pulse	-2147483648 to 2147483647	–	I32	ro	TxPDO	ALL	No	X	OI_O
6064h	00h	Position actual value	Command unit	-2147483648 to 2147483647	–	I32	ro	TxPDO	ALL	No	X	
6065h	00h	Following error window	Command unit	0 to 4294967295	100000	U32	rw	RxPDO	pp csp	Yes	A	OI_O
6066h	00h	Following error time out	ms	0 to 65535	0	U16	rw	RxPDO	pp csp	Yes	A	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
6067h	00h	Position window	Command unit	0 to 4294967295	10	U32	rw	RxPDO	pp ip	Yes	A	OI_O
6068h	00h	Position window time	ms	0 to 65535	0	U16	rw	RxPDO	pp ip	Yes	A	
6069h	00h	Velocity sensor actual value	—	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
606Ah	00h	Sensor selection code	—	-32768 to 32767	0	I16	rw	RxPDO	pv	No	X	OI_O
606Bh	00h	Velocity demand value	Command unit/s	-2147483648 to 2147483647	—	I32	ro	TxPDO	pv csv	No	X	OI_O
606Ch	00h	Velocity actual value	Command unit/s	-2147483648 to 2147483647	—	I32	ro	TxPDO	ALL	No	X	OI_O
606Dh	00h	Velocity window	Command unit/s	0 to 65535	52429	U16	rw	RxPDO	pv	Yes	A	OI_O
606Eh	00h	Velocity window time	ms	0 to 65535	0	U16	rw	RxPDO	pv	Yes	A	
606Fh	00h	Velocity threshold	Command unit/s	0 to 65535	52429	U16	rw	RxPDO	pv	Yes	A	
6070h	00h	Velocity threshold time	ms	0 to 65535	0	U16	rw	RxPDO	pv	Yes	A	
6071h	00h	Target torque	0.1%	-32768 to 32767	0	I16	rw	RxPDO	tq cst	Yes	A	OI_O
6072h	00h	Max torque	0.1%	0 to 65535	5000	U16	rw	RxPDO	ALL	Yes	A	OI_O
6073h	00h	Max current	0.1%	0 to 65535	0	U16	rw	No	tq	No	X	OI_O
6074h	00h	Torque demand	0.1%	-32768 to 32767	—	I16	ro	TxPDO	ALL	No	X	OI_O
6075h	00h	Motor rated current	mA	0 to 4294967295	0	U32	rw	No	ALL	No	X	OI_O
6076h	00h	Motor rated torque	mN･m	0 to 4294967295	—	U32	ro	No	ALL	No	X	OI_O
6077h	00h	Torque actual value	0.1%	-32768 to 32767	—	I16	ro	TxPDO	ALL	No	X	
6078h	00h	Current actual value	0.1%	-32768 to 32767	—	I16	ro	TxPDO	ALL	No	X	OI_O
6079h	00h	DC link circuit voltage	mV	0 to 4294967295	—	U32	ro	TxPDO	ALL	No	X	
607Ah	00h	Target position	Command unit	-2147483648 to 2147483647	0	I32	rw	RxPDO	pp csp	No	A	OI_O
607Bh	—	Position range limit	—	—	—	—	—	—	ALL	—	—	OI_O
	00h	Highest sub-index supported	—	2	—	U8	ro	No	ALL	No	X	
	01h	Min position range limit	Command unit	-2147483648 to 2147483647	-2147483648	I32	rw	RxPDO	ALL	Yes	X	
	02h	Max position range limit	Command unit	-2147483648 to 2147483647	2147483647	I32	rw	RxPDO	ALL	Yes	X	
607Ch	00h	Home offset	Command unit	-2147483648 to 2147483647	0	I32	rw	RxPDO	ALL	Yes	P, H	OI_O
607Dh	—	Software position limit	—	—	—	—	—	—	pp ip csp	—	—	OI_O
	00h	Number of entries	—	2	—	U8	ro	No	pp ip csp	No	X	
	01h	Min position limit	Command unit	-2147483648 to 2147483647	0	I32	rw	RxPDO	pp ip csp	Yes	P, H	
	02h	Max position limit	Command unit	-2147483648 to 2147483647	0	I32	rw	RxPDO	pp ip csp	Yes	P, H	
607Eh	00h	Polarity	—	0 to 255	0	U8	rw	No	ALL	Yes	P, H	—
		● bit 5: Torque polarity										OI_O
		● bit 6: Speed polarity										

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
607Eh	00h	- bit 7: Position polarity										OI_O
607Fh	00h	Max profile velocity	Command unit/s	0 to 4294967295	999642454	U32	rw	RxPDO	pp hm ip pv	Yes	B	OI_O
6080h	00h	Max motor speed	r/min	0 to 4294967295	7150	U32	rw	RxPDO	ALL	Yes	B	OI_O
6081h	00h	Profile velocity	Command unit/s	0 to 4294967295	0	U32	rw	RxPDO	pp ip	Yes	A	OI_O
6082h	00h	End velocity	Command unit/s	0 to 4294967295	0	U32	rw	RxPDO	pp ip	Yes	X	
6083h	00h	Profile acceleration	Command unit/s^2	0 to 4294967295	4194304000	U32	rw	RxPDO	pp pv ip	Yes	A	OI_O
6084h	00h	Profile deceleration	Command unit/s^2	0 to 4294967295	4194304000	U32	rw	RxPDO	pp pv ip csp csv	Yes	A	OI_O
6085h	00h	Quick stop deceleration	Command unit/s^2	0 to 4294967295	4194304000	U32	rw	RxPDO	pp pv hm ip csp csv	Yes	A	OI_O
6086h	00h	Motion profile type	—	-32768 to 32767	0	I16	rw	RxPDO	pp pv ip	Yes	A	OI_O
6087h	00h	Torque slope	0.1%/s	0 to 4294967295	1000	U32	rw	RxPDO	tq cst	Yes	A	OI_O
6088h	00h	Torque profile type	—	-32768 to 32767	0	I16	rw	RxPDO	tq	Yes	A	OI_O
608Fh	—	Position encoder resolution	—	—	—	—	—	—	ALL	—	—	OI_O
	00h	Highest sub-index supported	—	2	—	U8	ro	No	ALL	No	X	
	01h	Encoder increments	pulse	1 to 4294967295	—	U32	ro	No	ALL	No	X	
	02h	Motor revolutions	r (motor)	1 to 4294967295	—	U32	ro	No	ALL	No	X	
6091h	—	Gear ratio	—	—	—	—	—	—	ALL	—	—	
	00h	Number of entries	—	2	—	U8	ro	No	ALL	No	X	
	01h	Motor revolutions	r (motor)	1 to 4294967295	1	U32	rw	No	ALL	Yes	P, H	
	02h	Shaft revolutions	r (shaft)	1 to 4294967295	1	U32	rw	No	ALL	Yes	P, H	
6092h	—	Feed constant	—	—	—	—	—	—	ALL	—		
	00h	Highest sub-index supported	—	2	—	U8	ro	No	ALL	No	X	
	01h	Feed	Command unit	1 to 4294967295	8388608	U32	rw	No	ALL	Yes	P, H	
	02h	Shaft revolutions	r (shaft)	1 to 4294967295	1	U32	rw	No	ALL	Yes	P, H	
6098h	00h	Homing method	—	-128 to 127	0	I8	rw	RxPDO	hm	Yes	B	OI_O
6099h	—	Homing speeds	—	—	—	—	—	—	hm	—	—	OI_O
	00h	Number of entries	—	2	—	U8	ro	No	hm	No	X	
	01h	Speed during search for switch	Command unit/s	0 to 4294967295	873813	U32	rw	RxPDO	hm	Yes	A	
	02h	Speed during search for zero	Command unit/s	0 to 4294967295	87381	U32	rw	RxPDO	hm	Yes	A	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
609Ah	00h	Homing acceleration	Command unit/s^2	0 to 4294967295	4194304000	U32	rw	RxPDO	hm	Yes	A	OI_O
60A3h	00h	Profile jerk use	–	1 to 2, 255	1	U8	rw	No	pp pv ip	Yes	A	OI_O
60A4h	–	Profile jerk	–	–	–	–	–	–	pp pv ip	–	–	
	00h	Highest sub-index supported	–	2	–	U8	ro	No	pp pv ip	No	X	
	01h	Profile jerk1	Command unit/s^3	0 to 4294967295	0	U32	rw	No	pp pv ip	Yes	A	
	02h	Profile jerk2	Command unit/s^3	0 to 4294967295	0	U32	rw	No	pp pv ip	Yes	A	
60B0h	00h	Position offset	Command unit	-2147483648 to 2147483647	0	I32	rw	RxPDO	csp	Yes	A	OI_O
60B1h	00h	Velocity offset	Command unit/s	-2147483648 to 2147483647	0	I32	rw	RxPDO	pp pv hm ip csp csv	Yes	A	OI_O
60B2h	00h	Torque offset	0.1%	-32768 to 32767	0	I16	rw	RxPDO	ALL	Yes	A	OI_O
60B8h	00h	Touch probe function	–	0 to 65535	0	U16	rw	RxPDO	ALL	No	A	–
		● bit 0: Touch Probe 1 execute, stop										OI_O
		● bit 1: Touch Probe 1 event mode selection										
		● bit 2: Touch Probe 1 trigger selection (external input, Z-phase)										
		● bit 4: Touch Probe 1 rising edge selection										
		● bit 5: Touch Probe 1 falling edge selection										
		● bit 8: Touch Probe 2 execute, stop										
		● bit 9: Touch Probe 2 event mode selection (single, continuous)										
		● bit 10: Touch Probe 2 trigger selection (external input, Z-phase)										
		● bit 12: Touch Probe 2 rising edge selection										
		● bit 13: Touch Probe 2 falling edge selection										
		● bit 15: External scale monitor value 0 clear enable, disable										
60B9h	00h	Touch probe status	–	0 to 65535	–	U16	ro	TxPDO	ALL	No	X	OI_O
60BAh	00h	Touch probe 1 positive edge	Command unit	-2147483648 to 2147483647	–	I32	ro	TxPDO	ALL	No	X	OI_O
60BBh	00h	Touch probe 1 negative edge	Command unit	-2147483648 to 2147483647	–	I32	ro	TxPDO	ALL	No	X	
60BCh	00h	Touch probe 2 positive edge	Command unit	-2147483648 to 2147483647	–	I32	ro	TxPDO	ALL	No	X	
60BDh	00h	Touch probe 2 negative edge	Command unit	-2147483648 to 2147483647	–	I32	ro	TxPDO	ALL	No	X	
60C2h	–	Interpolation time period	–	–	–	–	–	–	ip csp csv cst	–	–	OI_O
	00h	Highest sub-index supported	–	2	–	U8	ro	No	ip csp csv cst	No	X	

Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
60C2h	01h	Interpolation time period value	—	0 to 255	1	U8	rw	No	ip csp csv cst	Yes	A	OI_O
	02h	Interpolation time index	—	-128 to 63	-3	I8	rw	No	ip csp csv cst	Yes	A	
60C5h	00h	Max acceleration	Command unit/s^2	0 to 4294967295	4294967295	U32	rw	RxPDO	pp hm pv ip	Yes	A	OI_O
60C6h	00h	Max deceleration	Command unit/s^2	0 to 4294967295	4294967295	U32	rw	RxPDO	pp hm pv ip	Yes	A	OI_O
60E0h	00h	Positive torque limit value	0.1%	0 to 65535	5000	U16	rw	RxPDO	ALL	Yes	A	OI_O
60E1h	00h	Negative torque limit value	0.1%	0 to 65535	5000	U16	rw	RxPDO	ALL	Yes	A	
60E3h	—	Supported homing methods	—	—	—	—	—	—	ALL	—	—	OI_O
	00h	Number of entries	—	32	—	U8	ro	No	ALL	No	X	
	01h	1st supported homing method	—	-128 to 127	—	I8	ro	No	ALL	No	X	
				⋮								
	20h	32nd supported homing method	—	-128 to 127	—	I8	ro	No	ALL	No	X	
60F2h	00h	Position option code	—	0 to 65535	0	U16	rw	RxPDO	pp	Yes	A	—
		● bits 1 to 0: relative option										OI_O
		● bits 3 to 2: change immediately option										
		● bits 5 to 4: request-response option										
		● bit 15: manufacturer-specific										
60F4h	00h	Following error actual value	Command unit	-2147483648 to 2147483647	—	I32	ro	TxPDO	pp hm ip csp	No	X	OI_O
60FAh	00h	Control effort	Command unit/s	-2147483648 to 2147483647	—	I32	ro	TxPDO	pp hm ip csp	No	X	OI_O
60FCh	00h	Position demand internal value	pulse	-2147483648 to 2147483647	—	I32	ro	TxPDO	pp hm ip csp	No	X	OI_O
60FDh	00h	Digital inputs	—	0 to 4294967295	—	U32	ro	TxPDO	ALL	No	X	OI_O
60FEh	—	Digital outputs	—	—	—	—	—	—	ALL	—	—	—
		● bit 0: set brake										OI_O
		● bit 16: EX-OUT1										
		● bit 19: vel-loop torque limit										
		● bit 20: vel-loop integral clear										
		● bit 28: Timestamp reference time reset										
	00h	Number of entries	—	2	—	U8	ro	No	ALL	No	X	
	01h	Physical outputs	—	0 to 4294967295	0	U32	rw	RxPDO	ALL	Yes	A	
	02h	Bit mask	—	0 to 4294967295	0	U32	rw	RxPDO	ALL	Yes	A	

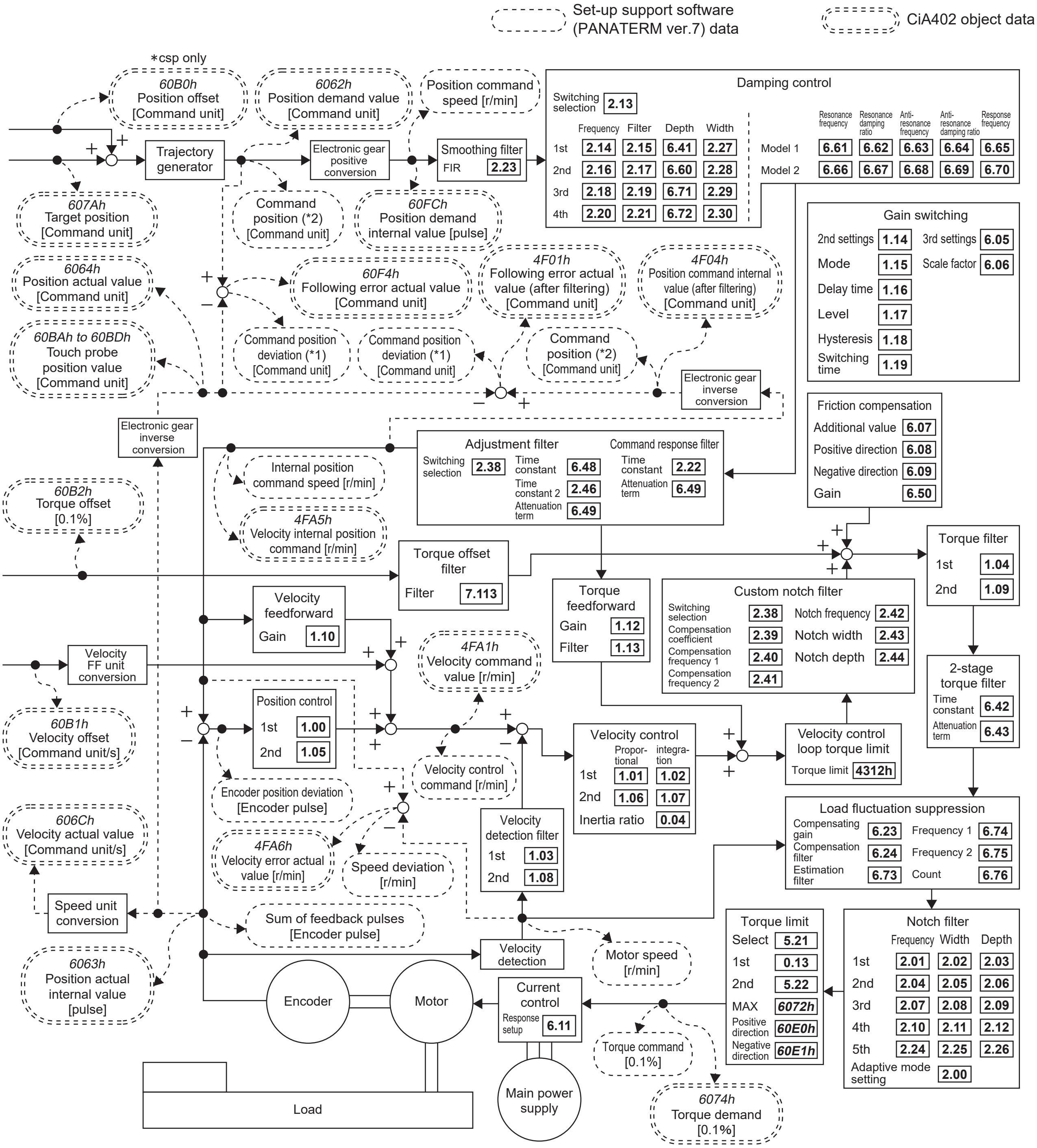
Index	Sub-Index	Name	Units	Range	Initial value	Data type	Access	PDO	Op-mode	EEPROM	Attribute	Reference
60FFh	00h	Target velocity	Command unit/s	-2147483648 to 2147483647	0	I32	rw	RxPDO	pv csv	No	A	OI_O
6403h	00h	Motor catalogue number	—	—	—	VS	ro	No	ALL	No	X	OI_O
6502h	00h	Supported drive modes	—	0 to 4294967295	—	U32	ro	TxPDO	ALL	No	X	OI_O

7.2 Control Mode Block Diagram

Block diagrams of each control mode including the various control functions are shown below.

7.2.1 Position Control Mode Block Diagram

Control block diagram: Position control (when two-degree-of-freedom control mode is enabled)



*1 Methods (criteria) for calculating position deviation on Set-up Support Software (PANATERM ver.7) and on an analog monitor will vary depending on the setting for Pr7.23 “Communication function extended setup 2” :bit 14 “Command position deviation output switching” . For details, see “When switching analog monitor output signal types” in Operating Instructions (Overall) “3.2.8 Wiring to Connector X7 (Connecting to External Monitor)” .

*2 Position commands in Set-up Support Software (PANATERM ver.7) depend on Pr7.99 “Communication function extended setup 6” :bit 3 “Command pulse accumulated value [command unit] output setting” settings.

