MITSUBISHI ELECTRIC
Changes for the Better

FATEC

AC Servo School Text
AC Servo Practice Course
(MELSERVO-J5)

●SAFETY PRECAUTIONS●

(Always read these instructions before exercise.)

When designing the system, always read the relevant manuals and give sufficient consideration to safety.
During the exercise, pay full attention to the following points and handle the product correctly.

[EXERCISE PRECAUTIONS]

⚠ CAUTION

- Follow the instructor's direction during the exercise.
- Do not remove the module of the demonstration machine or change wirings without permission.
  Doing so may cause failures, malfunctions, personal injuries and/or a fire.
- Turn off the power before mounting or removing the module.
  Failure to do so may result in malfunctions of the module or electric shock.
- When the demonstration machine (such as X/Y table) emits abnormal odor/sound, press the "Power switch" or "Emergency switch" to turn off.
- When a problem occurs, notify the instructor as soon as possible.

! WARNING

- Do not touch the terminals while the power is on to prevent electric shock.
- Do not operate the switches with wet hands. Doing so may cause an electric shock.
- To prevent an electric shock, ground the demonstration machine securely.
- Before opening the safety cover, turn off the power or ensure the safety.

CONTENTS

1 AC SERVO BASICS

1.1 About AC Servos

In JIS, a servomechanism is defined as "a controlling system configured to follow the desired change of the target using an object's conditions such as position, direction, and posture as the controlling amount". Once a target value (of a position, speed, etc.) is input from a command section, a servomechanism detects its current value (of a position, speed, etc.) and controls the difference between the two values to maintain the difference to be constantly as small as possible.

The elements composing a servomechanism are called the servo elements, which are a drive amplifier (AC servo amplifier), drive motor (AC servo motor), and detector. Figure 1.1 shows the configuration example.

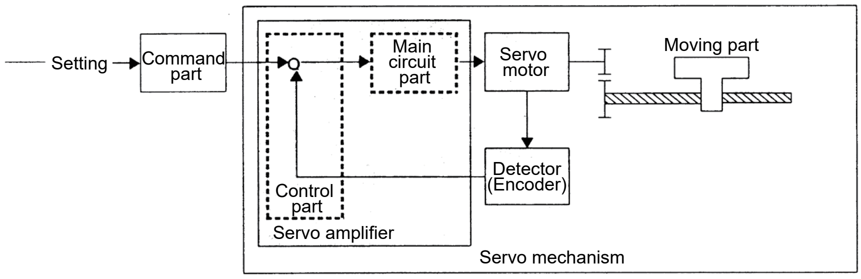


Figure 1.1 Configuration diagram of a servomechanism

1.2 Placement and Performance of AC Servos

Compared with general motors, a servo motor is designed considering especially about the moment of inertia of its rotor (termed J or GD2) and electrical response performance. Thus, a servo motor can respond to a sudden change of the voltage and current from a servo amplifier. In addition, the servo amplifier that drives the servo motor is configured so that the speed/position control commands can be correctly and quickly transmitted.

Based on the above perspective, this section explains the typical characteristics of the servo motor (its total characteristics in combination with a servo amplifier) by showing the comparisons with a motor driven by a general-purpose inverter which is a general variable speed device.

(1) Features of general-purpose servos and comparison with control devices

The speed - torque characteristics are generally used to indicate the motor characteristics. Figure 1.2 shows the characteristics comparison between a servo motor and a general-purpose motor with a general-purpose inverter.

This figure indicates that the servo motors have the following three features:

1) Wide speed control range
2) Torque characteristics stable both at high-speedand low-speed operations
3) Large maximum torque

* The large maximum torque and small motor moment of inertia enable rapid acceleration and deceleration.

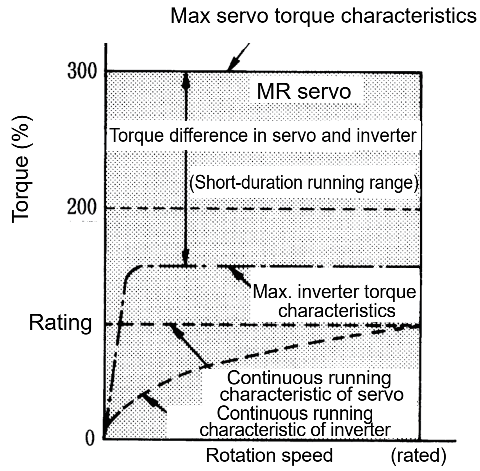


Figure 1.2 Torque characteristics comparison between servos and inverters

Table 1.1 Main performance of servo motors

Item	Specifications	Description
Speed control range	1: 1000 to 5000 (1: 10)	Enables operation without worrying about rotation stability or torque decrease until the speed becomes 1/1000 of the rated speed.
Torque characteristics	Torque does not decrease in low-speed operations	Allows both the continuous operation torque and maximum torque to be output at a constant level within the speed control range. Thus, the servo motor can be operated securely in any speed range even with the rated torque load.
Maximum torque	Approximately 300% (150%)	Allows the instantaneous maximum torque to be output at approximately 300% of the rated torque. Thus, as the servo motor supports a sudden acceleration/deceleration, it can be used for high-frequency positioning.

