# Panasonic

# Servo System MINAS A7N Series Operating Instructions (Tuning)

## **RTEX 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 <u>"1.1.1 Safety Precautions"</u> 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).

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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 <u>"1.1 Precautions"</u> before using this product.
- Before using the tuning and control functions, properly configure the settings described in <u>"2.2 Safety</u> <u>Function Setup Before Tuning"</u>.
- 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.

<u> </u> Danger	This indicates "a significant risk of death or serious injury".
<b>A</b> Caution	This indicates "a risk of injury or property damage".

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

$\bigcirc$	Must not be done.
	Must be done.

<u> </u>		
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, regener- ative 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 key- way 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 insu- lating 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.		
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	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. Do not place combustible materials near the motor, driver, regener- ative resistor, or dynamic brake resistor. Do not use in places subject to strong vibration or impact. Do not use with the cable immersed in oil or water. Do not install next to a heating element, such as a heater or large coil resistor. Never connect a commercial power supply directly to the motor. Do not perform wiring or operate with wet hands. Never put your hand inside the driver. In the case of a motor with axis end keyway, do not touch the key- way with bare hands. 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. Do not damage the cables, subject them to excessive force, place heavy objects on them, or pinch them. Install in an area free from excessive dust, water, oil, etc. Install the motor, driver, and peripheral devices to nonflammable materials such as metal. Wiring must be carried out by an expert in electrical work. Carry out wiring in accordance with the Operating Instructions. After correctly connecting cables, insulate the live parts with insu- lating material. Connect to the earth terminals of the motor and driver without fail. Install and mount securely to prevent any possible fire or personal injury during an earthquake. Install an overcurrent protection device, residual current device, overheating prevention device, and emergency stop device without fail.	

	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 installa- tion.	May cause injury or malfunction.	
	Do not stand on or place heavy objects on the product.	May cause electric shock, injury, malfunc- tion, 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.	
J	There should be no strong impact on the product.	May cause malfunction.	
There should be no strong impact on the motor axis. Do not turn the driver main power on and off frequently.		May cause detectors, etc., to malfunction	
		May cause malfunction.	
	Never run or stop the motor with the electromagnetic contactor in- stalled 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	
	Observe the specified mounting method and orientation.	- cause injury or malfunction.	
	Only use the eye bolt of the motor for transportation of the motor.	Use for transportation of the machine ma cause injury or malfunction.	
	Set the motor and driver ambient temperature within the tempera- ture 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, jury, 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 ma function.	
	Install safety devices for built-in brake or gear head idling or lock- ing, or grease leakage from gear head.	Non-installation may cause injury, damag or pollution.	
	The servo drive may start up with no warning when power is re- stored 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 the correct combination.	
	To perform a trial run, secure the motor, and install it in the me- chanical system after checking its operation while disconnected from the mechanical system.	Use of the wrong model or incorrect wirin may cause injury.	
	When an error occurs, clear the error and only restart after elimi- nating the cause and ensuring safety.	Not eliminating the cause of the error mig cause injury.	
	If the driver malfunctions, shut off the power on the power supply side of the driver.	Continued passage of a large current ma 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 Instruction	vo System Operating Instructions					
MINAS A7N Series Operating In- structions (Overall) RTEX Rotary Motor	01_0	IMG11	This manual describes the selection, connection, us- age, and error handling of servo drivers and servo motors to ensure correct and safe use of this prod- uct.			
MINAS A7N Series Operating In- structions (Tuning) RTEX Rotary Motor	OI_A	IMG23	This document describes the adjustment function of the servo driver.			
For MINAS Set-up Support Soft- ware (PANATERM ver.7) Operat- ing Manual	PT_OM	IMG15	This document describes how to use PANATERM ver. 7, the setup support software for this product.			
Servo Driver Standard Specification	า					
MINAS A7NSeries Standard Specifications Rotary Motor (Standard / Multi- function / Application specialized)	SS	SX-DSV03719	This document describes the hardware specifica- tions of the servo driver.			
Servo Driver Technical Reference	ervo Driver Technical Reference					
MINAS A7N Series Technical Ref- erence Functional Specification Rotary Motor (Standard / Multi- function / Application specialized)	TR_FS	SX-DSV03758	This document describes how to use the various functions of the servo driver.			
MINAS A7N Series Technical Ref- erence Communication Specifica- tion Rotary Motor (Standard / Multi- function / Application specialized)	TR_CS	SX-DSV03761	This document describes the interface that connects the servo driver to the host device.			
Motion Controller User's Manual	lotion 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

## 1.3.3 Software Version Confirmation Method

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

- Software version 1, Software version 2
  - RTEX communication command Type\_Code 140h (A4N-compatible), 14h (standard) (See Technical Reference Communication Specification)
  - 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
Profile position control (PP)
Cyclic velocity control (CV)
Cyclic torque control (CT)
Full-closed control function (rotary scale)
Batteryless absolute encoder
Position comparison output function
Continuous rotating absolute encoder function
Virtual full-closed control function
External scale position information monitor function for semi-closed control
Deterioration diagnosis warning function
Latch mode function with stop function
Retracting operation function
Fall prevention function for when alarm is triggered
Slow stop function
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 Class version		Class	Changed Function Details	Relevant Section	Supported Set- up Support Software (PAN-
CPU1	CPU2				ATERM ver.7)
1.04	1.02	First version	Newly created	_	7.0.0.0 and later
1.05	1.02	Extended Ver- sion 1	Monitor Signal Output	OI_O "3.2.8.1"	7.0.3.0 and later

## 1.3.6 Functional Differences from Previous Series

- For differences from the MINAS A6N Series, see Technical Reference Functional Specification "1.2.6 Functional Differences from Previous Series" and Technical Reference Communication Specification "1.2.6 Functional Differences from Previous Series".
- The MINAS A7N Series may not operate in complete compatibility with previous series (the A6N Series, etc.). Be sure to carry out an evaluation before changing from a previous series to the MINAS A7N Series, as parameter retuning may be required.

The initial values for the MINAS A7N Series are listed in Operating Instructions (Overall) "6.3 List of Parameters".

## 1.4 Trademarks

• MINAS, TUNE COMPASS, PANATERM, Realtime Express and RTEX are registered trademarks or trademarks of Panasonic Holdings Corporation in Japan and other countries.

# **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 <u>"2.3 Adjustment Workflow"</u>.



○: Supported ×: Not supported

Function name	Function overview	Operation	command	Set-up Sup-	Reference
			Upper com- mand	port Soft- ware (PANA- TERM ver.7) needed	
	Auto tuning (TUNE	COMPASS)			
TUNINGLESS	This function automatically tunes inertia based on the actual operation of the mo- tor, using the initial values as parame- ters. This function is enabled at the time of shipment. This function is useful when you want to move the motor immediately.	O (*1)	0	×	<u>"3.1.1 TU-</u> <u>NINGLESS"</u>
One Minute TUNING	A function that automatically tunes vari- ous parameters to satisfy target perform- ance 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 work- piece or position, only specific items can be auto tuned again.	0	×	0	<u>"3.1.2 One</u> <u>Minute TUN-</u> <u>ING</u> "

Function name	Function overview	Operation	command	Set-up Sup-	Reference
		Internal com- mand	Upper com- mand	port Soft- ware (PANA- TERM ver.7) needed	
precAlse 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 skil- led operators. The tuning results are ex- pected to exceed those of skilled opera- tors. This is also effective for reducing opera- tor labor hours, because it performs au- tomatic operation using Set-up Support Software (PANATERM ver.7) after initial setting of target performance and multi- ple operation patterns, etc.	0	×	0	<u>"3.1.3 pre-</u> <u>cAlse TUN-</u> <u>ING"</u>
	Manual Tu	ning			
Manual TUNING	Re-adjustment may be necessary to fur- ther improve responsiveness and stabili- ty, for example, after auto tuning. In such cases, this function manually sets indi- vidual 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.	O (*1)	Ο	O (*2)	<u>"3.2.1 Man-</u> <u>ual TUN-</u> <u>ING"</u>
Load fluctuation sup- pression tuning (stabilizing load fluc- tuation applications)	In devices where load inertia fluctuates, vibration may occur due to the effect of load inertia fluctuations. This function re- duces this vibration and improves stabili- ty.	O (*1)	0	O (*2)	<u>"3.2.2 Load</u> <u>Fluctuation</u> <u>Suppression</u> <u>Tuning (Sta- bilizing Load</u> <u>Fluctuation</u> <u>Applica-</u> tions)"

\*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 functions supported" column shows whether or not servo parameters can be tuned by each automatic tuning function.

	1		⊖: Su	pported X: No	ot supported
Function name	Function overview	Auto tun	ing functions s	upported	Refer-
		TUNING- LESS	One Minute TUNING	precAlse TUNING	ence
Real-time auto tuning func- tion	This function estimates machine load characteristics in real time and uses those results to automatically perform basic gain setting and load characteris- tic compensation. The tuning of stiffness parameters should yield a reduction in settling time.	O (*1)	0	0	<u>"4.1 Re-</u> <u>al-time</u> <u>Auto Tun-</u> <u>ing Func-</u> <u>tion</u> "
Gain switching function	A function that switches gain types, setting conditions, etc., based on com- mand inputs such as torque commands and speed commands, in order to per- form optimal control based on the oper- ating state of the servo driver. This is expected to shorten the settling time and suppress fine vibration while stopped.	×	×	0	<u>"4.2 Gai</u> <u>n Switch-</u> <u>ing Func-</u> <u>tion"</u>
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 expect- ed from the gain switching function.	×	×	0	<u>"4.3 3rd</u> <u>Gain</u> <u>Switching</u> <u>Func-</u> <u>tion"</u>
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.	0	0	0	<u>"4.4 Fee</u> <u>dforward</u> <u>Func-</u> <u>tion"</u>
Friction torque compensation function	This function reduces the effect of me- chanical system friction and improves responsiveness. This is expected to compensate the ef- fect of friction and improve command tracking.	×	0	0	<u>"4.5 Fric-</u> <u>tion Tor-</u> <u>que</u> <u>Compen-</u> <u>sation</u> <u>Func-</u> <u>tion</u> "

Function name	Function overview	Auto tun	ing functions s	upported	Refer-
		TUNING- LESS	One Minute TUNING	precAlse TUNING	ence
Load fluctuation control func- tion	In devices with which disturbance tor- que is applied, velocity change may oc- cur due to the disturbance torque. This function reduces this velocity change and improves stability. In devices where load inertia fluctu- ates, vibration may occur due to the ef- fect of load inertia fluctuations. This function reduces this vibration and im- proves stability. This is expected to compensate the ef- fect of disturbance torque and inertia change and improve operation stability.	×	0	0	<u>"4.6 Loa</u> <u>d Fluctu-</u> <u>ation</u> <u>Control</u> <u>Function</u> (Disturb- <u>ance</u> <u>Suppres-</u> <u>sion Ap-</u> <u>plica-</u> <u>tions)"</u> "4.7 Loa <u>d Fluctu-</u> <u>ation</u> <u>Control</u> <u>Function</u> (Load <u>Fluctua-</u> <u>tion Sta-</u> <u>bilization</u> <u>Applica-</u> <u>tions)"</u>
High response current con- trol function	This function improves the responsive- ness of the current controller by chang- ing the current response setting to a value greater than the initial value in order to improve the current control re- sponsiveness when operating at low current, such as with a processing ma- chine. This is expected to improve the re- sponsiveness of position control and speed control by enhancing current control performance in locus control.	×	×	0	<u>"4.8 High</u> <u>Re-</u> <u>Sponse</u> <u>Current</u> <u>Control</u> <u>Func-</u> <u>tion</u> "
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.	×	×	0	<u>"4.9 Qua</u> <u>drant</u> <u>Glitch</u> <u>Suppres-</u> <u>sion</u> <u>Func-</u> <u>tion</u> "

\*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.

 $\bigcirc$ : Supported X: Not supported

Function name	Function overview	Auto tuning (	TUNE COMPA ed	SS) support-	Refer- ence
		TUNING- LESS	One Minute TUNING	precAlse TUNING	
Torque filter function	Sounds and vibrations in the high fre- quency 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 fre-	0	0	0	<u>"5.1 Tor-</u> <u>que Filter</u> <u>Func-</u> <u>tion"</u>
	quency range $(^{*1})$ .				
2-stage torque filter function	This function sets a 2-stage torque fil- ter to suppress high-frequency vibra- tion components that cannot be re- moved by the <u>"5.1 Torque Filter Func-</u> <u>tion</u> " torque filter alone.	×	×	0	<u>"5.2 2-</u> <u>stage</u> <u>Torque</u> <u>Filter</u> <u>Func-</u>
	This function is expected to suppress sound and vibration in the high fre- quency range <sup>(*1)</sup> . The suppression ef- fect is stronger than that of a torque fil- ter.				<u>tion"</u>
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 vi- bration at specific frequencies in the high frequency range by setting a notch filter.	×	0	0	<u>"5.3 Notc</u> <u>h Filter</u> <u>Func-</u> <u>tion"</u>
	This function is expected to suppress noise and vibration caused by mechanical resonance of the device $(^{*2})$ .				
Adaptive filter function	This function auto tunes parameters re- lated to notch filters.	×	0	×	<u>"5.4 Ada</u> <u>ptive Fil-</u> <u>ter Func-</u> <u>tion"</u>
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 opera- tion 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.	×	0	0	<u>"5.5 Da</u> <u>mping</u> <u>Control</u> <u>Func-</u> <u>tion</u> "

Function name	Function overview	Auto tuning (	TUNE COMPA ed	SS) support-	Refer- ence
		TUNING- LESS	One Minute TUNING	precAlse 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 opera- tion 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.	×	×	0	<u>"5.6 Mod</u> <u>el-type</u> <u>Damping</u> <u>Filter</u> <u>Func-</u> <u>tion</u> "
Position command filter func- tion	A function that applies a positional command smoothing filter to a position command to gently accelerate or de- celerate the motor. This is expected to suppress vibration and velocity change caused by the command resolution and command up- dating cycle roughness.	×	0	0	<u>"5.7 Po-</u> <u>sition</u> <u>Com-</u> <u>mand Fil-</u> <u>ter Func-</u> <u>tion</u> "
Speed command accelera- tion/deceleration setting function	This function performs speed control by applying a speed command for which acceleration and deceleration have been tuned inside the servo driv- er 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.	×	×	×	<u>"5.8 Spe</u> ed Com- mand Ac- celera- tion/ Deceler- ation Set- ting Func- tion"
Hybrid vibration suppression function	This function suppresses vibration caused by the amount of torsion be- tween the motor and the load in full- closed control mode. This is expected to shorten the settling time.	×	×	×	<u>"5.9 Hy-</u> <u>brid Vi-</u> <u>bration</u> <u>Suppres-</u> <u>sion</u> <u>Func-</u> <u>tion</u> "

\*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)

		⊖: Supporte	d X: Not supported
Function name		Driver type	
	A7NE Standard type	A7NF Multi-function type	A7NR Application spe- cialized type
Control functions for control performance			
Real-time auto tuning function	0	0	0
Gain switching function	0	0	0
3rd gain switching function	0	0	0
Feedforward function	0	0	0
Friction torque compensation function	0	0	0
Load fluctuation control function	0	0	0
High response current control function	0	0	0
Quadrant glitch suppression function	0	0	0
Control functions to suppress abno	rmal noise and vibra	ation	
Torque filter function	0	0	0
2-stage torque filter function	0	0	0
Notch filter function	0	0	0
Adaptive filter function	0	0	0
Damping control function	0	0	0
Model-type damping filter function	0	0	0
Position command filter function	0	0	0
Speed command acceleration/deceleration setting function	0	0	0
Hybrid vibration suppression function	0	0	0

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

## 2.1.5 List of Control Functions (By Control Mode)

			⊖: Supporte	ed X: Not supported	
Function name		Contro	l mode		
	Position control	Speed control	Torque control	Full-closed con- trol	
Control functions for control performance					
Real-time auto tuning function	0	0	0	0	
Gain switching function	0	0	0	0	
3rd gain switching function	0	×	×	0	
Feedforward function	0	0	0	0	
Friction torque compensation function	0	0	×	0	
Load fluctuation control function	0	0	×	0	
High response current control function	0	0	0	0	
Quadrant glitch suppression function	0	×	×	0	
Control function	ons to suppress abno	ormal noise and vib	ation		
Torque filter function	0	0	0	0	
2-stage torque filter function	0	0	0	0	
Notch filter function	0	0	0	0	
Adaptive filter function	0	0	×	0	
Damping control function	0	×	×	0	
Model-type damping filter function	0	×	×	×	
Position command filter function	0	0	×	0	
Speed command acceleration/deceleration setting function	×	0	×	×	
Hybrid vibration suppression function	×	×	×	0	

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

## 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	This setting prevents moving parts from colliding with the mechanical end.
<ul> <li>Pr5.04 "Over-travel inhibit input set- up"</li> </ul>	
<ul> <li>Pr5.05 "Sequence at over-travel in- hibit"</li> </ul>	
Torque limit setup	This setting limits the maximum torque to prevent damage to moving parts.
<ul> <li>Pr0.13 "1st torque limit"</li> </ul>	
<ul> <li>Pr5.11 "Torque setup for emergency stop"</li> </ul>	
<ul> <li>Pr5.21 "Selection of torque limit"</li> </ul>	
Pr5.22 "2nd torque limit"	
Overspeed protection setup	This setting stops the alarm in the event of abnormally high speed.
Pr5.13 "Over-speed level setup"	
Position deviation excess protection set- up	This setting stops the alarm when abnormal position deviation from a command occurs in the position control mode.
<ul> <li>Pr0.14 "Position deviation excess setup"</li> </ul>	
<ul> <li>Pr5.20 "Position setup unit select"</li> </ul>	
Motor working range setup	This setting stops the alarm when the motor position exceeds the allowable width
<ul> <li>Pr5.14 "Motor working range setup"</li> </ul>	from the command range in the position control mode.
<ul> <li>Pr6.97 "Function expansion setup 3" :bit 2 "Motor movable range error protection expansion"</li> </ul>	
Hybrid deviation excess protection set- up	This setting prevents abnormal operation due to incorrect external scale settings, etc., in full-closed control mode.
<ul> <li>Pr3.28 "Hybrid deviation excess set- up"</li> </ul>	
• Pr3.29 "Hybrid deviation clear setup"	
Speed limit setting	This setting prevents the speed exceeding the speed limit value in torque control
Pr3.17 "Selection of speed limit"	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 <u>"3.1.2.5 Use Cases in Re-adjustment"</u> for details.
  - Tuning function Manual TUNING: See <u>"3.2.1.4.4 Tuning Procedure When Control Challenges Are Identified</u>" 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"
	<u>"4.4 Feedforward Function"</u>
	<u>"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)</u> "
	"4.8 High Response Current Control Function"
Reducing abnormal noise and oscillation.	<u>"5.3 Notch Filter Function"</u>
	"5.7 Position Command Filter Function"
Reducing vibration just before stopping.	"5.5 Damping Control Function"
	<u>"5.6 Model-type Damping Filter Function"</u>
Suppressing velocity changes during constant speed control.	"4.1 Real-time Auto Tuning Function"
	"4.6 Load Fluctuation Control Function (Disturbance Sup-
	pression Applications)"
	<u>"4.8 High Response Current Control Function"</u>
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"
	<u>"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)"</u>
	"4.8 High Response Current Control Function"
Reducing vibration when gain is increased in full-closed con- trol.	<u>"5.9 Hybrid Vibration Suppression Function"</u>

# **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 ( <u>"7.3 Parameters Related To TUNINGLESS"</u> ) 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 <u>"4.1 Real-time Auto Tuning Function"</u>.
- 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	<ul> <li>When small or large compared to the rotor inertia of the servo motor (less than 3× or 20× or more)</li> <li>When load inertia fluctuates</li> </ul>
Load	<ul> <li>When machine stiffness is extremely low</li> <li>When non-linear characteristics exist, such as backlash</li> </ul>
Operation pat- terns	<ul> <li>When used continuously at low speeds of less than 100 r/min</li> <li>When acceleration and deceleration are gentle, less than 2000 r/min in 1 s</li> <li>When the acceleration and deceleration torque is small compared to the unbalanced load and viscous friction torque</li> <li>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</li> </ul>

## 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 <u>"7.4 Parameters Related To One Minute TUNING</u>".

#### 3.1.2.4 Usage

Instructions for use are described according to the following steps.

- 1 <u>"Starting the Tuning Function"</u>
- 2 <u>"Initial Settings</u>"
- 3 <u>"Adjustment Operation"</u>
- 4 <u>"Confirming Tuning Results, Ending One Minute TUNING"</u>

### 3.1.2.4.1 Starting the Tuning Function

## << Procedure >>

- 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.

9						PANATERM ver.7				- 0	×
File(F)	Troubleshootir	ng(T)	Help(H)							_	
			E Device tree			{ĝ} Setting	嬰 Monitor	比 Logging	프운 Tuning	Device Info	
	-		MINAS A7BR		]		EtherCAT object	IO Setting	Alarm	Analog input	Trial ru
@Υ		Online	Axis0_No name set	SRV-OFF		Open file	Save file	Copy Load initia	values Load	Write	5
	-	USB	MADN085BRU 23080001				Jave me		Tvalues Load		Z-phase
	M.			Encoder Info				Config Reset			e search
	0		MINAS A7BR MHMG022U1A2 24020001	39405786 pulse	•	Search	Compa		✓ Add/delete c		ch▼
						Switch to HEX input	Display A6-compati	ble control parameters	Allow out-of-range settin	igs	

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



The "One Minute TUNING" settings screen is displayed.

One Minute TUNING				_ 🗆 ×
		0	2	
		Setting	Execute tuning	Tuning results
Recall conditions			Advanced setting	s
Applications				sing operation command settings and operation commands from the host device, or to change the
Positioning/general-purpose			required performan	ce, perform setup using "Advanced settings".
Do not use this function in a mechanism to deviate from the operating range whe	that causes the moving portion in the servo is off.			
* Two-degree-of-freedom control is enabled. To disable, it is necessary to change Pr6.47:bit and write to the driver.				
Operating range setting				
Protection Functions				
Pr5.12 Overload level(%)	0			
Pr5.13 Overspeed level[r/min]				
	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./Mit	n. positions or input a numeric value			
JOG speed[r/min]	60			
JOG acceleratio[ms/JOG speed]	50			
Servo-on O A Operates o	nly while the button is pressed.			
- direction	o to 0 + direction			
Current position	[command unit]			
· · · ·				
Minimum position	Maximum position			
[command unit]	[command unit]			
0	0			
				Next

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 <u>"Step 2"</u>.

If you do not wish to modify the settings, go to <u>"3.1.2.4.3 Adjustment Operation"</u>.

## **One Minute TUNING Settings Screen**

One Minute TUNING	- 0
	Detring Execute tuning Tuning results
Recall conditions         ● Ostooloning/general-purpose         ● Post-stoolon functions         ● Do to move-to the Max_Max_positions or input JoG acceleratomux/OG speed         ● Ost acceleratomux/OG speed       50         ● Ost acceleratomux/OG speed       50         ● Ost accelerato_mux/OG speed       0         ● Ost accelerato_mux/OG speed       0         ● Ost accelerato_mux/OG speed       0	a portion  a portion  a portion  a portion  b c c c c c c c c c c c c c c c c c c
	num position mend unti
	Next

## **2.** Select the application.

One Minute TUNING				_ 🗆 ×
		1 Setting	2 Execute tuning	Tuning results
Recall conditions Applications				ising operation command settings and operation commands from the host device, or to change the
<ul> <li>Positioning/general-purpose</li> <li>Do not use this function in a mechanism to deviate from the operating range when</li> </ul>	that causes the moving portion n the servo is off.		required performan	ce, perform setup using "Advanced settings".
* Two-degree-of-freedom control is enabled. To disable, it is necessary to change Pr6.47:bit and write to the driver.	0 from the setting screen			
Operating range setting				
Protection Functions				
Pr5.12 Overload level[%]	0			
Pr5.13 Overspeed level[r/min]				
	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/Mir	n. positions or input a numeric value			
JOG speed[r/min]	60			
JOG acceleratio[ms/JOG speed]	50			
Servo-on Current position				
Minimum position [command unit] 0	Maximum position [command unit] 0			
				Next

#### **3.** Set the protection functions.

One Minute TUNING	_    ×
	Image: Setting         Execute tuning           Tuning results
Recall conditions            Paplications             Point of the distance of in a mechanism that causes the moving portion             Point of the distance of in a mechanism that causes the moving portion             Point of the distance of in a mechanism that causes the moving portion             Point of the distance of in a mechanism that causes the moving portion             Point of the distance of in a mechanism that causes             Point of the distance on the operating range when the setting scores             Point of the distance             Point of the distance <td>Advanced settings To perform funing using operation command settings and operation commands from the host device, or to change the required performance, perform setup using "Advanced settings".</td>	Advanced settings To perform funing using operation command settings and operation commands from the host device, or to change the required performance, perform setup using "Advanced settings".
	Next

• 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.

One Minute TUNING	_ 🗆 ×
	Execute tuning Tuning results
Recall conditions         Applications         Image: Conditions of the operating range when the serve is off.         Image: Conditions of the operating range when the serve is off.         Image: Conditions of the operating range when the serve is off.         Image: Conditions of the operating range when the serve is off.         Image: Conditions of the operating range when the serve is off.         Image: Conditions of the operating range when the serve is off.         Image: Conditions of the operating range when the server is operating range when the server is operating range.         Image: Conditions of the operating range when the server is operating range.         Image: Conditions of the operations of range and range conditions of the operating range.         Image: Conditions of the operations range.         Image: Conditions of the operations of the operations range.         Image: Conditions of the operations of the operations of the operations range.         Image: Conditions of the operations of the operations of the operations range.         Image: Conditions of the operations of the operating conditions of the operating conditions	Setting     Execute tuning     Tuning results
[command unit] [command unit] 0	
	Next

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

Sets the input operations for the over-travel inhibit inputs (POT, NOT).
#### **5.** Sets the operating range.

One Minute TUNING				_ 🗆 ×
		1	2	
		Setting	Execute tuning	Tuning results
Recall conditions			Advanced setting	15
Applications				using operation command settings and operation commands from the host device, or to change the ce, perform setup using "Advanced settings".
Positioning/general-purpose				
Do not use this function in a mechanism to deviate from the operating range whe	that causes the moving portion on the servo is off.			
* Two-degree-of-freedom control is enabled. To disable, it is necessary to change Pr6.47:bit and write to the driver.	0 from the setting screen			
Operating range setting				
Protection Functions				
Pr5.12 Overload level[%]	0			
Pr5.13 Overspeed level[r/min]				
	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				
	n. positions or input a numeric value			
JOG speed[r/min]	60			
JOG acceleratio[ms/JOG speed]	50			
Servo-on Operates of	only while the button is pressed.			
- direction 🕨 G	o to 0 + direction			
Current position	[command unit]			
	0			
Minimum position	Maximum position			
[command unit]	[command unit]			
-40000000	400000000			
				Next

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 <u>"Step 7"</u>.
  - 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 <u>"Advanced settings items</u>" below for details of advanced settings items. After completing the settings, go to <u>"3.1.2.4.3 Adjustment Operation"</u>.

When changing the settings of the tuning target during re-adjustment, also refer to <u>"3.1.2.5 Use Cases in Re-adjustment"</u> to change the settings.

One Minute TUNING		
		Setting         Execute tuning           Tuning results
Recall conditions		Advanced settings
Applications		To perform tuning using operation command settings and operation commands from the host device, or to change th
Positioning/general-purpose		required performance, perform setup using "Advanced settings".
Do not use this function in a mechanism that causes	the moving portion	> Detailed protection function
to deviate from the operating range when the serve		> Required performance
* Two-degree-of-freedom control is enabled.		> Tuning conditions
To disable, it is necessary to change Pr6.47:bit 0 from the and write to the driver.	setting screen	> Command condition
Operating range setting		
Protection Functions		
Pr5.12 Overload level[%] 0		
Pr5.13 Overspeed level[r/min] 120		
<b>√</b> Autom	atic setting (overspeed	
Pr5.14 Motor mova[0.1 rotation] 10		
Operation limit		
Pr5.04 Over-travel inhibit input s 1: CoE-sid	e (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 th	e button is pressed	
- direction 🕨 🕨 Go to 0	+ direction	
Current position [command	unit]	
0		
Minimum position	Maximum position	
[command unit] -40000000	[command unit] 40000000	
-4000000	40000000	
		Next

# **Advanced Settings Items**

Advanced settings for <u>"Step 7"</u>. Configure items as required.

After configuring the settings, go to <u>"3.1.2.4.3 Adjustment Operation"</u>.

Image: Control     Image: Control   Image: Control   Image: Control   Image: Control   Image: Control   Image: Control   Image: Control   Image: Control   Image: Control   Image: Control   Image: Control   Image: Control   Imag	ne Minute TUNING	- 0
Applications   ● Dostiloning/general-purpose   ▲ Do not use this function is a mechanism that causes the moving portion to devide freedom control is anabled.   > Nor-dagene of-freedom control is anabled.   O diable, it is notarge Pr6.47.bit 0 from the setting screen and write to the drive.   > Destitioning/general-purpose   ▲ Automatic setting (overspeed		2     3 Setting Execute tuning Tuning results
<ul> <li>Positioning/general-purpose</li> <li>Positioning/general-purpose</li> <li>Positioning/general-purpose</li> <li>Positioning/general-purpose</li> <li>Position the operating range when the serve is off.</li> <li>Position functions</li> <li>Position function and unit</li> <li>Position function and unit<!--</td--><td>Recall conditions</td><td>€ Advanced settings</td></li></ul>	Recall conditions	€ Advanced settings
<ul> <li>Do not use this function in a mechanism that causes the moving portion to deviate from the operating range when the servo is off.</li> <li>Debracking of Frédom control is mabled.</li> <li>Do diable, it is necessary to change Pr6.472bit 0 from the setting screen and write to the drive.</li> <li>Depreting range setting</li> <li>Protection functions</li> <li>Pr5.12 Overload level[95]</li> <li>Automatic setting (overspeed.</li> <li>Pr5.13 Overspeed level[/min]</li> <li>Automatic setting (overspeed.</li> <li>Pr5.14 Motor mova[0.1 rotation]</li> <li>Operating range</li> <li>Use JOG to move to the Max/Min. positions or input a numeric value</li> <li>JOG sceler/(JMI)</li> <li>Servor on</li> <li>Current position (mint position (command unit))</li> <li>Maximum position (command unit)</li> <li>Maximum position (command unit)</li> <li>Maximum position (command unit)</li> <li>Maximum position (command unit)</li> </ul>	Applications	To perform tuning using operation command settings and operation commands from the host device, or to change required performance, perform setup using "Advanced settings".
A bord use this function in a mechanism that causes the moving portion to deviate this function in a mechanism that causes the moving portion to deviate the the methanism that causes the moving portion to deviate the the methanism that causes the moving portion to deviate the strange when the several ingre several ingre when the several ingre several ingre when the several ingre		Detailed protection function
<ul> <li>* Non-degree-of-freedom control is enabled.</li> <li>To disable, it is necessary to change P6.47.bit 0 from the setting screen and write the diview.</li> <li><b>Detection Functions</b> <ul> <li>Pris.12 Overload level[%]</li> <li>0</li> <li>Pris.13 Overspeed level[/min]</li> <li>120</li> <li>I Automatic setting (overspeed</li> <li>Pris.14 Motor mova[0.1 rotation]</li> <li>10</li> <li>Operating range</li> <li>Use JOG to move to the Max./Min. positions or input a numeric value</li> <li>JOG speed[/min]</li> <li>60</li> <li>50</li> <li>Servor Operation [mst/DOG speed]</li> <li>Servor Operation [mst/DOG speed]</li> <li>Operates only while the button is pressed.</li> <li>- direction</li> <li>Current position [command unit]</li> <li>Maximum position [command unit]</li> </ul> </li> </ul>	Do not use this function in a mechanism that causes the moving portion	
To disable, it is necessary to khange P6.47.bit 0 from the setting screen and write to the drive: <b>Deperating range setting</b> Protection functions Pr5.12 Overload level[%] 0 Pr5.13 Overspeed level[/min] 120 Pr5.14 Motor mova[0.1 rotation] 10 Operating range Use /OG to move to the Max./Min. positions or input a numeric value J/OG speed[/min] 60 Operating range Use /OG to move to the Max./Min. positions or input a numeric value J/OG speed[/min] 60 Operating range Use /OG to move to the Max./Min. positions or input a numeric value J/OG speed[/min] 60 Operating range Use /OG to move to the Max./Min. positions or input a numeric value J/OG speed[/min] 60 Current position [command unit] Maximum position [command unit] [command unit]		
Operating range setting         Protection Functions         Pr5.12 Overload level[96]         0         Pr5.13 Overspeed level[97/min]         120         Image: Pr5.14 Motor mova[0.1 rotation]         10         Operating range         Use /GG to move to the Max/Min. positions or input a numeric value         J/GG sceleration[ms//JOG speed]         50         Servor-on         Image: Current position (command unit)         0         Iminum position (command unit)         Iminum position (command unit)		
Protection Functions Pr5.12 Overload level[76] 0 Pr5.13 Overspeed level[7/min] 120 Pr5.14 Motor mova[0.1 rotation] 10 Operation limit Pr5.04 Over-travel inhibit input s 1: CoE-side (CI/402) deceler V Operating range Use JOG to move to the Max/Min. positions or input a numeric value JOG sceleratio[ms/JOG speed] 50 Servo- on O O + direction Current position [command unit] Maximum position [command unit] Maximum position		
Pi5.12 Overload level[%] 0 Pi5.13 Overspeed level[/min] 120 ✓ Automatic setting (overspeed Pi5.14 Motor mova[0.1 rotation] 10 Operation limit Pi 5.04 Over-twoel hihbit input s 1: CoE-side (CIA402) deceler ✓ Operating range Use JOG to move to the Max/Min. positions or input a numeric value JOG acceleratio[m://OG speed] JOG acceleratio[m://OG speed] Servo- on O O enters only while the button is pressed. - direction o enterson Current position [command unit] Mainimum position [command unit]		
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 IOG to move to the Max./Min. positions or input a numeric value   IOG speed[/min]   60   JOG speed[/min]   JOG sceelertio[ms/IOG speed]   50   Servor-on   Current position [command unit]     Maximum position [command unit]		
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 IOG to move to the Max./Min. positions or input a numeric value   JOG speed[/min]   60   JOG speed[/min]   60   Servor-on   Current position [command unit]     Mainum position [command unit]     Mainum position [command unit]	Pr5 13 Overspeed level(r/min) 120	
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 IOG to move to the Max/Min. positions or input a numeric value IOG speed[/min] 60 IOG speed[/min] 60 Servo-on O O O Operation (ms/IOG speed] 50 Servo-on O O O Operation (ms/IOG speed] 50 Current position fcommand unit] Operation I Operation (ms/IOG speed] 50 Current position fcommand unit] Maximum position fcommand unit]		
Operation limit Pr5.04 Over-travel inhibit input s 1: CoE-side (CIA402) deceler  Operating range Use IOG to now to the Max/Min. positions or input a numeric value IOG speed[//min] 60 IOG acceleratio[ms/IOG speed] 50 Servo-on Granted on Gurrent position [command unit] Maximum position [command unit]		
Pi5.04 Over-travel inhibit input s 1: CoE-side (CI.402) deceler  Operating range Use JOG to move to the Max./Min. positions or input a numeric value JOG speed[/min] 60 JOG acceleratio[ms/JOG speed] 50 Servo-on Curren position [command unit]		
Operating range Use JOG to move to the Max/Min. positions or input a numeric value JOG speed[/min] 60 JOG acceleratio[ms/JOG speed] 50 Servo-on O O O erates only while the button is pressed. - direction Gorrand unit] Current position [command unit] Maximum position [command unit]		
Use JOG to move to the Max/Min. positions or input a numeric value JOG speed[/min] 60 JOG acceleratioms/IOG speed] 50 Servo-on O O O perates only while the button is pressed. - direction G o 0 + direction Current position [command unit] Maximum position [command unit]		
JOG speed[/min] 60 JOG acceleratio_[ms/JOG speed] 50 Servo-on O O O Perates only while the button is pressed. - direction		
Servo-on  Correct position formand unit Correct position		
Go to 0     the direction     Go to 0     the direction     Current position (command unit)     Command unit)     Command unit)     Command unit)	JOG acceleratio[ms/JOG speed] 50	
- direction Go to 0 + direction Current position (command unit) 0 Minimum position [command unit]	Service on Operates only while the button is pressed.	
Minimum position [command unit] [command unit]		
Minimum position [command unit] [command unit]	Current position [command unit]	
[command unit] [command unit]	•	
[command unit] [command unit]		
	4000000	

# Detailed Protection Function

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

<ul> <li>Detailed protection function</li> </ul>	
	?
Tuning vibration automatic suppression effective level[%]	
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 auto- matic suppression effec-	If oscillation does not subside when auto tuning is in progress, the gain is automatically lowered to stabilize.
tive level	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.
	<ul> <li>Precautions –</li> <li>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.</li> </ul>

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".
	<ul> <li>Precautions –</li> <li>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.</li> </ul>
Tuning JOG test run command speed	Sets the motor speed in [r/min] units when checking the movable range.
Tuning JOG test run ac- celeration and decelera- tion 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	O After completion of command transfer judgment
	O 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 deter- mines 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 con- dition	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.
	<ul> <li>Precautions –</li> <li>The deviation of the command position deviation relative to the command input before position command filter is calculated.</li> </ul>
	For details, see Operating Instructions (Overall) "3.2.8 Wiring to Connector X7 (Connecting to External Monitor)" .

# Tuning conditions

<ul> <li>Tuning conditions</li> </ul>	?	
RTAT machine stiffness setting at the start of the tuning	Set automatically	ĺ
Stability margin[%]	12 Emphasis on balance	]
Tuning step		
	Advance operation	
	Homing operation	
Tuning target		
	Inertia ratio	
	Unbalanced load compensation	
	Dynamic friction compensation	
	Viscous friction compensation	
	RTAT machine stiffness setting	
	RTAT FF stiffness setting	
	Load fluctuation suppression (disturban ON 🔵	
	Notch filter	
	1st damping filter	
	2nd damping filter	

Item	Description
RTAT machine stiffness	Configures the real-time auto-tuning machine stiffness setup for auto tuning startup.
setting at the start of the tuning	When tuning for the first time, do not change the setting and use by checking the "Set automatical- ly" 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%
	<ul> <li>Manual: The lower slide bar can be used to set any value.</li> </ul>
	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 opera- tions, 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	<ul> <li>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.</li> <li>— Precautions —</li> <li>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.</li> </ul>
	• When two-degree-of-freedom control mode is disabled, "Viscous friction compensation" is set to "OFF".

# Command conditions

<ul> <li>Command condition</li> </ul>	?
Is there an upper command?	● No O 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 com- mand?	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 move- ment	Sets the amount of movement when the motor operation pattern for command response measure- ment 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 <u>"Step 5"</u> .
	<ul> <li>Precautions –</li> <li>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.</li> </ul>

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.
	<ul> <li>Precautions –</li> <li>Set a value smaller than the over-speed level setup. If it is larger, an error occurs.</li> </ul>
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 re- sponse measurement in the automatic adjustment process is generated inside the driver.
	<ul> <li>Precautions –</li> <li>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.</li> </ul>

After configuring the settings, go to <u>"3.1.2.4.3 Adjustment Operation"</u>.

# 3.1.2.4.3 Adjustment Operation

# << Procedure >>

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

## – Precautions –

• If <u>"Step 5</u>" of <u>"3.1.2.4.2 Initial Settings</u>" is not set for the operating range, the [Next] button cannot be clicked.

One Minute TUNING	_ 🗆 ×
	Setting Execute tuning Tuning results
Recall conditions         Applications	Setting       Execute tuning       Tuning results         Image: 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".         Image: Detailed protection function       Image: Required performance         Image: Tuning conditions       Image: Command condition         Image: Command condition       Image: Command condition
direction     Go to 0     + direction     Current position [command unit]     Minimum position [command unit]     40000000	
	Next

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		-		×
	1     2     3       Setting     Execute tuning     Tuning results			
Start     Back       Adjustment start       Step 2 Advance operation       Step 3 Load characteristic measurement       Step 4 Stiffness measurement       Step 5 Command response measurement				
<ul> <li>Step 6 Homing operation</li> <li>Adjustment complete</li> </ul>				
		N	ext	

# One Minute TUNING Execute Tuning Screen

 Once auto tuning is started, the parameters are tuned based on the <u>"Step 2</u>" to <u>"Step 6</u>" settings of <u>"3.1.2.4.2 Initial Settings</u>" 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		_ 🗆 ×
	<b>1 2 3</b>	
	Setting Execute tuning Tuning results	
Stop Back		
Adjustment start		
Step 2 Advance operation		
✓ Step 3 Load characteristic measurement		
✓ Step 4 Stiffness measurement		
✓ Step 5 Command response measurement		
V Step 6 Homing operation		
Adjustment complete		
		Next

## **One Minute TUNING In Progress Screen**

## – Precautions –

- If an error occurs during operation, resolve according to the message. For details on error content, see <u>"7.6 List of Errors Related to One Minute TUNING"</u>.
- 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 <u>"3.2 Manual Tuning"</u>.
- 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		_ 0
	1 2 3 Setting Execute tuning Tuning results	
Start Back 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		
		Next

# One Minute TUNING Completion Screen

The tuning results screen is displayed.

					Setting Execute tuning Tuning results
	Name	Unit	Before tuni	After tuning	Load characteristic Inertia ratio: 0 [%]     Operation command during tuning Amount of movement: 33,554,432 [Command unit] Maximum speed: 1.959 [rpm]
Pr0.02	Real-time auto-gain tunin		1	0	Acceleration and deceleration time 122 [ms]
Pr0.04	Inertia ratio	%	250	0	■ Tuning performance Positioning complete (In-position) range: 8400 [Command unit] Settling time: 0 [ms] Overshoot amount: 724 [Command unit]
Pr0.27	Selection of machine stiffn		16	29	Detailed measurement results     Graph
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	

## 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.

					2     3 Setting Execute tuning Tuning results
	Name	Unit	Before tuni	After tuning	Load characteristic Inertia ratio: 0 [%]
Pr0.02	Real-time auto-gain tunin		1	0	<ul> <li>Operation command during tuning Amount of movement: 33,554,432 [Command unit] Maximum speed: 1,959 [rpm] Acceleration and deceleration time 122 [ms]</li> </ul>
Pr0.04	Inertia ratio	%	250	0	■ Tuning performance Positioning complete (In-position) range: 8400 [Command unit] Settling time: 0 [ms] Overshoot amount: 724 [Command unit]
Pr0.27	Selection of machine stiffn		16	29	Detailed measurement results     Graph
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	

#### **One Minute TUNING Results Screen**

# << Procedure >>

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

e Minute	e TUNING				- 0
					Setting Execute tuning Tuning results
	Name	Unit	Before tuni	After tuning	■ Load characteristic Inertia ratio: 0 (%)
Pr0.02	Real-time auto-gain tunin		1	0	<ul> <li>Operation command during tuning Amount of movement: 33,554,432 [Command unit] Maximum speed: 1,959 [rpm] Acceleration and deceleration time 122 [ms]</li> </ul>
Pr0.04	Inertia ratio	%	250	0	■ Tuning performance Positioning complete (In-position) range: 8400 [Command unit] Settling time: 0 [ms] Overshoot amount: 724 [Command unit]
Pr0.27	Selection of machine stiffn		16	29	Detailed measurement results     Basic information
Pr0.28	Selection of feed forward		16	31	Just mornator     Tuning conditions
Pr1.00	1st gain of position loop	0.1/s	480	1850	Load characteristic
Pr1.01	1st velocity loop gain	0.1Hz	270	1025	Operation command     Tuning performance
Pr1.02	1st velocity loop integrati	0.1ms	210	70	> Protection Functions
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	> Graph
	1		1	I_	

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
	<ul> <li>Motor speed (maximum)</li> </ul>
	<ul> <li>Motor speed (minimum)</li> <li>Motor speed (minimum)</li> </ul>
	Torque command (maximum)
	Torque command (minimum)
	<ul> <li>Position deviation (maximum)</li> </ul>
	<ul> <li>Position deviation (minimum)</li> </ul>
	Fine vibration count
	INP change count at settling time
	Regenerative load factor
<u> </u>	

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

 To save the settings and information on the adjustment process (<u>"3.1.2.4.2 Initial Settings"</u> to <u>"3.1.2.4.3 Adjustment Operation"</u>) 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.