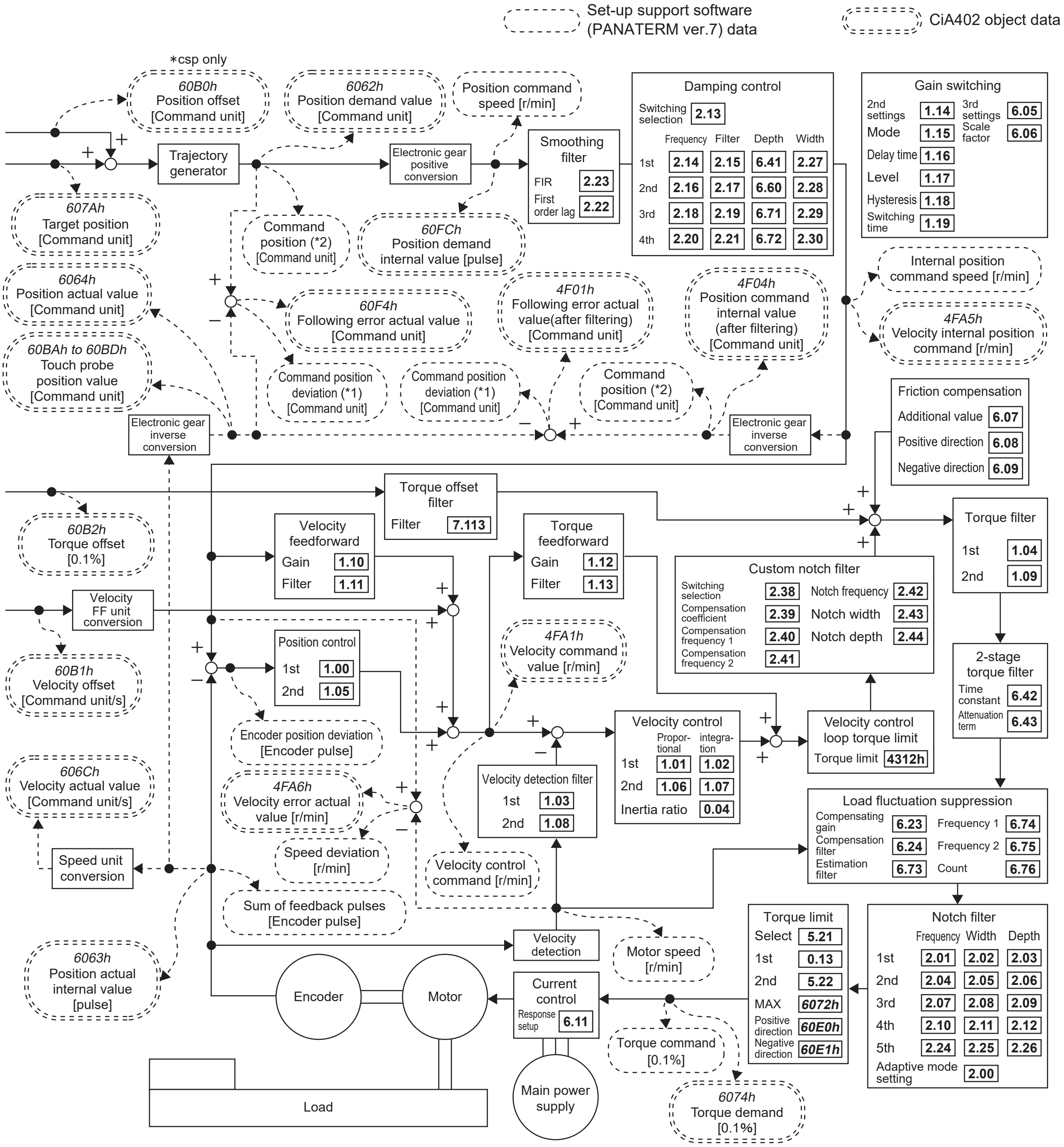
*3 When executing a trial run, Z-phase search, or frequency characteristics (position loop characteristics) from Set-up Support Software (PANATERM ver.7) , the driver switches to position control internally.

* Numbers in italics (e.g., *607Ah*) represent EtherCAT object numbers.

* Numbers in bold (e.g., **1.00**) represent servo parameter numbers.

* Some objects such as polarity are omitted.

Control block diagram: Position control (when two-degree-of-freedom control mode is disabled)



*1 Methods (criteria) for calculating position deviation on Set-up Support Software (PANATERM ver.7) and on an analog monitor will vary depending on the setting for Pr7.23 “Communication function extended setup 2” :bit 14 “Command position deviation output switching” . For details, see “When switching analog monitor output signal types” in Operating Instructions (Overall) “3.2.8 Wiring to Connector X7 (Connecting to External Monitor)” .

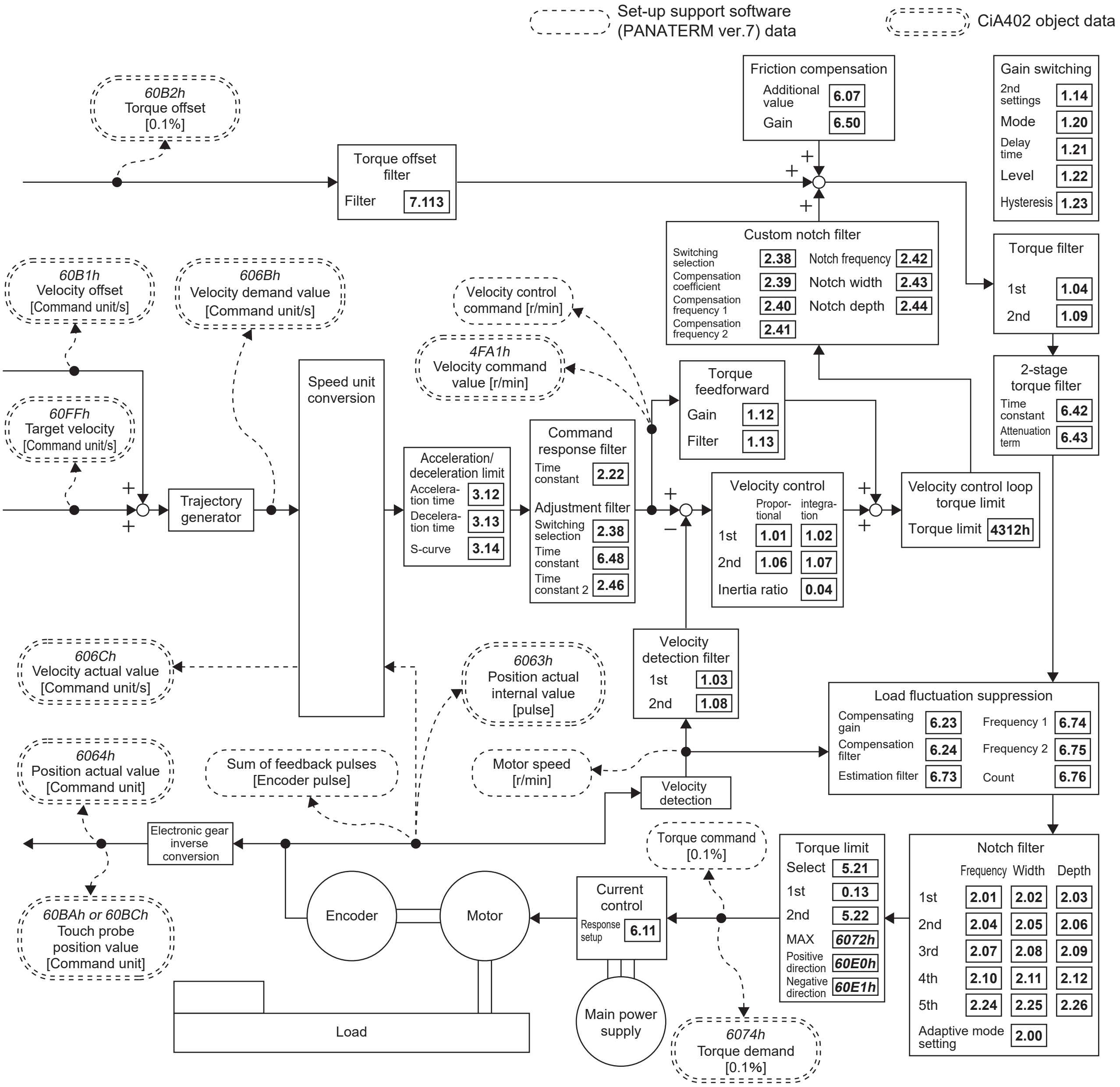
*2 Position commands in Set-up Support Software (PANATERM ver.7) depend on Pr7.99 “Communication function extended setup 6” :bit 3 “Command pulse accumulated value [command unit] output setting” settings.

*3 When executing frequency characteristics (velocity closed-loop characteristics analysis, torque speed (vertical)) from Set-up Support Software (PANATERM ver.7) , the driver switches to velocity control internally.

- * Numbers in italics (e.g., *607Ah*) represent EtherCAT object numbers.
- * Numbers in bold (e.g., **1.00**) represent servo parameter numbers.
- * Some objects such as polarity are omitted.