* Values in the parentheses in the specification column are the general specifications of general-purpose inverters.

(2) Applications of AC servos

In addition to the features mentioned in the previous section, the servo motor in combination with the servo amplifier has the positioning function that is distinctive from other variable speed devices.
This section explains the positioning function that is distinctive of servos and the representative applications of the servo motor based on the features described in the previous section (1). Details of the positioning function are described in Chapter 4.

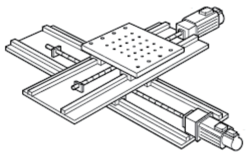
(a) Machines that require positioning

AC servos enable high-precision positioning in combination with dedicated positioning command modules. General Mitsubishi AC servos can perform positioning with 4000 to 67108864 resolutions, which is sufficient for positioning with 1μm accuracy on machines that feed 24 to 8m per minute.

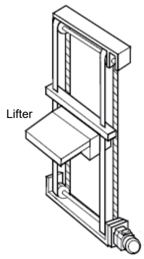
Application examples: Working machines, woodworking machines, transportation machines, packaging machines, inserter machines/mounter machines, feeder machines, cutter machines, and special working machines

1) X-Y table

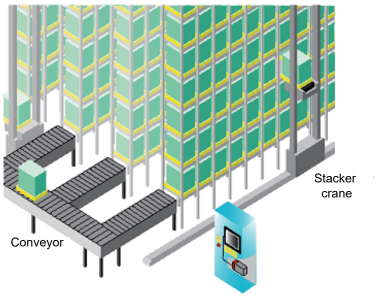
Performs high-speed and high-precision positioning by using two axes of AC servos with loads of ball screws connected to each X and Y axis.



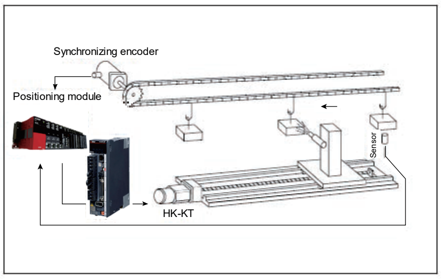
2) Transportation machine (vertical)
Performs transportation positioning of lifters. This type of machines use servo motors with electromagnetic brakes to prevent a drop at a power failure. (This application is also used in multistory parking garages.)



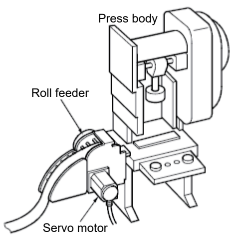
Automatic warehouses/picking systems
More automatic warehouses introduce AC servos into their picking parts and running parts to meet the needs of speeding up.
Smooth acceleration at a high speed can be achieved by adopting AC servo motors.
Automatic warehouses and picking systems connected with supply chain management (SCM) significantly improves the storage management efficiency of logistics from obtaining materials to product delivery.



3) Synchronized feeding (for coating lines)
Detects the positions of products by using the sensor to perform synchronized feeding with encoder signals. The motor returns the position to the home position after feeding a specified length, then waits for the next product.



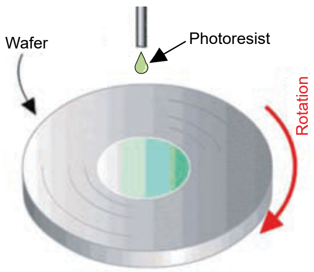
4) Press/roll feeder
Operates a feed roller using an AC servo motor to supply a material by a specified length. The material is to be supplied by the press while the press head is ascending, then punched once in position.



(b) Machines that require wide variable speed range
An AC servo has a high-accuracy speed control performance with a speed control range of 1: 2000 to 5000 and speed fluctuation ratio of 0.01% or less, besides the constant output torque which is a characteristic distinctive from other variable speed equipment. Thus, an AC servo is used for high-accuracy variable speed controls such as line controls.

Application examples: Printing machines, paper converting machines, film production lines, wire drawing machines, winding machines, feeding of various special working machines, various material handling systems, winding and unwinding, main shafts of woodworking machines

1) Spin coating
Produces semiconductor circuits using the principle as described below.
Spin coaters apply photosensitizer (photoresist) to semiconductor wafers.
The resist liquid is dropped on the wafer, then the centrifugal force spreads the liquid.
If the rotation speed of the wafer is too fast, the resist will splash off the wafer. If the rotation speed is too slow, the resist will be applied to the wafer unevenly.