One Minut	e TUNING				_ 🗆 ×
					1     2     3       Setting     Execute tuning     Tuning results
	Name	Unit	Before tuni	After tuning	Load characteristic Inertia ratio: 0 [%] Operation command during turning Amount of movement: 33,554,432 [Command unit] Maximum speed: 1.959 [rpm]
Pr0.02	Real-time auto-gain tunin		1	0	<ul> <li>Operation command during tuning. Amount of movement: 33,554,452 [Command unit]. Maximum speed: 1,959 [rpm] Acceleration and deceleration time 122 [ms]</li> </ul>
Pr0.04	Inertia ratio	%	250	0	■ Tuning performance Positioning complete (In-position) range: 8400 [Command unit] Settling time: 0 [ms] Overshoot amount: 724 [Command unit]
Pr0.27	Selection of machine stiffn		16	29	Detailed measurement results     Graph
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	
					Save results Complete

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.

			$\times$
Tuning will be finished. Are you sure you want to stop real-time	auto-tuning and wr	rite the adjusted para	meters to EEPROM?
	Yes	No	Cancel

## 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 <u>"Advanced</u>" (<u>"3.1.2.4.2 Initial Settings"</u> (<u>"Step 6"</u> 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 mov- ing part was changed.	Settings such as inertia ratio and machine stiffness require re-adjusting due to inertia fluctuations.	<ul> <li>Inertia ratio</li> <li>RTAT machine stiffness setting</li> <li>RTAT FF stiffness setting</li> <li>Load fluctuation suppression</li> <li>Notch filter</li> </ul>
Vibration as a result of a change in position.	Re-adjust damping control (damping filter) to suppress vibration.	<ul> <li>RTAT FF stiffness setting</li> <li>Load fluctuation suppression</li> <li>1st damping filter</li> <li>2nd damping filter</li> </ul>
Abnormal noise occurred due to aging.	Re-adjust the notch filter to suppress me- chanical resonance.	<ul><li>Load fluctuation suppression</li><li>Notch filter</li></ul>

## 3.1.3 precAlse 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 fluctua- tion control function	<ul> <li>The load fluctuation control function is enabled and load fluctuation compensation gain is 90 % or more</li> <li>Load fluctuation control function disabled</li> </ul>
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)
  - Al 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 *<u>"Initial settings"</u> ("Step 2")* in the usage instructions

## 3.1.3.4 Usage

Instructions for use are described according to the following steps.

- 1 <u>"Starting the Tuning Function"</u>
- 2 <u>"Initial Settings</u>"
- 3 <u>"Adjustment Operation"</u>
- 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.

8	<i>y</i>									
	File(F)	Troubleshooting(T)	Help(H)							_
			E Device tree			ôð Setting	嬰 Monitor	比 Logging	🕞 Tuning	🚺 Device Info 💐
		-	MINAS A7BR				EtherCAT object	IO Setting	Alarm	Analog input
d	₽∨	Online	Axis0_No name set	SRV-OFF						
		USB	MADN085BRU 23080001			Open file	Save file	Copy Load initia	values Load	Write
		u.	MINAS A7BR	Encoder Info 39405786 pulse				Config Reset		column 4
		(4)	MHMG022U1A2 24020001		•	Search	Compa	rison None	Add/delete of	olumn
						Switch to HEX input	Display A6-compati	ible control parameters	Allow out-of-range setting	ngs

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



The "precAIse TUNING" settings screen is displayed.

recAlse TUNING												
				0		2	3					
				Setting	Execute	e tuning	Tuning results					
Load tuning conditions	Check past results	Tuning based or	n past history Save	tuning condi	tions							
<ul> <li>Evaluation method setti</li> </ul>	ng					V Con	dition setting					
Evaluation target	Servo data	~	Advanced sensor se	tting:		Comma	nd input mode	Он	ost device			
Evaluation data compensation	tion Offset amount			[96]				P#	NATERM trial run	Trial	run pattern settings	]
	Average number	of points moved										
Evaluation metric	Settling width		8400	Com	mand unit							
	Settling time		0.000	[ms]								
Evaluation time/operation	count O Evaluation ti	me		(min)								
	Operation of the ope	ount	1000	[time	s]							
Measurement item	Evaluation target	Edit	Sampling cycle (ms)	0.7500			Measurement tin	ne (ms) 7	67.25			
Position command speed Torque command[%]			Trigger condition 1 o	or 2 🗸	Trigger p	osition 1,	/8 ¥					
Command position deviat Analog input[V]	ion[Command unit]	•		Target			Level			Slope	F	lter
Encoder position deviatio	n[Encoder unit]	_				50 Rising up -50 Falling down		~	No use	~		
			ingger z Position co	mmand speed	d[r/min] ~	-50			railing down	•	INO USE	
<ul> <li>Parameter setup</li> <li>Parameter class</li> </ul>	All parameters	✓ (i) Depe	ending on parameter s ectly.	ettings, AI set	values may r	iot be refle	cted or the motor n	nay oscill	ate. See the Techn	ical Reference to ensu	ire that each control	function operates
Tuning target Class No.	Name			Unit	Initial Valu	ie	Tuning range			Tuning step width		
✓ 0 27	Selection of machine st	iffness at real-time	e auto-gain tuning 2		29		0	~ 4	4	1		
Pr0.27 Selection of ma nput range: 0 - 44 When Pr2.45 "Function exp			gain tuning 2									
												Go to tuning

#### 3.1.3.4.2 Initial Settings

#### << Procedure >>

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

Go to <u>"Step 2"</u>.

• To use the contents of a previously saved configuration file

Perform one of the following operations before proceeding to <u>"Step 3"</u>.

• 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.

### precAlse TUNING Settings Screen

Verder mesereret conditions   • Verder medice     • Verder medice     • Verder meseretet conditions     • Verder meseretet     • Verder meseretet <th>precAlse TUNING</th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th></th> <th>×</th>	precAlse TUNING								×
V Faluation method setting V Faluation target Evaluation target Evaluation target Evaluation data compensation Offset amount Offset amount Offset amount Image: Command input mode Parameter setup Parameter data V Waveform measurement conditions Measurement time [ms] 767.25 Trigger 1 Position command speed[//min] V Barenter setup Parameter setup Parameter setup Parameter setup Parameter setup Parameter class Mal parameters at real-time auto-gain tuning 2 V Market on target on the statement tuning 10 meanuter settings. At set values may not be reflected or the motor may outcille. Set the Target on the statement tuning 10 meanuter settings. At set values may not be reflected or the motor may outcille. Set the Target on the statement tuning 10 meanuter settings. At set values may not be reflected or the motor may outcille. Set the Target on the statement tune 10 meanuter settings. At set values may not be reflected or the motor may outcille. Set the Target on the statement tune 10 meanuter settings. At set values may not be reflected or the motor may outcille. Set the Target on the statement tune 10 meanuter settings. At set values may not be reflected or the motor may outcille. Set the Target on the statement tune 10 meanuter settings. At set values may not be reflected or the motor may outcille. Set the Target on the statement tune 10 meanuter settings. At set values may not be reflected or the motor may outcille. Set the Target on the statement tune 10 meanuter settings. At set values may not be reflected or the motor may outcille. Set the Target on the statement tune 10 meanuter settings. At set values may not be reflected or the motor may outcille. Set the Target on the statement tune 10 meanuter settings. At set values may not be reflected or the motor may outcille. Set the Target on			1 Setting Exect	2 3 ute tuning Tuning results					
Evaluation target Servo data   Evaluation data compensation   Offset amount   0   Average number of points moved   1   Evaluation metric   Setting time   0000   (ms)   Evaluation time/operation count   0   0   0   0   0000   (ms)   Evaluation time/operation count   0   0   0   0   0   0   0   0   0   0   0   0   0   1   1   0    0   0   1    1    1    0    0   1   1   1    1    0    0   1   1    1	Load tuning conditions Check past results Tuning base	d on past history Save t	uning conditions						
Evaluation data compensation Offset amount   0 [Pk]   PANATERM trial run Trial run pattern settings Average number of points moved I Evaluation metric Setting time 0.000 (ms) Evaluation time/operation count Evaluation time 0 Operation count 1000 (times) Versement item Evaluation target Etal Setting option Trigger option Trigger option Trigger option Trigger option Trigger option deviation Encoder unit! Parameter dess All parameters Operating on parameter settings, Al set values may not be reflected or the motor may oscillate. See the Technical Reference to ensure that each control function operates Versemeter dess All parameters at real-time auto-gain tuning 2 Pro2.7 Selection of machines at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of machines stiffness at real-time auto-gain tuning 2 Pro2.7 Selection of mach	<ul> <li>Evaluation method setting</li> </ul>			✓ Condition setting					
Average number of points moved   Evaluation metric   Setting time   0.000   (ms)   Evaluation time/operation count   Calculation time/operation count   Implicit count   Vereform measurement conditions   Measurement time   Position command speed[/mini)   Torque command[%]   Command position deviation[Command unt]   Avalog input(%)   Rising up   No use   Figger 1   Position command speed[/mini)   Torque command[%]   Command position deviation[Command unt]   Avalog input(%)   Avalog input(%)   Parameter dass   All parameters   Operation or machine stiffness at real-time auto-gain tuning 2   Operation of machine stiffness at real-time auto-gain tuning 2   Imput range: 0 - 24   When P2.25 Selection of machine stiffness at real-time auto-gain tuning 2   Imput range: 0 - 44   When P2.25 Selection of machine stiffness at real-time auto-gain tuning 2   Imput range: 0 - 44   When P2.25 Selection of machine stiffness at real-time auto-gain tuning 2   Imput range: 0 - 44	Evaluation target Servo data	Advanced sensor sett	ing	Command input mode	Он	ost device			
Evaluation metric Setting width   Setting time 0.000   minil   Setting time   Operation court   Imminil   Imminil <td>Evaluation data compensation Offset amount</td> <td></td> <td>[96]</td> <td></td> <td>● P/</td> <td>ANATERM trial run</td> <td>Trial</td> <td>run pattern settings</td> <td></td>	Evaluation data compensation Offset amount		[96]		● P/	ANATERM trial run	Trial	run pattern settings	
Setting time   Setting time   Setting time   Operation count   Operation count   1000   timesj     V Waveform measurement conditions   Measurement item   Evaluation target   Edit   Sampling cycle [ms]   Operation count   1000   timesj     V Waveform measurement conditions   Measurement item   Evaluation target   Edit   Sampling cycle [ms]   Organ command speed[r/min]   Command opsicin deviation[Command unit]   Analog input(Y)   Encoder position deviation[Encoder unit]   Target   Ipger 1   Position command speed[r/min]   Sope   Filter   Trigger 2   Position command speed[r/min]   Sope   Tingger 2   Position command speed[r/min]   Sope   Timing target Class   No. Name   Toring target Class   No.	Average number of points mov	red 1							
Evaluation time/operation count       10       Imin]         Waveform measurement conditions         Measurement item       Evaluation target       Edit         Position command speed[//min]       Trigger condition [16        Measurement time [ms] 767.25         Torque command (%)       Trigger condition [1 or 2        Trigger position [78]         Command position deviation[Command unit]       Trigger 1       Position command speed[//min]       50         Encoder position deviation[Command unit]       Trigger 2       Position command speed[//min]       50         Encoder position deviation[Command unit]       Trigger 2       Position command speed[//min]       50         Parameter setup       Parameter setup       Position command speed[//min]       -50       Falling down       No use         V Parameter class       All parameters       ①       O perading on parameter settings. Al set values may not be reflected or the motor may oscillate. See the Technical Reference to ensure that each control function operates         Tuning target       Class No       Name       Unit       Initial Value       Tuning target       Tuning step width         0       0       7       Selection of machine stiffness at real-time auto-gain tuning 2       29       0       - 44       1         Pr0.275 Selection of machine stiffness at real-time auto-gain tuning 2	Evaluation metric Settling width	8400	Command unit						
Operation count   1000 ttimes]   Waveform measurement conditions   Measurement item E valuation target   Measurement item E valuation target   Postion command speed[//min] Target   Torque command (%) Command operation deviation[Command unit]   Analog input(V) Target   Encoder position deviation[Encoder unit] Position command speed[//min]   50 Rising up   No use V   Parameter setup Parameter class   All parameters Depending on parameter settings, Al set values may not be reflected or the motor may oscillate. See the Technical Reference to ensure that each control function operates   V Postection of machine stiffness at real-time auto-gain tuning 2   0 27   Selection of machine stiffness at real-time auto-gain tuning 2   1000 29   0 44	Settling time	0.000	[ms]						
<ul> <li>✓ Waveform measurement conditions</li> <li>Measurement item          <ul> <li>Edt</li> <li>Sampling cycle [ms]</li> <li>7,7500</li> <li>Measurement item [ms]</li> <li>767.25</li> </ul> </li> <li>Position command speed[//min]</li> <li>Torque command [%]</li> <li>Command opsition deviation [Command unit]</li> <li>Analog input(V)</li> <li>Encoder position deviation[Command unit]</li> <li>Position command speed[//min]              </li></ul> <li>50</li> <li>Rising up              <ul> <li>No use</li> <li>Rigger 2</li> <li>Position command speed[//min]                  </li> </ul> </li> <li>Parameter setup</li> <li>Parameter setus</li> <li>Parameter setus</li> <li>O pepending on parameter settings; Al set values may not be reflected or the motor may oscillate. See the Technical Reference to ensure that each control function operates correctly.</li> <li>Iming target Class No. Name         <ul> <li>Intial Value</li> <li>Tuning target</li> <li>Com and speed[//min]</li> <li>Selection of machine stiffness at real-time auto-gain tuning 2</li> <li>29</li> <li>- 44</li> <li>Intial value</li> <li>Intial value</li> <li>Intial value</li> <li>Intial value</li> <li>Intial value</li> <li>Intial value</li> <li>- 44</li> <li>Intial value</li> <li>- 44</li></ul></li>	Evaluation time/operation count O Evaluation time		[min]						
Measurement Item       • Evaluation target       Edit       Sampling cycle [ms]       0.7500       Measurement time [ms]       767.25         Position command speed[//min]       Torque command [%]       Image: Command	Operation count	1000	[times]						
Torque command [%]       Trigger condition [1 or 2 v Trigger position 1/8 v         Command position deviation[Command unit]       Trigger condition [1 or 2 v Trigger position 1/8 v         Encoder position deviation[Encoder unit]       Filter         Prostion command speed[//min] v       50         Rising up v       No use v         V       Parameter setup         Parameter class       All parameters v         O       Depending on parameter settings, Al set values may not be reflected or the motor may oscillate. See the Technical Reference to ensure that each control function operates         Turing target       Class         No.       Name         V       Selection of machine stiffness at real-time auto-gain tuning 2         Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2       0         Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2       0         Pr0.27 Selection of parameter set up 10° bit 5 = 1,       Image: 0 - 44	Measurement item	Sampling cycle [ms] 0	.7500	Measuremen	nt time [ms] 7	767.25			
Analog input(V) Encoder position deviation[Encoder unit]  Trigger 1 Position command speed[//min]   Trigger 2 Position command speed[//min]   So Rising up  No use  Parameter setup Parameter setup Parameter setus Iuning target Class No. Name Unit Initial Value Unit Initial Value Tuning range Unit Initial Value Initial Va	Torque command[%]	Trigger condition 1 or	2 🗸 Trigger	position 1/8					
Intercoder position deviation!       Trigger 2       Position command speed[//min]       50       Falling down       No use          V       Parameter setup       Parameter setup       Depending on parameter settings. Al set values may not be reflected or the motor may oscillate. See the Technical Reference to ensure that each control function operates         Tuning target       Class       No.       Name       Unit       Initial Value       Tuning range       Tuning step width         V       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       1       1       1       1         Unit turing transpector of machine stiffness at real-time auto-gain tuning 2       1       1       1       1         Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2       1       1       1       1       1         When Pr2.45 'Function expansion setup 10' bit 5 = 1,       .       .       .       .       .       .		Tringer 1 Devision and							
Parameter setup Parameter setup Parameter class     All parameters     Depending on parameter settings, Al set values may not be reflected or the motor may oscillate. See the Technical Reference to ensure that each control function operates     Tuning target Class No. Name     Unit Initial Value     Tuning range     Tuning step width     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2     Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2	Encoder position deviation/Encoder unit	1							
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       1       1       1       1         Input range 0       - 44       1       1       1       1       1       1         When Pr2.45       Function expansion setup 10° bit 5 = 1,       1       1       1       1       1		Parameter setup      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							
Pr0.27 Selection of machine stiffness at real-time auto-gain tuning 2 nput range 0 - 44 When Pr2.45 "function expansion setup 10" bit 5 = 1,							Tuning step width		
nput range: 0 - 44 When Pr2:45 "Function expansion setup 10" bit 5 = 1,	0 27 Selection of machine stiffness at real-	ime auto-gain tuning 2	29	0	~ 4	44	1		
Go to tuning	Input range: 0 - 44	to-gain tuning 2							
								Go to tur	ning

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

# Evaluation method setting

<ul> <li>Evaluation method setting</li> </ul>			
Evaluation target	Servo data 🗸 🗸	Advanced sensor setting:	
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	O Evaluation time	10	[min]
	Operation count	1000	[times]

● is [Me Wh Wh is s var	s automatically assig easurement items]. hen "Servo data" is s hen "Analog sensor" i	elected, the target data is selected, the target d	arget in [Waveform									
[Me Wh Wh is s var	easurement items]. hen "Servo data" is so hen "Analog sensor" i selected, click the [Ad	elected, the target data is selected, the target d		measurement conditions] -								
Wh is s var	hen "Analog sensor" i selected, click the [Ad	is selected, the target d	is command positi	• is automatically assigned to the evaluation target in [Waveform measurement conditions] - [Measurement items].								
is s var	selected, click the [Ad		When "Servo data" is selected, the target data is command position deviation.									
~		0		nput. When "Analog sensor' specifications from the "Ad								
	· Evaluation method setting											
Ev	valuation target	Analogue sensor 🗸	Advanced sensor setting:									
Ev	valuation data compensation	Offset amount	10	[%]								
		Average number of points moved	9									
Ev	valuation metric	Settling width	0.000	[V]								
		Settling time	0.000	[ms]								
E	valuation time/operation count	O Evaluation time	10	[min]								
		<ul> <li>Operation count</li> </ul>	1000	[times]								
				settings screen.								
It		between the analog output volta for the analog input value IVI co		×								
It	t register the correspondence	between the analog output volta for the analog input value [V] co		×								
It	t register the correspondence and calculate the tuning range			× neasured value,								
It	t register the correspondence and calculate the tuning range	for the analog input value [V] co	nversion.	× neasured value,								
It	t register the correspondence Ind calculate the tuning range Sensor specifications	for the analog input value [V] co Measured value [mm]	Analog output vo	× neasured value,								
lt ar	t register the correspondence ind calculate the tuning range Sensor specifications Maximum value	for the analog input value [V] co Measured value [mm] 1.0000	Analog output vo	× neasured value,								
lt ar	t register the correspondence and calculate the tuning range Sensor specifications Maximum value Minimum value	for the analog input value [V] co Measured value [mm] 1.0000	Analog output vo	× neasured value,								
lt ar	t register the correspondence and calculate the tuning range Sensor specifications Maximum value Minimum value Evaluation metric	for the analog input value [V] co Measured value [mm] 1.0000 -1.0000	Analog output vo	× neasured value,								

Item	Description					
Evaluation data com- pensation	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 set- ting 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/opera-	Sets the upper limit for the operation count or evaluation time.					
tion count	– Precautions –					
	<ul> <li>In the current version of Set-up Support Software (PANATERM ver.7), only "operation count" can be selected.</li> </ul>					
	<ul> <li>The actual operation count will be less than the set operation count due to the adjust- ment algorithm.</li> </ul>					
	The set upper limit value is displayed in the operation count [times] denominator on the Execute Tuning screen.					

## Waveform measurement conditions

<ul> <li>Waveform measurement conditions</li> </ul>								
Measurement item	Edit Sampling cycle [ms] 0.25	Measurement time [ms] 25	55.75					
Position command speed[r/min] Torque command[%] Command position deviation[Command unit]	Trigger condition 1 or 2 V Trigge	Trigger condition 1 or 2 V Trigger position 1/8 V						
Analog input[V]	Target Trigger 1 Position command speed[r/min]	Level	Slope	Filter				
Encoder position deviation[Encoder unit]		× -50						
Item		Description						

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	<ul> <li>See Set-up Support Software (PANATERM ver.7) Operating Manual.</li> <li>Precautions — <ul> <li>Set the sampling cycle so that the evaluation metric (settling time) can be determined within the measurement time.</li> </ul> </li> </ul>

# Parameter setup

<ul> <li>Parameter s</li> </ul>	✓ Parameter setup									
Parameter class 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										
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	
	4	01	Antonin lana min	0.111-	1025	4		20767	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.										
when Pf2.45	runctio	on exp	parision setup to coils 5 and 4 = 11b, the feedforward stillness is	set when real-t	ume auto tuning is ex	ecutea.				

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

<ul> <li>Condition setting</li> </ul>					
Command input mode	O Host device				
	PANATERM trial run     Trial run pattern settings				
Item	Description				
Command input mode	Set the command generation means.				
	<ul> <li>Precautions –</li> <li>In the current version of Set-up Support Software (PANATERM ver.7), only "PANA- TERM trial run" can be selected.</li> </ul>				

# Configure the advanced settings from the [Trial run pattern settings] button.

# Condition setting - Trial run pattern settings screen

Trial run patte	ern settings								×
			6		2				
			Tuning s	ettings Op	peration settings				
Protection F	unctions								
Pr5.12 Ove	erload level[%]	0	Operation No.	Start position	End position [Command unit]	Amount of movement [Command unit]	Target speed [r/min]	Acceleration and deceleration time [ms]	Operatin
Pr5.13 Ove	erspeed level[r/min]	120	1	0	0	0	1	1	
		Automatic setting (overspeed lev	)						
Pr5.14 Mot	tor movable[0.1 rotation]	10				(2)			
Operation li	mit					(2)			
Pr5.04 Ove	er-travel inhibit input setup	1: CoE-side (CiA402) deceleratio 🗸							
Operating Use JOG		ositions or input a numeric value							
JOG spee	ed[r/min]	60							
JOG acce	leration a[ms/JOG speed]	50							
Servo-on ( Minimum   [command	- direction G Current position position J unit	while the button is pressed. to to 0 + direction [command unit] Maximum position [command unit] 0 shooting							
								To trial run pattern	settings
(1)	Set the prote	ctive function and ope	rable rang	e for trial	run.				
(2)	The paramet	ers of the operation co	mmand fo	r which th	e respon	se is to be ev	aluated	are displayed.	
· /		the [To trial run patterr							atina
		n (1), and then click th						ave when the opera	ang

Trial run pattern settings									×
				1	2				
			Tuni	ng settings Oper	ation settings				
Protection Functions Pr5.12 Overload level[%] 0									Add Delete
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
Servo-on  C Operates according to the operation pattern  C Operation  C Operation									
Back									End

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 <u>"Step 1"</u> or <u>"Step 2"</u>, 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.

Setting Execute Luning Tuning results					
Load tuning conditions Check past results Tuning based on past history Swe tuning conditions					
Veraluation method setting     Condition setting					
Evaluation target Servo data V Advanced sensor setting: Command input mode O Host device					
Evaluation data compensation Offset amount 0 (%) Offset amount Trial run pattern settings					
Average number of points moved					
Evaluation metric Settling width B400 Command unit					
Setting time 0.000 [ms]					
Evaluation time/operation count O Evaluation time 10 [min]					
O Operation count     1000     [times]					
Waveform messurement conditions      Measurement item     Veluation target     Edit     Sampling cycle (ms] 0.75.00      Measurement time [ms] 767.25      Torque command[%]     Tigger condition 1 or 2 v Tigger position 1/8 v					
Command position deviation[Command unit]					
Analog input/Y Trigget 1 Position command specify/min) v 50 Reing up v Noue	~				
Trigger 2     Position command speed[//min]      -50     Falling down     No use	~				
Parameter setup Parameter setup Parameter setup Quantum dass All parameters Quantum dass All parameters Quantum dass					
Tuning target Class No. Name Unit Initial Value Tuning range Tuning step width					
Image: Constraint of the start and	_				
Pr0.28 Selection of feed forward stiffness at real-time auto-gain tuning					
Input range 0 - 44					
60 to 1	ning				

The screen switches to the Execute Tuning screen.

precAlse TUNING			×
	1 2 3 Setting Execute tuning Tuning results		
Settling time measurement data	Parameters		Waveform graph
Execute tuning Progress	Current operating conditions	100 -	100
Start Stop Status Elapsed time Operation count [h:mm]	Operation No.	0	
	Operation direction		90
Before tuning 000 /0	Amount of movement [Command unit]	0 90 -	90 -
Attempts [times] Select to check the settling time.	Max speed [r/min]	0	
Settling time[ms] Attempts [times]	Acceleration and deceleration time [ms/Max speed]	] 0 80 -	80 -
Current evaluation value	Display only parameters with differences		
- 🔶 Best evaluation value -	Name Unit Current	: 🔶 Best 70 -	70 -
Reset display range	Number of trials Times 0	0	
		60 -	- = 60 -
		eform [ – ]	eq [1/
			ds p
0.8	1	50 - 50	50 -
		Evaluation	ion co
		40 -	- 50 40 -
2000			
		30 -	30 -
B.0.4			
		20 -	20 -
0.2			
		10 -	10 -
0			
0 0.2 0.4 0.6 0.8 1 Number of trials [times]		0 -	0 20 40 60 80 100
rumoer or unas (unies)			0 20 40 60 80 100 Elapsed time[ms]
Back			Go to result

Go to <u>"3.1.3.4.3 Adjustment Operation"</u>.

### 3.1.3.4.3 Adjustment Operation

### << Procedure >>

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



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.

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 🗸
JOG speed[r/min] JOG acceleration and dece[ms/JOG speed	60 4] 50
	the button is pressed.
- direction	So to 0 + direction
Minimum position [command unit]	Maximum position [command unit]
	Maximum position [command unit] 400000

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



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 meas- urement 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 re- sults 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.



The tuning results screen is displayed.

## 3.1.3.4.4 Confirming Tuning Results, Ending precAlse TUNING

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



### precAlse TUNING Results Screen

(1)	Settling time meas-	The settling time transition in the adjustment process is displayed.
urement data		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 ad- justment process and the parameters for the selected settling time measurement data are dis- played.
(3)	Waveform graph of	The measurement data (time-series data) for the selected trial is displayed.
	selected data	When multiple operation commands are set in the operational conditions settings, measure- ment 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 precAlse 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.

- <u>"3.2.1.3.1 Tuning in Position Control Mode"</u>
- <u>"3.2.1.3.2 Tuning in Speed Control Mode"</u>
- <u>"3.2.1.3.3 Tuning in Torque Control Mode"</u>
- <u>"3.2.1.3.4 Tuning in Full-closed Control Mode"</u>

#### 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 <u>"7.2.1 Position Control Mode Block Diagram"</u>.

Refer to the following procedure for reference when tuning.

#### << Procedure >>

1. After tuning using an automatic tuning function, go to <u>"Step 3"</u>. When starting new tuning, configure initial settings for the parameters.

Reset the following parameters to the initial values. For initial values, see <u>"7.1 List of Parameters"</u>.

- 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 <u>"Step 5"</u>.

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 <u>"Step 5"</u>.

### – 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  $[Hz] \times 4 \ge$  speed loop gain [Hz]
  - The torque filter cut-off frequency can be obtained using the following formula.

Cut-off frequency [Hz] =  $1/(2 \pi \times Pr1.04$  "1st torque filter time constant" [0.01 ms]  $\times$  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

 $1,500,000 / (2 \pi \times Pr1.01 "1st velocity loop gain" [0.1 Hz])$ 

#### **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 <u>"Step 9</u>", and then go back to <u>"Step 4</u>" 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 <u>"Step 4"</u> 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) fre- quency 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 con- firm 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 <u>"3.2.1.3.1 Tuning in Position Control Mode"</u>. Tune parameters excluding the Pr1.00 "1st gain of position loop" setting in accordance with the <u>"3.2.1.3.1 Tuning in Position Control Mode"</u> procedure.

For speed control mode block diagram, see <u>"7.2.2 Speed Control Mode Block Diagram"</u>.

#### 3.2.1.3.3 Tuning in Torque Control Mode

In torque control, Pr3.21 "Velocity limit value 1" and Pr3.22 "Velocity limit value 2" act as speed limits to control the rotational velocity of the motor so that it does not exceed the speed limit value.

For a block diagram on torque control, see <u>"7.2.3 Torque Control Mode Block Diagram"</u>.

Details on setting speed limit values are provided below.

• Setting speed limit values

The setup method differs with Pr3.17 "Selection of speed limit".

Pr3.17 "Selection of speed limit"	Setup method
0	Pr3.21 "Velocity limit value 1"
1	SL_SW = 0:Pr3.21 "Velocity limit value 1"
	SL_SW = 1:Pr3.22 "Velocity limit value 2"

For details on RTEX communication command SL\_SW (speed limit switching command), see Technical Reference Communication Specification.

When the motor speed reaches the speed limit value, it switches from torque control via torque commands to speed control via speed limit values in the form of commands.

To ensure stable operation even when there are speed limits, it is necessary to set parameters according to <u>"3.2.1.3.2 Tuning in Speed Control Mode"</u>.

In the following cases, input to torque limit sections may be lower, possibly causing torque output to differ from torque commands.

- The speed limit value is too low.
- Speed loop gain is too low.
- The speed loop integral time constant is set to 1000 (disabled).

#### 3.2.1.3.4 Tuning in Full-closed Control Mode

In full-closed control, the same procedure as for <u>"3.2.1.3.1 Tuning in Position Control Mode"</u> 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 <u>"7.2.4 Full-closed Control Mode Block Diagram"</u>.

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.

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

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  $1/40 \leq$  External scale ratio  $\leq 20480$  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.



The "Manual TUNING" settings screen is displayed.

6					PANAT	ERM ver.7			– 🗆 X
	File(F) Tro	ubleshooting(T) Help(H)							
Device	ŝ	Setting 🛛 🛱 Monitor	ŀά ιο	ogging	프 <mark>은</mark> Tuning	Device Info	1	Trial run	Z-phase search
e tree	<	Manual TUNING		<ul> <li>Graph</li> <li>Wave graphic</li> </ul>	c Frequency response		rial run/Z-	1 Limit setting	2 Trial run
	Ba Damping Mode sett (i) Wher <u>A7 recon</u> (i) Wher	sic     Load characteri     Notch settings       1 settin     Application     Manual       ng ()     O:Disabled        Customize settings     I aunching for the first time immended settingis recommended        upgrading from A&A6 compatibility setting		Start measurement       Stop       Single trigger       Acquire         Measurement data management       Edit display range       Fixed display range         Reset zoom       Align with center of Y-axis         Display as elapsed time       Display as time standard       Load file         Save file			hase search	Protection Functions Pr5.12 Overload level[%] Pr5.13 Overspeed level[r/min] Pr5.14 Motor mova(0.1 rotation] Operation limit Pr5.04 Over-travel inhibit input s	
•	Inertia ra For more Gain settin Feedback Speed re	cteristic settings Automatic settingOFF io 0 advanced settings <u>Load characteristic settings</u>	•	✓ Graph display settings Operating range					n. positions or input a numeric value
	Overshoe Notch filte 3rd notch	l command smo 0.8 ot suppression [%] - 100.0 +	[	Start measurem     Measurement mode     With Position C <ul> <li>Measurement count</li> <li>Trial No.</li> <li>Settling time</li> <li>INP change count</li> <li>Vibration level</li> <li>Effective load factor</li> <li>Takt</li> <li>[%]</li> </ul> Takt     Takt <td< td=""><td>ct</td><td colspan="2">(3) Servo-on O Operates only while the button is pressed. - direction o o + direction Current position (command unit)</td></td<>			ct	(3) Servo-on O Operates only while the button is pressed. - direction o o + direction Current position (command unit)	
	For more Damping 1 1st damp For more a What if I h Refer to	advanced settings Notch settings				(2)		Minimum position [command unit]	Maximum position (command unit) 0 (command unit) 0 To trial run
_									
	(1)	This is the main screen. T	his	s displa	ys the param	eter tuning screen.			
	(2)	This displays the wavefor	mι	measur	rement and fre	equency response mea	sure	ement screens.	
	(3)	3) This displays the trial run operation screen.							

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

Selected driver:Axis0_No nan	Manual TUNI ne set	NG - <mark>(8)</mark>		
Basic	Load characteristic	settings	Notch settings	
Damping settings	Applicatior	ו	Manual	
Mode setting (i)	7:Cus	tomize2		
	Cust	omize set	tings	
i When launching for the f When upgrading from A				
Tuning conditions	💿 Pc	Positioning/general-purpose		
	O Pr	ocessing	machine	
	<b>O</b> Ci	istomize		
> Parameters for tuning	g conditions			
Load characteristic settings	Autor	natic setti	ngOFF	
Inertia ratio	250			
For more advanced settings	Load characteristic se	ettings		
Gain setting				
Feedback gain setting	_	16		
Speed response frequency [H	lz]		2	
Automatic oscillation suppr	ression OFF			
	Safet	ty functio	n	
FF gain setting	-	16		
Positional command smooth	ing filter [ms]			
Overshoot suppression [%]	-	100.0		
Notch filter settings	Autor	matic setti	ng:OFF	
3rd notch frequency [Hz]			50	
4th notch frequency [Hz]			50	
	Notch settings			
For more advanced settings				
For more advanced settings Damping filter setup	Autor	natic setti	ng:ON	
	Autor	natic setti	ng:ON	

For details on each item, see <u>"3.2.1.4.2 Main Screen Details"</u>.

	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)	<u>"Load characteristic set- tings"</u>	Tune the parameters related to setting and estimating load characteristics.
(4)	"Gain setting"	Tune the parameters related to feedback and feedforward collectively or when over- shoot 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)	<i>"What if I have a prob- lem?"</i>	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)	<u>"Manual"</u>	Displays the parameters shown in "Basic", "Load characteristic settings", "Notch set- tings", "Damping settings", and "Apply" in list format.
4. To end the Manual TUNING function, click the [<] button in the upper left corner.

5				PANATE	RM ver.7			– 🗆 X
Fi	ile(F) Troubleshooting(T) Help(H)							
Device tree	袋 Setting - 問 Monitor	Ŀб	Logging	프 <mark>아</mark> Tuning	Device Info	60		Z-phase search
e tree	K Manual TUNING		🗸 Graph			Inal runyz:	1	2
	Selected driver:Axis0_No name set		Wave grap	hic Frequency response		z-pn	Limit setting	Trial run
	Basic Load characteri Notch settings		Start n	neasurement Stop	Single trigger Acquire	-pnase search	Protection Functions Pr5.12 Overload level[%]	0
	Damping settin Application Manual		Measurem	ent data management Edit	display range Fixed display range	9	Pr5.13 Overspeed level[r/min]	120
	Mode setting () 0:Disabled ~		Reset zoon	Align with center of Y-axi	s	Ш	TIS.IS Overspeed level(/minj	Automatic setting (overspee
	(i) When launching for the first time		Display as	elapsed time Display as tim	e standard Load file	Ш	Pr5.14 Motor mova[0.1 rotation	n] 10
	A7 recommended setting is recommended		Save fil	e		11	Operation limit	
	<ol> <li>When upgrading from A6A6 compatibility setting is recommended</li> </ol>					81	Pr5.04 Over-travel inhibit input s.	1: CoE-side (CiA402) deceler 🗸
	Load characteristic settings Automatic settingOFF		🗸 Graph d	isplay settings			Operating range	
	Inertia ratio 0		Measurer	nent Condition Edit displaye	ed data Cursor		JOG speed[r/min]	Ain. positions or input a numeric value
	For more advanced settings Load characteristic settings							
►	Gain setting		Acquire	from driver Acquire from	n file Load condition presets	. ,	JOG acceleratio[ms/JOG speed	3] 50
	Feedback gain setting - 29 +	•				= 1		
	Speed response frequenc 102.5 Automatic oscillation su OFF		<ul> <li>Monitor</li> </ul>					
	Safety function		Simple mo	nitor IO monitor				
	FF gain setting - 31 +		Start mea	surem Measurement mode	e With Position C 🗸 Measurement count	2		
	Positional command smo 0.8				Int Vibration level Effective load factor Tak			
	Overshoot suppression [%] - 100.0 +		[times]	[ms] [times]	[%] [%] [ms	1	Servo-on O A Operates	only while the button is pressed.
	Notch filter settings Automatic setting:OFF						- direction	Go to 0 + direction
	3rd notch frequency [Hz]         5000           4th notch frequency [Hz]         5000						Current positio	n [command unit]
	For more advanced settings Notch settings						Current positio	0
	Damping filter setup Automatic setting:ON							
	1st damping frequency [Hz] 0						Minimum position	Maximum position
	For more advanced settings Damping settings						[command unit]	[command unit]
	What if I have a problem?						0	0
	Refer to Tuning Help <u>when problems occur</u> such as vibration or abnormal noise						Troub	leshooting To trial run

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.)

Finish Manual TUNING	×
It will disable the automatic configuration feature below. Is it okay to proceed and exit?	
Automatic inertia ratio setup O Retained O Disabled	
Automatic notch setting O Retained O Disabled	
Back End	

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

## **6.** Click the [Confirm] button.

Write to EEPROM			×
Target device: Axis0_N	lo name set		
Parameters to be writte	en: 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
		Confirm	Cancel

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.

	$\times$
Parameters will be written to EEPROM	I. Is it OK?
Yes	No

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.

<	Manua	al TUNING		
elected driver:Axis0_No nar	ne set			
Basic	Load charac	teristic settings	Notch set	tings
Damping settings	Арр	lication	Manua	al
Node setting 🕕		0:Disabled		~
		Customize sett	ings	
<ol> <li>When launching for the f</li> <li>When upgrading from A</li> </ol>		commended sett	ingis recommende	ed
oad characteristic settings		Automatic settir	IgOFF	
Inertia ratio		250		
For more advanced settings	Load characte	ristic settings		
iain setting				
Feedback gain setting		- 16		+
Speed response frequency [I				27.0
Automatic oscillation suppression OFF				
		Safety function		
FF gain setting		- 16		+
Positional command smooth	ning filter [ms]			9.2
Overshoot suppression [%]		- 100.0		+
lotch filter settings		Automatic settir	ng:OFF	
3rd notch frequency [Hz]				5000
4th notch frequency [Hz] For more advanced settings	Notch setting			5000
amping filter setup	rioter betang	Automatic settir	na:ON	
1st damping frequency [Hz]		/ decinate seta	.9.011	0
or more advanced settings D	amping settin	gs		
Vhat if I have a problem?				
	roblems occu	such as vibratio	n or abnormal noi	se

# **Category Selection**

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

Basic	Load characteristic settings	Notch settings	
Damping settings	Application	Manual	

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 "Realtime auto-gain tuning setup" are also set. For details, see the table below.

<	Manua	al TUNING			
Selected driver:Axis0_No nam	ne set				
Basic	Load charac	teristic settings		Notch setting	gs
Damping settings	Арр	lication		Manual	
Mode setting (j)		0:Disabled			~
		Customize sett	ings		
(i) When launching for the fi (i) When upgrading from A6					]
Load characteristic settings		Automatic settir	ngOFF		
Inertia ratio		250			
For more advanced settings	oad character	istic settings			
Gain setting					
Feedback gain setting		- 16			+
Speed response frequency [H	lz]				27.0
Automatic oscillation suppr	ession	OFF			
		Safety function			
FF gain setting		- 16			+
Positional command smooth	ing filter [ms]				3.7
Overshoot suppression [%]		- 100.0			+
Notch filter settings		Automatic settir	na:OFF		
3rd notch frequency [Hz]			5		5000
4th notch frequency [Hz]					5000
For more advanced settings	Notch settings				
Damping filter setup		Automatic settir	ng:ON		
1st damping frequency [Hz]					0
For more advanced settings Da	amping setting	<u>as</u>			
What if I have a problem? Refer to Tuning Help <u>when pr</u>	oblems occur	such as vibratior	n or abr	normal 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	The current settings for Pr0.02 "Real-time auto-gain tuning setup" are retained.		
(blue text)	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 (j)	7:Customize2	~	
	Customize settings		
<ul> <li>When launching for the first time<u>A7 recommended setting</u> is recommended</li> <li>When upgrading from A6<u>A6 compatibility setting</u> is recommended</li> </ul>			
Tuning conditions OPositioning/general-purpose			
	O Processing machine		
O Customize			
> Parameters for tuning conditions			

# **Customize Settings Screen**

Customize settings	×
In the auto tuning function customization settings Manual setting/automatic setting of each control Load characteristics estimation	
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
ОК	Cancel

Item	Description
Load characteristics esti- mation	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 stiff- ness 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 set-	Select settings for parameters related to friction torque compensation.				
ting switching	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 addi- tional 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 compen-	Select the method for setting Pr6.50 "Viscous friction compensating gain" .				
sating gain adjustment	ON: Automatic setting				
	OFF: Manual setting				

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

- <u>"4.1.1.4 Related Parameters"</u> of <u>"4.1.1 Real-time Auto Tuning (Two-degree-of-freedom Control Mode for Standard Type)</u>"
- <u>"4.1.3.4 Related Parameters"</u> of <u>"4.1.3 Real-time Auto Tuning (Two-degree-of-freedom Control Mode Disabled</u> <u>Type)</u>"

## Tuning conditions

1 When "7: Customize 2" is selected, "Tuning conditions" are displayed. Normally, select "Positioning/generalpurpose".

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			
	Customize settings			
<ul> <li>When launching for the first time<u>A7 recommended setting</u> is recommended</li> <li>When upgrading from A6<u>A6 compatibility setting</u> is recommended</li> </ul>				
Tuning conditions	Positioning/general-purpose			
	O Processing machine			
	O Customize			
> Parameters for tuning conditions				

- 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.
    - <u>"4.1.1.4 Related Parameters"</u> of <u>"4.1.1 Real-time Auto Tuning (Two-degree-of-freedom Control Mode for</u> <u>Standard Type)</u>"
    - <u>"4.1.3.4 Related Parameters"</u> of <u>"4.1.3 Real-time Auto Tuning (Two-degree-of-freedom Control Mode</u> <u>Disabled Type)</u>"

Mode setting (i)	7:Customize2
	Customize settings
When launching for the first time <u>A7 re</u> When upgrading from A6 <u>A6 compati</u>	ecommended settingis recommended bility settingis recommended
Tuning conditions	Positioning/general-purpose
	O Processing machine
	O Customize
> Parameters for tuning conditions	

## **Customize Settings Screen**

Tuning conditions	Positioning/general-purpose
	O Processing machine
	O Customize
<ul> <li>Parameters for tuning conditions</li> </ul>	
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 <u>"Mode Setting"</u>, 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.