7.2.2 Speed Control Mode Block Diagram

Control block diagram: Velocity control (when two-degree-of-freedom control mode is enabled)



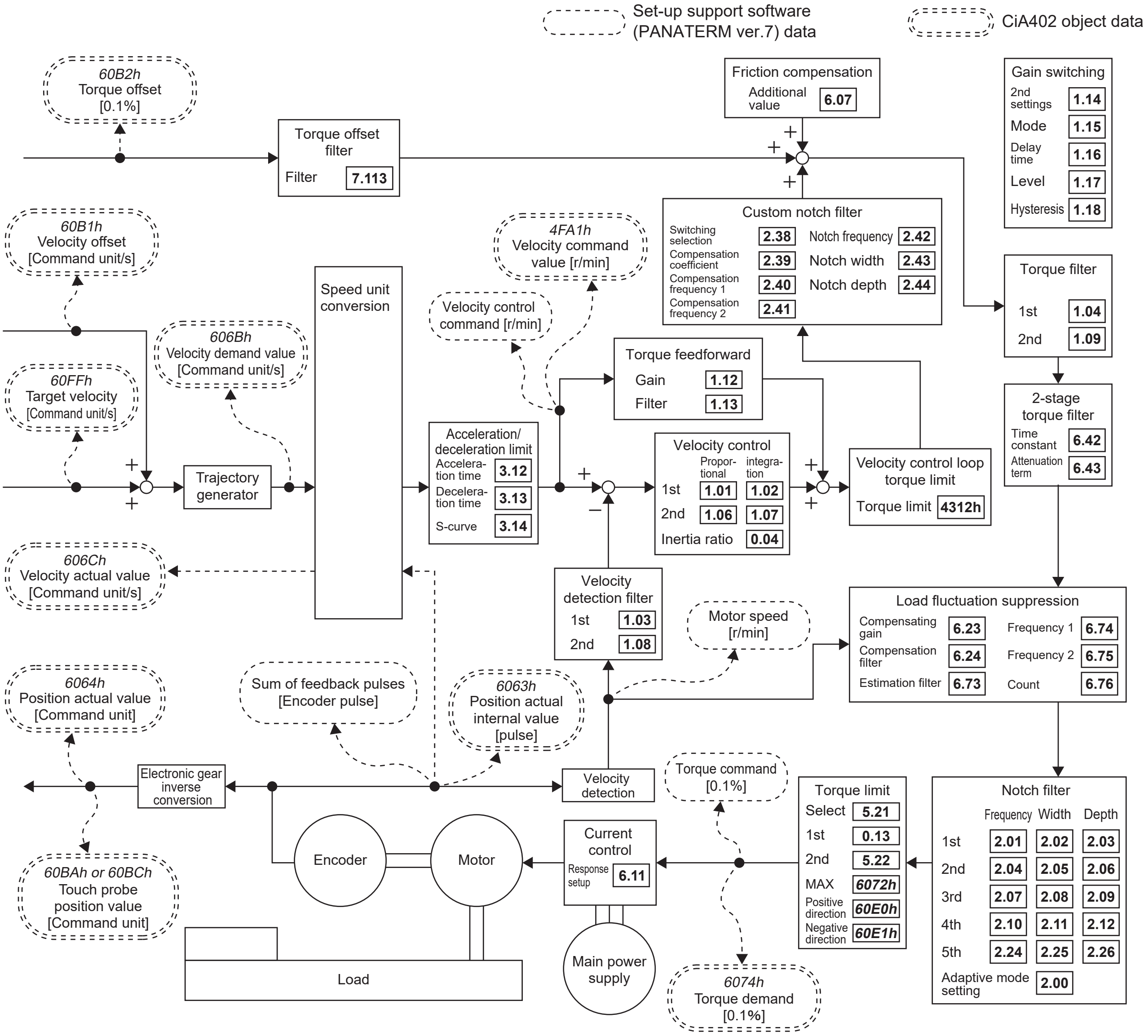
*1 When executing a trial run, Z-phase search, or frequency characteristics (position loop characteristics) from Set-up Support Software (PANATERM ver.7) , the driver switches to position control internally.

* Numbers in italics (e.g., *607Ah*) represent EtherCAT object numbers.

* Numbers in bold (e.g., **1.00**) represent servo parameter numbers.

* Some objects such as polarity are omitted.

Control block diagram: Velocity control (when two-degree-of-freedom control mode is disabled)

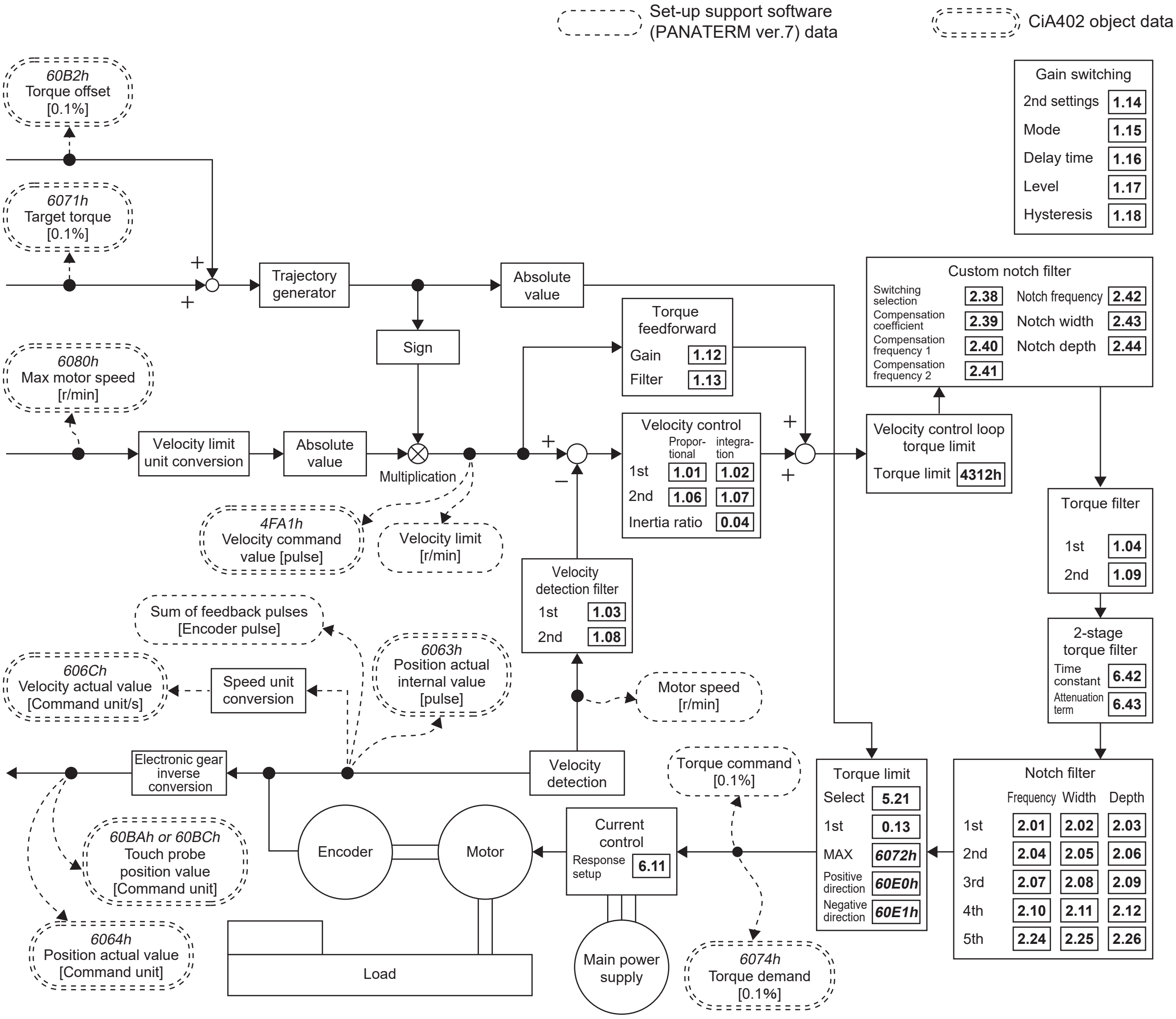


*1 When executing frequency characteristics (velocity closed-loop characteristics analysis, torque speed (vertical)) from Set-up Support Software (PANATERM ver.7) , the driver switches to velocity control internally.

- * Numbers in italics (e.g., *607Ah*) represent EtherCAT object numbers.
- * Numbers in bold (e.g., **1.00**) represent servo parameter numbers.
- * Some objects such as polarity are omitted.