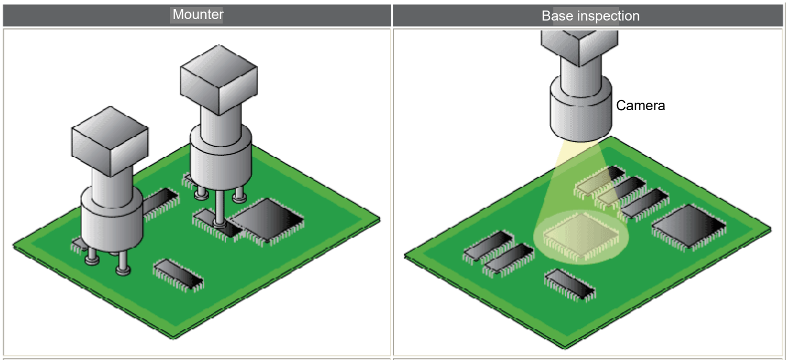


(c) High-frequency positioning

As explained in (a) "Machines that require positioning", the maximum torque of an AC servo is approximately 300% of the rated torque. This allows a motor as a single unit to follow a sudden acceleration/deceleration which takes approximately several tens of milliseconds from stop to the rated speed. Thus, the motor can support a high-frequency positioning of 100 times or more per minute. In addition, as its great features, an AC servo is maintenance-free because it has less mechanical contacting parts in comparison to other positioning methods (clutch brake, DC motor, etc.) and is less susceptible to the ambient temperature.

[Application examples: Press feeders, bag making machines, sheet cutters, loaders/unloaders, filling machines, packing machines, various material handling systems, mounters, bonders]

1) Mounter and board inspection

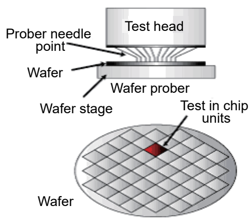


Mounter	Base inspection
Check whether the electronic components (LSI, resistor, capacitor, etc.) are mounted on the printed-circuit board. Positioning accuracy and high speed performance are requested.	Check whether the electronic components (LSI, resistor, capacitor, etc.) are mounted correctly on the printed-circuit board. In some cases, the board itself is also checked.

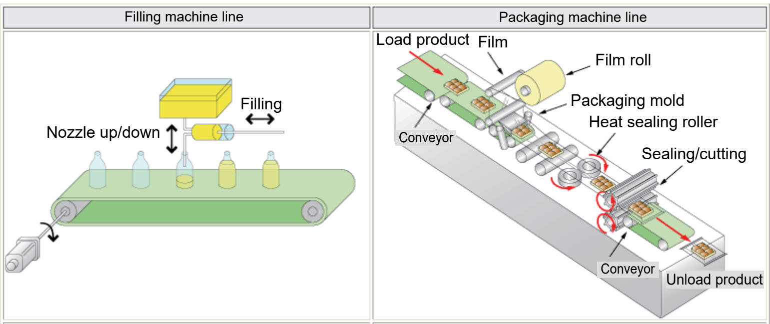
2) Wafer prober

Since many LSI chips are to be produced per wafer, each chip is to be inspected before assembly with a wafer prober and tester.

Precise positioning is required because this device sticks a needle into a chip. In addition, high speed is also required.



3) Filling machine line/packing machine line

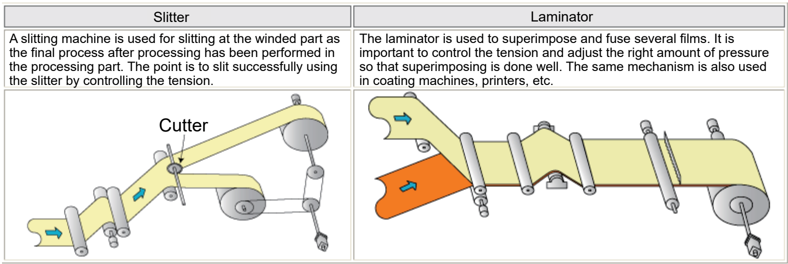


Filling machine line	Packaging machine line
Filling machine line Bottles capable of large amounts are filled with different volumes of liquid at fast speeds. The filling speed can be controlled according to the shape of the bottles so that the liquid does not bubble over the specified value.	Servo motors are used to pack foodstuff in film properly and hygienically. The point is to cut and separate the rolled film into precise sizes after the packaging is done according to the size of food products.

(d) Torque control

As torque control is available with specific models in addition to speed control and position control functions, an AC servo is applicable to various winding/unwinding devices and other devices in the field of tension control.