K Manual TUNING						
Selected driver:Axis0_No name set						
Basic	Basic Load characteristic settings Notch settings					
Damping settings	Appl	lication	Manual			
Load characteristics estimation						
Tuning conditions						
Estimated speed (i)		1: almost no change	9	~		
(i) Automatic oscillation suppression						
Related Parameters (j)						
Inertia ratio[%]	Inertia ratio[%]					
Estimated value [%]:0	Estimated value [%]:0		Reflect the estimated value			
. Torque command additional value[0.1	Torque command additional value[0.1%]		0			
Estimated value [%]:0.0	Estimated value [%]:0.0		Reflect the estimated value			
Positive direction torque compensation	on value[0.1%]	0				
Negative direction torque compensat	ion value[0.1%]	0				
Estimated value (positive) [%]:0.0	Estimated value (positive) [%]:0.0					
Estimated value (negative) [%]:0.0		Kellect the estimat				
Viscous friction compensating gain[0	.1%/(10000r/min)]	0				
Estimated value [%]:0.0	Estimated value [%]:0.0 Reflect the estimated value					
$\odot$ Set values may be automatically updated depending on real-time auto tuning mode settings. <u>Basic</u> Check the mode settings.						

## "Load Characteristic Settings" Advanced Settings Screen

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 re- sult. 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 "Se- lection 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 in- creases, but vibration is more likely to occur.						
	While checking the operation, increase the set value by increments of 1.						
	<ul> <li>Precautions –</li> <li>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.</li> </ul>						
	• Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03						
	• Pr2.45: bits 5 to 4 = 10b : Pr0.27						
	<ul> <li>Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28</li> </ul>						
	• 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 <u>"4.1 Real-time Auto Tuning Function"</u> for the relation-ship between the set values and the corresponding related parameters.						
	<ul> <li>To set the safety function (for automatically lowering the set value to eliminate oscilla- tion when tuning is in progress), click the [Safety function] button.</li> </ul>						
	"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)						
	Oscillation detection level 15 %						
	OK Cancel						
FF gain setting	<ul> <li>Used when tuning feedforward-related parameters collectively.</li> <li>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 <u>"4.1 Real-time Auto Tuning Function"</u> <u>"4.1.1.6 Basic Gain Parameter Setup Table"</u>.</li> </ul>						
	• 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 <u>"Mode Setting"</u>, 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

<		Manua	al TUNING			
Selected driver:Axis0_N	No name set					
Basic		Load charac	teristic setti:	ngs	Notch se	ttings
Damping se	ttings	Арр	lication		Manual	
Resonance monitor					Not detected	
Resonance frequency	[Hz] (i)					5000
(i) "5000" is displayed	d until resonance	is detected.				
Tuning based on positic (i) To perform tuning Pr2.00 Adaptive filter	based on the po	sitioning operatior	n, use the fo	_	ttings 1 to 5. precision adaptive filte	r V
PI2.00 Adaptive filter	mode			5. High-p	recision adaptive filte	•
Tuning based on freque	ncy characteristic	S		] Display r	otch filter characteris	ics in a graph
					Offset [dB]	0.0
	Fre	equency [Hz]		Width	D	epth
1th notch	5000		2		0	
2th notch	5000		2		0	
3th notch (i)	5000		2		0	
4th notch (i)	5000		2		0	
5th notch	5000		2		0	
Costom notch	5000		2		0	
(i) The 3rd and 4th no	otches are autom	atically set depend	ing on the s	etting 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		
E stage torque miter a				v		

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 <u>"Mode Setting"</u> , "5: High-precision adaptive fil- ter" 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 de- tails on Pr2.00 "Adaptive filter mode setup", see <u>"5.4 Adaptive Filter Function"</u> .
Display notch filter char- acteristics 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	Allows advanced settings to be set for notch filter and torque filter parameters. Notch filter pa-
2nd notch	rameters set automatically in Pr2.00 "Adaptive filter mode setup" cannot be changed. When real-
3rd notch	time auto-gain tuning setup is enabled, the torque filter parameters cannot be changed because the torque filter is set automatically.
4th notch	Custom notch functions the same as other notch filters. It can be used as a 6th notch filter.
5th notch	
Custom notch	
1st torque filter	
2-stage torque filter time constant	
2-stage torque filter at- tenuation term	

For details on functions, see <u>"5.3 Notch Filter Function</u>", <u>"5.1 Torque Filter Function</u>" and <u>"5.2 2-stage Torque Filter Function</u>".

## **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 <u>"Mode Setting</u>", 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					Selected driver:Axis0_No nar
Basic	Load characteristic settings		Notch settings	;	Basic
Damping settings	Application		Manual		Damping settings
Vibration monitor		Not	detected		Vibration monitor
Vibration frequency [Hz] (i)				0.0	Vibration frequency [Hz] ()
(i) "0.0" is displayed until vibration is d	etected				(i) "0.0" is displayed until vi
Damping filter setup					Damping filter setup
Pr2.13 Damping filter switching	0:	Use up to two sin	nultaneously	~	Pr2.13 Damping filter switchi
Automatic frequency setting ()	1st	damping freque	ncy	~	Automatic frequency setting
When vibrations are detected, the vi the target filter.	bration frequency value is automa	tically applied to	the damping fre	quency of	() When vibrations are determined the target filter.
IN I					IN I
✓ FIR filter	A	utomatic setting	]		
Pr2.23 Positional command FIR filt	er [0.1 ms] 10		-		Pr2.23 Positional comm
Smoothing filter					Smoothing filter
Pr2.22 Positional command smoot	thing filter [0.1 ms] 8				Pr2.22 Positional comm
Pr6.49 Command response filter a	ttenuation term setup 5:	1		~	Pr6.49 Command resp
Damping filter 1					Damping filter 1
Pr2.14 1st damping frequency [0.1	Hz] 0				[Enabled during positiv
Pr2.15 1st damping filter setup [0.	1 Hz] 0				Pr2.14 1st damping f
Pr2.27 1st damping width setting	0				Pr2.15 1st damping f
Pr6.41 1st damping depth	0				Pr2.27 1st damping v
Damping filter 2					Pr6.41 1st damping of
Pr2.16 2nd damping frequency [0.	1 Hz] 0				[Enabled during negati
Pr2.17 2nd damping filter setup [0	.1 Hz] 0				Pr2.16 2nd damping
Pr2.28 2nd damping width setting	0				Pr2.17 2nd damping
Pr6.60 2nd damping depth	0				Pr2.28 2nd damping
OUT					Pr6.60 2nd damping
Tuning filter					Damping filter 2
Filter function switching	A7	mode		~	[Enabled during positiv
Tuning filter time constant0.01ms]	4				Pr2.18 3rd damping
Pr6.49 Tuning filter attenuation ten	n setup 1:	No attenuation te	rm	~	Pr2.19 3rd damping f
					Pr2.29 3rd damping v
					Pr6.71 3rd damping o

## When Pr2.13 = 3

K Manual TUNING						
Selected driver:Axis0_No name set						
Basic	Load characteristic settings		Notch settings			
Damping settings	Application		Manual			
Vibration monitor			Not detected			
Vibration frequency [Hz] ()				0.0		
(i) "0.0" is displayed until vibration is	detected					
Damping filter setup						
Pr2.13 Damping filter switching		3: Switch	ing by command direction	~		
Automatic frequency setting (i)		1st damp	ping frequency	~		
When vibrations are detected, the the target filter.	vibration frequency value is auto	omatically	applied to the damping frequ	uency of		
IN						
Ļ						
FIR filter		Automa	itic setting			
Pr2.23 Positional command FIR f	filter [0.1 ms]	10				
Smoothing filter						
Pr2.22 Positional command smo	othing filter [0.1 ms]					
Pr6.49 Command response filter	attenuation term setup	5: 1		~		
Damping filter 1						
[Enabled during positive directio	n 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 setti	ng	0				
Pr6.41 1st damping depth	0					
[Enabled during negative direction	on operation]					
Pr2.16 2nd damping frequency	[0.1 Hz]	0				
Pr2.17 2nd damping filter setu	0					
Pr2.28 2nd damping width setting 0						
■ Pr6.60 2nd damping depth		0				
Damping filter 2						
[Enabled during positive directio	n 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 setti	ing	0				
Pr6.71 3rd damping depth		0				
[Enabled during negative direction	on operation]					
Pr2.20 4th damping frequency	[0.1 Hz]	0				
Pr2.21 4th damping filter setup	o [0.1 Hz]	0				
Pr2.30 4th damping width setti	ing	0				
▶ Pr6.72 4th damping depth		0				
OUT						
Tuning filter						
Filter function switching		A7 mode	9	~		
Tuning filter time constant0.01m	s]	4				
Pr6.49 Tuning filter attenuation to	erm setup	1: No att	enuation term	~		

## When Pr2.13 = 4

<		Manual TUNING			
Sele	cted driver:Axis0_No name set				
	Basic	Load characteristic setti	ngs	Notch settings	
	Damping settings	Application		Manual	
Vibra	ation monitor			Not detected	
Vibr	ation frequency [Hz] 🕕				0.0
í	"0.0" is displayed until vibration is o	detected			
Dam	ping filter setup				
Pr2.	13 Damping filter switching		4: No sw	itching (model type)	~
Aute	omatic frequency setting $(i)$		Disabled		~
()	When vibrations are detected, the v the target filter.	ibration frequency value is aut	omatically	applied to the damping free	uency of
IN					
↓ ↓					
	FIR filter		Automa	tic setting	
¥	Pr2.23 Positional command FIR fi	lter [0.1 ms]	10		
	Smoothing filter				
	Pr2.22 Positional command smoo	thing filter [0.1 ms]			
	Pr6.49 Command response filter a	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 frequen	cy [0.1 Hz]	0		
	Pr6.64 1st anti-resonance attenua	tion ratio	0		
Ļ	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 freque	ncy [0.1 Hz]	0		
	Pr6.69 2nd anti-resonance attenua	ation ratio	0		
Ļ	Pr6.70 2nd response frequency [0	.1 Hz]	0		
OUT	ſ				
		Display mod	el-type da	mping filter characteristics in	a graph
				Offset [dB] 0.0	
	Tuning filter				
	Filter function switching		A7 mode	•	~
	Tuning filter time constant0.01ms	1	4		
	Pr6.49 Tuning filter attenuation te	rm setup	1: No att	enuation term	~

### When Pr2.13 = 5

<		Manual TUNING				
Selec	ted driver:Axis0_No name set					
	Basic	Load characteristic setti	ngs	Notch	settings	
	Damping settings	Application		M	anual	
/ibra	tion monitor			Not detecte	d	
Vibr	ation frequency [Hz] ()					0.0
(j)	"0.0" is displayed until vibration is c	letected				
am	ping filter setup					
Pr2.1	13 Damping filter switching		5: Switch	by external input (	model type)	~
Auto	omatic frequency setting ()		Disabled			~
	When vibrations are detected, the v the target filter.	ibration frequency value is aut	omatically	applied to the dam	iping frequer	ncy of
IN						
¥						
-	FIR filter		Automa	tic setting		
¥	Pr2.23 Positional command FIR fil	ter [0.1 ms]	10			
	Smoothing filter					
	Pr2.22 Positional command smoo	thing filter [0.1 ms]	8			
	Pr6.49 Command response filter a	attenuation term setup	5: 1			~
	Model-type damping filter 1					
	[Enabled when VS-SEL1 = OFF]					
	Pr6.61 1st resonance frequency		0			
	Pr6.62 1st resonance attenuation	n ratio	0			
	Pr6.63 1st anti-resonance freque	ncy [0.1 Hz]	0			
	Pr6.64 1st anti-resonance attenu	ation 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 attenuatio	n ratio	0			
	Pr6.68 2nd anti-resonance frequ	ency [0.1 Hz]	0			
	Pr6.69 2nd anti-resonance atten	uation ratio	0			
Ļ	filtercombination7TextBlock_13Te	ext	0			
тис						
		Display mod	el-type da	mping filter charact	eristics in a g	raph
				Offset [d	B] 0.0	
	Tuning filter					
	Filter function switching		A7 mode	,		~
	Tuning filter time constant0.01ms		4			
	Pr6.49 Tuning filter attenuation ter	m setup	1: No att	enuation term		~

### When Pr2.13 = 6

When Pr2.13 = 7	Whe	ו Pr2	.13	=	7
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<	Manual TUNING		<		Manual TUNING			
Selected driver:Axis0 No name set			Sele	cted driver:Axis0 No name set				
Basic	Load characteristic setting	gs Notch settings		Basic	Load characteristic sett	ings	Notch settings	
Damping settings	Application	Manual		Damping settings	Application	-	Manual	
Vibration monitor		Not detected	Vibr	ation monitor			Not detected	
Vibration frequency [Hz] ()		0.0	Vib	ration frequency [Hz] ()				0.0
(i) "0.0" is displayed until vibration is	detected		0	"0.0" is displayed until vibration is	detected			
Damping filter setup			Dam	nping filter setup				
Pr2.13 Damping filter switching	-	6: Switch by command direction (model 💙	Pr2	13 Damping filter switching		7: Dampin	g 3 stages	~
Automatic frequency setting ()	[	Disabled 🗸		omatic frequency setting ()		Disabled		~
When vibrations are detected, the the target filter.	vibration frequency value is autor	matically applied to the damping frequency of	C	When vibrations are detected, the the target filter.	vibration frequency value is au	tomatically a	pplied to the damping frequ	iency of
IN			IN					
↓	_		↓					
FIR filter		Automatic setting		FIR filter		Automatie	setting	
	ilter [0.1 ms]	10	↓	Pr2.23 Positional command FIR fi	ilter [0.1 ms]	10		
Smoothing filter				Smoothing filter				
Pr2.22 Positional command smo	othing filter [0.1 ms]			Pr2.22 Positional command smoo	othing filter [0.1 ms]	8		
Pr6.49 Command response filter	attenuation term setup	5: 1 ~		Pr6.49 Command response filter	attenuation term setup	5: 1		$\sim$
<ul> <li>Model-type damping filter 1</li> </ul>				Damping filter 1				
[Enabled during positive direction	n operation]			Pr2.14 1st damping frequency [0.	.1 Hz]	0		
Pr6.61 1st resonance frequency	[0.1 Hz]	0		Pr2.15 1st damping filter setup [0	0.1 Hz]	0		
Pr6.62 1st resonance attenuatio	n ratio	0		Pr2.27 1st damping width setting		0		
Pr6.63 1st anti-resonance frequ	ency [0.1 Hz]	0		Pr6.41 1st damping depth		0		
Pr6.64 1st anti-resonance atten	uation ratio	D	i i	Damping filter 2				
Pr6.65 1st response frequency [	[0.1 Hz]	0		Pr2.16 2nd damping frequency [0	).1 Hz]	0		
[Enabled during negative directio	n operation]			Pr2.17 2nd damping filter setup [	[0.1 Hz]	0		
Pr6.66 2nd resonance frequency	y [0.1 Hz]	0		Pr2.28 2nd damping width setting	q	0		
Pr6.67 2nd resonance attenuation	on ratio	0		Pr6.60 2nd damping depth	-	0		
Pr6.68 2nd anti-resonance frequ	uency [0.1 Hz]	0		Damping filter 3		-		
Pr6.69 2nd anti-resonance atter		0		Pr2.18 3rd damping frequency [0	.1 Hz]	0		
Pr6.70 2nd response frequency		0		Pr2.19 3rd damping filter setup (	0.1 Hz]	0		
OUT	[0.1112]	<u> </u>		Pr2.29 3rd damping width setting	1	0		
	Display model	-type damping filter characteristics in a graph		Pr6.71 3rd damping depth	2	0		_
			♦ OU			0		
<ul> <li>Tuning filter</li> </ul>		Offset [dB] 0.0		Tuning filter				
Filter function switching	[	A7 mode 🗸		Filter function switching		A7 mode		~
Tuning filter time constant0.01ms	L	4		Tuning filter time constant0.01ms	5]	4		
Pr6.49 Tuning filter attenuation te		1: No attenuation term 🗸 🗸		Pr6.49 Tuning filter attenuation te	rm setup	1: No atter	uation term	~
	F			,				

For details on functions, see <u>"5.5 Damping Control Function</u>" and <u>"5.6 Model-type Damping Filter Function</u>".

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 set- ting	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] but- ton calculates and automatically sets the appropriate parameters.
	For details on functions, see <u>"5.7 Position Command Filter Function"</u> .
Smoothing filter	When the two-degree-of-freedom control mode for standard type is set and real-time auto tun- ing 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 <u>"5.7 Position Command Filter Function"</u> .

Item	Description
Damping filter 1	Parameters for damping filters that are not identified for automatic setting can be set manually.
Damping filter 2	For details on functions, see <u>"5.5 Damping Control Function"</u> and <u>"5.6 Model-type Damping</u>
Damping filter 3	Filter Function".
Damping filter 4	
Model type damping filter 1	
Model type damping filter 2	
Tuning filter	In the case of filter function switching, when "A7 recommended setting" is selected in <u>"Mode</u> <u>Setting"</u> , "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 ena- bled, the tuning filter time constant is automatically set. Otherwise, parameters can be set manually.
Display model-type damping filter character-	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.
istics in a graph	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 <u>"5.6 Model-type Damping Filter</u> <u>Function"</u> .
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.

<	Manual TUNING	
Selected driver:Axis0_No name se		
Basic	Load characteristic settings	Notch settings
Damping settings	Application	Manual
> Feedforward function		
> Load fluctuation control function	'n	
> High response current control	unction	
> Gain switching function		
> Quadrant glitch suppression fu	nction	
> Hybrid vibration suppression fu	nction	

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.

- <u>"4.4 Feedforward Function"</u>
- <u>"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)"</u>
- <u>"4.8 High Response Current Control Function"</u>
- <u>"4.2 Gain Switching Function"</u>
- <u>"4.3 3rd Gain Switching Function"</u>
- <u>"4.9 Quadrant Glitch Suppression Function"</u>
- <u>"5.9 Hybrid Vibration Suppression Function</u>"

### Manual

• Displays the parameters shown in "Basic", "Load characteristic settings", "Notch settings", "Damping settings", and "Apply" in list format.

<	Ma	anual TUNING		
Selected driver:Axis0_No name set				
Basic	Load ch	aracteristic set	tings	Notch settings
Damping settings		Application		Manual
Write to EEPROM Config	Reset			
Recall presets Load presets Sele	cted preset:All	parameters		
Name		Unit	Value	
Pr0.00 manufacturer use			1	
Pr0.01 Control mode setup			0: Semi-cl	osed control 🗸
Pr0.02 Real-time auto-gain tuning setup			7: Conven	tional control: Customization 🗸
Pr0.03 Real-time auto-tuning machine st	iffness 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 mo	tor revolution	pulse/r	2500	
Pr0.12 Reversal of pulse output logic			0: Encode	r, 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 🗸
Dra 16 Futamal ragonarativa rasistar act.				

# 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 <u>"5.3 Notch Filter Function"</u>.



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 <u>"5.5 Damping Control Function"</u>.



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 <u>"3.2.1.4.4 Tuning Procedure When Control Challenges Are Identified</u>" 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.

Issues during re-adjustment	Corresponding control function references
Shortening the settling time.	"4.1 Real-time Auto Tuning Function"
	<u>"5.7 Position Command Filter Function"</u>
Reducing overshoot/undershoot.	<u>"4.1 Real-time Auto Tuning Function"</u>
	"4.3 3rd Gain Switching Function"
	"4.4 Feedforward Function"
	<u>"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)</u> "
	"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.	<u>"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)</u> "
	"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.	<u>"4.9 Quadrant Glitch Suppression Function"</u>
Ensuring own axis is not moved when other axes are	"4.1 Real-time Auto Tuning Function"
moved.	<u>"4.6 Load Fluctuation Control Function (Disturbance Suppression Applications)</u> "
	"4.8 High Response Current Control Function"
Reducing vibration when gain is increased in full-closed control.	<u>"5.9 Hybrid Vibration Suppression Function"</u>

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

# 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	<ul> <li>Low stiffness (antiresonance points exists in the low frequency range of 10 Hz or less)</li> </ul>
	<ul> <li>Looseness, backlash, etc. are present and the load non-linearity is strong</li> </ul>

### 3.2.2.3 Tuning Procedure

For the tuning procedure using Set-up Support Software (PANATERM ver.7), see <u>"4.7.4.2 When Set-up Support</u> Software (PANATERM ver.7) Is Used" in <u>"4.7 Load Fluctuation Control Function (Load Fluctuation Stabilization</u> <u>Applications)</u>".

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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.

Setup value				
0	Disabled The real-time auto tuning function is disabled.			
1	1 Standard response This is an operation mode with an emphasis on stability. Unbalanced and friction compensation are not performed, and gain switching is no			
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 set- tling 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.		

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

Setup value	Operation mode	Description
5	Load characteristic The basic gain setting and friction compensation setting are not changed, only load a cateristic 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 applica- tion 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 normal- ly be selected.
		Some functions are not available depending on the control mode. For details, see <u>"De-tails on Pr6.32 "Real time auto tuning custom setup"</u> .

# 4.1.1.3 Operational Conditions

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

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	<ul> <li>When load inertia is small or large compared to the rotor inertia of the servo motor (less than 3× or 20× or more)</li> <li>When load inertia fluctuates</li> <li>When machine stiffness is extremely low</li> <li>When non-linear characteristics exist, such as looseness due to backlash</li> </ul>					
Operation pat- terns	<ul> <li>When used continuously at low speeds of less than 100 r/min</li> <li>When acceleration and deceleration are gentle, less than 2000 r/min in 1 s</li> <li>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</li> <li>Example of an operation pattern that obstructs function operation         Command         Time         Time</li></ul>					

### 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	В	Real-time auto- gain tuning setup	0 to 7	-	Sets the real-time auto tuning operation mode. Normally, select setting value 7.	
0	03	В	Real-time auto- tuning machine stiffness setup	0 to 31	_	Sets responsiveness when real-time auto tuning is ena- bled. Higher settings result in higher speed responsive- ness and servo stiffness, but make it more likely that vi- bration 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	В	Selection of ma- chine stiffness at real-time auto- gain tuning 2	0 to 44	_	Sets responsiveness when real-time auto tuning is ena- bled. Higher settings result in higher speed responsive- ness and servo stiffness, but make it more likely that vi- bration 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	В	Selection of feed forward stiffness at real-time auto- gain tuning	0 to 44	_	Sets responsiveness when real-time auto tuning is ena- bled. Higher settings result in higher speed responsive- ness, but make it more likely that overshoot will occur. Val- ues 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 tun- ing application se- lection	-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	В	Function expan- sion setup	-32768 to 32767	_	bit 14: Load fluctuation suppression function automatic tuning 0: Disabled 1: Enabled	
6	31	В	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 re- sponses to changes in load characteristics, but they also increase variations in disturbance estimation. Estimation results are saved in EEPROM every 30 mi- nutes regardless of the load characteristic estimated speed setting. When automatic vibration detection is enabled from Set- up Support Software (PANATERM ver.7), this setting will be ignered and the setting value will be set to 2	
					be ignored and the setting value will be set to 3.		
	Setup Mode value				Description		
	0 Does not change		Stops load cha	racteri	istics estimation.		
	1 Changes very little		Estimates char	nges in	load characteristics in minutes.		
	2 Changes slowly		Estimates char	stimates changes in load characteristics in seconds.			
	3	3	Changes precipitous	y Fastest estima	tion of	changes in load characteristics.	

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	32	В	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 <u>"7.1 List of Parameters"</u>.

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

bit	Name			Description			
1 to 0	Load characteristics estimation	<ul> <li>Set to enable or disable the load characteristics estimation function.</li> <li>0: Disabled</li> <li>1: Enabled</li> <li>— Precautions —</li> <li>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.</li> <li>To enable load characteristic estimation, set Pr6.31 "Real time auto tuning estimation speed" to a value other than 0 (no change).</li> </ul>					
3 to 2	Inertia Ratio Update	<ul> <li>Set updates in load characteristic estimation results for Pr0.04 "Inertia ratio".</li> <li>0: Disabled</li> <li>1: Enabled</li> <li>— Precautions —</li> <li>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.</li> </ul>					
6 to 4	Torque compensa- tion <sup>(*1)</sup>	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", Pr2.54 "Negative direction torque compensation value 2", Pr2.54 "Negative direction torque compensation value 2" and Pr6.50 "Viscous friction compensating gain".         Set up due       Mode       Description         0       Use current settings       Uses current settings.         1       Disable torque compensation       Clear Pr2.52, Pr2.53, Pr2.54, and Pr6.50 to 0.         2       Vertical axis mode       Update Pr2.52 and clear Pr2.53, Pr2.54 and Pr6.50 to 0.         3       Friction compensation       Update Pr2.52 and set weak compensation for Pr2.53, Pr2.54, and Pr6.50.         4       Friction compensation       Update Pr2.52 and set medium compensation for Pr2.53, Pr2.54, and Pr6.50.         5       Friction compensation       Update Pr2.52 and set medium compensation for Pr2.53, Pr2.54, and Pr6.50.         5       Friction compensation       Update Pr2.52 and set strong compensation for Pr2.53, Pr2.54, and Pr6.50.         6       Friction compensation       Update Pr2.52 and set strong compensation for Pr2.53, Pr2.54, and Pr6.50.         5       Friction compensation       Update Pr2.52 and set strong compensation for Pr2.53, Pr2.54, and Pr6.50.         •       Change the parameters to be used depending on the values set in Pr2.45 "Function expansion setup 10" :bit 2 "Friction torque compens					

bit	Name	Description						
7	Stiffness Setup (*2)	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						
		<ul> <li>Precautions –</li> <li>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.</li> </ul>						
		• Pr2.45: bits 5 to 4 = 00b, 01b : Pr0.03						
		• Pr2.45: bits 5 to 4 = 10b : Pr0.27						
		<ul> <li>Pr2.45: bits 5 to 4 = 11b : Pr0.27, Pr0.28</li> </ul>						
8	Fixed Parameter Setup <sup>(*2)</sup>	Set whether or not to change parameters that become fixed values when real-time auto tun- ing is enabled.						
		For details, see the table <u>"Values Set When Real-Time Auto Tuning is Enabled (Pr0.02 = 1</u> to 4, 7)" in <u>"4.1.1.4.3 Parameters Changed By This Function"</u> .						
		0: Use current settings						
		1: Set to fixed values						
10 to 9	Gain Switching Set- up <sup>(*2)</sup>	Select the method for setting parameters related to gain switching when real-time auto tun- ing is enabled.						
		0: Use current settings						
		1: Gain switching disabled						
		2: Gain switching enabled						
11	Torque compensa-	Select whether to enable bits 6 to 4 or bits 15 to 12 for torque compensation.						
	tion setting switch-	0: Enable bits 6 to 4						
	ing	1: Enable bits 15 to 12						
15 to 12	compensation set-	Select whether to use or update the current setting for the corresponding parameters when bit 11 "Torque compensation setting switching" = 1.						
	tings <sup>(*1)</sup>	0: Use current settings						
		1: Update						
		bit 15 bit 14 bit 13 bit 12						
		When Pr2.45:bit 2 = 1 Pr6.50 Pr2.54 Pr2.53 Pr2.52						
		When Pr2.45:bit 2 = 0         Pr6.50         Pr6.09         Pr6.08         Pr6.07						

\*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 <u>"1"</u> and <u>"2"</u> 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

 $2^0 \times 1 + 2^2 \times 1 + 2^4 \times 3 + 2^7 \times 1 + 2^8 \times 1 + 2^9 \times 2 = 1461$ 

# 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 Seriescompatible 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 set- ting resolution, individual FB/FF setting switching" .	bits 5 to 4 = 11b
Unbalanced load/ friction compensa- tion	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-de- gree-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 fluctua- tion 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	В	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-compati- ble specification) 1: Use Pr2.46 "Tuning filter 2" (MINAS A7 Series specifi- cation)
2	45	В	Function expan- sion 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 cal- culation bit 5 to 4: Stiffness setting resolution, individual FB/FF set- ting switching bit 31 to 6: Unused

· NI/A

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

### 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 specifica- tion)	01b
		10b: Manufacturer use	
		11b: Manufacturer use	
2	Friction torque compen- sation parameter selec- tion	<ul> <li>0: MINAS A6 Series-compatible specification settings</li> <li>Unbalanced load compensation value: Use Pr6.07</li> <li>Dynamic friction compensation value: Use Pr6.08, Pr6.09</li> <li>1: MINAS A7 Series specification settings</li> <li>Unbalanced load compensation value: Use Pr2.52</li> <li>Dynamic friction compensation value: Use Pr2.53, Pr2.54</li> </ul>	1
3	Load fluctuation sup- pression function auto- matic calculation	<ul> <li>0: Conventional setting (MINAS A6 Series specification)</li> <li>1: The following parameters are automatically calculated.</li> <li>Pr6.73 "Load estimation filter"</li> <li>Pr6.76 "Load estimation count"</li> </ul>	1
5 to 4	Stiffness setting resolu- tion, individual FB/FF setting switching	00b: 32 stiffness settings, FB/FF common setting (MINAS A6 Ser- ies-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 Ser- ies 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 para	Conditions for update <sup>(*2)</sup>	
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 compensa- tion 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 para	Conditions for update (*2)
Pr2.45:bit 2 = 1	
Pr6.50 "Viscous friction compensating	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 <u>"4.1.1.6 Basic Gain Parameter Setup Table"</u>.

- 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"	• When stiffness setup is enabled (Pr0.02 = 1 to 4, 7)
Pr1.01 "1st velocity loop gain"	
Pr1.02 "1st velocity loop integration time con- stant"	
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 con- stant"	
Pr1.09 "2nd torque filter time constant"	
Pr2.22 "Positional command smoothing filter"	• When stiffness setup is enabled (Pr0.02 = 1 to 4, 7)
	<ul> <li>In speed control, the first order lag filter is fixed.</li> </ul>
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)
	<ul> <li>In speed control, the first order lag filter is fixed.</li> </ul>
Pr6.49 "Command response/tuning filter at- tenuation 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 ra- tio is enabled
Pr1.106 "1st position loop gain change ratio"	<ul> <li>Sets the change ratio for Pr1.00 "1st gain of position loop"</li> <li>When this setup value is 0, this is set to 100%.</li> </ul>
Pr1.107 "1st velocity integration change ratio"	<ul> <li>Sets the change ratio for Pr1.02 "1st velocity loop integration time constant"</li> <li>When this setup value is 0, this is set to 100%.</li> </ul>
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"	<ul> <li>Sets the change ratio for Pr1.05 "2nd gain of position loop"</li> <li>When this setup value is 0, this is set to 100%.</li> </ul>
Pr1.110 "2nd velocity loop gain change ratio"	<ul> <li>Sets the change ratio for Pr1.06 "2nd velocity loop gain"</li> <li>When this setup value is 0, this is set to 100%.</li> </ul>
Pr1.111 "2nd velocity integration change ratio"	<ul> <li>Sets the change ratio for Pr1.07 "2nd velocity loop integration time constant"</li> <li>When this setup value is 0, this is set to 100%.</li> </ul>
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"	<ul> <li>Sets the change ratio for Pr6.24 "Load change compensation filter"</li> <li>When this setup value is 0, this is set to 100%.</li> </ul>
Pr1.114 "Smoothing filter change ratio"	<ul> <li>Sets the change ratio for Pr2.22 "Positional command smoothing filter" (*1)</li> </ul>
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 <u>"4.1.1.6 Basic Gain Parameter Setup Table"</u>.

### 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			

Target parameter	Value to be set					
	Pr0.02 = 1	Pr0.02 = 2	Pr0.02 = 3	Pr0.02 = 4	Pr0.02 = 7	
Pr1.16 "Delay time of position control switch- ing"	Set to 10					
Pr1.17 "Level of position control switching"	Set to 0					
Pr1.18 "Hysteresis at position control switch- ing"	Set to 0					
Pr1.19 "Position gain switching time"	Set to 10					
Pr1.20 "Mode of velocity control switching"	Set to 0					
Pr1.21 "Delay time of velocity control switch- ing"	Set to 0					
Pr1.22 "Level of velocity control switching"	Set to 0					
Pr1.23 "Hysteresis at velocity control switch- ing"	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					
Pr6.05 "Position 3rd gain valid time"	Set to 0 (disabl	led)	Set to "Pr2.22	× 20"		
			(However, the 1 10000.)	maximum value	is limited to	
Pr6.06 "Position 3rd gain scale factor"	Set to 100 (100	0%)	Set to 200 (200	)%)		

## 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".

Target parameter	Condition	Value t	o be set		
		Pr6.10:bit 14 = 1	Pr6.10:bit 14 = 0		
Pr6.10 "Function expan- sion setup"	When stiffness setup is enabled	bit 1 "Load fluctuation con- trol function" = 1 (enabled)	bit 1 "Load fluctuation con- trol function" = 0 (disabled)		
Pr6.23 "Load change com- pensation gain"	When stiffness setup is enabled	Set to 90 (90%)	Set to 0		
Pr6.24 "Load change com- pensation filter"	When stiffness setup is enabled	Updates to set value ac- cording to stiffness	Retain value		
Pr6.73 "Load estimation fil- ter"	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	d Set automatically			
Pr6.74 "Torque compensa- tion frequency 1"	Set to 0 regardless of the value of Pro	5.10:bit 14.			
Pr6.75 "Torque compensa- tion frequency 2"	Set to 0 regardless of the value of Pre	6.10:bit 14.			
Pr6.76 "Load estimation count"	When stiffness setup is enabled and Pr2.45 "Function expansion setup 10" :bit 3 = 0	d 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			

### 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 <u>"Supplement"</u>).
- 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.
- 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 <u>"Supplement"</u>).
- 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 <u>"Supplement"</u>) 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 <sup>(*1)</sup>			1st gain/	2nd gain					Load fluctuation suppression
Pr0.03 <sup>(*1)</sup>	Pr0.27 Pr0.28 <sup>(*1)</sup>	Pr1.00 Pr1.05	Pr1.01 Pr1.06	Pr1.02 Pr1.07	Pr1.04 Pr1.09 <sup>(*2)</sup>	Pr2.22		Pr6.48 <sup>(*3)</sup>	Pr6.24
		Position [0.1 s <sup>-1</sup> ]	Speed [0.1 Hz]	Speed in- tegration	Torque [0.01 ms]		onstant ms]	Time con- stant	compensation
				[0.1 ms]		Standard response mode	High re- sponse modes 1 to 3	[0.1 ms]	
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 <sup>(*1)</sup>			1st gain/2nd gain			Command response		Tuning fil- ter	Load fluctuation suppression
Pr0.03 <sup>(*1)</sup>	Pr0.27 Pr0.28 <sup>(*1)</sup>	Pr1.00 Pr1.05	Pr1.01 Pr1.06	Pr1.02 Pr1.07	Pr1.04 Pr1.09 <sup>(*2)</sup>	Pr2.22		Pr6.48 <sup>(*3)</sup>	Pr6.24
		Position [0.1 s <sup>-1</sup> ]	Speed [0.1 Hz]	Speed in- tegration	Torque [0.01 ms]		onstant ms]	Time con- stant	Load change compensation
				[0.1 ms]		Standard response mode	High re- sponse modes 1 to 3	[0.1 ms]	filter [0.01 ms]
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.

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
4	Load characteristics up-	synchronous mode, etc. Of the load characteristics, only the inertia ratio, dynamic friction compensation and vis-
	date	cous 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 acteristic 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.

#### Details on Pr0.02 "Real-time auto-gain tuning setup"

# 4.1.2.3 Operational Conditions

Item	Operational Conditions	
Control mode	Position control	
	<ul> <li>Pr6.47:bit 0 = 1 and bit 3 = 1 (synchronization type)</li> </ul>	

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.



## 4.1.2.4 Related Parameters

				-		—: None
Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
0	02	В	Real-time auto- gain tuning setup	0 to 7	-	Sets the real-time auto tuning operation mode.
0	03	В	Real-time auto- tuning machine stiffness setup	0 to 31	_	Sets responsiveness when real-time auto tuning is ena- bled. Higher settings result in higher speed responsive- ness and servo stiffness, but make it more likely that vi- bration 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	В	Selection of ma- chine stiffness at real-time auto- gain tuning 2	0 to 44	_	Sets responsiveness when real-time auto tuning is ena- bled. Higher settings result in higher speed responsive- ness and servo stiffness, but make it more likely that vi- bration 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	В	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.

Class	No.	Attribute <sup>(*1)</sup>	Parameter name	Setting range	Unit	Function
2	74	A	Tuning auto tun- ing application selection	-32768 to 32767	_	Cannot be used with two-degree-of-freedom control mode for synchronization type.
6	10	В	Function expan- sion setup	-32768 to 32767	_	bit 14: Load fluctuation suppression function automatic tuning 0: Disabled 1: Enabled
6	31	В	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 re- sponses to changes in load characteristics, but they also increase variations in disturbance estimation.
						Estimation results are saved in EEPROM every 30 mi- nutes regardless of the load characteristic estimated speed setting.
						When automatic vibration detection is enabled from Set- up Support Software (PANATERM ver.7), this setting will be ignored and the setting value will be set to 3.
	Setup Mode value		Mode			Description
	C		Does not change	Stops load characteristics estimation.		stics estimation.
	1		Changes very little Estimates chan		anges in load characteristics in minutes.	
	2 Changes slowly		Estimates char	Estimates changes in load characteristics in seconds.		
	3 Changes precipitously		Fastest estimat	Fastest estimation of changes in load characteristics.		
6	32	В	Real time auto tuning custom setup	-32768 to 32767	_	Cannot be used with two-degree-of-freedom control mode for synchronization type. Use with the setup value at 0.

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

# 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 Seriescompatible 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 set- ting resolution, individual FB/FF setting switching" .	bits 5 to 4 = 11b
Unbalanced load/fric- tion compensation	Can be changed with Pr2.45 "Function expansion setup 10" :bit 2 "Friction torque compensation parameter selection" .	
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 fluctua- tion 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	В	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-compati- ble specification) 1: Use Pr2.46 "Tuning filter 2" (MINAS A7 Series specifi- cation)
2	45	В	Function expan- sion 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 cal- culation bit 5 to 4: Stiffness setting resolution, individual FB/FF set- ting switching bit 31 to 6: Unused

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

# 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
		01b: Two-degree-of-freedom control (MINAS A7 Series specifica- tion)	
		10b: Manufacturer use	
		11b: Manufacturer use	
2	Friction torque compen-	0: MINAS A6 Series-compatible specification settings	1
	sation parameter selec-	Unbalanced load compensation value: Use Pr6.07	
	tion	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	
3	Load fluctuation sup- pression function auto- matic calculation	0: Conventional setting (MINAS A6 Series specification)	1
		1: The following parameters are automatically calculated.	
	matic calculation	Pr6.73 "Load estimation filter"	
		Pr6.76 "Load estimation count"	
5 to 4	Stiffness setting resolu- tion, individual FB/FF	00b: 32 stiffness settings, FB/FF common setting (MINAS A6 Ser- ies-compatible specification)	11b
	setting switching	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	
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 para	ameter <sup>(*1)</sup>	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 addi- tional value 2" Pr6.07 "Torque command ad- ditional value"		When in synchronous friction compensation mode (Pr0.02 = 2) or load characteristics update mode (Pr0.02 = 4)
Pr2.53 "Positive direction tor- que compensation value 2" Pr6.08 "Positive direction tor- que compensation value"		
Pr2.54 "Negative direction tor- que compensation value 2" Pr6.09 "Negative direction tor- que compensation value"		
Pr6.50 "Viscous friction compen	sating 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 <u>"4.1.2.6 Basic Gain Parameter Setup Table"</u>.

- 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"	• When in synchronous mode, synchronous friction compensation mode,
Pr1.01 "1st velocity loop gain"	stiffness setting mode, or load fluctuation support mode (Pr0.02 = 1 to 3, or 6)
Pr1.02 "1st velocity loop integration time con- stant"	
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 con- stant"	
Pr1.09 "2nd torque filter time constant"	

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 at- tenuation term"	• Set the tens place to 1 and keep the ones place unchanged when in syn- chronous mode, synchronous friction compensation mode, stiffness set- ting 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 compensa- tion 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 switch- ing"	Set to 10 (1.0 ms).
Pr1.17 "Level of position control switching"	Set to 0
Pr1.18 "Hysteresis at position control switch- ing"	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 switch- ing"	Set to 0
Pr1.22 "Level of velocity control switching"	Set to 0
Pr1.23 "Hysteresis at velocity control switch- ing"	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 expan- sion setup"	When stiffness setup is enabled	bit 1 "Load fluctuation con- trol function" = 1 (enabled)	bit 1 "Load fluctuation con- trol function" = 0 (disabled)			
Pr6.23 "Load change com- pensation gain"	When stiffness setup is enabled	Set to 90 (90%)	Set to 0			
Pr6.24 "Load change com- pensation filter"	When stiffness setup is enabled	Updates to set value ac- cording to stiffness	Retain value			
Pr6.73 "Load estimation fil- ter"	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 compensa- tion frequency 1"	Set to 0 regardless of the value of Pro	5.10:bit 14.				
Pr6.75 "Torque compensa- tion frequency 2"	Set to 0 regardless of the value of Pro	5.10: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 <u>"Supplement"</u>).
- 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.
- 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 <u>"Supplement"</u>).
- 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 <u>"Supplement"</u>) 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
Stiff	Stiffness 1st gain/2nd gain		Tuning filter				ation suppo 02 = 6)	ort mode			
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 <sup>-1</sup> ]	Speed [0.1 Hz]	Speed integra- tion [0.1 ms]	Torque [0.01 ms ]	Time constant [0.1 ms]	Load change compen- sation filter [0.01 ms ]	Load fluctua- tion po- sition loop gain [0.1 s <sup>-1</sup> ]	Load change compen- sation filter [0.01 ms ]	Torque compen- sation frequen- cy L [0.1 Hz]	Torque compen- sation frequen- cy 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 fluctua- tion con- trol func- tion	Only in load fluctuation support mode (Pr0.02 = 6)			ort mode
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 <sup>-1</sup> ]	Speed [0.1 Hz]	Speed integra- tion [0.1 ms]	Torque [0.01 ms ]	Time constant [0.1 ms]	Load change compen- sation filter [0.01 ms ]	Load fluctua- tion po- sition loop gain [0.1 s <sup>-1</sup> ]	Load change compen- sation filter [0.01 ms ]	Torque compen- sation frequen- cy L [0.1 Hz]	Torque compen- sation frequen- cy 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 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 char- acteristic 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 applica- tion 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 <u>"Details on Pr6.32</u> <u>"Real time auto tuning custom setup" "</u> .