7.2.3 Torque Control Mode Block Diagram

Control block diagram: Torque control

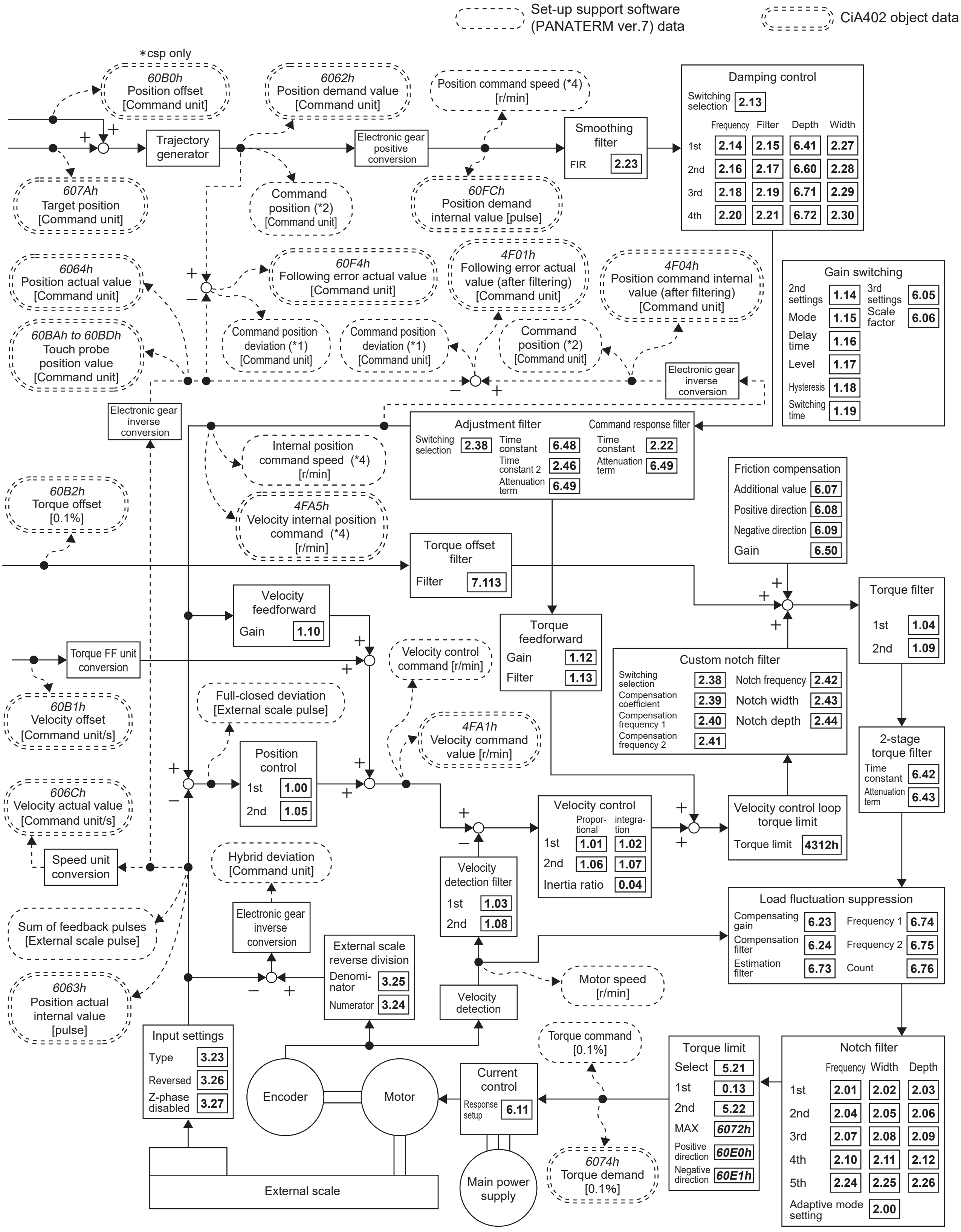


*1 When executing frequency characteristics (torque speed (normal)) from Set-up Support Software (PANATERM ver.7) , the driver switches to velocity control internally.

- * Numbers in italics (e.g., *607Ah*) represent EtherCAT object numbers.
- * Numbers in bold (e.g., **1.00**) represent servo parameter numbers.
- * Some objects such as polarity are omitted.

7.2.4 Full-closed Control Mode Block Diagram

Control block diagram: Full-closed control (when two-degree-of-freedom control mode is enabled)



*1 Methods (criteria) for calculating position deviation on Set-up Support Software (PANATERM ver.7) and on an analog monitor will vary depending on the setting for Pr7.23 “Communication function extended setup 2” :bit 14 “Command position deviation output switching” . For details, see “When switching analog monitor output signal types” in Operating Instructions (Overall) “3.2.8 Wiring to Connector X7 (Connecting to External Monitor)” .

*2 Position commands in Set-up Support Software (PANATERM ver.7) depend on Pr7.99 “Communication function extended setup 6” :bit 3 “Command pulse accumulated value [command unit] output setting” settings.

*3 When executing a trial run, Z-phase search, or frequency characteristics (position loop characteristics) from Set-up Support Software (PANATERM ver.7) , the driver switches to position control internally.

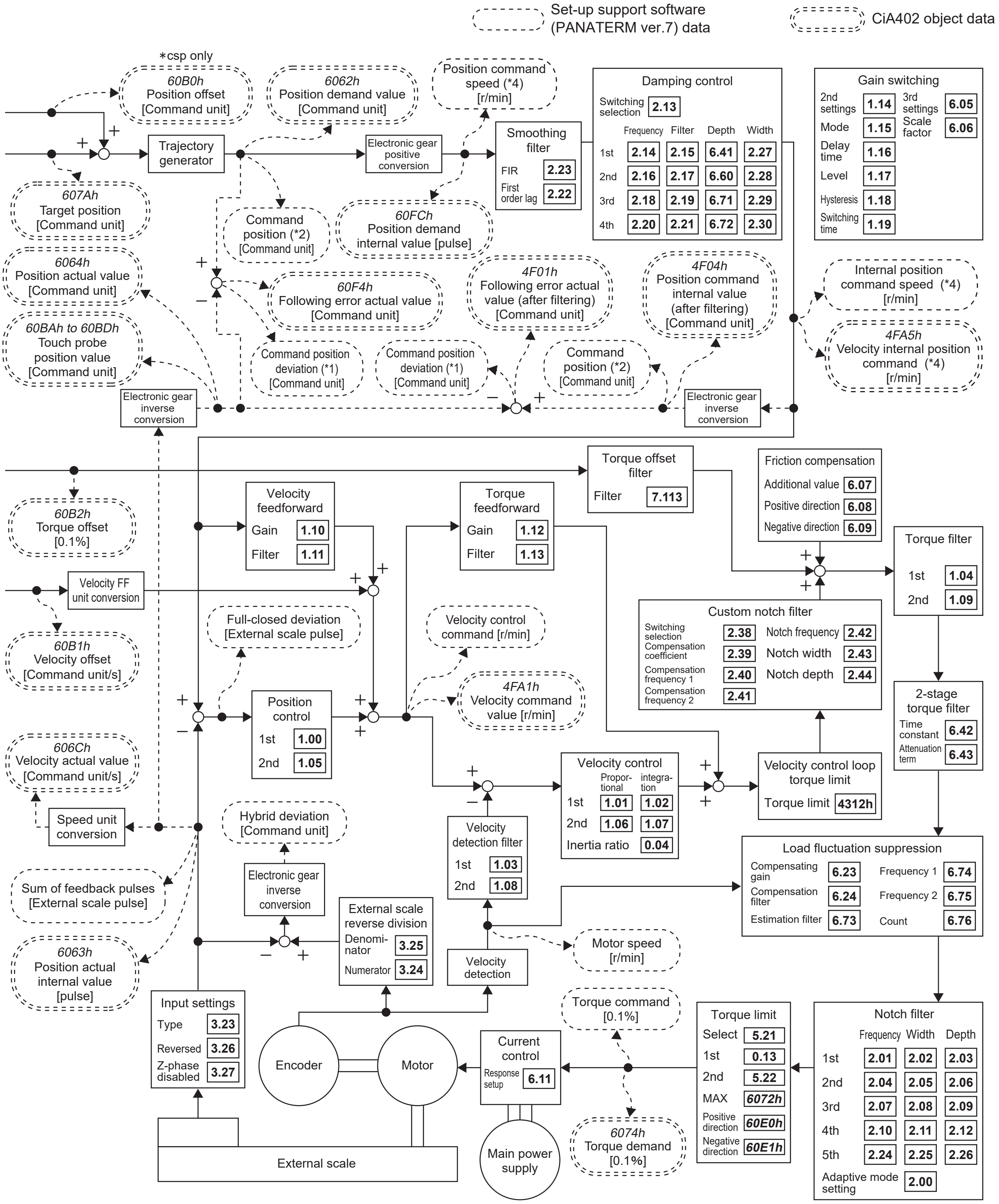
*4 Velocity [r/min] unit calculated from encoder, not external scale.

* Numbers in italics (e.g., *607Ah*) represent EtherCAT object numbers.

* Numbers in bold (e.g., **1.00**) represent servo parameter numbers.

* Some objects such as polarity are omitted.

Control block diagram: Full-closed control (when two-degree-of-freedom control mode is disabled)



*1 Position deviation [command unit] operation criteria in Set-up Support Software (PANATERM ver.7) can be changed with Pr7.23 “Communication function extended setup 2” :bit 14.

*2 Position commands in Set-up Support Software (PANATERM ver.7) depend on Pr7.99 “Communication function extended setup 6” :bit 3 “Command pulse accumulated value [command unit] output setting” settings.

*3 When executing a trial run, Z-phase search, or frequency characteristics (position loop characteristics) from Set-up Support Software (PANATERM ver.7) , the driver switches to position control internally.

*4 Velocity [r/min] unit calculated from encoder, not external scale.

* Numbers in italics (e.g., *607Ah*) represent EtherCAT object numbers.

* Numbers in bold (e.g., **1.00**) represent servo parameter numbers.

* Some objects such as polarity are omitted.

7.3 Parameters Related To TUNINGLESS

- Pr0.02 “Real-time auto-gain tuning setup”
- Pr0.03 “Real-time auto-tuning machine stiffness setup”
- Pr0.04 “Inertia ratio”
- Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2”
- Pr0.28 “Selection of feed forward stiffness at real-time auto-gain tuning”
- Pr1.00 “1st gain of position loop”
- Pr1.01 “1st velocity loop gain”
- Pr1.02 “1st velocity loop integration time constant”
- Pr1.03 “1st filter of velocity detection”
- Pr1.04 “1st torque filter time constant”
- Pr1.10 “Velocity feed forward gain”
- Pr1.11 “Velocity feed forward filter”
- Pr1.12 “Torque feed forward gain”
- Pr1.13 “Torque feed forward filter”
- Pr1.14 “2nd gain setup”
- Pr2.00 “Adaptive filter mode setup”
- Pr2.01 “1st notch frequency”
- Pr2.02 “1st notch width selection”
- Pr2.03 “1st notch depth selection”
- Pr2.04 “2nd notch frequency”
- Pr2.05 “2nd notch width selection”
- Pr2.06 “2nd notch depth selection”
- Pr2.07 “3rd notch frequency”
- Pr2.08 “3rd notch width selection”
- Pr2.09 “3rd notch depth selection”
- Pr2.10 “4th notch frequency”
- Pr2.11 “4th notch width selection”
- Pr2.12 “4th notch depth selection”
- Pr2.13 “Selection of damping filter switching”
- Pr2.14 “1st damping frequency”
- Pr2.15 “1st damping filter setup”
- Pr2.16 “2nd damping frequency”
- Pr2.17 “2nd damping filter setup”
- Pr2.18 “3rd damping frequency”
- Pr2.19 “3rd damping filter setup”
- Pr2.20 “4th damping frequency”
- Pr2.21 “4th damping filter setup”
- Pr2.22 “Positional command smoothing filter”
- Pr2.23 “Positional command FIR filter”
- Pr2.24 “5th notch frequency”
- Pr2.25 “5th notch width selection”