1) Slitter/laminator



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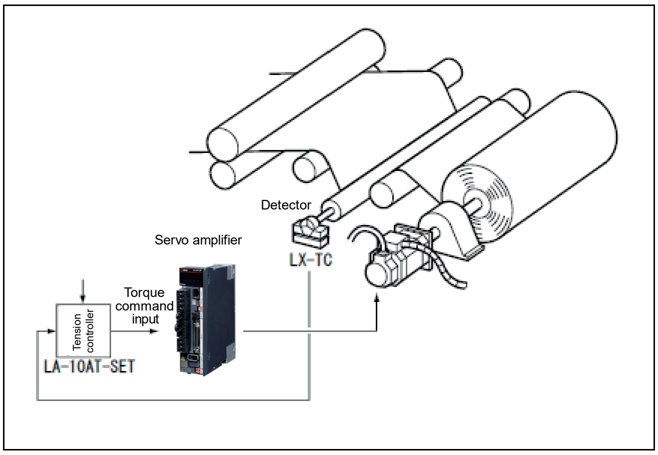
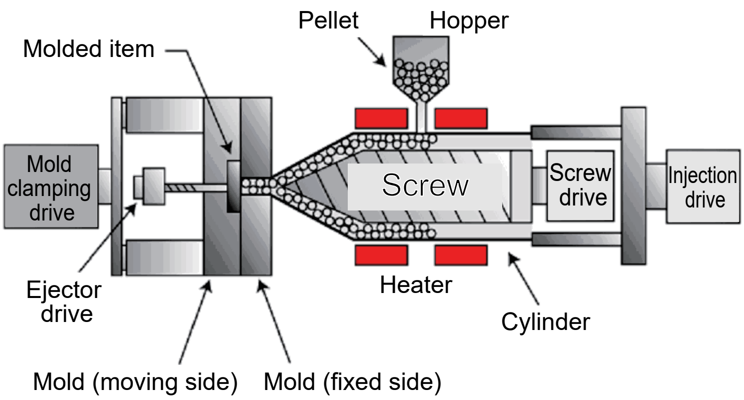


3) Injection molding machines

Injects plastic pellets to the mold. The plastic pellets are the material of the molded product and are melted by the heater at the area composed of the cylinder and screw shaft.

Then, the mold opens after cooling, and the ejector pin pushes out the molded product.

The mold clamping force is so large that it exceeds 3000t in some applications for large-sized components.

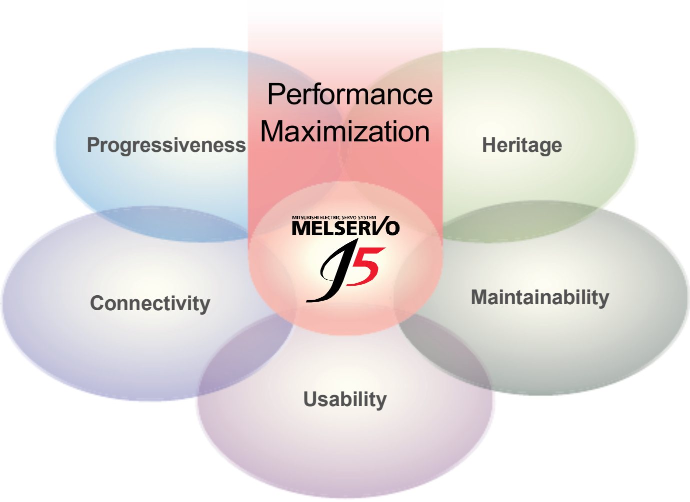


1.3 About MELSERVO

1.3.1 Features of the MELSERVO-J5

Since the release of the general-purpose AC servo in 1982, we have always been adopting the industrial sector's requirements to our latest products reflecting the innovations.
Today, the environment surrounding the servo is moving over to the next generation. To maximize the machine's performance, servos are required to make enhancements such as supporting a higher speed and accuracy, shortening the startup time, and improving the diagnosis and maintenance functions. The MR-J5 series has been developed to meet these requirements.

Maximize system performance



Progressiveness
For evolution of machines
- Performance improvement
- Program standardization

Connectivity
For flexible system configurations
- Integration with connectable devices