# 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.



# 4.1.3.4 Related Parameters

4.1.3.4.1	Parameters	That Control t	he Operation	of This Function
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						—: None
Class	No.	Attribute <sup>(*1)</sup>	Parameter name	Setting range	Unit	Function
0	02	В	Real-time auto- gain tuning setup	0 to 7	-	Sets the real-time auto tuning operation mode.
0	03	В	Real-time auto- tuning machine stiffness setup	0 to 31	_	Sets responsiveness when real-time auto tuning is ena- bled. Higher settings result in higher speed responsive- ness and servo stiffness, but make it more likely that vi- bration 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	В	Selection of ma- chine stiffness at real-time auto- gain tuning 2	0 to 44	_	Sets responsiveness when real-time auto tuning is ena- bled. Higher settings result in higher speed responsive- ness and servo stiffness, but make it more likely that vi- bration 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	В	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 <sup>(*1)</sup>	Parameter name	Setting range	Unit	Function		
2	74	A	Tuning auto tun- ing application se- lection	-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 funct tuning         0: Disabled       1: Enabled		0: Disabled				
6	31	В	Real time auto 0 to 3 tuning estimation speed		_	Sets load characteristics estimated speed when real-time auto-tuning is enabled. Higher settings result in faster re- sponses to changes in load characteristics, but they also increase variations in disturbance estimation. Estimation results are saved in EEPROM every 30 mi- nutes regardless of the load characteristic estimated speed setting. When automatic vibration detection is enabled from Set- up Support Software (PANATERM ver.7), this setting will be ignored and the setting value will be set to 3.		
	Set val		Mode			Description		
	0		Does not change	Stops load cha	racteri	stics estimation.		
	1		Changes very little	Estimates char	nges in	load characteristics in minutes.		
	2		Changes slowly	Estimates char	Estimates changes in load characteristics in seconds.			
	3		Changes precipitously	y Fastest estimat	tion of	changes in load characteristics.		
6	32	В	Real time auto tuning custom setup	-32768 to 32767	_	<ul> <li>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.</li> </ul>		

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

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

bit	Mode	Description
1 to 0	Load characteristics estimation	<ul> <li>Set to enable or disable the load characteristics estimation function.</li> <li>0: Disabled</li> <li>1: Enabled</li> <li>— Precautions —</li> <li>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.</li> <li>To enable load characteristic estimation, set Pr6.31 "Real time auto tuning estimation speed" to a value other than 0 (no change).</li> </ul>
3 to 2	Inertia ratio update	<ul> <li>Set updates in load characteristic estimation results for Pr0.04 "Inertia ratio".</li> <li>0: Disabled</li> <li>1: Enabled</li> <li>Precautions –</li> <li>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.</li> </ul>

bit	Mode	Description						
6 to 4	Torque compensa- tion <sup>(*1)</sup>	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".						
		Setup value	Mode	Description				
		0	Use current settings	Uses current settings.				
		1	Disable torque compen- sation	Clear Pr2.52, Pr2.53, Pr2.54, and Pr6.50 to 0.				
		2	Vertical axis mode	Update Pr2.52 and clear Pr2.53, Pr2.54 and Pr6.50 to 0.				
		3	Friction compensation (weak)	Update Pr2.52 and set weak compensation for Pr2.53, Pr2.54, and Pr6.50.				
		4	Friction compensation (medium)	Update Pr2.52 and set medium compensation for Pr2.53, Pr2.54, and Pr6.50.				
		5	Friction compensation (strong)	Update Pr2.52 and set strong compensation for Pr2.53, Pr2.54 and Pr6.50.				
		<ul> <li>Precautions –</li> <li>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.</li> <li>Pr2.45: bit 2=0 : Pr6.07, Pr6.08, Pr6.09</li> <li>Pr2.45: bit 2=1 : Pr2.52, Pr2.53, Pr2.54</li> </ul>						
7	Stiffness setup (*2)	stiffness s Pr0.28 "Su 0: Disab 1: Enabl <b>— Preca</b> • Chan expares switch • Pr • Pr • Pr	etup", Pr0.27 "Selection o election of feed forward stif led ed <b>utions —</b> ge the parameters to be us	) : Pr0.03 ).27				
8	Fixed parameter setup <sup>(*2)</sup>	Set whether or not to change parameters that become fixed values when real-time auto tuning is enabled.         For details, see the table <u>"Values Set When Real-Time Auto Tuning is Enabled (Pr0.02 = 1 to 4, 6, 7)</u> " in <u>"4.1.3.4.3 Parameters Changed By This Function"</u> .         0: Use current settings         1: Set to fixed values						
10 to 9	Gain switching set- up <sup>(*2)</sup>	<ul> <li>1: Set to fixed values</li> <li>Select the method for setting parameters related to gain switching when real-time auto tuning is enabled.</li> <li>0: Use current settings</li> <li>1: Gain switching disabled</li> <li>2: Gain switching enabled</li> </ul>						
11	Torque compensa- tion setting switch- ing	0: Enabl	ether to enable bits 6 to 4 o e bits 6 to 4 e bits 15 to 12	or bits 15 to 12 for torque compensation.				

bit	Mode	Description							
15 to 12	Individual torque compensation set- tings <sup>(*1)</sup>	Select whether to use or update the current setting for the corresponding parameters v bit 11 "Torque compensation setting switching" = 1. 0: Use current settings 1: Update							
			bit 15 bit 14 bit 13 bit 12						
		When Pr2.45:bit 2 = 1							
		When Pr2.45:bit 2 = 0	When Pr2.45:bit 2 = 0         Pr6.50         Pr6.09         Pr6.08         Pr6.07						

\*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 <u>"1"</u> and <u>"2"</u> 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

 $2^0 \times 1 + 2^2 \times 1 + 2^4 \times 3 + 2^7 \times 1 + 2^8 \times 1 + 2^9 \times 2 = 1461$ 

# 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 Seriescompatible 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 set- ting 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/fric- tion 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 fluctua- tion suppression function automatic calculation".	bit 3 = 1

#### \*1 Normally used with initial values.

						—: None
Class	No.	Attribute <sup>(*1)</sup>	Parameter name	Setting range	Unit	Function
2	38	В	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-compati- ble specification) 1: Use Pr2.46 "Tuning filter 2" (MINAS A7 Series specifi- cation)
2	45	В	Function expan- sion 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 cal- culation bit 5 to 4: Stiffness setting resolution, individual FB/FF set- ting switching bit 31 to 6: Unused

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

# 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
		01b: Two-degree-of-freedom control (MINAS A7 Series specifica- tion)	
		10b: Manufacturer use	
		11b: Manufacturer use	
2	Friction torque compen- sation parameter selec- tion	<ul> <li>0: MINAS A6 Series-compatible specification settings</li> <li>Unbalanced load compensation value: Use Pr6.07</li> <li>Dynamic friction compensation value: Use Pr6.08, Pr6.09</li> <li>1: MINAS A7 Series specification settings</li> <li>Unbalanced load compensation value: Use Pr2.52</li> <li>Dynamic friction compensation value: Use Pr2.53, Pr2.54</li> </ul>	1
3	Load fluctuation sup- pression function auto- matic calculation	<ul> <li>0: Conventional setting (MINAS A6 Series specification)</li> <li>1: The following parameters are automatically calculated.</li> <li>Pr6.73 "Load estimation filter"</li> <li>Pr6.76 "Load estimation count"</li> </ul>	1

bit	Name	Description	Initial value
5 to 4	Stiffness setting resolu- tion, individual FB/FF setting switching	00b: 32 stiffness settings, FB/FF common setting (MINAS A6 Ser- ies-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 Ser- ies specification) Use Pr0.27 and Pr0.28	11Ь
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 para	Conditions for update	
Pr2.45:bit 2 = 1	Pr2.45:bit 2 = 0	
Pr0.04 "Inertia ratio"		When inertia ratio update is enabled (Pr $0.02 = 1$ to 4, 6, 7)
Pr2.52 "Torque command additional value 2"	Pr6.07 "Torque command additional value"	When vertical axis mode or friction compensa- tion 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	When Pr0.02 = 6, 7 (customize mode) with vis- cous 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 <u>*'4.1.3.6 Basic Gain Parameter Setup Table*</u>".

- 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"	• When stiffness setup is enabled (Pr0.02 = 1 to 4, 7)
Pr1.01 "1st velocity loop gain"	
Pr1.02 "1st velocity loop integration time con- stant"	
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 con- stant"	
Pr1.09 "2nd torque filter time constant"	

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 ra- tio 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"	<ul> <li>Sets the change ratio for Pr1.02 "1st velocity loop integration time con- stant"</li> </ul>
	• 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 con- stant"
	• 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 switch- ing"	Set to 50 (5	ms).				
Pr1.17 "Level of position control switching"	Set to 50					
Pr1.18 "Hysteresis at position control switch- ing"	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 switch- ing"	Set to 0					
Pr1.22 "Level of velocity control switching"	Set to 0					
Pr1.23 "Hysteresis at velocity control switch- ing"	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 expan- sion setup"			bit 1 "Load fluctuation con- trol function" = 0 (disabled)	
Pr6.23 "Load change com- pensation gain"	When stiffness setup is enabled	Set to 90 (90%)	Set to 0	
Pr6.24 "Load change com- pensation filter"	When stiffness setup is enabled	Updates to set value ac- cording to stiffness	Retain value	
Pr6.73 "Load estimation fil- ter"	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 compensa- tion frequency 1"	Set to 0 regardless of the value of Pre	et to 0 regardless of the value of Pr6.10:bit 14.		
Pr6.75 "Torque compensa- tion 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	d 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 <u>"Supplement"</u>).
- 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 <u>"Supplement"</u>).
  - 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 <u>"Supplement"</u>) 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					
Stiff	ness		1st	gain			2nd	gain		For load fluc- tuation 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 <sup>-1</sup> ]	Speed [0.1 Hz]	Speed integra- tion [0.1 ms]	Torque [0.01 ms]	Position [0.1 s <sup>-1</sup> ]	Speed [0.1 Hz]	Speed integra- tion [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	

Stiffi	ness		1st	gain		2nd gain				For load fluc- tuation 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 <sup>-1</sup> ]	Speed [0.1 Hz]	Speed integra- tion [0.1 ms]	Torque [0.01 ms]	Position [0.1 s <sup>-1</sup> ]	Speed [0.1 Hz]	Speed integra- tion [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 <sup>(*1)</sup>	Parameter name	Setting range	Unit	Function
1	14	В	2nd gain setup	0 to 1	_	<ul> <li>Set when performing optimum tuning using the gain switching function.</li> <li>0: Disabled (Fixes 1st gain)</li> <li>1: Enabled (Enables gain switching between 1st gain and 2nd gain)</li> </ul>

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

## Position control mode, full-closed control mode

						—: N/A
Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
1	15	В	Mode of position control switching	0 to 10	_	Sets the trigger condition for gain switching during po- sition control and full-closed control. (Setup value): (switching condition) 0: 1st gain fixed 1: 2nd gain fixed 2: RTEX communication gain switching command (Gain_SW) 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	В	Delay time of po- sition 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	В	Level of position control switching	0 to 20000	Depends on the mode	<ul> <li>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.</li> <li>Units vary with switching mode setting.</li> <li>Set the level equal to or higher than the hysteresis.</li> </ul>
1	18	В	Hysteresis at po- sition control switching	0 to 20000	Depends on the mode	<ul> <li>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.</li> <li>Units vary with switching mode setting.</li> <li>When the level is less than the hysteresis, the hysteresis is re-set internally so that it is equal to the level.</li> </ul>
1	19	В	Position gain switching time	0 to 10000	0.1 ms	Sudden increases in position loop gain can be sup- pressed 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 <u>"7.1 List of Parameters"</u>.

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 <sup>(*1)</sup>	Parameter name	Setting range	Unit	Function
1	20	В	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: RTEX communication gain switching command (Gain_SW) 3: Torque command 4: Speed command variation 5: Speed command
1	21	В	Delay time of ve- locity 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	В	Level of velocity control switching	0 to 20000	Depends on the mode	<ul> <li>Sets triggering level during velocity control when Pr1.20 "Mode of velocity control switching" is 3 to 5.</li> <li>Units vary with switching mode setting.</li> <li>Set the level equal to or higher than the hysteresis.</li> </ul>
1	23	В	Hysteresis at ve- locity control switching	0 to 20000	Depends on the mode	<ul> <li>Sets triggering hysteresis during velocity control when Pr1.20 "Mode of velocity control switching" is 3 to 5.</li> <li>Units vary with switching mode setting.</li> <li>When the level is less than the hysteresis, the hys- teresis is re-set internally so that it is equal to the level.</li> </ul>

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

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 <sup>(*1)</sup>	Parameter name	Setting range	Unit	Function
1	24	В	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: RTEX communication gain switching command (Gain_SW) 3: Torque command
1	25	В	Delay time of tor- que 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	В	Level of torque control switching	0 to 20000	Depends on the mode	<ul> <li>Sets triggering level during torque control when Pr1.24</li> <li>"Mode of torque control switching" is 3.</li> <li>Units vary with switching mode setting.</li> <li>Set the level equal to or higher than the hysteresis.</li> </ul>
1	27	В	Hysteresis at tor- que control switching	0 to 20000	Depends on the mode	<ul> <li>Sets triggering hysteresis during torque control when Pr1.24 "Mode of torque control switching" is 3.</li> <li>Units vary with switching mode setting.</li> <li>When the level is less than the hysteresis, the hysteresis is re-set internally so that it is equal to the level.</li> </ul>

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

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.

O: Enabled 2	X: Disabled
--------------	-------------

				~	abled X:	Disable			
Control switching	Switching con- dition	Gain switching details	Control mode						
mode setting values	dition		Posi- tion	Full- closed	Speed	Torque			
0	1st gain fixed	Fixed to 1st gain (Pr1.00 to Pr1.04)	0	0	0	0			
1	2nd gain fixed	Fixed to 2nd gain (Pr1.05 to Pr1.09)	0	0	0	0			
2	RTEX commu- nication gain switching com- mand (Gain_SW)	1st gain when RTEX communication gain switching command (Gain_SW) is 0, and 2nd gain when the command is 1.	0	0	0	0			
3	Torque com- mand magni- tude	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 - hystere- sis) [%] for the delay time in 2nd gain.	0	0	0	0			
4	Large amount of speed com- mand variation	Switches to 2nd gain if previously the absolute value of speed command variation exceeded (level + hyste- resis) [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. <b>Notes</b> • Except with speed control, the 1st gain is fixed.	×	×	0	×			
5	Speed com- mand magni- tude	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 - hystere- sis) [r/min] for the delay time in 2nd gain.	0	0	0	×			
6	Position devia- tion magnitude	<ul> <li>Switches to 2nd gain if previously the absolute value of position deviation exceeded (level + hysteresis) [pulse] in 1st gain.</li> <li>Returns to 1st gain if previously the absolute value of position deviation remained below (level - hysteresis) [pulse] for the delay time in 2nd gain.</li> <li>Notes <ul> <li>Level and hysteresis units [pulse] are set by encoder resolution for position control and by feedback scale resolution for full-closed control.</li> <li>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.</li> </ul> </li> </ul>	0	0	×	×			
7	With position command	Switches to 2nd gain if previously the position com- mand was not 0 in 1st gain. Returns to 1st gain if previously the position com- mand remained 0 for the delay time in 2nd gain.	0	0	×	×			
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 com- pleted state continued for the delay time in 2nd gain.	0	0	×	×			

Control	Switching con-	Gain switching details	Control mode					
switching mode setting values	dition		Posi- tion	Full- closed	Speed	Torque		
9	Actual Speed - Large	Shifts to 2nd gain when the actual speed absolute value exceeds (level + hysteresis) [r/min] in the previous 1st gain.	0	0	×	×		
		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.						
10	With Position Command + Actual Speed	Switches to 2nd gain if previously the position com- mand 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 previ- ous 2nd gain.	0	0	×	×		

# 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  $62.5 \,\mu$ s". 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  $\mu$ s = 3.2, which is a rise of 3 steps. (Actual switching time is 62.5  $\mu$ s × 3 = 250  $\mu$ s = 187.5  $\mu$ s) \*The gain switching flag changes at the moment of switching from low gain.

When Pr1.19 "Position gain switching time" is 0



#### 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.
- 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.
- 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"  $\leq$  Pr1.17 "Level of position control switching".







# 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.

892				PANATERM ver./				
File(F)	Troubleshooting(T)	Help(H)						_
		E Device tree		ôð Setting	嬰 Monitor	比 Logging	🕞 Tuning	🚺 Device Info
	-	MINAS A7BR		All parameters	EtherCAT object	IO Setting	Alarm	Analog input
₫∨	Online	Axis0_No name set SRV-OF	-					
	USB	MADN085BRU 23080001		Open file	Save file	Copy Load initia	l values Load	Write
			ier Info 6 pulse		Config		:	olumn
		MINAS A7BR 3940578 MHMG022U1A2 24020001	• puise	Search	Compar	rison None	Add/delete d	olumn
				Switch to HEX input	Display A6-compati	ible control parameters	Allow out-of-range setting	igs

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



The "Manual TUNING" settings screen is displayed.

5				PANATE	RM ver.7						
F	ile(F) Troubleshooting(T) Help(H)										
Devie	袋 Setting - 関 Monitor	Ŀζι	ogging	⊡ <mark>⊡</mark> Tuning	Device Info	1	) Trial run	Z-ph	ase search		
Device tree	Manual TUNING		✓ Graph			Trial run/Z	1	2			
	Selected driver:Axis0_No name set		Wave grap	hic Frequency response			Limit setting	Trial ru	n		
	Basic Load characteri Notch settings	וו	Start i	measurement Stop	Single trigger Acquire	phase search	Protection Functions				
	Damping settin Application Manual	1				arch	Pr5.12 Overload level[%]	0			
	Mode setting (i) 0:Disabled V		Measurem	ent data management Edit	display range Fixed display range		Pr5.13 Overspeed level[r/min]				
	Mode setting (i) 0:Disabled  Customize settings		Reset zoor	m Align with center of Y-axi	s	ш		Automatic :	setting (overspee		
	When launching for the first time		Display as	elapsed time Display as tim	e standard Load file		Pr5.14 Motor mova[0.1 rotation	10			
	A7 recommended setting is recommended		Save fi				Operation limit				
	<ol> <li>When upgrading from A6<u>A6 compatibility setting</u> is recommended</li> </ol>		Saven	ie .		81	Pr5.04 Over-travel inhibit input s	1: CoE-side (Ci	A402) deceler 🗸		
	Load characteristic settings Automatic settingOFF		🗸 Graph d	display settings			Operating range				
	Inertia ratio 0			Use JOG to move to the Max/Min. positions or inpu							
	For more advanced settings Load characteristic settings		Measure	ment Condition Edit displaye	ed data Cursor		JOG speed[r/min]	60			
	Gain setting		Acquire	e from driver Acquire from	n file Load condition presets		JOG acceleratio[ms/JOG speed	50			
	Feedback gain setting - 29 +	•									
	Speed response frequenc 102.5		<ul> <li>Monito</li> </ul>	r							
	Automatic oscillation su OFF		Simple mo	Simple monitor							
	Safety function					_					
	FF gain setting - 31 +		Start me	Measurement mode	e With Position C Y Measurement count	2					
	Positional command smo 0.8				Int Vibration level Effective load factor Tal						
	Overshoot suppression [%] - 100.0 +		[times]	[ms] [times]	[%] [%] [m	5]	Servo-on Operates	only while the bu	tton is pressed.		
	Notch filter settings Automatic setting:OFF						- direction	o to 0	- direction		
	3rd notch frequency [Hz]         5000           4th notch frequency [Hz]         5000						Current analities	fcommand unit			
	For more advanced settings Notch settings						Current position	0_	I		
	Damping filter setup Automatic setting:ON										
	1st damping frequency [Hz] 0						Minimum position		Maximum position		
	For more advanced settings Damping settings						[command unit]		[command unit]		
	What if I have a problem?						0		0		
	Refer to Tuning Help <u>when problems occur</u> such as vibration or abnormal noise						Troubl	eshooting	To trial run		

**4.** Click the [Application] button.

<	Manual TUNING					
Selected driver:Axis0_No name set						
Basic		Load characteristic settings	Notch settings			
Damping settir	ngs	Application	Manual			
> Feedforward fun	ction					
> Load fluctuation	control fun	ction				
> High response c	urrent conti	ol function				
> Gain switching fu	unction					
> Quadrant glitch	suppressior	function				
> Hybrid vibration	suppressio	n function				

5. Click on ">" of "> Gain switching function" to expand "Gain switching function".

elected driver:Axis0_No name set					
Basic Load chara		eristic settings	Notch settings		
Damping settings	Application		Manual		
> Feedforward function					
<ul> <li>Load fluctuation control fur</li> </ul>	nction				
> High response current cont	rol function				
<ul> <li>Gain switching function</li> </ul>					
Enabling this allows gain to be	changed durin		mmediately after stopping		
1st gain of position loop		480			
1st velocity loop gain		270			
1st velocityintegral time consta	ant	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 switchi	ng enabled 🗸 🗸		
Mode of position control switching		0: 1st gain fixe	d v		
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]					
Position 3rd gain scale factor [	%]				
> Quadrant glitch suppression	n function				

**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 <u>"4.2 Gain Switching Function</u>"), 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	В	2nd gain setup	0 to 1	_	<ul> <li>Set when performing optimum tuning using the gain switching function.</li> <li>0: Disabled (Fixes 1st gain)</li> <li>1: Enabled (Enables gain switching between 1st gain and 2nd gain)</li> </ul>
1	15	В	Mode of position control switching	0 to 10		Sets the trigger condition for gain switching during posi- tion control and full-closed control. (Setup value): (switching condition) 0: 1st gain fixed 1: 2nd gain fixed 2: RTEX communication gain switching command (Gain_SW) 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	В	Position 3rd gain valid time	0 to 10000	0.1 ms	Sets time for 3rd gain to be enabled.
6	06	В	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 <u>"7.1 List of Parameters"</u>.

# 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)



#### – 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 <u>"Step 4"</u>, 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 <u>"4.2 Gain Switching Function"</u> <u>"4.2.4.2 When Set-up Support Software (PANATERM ver.7) Is Used"</u>.

# 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 forward 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 forward 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 these functions, some RTEX communication commands can be sent with feedforward values set as command arguments. Feedforward values via RTEX communication are added to internally calculated feedforward values based on the function parameter settings. For details, see Technical Reference Communication Specification.

# 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						

#### – Precautions –

- If the control mode is switched to torque control mode from any control mode other than torque control mode during motor operation, feedforward may operate even though torque control is in progress.
- Feedforward via RTEX communication should be filtered by the host device.

# 4.4.3 Related Parameters

						—: N/A
Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
1	10	В	Velocity feed for- ward gain	0 to 4000	0.1%	Multiply the velocity control command calculated ac- cording to the internal position command by the ratio of this parameter and add the result to the speed com- mand resulting from the position control process.
1	11	В	Velocity feed for- ward filter	0 to 6400	0.01 ms	Sets the time constant of first order lag filter which af- fects the input of velocity feedforward. Disabled when the set value is 0 to 3. Invalid during two-degree-of-freedom control mode.
1	12	В	Torque feed for- ward gain	0 to 2000	0.1%	Multiply the torque command calculated according to the velocity control command by the ratio of this param- eter and add the result to the torque command resulting from the velocity control process.
1	13	В	Torque feed for- ward 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 <u>"7.1 List of Parameters"</u>.

# 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 <u>"Tuning speed feedforward"</u> and <u>"Tuning torque feedforward"</u> 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 realtime 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.

9					PANATERM ver.7				
File(F	) Troubleshooting(T)	Help(H)							_
		E Device tree				閥 Monitor	ピ Logging	프 <b>음</b> Tuning	🚺 Device Info 🖄
	-	MINAS A7BR				EtherCAT object	IO Setting	Alarm	Analog input
കം	Online	Axis0_No name set	SRV-OFF	Ľ					
	USB	MADN085BRU 23080001			Open file	Save file	Copy Load initia	I values Load	Write
	•0		Encoder Info				Config Reset		Write phase search
		MINAS A7BR MHMG022U1A2 24020001	39405786 pulse	•	Search	Compar	ison None	✓ Add/delete c	
					Switch to HEX input	Display A6-compatil	ole control parameters	Allow out-of-range settin	gs

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



The "Manual TUNING" settings screen is displayed.

5									
F	File(F) Troubleshooting(T) Help(H)								
Devi	袋 Setting	Ŀζι	ogging	📴 Tuning	Device Info	Ø		Z-pha	ase search
Device tree	Manual TUNING		✓ Graph Wave graph	hic Frequency response		Trial run/Z	0	2	
	Selected driver:Axis0_No name set		wave grap	Frequency response			Limit setting	Trial run	1
	Basic Load characteri Notch settings		Start n	neasurement Stop	Single trigger Acquire	phase search	Protection Functions	0	
	Damping settin Application Manual					arch	Pr5.12 Overload level[%]	0	
	Mode setting (i) 0:Disabled V		Measureme	ent data management Edit	display range Fixed display range		Pr5.13 Overspeed level[r/min]		
	Customize setting		Reset zoon	Align with center of Y-axi	s	ш		🛃 Automatic s	etting (overspee
	(i) When launching for the first time		Display as e	elapsed time Display as tim	e standard Load file		Pr5.14 Motor mova[0.1 rotation]	10	
	A7 recommended settingis recommended		Save file				Operation limit		
	(i) When upgrading from A6A6 compatibility setting is recommended		Save III	e		81	Pr5.04 Over-travel inhibit input s	1: CoE-side (CiA	A402) deceler 🗸
	Load characteristic settings Automatic settingOFF		🗸 Graph d	isplay settings			Operating range		
	Inertia ratio 0						Use JOG to move to the Max./M	n. positions or in	put a numeric value
	For more advanced settings Load characteristic settings		Measuren	ment Condition Edit displaye	d data Cursor		JOG speed[r/min]	60	
•	Gain setting		Acquire	from driver Acquire from	n file Load condition presets		JOG acceleratio[ms/JOG speed]	50	
	Feedback gain setting - 29 +	•							
	Speed response frequenc 102.5		<ul> <li>Monitor</li> </ul>						
	Automatic oscillation su OFF		Simple mor	nitor IO monitor					
	FF gain setting - 31 +		Start mea	surem Measurement mode	e With Position C ✔ Measurement count	2			
	Positional command smo 0.8					_			
	Overshoot suppression [%] - 100.0 +		[times]		Int Vibration level Effective load factor Tak [%] [%] [m:		Servo-on Operates of	only while the but	ton is pressed.
	Notch filter settings Automatic setting:OFF								
	3rd notch frequency [Hz] 5000						- direction 🕨 G	o to 0 +	direction
	4th notch frequency [Hz] 5000						Current position	[command unit]	
	For more advanced settings Notch settings							0	
	Damping filter setup Automatic setting:ON								
	1st damping frequency [Hz] 0						Minimum position		Maximum position
	For more advanced settings Damping settings						[command unit]		[command unit]
	What if I have a problem? Refer to Tuning Help when problems occur such as						0		0
	vibration or abnormal noise						Trouble	eshooting	To trial run

**4.** Click the [Application] button.

<	Manual TUNING										
Selected driver:Axis0_No name set											
Basic	Basic Load characteristic settings Notch settings										
Damping set	tings	Application	Manual								
> Feedforward fu	Feedforward function										
> Load fluctuation	on control fu	unction									
> High response	current cor	ntrol function									
> Gain switching	function										
> Quadrant glitc	h suppressi	on function									
> Hybrid vibratio	n suppressi	on function									

5. Click on ">" of "> Feedforward function" to expand "Feedforward Function".

Manual TUNING									
Selected driver:Axis0_No name set									
Basic	Load characteristic setting	s Notch settings							
Damping settings	Application	Manual							
<ul> <li>Feedforward function</li> <li>Tuning may reduce overshoot,</li> </ul>	/undershoot.								
Speed FF gain [0.1%]	1000								
Speed FF filter [0.01 ms]	0	0							
Torque FF gain [0.1%]	1000								
Torque FF filter [0.01 ms]	0								
Load fluctuation control fu	nction								
<ul> <li>High response current cont</li> </ul>	trol function								
> Gain switching function									
> Quadrant glitch suppressio	n function								
> Hybrid vibration suppression	on function								

6. For details on tuning each parameter, see <u>"4.4.4.1 For Manual Setting"</u>.

# 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

Item	Operational Conditions								
Control mode	Possible modes of operation depend on the type of friction torque compensation.								
	Compensation descrip- tion	Operable modes							
	Unbalanced load com- pensation	Position control mode, speed control mode, full-closed control mode							
	Dynamic friction com- pensation	Position control mode, full-closed control mode							
	Viscous friction compen- sation	When two-degree-of-freedom control mode is enabled in position control mode, speed control mode, or full-close control mode							

# 4.5.3 Related Parameters

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	45	В	Function expan- sion 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	В	Torque command additional value 2	-1000 to 1000	0.1%	Sets the offset torque to be added to the torque com- mand when Pr2.45: bit 2 "Friction torque compensation parameter selection" = 1.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	53	В	Positive direction torque compen- sation value 2	-1000 to 1000	0.1%	Sets the value to be added to the torque command dur- ing positive direction operation when Pr2.45: bit 2 "Fric- tion torque compensation parameter selection" = 1.
2	54	В	Negative direc- tion torque com- pensation value 2	-1000 to 1000	0.1%	Sets the value to be added to the torque command dur- ing negative direction operation when Pr2.45: bit 2 "Fric- tion torque compensation parameter selection" = 1.
6	07	В	Torque command additional value	-100 to 100	%	Sets the offset torque to be added to the torque com- mand when Pr2.45: bit 2 "Friction torque compensation parameter selection" = 0.
6	08	В	Positive direction torque compen- sation value	-100 to 100	%	Sets the value to be added to the torque command dur- ing positive direction operation when Pr2.45: bit 2 "Fric- tion torque compensation parameter selection" = 0.
6	09	В	Negative direc- tion torque com- pensation value	-100 to 100	%	Sets the value to be added to the torque command dur- ing negative direction operation when Pr2.45: bit 2 "Fric- tion torque compensation parameter selection" = 0.
6	50	В	Viscous friction compensating gain	0 to 10000	0.1 %/ (10000 r /min)	<ul> <li>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.</li> <li>Setting the value of the viscous friction coefficient estimation of real-time auto tuning can improve the encoder position deviation of the settling area.</li> </ul>

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

# 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.

0				PANATERM ver.7				— 🗆 ×
File(F)	Troubleshooting(T)	Help(H)						_
		E Device tree		<il> <li>Setting</li> </il>	嬰 Monitor	匕 Logging	프운 Tuning	Device Info
	-	MINAS A7BR		All parameters	EtherCAT object	IO Setting	Alarm	Analog input
ֈ֎৵	Online	Axis0_No name set SRV-OFF						
	USB	MADN085BRU 23080001		Open file	Save file	Copy Load initia	I values Load	Write
	•0	Encod	r Info			Config Reset		
	5	MINAS A7BR 39405786 MHMG022U1A2 24020001	pulse	Search Search	Compa		Add/delete c	

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



The "Manual TUNING" settings screen is displayed.

é	5								
	File	e(F) Troubleshooting(T) Help(H)							
Devi		袋 Setting	Ŀζ	ogging	프 <mark>은</mark> Tuning	Device Info	Ø	Trial run	Z-phase search
Device tree		K Manual TUNING		✓ Graph Wave graph	ic Frequency response		Irial run/Z-phase search		2
	1	Selected driver:Axis0_No name set					phas	Limit setting	Trial run
	IJ	Basic Load characteri Notch settings		Start m	neasurement Stop	Single trigger Acquire	ie sei	Protection Functions Pr5.12 Overload level(%)	0
	ll	Damping settin Application Manual		Measureme	ent data management Edit	display range Fixed display range	arch		
		Mode setting (i) 0:Disabled V		measureme			- 11	Pr5.13 Overspeed level[r/min]	
		Customize settings		Reset zoom	Align with center of Y-axis	s	- 11		Automatic setting (overspee
		(i) When launching for the first time		Display as e	elapsed time Display as tim	e standard Load file		Pr5.14 Motor mova[0.1 rotation	] 10
		A7 recommended settingis recommended		Save file				Operation limit	
		<ol> <li>When upgrading from A6<u>A6 compatibility setting</u> is recommended</li> </ol>		save me	2		- 51	Pr5.04 Over-travel inhibit input s	1: CoE-side (CiA402) deceler 🗸
	l	Load characteristic settings Automatic settingOFF		🗸 Graph di	splay settings			Operating range	
		Inertia ratio 0		Manauran	nent Condition Edit displaye	d data Cursor			in. positions or input a numeric value
		For more advanced settings Load characteristic settings		weasuren	Eult displaye		-	JOG speed[r/min]	60
•	(	Gain setting		Acquire	from driver Acquire fron	n file Load condition presets		JOG acceleratio[ms/JOG speed	] 50
		Feedback gain setting - 29 +	•						
		Speed response frequenc 102.5		<ul> <li>Monitor</li> </ul>					
		Automatic oscillation su OFF Safety function		Simple mon	itor IO monitor				
		FF gain setting - 31 +		Start mea	surem Measurement mode	e With Position C 🖌 Measurement cou	int 2		
		Positional command smo 0.8				Int Vibration level Effective load factor			
		Overshoot suppression [%] - 100.0 +		[times] [	[ms] [times]	[%] [%]	[ms]	Servo-on Operates	only while the button is pressed.
	1	Notch filter settings Automatic setting:OFF						- direction	io to 0 + direction
		3rd notch frequency [Hz] 5000							
		4th notch frequency [Hz] 5000 For more advanced settings Notch settings							n (command unit) 0
	١,								
	ľ	Damping filter setup Automatic setting:ON 1st damping frequency [Hz] 0						1.0 S S	▲
	F	For more advanced settings Damping settings						Minimum position [command unit]	Maximum position [command unit]
		What if I have a problem?						0	0
		Refer to Tuning Help when problems occur such as						Traubl	eshooting To trial run
		vibration or abnormal noise						Iroubi	eshooting 16 thai run

4. Select "Mode setting" from the drop-down list. Select "7: Customize 2" and click the [Customize settings] button.

Mode setting (i)	7:Customize2 ✓					
	Customize settings					
<ul> <li>When launching for the first time<u>A7 recommended setting</u> is recommended</li> <li>When upgrading from A6<u>A6 compatibility setting</u> is recommended</li> </ul>						
Tuning conditions	• Positioning/general-purpose					
	O Processing machine					
	O Customize					
> Parameters for tuning conditions						

- 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 setting: Manual setting/automatic setting of each control Load characteristics estimation	
Inertia Ratio Update	
Stiffness Setup	
Fixed Parameter Setup	OFF
Gain Switching Setup	0:Use current settings 🗸
Torque compensation setting switching	
Tuning torque command additional value	OFF
Tuning positive direction torque compensation	OFF
Tuning negative direction torque compensation	OFF
Tuning viscous friction compensating gain	OFF
ОК	Cancel

- 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 <u>"Step 6"</u>.

# 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)
	<ul> <li>Looseness, backlash, etc. are present and the load non-linearity is strong</li> </ul>

# 4.6.3 Related Parameters

-: None

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	45	A	Function expan- sion setup 10	-2147483648 to 2147483647	_	<ul> <li>Sets automatic calculation of parameters for load fluctuation suppression.</li> <li>bit 3: Load fluctuation suppression function automatic calculation</li> <li>0: Conventional setting (MINAS A6 Series specification)</li> <li>1: The following parameters are automatically calculated</li> <li>Pr6.73 "Load estimation filter"</li> <li>Pr6.76 "Load estimation count"</li> </ul>

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	10	В	Function expan- sion setup	-32768 to 32767		<ul> <li>Sets the load fluctuation suppression function.</li> <li>bit 1: Load fluctuation control function <ol> <li>Disabled</li> <li>Enabled</li> </ol> </li> <li>Disabled <ol> <li>Enabled</li> <li>Enabled</li> </ol> </li> <li>Disabled <ol> <li>Enabled</li> </ol> </li> <li>Disabled</li> <li>Enabled</li> <li>Disabled <ol> <li>Enabled</li> </ol> </li> <li>Disabled <ol> <li>Enabled</li> </ol> </li> <li>Disabled <ol> <li>Enabled</li> </ol> </li> <li>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.</li> </ul>
6	23	В	Load change compensation gain	-100 to 100	%	Sets compensation gain with respect to load fluctuation.
6	24	В	Load change compensation fil- ter	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	В	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	В	Torque compen- sation 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 be- tween Pr6.74 "Torque compensation frequency 1" and Pr6.75 "Torque compensation frequency 2" is within the range of the following formula. 1.0 Hz $\leq$ Pr6.75 $<$ Pr6.74 $\leq$ (Pr6.75 $\times$ 32)
6	75	В	Torque compen- sation 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 be- tween Pr6.74 "Torque compensation frequency 1" and Pr6.75 "Torque compensation frequency 2" is within the range of the following formula. 1.0 Hz $\leq$ Pr6.75 $\leq$ Pr6.74 $\leq$ (Pr6.75 $\times$ 32)
6	76	В	Load estimation count	0 to 8	_	Sets count relating to load estimation.

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

# 4.6.4 How to Use

# 4.6.4.1 For Manual Setting

#### << Procedure >>

- 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 <u>"Step 1"</u>, 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.

<u>@</u>				PANAT	ERM ver.7				- 🗆 ×
File(F)	Troubleshooting	(T) Help(H)							_
		E Device tree		{ĝ} Se	rtting	閥 Monitor	ピム Logging	📑 Tuning	Device Info
	<b>a</b>	MINAS A7BR		All para	meters E	therCAT object	IO Setting	Alarm	Analog input
⊕∨	On	line Axis0_No name set	SRV-OFF						
	U.	SB MADN085BRU 23080001		Open	file Save 1	file	Copy Load initial	values Load	Write
	M		Encoder Info				Config Reset		
		MINAS A7BR MHMG022U1A2 24020001	39405786 pulse	Search		Compari	son None	✓ Add/delete d	
				Switch to	HEX input	Display A6-compatib	le control parameters	Allow out-of-range settin	ngs

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



The "Manual TUNING" settings screen is displayed.

	9											
Manual TUNING Graph Selected driverAxis0 (No name set Selected driverAxis0 (No name set) Damping settin. Application Manual Mode setting: Obtabled Catannassement Sing: Cade dranketeristic settings: Catannassement Catannassement Edit display range Freed display range Freed display range P5:14 Motor mova[0:1 rotation] </td <td>File(</td> <td>F) Troubleshooting(T) He</td> <td>p(H)</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	File(	F) Troubleshooting(T) He	p(H)									
Selected diver/xii0 (No name set       Unit setting       Unit setting       Init se	Devie	🔅 Setting	閥 Monitor	ŀ∕ą Logg	ging	🔤 Tuning	Device Info				Z-ph	ase search
Basic       Load characteri       Notch settings         Damping settin       Application       Manual         Mode setting       Objected       Image: Control of State measurement       Edd display range         When launching for the first time       Image: Control of State measurement       Edd display range       Field display range       Protection Functions         Mode setting       Objected       Image: Control of State measurement       Edd display range       Field display range       Protection Functions         Mode setting       Objected       Image: Control of State measurement       Edd display range       Protection Functions       Protection Functions         Mode setting       Objected       Image: Control of State measurement       Edd display range       Protection Functions       Protection Functions         Mode setting       Objected       State measurement       Edd display range       Protection Functions       Protection Functions         State measurement       Objected       Load functions       Protection Functions       Protection Functions         State measurement       Objected       Load functions       Protection Functions       Protection Functions         State measurement       Control       Consort       Consort       Consort       Operates only while the button is presesed	-			- 11 -		Frequency response		run/2-	3	1 t setting		n
vibration or abnormal noise Troubleshooting To trial ru	M ( , ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( )	Basic         Load chara           Damping settin         Applicat           Damping settin         Applicat           Ode setting ①         DD           ① When launching for the first         Co.           ⑦ When uparding from A666         seconomended           ad characteristic settings         Automatic settings           ad characteristic settings         Automatic settings           sin setting         -           Gedback gain setting         -           Speed response frequenc         Automatic oscillation su           Overshoot suppression [%]         -           ostificinal command smo         -           Overshoot suppression [%]         -           otch filter settings         Automatic settings Not anning filter settings Not anning filter settings Mut std amping filter settings Mut std amping filter settings Mut std amping filter settings Damy hat filt have a problem?	eri Notch settings n Manual abled tomize settings me meneded compatibility setting matic settingOFF characteristic settings 29 + 102.5 ty function 31 + 0.8 100.0 + settings matic settingsOFF 5000 5000 h settings matic settingsOFF 0 0 0 0 0 0 0 0 0 0 0 0 0		Start measurement d     Start measurement     Areset zoom     Complex as elaps     Save file     Graph displa     Measurement     Acquire fron     Monitor     Simple monitor     Start measure     Trial No.   Sett!	arement Stop ata management Edit Align with center of Y-axi ed time Display as tim y settings Condition Edit displaye a driver Acquire fror 10 monitor m Measurement mod ng time INP change co.	display range Fixed display range s te standard Load file ad data Cursor n file Load condition pre e With Position C V Measurer nt Vibration level Effective load	ge g	Limit Protection Functions Pr5.12 Overload leve Pr5.13 Overspeed le Pr5.14 Motor mova. Operation limit Pr5.04 Over-travel in Operation limit Pr5.04 Over-travel in Operating range Use JOG to move t JOG speed[r/min] JOG acceleratio[n Cu - direction Cu	(%) (%) (%) (%) (%) (%) (%) (%) (%) (%)	0 120 2 Automatic : 10 1: CoE-side (Ci. 60 50 n) while the bu (command unit)	A402) deceler × apput a numeric value tton is pressed. direction

**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.

<	K Manual TUNING								
Selected driver:Axis0_No name set									
Basic	Load charac	teristic	settin	Notch set	tings				
Damping settings	Арр	lication	n	Manua	ıl				
Mode setting (i)		7:Cus	tomize2		~				
		Cust	omize sett	ings					
(i) When launching for the f					ed				
(i) When upgrading from A	6 <u>A6 compatik</u>	-							
Tuning conditions		• Po	sitioning/	general-purpose					
		O Pr	ocessing r	nachine					
		O Ci	ustomize						
> Parameters for tuning	g conditions								
Load characteristic settings		Automatic settingON							
Inertia ratio									
For more advanced settings	Load characte	eristic settings							
Gain setting									
Feedback gain setting		-	16		+				
Speed response frequency [H					27.0				
Automatic oscillation supp	ression	OFF							
		Safe	ty functior	1					
FF gain setting		-	16		+				
Positional command smooth	iing filter [				3.7				
Overshoot suppression [%]		-	100.0		+				
Notch filter settings		Autor	natic setti	ng:ON					
	3rd notch frequency [Hz]				5000 5000				
4th notch frequency [Hz] For more advanced settings	Notch settina	s			5000				
Damping filter setup			natic setti	ng:ON					
1st damping frequency [Hz]									
For more advanced settings D	amping settin	gs							
What if I have a problem? Refer to Tuning Help <u>when p</u>	roblems occu	r such	as vibratic	n or abnormal no	ise				

## **5.** Click the [Application] button.



6. Click ">" of "> Load fluctuation control function" to expand "Load fluctuation control function".

<	Manual	TUNING							
Selected driver:Axis0_No nar	ne set								
Basic	Basic Load characteristic settin Notch settings								
Damping settings	Applie	cation	Manual						
> Feedforward function									
✓ Load fluctuation control f	unction								
the movement of other axes Use to suppress overshoot, to occur. Load fluctuation suppression	etc. Be aware th	at increasing co	ntrol may cause oscillation						
Load fluctuation suppression	n function aut								
Load change compensation	gain [%]	90							
Load change compensation	filter [0.01 ms]	590							
Load estimation filter [0.01 r	ns]	4							
Torque compensation freque	ency 1 [0.1 Hz]	0							
Torque compensation freque	ency 2 [0.1 Hz]	0							
Load estimation count		0							
> High response current co	High response current control function								
> Gain switching function									
> Quadrant glitch suppress	ion function								
> Hybrid vibration suppress	ion function								

**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".

Manual TUNING										
Selected driver:Axis0_No name set										
Basic	Basic Load characteristic settings Notch setting									
Damping settings	Ар	olication		Manual						
Mode setting 🚺		0:Disa	bled		~					
		Custo	omize sett	ings						
(i) When launching for the f (i) When upgrading from A										
Load characteristic settings		Autom	natic settir	IgOFF						
Inertia ratio		250								
For more advanced settings	Load characte	eristic se	ttings							
Gain setting										
Feedback gain setting		-		+						
Speed response frequency [H	lz]				27.0					
Automatic oscillation supp	ression	OFF								
		Safety function								
FF gain setting		-	16		+					
Positional command smooth	ning filter (ms	]			9.2					
Overshoot suppression [%]		-	100.0		+					
Notch filter settings		Autom	natic settir	ig:OFF						
3rd notch frequency [Hz]					5000					
4th notch frequency [Hz]					5000					
For more advanced settings	Notch setting									
amping filter setup Automatic setting:ON										
1st damping frequency [Hz] For more advanced settings D	amping settir	nas			0					
What if I have a problem?	amping setu	95								
Refer to Tuning Help when p	roblems occu	r such a	s vibratior	n 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.