- Pr2.26 “5th notch depth selection”
- Pr2.27 “1st damping width setting”
- Pr2.28 “2nd damping width setting”
- Pr2.29 “3rd damping width setting”
- Pr2.30 “4th damping width setting”
- Pr2.38 “Filter function switching”
- Pr2.39 “Custom notch compensation coefficient”
- Pr2.40 “Custom notch compensation frequency 1”
- Pr2.41 “Custom notch compensation frequency 2”
- Pr2.42 “Custom notch frequency”
- Pr2.43 “Custom notch width”
- Pr2.44 “Custom notch depth”
- Pr2.45 “Function expansion setup 10”
- Pr2.46 “Tuning filter 2”
- Pr2.52 “Torque command additional value 2”
- Pr2.53 “Positive direction torque compensation value 2”
- Pr2.54 “Negative direction torque compensation value 2”
- Pr5.45 “Quadrant glitch positive-direction compensation value”
- Pr5.46 “Quadrant glitch negative-direction compensation value”
- Pr6.05 “Position 3rd gain valid time”
- Pr6.06 “Position 3rd gain scale factor”
- Pr6.07 “Torque command additional value”
- Pr6.08 “Positive direction torque compensation value”
- Pr6.09 “Negative direction torque compensation value”
- Pr6.10 “Function expansion setup”
- Pr6.11 “Current loop gain response setup”
- Pr6.23 “Load change compensation gain”
- Pr6.24 “Load change compensation filter”
- Pr6.32 “Real time auto tuning custom setup”
- Pr6.41 “1st damping depth”
- Pr6.42 “2-stage torque filter time constant”
- Pr6.43 “2-stage torque filter attenuation term”
- Pr6.47 “Function expansion setup 2”
- Pr6.50 “Viscous friction compensating gain”
- Pr6.60 “2nd damping depth”
- Pr6.71 “3rd damping depth”
- Pr6.72 “4th damping depth”
- Pr6.73 “Load estimation filter”
- Pr6.74 “Torque compensation frequency 1”
- Pr6.75 “Torque compensation frequency 2”
- Pr6.76 “Load estimation count”
- Pr6.121 “Current feed forward response setup”

7.4 Parameters Related To One Minute TUNING

- Pr0.02 “Real-time auto-gain tuning setup”
- Pr0.04 “Inertia ratio”
- Pr0.27 “Selection of machine stiffness at real-time auto-gain tuning 2”
- Pr0.28 “Selection of feed forward stiffness at real-time auto-gain tuning”
- Pr1.00 “1st gain of position loop”
- Pr1.01 “1st velocity loop gain”
- Pr1.02 “1st velocity loop integration time constant”
- Pr1.03 “1st filter of velocity detection”
- Pr1.04 “1st torque filter time constant”
- Pr1.05 “2nd gain of position loop”
- Pr1.06 “2nd velocity loop gain”
- Pr1.07 “2nd velocity loop integration time constant”
- Pr1.08 “2nd filter of velocity detection”
- Pr1.09 “2nd torque filter time constant”
- Pr1.10 “Velocity feed forward gain”
- Pr1.11 “Velocity feed forward filter”
- Pr1.12 “Torque feed forward gain”
- Pr1.13 “Torque feed forward filter”
- Pr1.14 “2nd gain setup”
- Pr1.15 “Mode of position control switching”
- Pr1.16 “Delay time of position control switching”
- Pr1.17 “Level of position control switching”
- Pr1.18 “Hysteresis at position control switching”
- Pr1.19 “Position gain switching time”
- Pr1.20 “Mode of velocity control switching”
- Pr1.21 “Delay time of velocity control switching”
- Pr1.22 “Level of velocity control switching”
- Pr1.23 “Hysteresis at velocity control switching”
- Pr1.24 “Mode of torque control switching”
- Pr1.25 “Delay time of torque control switching”
- Pr1.26 “Level of torque control switching”
- Pr1.27 “Hysteresis at torque control switching”
- Pr2.00 “Adaptive filter mode setup”
- Pr2.01 “1st notch frequency”
- Pr2.02 “1st notch width selection”
- Pr2.03 “1st notch depth selection”
- Pr2.04 “2nd notch frequency”
- Pr2.05 “2nd notch width selection”
- Pr2.06 “2nd notch depth selection”
- Pr2.07 “3rd notch frequency”
- Pr2.08 “3rd notch width selection”

- Pr2.09 “3rd notch depth selection”
- Pr2.10 “4th notch frequency”
- Pr2.11 “4th notch width selection”
- Pr2.12 “4th notch depth selection”
- Pr2.13 “Selection of damping filter switching”
- Pr2.14 “1st damping frequency”
- Pr2.15 “1st damping filter setup”
- Pr2.16 “2nd damping frequency”
- Pr2.17 “2nd damping filter setup”
- Pr2.18 “3rd damping frequency”
- Pr2.19 “3rd damping filter setup”
- Pr2.20 “4th damping frequency”
- Pr2.21 “4th damping filter setup”
- Pr2.22 “Positional command smoothing filter”
- Pr2.23 “Positional command FIR filter”
- Pr2.24 “5th notch frequency”
- Pr2.25 “5th notch width selection”
- Pr2.26 “5th notch depth selection”
- Pr2.27 “1st damping width setting”
- Pr2.28 “2nd damping width setting”
- Pr2.29 “3rd damping width setting”
- Pr2.30 “4th damping width setting”
- Pr2.38 “Filter function switching”
- Pr2.39 “Custom notch compensation coefficient”
- Pr2.40 “Custom notch compensation frequency 1”
- Pr2.41 “Custom notch compensation frequency 2”
- Pr2.42 “Custom notch frequency”
- Pr2.43 “Custom notch width”
- Pr2.44 “Custom notch depth”
- Pr2.45 “Function expansion setup 10”
- Pr2.46 “Tuning filter 2”
- Pr2.52 “Torque command additional value 2”
- Pr2.53 “Positive direction torque compensation value 2”
- Pr2.54 “Negative direction torque compensation value 2”
- Pr2.61 “Target settling time”
- Pr2.62 “Settling time count condition”
- Pr2.63 “Allowable overshoot amount”
- Pr2.64 “Tuning amount of movement”
- Pr2.65 “Tuning max speed”
- Pr2.66 “Tuning acceleration and deceleration time”
- Pr2.67 “Tuning wait time”
- Pr2.68 “Tuning operating range upper limit”
- Pr2.69 “Tuning operating range lower limit”

- Pr2.70 “Tuning overspeed level setting”
- Pr2.71 “Tuning torque limit”
- Pr2.72 “Tuning start RTAT machine stiffness setting”
- Pr2.73 “Tuning stability margin”
- Pr2.74 “Tuning auto tuning application selection”
- Pr2.75 “Tuning step selection”
- Pr2.76 “Tuning target function selection”
- Pr2.77 “Tuning start position”
- Pr2.78 “Tuning vibration automatic suppression effective level”
- Pr2.79 “Tuning JOG test run command speed”
- Pr2.80 “Tuning JOG test run acceleration and deceleration time”
- Pr5.45 “Quadrant glitch positive-direction compensation value”
- Pr5.46 “Quadrant glitch negative-direction compensation value”
- Pr5.47 “Quadrant glitch compensation delay time”
- Pr5.48 “Quadrant glitch compensation filter setting L”
- Pr5.49 “Quadrant glitch compensation filter setting H”
- Pr6.05 “Position 3rd gain valid time”
- Pr6.06 “Position 3rd gain scale factor”
- Pr6.07 “Torque command additional value”
- Pr6.08 “Positive direction torque compensation value”
- Pr6.09 “Negative direction torque compensation value”
- Pr6.10 “Function expansion setup”
- Pr6.11 “Current loop gain response setup”
- Pr6.23 “Load change compensation gain”
- Pr6.24 “Load change compensation filter”
- Pr6.32 “Real time auto tuning custom setup”
- Pr6.41 “1st damping depth”
- Pr6.42 “2-stage torque filter time constant”
- Pr6.43 “2-stage torque filter attenuation term”
- Pr6.47 “Function expansion setup 2”
- Pr6.48 “Tuning filter”
- Pr6.49 “Command response/tuning filter attenuation term”
- Pr6.50 “Viscous friction compensating gain”
- Pr6.60 “2nd damping depth”
- Pr6.61 “1st resonance frequency”
- Pr6.62 “1st resonance attenuation ratio”
- Pr6.63 “1st anti-resonance frequency”
- Pr6.64 “1st anti-resonance attenuation ratio”
- Pr6.65 “1st response frequency”
- Pr6.66 “2nd resonance frequency”
- Pr6.67 “2nd resonance attenuation ratio”
- Pr6.68 “2nd anti-resonance frequency”
- Pr6.69 “2nd anti-resonance attenuation ratio”

- Pr6.70 “2nd response frequency”
- Pr6.71 “3rd damping depth”
- Pr6.72 “4th damping depth”
- Pr6.73 “Load estimation filter”
- Pr6.74 “Torque compensation frequency 1”
- Pr6.75 “Torque compensation frequency 2”
- Pr6.76 “Load estimation count”
- Pr6.80 “3rd resonance frequency”
- Pr6.121 “Current feed forward response setup”