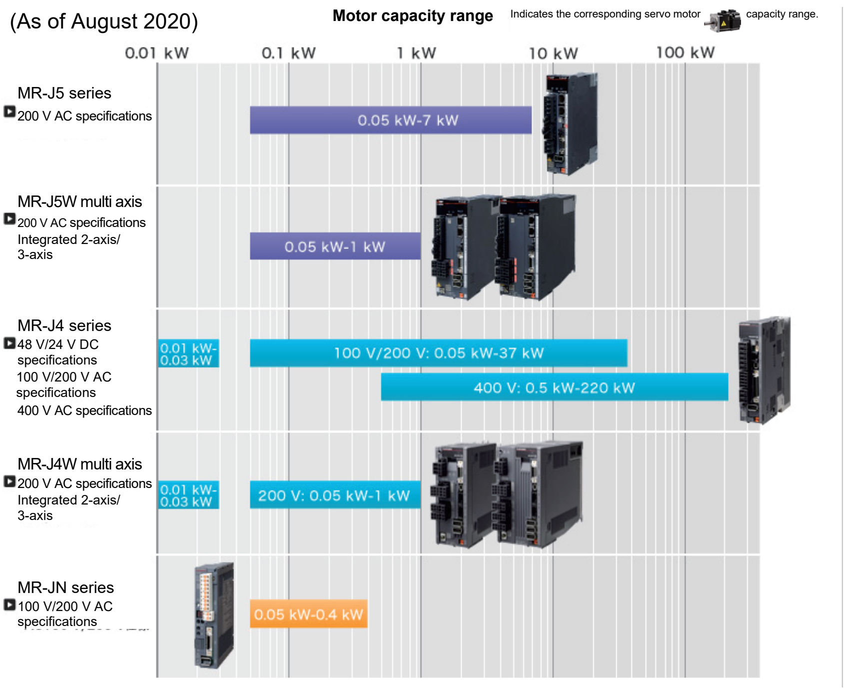
Usability
For quick operation start
- Tool enhancement
- Improved drive system usability

Maintainability
For prompt detection and diagnosis of failures
- Predictive/preventative maintenance
- Corrective maintenance

Heritage
For utilization of existing devices
- Interchangeability with previous generation models

1.3.2 Product lines

The MELSERVO series lineups are as follows.



1.3.3 Comparison table of general-purpose servo amplifier specifications

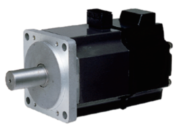
Item \ Model	MR-J5-□ series	MR-J4-□ series	MR-JN-□ series
Appearance			
Features	●Enhanced performance and functions of the MELSERVO-J4 series ●High-performance servo amplifier and high-resolution servo motor of the industry-leading level ●MR Configurator2 (SW1DNC-MRC2-J) ●CC-Link IE TSN-compatible	●Enhanced performance and functions of the MELSERVO-J3 series ●High-resolution servo motor ●MR Configurator2 (SW1DNC-MRC2-J) ●Compatible with the high-speed optical communication SSCNET III/H	●One-touch servo ●MR Configurator2 (SW1DNC-MRC2-J) ●Equipped with one-touch tuning/real-time auto tuning and tough drive function
Supported motor capacity	0.05kW-7kW	0.01kW-55kW	0.05kW-0.4kW
Brake/gear reducer	Brake: provided/gear reducer: not provided	Provided	Provided
Encoder signal	Serial communication	Serial communication	Serial communication
Position resolution	67108864 p/rev	4194304 p/rev	131072 p/rev
Detection method	INC/ABS	INC/ABS	INC
Speed (r/min) Rated speed	3000	3000	3000
Speed (r/min) Maximum speed	6700	6000	4500
Maximum torque % (Rated torque % ratio)	450% [*1]	400% [*2]	300%
Control mode	Position/speed/torque	Position/speed/torque	Position/speed/torque
Frequency response	3.5kHz	2.5kHz	-
Control theory	Sine-wave PWM control/current control	Sine-wave PWM control/current control	Sine-wave PWM control/current control
One-touch tuning	Provided	Provided	Provided
Auto tuning	Real-time	Real-time	Real-time
Personal computer interface	Standard equipment	Standard equipment	Standard equipment
Speed control range	1: 5000	1: 5000	1: 5000
External power supply for interface	24V DC is required	24V DC is required	24V DC is required
Regenerative brake resistor	Built-in	Built-in	Built-in
Dynamic brake	Built-in	Built-in	Built-in
Display (main body)	5-digit display	5-digit display (3-digit display for alarms)	3-digit display
Setting keys etc.	Four setting buttons	Four setting buttons	Four setting buttons
Analog monitor	2 channels	2 channels	Not provided
Pulse dividing output	A, B, and Z-phase	A, B, and Z-phase	A, B, and Z-phase
Test mode operation	Possible	Possible	Possible
Motor-less operation	Possible	Possible	Possible
EN standards	Compliant	Compliant	Compliant
UL/cUL standards	Compliant	Compliant	Compliant
Compatible motor	●HK-KT series ●HK-ST series	●HG-AK series ●HG-KR series ●HG-MR series ●HG-SR series ●HG-JR series ●HG-PR series ●HG-UR series	●HF-KN series

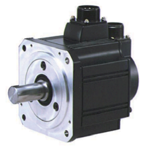
*1. Only for servo motors of the HK-KT series
*2. Only for servo motors of the HG-JR series

1.3.4 Model series and features of servo motors

The AC servo MELSERVO-J5, J4, and JN series have various models of motors compatible with various applications.