Example of operation before tuning

Example of operation after tuning





# 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)				
<ul> <li>Looseness, backlash, etc. are present and the load non-linearity is strong</li> </ul>					

# 4.7.3 Related Parameters

—: None

						—: None
Class	No.	Attribute (*1)	Parameter name	Setting range	Chrit	Function
2	45	A	Function expan- sion setup 10	-2147483648 to 2147483647	_	<ul> <li>Sets automatic calculation of parameters for load fluctuation suppression.</li> <li>bit 3: Load fluctuation suppression function automatic calculation</li> <li>0: Conventional setting (MINAS A6 Series specification)</li> <li>1: The following parameters are automatically calculated</li> <li>Pr6.73 "Load estimation filter"</li> <li>Pr6.76 "Load estimation count"</li> </ul>
6	10	В	Function expan- sion setup	-32768 to 32767		<ul> <li>Sets the load fluctuation suppression function.</li> <li>bit 1: Load fluctuation control function <ol> <li>Disabled</li> <li>Enabled</li> </ol> </li> <li>bit 2: Load fluctuation stabilization setting <ol> <li>Disabled</li> <li>Enabled</li> </ol> </li> <li>bit 14: Load fluctuation suppression function automatic tuning <ol> <li>Disabled</li> <li>Enabled</li> </ol> </li> <li>Disabled</li> <li>Enabled</li> <li>Notes <ol> <li>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.</li> </ol> </li> </ul>
6	23	В	Load change compensation gain	-100 to 100	%	Sets compensation gain with respect to load fluctuation.
6	24	В	Load change compensation fil- ter	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	В	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	В	Torque compen- sation 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 be- tween Pr6.74 "Torque compensation frequency 1" and Pr6.75 "Torque compensation frequency 2" is within the range of the following formula. 1.0 Hz $\leq$ Pr6.75 $<$ Pr6.74 $\leq$ (Pr6.75 $\times$ 32)
6	75	В	Torque compen- sation 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 be- tween Pr6.74 "Torque compensation frequency 1" and Pr6.75 "Torque compensation frequency 2" is within the range of the following formula. 1.0 Hz $\leq$ Pr6.75 $<$ Pr6.74 $\leq$ (Pr6.75 $\times$ 32)

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	76	В	Load estimation count	0 to 8	_	Sets count relating to load estimation.

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

# 4.7.4 How to Use

# 4.7.4.1 For Manual Setting

## << Procedure >>

- 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.

1	29 <b>7</b>								
	File(F) T	roubleshooting(T)	Help(H)						_
			E Device tree		ôð Setting	嬰 Monitor	匕 Logging	프 <mark>은</mark> Tuning	🚺 Device Info 💐
			MINAS A7BR		All parameters	EtherCAT object	IO Setting	Alarm	Analog input
(	ም~ 🚦	Online	Axis0_No name set SRV-O	FF					
		USB	MADN085BRU 23080001		Open file	Save file	Copy Load initia	values Load	Write 2-phase
		-0	Enco	oder Info			Config Reset		se se
		<b>1</b>	MINAS AV DI	'86 pulse	Search	Compar	ison None	✓ Add/delete c	olumn v
			MHMG022U1A2 24020001		Switch to HEX input			Allow out-of-range settin	ıgs

**3.** In the "Tuning" tab screen, select "Load fluctuation suppression tuning (Load fluctuation stabilization applications)", and click the [Go to the Tuning screen] button.



A dialog box for enabling the load fluctuation control function is displayed.

4. Check the contents, and click the [OK] button or [Cancel] button.

$\times$
The parameters will be changed to the following values to enable this function. If there is no problem, press OK.
<ul> <li>PR0.02 (Real -time auto tuning setting) = 6 (Load fluctuation mode)</li> <li>PR6.10 Bit1: 1 (Load fluctuation suppression function Valid)</li> <li>PR6.10 bit2: 1 (Load fluctuation stabilization settings Valid)</li> <li>PR6.10 bit14: 1 (Load fluctuation suppression function automatically adjusted Valid)</li> <li>PR6.47 bit 0 (2 freedom control mode) = 1 (Valid)</li> <li>PR6.47 bit 3 (Auto tuning selection) = 1 (Synchronous type)</li> </ul>
OK Cancel

## – 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.

×
o enable this function, it is necessary to reset the control power supply. fter writing the previous parameter changes to EEPROM, reset the control power supply. After this, automatic parameter recovery is no longer possible.
there is no problem, please press "OK". "Cancel" is pressed, you will exit this screen without changing the parameters.
OK Cancel

The load fluctuation suppression tuning screen is displayed.

6	)			PANATERM	ver.7			- 🗆 X
F	ile(F) Tro	ubleshooting(T) Help(H)				_		
Devic	÷	Setting	Ľ∕ Logging	聲 Tuning	Device Info	1	Trial run	Z-phase search
e tree	<	Load fluctuation suppression	tuning	✓ Graph		Trial run/	1	2
	Selected d	river:Axis0_No name set		Wave graphic Frequency resp	onse	Z-pha	Limit setting	Trial run
	_	asic Notch settings	Damping settings		Stop Single trigger	ase search	Protection Functions Pr5.12 Overload level[%]	0
	while drivin	ion to properly adjust even when the g.	load inner fluctuates			5	Pr5.13 Overspeed level[r/min]	120
	Tuning con	ditions 💿 Easy tu	ning O Manual tuning	Edit display range Fixed disp	lay range Reset zoom	ш		Automatic setting (overspee
	Feedback	gain setting - 16	+	Align with center of Y-axis Display as elapsed time Disp	lay as time standard	ш	Pr5.14 Motor mova[0.1 rotation]	10
	Automa	tic oscillation suppressi OFF		Load file Save file		11	Operation limit	
		Safety fun	nction	Load me			Pr5.04 Over-travel inhibit input s	1: CoE-side (CiA402) deceler 💙
				<ul> <li>Graph display settings</li> </ul>			Operating range	n. positions or input a numeric value
		change compensation 0		Measurement Condition Edi	t displayed data Cursor		JOG speed[r/min]	60
Þ		change compensation 53		meddarentent contation Edi		_ ▶	JOG acceleratio[ms/JOG speed]	50
		estimation filter[0.01 0	ľ	✓ Monitor	(2)	-		
		ue compensation frequ 0		Internal status dis0_No name s	Physical s O Logical st	10	(*	3)
		ue compensation frequ 0		Control mode Position con	Function name 🗸	ш	(	5)
		tional command smoot 92		Power suppl 276 Driver temp 39	Connector Pin Si Status	ш		
	F12.22 F031			Command 0	SI1 input 5	ш	Servo-on 🔘 🕂 Operates o	only while the button is pressed.
		2.5		Actual spee 0	SI2 input         7            SI3 input         8	ш	- direction 🕨 G	p to 0 + direction
		(1)		Torque com 0 Overload Io 0	SI4 input 9	11	Current position	[command unit]
				Regenerativ 0	SI5 input 1			
				Warning 0x00	SI6 input 1			
				Error 0.0	SI7 input 1 SI8 input 1		Minimum position [command unit]	Maximum position [command unit]
				Driver derati 0	SI8 input 1 SO1 output 1		0	0
				OFF Pulse offset display	SO2 output 2		Trouble	eshooting To trial run
				Le di Li su		-		
	(1)	This is the main s	creen. This dis	plays the paramet	er tuning screen.			
	(2)	This displays the	waveform meas	surement and freq	uency response me	asu	rement screens.	
	(3)	This displays the t						

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.

<ul> <li>Load fluctuation suppression tuning</li> </ul>								
Selected driver:Axis0_No na	Selected driver:Axis0_No name set							
Basic	Notch s	settings Damping settings						
It is a function to properly ac	djust even wh	en the load inr	ner fluctuates while driving.					
Tuning conditions		💿 Easy tunir	ng 🔿 Manual tuning					
Feedback gain setting		- 16	+					
Automatic oscillation sup	pression	OFF						
		Safety function						
Pr6.23 Load change compen	isation gain	0						
Pr6.24 Load change compen	sation 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 coun	it[]	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 <u>"Step 8"</u>.

<ul> <li>Load fluctuation suppression tuning</li> </ul>						
Selected driver:Axis0_No name set						
Basic Notch	settings	Damping settings				
It is a function to properly adjust even w	nen the load in	ner fluctuates while driving.				
Tuning conditions	Tuning conditions O Manual tuning					
Feedback gain setting	- 16	+				
Automatic oscillation suppression	OFF					
	Safety function					
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 function	×
Safety functions can be set during gain adjustment. When this function is enabled, the Feedback gain settin immediately suppress vibration if any vibrations occur the torque command.	5
Safety function (Automatic oscillation suppression function)	🔿 Yes 💿 No
Oscillation detection level	15 %
	OK Cancel

8. Select "Manual tuning" for the tuning condition.

The parameters at the bottom of the screen can now be changed. Tune these parameters.

<ul> <li>Load fluctuation suppression tuning</li> </ul>								
Selected driver:Axis0_No name set								
Basic	ettings	Damping settings						
It is a function to properly adju	It is a function to properly adjust even when the load inner fluctuates while driving.							
Tuning conditions		O Easy tunir	ng 🗿 Manual tuning					
Feedback gain setting		- 16	+					
Automatic oscillation suppr	ression	OFF						
		Safety funct	ion					
Pr6.23 Load change compensa	ition gain	0						
Pr6.24 Load change compensa	tion filter	53						
Pr6.73 Load estimation filter[0.	.01ms]	0						
Pr6.74 Torque compensation f	requency	0						
Pr6.75 Torque compensation f	requency	0						
Pr6.76 Load estimation count[]		0						
Pr2.22 Positional command sm	noothing	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 <u>"5.3 Notch Filter Function"</u>.
- 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 <u>"5.5 Damping Control Function"</u> and <u>"5.6 Model-type Damping Filter Function"</u>.

# 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	В	Current loop gain response setup		10 to 300	%	Tunes the current response with the current response de- fault as 100%.
6	121	В	Current feed for- ward response setup		0 to 300	%	Tunes the current feedforward response with the current feedforward response default as 100%.

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

## – 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 A6N Series, but was changed to "Current loop gain response setup" from the MINAS A7N Series.

If the value is 100% or higher, the responsiveness is the same as for the MINAS A6NSeries. If the value is 99% or less, set Pr6.121 "Current feed forward response setup" to 0% to obtain responsiveness equivalent to the MINAS A6N 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.

										ĸ
File(F)	Troubleshooting(T)	Help(H)							_	
		E Device tree				閥 Monitor	ද්ර Logging	프 <b>은</b> Tuning		3
	-	MINAS A7BR				EtherCAT object	IO Setting	Alarm	Analog input	Trial run
Ტ⋎	Online	Axis0_No name set	SRV-OFF	E	Open file	Save file	Copy Load initia	values Load		
	USB NL	MADN085BRU 23080001	Encoder Info 39405786 pulse		Opennie		Config Reset			Z-phase search
		MINAS A7BR MHMG022U1A2 24020001	55405700 puise	٩	Search		son None	Add/delete c		a ∎
					Switch to HEX input	Display A6-compatib	ole control parameters	Allow out-of-range settin	ngs	

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



The "Manual TUNING" settings screen is displayed.

5	<u>0</u>								
F	File(F) Troubleshooting(T) Help(H)								
Devi	袋 Setting 昭 Monitor	Ŀζι	ogging	프 <mark>아</mark> Tuning	Device Info	Q		Z-pha	ise search
Device tree	Manual TUNING		✓ Graph Wave graph	hic Frequency response		Trial run/Z	0	2	
	Selected driver:Axis0_No name set		wave grap	frequency response			Limit setting	Trial run	
	Basic Load characteri Notch settings		Start n	neasurement Stop	Single trigger Acquire	phase search	Protection Functions	0	
	Damping settin Application Manual					arch	Pr5.12 Overload level[%]	0	
	Mode setting (i) 0:Disabled V		Measureme	ent data management Edit	display range Fixed display range		Pr5.13 Overspeed level[r/min]		
	Customize setting		Reset zoon	Align with center of Y-axi	s	ш		🛃 Automatic se	etting (overspee
	(i) When launching for the first time		Display as e	elapsed time Display as tim	e standard Load file		Pr5.14 Motor mova[0.1 rotation]	10	
	A7 recommended settingis recommended		Save file				Operation limit		
	<ul> <li>When upgrading from A6<u>A6 compatibility setting</u> is recommended</li> </ul>		Save III	e		81	Pr5.04 Over-travel inhibit input s	1: CoE-side (CiA	402) deceler 🗸
	Load characteristic settings Automatic settingOFF		🗸 Graph d	isplay settings			Operating range		
	Inertia ratio 0						Use JOG to move to the Max./M	n. positions or inp	out a numeric value
	For more advanced settings Load characteristic settings		Measuren	ment Condition Edit displaye	ed data Cursor		JOG speed[r/min]	60	
•	Gain setting		Acquire	from driver Acquire from	n file Load condition presets	•	JOG acceleratio[ms/JOG speed]	50	
	Feedback gain setting - 29 +	•				_			
	Speed response frequenc 102.5		<ul> <li>Monitor</li> </ul>						
	Automatic oscillation su OFF		Simple mor	nitor IO monitor					
	FF gain setting - 31 +		Start mea	surem Measurement mode	e With Position C 💙 Measurement count	2			
	Positional command smo 0.8					_			
	Overshoot suppression [%] - 100.0 +		[times]		Int Vibration level Effective load factor Tal [%] [%] [m]		Servo-on Operates of	only while the butt	ton is pressed.
	Notch filter settings Automatic setting:OFF								
	3rd notch frequency [Hz] 5000						- direction 🕨 G	o to 0 +	direction
	4th notch frequency [Hz] 5000						Current position	[command unit]	
	For more advanced settings Notch settings							0	
	Damping filter setup Automatic setting:ON								
	1st damping frequency [Hz] 0						Minimum position		Maximum position
	For more advanced settings Damping settings						[command unit]		[command unit]
	What if I have a problem? Refer to Tuning Help when problems occur such as						0		0
	vibration or abnormal noise						Trouble	eshooting	To trial run

**4.** Click the [Application] button.

<	Manual TUNING										
Selected driver:Axis0_No name set											
Basic	Basic Load characteristic settings Notch settings										
Damping settings	Application	Manual									
> Feedforward function											
> Load fluctuation control f	unction										
> High response current cor	ntrol function										
> Gain switching function											
> Quadrant glitch suppressi	on function										
> Hybrid vibration suppress	ion function										

5. Click on ">" of "> High response current control function" to expand "High response current control function".

elected driver:Axis0 No n	ame cet								
Basic	Load characteri	stic settings	Notch settings						
Damping settings	Applica	-	Manual						
> Feedforward function									
> Load fluctuation contro	l function								
<ul> <li>High response current of</li> </ul>	ontrol function	High response current control function							
5 11	-		e to be generated.						
Enabling this can suppress Increasing control may cau Current loop gain respons	se high-frequency a		e to be generated.						
Increasing control may cau Current loop gain respons	se high-frequency a e setup [%]	abnormal nois	e to be generated.						
Increasing control may cau Current loop gain respons	se high-frequency a e setup [%]	abnormal nois	e to be generated.						
Increasing control may cau Current loop gain respons Current feed forward respo	se high-frequency a e setup [%] 1 onse setup [%] 1	abnormal nois	e to be generated.						

6. For details on tuning each parameter, see <u>"4.8.4.1 For Manual Setting"</u>.

# 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	<ul> <li>Low stiffness (antiresonance points exists in the low frequency range of 10 Hz or less)</li> <li>Looseness, backlash, etc. are present and the load non-linearity is strong</li> <li>When the operation pattern changes</li> </ul>

# 4.9.3 Related Parameters

-: None Class Attribute (\*1) Unit Parameter name Setting range Š Functior 45 Quadrant glitch -1000 to 1000 0.1% Sets the compensation value to be added to the torque 5 В positive-direction command when the position command is in positive dicompensation rection when the quadrant glitch compensation function value is enabled. 5 46 В Quadrant glitch -1000 to 1000 0.1% Sets the compensation value to be added to the torque negative-direccommand when the position command is in negative dition compensarection when the quadrant glitch compensation function tion value is enabled. 0 to 1000 5 47 Quadrant glitch Sets the delay time until the compensation value is В ms compensation switched when the initial position command is input or delay time 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	В	Quadrant glitch compensation fil- ter 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	В	Quadrant glitch compensation fil- ter 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 expan- sion 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	В	Function expan- sion 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 <u>"7.1 List of Parameters"</u>.

# 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.

899					PANATERM ver.7				
File(F)	Troubleshooting(T)	Help(H)							_
		E Device tree			<li>Setting</li>	閥 Monitor	I∕G Logging	프 <b>은</b> Tuning	🚺 Device Info
	-	MINAS A7BR				EtherCAT object	IO Setting	Alarm	Analog input
രം∨	Online	Axis0_No name set	SRV-OFF			· · · · ·			
	USB	MADN085BRU 23080001			Open file	Save file	Copy Load initia	values Load	Write
	N.	Encoder MINAS A700 39405786 0					Config Reset		olumn 4
		MINAS A7BR MHMG022U1A2 24020001	55465100 paise	•	Search	Compar	ison None	✓ Add/delete o	olumn
					Switch to HEX input	Display A6-compati	ble control parameters	Allow out-of-range settin	igs

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



The "Manual TUNING" settings screen is displayed.

5									
F	File(F) Troubleshooting(T) Help(H)								
Devie	Setting     Onitor	Ŀζ	ogging	📴 Tuning	Device Info	Ø		Z-ph	nase search
Device tree	Manual TUNING		🗸 Graph			Trial run/Z	1	2	
	Selected driver:Axis0_No name set		Wave graph	ic Frequency response			Limit setting	Trial ru	n
	Basic Load characteri Notch settings		Start m	easurement Stop	Single trigger Acquire	-phase search	Protection Functions		
	Damping settin Application Manual					earch	Pr5.12 Overload level[%]	0	
			Measureme	nt data management Edit	display range Fixed display range	-	Pr5.13 Overspeed level[r/min]		
	Mode setting () 0:Disabled  Customize settings		Reset zoom	Align with center of Y-axi	s			Automatic :	setting (overspee
	When launching for the first time		Display as e	lapsed time Display as tim	ne standard Load file		Pr5.14 Motor mova[0.1 rotation]	10	
	A7 recommended settingis recommended		Save file				Operation limit		
	When upgrading from A6 <u>A6 compatibility setting</u> is recommended		Save The				Pr5.04 Over-travel inhibit input s	1: CoE-side (Ci	A402) deceler 🗸
	Load characteristic settings Automatic settingOFF		🗸 Graph di	splay settings			Operating range		
	Inertia ratio 0						Use JOG to move to the Max./M	in. positions or ir	nput a numeric value
	For more advanced settings Load characteristic settings		Measuren	ent Condition Edit displaye	ed data Cursor		JOG speed[r/min]	60	
	Gain setting		Acquire	from driver Acquire from	n file Load condition presets		JOG acceleratio[ms/JOG speed]	50	
ſ	Feedback gain setting - 29 +	•				- 1			
	Speed response frequenc 102.5		<ul> <li>Monitor</li> </ul>						
	Automatic oscillation su OFF		Simple mor	itor IO monitor					
	Safety function								
	FF gain setting - 31 +		Start mea	Measurement mod	e With Position C 🗸 Measurement count	2			
	Positional command smo 0.8				unt Vibration level Effective load factor Takt				
	Overshoot suppression [%] - 100.0 +		[times]	ms] [times]	[%] [%] [ms]		Servo-on Operates of	only while the bu	tton is pressed.
	Notch filter settings Automatic setting:OFF						- direction	o to 0	+ direction
	3rd notch frequency [Hz] 5000						Current position	· · · · · · · · · · · · · · · · · · ·	
	4th notch frequency [Hz] 5000 For more advanced settings <u>Notch settings</u>						Current position	i (command unit) 0	1
	Damping filter setup Automatic setting:ON								
	1st damping frequency [Hz] 0						Minimum position		Maximum position
	For more advanced settings Damping settings						[command unit]		[command unit]
	What if I have a problem?						0		0
	Refer to Tuning Help <u>when problems occur</u> such as vibration or abnormal noise						Troubl	eshooting	To trial run
**4.** Click the [Application] button.

<	Manual TUNING								
Selected driver:Axis0_No name set									
Basic	Basic Load characteristic settings Notch settings								
Damping settings	Damping settings Application Manual								
Feedforward function									
> Load fluctuation control f	unction								
> High response current cor	ntrol function								
> Gain switching function									
> Quadrant glitch suppressi	on function								
> Hybrid vibration suppress	ion function								

5. Click on ">" of "> Quadrant glitch suppression function" to expand "Quadrant glitch suppression function".

Selected driver:Axis0_No name set									
Basic Load characteristic settings Notch settings									
Damping settings	Appli	cation	Manual						
<ul> <li>Feedforward function</li> </ul>									
Load fluctuation control fit	unction								
> High response current cor	ntrol function								
<ul> <li>Gain switching function</li> </ul>									
Quadrant glitch suppression function Enabling this can suppress quadrant glitching when the direction of movement is reversed. Enable quadrant glitch compensation func      OFF Quadrant glitch positive-direction compen      Quadrant glitch negative-direction compen      Quadrant glitch compensation delay time      Quadrant glitch compensation filter settin      Quadrant glitch compensation filter settin      Quadrant glitch compensation filter settin      Quadrant glitch compensation filter settin									

- **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.

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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	В	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	В	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 <u>"7.1 List of Parameters"</u>.

The two types of torque filter are 1st torque filter and 2nd torque filter.

See <u>"4.2 Gain Switching Function</u>" 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 =  $1/(2 \pi \times \text{parameter setup value} \times 0.00001)$ 

### 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.



The "Manual TUNING" settings screen is displayed.

4. Click on the [Notch settings] button or "Notch settings" in blue text.

5				PANATE	RM ver.7			– 🗆 X
Fi	ile(F) Troubleshooting(T) Help(H)							
Devic	🔅 Setting 🛛 🐯 Monitor	Ŀč	ረ Logging	프 <mark>은</mark> Tuning	Device Info	2	Trial run	Z-phase search
e tree	K Manual TUNING		✓ Gr			Trial run/Z-phase search	1	2
	Selected driver:Axis0_No name set		Wave	graphic Frequency response		Z-pha	Limit setting	Trial run
	Basic Load characteri Notch setti	ngs		tart measurement	Single trigger Acquire	ise se	Protection Functions	
	Damping settin Application Manual					Parch	Pr5.12 Overload level[%]	0
	Mode setting (i) 0:Disabled		Meas	urement data management Edit	display range Fixed display range		Pr5.13 Overspeed level[r/min]	120
		<u> </u>	Rese	zoom Align with center of Y-axi	s			Automatic setting (overspee
	(i) When launching for the first time		Displ	y as elapsed time Display as tim	e standard Load file		Pr5.14 Motor mova[0.1 rotation]	10
	A7 recommended setting is recommended			ve file			Operation limit	
	(i) When upgrading from A6 <u>A6 compatibility setting</u> is recommended			ve me		8.0	Pr5.04 Over-travel inhibit input s	1: CoE-side (CiA402) deceler 🗸
	Load characteristic settings Automatic settingOFF		✓ Gr	aph display settings			Operating range	
	Inertia ratio 0						Use JOG to move to the Max./Mi	n. positions or input a numeric value
	For more advanced settings Load characteristic setting	1	Me	surement Condition Edit displaye	d data Cursor		JOG speed[r/min]	60
	Gain setting		A	quire from driver Acquire fron	n file Load condition presets		JOG acceleratio[ms/JOG speed]	50
Ĩ.	Feedback gain setting - 29	•	•					
		2.5	✓ M	onitor				
	Automatic oscillation su OFF		Simp	e monitor IO monitor				
	Safety function					_		
					With Position C V Measurement count	_		
		0.8		No. Settling time INP change cou s] [ms] [times]	Int Vibration level Effective load factor Takt [%] [%] [ms			
		-					Servo-on Operates of	nly while the button is pressed.
	Notch filter settings Automatic setting:OFF 3rd notch frequency [Hz] 50	00					- direction	to 0 + direction
		00					Current position	[command unit]
	For more advanced settings Notch settings							
	Damping filter setup Automatic setting:ON							
	1st damping frequency [Hz] For more advanced settings Damping settings	0					Minimum position	Maximum position
	What if I have a problem?						[command unit]	[command unit]
	Refer to Tuning Help when problems occur such as							shooting To trial run
	vibration or abnormal noise	_				_	IIOdbie	

The advanced notch settings screen is displayed.

5. Tune the "1st torque filter". For details on parameter tuning, see <u>"5.1.4.1 For Manual Setting"</u>.

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.

K Manual TUNING								
Selected driver:Axis0_	No nam	ie set						
Basic		Load chara	cteristic s	ettings		Not	ch settings	
Damping setting	s	Ap	Application			Manual		
Resonance monitor					No	ot dete	cted	
Resonance frequency	[Hz] 🚺	)					5000	
(i) "5000" is displaye	d until r	esonance is	detected.					
Tuning based on positi i To perform tuning to 5.			ioning op	eration, u	use the	e follov	ving settings 1	
Pr2.00 Adaptive filter	mode			5: High	n-prec	ision a	daptive fi 🗸	
Tuning based on frequency characteristics							teristics in a	
Offset [dB] 0.0						0.0		
	Free	quency [Hz]		Width			Depth	
1th notch	5000		2			0		
2th notch	5000		2			0		
3th notch (i)								
4th notch 🕕								
5th notch	5000		2			0		
Costom notch	5000		2			0		
i The 3rd and 4th n Adaptive filter mo		are automati	cally set d	epending	g on tl	ne sett	ng for Pr2.00	
Torque filter								
1st torque filter [0.01	ms]			10				
2-stage torque filter t	ime cor	istant [0.01 n	ns]	0				
2-stage torque filter a	ittenuat	ion term		1000				
Mode setting				7:Custo	omizei	2	~	
Gain setting								
Feedback gain setting	l I			-	16		+	
1st velocity loop gain	[0.1 Hz	]		270				
1st velocityintegral tir	ne cons	tant [0.01 ms	;]	210				
<ul> <li>Load fluctuation or</li> </ul>	antrol fi	unction						
<ul> <li>Load fluctuation control function</li> <li>Enabling this can more effectively suppress the effects of motion caused by friction or the movement of other axes, etc.</li> <li>Use to suppress overshoot, etc. Be aware that increasing control may cause oscillation to occur.</li> </ul>								
Load fluctuation supp	pression	function ena	bled					
Load fluctuation supp	ression	function aut	omatic t					
Load change compen	sation <u>c</u>	jain [%]		90				
Load change compen	Load change compensation filter [0.01 ms]							
Load estimation filter	[0.01 m	is]		4				
Torque compensation	freque	ncy 1 [0.1 Hz	]					
Torque compensation	freque	ncy 2 [0.1 Hz	]					
Load estimation coun	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 <u>"5.1 Torque Filter Function</u>" 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	В	2-stage torque fil- ter time constant	0 to 2500	0.01 ms	<ul> <li>Sets the 2-stage torque filter time constant.</li> <li>When Pr6.43 = 0 to 49</li> <li>0 to 3: 2-stage torque filter disabled</li> <li>4 to 2500: Setting value [×0.01 ms]</li> <li>When Pr6.43 = 50 to 1000</li> <li>0: 2-stage torque filter disabled</li> <li>1 to 3: 4 [×0.01 ms]</li> <li>4 to 159: Setting value [×0.01 ms]</li> <li>159 to 2500: 159 [×0.01 ms]</li> </ul>
6	43	В	2-stage torque fil- ter attenuation term	0 to 1000	_	<ul> <li>Sets the 2-stage torque filter attenuation term.</li> <li>0 to 49: Operates as the first order lag filter.</li> <li>50 to 1000: Operates as the second order lag filter. With a setting value of 1000, becomes a second order lag filter with ζ = 1.0. The smaller the setting value, the more it vibrates. Normally use with a setting value of 1000.</li> </ul>

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

The torque filter cut-off frequency of the 2-stage torque filter can be obtained using the following formula. Cut-off frequency [Hz] fc =  $1/(2 \pi \times \text{parameter setup value} \times 0.00001)$ 

### 2-stage torque filter characteristics figure

Frequency responses when first order lag filter

Frequency responses when second order lag filter



### 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.



The "Manual TUNING" settings screen is displayed.

4. Click on the [Notch settings] button or "Notch settings" in blue text.

5		PANATERM ver.7	- 🗆 X
Fi	le(F) Troubleshooting(T) Help(H)		
Devic	儆 Setting	숙 Logging 📴 Tuning 👔 Device Info 🔊 Trial run	Z-phase search
ce tree	< Manual TUNING	✓ Graph 10	2
ree A	Manual TUNING       Selected driver:Axis0_No name set       Basic     Load characteri       Notch setting:       Damping settin     Application       Manual       Mode setting ①     Disabled       ①     Othern launching for the first time       AI recommended     O       ①     When upgrading from A666 compatibility setting is recommended       Load characteristic settings     Automatic settingOFF       Inertia ratio     0       For more advanced settings Load characteristic settings       Gain setting     -       Feedback gain setting     -       Prover seponse frequenc     102.5       Automatic oscillation su     OFF       Safety function     +       Positional command smo     0.8       Overshoot suppression [%]     -       3rd notch frequency [Hz]     5000       4th notch frequency [Hz]     5000       For more advanced settings     Automatic setting:ON       1st damping filter setup     Automatic setting:ON       1st damping frequency [Hz]     0       For more advanced settings     Damping setting:ON	Wave graphic       Frequency response         Wave graphic       Frequency response         Start measurement       Stop         Start measurement       Stop         Start measurement       Edit display range         Fixed display range       Fixed display range         Post editor functions       Pr5.14 Motor mova(0.1 rotat         Operation limit       Pr5.14 Motor mova(0.1 rotat         Save file       Pr5.14 Motor mova(0.1 rotat         V Monitor       Operation limit         Start measurem       Acquire from file         Load condition presets       Use JOG to move to the Max         JOG speed[/min]       JOG acceleratio[ms/JOG sp         Wave monitor       Measurement mode       With Position C v       Measurement count (2         Trial No.       Setting time INP change count Vibration level       Effective load factor       Takt         Yes       Yes       Yes       Yes       Servo-on       Correction       - direction	Trial run
	What if I have a problem? Refer to Tuning Help <u>when problems occur</u> such as vibration or abnormal noise		0 Dubleshooting To trial run

The advanced notch settings screen is displayed.

5. Tune the "2-stage torque filter time constant". For details on parameter tuning, see <u>"5.2.4.1 For Manual Setting</u>". 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.

<	Man	ual TUNIN	G				
Selected driver:Axis0_1	No name set						
Basic	Load char	acteristic s	ettings		Not	ch settings	
Damping setting	s Ap	Application			Manual		
Resonance monitor				No	ot dete	cted	
Resonance frequency	[Hz] (i)					5000	
(i) "5000" is displaye	d until resonance is	detected.					
Tuning based on positio To perform tuning to 5.		tioning op	eration, u	ise the	e follov	ving settings 1	
Pr2.00 Adaptive filter	mode		5: High	-preci	sion a	daptive fi 🗸	
Tuning based on freque	ency characteristics	🗌 Disp	ay notch	filter	charac	teristics in a	
				Offse	t [dB]	0.0	
	Frequency [Hz]		Width		_	Depth	
1th notch	5000	2			0		
2th notch	5000	2			0		
3th notch 🚺							
4th notch 🚺							
5th notch	5000	2			0		
Costom notch	5000	2			0		
Torque filter 1st torque filter [0.01	ms]		10				
2-stage torque filter ti	me constant [0.01 r	ms]	0				
2-stage torque filter a	ttenuation term		1000				
Mode setting			7:Custo	omizeź	2	~	
Gain setting							
Feedback gain setting			- 16 +				
1st velocity loop gain	[0.1 Hz]		270				
1st velocityintegral tin	ne constant [0.01 m	s]	210				
<ul> <li>Load fluctuation cc</li> <li>Enabling this can more the movement of other Use to suppress overse to occur.</li> </ul>	e effectively suppre er axes, etc.						
Load fluctuation supp	ression function en	abled					
Load fluctuation supp	ression function au	tomatic t					
Load change compension	90						
Load change compension	590						
Load estimation filter	[0.01 ms]		4				
Torque compensation	frequency 1 [0.1 Ha	z]					
Torque compensation	frequency 2 [0.1 Hz	z]					
Load estimation coun	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	В	1st notch fre- quency	10 to 5000	Hz	Sets 1st notch filter center frequency. A setup value of 5000 disables the notch filter.
2	02	В	1st notch width selection	0 to 20	-	Sets 1st notch filter frequency width.
2	03	В	1st notch depth selection	0 to 99	-	Sets depth in 1st notch filter center frequency.
2	04	В	2nd notch fre- quency	10 to 5000	Hz	Sets 2nd notch filter center frequency. A setup value of 5000 disables the notch filter.
2	05	В	2nd notch width selection	0 to 20	-	Sets 2nd notch filter frequency width.
2	06	В	2nd notch depth selection	0 to 99	_	Sets depth in 2nd notch filter center frequency.
2	07	В	3rd notch fre- quency	10 to 5000	Hz	Sets 3rd notch filter center frequency. A setup value of 5000 disables the notch filter. The pa- rameter value is set automatically when the adaptive fil- ter function is used.
2	08	В	3rd notch width selection	0 to 20	_	Sets 3rd notch filter frequency width. The parameter value is set automatically when the adap- tive filter function is used.
2	09	В	3rd notch depth selection	0 to 99	_	Sets depth in 3rd notch filter center frequency. The parameter value is set automatically when the adap- tive filter function is used.
2	10	В	4th notch fre- quency	10 to 5000	Hz	Sets 4th notch filter center frequency. A setup value of 5000 disables the notch filter. The pa- rameter value is set automatically when the adaptive fil- ter function is used.
2	11	В	4th notch width selection	0 to 20	_	Sets 4th notch filter frequency width. The parameter value is set automatically when the adap- tive filter function is used.
2	12	В	4th notch depth selection	0 to 99	-	Sets depth in 4th notch filter center frequency. The parameter value is set automatically when the adap- tive filter function is used.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	24	В	5th notch fre- quency	10 to 5000	Hz	Sets 5th notch filter center frequency. A setup value of 5000 disables the notch filter.
2	25	В	5th notch width selection	0 to 20	-	Sets 5th notch filter frequency width.
2	26	В	5th notch depth selection	0 to 99	-	Sets depth in 5th notch filter center frequency.
2	39	В	Custom notch compensation co- efficient	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	В	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	В	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	В	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	В	Custom notch width	0 to 20	_	Sets the notch width of the custom notch filter.
2	44	В	Custom notch depth	0 to 99	_	Sets the notch depth of the custom notch filter.

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

### 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.

depth								
Notch depth set value Pr2.03, Pr2.06, Pr2.09, Pr2.12, Pr2.26, Pr2.44	Notch depth (ra- tio)	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 depth set value and notch depth

Relation between notch width set value and notch width

Notch width set value Pr2.02, Pr2.05, Pr2.08,	Notch width
Pr2.11, Pr2.25, Pr2.43	
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 <u>"5.4 Adaptive Filter Function"</u>.

### 5.3.4 How to Use

#### 5.3.4.1 For Manual Setting

Tune using an adaptive filter. For details, see <u>"5.4 Adaptive Filter Function"</u>.

### 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.

<u></u>									
File(F)	Troubleshooting(T)	Help(H)							
		E Device tree			{ĝ} Setting	閥 Monitor	Ir <sub>G Logging</sub>	프 <mark>은</mark> Tuning	🚺 Device Info 🖉
	-	MINAS A7BR				EtherCAT object	IO Setting	Alarm	Analog input
₫⋎	Online	Axis0_No name set	SRV-OFF						
	USB	MADN085BRU 23080001			Open file	Save file	Copy Load initia	values Load	Write 2:pha
	M.		Encoder Info				Config Reset		se search
	5	MINAS A7BR MHMG022U1A2 24020001	39405786 pulse	•	Search	Compar	ison None	✓ Add/delete c	
					Switch to HEX input	Display A6-compatil	ble control parameters	Allow out-of-range settin	gs

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



The "Manual TUNING" settings screen is displayed.

4. Click on the [Notch settings] button or "Notch settings" in blue text.

	2							
	File	e(F) Troubleshooting(T) Help(H)						
DEVIN		Setting     Of Monitor	ピ Loggir	g 프 <del>을</del> Tuning	Device Info	Ø		Z-phase search
Device tiee		< Manual TUNING		Graph		Trial run/Z-phase search	1	2
	s	Selected driver:Axis0_No name set	Wa	ve graphic Frequency response		Z-pha	Limit setting	Trial run
	ļ	Basic         Load characteri         Notch settings           Damping settin         Application         Manual		Start measurement Stop	Single trigger Acquire	ise searc	Protection Functions Pr5.12 Overload level[%]	0
		Mode setting (i) 0:Disabled	Me	asurement data management Edi	t display range Fixed display range	5	Pr5.13 Overspeed level[r/min]	
		Customize setting	Re	et zoom Align with center of Y-a:	xis			Automatic setting (overspee
		(i) When launching for the first time	Dis	play as elapsed time Display as ti	me standard Load file		Pr5.14 Motor mova[0.1 rotation]	10
		A7 recommended settingis recommended		Save file			Operation limit	
		(i) When upgrading from A6 <u>A6 compatibility setting</u> is recommended					Pr5.04 Over-travel inhibit input s	1: CoE-side (CiA402) deceler 🗸
	ι	Load characteristic settings Automatic settingOFF	~	Graph display settings			Operating range	
		Inertia ratio 0	N	leasurement Condition Edit display	red data Cursor			n. positions or input a numeric value
		For more advanced settings Load characteristic settings					JOG speed[r/min]	
		Gain setting		Acquire from driver Acquire fro	m file Load condition presets	•	JOG acceleratio[ms/JOG speed]	50
		Feedback gain setting - 29 +	<					
		Speed response frequenc 102.5	× 1	Vionitor				
		Automatic oscillation su OFF Safety function	Sim	ple monitor IO monitor				
		FF gain setting - 31 +	s	art measurem Measurement mo	de With Position C 🗸 Measurement count			
		Positional command smo 0.8	Tri	al No. Settling time INP change co	ount Vibration level Effective load factor Takt			
		Overshoot suppression [%] - 100.0 +	[ti	nes] [ms] [times]	[%] [%] [ms]		Servo-on Operates of	only while the button is pressed.
		Notch filter settings Automatic setting:OFF					- direction	o to 0 + direction
		3rd notch frequency [Hz] 5000					Current position	
		4th notch frequency [Hz] 5000 For more advanced setting: Notch settings					Current position	[command unit]
	E	Damping filter setup Automatic setting:ON						
		1st damping frequency [Hz] 0					Minimum position	Maximum position
	F	For more advanced settings Damping settings					[command unit]	[command unit]
		What if I have a problem?					0	0
		Refer to Tuning Help <u>when problems occur</u> such as vibration or abnormal noise				_	Trouble	eshooting To trial run

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".

<	K Manual TUNING								
Selected driver:Axis0_No name set									
Basic		ettings		Not	ch settings				
Damping setting	s	Appl	ication				Manual		
Resonance monitor Not detected									
Resonance frequency	[Hz] (	)					5000		
(i) "5000" is displaye	d until	esonance is de	etected.						
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	-preci	ision a	daptive fi 💙		
Tuning based on freque	ency chi	aracteristics (	Displ	ay notch					
	Fro	quency [Hz]		Width	Offse	t [dB]	0.0 Depth		
1th notch	5000	quency [nz]	2	width		0	Depth		
2th notch	5000		2			0			
3th notch (i)	5000		2			0			
4th notch (i)									
5th notch	5000		2		_	0			
Costom notch	5000		2			0			
(i) The 3rd and 4th n	otches	are automatica	lly set d	epending	) on ti	ne sett	ing for Pr2.00		
Torque filter 1st torque filter (0.01 2-stage torque filter t 2-stage torque filter a	ime cor		]	10 0 1000					
Mode setting				7:Custo	omize	2	~		
Gain setting Feedback gain setting									
					16		+		
1st velocity loop gain				270					
1st velocityintegral tin	ne cons	tant (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									
	Load fluctuation suppression function automatic t (INC) Load change compensation gain (%) 90								
Load change compen		590							
Load estimation filter				4					
Torque compensation	-			0					
Torque compensation									
Load estimation coun									

• To set with "Tuning based on positioning operation"

Up to two adaptive filters can be used for auto tuning.

For details, see <u>"5.4 Adaptive Filter Function</u>".

• To set with "Tuning based on frequency characteristics"

Make the following preparations.

- Measure frequency response. For details, see <u>"6.2 Frequency Response Measurement"</u>.
- 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	<ul> <li>Resonance frequency is less than three times the speed response frequency [Hz]</li> <li>When the resonance peak is low or the control gain is low and the effect is not apparent in the motor speed</li> <li>When there are three or more resonance points</li> </ul>
Load	When motor speed fluctuations with high-frequency components occur due to non-linear characteristics such as backlash
Command pat- tern	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

			1	1		—: None
Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	00	В	Adaptive filter mode setup	0 to 6		<ul> <li>Sets adaptive filter operation mode.</li> <li>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.</li> <li>0: Disable adaptive filter</li> <li>Adaptive filter is disabled. Maintains current values of parameters related to 3rd and 4th notch filters.</li> <li>1: Enable one adaptive filter</li> <li>One adaptive filter is enabled. Updates parameters related to 3rd notch filter according to adaptation results.</li> <li>2: Enable two adaptive filters</li> <li>Two adaptive filters are enabled. Updates parameter related to 3rd and 4th notch filters according to adaptation results.</li> <li>3: Resonance frequency measurement mode</li> <li>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.</li> <li>4: Clear adaptation results</li> <li>Clears adaptation results by disabling parameters related to 3rd and 4th notch filters.</li> <li>5: High-precision adaptive filter</li> <li>Two adaptive filters are enabled. Updates parameter related to 3rd and 4th notch filters.</li> <li>5: High-precision adaptive filter</li> <li>Two adaptive filters are enabled. Updates parameters related to 3rd and 4th notch filters.</li> <li>6: High-precision adaptive filter</li> <li>Two adaptive filters are enabled. Updates parameter related to 3rd and 4th notch filters.</li> <li>6: High-precision adaptive filters are enabled. Updates parameter related to 3rd and 4th notch filters according to adaptation results.</li> </ul>

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

The following parameters are set automatically when adaptive filter is enabled.