7.5 Other Parameters Related To Tuning

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
0	04	B	Inertia ratio	0 to 100000	%	Sets the ratio of load inertia to motor rotor inertia.
1	00	B	1st gain of position loop	0 to 30000	0.1 s^{-1}	Sets the 1st position loop gain.
1	01	B	1st velocity loop gain	1 to 32767	0.1 Hz	Sets the 1st velocity loop gain.
1	02	B	1st velocity loop integration time constant	1 to 10000	0.1 ms	Sets the 1st velocity loop integration time constant. The integral is retained at the set value of 9999. Disabled when set value is 10000.
1	03	B	1st filter of velocity detection	0 to 5	—	Sets the 1st filter of velocity detection in 6 stages.
1	106	B	1st position loop gain change ratio	0 to 300	%	Sets the change ratio of Pr1.00 “1st gain of position loop” at the stiffness setting value when the gain change ratio is enabled . When this setup value is 0, this is set to 100 %.
1	107	B	1st velocity integration change ratio	0 to 300	%	Sets the change ratio of Pr1.02 “1st velocity loop integration time constant” at the stiffness setting value when the gain change ratio is enabled . When this setup value is 0, this is set to 100%.
1	108	B	1st torque filter change ratio	0 to 300	%	Sets the change ratio of Pr1.04 “1st torque filter time constant” at the stiffness setting value when the gain change ratio is enabled .
1	109	B	2nd position loop gain change ratio	0 to 300	%	Sets the change ratio of Pr1.05 “2nd gain of position loop” at the stiffness setting value when the gain change ratio is enabled . When this setup value is 0, this is set to 100%.
1	110	B	2nd velocity loop gain change ratio	0 to 300	%	Sets the change ratio of Pr1.06 “2nd velocity loop gain” at the stiffness setting value when the gain change ratio is enabled . When this setup value is 0, this is set to 100%.
1	111	B	2nd velocity integration change ratio	0 to 300	%	Sets the change ratio of Pr1.07 “2nd velocity loop integration time constant” at the stiffness setting value when the gain change ratio is enabled . When this setup value is 0, this is set to 100 %.
1	112	B	2nd torque filter change ratio	0 to 300	%	Sets the change ratio of Pr1.09 “2nd torque filter time constant” at the stiffness setting value when the gain change ratio is enabled .
1	113	B	Load fluctuation compensation filter change ratio	0 to 300	%	Sets the change ratio of Pr6.24 “Load change compensation filter” at the stiffness setting value when the gain change ratio is enabled . When this setup value is 0, this is set to 100%.
1	114	B	Smoothing filter change ratio	0 to 300	%	Sets the change ratio of Pr2.22 “Positional command smoothing filter” at the stiffness setting value when the gain change ratio is enabled .
1	115	B	Tuning filter change ratio	0 to 300	%	Sets the change ratio of Pr6.48 “Tuning filter” at the stiffness setting value when the gain change ratio is enabled .
2	61	A	Target settling time	0 to 32767	ms	Sets the target settling time during tuning. If the setup value is 0, the settling time is tuned to be shorter.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	62	A	Settling time count condition	0 to 1	—	Specifies the condition for counting the settling time during tuning. 0: Counted after completion of command transfer judgment. 1: Counted at start of command transfer judgment.
2	63	A	Allowable overshoot amount	0 to 500	%	Sets the allowable amount of overshoot during tuning as a percentage of Pr4.31 "Positioning complete (In-position) range" . Set to 0 to tune without overshoot.
2	64	A	Tuning amount of movement	0 to 2147483647	Command unit	Sets the amount of movement when using operation commands during tuning. This can be set when tuning is performed using only operation commands from the servo driver. If the setup value is 0, the value automatically determined by the servo driver is used.
2	65	A	Tuning max speed	0 to 20000	r/min	Sets the maximum speed when using operation commands during tuning. This can be set when tuning is performed using only operation commands from the servo driver. If the setup value is 0, the value automatically determined by the servo driver is used.
2	66	A	Tuning acceleration and deceleration time	0 to 5000	ms	Sets the acceleration/deceleration time when using operation commands during tuning. This can be set when tuning is performed using only operation commands from the servo driver. If the setup value is 0, the value automatically determined by the servo driver is used.
2	67	A	Tuning wait time	0 to 10000	ms	Sets the waiting time when using operation commands during tuning. This can be set when tuning is performed using only operation commands from the servo driver.
2	68	A	Tuning operating range upper limit	0 to 1073741823	Command unit	Sets the amount of movement that the motor is allowed to move in the positive direction from the tuning start position during tuning.
2	69	A	Tuning operating range lower limit	-1073741824 to 0	Command unit	Sets the amount of movement that the motor is allowed to move in the negative direction from the tuning start position during tuning.
2	70	A	Tuning overspeed level setting	0 to 20000	r/min	Sets the upper limit for the allowable motor speed during tuning. Various speed protection settings are used when the setup value is 0.
2	71	A	Tuning torque limit	0 to 500	%	Sets the upper-limit value (absolute value) for the allowable torque command during tuning. Torque limit settings are used when the setup value is 0.
2	72	A	Tuning start RTAT machine stiffness setting	0 to 44	—	Specifies the RTAT machine stiffness setting at the start of the tuning.
2	73	A	Tuning stability margin	0 to 100	%	Specifies the stability margin during tuning in %.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	75	A	Tuning step selection	-32768 to 32767	—	Specifies the target step for performing tuning. If the bit is 0, it is excluded from the step to be adjusted. If the bit is 1, it is the step to be adjusted. bit 0: Advance operation bit 1: Homing operation bit 2 to 15: Manufacturer use
2	76	A	Tuning target function selection	-32768 to 32767	—	Specifies the function to be tuned. If the bit is 0, it is excluded from the parameters to be tuned. If the bit is 1, it is the parameter to be tuned. bit 0: Inertia ratio bit 1: Unbalanced load compensation (default disabled) bit 2: Dynamic friction compensation (default disabled) bit 3: Viscous friction compensation (default disabled) bit 4: RTAT machine stiffness setting (position and speed gains, speed integration time constant, torque filter) bit 5: RTAT feedforward control section stiffness setting (smoothing filter time constant) bit 6: Notch filter bit 7: 1st damping filter bit 8: 2nd damping filter bit 9: Load fluctuation control function bit 15 to 10: Manufacturer use
2	77	A	Tuning start position	-1073741824 to 1073741823	Command unit	Sets the initial position at the start of tuning.
2	78	A	Tuning vibration automatic suppression effective level	0 to 100	%	Sets the threshold for automatic vibration suppression during tuning.
2	79	A	Tuning JOG test run command speed	0 to 500	r/min	Sets the command speed for JOG trial runs at the time of tuning.
2	80	A	Tuning JOG test run acceleration and deceleration time	0 to 5000	ms	Sets the acceleration/deceleration time during JOG trial run at the time of tuning.
4	31	A	Positioning complete (In-position) range	0 to 2097152	Command unit	Sets the threshold value of position deviation that outputs the positioning complete signal (INP). The command unit is used as the default unit but can be replaced by the encoder unit or external scale unit by using Pr5.20 “Position setup unit select” . However, in such cases, note that the unit of Pr0.14 “Position deviation excess setup” will also be changed. The position deviation value can switch the command before and after the position command filter using the Pr7.23 “Communication function extended setup 2” :bit 14 setting.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	10	B	Function expansion setup	-32768 to 32767	—	bit 4: Current response improvement 0: Disabled 1: Enabled Set to bit = 1 (enabled) when in synchronous mode, synchronous friction compensation mode, stiffness setting mode, or load fluctuation support mode (Pr0.02 = 1 to 3, or 6).
6	47	R	Function expansion setup 2	-32768 to 32767	—	Set the functions in bit units. bit 0: Two-degree-of-freedom control mode 0: Disabled 1: Enabled bit 3: Two-degree-of-freedom control real-time auto tuning selection 0: Standard type 1: Synchronization type **Notes** ● bit 3 can only be used when bit 0 is 1.

*1 For attributes, see *“7.1 Object Dictionary List”* .

7.6 List of Errors Related to One Minute TUNING

—: N/A

Error No.	Error name	Primary Causes and Measures	Reference
257	Initial setting error 1	Command conditions are not set. Set Tuning amount of movement [command unit], Tuning max speed [r/min], and Tuning acceleration and deceleration time [ms/max speed] all to a value greater than 0.	*"Advanced Settings Items"* - *"Command conditions"* of *"3.1.2.4.2 Initial Settings"*
258	Initial setting error 2	Target settling time is set greater than the command (Tuning wait time - 500 ms). Set Target settling time [ms] to a value smaller than (Tuning wait time -500 ms).	*"Advanced Settings Items"* - *"Required performance"* of *"3.1.2.4.2 Initial Settings"*
259	Initial setting error 3	Target settling time is set greater than the command (operation time +Tuning wait time - 500 ms) in [Command conditions]. Set Target settling time [ms] to a value smaller than (operating time + Tuning wait time - 500 ms). The value obtained by adding the operating time and tuning wait time [ms] is 10000 [ms] or more. Set the tuning amount of movement [command unit], tuning max speed [r/min], tuning acceleration and deceleration time [ms/JOG speed], and tuning wait time [ms] so that the sum of the operating time and tuning wait time [ms] is less than 10000 [ms]. **Notes** ● Operating time is the time from the start of command transfer to the completion of transfer.	*"Advanced Settings Items"* - *"Required performance"* of *"3.1.2.4.2 Initial Settings"* *"Advanced Settings Items"* - *"Command conditions"*
260	Initial setting error 4	Positioning complete (In-position) range is set greater than the operating range. Set Positioning complete (In-position) range [command unit] to a value smaller than the operating range [command unit].	*"Advanced Settings Items"* - *"Required performance"* of *"3.1.2.4.2 Initial Settings"*
261	Initial setting error 5	Positioning complete (In-position) range is set greater than the command amount of movement. Set Positioning complete (In-position) range [command unit] to a value smaller than Tuning amount of movement [command unit].	*"Advanced Settings Items"* - *"Required performance"* of *"3.1.2.4.2 Initial Settings"*
263	Initial setting error 6	Allowable overshoot amount is set greater than the operating range. (Set Positioning complete (In-position) range [command unit] × Allowable overshoot amount[%]/100) to a value smaller than the operating range [command unit].	"Step 5" of *"3.1.2.4.2 Initial Settings"* *"Advanced Settings Items"* - *"Required performance"*
264	Initial setting error 7	The command amount of movement exceeds the operating range. Set Tuning amount of movement [command unit] to the operating range [command unit] or less.	*"Advanced Settings Items"* - *"Command conditions"* of *"3.1.2.4.2 Initial Settings"* "Step 5"
265 266	Initial setting error 8	The JOG trial run command speed or command maximum speed exceeds Over-speed level setup. Set Tuning JOG test run command speed [r/min] and Tuning max speed [r/min] to Over-speed level setup [r/min] or less.	*"Advanced Settings Items"* - *"Detailed Protection Function"* of *"3.1.2.4.2 Initial Settings"* "Step 3"