- MELSERVO-J5 series: ABS, 26 bit (60000000 pulses) encoder
- MELSERVO-J4 series: ABS, 22 bit (4000000 pulses) encoder
- MELSERVO-JN series: INC, 17 bit (130000 pulses) encoder

Series			Capacity (W)	Encoder resolution Pulse/rev	Supported encoder	Rated speed	Compatible servo amplifier model	IP rating	Application
Small capacity/ ultra-low inertia		HG-MR	50W-750W	4194304	ABS/INC	3000r/min	MR-J4	IP65	Belt drives Robots Inserters Mounters X-Y tables Food processing machines Semiconductor manufacturing systems Textile machines etc.
Small capacity and low inertia		HG-KR	50W-750W	4194304	ABS/INC	3000r/min	MR-J4	IP65	Belt drives Robots Inserters Mounters X-Y tables Food processing machines Semiconductor manufacturing systems Textile machines etc.
		HK-KT*1	50W-2000W	67108864	ABS/INC	3000r/min	MR-J5	IP67	Belt drives Robots Mounters X-Y tables Semiconductor manufacturing systems Battery manufacturing systems etc.
		HF-KN	50W-400W	131072	INC	3000r/min	MR-JN	IP65	Inserters Mounters Bonders Printed board punching machines In-circuit testers Label printing Knitting machines Embroidery machines etc.
Ultra-compact size, ultra-small capacity		HG-AK	10W-30W	262144	ABS/INC	3000r/min	MR-J4W2-0303B6 MR-J4-03A6(-RJ)	IP55	Mounters Semiconductor manufacturing systems Compact robots Electronic component manufacturing machines Small actuators etc.
Medium capacity, ultra-low inertia		HG-RR	1000W-5000W	4194304	ABS/INC	1500r/min 3000r/min	MR-J4	IP65	Ultra-high-throughput material handling systems etc.

Series			Capacity (W)	Encoder resolution Pulse/rev	Supported encoder	Rated speed	Compatible servo amplifier model	IP rating	Application
Medium capacity, medium inertia		HK-ST	300W-7000W	67108864	ABS/INC	2000r/min	MR-J5	IP67	Material handling systems Robots X-Y tables Battery manufacturing systems etc.
		HG-SR	500W-7000W	4194304	ABS/INC	1000r/min 2000r/min	MR-J4	IP67	Material handling systems Robots X-Y tables etc.
Medium capacity, flat type		HG-UR	750W-5000W	4194304	ABS/INC	2000r/min	MR-J4	IP65	Robots Food processing machines etc.
Medium/large/ultra-large capacity, low inertia		HG-JR	500W-220000W	4194304	ABS/INC	1000r/min 1500r/min 2000r/min 3000r/min	MR-J4	IP67/ IP44	Food packaging machines Printing machines Injection molding machines Press machines etc.

*1. The HK-KT series also has the flat type.

- The MR-J5 series servo amplifier can drive the linear servo motors and direct drive motors, in addition to the rotary servo motors shown above as standard.
  The linear servo motor has the LM series (LM-H3, LM-F, LM-K2, and LM-U2) and the direct drive motor has the TM series (TM-RG2M, TM-RU2M, and TM-RFM).
- The MR-J5 series (MR-J5-G, MR-J5W2-G, MR-J5-A) servo amplifiers support the fully closed loop control as the standard specification.
  (The MR-J5 series servo amplifiers support the two-wire type serial linear encoders.)
  (The MR-J5-G-RJ and MR-J5-A-RJ servo amplifiers support the four-wire type serial linear encoders and pulse train interface (A/B/Z-phase differential output type) linear encoders.)

* The motor cannot be used with some models of servo amplifiers. Refer to the Mitsubishi Electric FA site, catalogs, etc. for details of the combinations.

1.4 AC Servo Mechanisms

1.4.1 Servo amplifier block diagram and operating principle

The basic functions and operating principle of the servo amplifier are shown in the block diagram below.