						—: None
Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	07	В	3rd notch fre- quency	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	В	3rd notch width selection	0 to 20	-	Set automatically when adaptive filter is enabled.
2	09	В	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	В	4th notch frequen- cy	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	В	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	В	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 <u>"7.1 List of Parameters"</u>.

### 5.4.4 How to Use

### 5.4.4.1 For Manual Setting

#### << Procedure >>

- 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 <u>"1"</u> to <u>"3"</u> 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.

2					PANATERM ver.7				
File(F)	Troubleshooting(T)	Help(H)							
		E Device tree			ô Setting		匕 Logging	📑 Tuning	🚺 Device Info
	-	MINAS A7BR				EtherCAT object	IO Setting	Alarm	Analog input
⊕∨	Online	Axis0_No name set	SRV-OFF	IF.					
	USB	MADN085BRU 23080001			Open file	Save file	Copy Load initia	I values Load	Write
	M		Encoder Info				Config Reset		se sea
	<b>1</b>	MINAS A7BR	39405786 pulse		Count		ison None	✓ Add/delete	arch arch
	1007	MHMG022U1A2 24020001			Search	Compari			
					Switch to HEX input	Display A6-compatib	ble control parameters	Allow out-of-range set	tings

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



The "Manual TUNING" settings screen is displayed.

4. Click on the [Notch settings] button or "Notch settings" in blue text.

5			PANATE	RM ver.7			– 🗆 X
Fi	ile(F) Troubleshooting(T) Help(H)						
Devic	袋 Setting	ŀ∕{ Logg	ng 📴 Tuning	Device Info	1	Trial run	Z-phase search
ce tree	< Manual TUNING		Graph ave graphic Frequency response		Trial run/2	1	2
	Selected driver:Axis0_No name set Basic Load characteri Notch settings		Start measurement Stop	Single trigger Acquire	run/Z-phase search	Limit setting Protection Functions	Trial run
	Damping settin Application Manual Mode setting (1) 0:Disabled		easurement data management Edit	display range Fixed display range	arch	Pr5.12 Overload level[%] Pr5.13 Overspeed level[r/min]	120
	Customize settings		eset zoom Align with center of Y-axi		Ш	Pr5.14 Motor mova[0.1 rotation]	Automatic setting (overspee
	When launching for the first time <u>A7 recommended setting</u> is recommended     When upgrading from A6 <u>A6 compatibility setting</u>		Save file			Operation limit Pr5.04 Over-travel inhibit input s	1: CoE-side (CiA402) deceler V
	is recommended Load characteristic settings Automatic settingOFF	~	Graph display settings			Operating range	n. positions or input a numeric value
	Inertia ratio 0 For more advanced settings Load characteristic settings	Ľ		d data Cursor		JOG speed[r/min]	60
Þ	Gain setting - 29 +	. =	Acquire from driver Acquire from	n file Load condition presets	-	JOG acceleratio[ms/JOG speed]	50
	Speed response frequenc 102.5 Automatic oscillation su OFF Safety function		Monitor mple monitor IO monitor				
	FF gain setting - 31 + Positional command smo 0.8			With Position C V Measurement count Int Vibration level Effective load factor Takt [%]	2		
	Overshoot suppression [%]     -     100.0     +       Notch filter settings     Automatic setting:OFF						only while the button is pressed.
	3rd notch frequency [Hz]     5000       4th notch frequency [Hz]     5000       For more advanced settings Notch settings					Current position	
	Damping filter setup Automatic setting:ON 1st damping frequency [Hz] 0					Minimum position	Maximum position
	For more advanced settings <u>Damping settings</u> What if I have a problem?					[command unit]	[command unit]
	Refer to Tuning Help <u>when problems occur</u> such as vibration or abnormal noise						eshooting To trial run

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).

<		Manua	al TUNIN	G			
Selected driver:Axis0	_No nam	ie set					
Basic		Load charad	teristic s	ettings		Not	ch settings
Damping settir	igs	App	Application				Manual
Resonance monitor					No	t dete	cted
Resonance frequence	y [Hz] (	)					5000
(i) "5000" is display	ved until i	esonance is d	etected.				
funing based on posi	tioning o	peration					
<ol> <li>To perform tunir to 5.</li> </ol>			oning op	eration,	use the	follov	ving settings 1
Pr2.00 Adaptive filte	er mode			5: Hig	h-preci	sion a	daptive fi 🗸
uning based on freq	uency cha	vacteristics	Disn	lav notc	h filter (	harac	teristics in a
aning based on neq.	acricy cit	accentrates		ay note	Offset		
	Free	quency [Hz]		Width	0.1001	[00]	Depth
1th notch	5000		2			0	
2th notch	5000		2			0	
3th notch 🕕							
4th notch 🚺							
5th notch	5000		2			0	
Costom notch	5000		2			0	
forque filter 1st torque filter [0.0 2-stage torque filter	-	istant (0.01 m	s]	10			
2-stage torque filter			-1	1000			
Mode setting				7:Cust	omize2		~
Gain setting							
Feedback gain settir	ıg			<u> </u>	16		+
1st velocity loop gai	in [0.1 Hz	]		270			
1st velocityintegral t	ime cons	tant [0.01 ms]		210			
<ul> <li>Load fluctuation</li> <li>Enabling this can me the movement of ot Use to suppress over to occur.</li> </ul>	ore effect her axes,	ively suppress etc.					
Load fluctuation sup Load fluctuation sup					)		
Load change compe	ensation o	jain [%]		90			
Load change compe	ensation f	ilter [0.01 ms]		590			
Load estimation filte	er [0.01 m	s]		4			
Torque compensatio	on freque	ncy 1 [0.1 Hz]					
Torque compensatio	on freque	ncy 2 [0.1 Hz]					
Load estimation cou	int			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

ltem	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 condi- tions	<ul> <li>When vibration is excited by primary causes other than commands (external forces, etc.)</li> <li>When the ratio of resonance frequency to antiresonance frequency is large</li> <li>When the vibration frequency is outside the range of 0.5 to 300.0 Hz</li> </ul>

### 5.5.3 Related Parameters

						—: None
Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	13	В	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	В	1st damping fre- quency	0 to 3000	0.1 Hz	Sets the 1st control frequency of damping control that suppresses the vibration at load edge. Measure the fre- quency 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	В	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 damp- ing frequency, or (3000-damping frequency), whichever is smaller.
6	41	В	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	В	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	В	2nd damping fre- quency	0 to 3000	0.1 Hz	Sets the 2nd control frequency of damping control that suppresses the vibration at load edge. Measure the fre- quency 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	В	2nd damping fil- ter 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 damp- ing frequency, or (3000-damping frequency), whichever is smaller.
6	60	В	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	В	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	В	3rd damping fre- quency	0 to 3000	0.1 Hz	Sets the 3rd control frequency of damping control that suppresses the vibration at load edge. Measure the fre- quency 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	В	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 damp- ing frequency, or (3000-damping frequency), whichever is smaller.
6	71	В	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	В	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	В	4th damping fre- quency	0 to 3000	0.1 Hz	Sets the 4th control frequency of damping control that suppresses the vibration at load edge. Measure the fre- quency 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	В	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 damp- ing frequency, or (3000-damping frequency), whichever is smaller.
6	72	В	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	В	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	В	Detection start vi- bration 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 frequen- cy detection process after the command is completed.
2	51	В	Detected vibra- tion amplitude	0 to 134217728	Com- mand 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 au- tomatically inside the driver.

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

#### Setup Description value 0 Each damping control filter can be enabled or disabled as follows. 1st damping 2nd damping 3rd damping 4th damping Setup value 0 Disabled Disabled Enabled Enabled 1 to 2 Manufacturer use (setting is prohibited) 3 Depending on the direction of the position command, each damping control filter is switched between enabled and disabled as follows. Position command direction 4th damping Setup 1st damping 2nd damping 3rd damping value 3 Positive direction Enabled Disabled Enabled Disabled Negative direction Disabled Enabled Disabled Enabled 4 to 6 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) Setup Position command direction 1st model-type damping control 2nd model-type damping control value 4 Enabled Enabled 5 Manufacturer use (setting is prohibited) 6 Positive direction Enabled Disabled Negative direction Disabled Enabled Position Control (Two-degree-of-freedom Control Mode Disabled) Setup 1st damping 2nd damping 3rd damping 4th damping value 4 Enabled Enabled Enabled Disabled 5,6 Enabled Enabled Disabled Disabled **Full-closed Control** 2nd damping 3rd damping 4th damping Setup 1st damping value 4 to 6 Enabled Enabled Disabled Disabled 7 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 1st damping 2nd damping 3rd damping 4th damping Setup value 7 Enabled Enabled Enabled Disabled Position Control (Two-degree-of-freedom Control Mode Disabled) Setup 1st damping 2nd damping 3rd damping 4th damping value 7 Enabled Enabled Disabled Disabled

### Pr2.13 "Selection of damping filter switching" details

### 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 (Inposition) 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.

9						PANATERM ver.7				— 🗆 ×
File(F)	Troublesho	oting(T)	Help(H)							_
			E Device tree			ô Setting	閥 Monitor	ピ Logging	프 <mark>은</mark> Tuning	Device Info
	-		MINAS A7BR		]		EtherCAT object	IO Setting	Alarm	Analog input
⊕∨	8	Online	Axis0_No name set	SRV-OFF						
		USB	MADN085BRU 23080001			Open file	Save file	Copy Load initia	values Load	Write
	.0			Encoder Info	1			Config Reset		
	4		MINAS A7BR	39405786 pulse						
	14 P		MHMG022U1A2 24020001		•	Search	Compa	rison None	Add/delete c	olumn
					-	Switch to HEX input	Display A6-compati	ible control parameters	Allow out-of-range settin	as

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



The "Manual TUNING" settings screen is displayed.

4. Click on the [Damping settings] button or "Damping settings" in blue text.

6				PANATI	ERM ver.7			- 🗆 X
F	File(F) Troubleshooting(T) Help(H)							
Devic	袋 Setting 昭 Monitor	Ŀζ	Logging	🖻 Tuning	Device Info	2		Z-phase search
Device tree	< Manual TUNING		🗸 Graph	_			1	2
	Selected driver:Axis0_No name set		Wave grap	hic Frequency response		/2-pha	Limit setting	Trial run
	Basic Load characteri Notch settin	s	Start	measurement Stop	Single trigger Acquire	phase search	Protection Functions Pr5.12 Overload level[%]	0
	Damping settin Application Manual Mode setting (i) 0:Disabled	1	Measurem	ent data management Edit	display range Fixed display range	9	Pr5.13 Overspeed level[r/min]	120
	Customize settings		Reset zoo			- 11		Automatic setting (overspee
	(i) When launching for the first time		Display as	elapsed time Display as tim	he standard Load file	- 11	Pr5.14 Motor mova[0.1 rotation	] [10
	A7 recommended settingis recommended (i) When upgrading from A6A6 compatibility setting		Save fi	le		- 11	Operation limit	
	is recommended						Pr5.04 Over-travel inhibit input s	. 1: CoE-side (CiA402) deceler 💙
	Load characteristic settings Automatic settingOFF		🗸 Graph o	display settings			Operating range	
	Inertia ratio 0		Measure	ment Condition Edit displaye	ed data Cursor		Use JOG to move to the Max./M JOG speed[r/min]	in. positions or input a numeric value
	For more advanced settings Load characteristic settings							
►	Gain setting		Acquin	e from driver Acquire from	n file Load condition presets	JL 🔤 🖡	JOG acceleratio[ms/JOG speed	] 50
	Feedback gain setting - 29 +							
	Speed response frequenc 102	5	<ul> <li>Monito</li> </ul>	r				
	Automatic oscillation su OFF Safety function		Simple mo	nitor IO monitor				
	FF gain setting - 31 +		Start me		e With Position C 🗸 Measurement			
	Positional command smo	3	Trial No. [times]		unt Vibration level Effective load facto [%] [%]	or Takt [ms]		
	Overshoot suppression [%] - 100.0 +		tennesi	[maj [maj	[10]	[[(i)]]	Servo-on Operates	only while the button is pressed.
	Notch filter settings Automatic setting:OFF						- direction	io to 0 + direction
	3rd notch frequency [Hz] 50 4th notch frequency [Hz] 50						Current parities	n [command unit]
	For more advanced settings Notch settings	,						0
	Damping filter setup Automatic setting:ON							
	1st damping frequency [Hz]	0					Minimum position	Maximum position
	For more advanced settings Damping settings						[command unit]	[command unit]
	What if I have a problem?						0	0
	Refer to Tuning Help <u>when problems occur</u> such as vibration or abnormal noise						Troubl	eshooting To trial run

The advanced damping settings screen is displayed.

<		Manual TUNING	5						
Select	ted driver:Axis0_No nam	ie set							
	Basic	Load characteristic se	ettings	Notch settings					
	Damping settings		Manual						
Vibrat	ion monitor		Not detected						
Vibra	tion frequency [Hz] ()				0.0				
() "0.0" is displayed until vibration is detected									
Damp	ing filter setup								
Pr2.1	3 Damping filter switchin	g	0: Use	up to two simultaneo	~				
Auto	matic frequency setting (	D	1st dar	nping frequency	~				
	When vibrations are deter to the damping frequency		uency va	lue is automatically app	lied				
IN	to the dumping frequency	of the target filter.							
Ţ									
Ě	FIR filter		Auton	natic setting					
Ļ	Pr2.23 Positional comm	and FIR filter [0.1 ms]	10						
	Smoothing filter								
	Pr2.22 Positional comm	and smoothing filter							
	Pr6.49 Command respo	nse filter attenuation	5: 1 🗸						
	Damping filter 1								
	Pr2.14 1st damping free	uency [0.1 Hz]	0						
	Pr2.15 1st damping filte	r setup [0.1 Hz]	0						
	Pr2.27 1st damping wid	th setting	0						
¥	Pr6.41 1st damping dep	th	0						
	Damping filter 2								
	Pr2.16 2nd damping fre		0		_				
	Pr2.17 2nd damping filt	er setup [0.1 Hz]	0						
	Pr2.28 2nd damping wid	dth setting	0						
¥	Pr6.60 2nd damping de	pth	0						
OUT	T : 40								
-	Tuning filter Filter function switching		A7 mo	40	~				
	-	nt0.01msl	4	16	·				
	Tuning filter time consta			thenustion term					
	Pr6.49 Tuning filter atter	nuation term setup	I: No a	ttenuation 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 <u>"5.5.3 Related Parameters"</u>.

### – 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 fre- quency setting	Description
Disabled	None of the damping frequencies are set automatically.
1st damping fre- quency	When vibrations are detected, the vibration frequency value is automatically applied to the damping frequency of the target filter.
2nd damping fre- quency	
3rd damping fre- quency	
4th damping fre- quency	

**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 <u>"5.5.4.1 For Manual Setting"</u>.

### 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 <u>"5.5 Damping Control Function"</u>.)



### 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 condi- tions	<ul> <li>When vibration is excited by primary causes other than commands (external forces, etc.)</li> <li>When the resonance frequency and antiresonance frequency are not between 5.0 and 300.0 Hz</li> </ul>

If the parameter settings are as follows, the filter operates as a conventional damping filter (see <u>"5.5 Damping Control Function"</u>).

Item	Conditions for operating as a conventional damping filter
Parameter set- up	<ul> <li>When the resonance frequency and antiresonance frequency do not have the following relationship 5.0 Hz ≤ antiresonance frequency &lt; resonance frequency ≤ 300.0 Hz</li> <li>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</li> <li>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)</li> </ul>

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

						Norie
Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	13	В	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	В	1st resonance frequency	0 to 3000	0.1 Hz	Sets model-type damping filter load resonance frequen- cy.
6	62	В	1st resonance at- tenuation ratio	0 to 1000	_	Sets the model-type damping filter load resonance damping ratio. The damping ratio can be set as the setup value multi- plied by 0.001. A setting value of 1000 results in an at- tenuation of 1 (no peak). The smaller the setting value, the smaller the damping ratio (higher resonance peak).
6	63	В	1st anti-reso- nance frequency	0 to 3000	0.1 Hz	Sets the model-type damping filter load anti-resonance frequency.
6	64	В	1st anti-reso- nance attenua- tion 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 multi- plied by 0.001. A setting value of 1000 results in an at- tenuation of 1 (no peak). The smaller the setting value, the smaller the damping ratio (higher resonance peak).
6	65	В	1st response fre- quency	0 to 3000	0.1 Hz	Sets the model-type damping filter load response fre- quency.
6	66	В	2nd resonance frequency	0 to 3000	0.1 Hz	Sets the model-type damping filter load 2nd resonance frequency.
6	67	В	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 multi- plied by 0.001. A setting value of 1000 results in an at- tenuation of 1 (no peak). The smaller the setting value, the smaller the damping ratio (higher resonance peak).
6	68	В	2nd anti-reso- nance frequency	0 to 3000	0.1 Hz	Sets the model-type damping filter load 2nd anti-reso- nance frequency.

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
6	69	В	2nd anti-reso- nance attenua- tion ratio	0 to 1000	_	Sets the model-type damping filter load 2nd anti-reso- nance attenuation ratio The damping ratio can be set as the setup value multi- plied by 0.001. A setting value of 1000 results in an at- tenuation of 1 (no peak). The smaller the setting value, the smaller the damping ratio (higher resonance peak).
6	70	В	2nd response fre- quency	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 <u>"7.1 List of Parameters"</u>.

### Pr2.13 "Selection of damping filter switching" details

value	up Description ue									
0	Each damping control filter can be enabled or disabled as follows.									
	Setup value	1st damping	2nd damping	3rd damping	4th damping					
	0	Enabled	Enabled	Disabled	Disabled					
1 to 2	Manufacturer use (setting is prohibited)									
3	Depending on the direction of the position command, each damping control filter is switched between enabled and disabled as follows.									
	Setup value	Position command direction		1st damping	2nd damping	3rd d	lamping	4th damping		
	3	Positive	direction	Enabled	Disabled	En	abled	Disabled		
		Negative	e direction	Disabled	Enabled	Dis	sabled	Enabled		
	Setup		o-degree-of-				2nd model-type damping control		ng control	
	value									
					mahlad			Freeblad		
	4			E	nabled Manufacturer		etting is r	Enabled		
	4	Positive	- 		Manufacturer	use (se	etting is p	prohibited)		
	5		- e direction	E		use (se	etting is p			
	5	Negative		E	Manufacturer			prohibited) Disabled		
	5	Negative	e direction o-degree-of-	E	Manufacturer			prohibited) Disabled		
	5 6 Position Setup	Negative Control (Tw	e direction o-degree-of-	Freedom Cor	Manufacturer inabled isabled ntrol Mode D			prohibited) Disabled		
	5 6 Position Setup value	Negative Control (Tw 1st damping	e direction o-degree-of- 2nd damping	Freedom Cor 3rd damping	Manufacturer inabled isabled htrol Mode D 4th damping			prohibited) Disabled		
	5 6 Position Setup value 4 5, 6	Negative Control (Tw 1st damping Enabled	e direction o-degree-of- 2nd damping Enabled	freedom Cor 3rd damping Enabled	Manufacturer inabled isabled htrol Mode D 4th damping Disabled			prohibited) Disabled		
	5 6 Position Setup value 4 5, 6	Negative Control (Tw 1st damping Enabled Enabled	e direction o-degree-of- 2nd damping Enabled Enabled	freedom Cor 3rd damping Enabled	Manufacturer inabled isabled htrol Mode D 4th damping Disabled			prohibited) Disabled		
Setup value		Description								
--	--	---	---------	-----------	----------	--	--	--		
7	Depending	Depending on the control mode, each damping control filter is switched between enabled and disabled as follows.								
	Position	Position Control (Two-degree-of-freedom Control Mode Enabled), Full-closed Control								
	Setup value         1st damping         2nd damping         3rd damping         4th damping									
	7	Enabled	Enabled	Enabled	Disabled					
Position Control (Two-degree-of-freedom Control Mode Dis Setup 1st damping 2nd damping 3rd damping 4th damping value				visabled)						
	7	Enabled	Enabled	Disabled	Disabled					

## 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.

822								
File(F)	Troubleshooting(T)	Help(H)						_
		E Device tree		{ĝ} Setting	閥 Monitor	I∕ <sub>Q Logging</sub>	프 <b>은</b> Tuning	🗓 Device Info 🖗
	-	MINAS A7BR		All parameters	EtherCAT object	IO Setting	Alarm	Analog input
ଡ଼⋎	Online	Axis0_No name set	SRV-OFF					
	USB	MADN085BRU 23080001		Open file	Save file	Copy Load initia	values Load	Write
	N.	10000 1700	Encoder Info 19405786 pulse			Config Reset		se searc
	6	MINAS A7BR 31 MHMG022U1A2 24020001		Search	Compar	ison None	✓ Add/delete o	olumn
				Switch to HEX input	Display A6-compati	ble control parameters	Allow out-of-range settin	igs

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



The "Manual TUNING" settings screen is displayed.

4. Click on the [Damping settings] button or "Damping settings" in blue text.

	-					LINW VELT			<b>_</b>
	ile(F) Troubleshooting	g(T) Help(H)							
Devic	🔅 Setting	閥 Monitor	ŀ∕q Lo	gging	E Tuning	Device Info	Q	Trial run	Z-phase search
Device tree	<	Manual TUNING		<ul> <li>Graph</li> <li>Wave graphic</li> </ul>	Frequency response		Trial run/Z-phase search	1	2
	Selected driver:Axis0_	No name set		wave graphic	riequency response		pha	Limit setting	Trial run
	Basic L Damping settin	oad characteri Notch settings Application Manual		🛑 Start mea	asurement Stop	Single trigger Acquire	] se searc	Protection Functions Pr5.12 Overload level[%]	0
	Mode setting (i)	0:Disabled	ן	Measurement	data management Edi	t display range Fixed display range		Pr5.13 Overspeed level[r/min]	
	mode setting (	Customize settings		Reset zoom	Align with center of Y-a:	dis			Automatic setting (overspee
	(i) When launching for	or the first time		Display as ela	psed time Display as ti	ne standard Load file		Pr5.14 Motor mova[0.1 rotation]	10
	A7 recommended set		ſ	Save file				Operation limit	
	When upgrading f is recommended	from A6A6 compatibility setting						Pr5.04 Over-travel inhibit input s	1: CoE-side (CiA402) deceler 💙
	Load characteristic setti			<ul> <li>Graph disp</li> </ul>	lay settings			Operating range	n. positions or input a numeric value
	Inertia ratio	0		Measureme	nt Condition Edit display	red data Cursor		JOG speed[r/min]	60
	For more advanced se	ettings Load characteristic settings					-		
•	Gain setting			Acquire fro	om driver Acquire fro	m file Load condition presets		JOG acceleratio[ms/JOG speed]	50
	Feedback gain setting	- 29 +	•				_		
	Speed response frequ			<ul> <li>Monitor</li> </ul>					
	Automatic oscillation	n su OFF		Simple monite	or IO monitor				
		Safety function	111				_		
	FF gain setting	- 31 +		Start measu	Measurement mo	de With Position C Y Measurement cou	nt 2		
	Positional command s	smo 0.8				unt Vibration level Effective load factor			
	Overshoot suppressio	m [%] - 100.0 +		[times] [m	s] [times]	[%] [%]	ms]	Servo-on Operates o	only while the button is pressed.
	Notch filter settings	Automatic setting:OFF						- direction	o to 0 + direction
	3rd notch frequency [	-							
	4th notch frequency [I For more advanced se							Current position	[command unit] )
	Damping filter setup	Automatic setting:ON							
	1st damping frequence							Minimum position	Maximum position
	For more advanced set							[command unit]	[command unit]
	What if I have a probler	m?						0	0
	Refer to Tuning Help y vibration or abnormal	when problems occur such as noise						Trouble	eshooting To trial run

The advanced damping settings screen is displayed.

<	Manual TUNING						
Selec	ted driver:Axis0_No nam	ne set					
	Basic	Load characteristic se	ettings	Notch settings			
	Damping settings	Application		Manual			
Vibrat	tion monitor		Not detected				
Vibra	ition frequency [Hz] (i)			0.0			
(j)	"0.0" is displayed until vib	pration is detected					
Damp	ping filter setup						
Pr2.1	3 Damping filter switchir	ıg	4: No s	witching (model type) 🛛 🗸			
Auto	matic frequency setting (	j)	Disable	ed 🗸			
	When vibrations are dete to the damping frequenc		iency va	lue is automatically applied			
IN	to the damping nequenc	y of the target filter.					
	FIR filter		Auton	natic setting			
Ţ	Pr2.23 Positional comm	and FIR filter [0.1 ms]	10				
Ě	Smoothing filter						
	Pr2.22 Positional comm	and smoothing filter					
	Pr6.49 Command respo	nse filter attenuation	5: 1 🗸				
	Model-type damping fi	lter 1					
	Pr6.61 1st resonance fre	equency [0.1 Hz]	0				
	Pr6.62 1st resonance at	tenuation ratio	0				
	Pr6.63 1st anti-resonand	ce frequency [0.1 Hz]	0				
	Pr6.64 1st anti-resonand	ce attenuation ratio	0				
¥	Pr6.65 1st response free	quency [0.1 Hz]	0				
	Model-type damping fi	lter 2					
	Pr6.66 2nd resonance fr	equency [0.1 Hz]	0				
	Pr6.67 2nd resonance a	ttenuation ratio	0				
	Pr6.68 2nd anti-resonar	ice frequency [0.1 Hz]	0				
	Pr6.69 2nd anti-resonar	ce attenuation ratio	0				
↓	Pr6.70 2nd response fre	quency [0.1 Hz]	0				
OUT	OUT						
		isplay model-type dam	ping filt	er characteristics in a graph			
				Offset [dB] 0.0			
	Tuning filter		17				
	Filter function switching		A7 mode 🗸				
	Tuning filter time consta		4				
	Pr6.49 Tuning filter atter	nuation term setup	1: No a	ttenuation 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 <u>"5.6.3 Related Parameters"</u>.
   Precautions
  - Only parameters for model-type damping filter that can be used are displayed.
- Frequency response is measured using the torque speed mode of the frequency response measurement function. For details, see <u>"6.2 Frequency Response Measurement"</u>.

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)





**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

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
2	22	В	Positional com- mand 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 fil- ter 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	В	Positional com- mand FIR filter	0 to 10000	0.1 ms	Sets the average movement time for the position com- mand.
6	49	В	Command re- sponse/tuning fil- ter attenuation term	0 to 99	_	Sets the "command response filter" and "tuning filter" at- tenuation 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 <math>\zeta</math> is 1.0, 0.86, 0.71, 0.50, 0.35, in that order (operates as second order lag filter) &lt; Example of this parameter setup &gt; To set the command response filter to <math>\zeta = 1.0</math> and the tuning filter to <math>\zeta = 0.71</math>, set the setting value to 75 (ones <math>= 5 (\zeta = 1.0)</math>, tens <math>= 7 (\zeta = 0.71)</math>). Note that Pr2.22 "Positional command smoothing filter" is applied to the command response filter time constant.</target>

5.7.3 Related Parameters

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

## – 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	К2
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 <u>"\*2"</u> 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 <u>"2"</u> 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 <u>"4.1.1.6 Basic Gain Parameter Setup Table"</u>.

## 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.

<b>a</b>				PANATERM ver.7				
File(F)	Troubleshooting(T)	Help(H)						_
		E Device tree		{ĝ} Setting	閥 Monitor	Ir <sub>G Logging</sub>	프 <b>은</b> Tuning	Device Info
	-	MINAS A7BR		All parameters	EtherCAT object	IO Setting	Alarm	Analog input
∮∨	Online	Axis0_No name set	SRV-OFF					
	USB	MADN085BRU 23080001		Open file	Save file	Copy Load initia	values Load	Write
	.0		Encoder Info			Config Reset		
	5	MINAS A7BR MHMG022U1A2 24020001	39405786 pulse	Search	Compar	ison None	Add/delete d	olumn
				Switch to HEX input	Display A6-compati	ble control parameters	Allow out-of-range settin	igs

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



The "Manual TUNING" settings screen is displayed.

4. Click on the [Damping settings] button or "Damping settings" in blue text.

	<ul> <li>File(F) Troubleshooting(T) Help(H)</li> </ul>		PAINALENWI VELT			U
		K Logging 프를 Tur	ing Device Info	S)	Trial run	Z-phase search
Device tree	Annual TUNING Selected driver:Axis0 No name set	Graph     Wave graphic Frequency re		Trial run/Z-phase search	Limit setting	2 Trial run
	Basic     Load characteri     Notch settings       Damping settin     Application     Manual       Mode setting ①     0:Disabled        ①     When launching for the first time     A7 recommended settings recommended       ①     When upgrading from A6A6 compatibility setting is recommended		Stop Single trigger Acquire Left display range Fixed display range hter of Y-axis isplay as time standard Load file	hase search	Protection Functions Pr5.12 Overload level[%] Pr5.13 Overspeed level[r/min] Pr5.14 Motor mova[0.1 rotation] Operation limit Pr5.04 Over-travel inhibit input s	
Þ	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 Safety function FF gain setting - 31 +	Acquire from driver Monitor Simple monitor IO monitor	Edit displayed data Cursor Acquire from file Load condition presets	2	Operating range Use JOG to move to the Max/Mi JOG speed[r/min] JOG acceleratio[ms/JOG speed]	n. positions or input a numeric value 60 50
	Positional command smo     0.8       Overshoot suppression [%]     100.0       +     100.0       > 100.0     +       Notch filter settings     Automatic setting:OFF       3rd notch frequency [Hz]     5000       4th notch frequency [Hz]     5000       For more advanced settings Notch 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		P change count Vibration level Effective load factor Tak nes] [%] [%] [%]		- direction G Current position [command unit]	Inly while the button is pressed.

The advanced damping settings screen is displayed.

5. Tune the Pr2.23 Positional command FIR filter and the Pr2.22 Positional command smoothing filter.

<	Manual TUNING						
Selec	ted driver:Axis0_No nam	ne set					
	Basic	Load characteristic se	ettings	Notch se	ttings		
	Damping settings	Manual					
Vibrat	tion monitor			Not detected			
Vibra	ition frequency [Hz] ()				0.0		
(j)	"0.0" is displayed until vib	oration is detected					
Damp	ping filter setup						
Pr2.1	3 Damping filter switchin	g	0: Use	up to two simulta	neo 🗸		
Auto	matic frequency setting (	D	1st dar	nping frequency	~		
	When vibrations are dete to the damping frequenc		lency va	lue is automatical	ly applied		
IN	to the damping nequent	, or the target inten					
Ţ							
	FIR filter		Auton	natic setting			
Ļ	Pr2.23 Positional comm	and FIR filter [0.1 ms]	10				
	Smoothing filter						
	Pr2.22 Positional comm	and smoothing filter	37				
	Pr6.49 Command respo	nse filter attenuation	5: 1		~		
	Damping filter 1						
	Pr2.14 1st damping free	quency [0.1 Hz]	0				
	Pr2.15 1st damping filte	er setup [0.1 Hz]	0				
	Pr2.27 1st damping wid	th setting	0				
¥	Pr6.41 1st damping dep	oth	0				
	Damping filter 2						
	Pr2.16 2nd damping fre	quency [0.1 Hz]	0				
	Pr2.17 2nd damping filt	er setup [0.1 Hz]	0				
	Pr2.28 2nd damping wi	dth setting	0				
¥	Pr6.60 2nd damping de	pth	0				
OUT							
	Tuning filter		47				
	Filter function switching		A7 mo	ae	<b></b>		
	Tuning filter time consta		4				
	Pr6.49 Tuning filter atter	nuation term setup	1: No a	ttenuation 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 <u>"5.7.4.1 For Manual Setting"</u>.

• Tuning "Smoothing filter"

Tune Pr2.22 "Positional command smoothing filter" to suppress vibration and velocity change caused by command resolution.

• See <u>"5.7.4.1 For Manual Setting"</u>.

## 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

ltem	Operational Conditions
Control mode	Speed control

## 5.8.3 Related Parameters

Class	No.	Attribute (*1)	Parameter name	Setting range	Unit	Function
3	12	В	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	В	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	В	Sigmoid acceler- ation / decelera- tion 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 <u>"7.1 List of Parameters"</u>.

#### - 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)  $[ms] = Vc/1000 \times Pr3.12 \times 1 ms$ 

Deceleration time (td)  $[ms] = Vc/1000 \times Pr3.13 \times 1 ms$ 



## 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

Command

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 condi- tions	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	В	Hybrid vibration suppression gain	0 to 30000	0.1 s <sup>-1</sup>	Sets hybrid vibration suppression gain. Normally set to the same value as the position loop gain, and then fine-tune as necessary.
6	35	В	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 <u>"7.1 List of Parameters"</u>.

## 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").

- 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 >>

9

- 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.

File(F)	Troubleshooting(T)	Help(H)							
		E Device tree			ôð Setting	閔 Monitor	ピ Logging	프 <b>은</b> Tuning	🚺 Device Info 🖉
	<b>d</b>	MINAS A7BR				EtherCAT object	IO Setting	Alarm	Analog input
⊕∨	Online	Axis0_No name set	SRV-OFF						
	USB	MADN085BRU 23080001			Open file	Save file	Copy Load initia	l values Load	Write
	M.		Encoder Info 39405786 pulse				Config Reset		se searc
	<b>I</b>	MINAS A7BR MHMG022U1A2 24020001	55405700 pulse	•	Search	Compar	ison None	✓ Add/delete c	olumn 4
		WITHWOOZ2017A2 24020001			Switch to HEX input	Display A6-compati	ble control parameters	Allow out-of-range settin	gs

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



The "Manual TUNING" settings screen is displayed.

5				PANATE	RM ver.7				
F	File(F) Troubleshooting(T) Help(H)								
Devie		Ŀάι	ogging	프 <mark>은</mark> Tuning	Device Info	Ø	Trial run	Z-phas	e search
Device tree	Manual TUNING		✓ Graph			Trial run/Z	1	2	
	Selected driver:Axis0_No name set		Wave graph	Frequency response		Z-pha	Limit setting	Trial run	
	Basic Load characteri Notch settings	٦.	Start m	neasurement Stop	Single trigger Acquire	-phase search	Protection Functions		
	Damping settin Application Manual	1				earch	Pr5.12 Overload level[%]	0	
		-	Measureme	ent data management Edit	display range Fixed display range	-	Pr5.13 Overspeed level[r/min]		
	Mode setting (i) 0:Disabled  Customize settings		Reset zoom	Align with center of Y-axi	s			Automatic set	ting (overspee
	(i) When launching for the first time		Display as e	elapsed time Display as tim	e standard Load file		Pr5.14 Motor mova[0.1 rotation]	10	
	A7 recommended settingis recommended		Save file				Operation limit		
	<ol> <li>When upgrading from A6A6 compatibility setting is recommended</li> </ol>		Save In				Pr5.04 Over-travel inhibit input s	1: CoE-side (CiA4	02) deceler 🗸
	Load characteristic settings Automatic settingOFF		🗸 Graph di	splay settings			Operating range		
	Inertia ratio 0				11. 6		Use JOG to move to the Max./M	· · ·	ut a numeric value
	For more advanced settings Load characteristic settings		Measuren	Measurement Condition Edit displayed data Cursor			JOG speed[r/min]	60	
	Gain setting		Acquire	from driver Acquire from	n file Load condition presets		JOG acceleratio[ms/JOG speed	50	
1	Feedback gain setting - 29 +	•				- 1			
	Speed response frequenc 102.5		<ul> <li>Monitor</li> </ul>						
	Automatic oscillation su OFF		Simple mor	nitor IO monitor					
	Safety function								
	FF gain setting - 31 +		Start mea	surem Measurement mod	e With Position C 💙 Measurement count	2			
	Positional command smo 0.8				Int Vibration level Effective load factor Takt				
	Overshoot suppression [%] - 100.0 +		[times]	[ms] [times]	[%] [%] [ms]		Servo-on Operates	only while the butto	on is pressed.
	Notch filter settings Automatic setting:OFF						- direction	o to 0 + d	lirection
	3rd notch frequency [Hz]         5000           4th notch frequency [Hz]         5000						Current position	[command unit]	
	4th notch frequency [HZ] 5000 For more advanced settings Notch settings						Current position		
	Damping filter setup Automatic setting:ON								
	1st damping frequency [Hz] 0						Minimum position	<b>_</b>	Aaximum position
	For more advanced settings Damping settings						[command unit]		command unit]
	What if I have a problem?						0	[	0
	Refer to Tuning Help <u>when problems occur</u> such as vibration or abnormal noise						Troubl	eshooting	To trial run

**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 f	unction							
> High response current cor	ntrol function							
> Gain switching function								
> Quadrant glitch suppressi	on function							
> Hybrid vibration suppress	ion 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 set	tings Notch settings				
Damping settings	Application	Manual				
> Feedforward functio	n					
> Load fluctuation cor	trol function					
> High response curre	nt control function					
> Gain switching funct	ion					
> Quadrant glitch sup	pression function					
	Hybrid vibration suppression function Enabling this suppresses oscillation.					
Hybrid vibration suppr	ession gain [0.1/s] 0					
Hybrid vibration suppr	ession filter [0.01 ms] 10					

6. For details on tuning each parameter, see <u>"5.9.4.1 For Manual Setting"</u>.

# **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.

<b>@</b>								
File	(F) Troubleshooting(T)	Help(H)						
Devi	🔅 Setting	- E Monitor	්ර Logging	프 <b>음</b> Tuning	Device Info			
Device tree	Wave graphic	Frequency response						
	Start measurement	Stop Stop	gle trigger Acquire	Multiple axis measur	ement settings Measuremen	t data management Add graph	Load file Save file	
Ī	Axis0 Graph1 x							
	Edit display range Fixe	d display range Reset zo	oom Align with center of	Y-axis		Display as el	apsed time Display as time standard	ā
•								
~	Graph display settings							
	Measurement Condition	Edit displayed data Curs	sor					
	Acquire from driver	Acquire from file	Load condition presets	Save condition presets				
	Measurement item	Edit	Sampling cycle [ms] 0.7500	0	Measurement time [ms] 1,	535.25		
	Actual speed[r/min]				_	_		
	Position command speed Torque command[%]	d[r/min]	Trigger condition 1 or 2	✓ Trigger position	1/8 V Data averaç	ge ON O		
	Command position devia	ation[Command unit]		arget	Level	Slope	Filter	1
			Trigger 1 Position comman Trigger 2 Position comman	la speca[i/min]		Rising up V Falling down V	No use V	
			rosition comman	iu speeu(i/min)			Ino use	1

2. In "Measurement condition" of "Graph display settings", set the measurement items, measurement conditions, sampling cycle, and trigger.

<ul> <li>Graph display settings</li> </ul>					
Measurement Condition Edit displayed data	Cursor				
Acquire from driver Acquire from file	Load condition presets Save condition preset	ts			
Measurement item Edit	Sampling cycle [ms] 0.7500	Measurement time [ms] 1,5	35.25		
Actual speed[r/min]	0				
Position command speed[r/min]	Trigger condition 1 or 2	sition 1/8 V Data average	e ON		
Torque command[%]			_		
Command position deviation[Command unit]	Target	Level	Slope	Filter	
	Trigger 1 Position command speed[r/min] V	50	Rising up 🗸	No use	~
	Trigger 2 Position command speed[r/min] V	50	Falling down 🗸	No use	~

**3.** Click the [Start measurement] button.

<b>a</b>								
File(F)		Troubleshooting(T)	Help(H)					
Device tree		🔅 Setting	閥 Monitor					
		Wave graphic	Frequency response					
		Start measurement	Stop Single					

The measurement results are displayed.

5								
F	ile(F) Troubleshooting(T) Help(H)							
Devi	袋 Setting 쩐 Monitor	්ර Logging	프 <del>을</del> Tuning	Device Info				Ø
Device tree	Wave graphic Frequency respon	se						Trial run/Z-phase search
	Start measurement Stop	Single trigger Acquire	Multiple axis measurer	nent settings Measurement data r	nanagement	Add graph		n/Z-p
	Load file Save file							hase s
	Axis0 Graph1 x							earch
	Edit display range Fixed display range R	eset zoom Align with center of Y-	-axis	Display as	elapsed time	isplay as time stand	lard	
		0-					]	
		0-						
	70         -0<	0-	hum	mund				
	Actual speed[[7/min]]	0		human				
	1200000 - 0							
Þ								•
	-2000000120012001200		128	256	384	5	12	
		0		apsed time [ms]	504	5	12	
	<ul> <li>Graph display settings</li> </ul>							
	Measurement Condition Edit displayed data	Cursor						
	Acquire from driver Acquire from file	Load condition presets	Save condition presets					
	Measurement item Edit	Sampling cycle [ms] 0.2500		Measurement time [ms] 511.75				
	Actual speed[r/min]							
	Position command speed[r/min] Torque command[%]	Trigger condition 1 and 2	✓ Trigger position		D			
	Command position deviation[Command unit]	Target Trigger 1 Position command	Lev	Rising up	✓ No use	Filter	~	
		Trigger 2 Position command	<u> </u>	Falling down	✓ No use		~	
		]		/ L	) (			

## 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.



## 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.

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.	

## 6.2.2 Types of Measurement Modes

# 6.2.3 Changes from measurements using A6 Series drivers

Measurement mode	Change
Speed closed loop characteristics	<ul> <li>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).</li> </ul>
	<ul> <li>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.</li> </ul>
Torque speed (normal)	• Because torque commands are applied as noise signals after various filters, mechanical charac- teristics 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 Soft- ware (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.
	<ul> <li>Torque commands are applied as noise signals after the various filters.</li> </ul>
	• 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 charac-	<ul> <li>Torque commands are applied as noise signals after the various filters.</li> </ul>
teristics	• 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.

9						
Fil	e(F) Troubleshooting(T) Help(H)					
Devic	Setting     Of Monitor	년 Logging	프음: Tuning	Device Info		100
Device tree	Wave graphic Frequency respo	nse				
	Selected driver:Axis0_No name set					-7/11
	Parameter auto-update		Automatic servo-on/off	Servo-on O Start measurement	Stop Measurement data management	100 TOTAL SCOLO
	Write to EEPROM Config	Reset	Reset display range	ad file Save file		aici
	Recall presets Load presets Selected p	oreset:All parameters	Smoothing	12		_
	Name Unit	Value				_
	Pr0.00 manufacturer use	1	<u>e</u> -20 <u>9</u> -40			
	Pr0.01 Control mode setup	0: Semi-closed c 🗸	-60 + + + + + + + + + + + + + + + + + + +	100 Erea	1000 Jency [Hz]	
	Pr0.02 Real-time auto-gain tu	0: Conventional 🗸			ing frag	
	Pr0.03 Real-time auto-tuning	13	Display phase graph			
•	Pr0.04 Inertia ratio %	100	5 100 9 0 9			••••••
	Pr0.08 manufacturer use	0	4 = -200 -300			
	Pr0.09 manufacturer use	1	10	100 Frequ	1000 uency [Hz]	
	Pr0.10 manufacturer use	1	<ul> <li>Frequency characteristic set</li> </ul>			- 1
	Pr0.11 Number of output puls pulse/r	2500		up/anarysis : of displayed data Resonance/antiresonance	frequency display	
	Pr0.12 Reversal of pulse outpu	0: Encoder, posit 🗸	Measurement mode Speed closed loop characteristics			
	Pr0.13 1st torque limit %	350				
	Pr0.14 Position deviation exce Command	83886080	Input signal 1 amplitude (r/			
	Pr0.15 Absolute encoder setup	1: Used in incre V	Input signal 1 offset [r/min]	50		
	Pr0.16 External regenerative re	3: No regenerati 🗸	▲ Setting a large offset may	r cause operating limits to be exceeded.		