Error No.	Error name	Primary Causes and Measures	Reference
267 268	Initial setting error 9	The JOG trial run command speed or command maximum speed exceeds Tuning overspeed level setting. Set Tuning JOG test run command speed [r/min] and Tuning max speed [r/min] to Tuning overspeed level setting [r/min] or less.	*"Advanced Settings Items"* - *"Command conditions"* of *"3.1.2.4.2 Initial Settings"* *"Advanced Settings Items"* - *"Detailed Protection Function"*
275	Initial setting error 10	The set command acceleration is outside the allowable range for One Minute TUNING. Set the command acceleration to be in the range of 125001 to 4294967295 [command unit/s^2], referring to the formula below. Acceleration [command unit/s^2] = Tuning max speed [r/min]/Tuning acceleration and deceleration time [ms/max speed] × 1000/60 × (encoder resolution / electronic gear ratio) *For rotary type motor	*"Advanced Settings Items"* - *"Command conditions"* of *"3.1.2.4.2 Initial Settings"*
277	Initial setting error 11	A tuning target is not selected. Turn ON one of the tuning targets.	*"Advanced Settings Items"* - *"Tuning conditions"* of *"3.1.2.4.2 Initial Settings"*
278	Initial setting error 12	Tuning cannot be performed correctly because the set operating range is too small. Set a larger operating range. For One Minute TUNING, a setting of 0.5 rotations or more is recommended for the amount of motor rotations.	"Step 5" of *"3.1.2.4.2 Initial Settings"*
279	Initial setting error 13	Tuning cannot be performed correctly because the value set for Tuning amount of movement is too small. Increase the value set for Tuning amount of movement.	*"Advanced Settings Items"* - *"Command conditions"* of *"3.1.2.4.2 Initial Settings"*
513	Load characteristic measurement error	Load characteristic measurement failed. 1 Execute One Minute TUNING once more with a larger operating range. 2 If the inertia estimating conditions cannot be met due to the device mechanism, set the specification value to the inertia ratio and perform One Minute TUNING with the inertia ratio, unbalanced load compensation, dynamic friction compensation, and viscous friction compensation of Tuning target function selection all turned to OFF.	"Step 5" of *"3.1.2.4.2 Initial Settings"* *"Advanced Settings Items"* - *"Tuning conditions"*
769	Oscillation error	Oscillation detected during operation. Execute One Minute TUNING once more after lowering the speed loop gain value on the Parameter Settings screen.	PT_OM "8.11 All Parameters"
1025	Torque saturation error	Tuning torque limit exceeded during operation. Execute One Minute TUNING once more after revising command conditions to reduce acceleration.	*"Advanced Settings Items"* - *"Command conditions"* of *"3.1.2.4.2 Initial Settings"*
1281	Stiffness measurement error	RTAT machine stiffness setting, notch, and load fluctuation suppression could not be adjusted. Execute One Minute TUNING once more after lowering the speed loop gain value on the Parameter Settings screen.	PT_OM "8.11 All Parameters"
1537	Device characteristics measuring error 1	Device characteristics could not be measured correctly. Execute One Minute TUNING once more with a larger operating range.	"Step 5" of *"3.1.2.4.2 Initial Settings"*
1793	Device characteristics measuring error 2	Device characteristics could not be measured correctly. Execute One Minute TUNING once more with a smaller operating range.	"Step 5" of *"3.1.2.4.2 Initial Settings"*

Error No.	Error name	Primary Causes and Measures	Reference
2049	Control mode error 1	Not supported in full-closed control. (Supported in position control and speed control modes.)	—
2050	Control mode error 2	The control mode was changed to something other than position control mode during operation. Do not switch to a mode other than position control mode when executing One Minute TUNING.	—
2305	Control mode error 3	Two-degree-of-freedom control mode for synchronization type is not supported. (Two-degree-of-freedom control mode for standard type and two-degree-of-freedom control mode disabled type are supported.)	—
2306	Auto tuning application selection error	Customize is not supported with Tuning auto tuning application selection. (Positioning/general-purpose are supported.)	—
2817	Command input error	A command was input that exceeds the movable range during operation. Contact the manufacturer.	—

7.7 Glossary

Abbreviations used in this document and their official names are shown below.

■ Servo Driver-related/Servo Motor-related

Abbreviation	Official Name
CCW	Counterclockwise Rotation
csp	Cyclic synchronous position mode
cst	Cyclic synchronous torque mode
cstca	Cyclic synchronous torque mode with commutation angle
csv	Cyclic synchronous velocity mode
CW	Clockwise Rotation
DB	Dynamic Brake
EDM	External Device Monitoring
FB	Feedback
FF	Feed forward
FFT	Fast Fourier Transform
FIR	Finite Impulse Response
hm	Homing mode
HPF	High Pass Filter
ip	Interpolated position mode
LSD	Least Significant Digit
LV	Low Voltage
MSD	Most Significant Digit
OSS	Open Source Software
pp	Profile position mode
pv	Profile velocity mode
Recv	Receive
RTAT	Real-Time Auto Tuning
SRV	Servo
SSU	STO Signal Unmatch
STO	Safe Torque Off
TFF	Torque Feed Forward
tq	Torque profile mode
vl	Velocity mode

■ EtherCAT Communication-related

Abbreviation	Official Name
AL	Application Layer
Boot	Bootstrap
CoE	CANopen over EtherCAT
DC	Distributed Clocks
ENI	EtherCAT Network Information
EoE	Ethernet over EtherCAT
ESC	EtherCAT SubDevice Controller

Abbreviation	Official Name
ESI	EtherCAT SubDevice Information
ESM	EtherCAT State Machine
ETG	EtherCAT Technology Group
FMMU	Fieldbus Memory Management Unit
FoE	File Access over EtherCAT
FSA	Finite State Automaton
OP	Operational
PDI	Physical Device Interface
PDO	Process Data Object
PDS	Power Drive Systems
PreOP	Pre-Operational
RxPDO	Receive PDO
SafeOP	Safe-Operational
SDO	Service Data Object
SII	SubDevice Information Interface
SM	SyncManager
SoE	Sercos over EtherCAT
TxPDO	Transmit PDO
VoE	Vendor-specific over EtherCAT

■ Object-related

Data type

Abbreviation	Official Name
U8	Unsigned8
U16	Unsigned16
U32	Unsigned32
I8	Integer8
I16	Integer16
I32	Integer32
VS	Visible String
BOOL	Boolean
OS	Octet String

Access

Abbreviation	Official Name
r	read
rw	read-write
ro, RO	read-only
c	constant

REVISIONS

Date	Rev.	Page	Description
Sep. 13, 2024	0.0	–	NEWLY ISSUED
Dec. 20, 2024	0.1	2.1.3, 3.1.3.2, 3.1.3.4.2	Revised the precAIseTUNING specifications and added their associated Precautions
Feb. 5, 2025	0.2	3.1.3.4.3	Added a note about precAIseTUNING Removed the precAIse TUNING temporary stop function
Apr. 1, 2025	0.3	1.3.4	Changed Function (Add to Unsupported Features) ● position comparison output function ● Monitor Signal Output
Apr. 11, 2025	1.0	1.3.2, 1.3.5	Software version upgrade ● CPU1: Ver1.04→Ver1.05 ● Manufacture Software: Ver1.00→Ver1.01
		1.3.4	Remove from the list of Unsupported Features ● position comparison output function ● Monitor Signal Output
		7.1.2.8	Updated Object Dictionary List ● Changed the Initial value of 3780h ● Add 37B7h
		7.1.2.11	Updated Object Dictionary List ● Add 3A01h
		7.6	Corrected typographical errors (Err275, Err277)
May 28, 2025	1.1	4.4.3, 4.6.3, 4.7.3, 4.9.3, 4.10.3, 5.1.3, 5.2.3, 5.9.3, 7.2.4	Added Description

Repairs, Inquiries and Technical Information

Repairs

Contact your dealer regarding repairs.

If installed in a machine or device, consult with the machine or device manufacturer first.

Contact us

If you have any questions, please contact the seller of the product (Sales office or Distributor).

Technical information

- **Operating instructions, technical reference, CAD data downloads, and Web-based inquiries are available online.**

“industry.panasonic.com/global/en/”

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