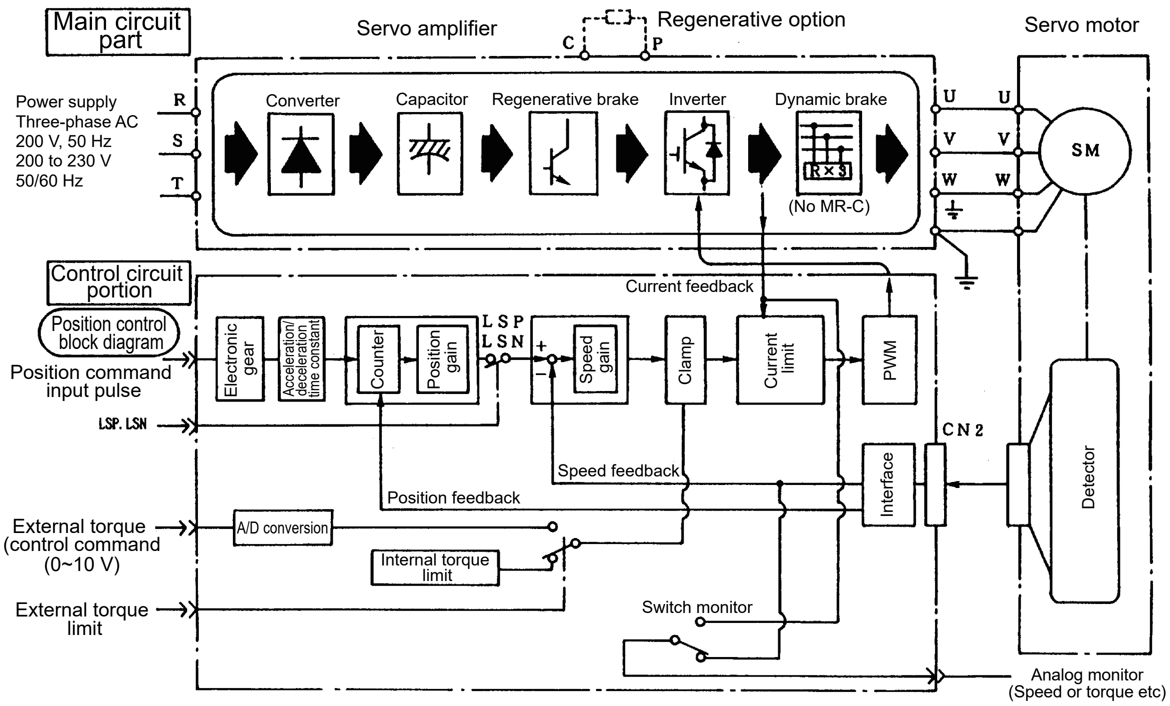


Figure 1.3 AC servo (pulse train method) block diagram

(1) Main circuit
As the basic functions, the main circuit rectifies and smooths AC power (3-phase 200 to 230V AC, 50/60Hz) by using converters (diode bridges and capacitors). Then, it performs sine-wave PWM control using the inverter (IGBT) and supplies the 3-phase current which has a desired voltage and frequency to the motor to control the motor speed and torque.

(a) Converter and smoothing capacitor
A diode bridge rectifies AC power, then a smoothing capacitor makes DC power with a small ripple.

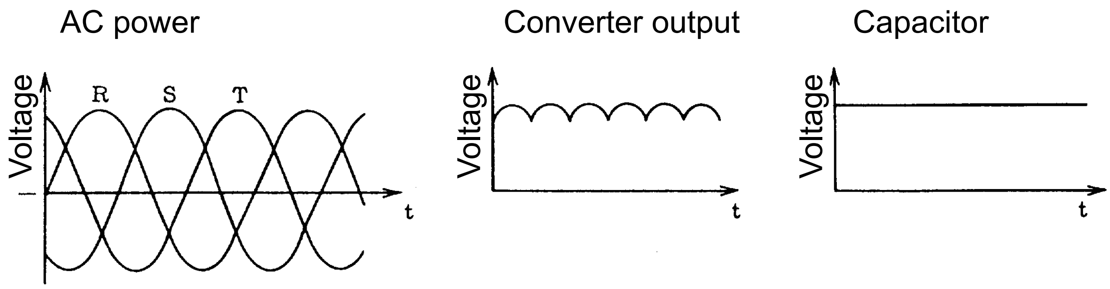


Figure 1.4 Servo amplifier voltage of each part

(b) Inverter
An inverter generates a current that has a frequency in accordance with the motor speed and appropriate strength for the load torque from the DC power generated by the converter and smoothing capacitor, then supplies the current to the motor.

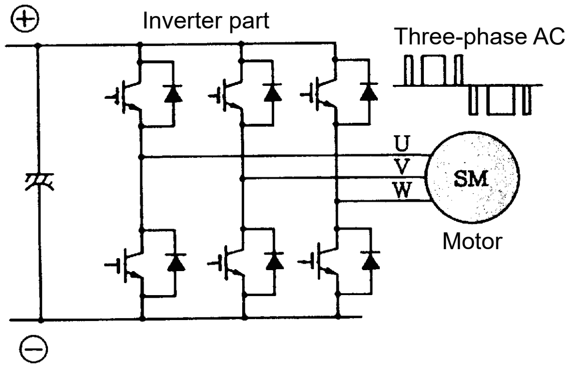


Figure 1.5 Structure of inverter section

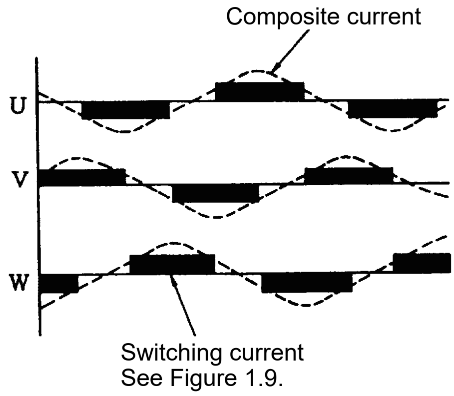


Figure 1.6 Inverter output current

The motor rotation direction and speed (frequency) are controlled by switching on and off the transistor in the inverter section in accordance with the direction and width of the current, as shown in Figure 1.7.
The strength of the current is controlled by the width of the current, and this method is called the pulse width modulation (PWM) control.