2. Select the desired measurement mode from the "Measurement mode" drop-down list.

<ul> <li>Frequency characteristic setu</li> </ul>	p/analysis
Measurement Condition List	of displayed data Resonance/antiresonance frequency display
Measurement mode Speed of	losed loop characteristics
Sampling rate	0:5000Hz 🗸
Input signal 1 amplitude [r/	50
Input signal 1 offset [r/min]	50
A 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 <u>"Step 5"</u> ) Therefore, if the movable range of the device is narrow, the moving part may collide with the mechanical end.	
Torque speed (normal)	<ul> <li>Do not use in devices with a Z axis that may cause the mechanism to fall when in servo-on.</li> <li>For such devices, use torque speed (vertical).</li> </ul>	
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 <u>"4.1.1.6 Basic Gain Parameter Setup Table"</u> of <u>"4.1 Real-time Auto Tuning Function"</u> .	
	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.

<ul> <li>Frequency characteristic setu</li> </ul>	ip/analysis
Measurement Condition List	of displayed data Resonance/antiresonance frequency display
Measurement mode Speed	closed loop characteristics
Sampling rate	0:5000Hz V
Input signal 1 amplitude [r/	50
Input signal 1 offset [r/min]	50
A 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 <u>"Amplitude and offset setting ranges</u>" 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.

<ul> <li>Frequency characteristic set</li> </ul>	up/analysis
Measurement Condition List	of displayed data Resonance/antiresonance frequency display
Measurement mode Speed	closed loop characteristics
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.

-: N/A

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  $[r] = offset [r/min] \times 0.017 \times (sampling rate + 1)$ 

Measurement mode Amplitude setting range Offset setting range 1 r/min to rated speed [r/min] Speed closed loop - rated speed [r/min] to rated speed [r/min] characteristics Torque speed (normal) 1 to 100% \_ Torque speed (verti-1 to 100% cal) Position loop charac-1 to 100% teristics Frequency characteristic setup/analysis Measurement Condition List of displayed data Resonance/antiresonance frequency display Measurement mode Speed closed loop characteristics Some parameters are temporarily changed when measuring. Sampling rate 0:5000Hz v

Amplitude and offset setting ranges

Input signal 1 amplitude [r/... 50 Input signal 1 offset [r/min]

input signar i amplitude [i/	50	
Input signal 1 offset [r/min]	50	
\Lambda 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".



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.

**a** File(F) Troubleshooting(T) Help(H) 🔅 Setting 閥 Monitor 프<mark>라</mark> Tuning Device Info Wave graphic Selected driver:Axis0\_No name set Parameter auto-update Automatic servo-on/off Servo-on Start measurement Measurement data management Reset display range Load file Save file Write to EEPROM Config Reset 0 12 Smoothing Recall presets Load presets Selected preset:All parameters 20 0 <del>-</del> -20 -[dB] Name Unit Value - 40 - 20 -Pr0.00 manufacturer use Pr0.01 Control mode setup 0: Semi-closed c... ~ 1000 10 100 Frequency [Hz] Pr0.02 Real-time auto-gain tu.. 0: Conventional... 🗸 🕑 Display phase graph Pr0.03 Real-time auto-tuning.. 13 Pr0.04 Inertia ratio 100 0 0 200 Pr0.08 manufacturer use Pr0.09 manufacturer use 10 100 1000 Frequency [Hz] Pr0.10 manufacturer use 1 Frequency characteristic setup/analysis Pr0.11 Number of output puls... pulse/r 2500 Measurement Condition List of displayed data Resonance/antiresonance frequency display Pr0.12 Reversal of pulse outpu. 0: Encoder, posit... 🗸 O
 Some parameters are temporarily changed when measuring. Measurement mode Speed closed loop characteristics Pr0.13 1st torque limit 350 0:5000Hz ~ Sampling rate Pr0.14 Position deviation exce... Command.. 83886080 Input signal 1 amplitude (r/... 50 Pr0.15 Absolute encoder setup ~ 1: Used in incre... Input signal 1 offset [r/min] 50 ▲ Setting a large offset may cause operating limits to be exceeded. Pr0.16 External regenerative re. 3: No regenerati... 🗸

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.

#### Measurement error troubleshooting

Error	Solution
After the measurement, a "Torque sa- turated. Lower the amplitude and measure again" pop-up dialog ap- peared. 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
An "Alarm triggered during measure-	relevant torque limit-related parameters. After clearing the alarm, set the amplitude to a smaller value and measure
An Err16.0 alarm was triggered.	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 measure- ment" pop-up dialog appeared.	After clearing the alarm, set the amplitude to a smaller value and measure again.
An Err26.0 alarm was triggered.	This error always occurs when the speed closed loop characteristics are meas- ured 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 measure- ment" pop-up dialog appeared.	After clearing the alarm, set the amplitude to a smaller value and measure again.
An Err26.1 alarm was triggered.	This error always occurs when the speed closed loop characteristics are meas- ured 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
	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 <u>"Step 6</u>", 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.



# 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 <u>"6.2.5 Measurement Procedure"</u>.
- 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 <u>"5.6 Model-type Damping Filter Function"</u>.



## 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 <u>"6.2.5 Measurement Procedure"</u>.
- 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 <u>"3.2.1 Manual TUNING"</u>.

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 <u>"5.3 Notch Filter Function"</u>.



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# 7.1 List of Parameters

Information on the parameters used for this product, such as parameter numbers, names, setting ranges and initial values, are shown in a list for each parameter class (whole number).

For this product, parameters are classified into the 11 classes below.

Para	meter No.	Class name	Description	Reference
Clas s	No. <sup>(*1)</sup>			
0	00 to 28	Basic setting	Parameters relating to basic settings	"7.1.2 Class 0: Basic Settings"
1	00 to 115	Gain adjustment	Parameters relating to gain adjustment	"7.1.3 Class 1: Gain Adjustment"
2	00 to 80	Vibration suppression	Parameters relating to vibration sup- pression	<u>"7.1.4 Class 2: Vibration Suppression"</u>
3	04 to 42	Velocity, torque con- trol	Parameters relating to velocity and tor- que control	<u>"7.1.5 Class 3: Velocity/Torque Control/</u> Full-closed Control"
4	00 to 67	I/O monitor setting	Parameters relating to the interface monitor	<u>"7.1.6 Class 4: I/O Monitor Settings"</u>
5	03 to 112	Enhancing setting	Parameters relating to enhancing set- ting	<u>"7.1.7 Class 5: Enhancing Settings"</u>
6	02 to 127	Special setting	Parameters relating to special setting	"7.1.8 Class 6: Special Settings"
7	00 to 127	Special setting 2		"7.1.9 Class 7: Special Settings 2"
8	00 to 19	Special setting 3		"7.1.10 Class 8: Special Settings 3"
11	00 to 26	Manufacturer use	Parameters for manufacturer use	"7.1.11 Class 11: Manufacturer Use"

\*1 No. is a 2- or 3-digit number.

## 7.1.1 Sample Description

The following is an example of entries for a List of Parameters.

#### Class 0: Basic Settings

	No. (*2)	Parameter names (*3)	Setting range	Factory default values	Unit	At- trib- ute (*4)		elated mode S			Refer- ences (*6)	
**	**	*****	_	******	_	_	×	×	×	×	—	
**	**	*****	******	*****	_	В	0	0	0	0	******	

\*1 Shows the classification of the parameter (large number). Shows the X section of PrX.YY.

\*2 Shows the parameter No. (small number). Shows the Y section of PrX.YY.

- \*3 Shows the parameter name. Do not change the setup value from the factory default value for the "Manufacturer use" parameter.
- \*4 For parameter attributes, see <u>"Parameter Attributes"</u>.
- \*5 Shows the relationships between parameters and control modes. Shows whether a parameter is enabled or disabled for each control mode.

Control modes are indicated using the symbols below.

Symbol	Control mode			
Р	Position control			

○: Enabled ×: Disabled —: N/A
Symbol	Control mode
S	Velocity control
Т	Torque control
F	Full-closed control

\*6 Parameter references. The references provide details on parameters and describe their related functions.

For details on abbreviations used for document names, see <u>"1.2"</u>.

## Parameter Attributes

There are attributes for the parameters.

The attribute indicates the timing under which the parameter change description is enabled.

Symbol	When the changed parameter details are enabled
А	Always enabled
В	Always enabled
	Changes are prohibited while the motor is running and during command transfer. If parameters are changed while the motor is running and during position command transfer, the time it takes for the changes to be reflected will be uncertain, which may transiently lead to unstable operation.
С	Enabled after executing the RTEX communication reset command attribute C parameter enabling mode or by the same operation as attribute R below
R	Enabled by turning the control power back on after EEPROM writing or after executing the RTEX communication reset command software reset mode
RO	In read-only, changes cannot be made using the normal procedure for changing parameters

For the details on the RTEX communication reset command, see Technical Reference Communication Specification - . For details on bit allocation of parameter attributes that can be read by parameter attribute reading, see Technical Reference Communication Specification - .

## – Precautions –

• If, after changing a parameter, the power is turned off or the reset command software reset mode is executed, the changed value is lost.

To save the changed value, ensure that it is written to EEPROM.

Use the parameter command or Set-up Support Software (PANATERM ver.7) to write values to EEPROM.

Refer to the operating instructions for the host device or the operating instructions for the Set-up Support Software (PANATERM ver.7).

## Attribute C Parameter Enabling Mode

This is executed using the RTEX communication reset command from the host device. Refer to the operating instructions for the host device for the reset command for the host device.

Use this mode to enable the attribute C parameter change value when communication with the host device is established without turning the servo driver control power on again or performing a software reset.

It is not necessary to write the parameter to EEPROM before executing this mode. (It is not an issue if it is written to EEPROM).

Execute the reset command in a servo-off state and maintain servo-off state during reset command processing. If this command is received in servo-on state, this leads to command error (0045h). Also, if servo-on is executed (Servo\_On = 1) while this command is processed, Err27.7.0 "Position information initialization error protection" is generated.

After the command is executed, position information is initialized, including actual position and position deviation, and is the same as when reset. Also, homing is not completed (excluding when in absolute mode) and latch is not completed. After the command is completed successfully, execute homing again.

The status during command execution and the output signals are as follows.

Status/output signal	Before execution	While executing	After execution
Position information	Current position informa- tion	Initialization	Information on current position with reference to the po- sition at which command was executed (*1)
Homing state	Current state	Indeterminate	<ul><li>Not complete in incremental mode</li><li>Complete in absolute mode</li></ul>
Latch state	Current state	Indeterminate	Not complete
Busy (non-cyclic status)	0	1	0
Other status	Current state	Indeterminate	Current state
Output signal	Current state	Indeterminate	Current state

\*1 Position information after command execution (initialization)

• Incremental mode

All position information = 0

Absolute mode

All position information = Value of absolute encoder (scale)/ electronic gear ratio + Pr7.13 "Absolute home position offset"

## – Precautions –

• While executing the command, do not run operations from Set-up Support Software (PANATERM ver.7).

# 7.1.2 Class 0: Basic Settings

Paramet	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute		elate trol r			Reference
Class	No.						Ρ	S	Т	F	
0	00	Rotational direction setup	0 to 1	1	_	С	0	0	0	0	01_0
0	01	Control mode setup	0 to 6	0	_	R	0	0	0	0	01_0
0	02	Real-time auto-gain tuning setup	0 to 7	1	_	В	0	0	0	0	"4.1.1.4"
0	03	Real-time auto-tuning machine stiff- ness setup	0 to 31	Sizes A, B: 13 Sizes C, D: 11 (13) <sup>(*3)</sup>	_	В	0	0	0	0	<u>"4.1.2.4"</u> "4.1.3.4"
0	04	Inertia ratio	0 to 100000	250	%	В	0	0	0	0	<u>"7.5"</u>
0	08	Number of command pulses per one motor revolution	0 to 134217728	8388608	pulse	С	0	0	0	0	OI_O TR_CS
0	09	Numerator of electronic gear	0 to 2 <sup>30</sup>	1	_	С	0	0	0	0	
0	10	Denominator of electronic gear	1 to 2 <sup>30</sup>	1	_	С	0	0	0	0	
0	11	Number of output pulses per motor revolution	1 to 33554432	2500	pulse	R	0	0	0	0	01_0
0	12	Reversal of pulse output logic	0 to 3	0	_	R	0	0	0	0	
0	13	1st torque limit	0 to 500	500 (*2)	%	В	0	0	0	0	01_0
0	14	Position deviation excess setup	0 to 2 <sup>30</sup>	83886080	Command unit	A	0	×	×	0	01_0
0	15	Absolute encoder setup	0 to 4	1	-	С	0	0	0	×	OI_O TR_CS
0	16	External regenerative resistor setup	0 to 3	Sizes A, B: 3 Sizes C, D: 0	_	С	0	0	0	0	01_0
0	17	Selection of load factor for external regenerative resistor	0 to 4	0	_	С	0	0	0	0	
0	18	Manufacturer use	_	0	_	_	-	-	-	-	_
0	22	Sensor feedback control mode set- up (*1)	0 to 1	0	-	R	0	×	×	×	OI_O TR_CS
0	27	Selection of machine stiffness at re- al-time auto-gain tuning 2	0 to 44	Sizes A, B: 16 Sizes C, D: 12 (16) <sup>(*3)</sup>	_	В	0	0	0	0	<u>"4.1.1.4"</u> "4.1.2.4"
0	28	Selection of feed forward stiffness at real-time auto-gain tuning	0 to 44	Sizes A, B: 16 Sizes C, D: 12 (16) <sup>(*3)</sup>	_	В	0	0	0	0	<u>"4.1.3.4"</u>

 $\bigcirc$ : Enabled X: Disabled —: N/A

\*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.

# 7.1.3 Class 1: Gain Adjustment

aramet	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute			ed co		led —: N/ Reference
			5 5-				t	rol r	nod	e	
Class	No.						P	S	Т	F	
1	00	1st gain of position loop	0 to 30000	Sizes A, B : 480 Sizes C, D: 320 (480) (*1)	0.1 s <sup>-1</sup>	В	0	×	×	0	<u>"4.1.1.4"</u> <u>"4.1.2.4"</u> <u>"4.1.3.4"</u>
1	01	1st velocity loop gain	1 to 32767	Sizes A, B: 270 Sizes C, D: 180 (270) (*1)	0.1 Hz	В	0	0	0	0	
1	02	1st velocity loop integration time constant	1 to 10000	Sizes A, B: 210 Sizes C, D: 310 (210) (*1)	0.1 ms	В	0	0	0	0	
1	03	1st filter of velocity detection	0 to 5	0	_	В	0	0	0	0	
1	04	1st torque filter time constant	0 to 2500	Sizes A, B: 84 Sizes C, D: 126 (84) <sup>(*1)</sup>	0.01 ms	В	0	0	0	0	<u>"5.1.3"</u>
1	05	2nd gain of position loop	0 to 30000	Sizes A, B: 480 Sizes C, D: 320 (480) ( <sup>*1</sup> )	0.1 s <sup>-1</sup>	В	0	×	×	0	<u>"7.5"</u>
1	06	2nd velocity loop gain	1 to 32767	Sizes A, B: 270 Sizes C, D: 180 (270) ( <sup>*1</sup> )	0.1 Hz	В	0	0	0	0	
1	07	2nd velocity loop integration time constant	1 to 10000	Sizes A, B: 210 Sizes C, D: 310 (210) (*1)	0.1 ms	В	0	0	0	0	
1	08	2nd filter of velocity detection	0 to 5	0	_	В	0	0	0	0	
1	09	2nd torque filter time constant	0 to 2500	Sizes A, B: 84 Sizes C, D: 126 (84) <sup>(*1)</sup>	0.01 ms	В	0	0	0	0	<u>"5.1.3"</u>
1	10	Velocity feed forward gain	0 to 4000	1000	0.1 %	В	0	×	×	0	<u>"4.4.3"</u>
1	11	Velocity feed forward filter	0 to 6400	0	0.01 ms	В	0	×	×	0	
1	12	Torque feed forward gain	0 to 2000	1000	0.1 %	В	0	0	0	0	
1	13	Torque feed forward filter	0 to 6400	0	0.01 ms	В	0	0	0	0	
1	14	2nd gain setup	0 to 1	1	_	В	0	0	0	0	<u>"4.2.3"</u> <u>"4.3.3"</u> Ol_O
1	15	Mode of position control switching	0 to 10	0	_	В	0	×	×	0	<u>"4.3.3"</u>
1	16	Delay time of position control switching	0 to 10000	10	0.1 ms	В	0	×	×	0	
1	17	Level of position control switching	0 to 20000	0	-	В	0	×	×	0	<u>"4.2.3"</u>
1	18	Hysteresis at position control switching	0 to 20000	0	-	В	0	×	×	0	
1	19	Position gain switching time	0 to 10000	10	0.1 ms	В	0	×	×	0	
1	20	Mode of velocity control switching	0 to 5	0	_	В	×	0	×	×	
1	21	Delay time of velocity control switching	0 to 10000	0	0.1 ms	В	×	0	×	×	
1	22	Level of velocity control switching	0 to 20000	0	—	В	×	0	×	×	
1	23	Hysteresis at velocity control switching	0 to 20000	0	_	В	×	0	×	×	
1	24	Mode of torque control switching	0 to 3	0	—	В	×	×	0	×	
1	25	Delay time of torque control switch- ing	0 to 10000	0	0.1 ms	В	×	×	0	×	
1	26	Level of torque control switching	0 to 20000	0	—	В	×	×	0	×	
1	27	Hysteresis at torque control switch- ing	0 to 20000	0	—	В	×	×	0	×	

Paramet	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute	1	elate trol r			Reference
Class	No.						Р	S	Т	F	
1	28	Manufacturer use	_	0	_	-	-	-	-	-	_
			:		1						
1	78	Manufacturer use	_	0	_	-	-	-	-	-	
1	106	1st position loop gain change ratio	0 to 300	100	%	В	0	×	×	0	<u>"7.5"</u>
1	107	1st velocity integration change ratio	0 to 300	100	%	В	0	0	0	0	
1	108	1st torque filter change ratio	0 to 300	100	%	В	0	0	0	0	
1	109	2nd position loop gain change ratio	0 to 300	100	%	В	0	×	×	0	
1	110	2nd velocity loop gain change ratio	0 to 300	100	%	В	0	0	0	0	
1	111	2nd velocity integration change ratio	0 to 300	100	%	В	0	0	0	0	
1	112	2nd torque filter change ratio	0 to 300	100	%	В	0	0	0	0	
1	113	Load fluctuation compensation filter change ratio	0 to 300	100	%	В	0	0	0	0	
1	114	Smoothing filter change ratio	0 to 300	100	%	В	0	0	0	0	
1	115	Tuning filter change ratio	0 to 300	100	%	В	0	0	0	0	

\*1 Values in parentheses are initial values for models with an instantaneous maximum current (peak value) of less than 24 A.

# 7.1.4 Class 2: Vibration Suppression

Paramete	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute	Re	elate trol r	ed co	on-	Reference
Class	No.						Ρ	S	Т	F	
2	00	Adaptive filter mode setup	0 to 6	0	_	В	0	0	×	0	<u>"5.4.3"</u>
2	01	1st notch frequency	10 to 5000	5000	Hz	В	0	0	0	0	<u>"5.3.3"</u>
2	02	1st notch width selection	0 to 20	2	_	В	0	0	0	0	
2	03	1st notch depth selection	0 to 99	0	_	В	0	0	0	0	
2	04	2nd notch frequency	10 to 5000	5000	Hz	В	0	0	0	0	
2	05	2nd notch width selection	0 to 20	2	-	В	0	0	0	0	
2	06	2nd notch depth selection	0 to 99	0	_	В	0	0	0	0	
2	07	3rd notch frequency	10 to 5000	5000	Hz	В	0	0	0	0	<u>"5.3.3"</u>
2	08	3rd notch width selection	0 to 20	2	_	В	0	0	0	0	<u>"5.4.3"</u>
2	09	3rd notch depth selection	0 to 99	0	_	В	0	0	0	0	
2	10	4th notch frequency	10 to 5000	5000	Hz	В	0	0	0	0	
2	11	4th notch width selection	0 to 20	2	_	В	0	0	0	0	
2	12	4th notch depth selection	0 to 99	0	_	В	0	0	0	0	
2	13	Selection of damping filter switching	0 to 7	0	_	В	0	×	×	0	<u>"5.5.3"</u> "5.6.3"
2	14	1st damping frequency	0 to 3000	0	0.1 Hz	В	0	×	×	0	<u>"5.5.3"</u>
2	15	1st damping filter setup	0 to 1500	0	0.1 Hz	В	0	×	×	0	
2	16	2nd damping frequency	0 to 3000	0	0.1 Hz	В	0	×	×	0	
2	17	2nd damping filter setup	0 to 1500	0	0.1 Hz	В	0	×	×	0	
2	18	3rd damping frequency	0 to 3000	0	0.1 Hz	В	0	×	×	0	
2	19	3rd damping filter setup	0 to 1500	0	0.1 Hz	В	0	×	×	0	
2	20	4th damping frequency	0 to 3000	0	0.1 Hz	В	0	×	×	0	
2	21	4th damping filter setup	0 to 1500	0	0.1 Hz	В	0	×	×	0	
2	22	Positional command smoothing fil- ter	0 to 10000	Sizes A, B: 92 Sizes C, D: 139 (92) <sup>(*1)</sup>	0.1 ms	В	0	0	×	0	<u>"5.7.3"</u> OI_O
2	23	Positional command FIR filter	0 to 10000	10	0.1 ms	В	0	×	×	0	<u>"5.7.3"</u>
2	24	5th notch frequency	10 to 5000	5000	Hz	В	0	0	0	0	<u>"5.3.3"</u>
2	25	5th notch width selection	0 to 20	2	_	В	0	0	0	0	
2	26	5th notch depth selection	0 to 99	0	_	В	0	0	0	0	
2	27	1st damping width setting	0 to 1000	0	_	В	0	×	×	0	<u>"5.5.3"</u>
2	28	2nd damping width setting	0 to 1000	0	_	В	0	×	×	0	
2	29	3rd damping width setting	0 to 1000	0	_	В	0	×	×	0	
2	30	4th damping width setting	0 to 1000	0	_	В	0	×	×	0	
2	31	Manufacturer use	_	0	_	_	-	-	-	-	-
			!					-	•		
2	37	Manufacturer use	_	0	_	_	-	-	-	-	
2	38	Filter function switching	-32768 to 32767	3	—	В	0	0	0	0	—
		bit 0: Custom notch filter	-						•		01_0
		bit 1: Tuning filter 2									<u>"4.1.1.4"</u>
											<u>"4.1.2.4"</u>
											<u>"4.1.3.4"</u> OI_O

Paramete	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute			ed co nod		Reference
Class	No.						Р	s	Т	F	
2	39	Custom notch compensation coefficient	0 to 1000	0	0.01	В	0	0	0	0	OI_O <u>"5.3.3"</u>
2	40	Custom notch compensation fre- quency 1	0 to 10000	0	0.1 Hz	В	0	0	0	0	
2	41	Custom notch compensation fre- quency 2	0 to 10000	0	0.1 Hz	В	0	0	0	0	
2	42	Custom notch frequency	10 to 5000	5000	Hz	В	0	0	0	0	
2	43	Custom notch width	0 to 20	2	-	В	0	0	0	0	
2	44	Custom notch depth	0 to 99	0	-	В	0	0	0	0	
2	45	Function expansion setup 10	-2147483648 to 2147483647	61	-	В	0	0	0	0	_
		bit 1 to 0: Two-degree-of-freedom	o control function se	etting							<u>"4.1.1.4"</u> <u>"4.1.2.4"</u> <u>"4.1.3.4"</u> OI_O
		bit 2: Friction torque compensatio	n parameter select	lion							<u>"7.5"</u>
		bit 3: Load fluctuation suppression	n function automati	ic calculation							<u>"4.1.1.4'</u> <u>"4.1.2.4'</u> <u>"4.1.3.4'</u> <u>"4.6.3"</u> <u>"4.7.3"</u>
		<ul> <li>bit 5 to 4: Stiffness setting resolut</li> </ul>	ion, individual FB/F	F setting switching							<u>"4.1.1.4"</u> "4.1.2.4"
											<u>"4.1.2.4</u> "4.1.3.4
2	46	Tuning filter 2	0 to 20000	Size A: 110 Size B: 120 Sizes C, D: 170 (120) (*1)	0.01 ms	В	0	×	×	0	01_0
2	50	Detection start vibration count	0 to 100	3	_	В	0	×	×	×	"5.5.3"
2	51	Detected vibration amplitude	0 to 134217728	0	Command unit	В	0	×	×	×	
2	52	Torque command additional value 2	-1000 to 1000	0	0.1 %	В	0	0	×	0	<u>"4.5.3"</u>
2	53	Positive direction torque compensa- tion value 2	-1000 to 1000	0	0.1 %	В	0	×	×	0	
2	54	Negative direction torque compen- sation value 2	-1000 to 1000	0	0.1 %	В	0	×	×	0	
2	61	Target settling time	0 to 32767	0	ms	A	0	0	0	0	<u>"7.5"</u>
2	62	Settling time count condition	0 to 1	0	-	А	0	0	0	0	
2	63	Allowable overshoot amount	0 to 500	100	%	A	0	0	0	0	
2	64	Tuning amount of movement	0 to 2147483647	0	Command unit	A	0	0	0	0	
2	65	Tuning max speed	0 to 20000	0	r/min	A	0	0	0	0	
2	66	Tuning acceleration and decelera- tion time	0 to 5000	0	ms	A	0	0	0	0	
2	67	Tuning wait time	0 to 10000	2000	ms	A	0	0	0	0	
2	68	Tuning operating range upper limit	0 to 1073741823	8388608	Command unit	A	0	0	0	0	
2	69	Tuning operating range lower limit	-1073741824 to 0	-8388608	Command unit	A	0	0	0	0	
2	70	Tuning overspeed level setting	0 to 20000	0	r/min	A	0	0	0	0	
2	71	Tuning torque limit	0 to 500	0	%	A	0	0	0	0	
2	72	Tuning start RTAT machine stiffness setting	0 to 44	8	_	A	0	0	0	0	
2	73	Tuning stability margin	0 to 100	80	%	A	0	0	0	0	

Paramete	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute			ed co node		Reference		
Class	No.						Ρ	S	Т	F			
2	74	Tuning auto tuning application se- lection	-32768 to 32767	0	_	A	0	0	0	0	<u>"4.1.1.4"</u> <u>"4.1.2.4"</u> <u>"4.1.3.4"</u>		
2	75	Tuning step selection	-32768 to 32767	3	_	A	0	0	0	0	_		
		• bit 0: Advance operation			1						<u>"7.5"</u>		
		bit 1: Homing operation											
2	76	Tuning target function selection	-32768 to 32767	1009	_	A	0	0	0	0	_		
		bit 0: Inertia ratio									"7.5"		
		bit 1: Unbalanced load compensation	tion (default disabl	ed)									
		bit 2: Dynamic friction compensat	ion (default disable	ed)									
		bit 3: Viscous friction compensation (default disabled)											
		• bit 4: RTAT machine stiffness sett	ing (position and s	peed gains, speed integrat	ion time const	ant, torque fi	lter)						
		• bit 5: RTAT feedforward control se	ection stiffness sett	ing (smoothing filter time c	onstant)								
		bit 6: Notch filter											
		• bit 7: 1st damping filter											
		• bit 8: 2nd damping filter											
		• bit 9: Load fluctuation control fund	tion										
2	77	Tuning start position	-1073741824 to 1073741823	0	Command unit	A	0	0	0	0	<u>"7.5"</u>		
2	78	Tuning vibration automatic suppres- sion effective level	0 to 100	15	%	A	0	0	0	0			
2	79	Tuning JOG test run command speed	0 to 500	60	r/min	A	0	0	0	0			
2	80	Tuning JOG test run acceleration and deceleration time	0 to 5000	50	ms	A	0	0	0	0			

\*1 Values in parentheses are initial values for models with an instantaneous maximum current (peak value) of less than 24 A.

# 7.1.5 Class 3: Velocity/Torque Control/Full-closed Control

Paramet	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute		elate trol r			Reference
Class	No.						Р	s	Т	F	
3	04	Manufacturer use	_	0	_	_	-	-	-	-	_
				1							
3	07	Manufacturer use	-	0	_	_	-	-	-	-	
3	12	Acceleration time setup	0 to 10000	0	ms/(1000 r/min)	В	×	0	×	×	<u>"5.8.3"</u>
3	13	Deceleration time setup	0 to 10000	0	ms/(1000 r/min)	В	×	0	×	×	
3	14	Sigmoid acceleration / decel- eration time setup	0 to 1000	0	ms	В	×	0	×	×	
3	17	Selection of speed limit	0 to 1	0	_	В	×	×	0	×	01_0
3	21	Velocity limit value 1	0 to 20000	0	r/min	В	×	×	0	×	
3	22	Velocity limit value 2	0 to 20000	0	r/min	В	×	×	0	×	
3	23	External scale selection	0 to 2	0	—	R	0	0	0	0	01_0
3	24	Numerator of external scale division	0 to 2 <sup>27</sup>	0	_	R	×	×	×	0	01_0
3	25	Denominator of external scale division	1 to 2 <sup>27</sup>	10000	_	R	×	×	×	0	
3	26	Reversal of direction of exter- nal scale	0 to 3	0	_	R	0	0	0	0	01_0
3	27	External scale Z phase dis- connection detection disable	0 to 1	0	_	R	0	0	0	0	01_0
3	28	Hybrid deviation excess setup	1 to 2 <sup>27</sup>	16000	Command unit	С	×	×	×	0	01_0
3	29	Hybrid deviation clear setup	0 to 100	0	Rotation	С	×	×	×	0	
3	33	Analog input gain <sup>(*1)</sup>	0 to 30000	0	Command unit/mV	В	0	×	×	0	01_0
3	34	Analog input polarity (*1)	0 to 1	0	_	В	0	×	×	0	
3	35	Analog input integration time constant <sup>(*1)</sup>	0 to 100000	0	0.01 ms	В	0	×	×	0	
3	36	Analog input integration limit (*1)	0 to 2147483647	0	Command unit	В	0	×	×	0	
3	42	Sensor feedback control func- tion extended setup (*1)	-32768 to 32767	0	_	В	0	×	×	×	_
		bit 0: Displacement control	unction position cc	mmand latch switching	1	1	I	I	<u> </u>	1	OI_O TR_CS

 $\bigcirc:$  Enabled X: Disabled —: N/A

\*1 Cannot be used with the standard type or multi-function type. Do not change the factory default value.

# 7.1.6 Class 4: I/O Monitor Settings

_		_	-				1				oled —: N/A
Paramete	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute			ed co nod		Reference
Class	No.						Ρ	S	Т	F	
4	00	SI1 input selection	0 to 00FFFFFFh	3289650	_	С	0	0	0	0	01_0
4	01	SI2 input selection	0 to 00FFFFFFh	8487297	_	С	0	0	0	0	
4	02	SI3 input selection	0 to 00FFFFFFh	8553090	_	С	0	0	0	0	
4	03	SI4 input selection	0 to 00FFFFFFh	3026478	_	С	0	0	0	0	
4	04	SI5 input selection	0 to 00FFFFFFh	2236962	—	С	0	0	0	0	
4	05	SI6 input selection	0 to 00FFFFFFh	2171169	_	С	0	0	0	0	
4	06	SI7 input selection	0 to 00FFFFFFh	2829099	—	С	0	0	0	0	
4	07	SI8 input selection	0 to 00FFFFFFh	3223857	—	С	0	0	0	0	
4	10	SO1 output selection	0 to 00FFFFFFh	197379	—	С	0	0	0	0	01_0
4	11	SO2 output selection	0 to 00FFFFFFh	1052688	-	С	0	0	0	0	
4	12	SO3 output selection	0 to 00FFFFFFh	65793	-	С	0	0	0	0	
4	16	Type of analog monitor 1	0 to 35	0	-	А	0	0	0	0	01_0
4	17	Analog monitor 1 output gain	0 to 214748364	0	_	А	0	0	0	0	
4	18	Type of analog monitor 2	0 to 35	0	_	А	0	0	0	0	
4	19	Analog monitor 2 output gain	0 to 214748364	0	_	А	0	0	0	0	
4	21	Analog monitor output setup	0 to 2	0	_	А	0	0	0	0	
4	22	Analog input (AIN) offset setting <sup>(*1)</sup>	-26666 to 26666	0	0.375 mV	В	0	0	0	0	01_0
4	23	Analog input (AIN) filter setting <sup>(*1)</sup>	0 to 6400	0	0.01 ms	В	0	0	0	0	TR_CS
4	24	Analog input (AIN) excessive set- ting <sup>(*1)</sup>	0 to 100	0	0.1 V	В	0	0	0	0	
4	31	Positioning complete (In-position) range	0 to 2097152	8400	Command unit	A	0	×	×	0	<u>"7.5"</u> OI_O
4	32	Positioning complete (In-position) output setup	0 to 10	0	_	A	0	×	×	0	01_0
4	33	INP hold time	0 to 30000	0	ms	А	0	×	×	0	
4	34	Zero-speed	10 to 20000	50	r/min	А	0	0	0	0	0I_0
4	35	Speed coincidence range	10 to 20000	50	r/min	А	×	0	0	×	0I_0
4	36	At-speed (Speed arrival)	10 to 20000	1000	r/min	А	×	0	0	×	0I_0
4	37	Mechanical brake action at stalling setup	0 to 10000	0	ms	В	0	0	0	0	01_0
4	38	Mechanical brake action at running setup	0 to 32000	0	ms	В	0	0	0	0	01_0
4	39	Brake release speed setup	30 to 3000	30	r/min	В	0	0	0	0	01_0
4	40	Selection of alarm output 1	0 to 32767	0	_	A	0	0	0	0	01_0
4	41	Selection of alarm output 2	0 to 32767	0	_	A	0	0	0	0	
4	42	Positioning complete (In-position) range 2	0 to 2097152	8400	Command unit	A	0	×	×	0	01_0
4	44	Position comparison output pulse width setting	0 to 32767	0	0.1 ms	R	0	0	0	0	01_0
4	45	Position comparison output polarity selection	0 to 7	0	_	R	0	0	0	0	_
		<ul> <li>bit 0: Polarity for SO1 (general-put)</li> </ul>	irpose output) or O	CMP1 (encoder/position co	omparison out	put terminal)					01_0
		<ul> <li>bit 1: Polarity for SO2 (general-put)</li> </ul>	irpose output) or O	CMP2 (encoder/position co	omparison out	put terminal)					
		<ul> <li>bit 2: Polarity for SO3 (general-put)</li> </ul>	irpose output) or O	CMP3 (encoder/position co	omparison out	put terminal)					
4	47	Pulse output selection	0 to 1	0	_	R	0	0	0	0	01_0
4	48	Position comparison value 1	-2147483648 to 2147483647	0	Command unit	A	0	0	0	0	01_0

 $\bigcirc:$  Enabled X: Disabled —: N/A

Paramet	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute		elate trol r			Reference
Class	No.						Ρ	S	Т	F	
4	49	Position comparison value 2	-2147483648 to 2147483647	0	Command unit	A	0	0	0	0	01_0
4	50	Position comparison value 3	-2147483648 to 2147483647	0	Command unit	A	0	0	0	0	
4	51	Position comparison value 4	-2147483648 to 2147483647	0	Command unit	A	0	0	0	0	
4	52	Position comparison value 5	-2147483648 to 2147483647	0	Command unit	A	0	0	0	0	
4	53	Position comparison value 6	-2147483648 to 2147483647	0	Command unit	A	0	0	0	0	
4	54	Position comparison value 7	-2147483648 to 2147483647	0	Command unit	A	0	0	0	0	
4	55	Position comparison value 8	-2147483648 to 2147483647	0	Command unit	A	0	0	0	0	
4	56	Position comparison output delay compensation amount	-32768 to 32767	0	0.1 µs	В	0	0	0	0	
4	57	Position comparison output assign- ment setting	-2147483648 to 2147483647	0	-	R	0	0	0	0	_
		• bit 3 to 0: Position comparison 1	•		•	•					01_0
		• 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								
4	63	Manufacturer use	_	5242884	-	_	-	-	-	-	_
4	64	Manufacturer use	_	64	-	-	-	-	-	-	_
4	65	Analog input internal offset setting	-32768 to 32767	0	mV	А	0	0	0	0	01_0
4	66	Analog input deviation limit setting	0 to 65535	0	mV	А	0	0	0	0	TR_CS
4	67	Analog input voltage dead zone set- ting	0 to 65535	0	mV	В	0	0	0	0	

\*1 Cannot be used with the standard type or multi-function type. Do not change the factory default value.

# 7.1.7 Class 5: Enhancing Settings

						◯: Enal	olec	ч×	: D	isab	oled —: N/A
Paramete	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute		elate trol i			Reference
Class	No.						Ρ	S	Т	F	
5	03	Denominator of pulse out- put division	0 to 134217728	0	_	R	0	0	0	0	01_0
5	04	Over-travel inhibit input setup	0 to 2	1	_	С	0	0	0	0	OI_O TR_CS
5	05	Sequence at over-travel in- hibit	0 to 2	0	_	С	0	0	0	0	01_0
5	06	Sequence at servo-off	0 to 9	0	_	В	0	0	0	0	01_0
5	07	Sequence upon main pow- er off	0 to 9	0	_	В	0	0	0	0	01_0
5	08	L/V trip selection upon main power off	0 to 3	1	_	В	0	0	0	0	-
		• bit 0: Operation selection	with main power s	supply OFF							01_0
		• bit 1: Main power off war	ning condition dete	ction time							
5	09	Detection time of main power off	20 to 2000	70	ms	С	0	0	0	0	01_0
5	10	Sequence at alarm	0 to 7	0	_	В	0	0	0	0	01_0
5	11	Torque setup for emergen- cy stop	0 to 500	0	%	В	0	0	0	0	01_0
5	12	Motor overload level setup	0 to 500	0	%	A	0	0	0	0	01_0
5	13	Over-speed level setup	0 to 20000	0	r/min	В	0	0	0	0	0I_0
5	14	Motor working range setup	0 to 1000	10	0.1 rotation	A	0	×	×	0	0I_0
5	15	Control input signal reading setup	0 to 3	0	_	С	0	0	0	0	01_0
5	20	Position setup unit select	0 to 1	0	-	С	0	×	×	0	01_0
5	21	Selection of torque limit	0 to 4	1	_	В	0	0	×	0	OI_O TR_CS
5	22	2nd torque limit	0 to 500	500 (*1)	%	В	0	0	×	0	01_0
5	23	Torque limit switching set- up 1	0 to 4000	0	ms/100 %	В	0	0	×	0	
5	24	Torque limit switching set- up 2	0 to 4000	0	ms/100 %	В	0	0	×	0	
5	25	Positive direction torque limit	0 to 500	500 (*1)	%	В	0	0	×	0	
5	26	Negative direction torque limit	0 to 500	500 (*1)	%	В	0	0	×	0	
5	29	Manufacturer use	_	2	-	-	-	-	-	-	_
5	31	USB axis address	0 to 127	1	_	С	0	0	0	0	PT_OM
5	33	Pulse regenerative output limit setup	0 to 1	0	_	С	0	0	0	0	01_0
5	34	Manufacturer use	_	4	_	-	-	-	-	-	_
5	36	Manufacturer use	—	0	_	_	-	-	-	-	_
5	45	Quadrant glitch positive-di- rection compensation value	-1000 to 1000	0	0.1 %	В	0	×	×	0	<u>"4.9.3"</u>
5	46	Quadrant glitch negative- direction compensation val- ue	-1000 to 1000	0	0.1 %	В	0	×	×	0	
5	47	Quadrant glitch compensa- tion delay time	0 to 1000	0	ms	В	0	×	×	0	
5	48	Quadrant glitch compensa- tion filter setting L	0 to 6400	0	0.01 ms	В	0	×	×	0	
5	49	Quadrant glitch compensa- tion filter setting H	0 to 10000	0	0.1 ms	В	0	×	×	0	

Paramet	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute		elate trol r			Reference
Class	No.						Р	S	Т	F	
5	50	Manufacturer use	_	0	_	_	-	-	-	—	_
		1		i	1						
5	55	Manufacturer use	_	0	_	_	-	-	-	-	
5	56	Slow stop deceleration time setting	0 to 10000	0	ms/(1000 r/min)	В	0	0	0	×	OI_0
5	57	Slow stop S-shape acceler- ation and deceleration set- ting	0 to 1000	0	ms	В	0	0	0	×	
5	66	Deterioration diagnosis convergence judgment time	0 to 10000	0	0.1 s	A	0	0	0	0	01_0
5	67	Deterioration diagnosis in- ertia ratio upper limit	0 to 10000	0	%	A	0	0	0	0	
5	68	Deterioration diagnosis in- ertia ratio lower limit	0 to 10000	0	%	A	0	0	0	0	
5	69	Deterioration diagnosis un- balanced load upper limit	-1000 to 1000	0	0.1 %	A	0	0	0	0	
5	70	Deterioration diagnosis un- balanced load lower limit	-1000 to 1000	0	0.1 %	A	0	0	0	0	
5	71	Deterioration diagnosis dy- namic friction upper limit	-1000 to 1000	0	0.1 %	A	0	0	0	0	
5	72	Deterioration diagnosis dy- namic friction lower limit	-1000 to 1000	0	0.1 %	A	0	0	0	0	
5	73	Deterioration diagnosis vis- cous friction upper limit	0 to 10000	0	0.1%/(10000 r/min)	A	0	0	0	0	
5	74	Deterioration diagnosis vis- cous friction lower limit	0 to 10000	0	0.1%/(10000 r/min)	A	0	0	0	0	
5	75	Deterioration diagnosis ve- locity setting	-20000 to 20000	0	r/min	A	0	0	0	0	
5	76	Deterioration diagnosis tor- que average time	0 to 10000	0	ms	А	0	0	0	0	
5	77	Deterioration diagnosis tor- que upper limit	-1000 to 1000	0	0.1 %	A	0	0	0	0	
5	78	Deterioration diagnosis tor- que lower limit	-1000 to 1000	0	0.1 %	А	0	0	0	0	
5	95	Manufacturer use	_	0	0	_	-	-	-	-	_
5	110	Driver derating factor	0 to 100	100	%	А	0	0	0	0	01_0
5	112	Manufacturer use	-	0	_	_	-	-	-	-	_

\*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".

# 7.1.8 Class 6: Special Settings

	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute		elate trol i			Reference
Class	No.	-					Р	S	Т	F	
6	02	Speed deviation excess setup	0 to 20000	0	r/min	A	0	×	×	×	01_0
6	03	Manufacturer use	_	0	_	-	-	-	-	-	_
6	05	Position 3rd gain valid time	0 to 10000	0	0.1 ms	В	0	×	×	0	<u>"4.3.3"</u>
6	06	Position 3rd gain scale fac- tor	50 to 1000	100	%	В	0	×	×	0	
6	07	Torque command addition- al value	-100 to 100	0	%	В	0	0	×	0	<u>"4.5.3"</u>
6	08	Positive direction torque compensation value	-100 to 100	0	%	В	0	×	×	0	
6	09	Negative direction torque compensation value	-100 to 100	0	%	В	0	×	×	0	
6	10	Function expansion setup	-32768 to 32767	16	_	В	0	0	0	0	_
		bit 1: Load fluctuation cor	ntrol function								<u>"4.6.3"</u>
		• bit 2: Load fluctuation sta	bilization setting								<u>"4.7.3"</u>
		• bit 4: Current response in	nprovement								<u>"7.5"</u>
		• bit 10: Fall prevention fun	ction during an ala	arm							01_0
		• bit 11: Encoder overheat	error protection de	tection							01_0
		bit 14: Load fluctuation su	uppression function	n automatic tuning							<u>"4.1.1.4"</u>
											<u>"4.1.2.4"</u>
											<u>"4.1.3.4"</u>
											<u>"4.6.3"</u> "4.7.3"
		bit 15: Slow stop function									<u>"4.6.3"</u> <u>"4.7.3"</u> OI_O
6	11	bit 15: Slow stop function Current loop gain response setup	10 to 300	100	%	В	0	0	0	0	<u>"4.7.3"</u>
6	11	Current loop gain response		100 200	% ms	B	0	0	0	0	<u>"4.7.3"</u> OI_O
-		Current loop gain response setup Emergency stop time at	10 to 300								<u>"4.7.3"</u> Ol_O <u>"4.8.3"</u>
6	14	Current loop gain response setup Emergency stop time at alarm	10 to 300 0 to 1000	200	ms	В	0	0	0	0	<u>""4.7.3"</u> OI_O <u>""4.8.3"</u> OI_O
6	14 15	Current loop gain response setup Emergency stop time at alarm 2nd overspeed level setting	10 to 300 0 to 1000 0 to 20000	200	ms r/min	B	0	0	0	0	"4.7.3"           Ol_O           "4.8.3"           Ol_O           Ol_O           Ol_O
6 6 6	14 15 18	Current loop gain response setup Emergency stop time at alarm 2nd overspeed level setting Power-up wait time	10 to 300 0 to 1000 0 to 20000	200 0 0	ms r/min 0.1 s	B	0	0	0	0	"4.7.3"           Ol_O           "4.8.3"           Ol_O           Ol_O           Ol_O
6 6 6	14 15 18	Current loop gain response setup Emergency stop time at alarm 2nd overspeed level setting Power-up wait time	10 to 300 0 to 1000 0 to 20000	200 0 0 0	ms r/min 0.1 s	B	0	0	0	0	"4.7.3"           Ol_O           "4.8.3"           Ol_O           Ol_O           Ol_O
6 6 6 6	14 15 18 19	Current loop gain response setup Emergency stop time at alarm 2nd overspeed level setting Power-up wait time Manufacturer use	10 to 300 0 to 1000 0 to 20000	200 0 0 0	ms r/min 0.1 s —	B	0	0	0	000	<u>"4.7.3"</u> Ol_O <u>"4.8.3"</u> Ol_O Ol_O Ol_O
6 6 6 6	14 15 18 19 21	Current loop gain response setup Emergency stop time at alarm 2nd overspeed level setting Power-up wait time Manufacturer use Manufacturer use AB phase external scale pulse outputting method	10 to 300 0 to 1000 0 to 20000 0 to 100 - -	200 0 0 0 i 0	ms r/min 0.1 s —	B B R -	0 0 -	0	0	000	<u>"4.7.3"</u> Ol_O <u>"4.8.3"</u> Ol_O Ol_O Ol_O Ol_O - Ol_O Ol_O
6 6 6 6 6	14 15 18 19 21 22	Current loop gain response setup Emergency stop time at alarm 2nd overspeed level setting Power-up wait time Manufacturer use Manufacturer use AB phase external scale pulse outputting method selection Load change compensa-	10 to 300 0 to 1000 0 to 20000 0 to 100 - 0 to 1 0 to 1	200 0 0 0 i 0 0 0	ms r/min 0.1 s	B B R -	0 0 0 -	0 0 - - ×	0 0 - ×	000-	<u>"4.7.3"</u> Ol_O <u>"4.8.3"</u> Ol_O         Ol_O
6 6 6 6 6 6	14       15       18       19       21       22       23	Current loop gain response setup Emergency stop time at alarm 2nd overspeed level setting Power-up wait time Manufacturer use Manufacturer use AB phase external scale pulse outputting method selection Load change compensa- tion gain Load change compensa-	10 to 300 0 to 1000 0 to 20000 0 to 100 - 0 to 1 -100 to 100	200 0 0 0 : 0 0 0 0	ms	B B R  R R B	0 0 - - ×	0 0 - ×	0 0 - × ×	0001	<u>"4.7.3"</u> Ol_O <u>"4.8.3"</u> Ol_O Ol_O Ol_O Ol_O Ol_O Ol_O
6 6 6 6 6 6 6	14           15           18           19           21           22           23           24	Current loop gain response setup Emergency stop time at alarm 2nd overspeed level setting Power-up wait time Manufacturer use Manufacturer use AB phase external scale pulse outputting method selection Load change compensa- tion gain Load change compensa- tion filter	10 to 300 0 to 1000 0 to 20000 0 to 100 - 0 to 1 -100 to 100 10 to 2500	200 0 0 0 1 0 0 0 53	ms	B B R  R B B B	0 0 - - ×	0 0 - ×	0 0 - × ×	000-	<u>"4.7.3"</u> Ol_O <u>"4.8.3"</u> Ol_O Ol_O Ol_O Ol_O - Ol_O Ol_O <u>-</u>
6 6 6 6 6 6 6 6 6	14 15 18 19 21 22 22 23 23 24 26	Current loop gain response setup Emergency stop time at alarm 2nd overspeed level setting Power-up wait time Manufacturer use Manufacturer use AB phase external scale pulse outputting method selection Load change compensa- tion gain Load change compensa- tion filter Manufacturer use	10 to 300 0 to 1000 0 to 20000 0 to 100 	200 0 0 0 : 0 0 0 53 0	ms r/min 0.1 s % 0.01 ms	B B R - - R B B B -	0 0 - - × 0 0 0 -	0 0 - × 0 0	0 0 - × × ×	000-	<u>"4.7.3"</u> Ol_O <u>"4.8.3"</u> Ol_O Ol_O Ol_O Ol_O - Ol_O - Ol_O <u>0l_O</u> -
6 6 6 6 6 6 6 6 6	14 15 18 19 21 22 22 23 23 24 26	Current loop gain response setup Emergency stop time at alarm 2nd overspeed level setting Power-up wait time Manufacturer use Manufacturer use AB phase external scale pulse outputting method selection Load change compensa- tion gain Load change compensa- tion filter Manufacturer use Warning latch state setup	10 to 300 0 to 1000 0 to 20000 0 to 100 	200 0 0 0 : 0 0 0 53 0	ms r/min 0.1 s % 0.01 ms	B B R - - R B B B -	0 0 - - × 0 0 0 -	0 0 - × 0 0	0 0 - × × ×	000-	<u>"4.7.3"</u> Ol_O <u>"4.8.3"</u> Ol_O Ol_O Ol_O Ol_O - Ol_O - Ol_O <u>-</u> Ol_O - -
6 6 6 6 6 6 6 6 6	14 15 18 19 21 22 22 23 23 24 26	Current loop gain response setup Emergency stop time at alarm 2nd overspeed level setting Power-up wait time Manufacturer use Manufacturer use AB phase external scale pulse outputting method selection Load change compensa- tion gain Load change compensa- tion filter Manufacturer use Warning latch state setup • bit 0: Expanded warnings	10 to 300 0 to 1000 0 to 20000 0 to 100 	200 0 0 0 : 0 0 0 53 0	ms r/min 0.1 s % 0.01 ms	B B R - - R B B B -	0 0 - - × 0 0 0 -	0 0 - × 0 0	0 0 - × × ×	000-	<u>"4.7.3"</u> OI_O <u>"4.8.3"</u> OI_O OI_O OI_O OI_O - OI_O - OI_O - - -

Paramete	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute			ed co nod		Reference
Class	No.						Р	S	Т	F	
6	32	Real time auto tuning cus- tom setup	-32768 to 32767	0	-	В	0	0	0	0	_
		• bit 1 to 0: Load character	istics estimation		1		1	1	1		<u>"4.1.1.4</u> "
		• bit 3 to 2: Inertia Ratio U	odate								<u>"4.1.2.4</u> "
		• bit 6 to 4: Torque comper	nsation								<u>"4.1.3.4</u> "
		bit 7: Stiffness Setup									
		bit 8: Fixed Parameter Se	etup								
		<ul> <li>bit 10 to 9: Gain Switchin</li> </ul>	g Setup								
		bit 11: Torque compensat		ng							
		<ul> <li>bit 15 to 12: Individual to</li> </ul>		-							
6	34	Hybrid vibration suppres- sion gain	0 to 30000	0	0.1 s <sup>-1</sup>	В	×	×	×	0	<u>"5.9.3"</u>
6	35	Hybrid vibration suppres-	0 to 32000	10	0.01 ms	В	×	×	×	0	
6	36	Dynamic brake operation input setup	0 to 1	0	_	R	0	0	0	0	01_0
6	37	Oscillation detecting level	0 to 1000	0	0.1 %	В	0	0	0	0	01_0
6	38	Warning mask setup	-32768 to 32767	4	_	C	0	0	0	0	
6	39	Warning mask setup 2	-32768 to 32767	0	_	с С	0	0	0	0	
6	41	1st damping depth	0 to 1000	0	_	B	0	×	×	0	"5.5.3"
6	42	2-stage torque filter time	0 to 2500	0	0.01 ms	B	0	0	0	0	<u>"5.2.3"</u>
6	42	2-stage torque filter attenu-	0 to 1000	0	0.01 ms	B	0	0	0	0	
6	40	ation term Function expansion setup	-32768 to 32767	1		R	0	0	0	0	
0	41	2	-3270810 32707	1		K					_
		<ul> <li>bit 0: Two-degree-of-free</li> </ul>	dom control mode				•				<u>"7.5"</u> OI_O
		bit 2: Encoder communic	ation error/warning	judgment setup							01_0
		• bit 3: Two-degree-of-free	dom control real-ti	me auto tuning selection							<u>"7.5"</u> Ol_O
		<ul> <li>bit 14: Quadrant glitch co</li> </ul>	mpensation function	on							<u>"4.9.3"</u>
6	48	Tuning filter	0 to 2000	Size A: 11 Size B: 12	0.1 ms	В	0	0	×	0	0I_0
				Sizes C, D: 17 (12) <sup>(*1)</sup>							
6	49	Command response/tuning filter attenuation term	0 to 99	15	-	В	0	×	×	0	<u>"5.7.3"</u> OI_O
6	50	Viscous friction compensat- ing gain	0 to 10000	0	0.1 %/ (10000 r/min)	В	0	0	×	0	01_0
6	51	Wait time for emergency stop	0 to 10000	0	ms	В	0	0	0	0	01_0
6	52	Manufacturer use	_	0	_	_	-	-	-	_	_
				l							
6	54	Manufacturer use	_	0	_	_	-	-	-	-	
6	57	Torque saturation error pro- tection detection time	0 to 5000	0	ms	В	0	0	×	0	01_0
6	58	Manufacturer use	_	0	-	_	-	-	-	-	_
6	59	Manufacturer use	_	0	-	_	-	-	-	-	_
6	60	2nd damping depth	0 to 1000	0	_	В	0	×	×	0	<u>"5.5.3"</u>
6	61	1st resonance frequency	0 to 3000	0	0.1 Hz	В	0	×	×	×	"5.6.3"
6	62	1st resonance attenuation ratio	0 to 1000	0	-	В	0	×	×	×	
6	63	1st anti-resonance fre-	0 to 3000	0	0.1 Hz	В	0	×	×	×	

Class	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute			ed co nod		Reference
	No.	-					Р	S	Т	F	
6	64	1st anti-resonance attenua- tion ratio	0 to 1000	0	_	В	0	×	×	×	<u>"5.6.3"</u>
6	65	1st response frequency	0 to 3000	0	0.1 Hz	В	0	×	×	×	
6	66	2nd resonance frequency	0 to 3000	0	0.1 Hz	В	0	×	×	×	
6	67	2nd resonance attenuation ratio	0 to 1000	0	_	В	0	×	×	×	
6	68	2nd anti-resonance fre- quency	0 to 3000	0	0.1 Hz	В	0	×	×	×	
6	69	2nd anti-resonance attenu- ation ratio	0 to 1000	0	_	В	0	×	×	×	
6	70	2nd response frequency	0 to 3000	0	0.1 Hz	В	0	×	×	×	
6	71	3rd damping depth	0 to 1000	0	_	В	0	×	×	0	<u>"5.5.3"</u>
6	72	4th damping depth	0 to 1000	0	_	В	0	×	×	0	
6	73	Load estimation filter	0 to 2500	0	0.01 ms	В	0	0	×	0	<u>"4.6.3"</u>
6	74	Torque compensation fre- quency 1	0 to 5000	0	0.1 Hz	В	0	0	×	0	<u>"4.7.3"</u>
6	75	Torque compensation fre- quency 2	0 to 5000	0	0.1 Hz	В	0	0	×	0	
6	76	Load estimation count	0 to 8	0	_	В	0	0	×	0	
6	85	Retracting operation condi- tion setting	-32768 to 32767	0	_	С	0	0	0	0	_
		• bits 0 to 3: Retracting op	eration initialization	conditions (I/O)							01_0
		• bits 7 to 4: Retracting op	eration initialization	conditions (communicatio	n)						
		• bits 9 to 8: Judgment cor	dition for stopping	retracting operation							
6	86	Retracting operation alarm setting	-32768 to 32767	0	_	С	0	0	0	0	_
		• bit 0: Err85.0.0 "Retractir	ng operation comple	etion (I/O)" /Err87.1.0 "Retr	acting operation comp	pletion (I/O)"					01_0
		• bit 1: Err85.1.0 "Retractir nication)"	ng operation comple	etion (communication)" /Er	r87.2.0 "Retracting op	eration compl	etior	n (co	mm	u-	
		• bit 2: Err85.2.0 "Retractir	g operation error"	/Err87.3.  #Retracting op	eration error"						
		<ul> <li>bit 15: Retracting operati</li> </ul>	on-related alarm sv	witching							
6	87	<ul> <li>bit 15: Retracting operati</li> <li>Manufacturer use</li> </ul>	on-related alarm sv —	vitching 0	-	-	-	-	-	_	_
6	87 88		on-related alarm sv — 0 to 65534	-		- C	- 0	-	-	-	– OI_O TR_CS
-		Manufacturer use Absolute encoder multi-	_	0	%		_				_
6	88	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de-	— 0 to 65534	0			0	0	0	0	TR_CS
6	88 95	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re-	- 0 to 65534	0		A	0	0	0	0	TR_CS
6 6 6	88 95 96	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re- lease level Function expansion setup	 0 to 65534 0 to 114 0 to 114 -2147483648 to 2147483647	0 0 0 0 1024		A	0	0 0	0 0	0 0 0	TR_CS
6 6 6	88 95 96	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re- lease level Function expansion setup 3		0 0 0 0 1024		A	0	0 0	0 0	0 0 0	TR_CS OI_O
6 6 6	88 95 96	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re- lease level Function expansion setup 3 • bit 0: Quadrant glitch cor		0 0 0 0 1024 ear		A	0	0 0	0 0	0 0 0	TR_CS OI_O 
6 6 6	88 95 96	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re- lease level Function expansion setup 3 • bit 0: Quadrant glitch cor • bit 1: Deterioration Diagn		0 0 0 0 1024 ear		A	0	0 0	0 0	0 0 0	TR_CS OI_O - - - 0I_O OI_O
6 6 6	88 95 96	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re- lease level Function expansion setup 3 • bit 0: Quadrant glitch cor • bit 1: Deterioration Diagn • bit 2: Motor movable range	- 0 to 65534 0 to 114 0 to 114 -2147483648 to 2147483647 npensation HPF cle osis Warning Func ge error protection	0 0 0 1024 ear tion expansion		A	0	0 0	0 0	0 0 0	TR_CS OI_O - - - 0I_O OI_O
6 6 6	88 95 96	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re- lease level Function expansion setup 3 • bit 0: Quadrant glitch cor • bit 1: Deterioration Diagn • bit 2: Motor movable rang • bit 6: Manufacturer use	O to 65534     O to 114     O to 114     O to 114     -2147483648 to     2147483647     npensation HPF cle osis Warning Func ge error protection o on output function s	0 0 0 1024 ear tion expansion		A	0	0 0	0 0	0 0 0	TR_CS OI_O - - - - - 0I_O OI_O OI_O -
6 6 6	88 95 96	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re- lease level Function expansion setup 3 • bit 0: Quadrant glitch cor • bit 1: Deterioration Diagn • bit 2: Motor movable rang • bit 6: Manufacturer use • bit 10: Position comparis	O to 65534     O to 114     O to 114     O to 114     -2147483648 to     2147483647     npensation HPF cle osis Warning Func ge error protection o on output function s	0 0 0 1024 ear tion expansion		A	0	0 0	0 0	0 0 0	TR_CS OI_O   OI_O OI_O OI_O  OI_O OI_O
6 6 6	88 95 96 97	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re- lease level Function expansion setup 3 • bit 0: Quadrant glitch cor • bit 1: Deterioration Diagn • bit 2: Motor movable rang • bit 2: Motor movable rang • bit 6: Manufacturer use • bit 10: Position comparis • bit 27: Alarm display swit Function expansion setup		0 0 0 1024 ear tion expansion selection		A	0	0	0	0	TR_CS OI_O   OI_O OI_O OI_O  OI_O OI_O
6 6 6	88 95 96 97	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re- lease level Function expansion setup 3 • bit 0: Quadrant glitch cor • bit 1: Deterioration Diagn • bit 2: Motor movable rang • bit 6: Manufacturer use • bit 10: Position comparis • bit 27: Alarm display switt Function expansion setup 4	O to 65534     O to 114     O to 114	0 0 0 1024 ear tion expansion selection 0		A	0	0	0	0	TR_CS OI_O     OI_O OI_O  OI_O TR_FS 
6 6 6	88 95 96 97	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re- lease level Function expansion setup 3 • bit 0: Quadrant glitch cor • bit 1: Deterioration Diagn • bit 2: Motor movable rang • bit 2: Motor movable rang • bit 6: Manufacturer use • bit 10: Position comparis • bit 27: Alarm display swit Function expansion setup 4	O to 65534     O to 114     O to 114	0 0 0 1024 ear tion expansion selection 0		A	0	0	0	0	TR_CS OI_O   OI_O OI_O OI_O  OI_O TR_FS  TR_CS
6 6 6 6	88 95 96 97 97 98	Manufacturer use Absolute encoder multi- turn data upper-limit value Motor overload warning de- tection level Motor overload warning re- lease level Function expansion setup 3 • bit 0: Quadrant glitch cor • bit 1: Deterioration Diagn • bit 2: Motor movable rang • bit 2: Motor movable rang • bit 2: Motor movable rang • bit 10: Position comparis • bit 10: Position comparis • bit 27: Alarm display switt Function expansion setup 4 • bit 3: Effective bit expans • bit 9: Virtual full-closed co	O to 65534     O to 114     O to 114     O to 114     O to 114     -2147483648 to     2147483647     npensation HPF cle osis Warning Func ge error protection on output function s ch setting     -2147483648 to     2147483648 to     2147483647 ion for multi-turn da ontrol mode function	0 0 0 1024 ear tion expansion selection 0 ata		A A B R					TR_CS OI_O - - OI_O OI_O OI_O OI_O TR_FS - TR_CS OI_O

Paramete	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute				Related con- trol mode			Reference
Class	No.						Р	s	Т	F			
6	125	Manufacturer use	_	0	_	_	-	-	_	-	-		
6	126	Warning 2 mask setup	-2147483648 to 2147483647	0	_	С	0	0	0	0	01_0		
6	127	Warning 3 mask setup	-2147483648 to 2147483647	0	_	С	0	0	0	0			

\*1 Values in parentheses are initial values for models with an instantaneous maximum current (peak value) of less than 24 A.

# 7.1.9 Class 7: Special Settings 2

Paramete	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute	R	elate trol i	ed c	on-	oled —: N// Reference
Class	No.	-					P	s	Т	F	
7	00	Display on LED	0 to 32767	0	_	A	0	0	0	0	01_0
7	01	Address display time setup upon power-up	-1 to 1000	0	100 ms	R	0	0	0	0	
7	03	Output setup during torque limit	0 to 1	0	_	A	×	×	0	×	01_0
7	04	Manufacturer use	_	0	-	-	-	-	-	-	_
			:								
7	08	Manufacturer use	—	0	_	—	-	-	-	-	
7	09	Correction time of latch delay 1	-2000 to 2000	360	25 ns	В	0	0	0	0	TR_CS
7	10	Software limit function	0 to 3	0	-	A	0	×	×	0	TR_CS
7	11	Positive side software limit value	-1073741823 to 1073741823	500000	Command unit	A	0	×	×	0	
7	12	Negative side software limit value	-1073741823 to 1073741823	-500000	Command unit	A	0	×	×	0	
7	13	Absolute home position offset	-2147483648 to 2147483647	0	Command unit	С	0	0	0	0	OI_O TR_CS
7	14	Main power off warning detection time	0 to 2000	0	ms	С	0	0	0	0	01_0
7	15	Positioning proximity range	0 to 1073741823	10	Command unit	A	0	×	×	0	TR_CS
7	16	Torque saturation error protection frequency	0 to 30000	0	Incidences	В	0	0	×	0	01_0
7	20	RTEX communication cycle setup	-1 to 12	3	_	R	0	0	0	0	0I_0
7	21	RTEX command updating cycle ra- tio setup	1 to 2	2	-	R	0	0	0	0	TR_CS
7	22	RTEX function expansion setup 1	-32768 to 32767	0	_	R	0	0	0	0	-
		• bit 0: RTEX communication data	size								0I_0
		• bit 1: Interaxis full-synchronous m	node using RTEX c	ommunication TMG_CNT							TR_CS
		bit 4: External scale position infor	mation monitoring	function setting for semi-cl	osed control						OI_O TR_CS
		• bit 5: Command position change	saturation function	selection							TR_CS
		• bit 6: Homing return velocity limit	enabled								TR_CS
7	23	RTEX function expansion setup 2	-32768 to 32767	18	_	В	0	0	0	0	-
		bit 0: Parameter writing via RTEX	communication pe	ermitted							TR_CS
		• bit 1: Alarm No. sub-number setti	ng								TR_CS
		• bit 2: RTEX status response cond	lition setting with P	OT and NOT functions dis	abled						01_0
											TR_CS
		bit 3: POT and NOT RTEX status	bit arrangement se	ettings							OI_O TR_CS
		bit 4: COM-LED compatibility (CC	M-LED is the phas	se status)							OI_0
		bit 5: Non-cyclic Command Startu									TR_CS
		bit 6: POT and NOT RTEX status									01_0
											TR_CS
		• bit 7: RTEX status bit arrangement	nt settings for PSL	and NSL							TR_CS
		• bit 8: RTEX status selection of In	_Progress/AC_OFF								01_0
							~				TR_CS
		bit 9: Command error return switce     inhibit deceleration to stop	ching for commands	s received in the direction of	ot over-travel i	nhibit input a	tter o	over	-trav	/el	OI_O TR_CS
		bit 14: Position deviation [comma	nd unit] output setu	ıp							01_0
		• bit 15: In_Progress/AC_OFF/Pr7.	112 value								01_0
											TR_CS

Paramete	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute			ed co nod		Reference
Class	No.						Ρ	S	Т	F	
7	24	RTEX function expansion setup 3	-32768 to 32767	0	-	С	0	0	0	0	_
		• bit 0: EX-OUT1 output status sett	ing at the time of c	ommunication interrupted a	after RTEX cor	nmunication	is es	stabl	ishe	d	TR_FS
		• bit 1: EX-OUT2 output status sett	ing at the time of c	ommunication interrupted a	after RTEX cor	nmunication	is es	stabl	ishe	d	TR_CS
		• bit 3: RTEX communication In_Po	sition judgment co	ndition setting							01_0
		bit 4: Servo_Active ON timing swi	tching								TR_CS
		bit 5: Latch position detection dela	ay compensation fu	unction switching							TR_CS
		bit 7: Internal value status selection	on of TFF from RTE	EX communication (fall pre	vention when	servo-on)					OI_O TR_CS
7	25	RTEX velocity unit setup	0 to 1	0	-	С	0	0	0	0	01_0
7	26	RTEX continuous communication error warning setup	0 to 32767	0	Incidences	A	0	0	0	0	01_0
7	27	RTEX accumulated communication error warning setup	0 to 32767	0	Incidences	A	0	0	0	0	
7	28	RTEX_Update_Counter error warn- ing setup	0 to 32767	0	Incidences	A	0	0	0	0	
7	29	RTEX monitor select 1	0 to 32767	0	-	A	0	0	0	0	TR_CS
7	30	RTEX monitor select 2	0 to 32767	0	-	A	0	0	0	0	TR_CS
7	31	RTEX monitor select 3	0 to 32767	0	-	A	0	0	0	0	
7	32	RTEX monitor select 4	0 to 32767	0	-	A	0	0	0	0	TR_CS
7	33	RTEX monitor select 5	0 to 32767	0	-	A	0	0	0	0	TR_CS
7	34	RTEX monitor select 6	0 to 32767	0	_	A	0	0	0	0	
7	35	RTEX command setup 1	0 to 2	0	_	С	0	0	0	0	01_0
7	36	RTEX command setup 2	0 to 2	0	_	С	0	0	0	0	TR_CS
7	37	RTEX command setup 3	0 to 2	0	-	С	0	0	0	0	
7	38	RTEX_Update_Counter error pro- tection setup	0 to 32767	0	Incidences	A	0	0	0	0	01_0
7	39	Manufacturer use	_	0	-	-	-	-	-	-	_
7	41	RTEX function expansion setup 5	-32768 to 32767	0	-	R	0	0	0	0	_
		• bit 7: Over-travel inhibit input dete	ection setting during	g Z-phase homing return o	peration						TR_CS
7	44	Manufacturer use	_	16908546	_	_	-	-	-	-	_
7	78	Latch trigger signal reading setting with stop function	0 to 3	0	-	С	0	×	×	0	01_0
7	80	Manufacturer use	_	0	-	-	-	-	-	-	_
7	87	Manufacturer use	_	0	-	-	-	-	-	-	_
			i								
7	89	Manufacturer use	_	0	_	_	-	-	-	-	
7	91	RTEX communication cycle expan- sion setup	0 to 2000000	500000	ns	R	0	0	0	0	OI_O TR_CS
7	92	Correction time of latch delay 2	-2000 to 2000	0	25 ns	В	0	0	0	0	TR_CS
7	93	Homing return speed limit value	0 to 20000	0	r/min	С	0	0	0	0	TR_CS
7	95	RTEX continuous communication error protection 1 detection count	0 to 17	4	Incidences	R	0	0	0	0	TR_CS OI_O
7	96	RTEX continuous communication error protection 2 detection count	0 to 17	12	Incidences	R	0	0	0	0	TR_CS OI_O
7	97	RTEX communication timeout error protection detection count	0 to 17	4	Incidences	R	0	0	0	0	01_0
7	98	RTEX cyclic data error protection 1/2 detection count	0 to 17	4	Incidences	R	0	0	0	0	01_0

Paramet	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute			ed co nod		Reference
Class	No.						Ρ	S	Т	F	
7	99	RTEX function expansion setup 6	-32768 to 32767	0	_	В	0	0	0	0	_
		bit 0: Enable/disable FFT executi	on while RTEX con	nmunication is established							OI_O TR_CS
		• bit 3: Command pulse accumulat	ed value [command	d unit] output setting							01_0
		bit 7: Monitor command regenera	tive load factor unit	switching							TR_CS
7	100	Manufacturer use	_	0	_	-	-	-	-	-	_
7	104	Manufacturer use	_	0	_	-	-	-	-	-	
7	108	RTEX communication synchroniza- tion setup	0 to 7	7	-	R	0	0	0	0	01_0
7	109	Manufacturer use	_	1	_	-	-	-	-	-	_
7	110	RTEX function expansion setup 7	-2147483648 to 2147483647	0	_	В	×	×	×	0	_
		bit 4: Profile position control mode	e startup condition	expansion	•						TR_CS
		• bit 16: External scale position var	iation enabled durii	ng virtual full-closed contro	l mode						OI_0
7	111	Trigger signal allocation setting of latch mode with stop function	0 to 64	0	_	С	0	×	×	0	OI_O TR_CS
7	112	Selection of RTEX communication status flag	0 to 2	0	_	В	0	0	0	0	01_0
7	127	Manufacturer use	_	0	_	-	-	-	-	-	_

# 7.1.10 Class 8: Special Settings 3

		1	i						. D	Sac	oled —: N/A
Paramete	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute			ed co nod		Reference
Class	No.						Ρ	s	Т	F	
8	00	Manufacturer use	_	0	-	_	-	-	-	-	-
8	01	Profile linear acceleration constant	1 to 429496	100	10,000 command units/s <sup>2</sup>	В	0	0	0	0	OI_O TR_CS
8	02	Manufacturer use	-	0	-	_	-	-	-	-	-
8	03	Manufacturer use	_	0	_	_	-	-	-	-	_
8	04	Profile linear deceleration constant	1 to 429496	100	10,000 command units/s <sup>2</sup>	В	0	0	0	0	OI_O TR_CS
8	05	Manufacturer use	-	0	-	_	-	-	-	-	-
8	10	Amount of travel after pro- file position latch detection	-1073741823 to 1073741823	0	Command unit	В	0	×	×	0	TR_CS
8	12	Profile homing mode set- ting	0 to 1	0	_	В	0	×	×	0	
8	13	Profile homing speed 1	0 to 2147483647	50	Command unit/s or r/min	В	0	×	×	0	
8	14	Profile homing speed 2	0 to 2147483647	5	Command unit/s or r/min	В	0	×	×	0	
8	15	Manufacturer use	_	0	-	_	-	-	-	-	-
8	17	Relative movement of re- tracting operation	-2147483647 to 2147483647	0	Command unit	В	0	0	0	0	01_0
8	18	Retracting operation speed	0 to 2147483647	0	Command unit/s or r/min	В	0	0	0	0	
8	19	Manufacturer use	_	0	_	_	-	-	-	—	-

# 7.1.11 Class 11: Manufacturer Use

Paramete	er No.	Parameter name	Setting range	Factory default values	Unit	Attribute			ed co nod		Reference
Class	No.						Ρ	S	Т	F	
11	00	Manufacturer use	_	1	_	_	-	-	-	-	_
11	01	Manufacturer use	_	503578880	_	_	-	-	-	-	—
11	02	Manufacturer use	_	658185	_	_	-	-	-	-	_
11	03	Manufacturer use	_	-1	_	_	-	-	-	-	—
11	04	Manufacturer use	_	-1	_	_	-	-	-	-	_
11	05	Manufacturer use	_	-1	_	_	-	-	-	-	—
11	06	Manufacturer use	_	-1	_	_	-	-	-	-	—
11	07	Manufacturer use	_	16	_	_	-	-	-	-	—
11	08	Manufacturer use	_	6	_	_	-	-	-	-	—
11	09	Manufacturer use	_	1	_	_	-	-	-	-	—
11	10	Manufacturer use	_	129	_	_	-	-	-	-	—
11	11	Manufacturer use	_	0	_	_	-	-	-	-	_
11	12	Manufacturer use	_	0	_	_	-	-	-	-	-
11	13	Manufacturer use	_	0	_	_	-	-	-	-	_
11	14	Manufacturer use	_	0	_	_	-	-	-	-	—
11	15	Manufacturer use	_	0	_	_	-	-	-	-	—
11	16	Manufacturer use	_	255	_	_	-	-	-	-	_
11	17	Manufacturer use	_	0	_	_	-	-	-	-	—
11	18	Manufacturer use	_	0	_	_	-	-	-	-	—
11	19	Manufacturer use	_	0	_	_	-	-	-	-	_
11	20	Manufacturer use	_	0	_	_	-	-	-	-	_
11	21	Manufacturer use	_	0	-	_	-	-	-	-	_
11	22	Manufacturer use	-	15	-	_	-	-	-	-	—
11	23	Manufacturer use	-	0	-	_	-	-	-	-	_
11	24	Manufacturer use	_	0	-	_	-	-	-	-	_
11	25	Manufacturer use	_	0	-	_	-	-	-	-	_
11	26	Manufacturer use	_	0	_	_	-	-	-	-	_

 $\bigcirc$ : Enabled  $\times$ : Disabled —: N/A

# 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



- \*1 Position deviation [command unit] operation criteria can be changed in 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.



# Control Block Diagram: Position Control (Two-degree-of-freedom Control Mode Disabled)

- \*1 Position deviation [command unit] operation criteria can be changed in 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.

# 7.2.2 Speed Control Mode Block Diagram



#### IMG23 Rev.1.1



# IMG23 Rev.1.1

# 7.2.3 Torque Control Mode Block Diagram



# 7.2.4 Full-closed Control Mode Block Diagram



- \*1 Position deviation [command unit] operation criteria can be changed in 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 Velocity [r/min] unit calculated from encoder, not external scale.



# Control Block Diagram: Full-closed Control (Two-degree-of-freedom Control Mode Disabled)

- Position deviation [command unit] operation criteria can be changed in Pr7.23 "Communication function extended setup \*1 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 Velocity [r/min] unit calculated from encoder, not external scale.

# 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 <sup>(*1)</sup>	Parameter name	Setting range	Unit	Function
0	04	В	Inertia ratio	0 to 100000	%	Sets the ratio of load inertia to motor rotor inertia.
1	00	В	1st gain of posi- tion loop	0 to 30000	0.1 s <sup>-1</sup>	Sets the 1st position loop gain.
1	01	В	1st velocity loop gain	1 to 32767	0.1 Hz	Sets the 1st velocity loop gain.
1	02	В	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	В	1st filter of veloci- ty detection	0 to 5	_	Sets the 1st filter of velocity detection in 6 stages.
1	106	В	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	В	1st velocity inte- gration change ratio	0 to 300	%	Sets the change ratio of Pr1.02 "1st velocity loop inte- gration 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	В	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	В	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	В	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	В	2nd velocity inte- gration change ratio	0 to 300	%	Sets the change ratio of Pr1.07 "2nd velocity loop inte- gration 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	В	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	В	Load fluctuation compensation fil- ter change ratio	0 to 300	%	Sets the change ratio of Pr6.24 "Load change compen- sation 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	В	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	В	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	_	<ul> <li>Specifies the condition for counting the settling time during tuning.</li> <li>0: Counted after completion of command transfer judgment.</li> <li>1: Counted at start of command transfer judgment.</li> </ul>
2	63	A	Allowable over- shoot amount	0 to 500	%	Sets the allowable amount of overshoot during tuning as a percentage of Pr4.31 "Positioning complete (In-posi- tion) range" . Set to 0 to tune without overshoot.
2	64	A	Tuning amount of movement	0 to 2147483647	Com- mand unit	Sets the amount of movement when using operation commands during tuning. This can be set when tuning is performed using only op- eration commands from the servo driver. If the setup value is 0, the value automatically deter- mined by the servo driver is used.
2	65	A	Tuning max speed	0 to 20000	r/min	Sets the maximum speed when using operation com- mands during tuning. This can be set when tuning is performed using only op- eration commands from the servo driver. If the setup value is 0, the value automatically deter- mined by the servo driver is used.
2	66	A	Tuning accelera- tion and deceler- ation time	0 to 5000	ms	Sets the acceleration/deceleration time when using op- eration commands during tuning. This can be set when tuning is performed using only op- eration commands from the servo driver. If the setup value is 0, the value automatically deter- mined 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 op- eration commands from the servo driver.
2	68	A	Tuning operating range upper limit	0 to 1073741823	Com- mand unit	Sets the amount of movement that the motor is allowed to move in the positive direction from the tuning start po- sition during tuning.
2	69	A	Tuning operating range lower limit	-1073741824 to 0	Com- mand 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 over- speed level set- ting	0 to 20000	r/min	Sets the upper limit for the allowable motor speed dur- ing 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 allow- able 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 se- lection	-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 fil- ter) 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 posi- tion	-1073741824 to 1073741823	Com- mand unit	Sets the initial position at the start of tuning.
2	78	A	Tuning vibration automatic sup- pression 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 com- plete (In-position) range	0 to 2097152	Com- mand unit	Sets the threshold value of position deviation that out- puts 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 devia- tion 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	В	Function expan- sion 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 set- ting mode, or load fluctuation support mode (Pr0.02 = 1 to 3, or 6).
6	47	R	Function expan- sion 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 tun- ing selection 0: Standard type 1: Synchronization type <b>Notes</b> • bit 3 can only be used when bit 0 is 1.

\*1 For attributes, see <u>"7.1 List of Parameters"</u>.

# 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.	<u>"Advanced Settings</u> <u>Items" - "Command</u> <u>conditions"</u> of <u>"3.1.2.4.2 Initial Set-</u> <u>tings"</u>
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).	<u>"Advanced Settings</u> <u>Items" - "Required</u> <u>performance"</u> of <u>"3.1.2.4.2 Initial Set-</u> <u>tings"</u>
259	Initial setting error 3	<ul> <li>Target settling time is set greater than the command (operation time +Tuning wait time - 500 ms) in [Command conditions].</li> <li>Set Target settling time [ms] to a value smaller than (operating time + Tuning wait time - 500 ms).</li> <li>The value obtained by adding the operating time and tuning wait time [ms] is 10000 [ms] or more.</li> <li>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] is less than 10000 [ms].</li> <li>Notes</li> <li>Operating time is the time from the start of command transfer to the completion of transfer.</li> </ul>	"Advanced Settings Items" - "Required performance" of "3.1.2.4.2 Initial Set- tings" "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].	<u>"Advanced Settings</u> <u>Items" - "Required</u> <u>performance"</u> of <u>"3.1.2.4.2 Initial Set-</u> <u>tings"</u>
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].	<u>"Advanced Settings</u> <u>Items" - "Required</u> <u>performance"</u> of <u>"3.1.2.4.2 Initial Set-</u> <u>tings"</u>
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].	<u>"Step 5"</u> of <u>"3.1.2.4.2 Initial Set-</u> <u>tings"</u> <u>"Advanced Settings</u> <u>Items" - "Required</u> <u>performance"</u>
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 Set- tings" "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.	<u>"Advanced Settings</u> <u>Items" - "Detailed Pro-</u> tection Function" of <u>"3.1.2.4.2 Initial Set-</u> <u>tings"</u> <u>"Step 3"</u>

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 <u>Items" - "Command</u> <u>conditions"</u> of "3.1.2.4.2 Initial Set- <u>tings"</u> "Advanced Settings <u>Items" - "Detailed Pro-</u> <u>tection Function"</u>	
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 <sup>2</sup> ], referring to the formula below. Acceleration [command unit/s <sup>2</sup> ] = Tuning max speed [r/min]/Tun- ing acceleration and deceleration time [ms/max speed] × 1000/60 × (encoder resolution / electronic gear ratio) *For rotary type mo- tor	<u>"Advanced Settings</u> <u>Items"</u> - <u>"Command</u> <u>conditions"</u> of <u>"3.1.2.4.2 Initial Set-</u> <u>tings"</u>	
277	Initial setting error 11	A tuning target is not selected. Turn ON one of the tuning targets.	<u>"Advanced Settings</u> <u>Items" - "Tuning condi-</u> <u>tions" of "3.1.2.4.2 Ini-</u> <u>tial Settings"</u>	
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 rec- ommended for the amount of motor rotations.	<u>"Step 5"</u> of " <u>3.1.2.4.2 Initial Set-</u> <u>tings</u> "	
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.	<u>"Advanced Settings</u> <u>Items" - "Command</u> <u>conditions"</u> of " <u>3.1.2.4.2 Initial Set-</u> <u>tings"</u>	
513	Load characteristic measurement error	<ul> <li>Load characteristic measurement failed.</li> <li>1 Execute One Minute TUNING once more with a larger operating range.</li> <li>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.</li> </ul>	<u>"Step 5"</u> of <u>"3.1.2.4.2 Initial Set- tings"</u> <u>"Advanced Settings</u> <u>Items"</u> - <u>"Tuning condi-</u> tions"	
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 Pa- rameters"	
1025	Torque saturation error	Tuning torque limit exceeded during operation. Execute One Minute TUNING once more after revising command conditions to reduce acceleration.	<u>"Advanced Settings</u> <u>Items"</u> - <u>"Command</u> <u>conditions"</u> of <u>"3.1.2.4.2 Initial Set-</u> <u>tings"</u>	
1281	Stiffness measurement error	RTAT machine stiffness setting, notch, and load fluctuation sup- pression 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 Pa- rameters"	
1537	Device characteristics measuring error 1	Device characteristics could not be measured correctly. Execute One Minute TUNING once more with a larger operating range.	<u>"Step 5"</u> of <u>"3.1.2.4.2 Initial Set-</u> <u>tings"</u>	
1793	Device characteristics measuring error 2	Device characteristics could not be measured correctly. Execute One Minute TUNING once more with a smaller operating range.	<u>"Step 5"</u> of <u>"3.1.2.4.2 Initial Set-</u> <u>tings"</u>	

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 op- eration. Contact the manufacturer.	-

# 7.7 Glossary

Abbreviation	Official Name
CCW	Counterclockwise Rotation
СР	Cyclic Position Mode
CP	Continuous Path
СТ	Cyclic Torque Mode
CV	Cyclic Velocity Mode
CW	Clockwise Rotation
DB	Dynamic Brake
EDM	External Device Monitoring
EXPOS	External scale position
FB	Feedback
FF	Feed Forward
FFT	Fast Fourier Transform
FIR	Finite Impulse Response
HPF	High Pass Filter
LSD	Least Significant Digit
LV	Low Voltage
MSD	Most Significant Digit
OSS	Open Source Software
PP	Profile Position Mode
Recv	Receive
RTAT	Real-Time Auto Tuning
SRV	Servo
SSU	STO Signal Unmatch
STO	Safe Torque Off
TFF	Torque Feed Forward

Abbreviations used in this document and their official names are shown below.

# 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 asso- ciated 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	<ul><li>Changed Function (Add to Unsupported Features)</li><li>Monitor Signal Output</li></ul>
Apr. 11, 2025	1.0	1.3.2, 1.3.5	Software version upgrade ● CPU1: Ver1.04→Ver1.05
		1.3.4	Remove from the list of Unsupported Features <ul> <li>Monitor Signal Output</li> </ul>
		7.6	Corrected typographical errors (Err275, Err277)
May 28, 2025	1.1	4.4.3, 4.6.3, 4.7.3, 4.9.3, 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/"

# Industrial Device Business Division, Panasonic Industry Co., Ltd.

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