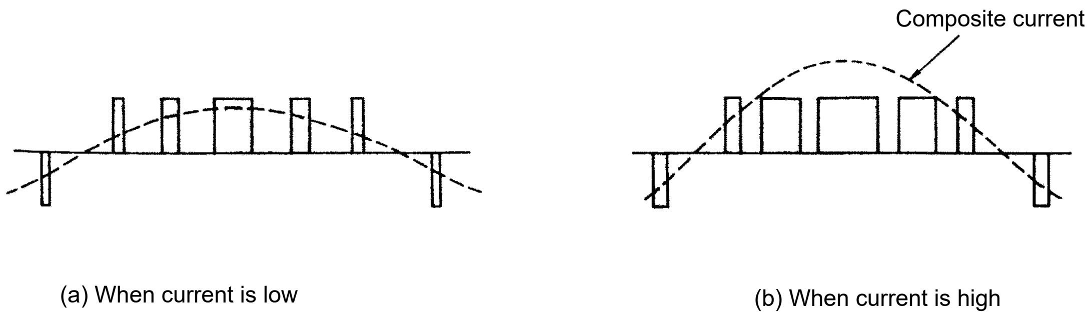


Figure 1.7 Current control by PWM

(c) Regenerative brake

1) Regenerative brake circuit

The regenerative brake operates when the actual motor speed exceeds the command speed, specifically when the motor decelerates, moves downward along a vertical axis, or applies a brake on an unwinding axis. The regenerative brake generates braking force by absorbing (consuming) the rotation energy of the motor and load using the built-in regenerative resistor on the servo amplifier side.
This operation status is called regenerative operation, and a servo amplifiers generally has a regenerative circuit. The regenerative circuit behaves as a load for the motor in this case, thus the regenerative braking force varies depending on the energy consumption rate of the circuit. In addition, as the amount of the regenerative energy varies depending on the operation conditions, the energy can be consumed in a circuit provided besides the servo amplifier when a large amount of the regenerative energy needs to be consumed.

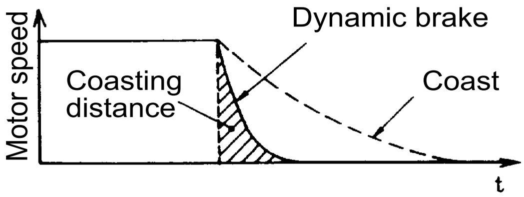
2) Types of regenerative brake circuits

- When a small-capacity model is being used and the regenerative energy is small, regeneration is performed by temporarily charging the smoothing capacitor mentioned above. This is called the capacitor regeneration method, which is to be used for a capacity of approximately 0.4kW or less.
- For a medium-capacity model, current is applied to the resistor so that the energy is consumed as heat. This is called the resistance regeneration method. Note that a larger regenerative energy requires a larger resistor which may affect the peripheral equipment due to the generated heat.
- To make up the above disadvantage of the resistance regeneration method, recently the method that returns the regenerative energy to the power supply has come to be used for a large-capacity model. This is called the power supply regeneration method, which is to be used for a capacity of approximately 11kW or more.

(d) Dynamic brake

If the motor stops by output from the inverter section (base circuit shut-off) at a power failure, alarm occurrence or other occasions, the motor coasts and it takes a long time for the motor to stop completely. This extends the coasting distance, possibly causing malfunctions such as collision with the stroke end.

The dynamic brake is the function that shorts between the servo motor terminals using an appropriate resistor consuming the rotation energy as heat to quickly stop the servo motor at a base circuit shut-off. Although the dynamic brake is normally built in the servo amplifier, it is separated from the servo amplifier of some models such as the MR-C series and the MR-J4 series with a capacity of 11kW or more. In addition, as the dynamic brake does not have power for holding the motor at a stop, mechanical braking at the same time as braking is required to hold the motor when operating a vertical feed.

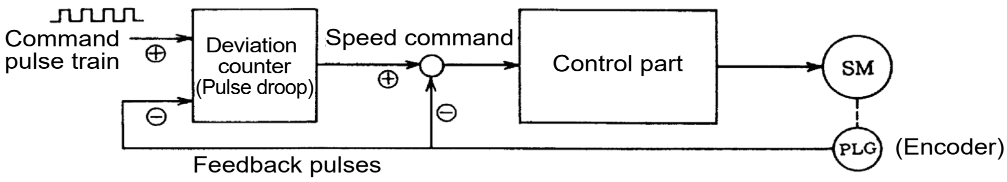


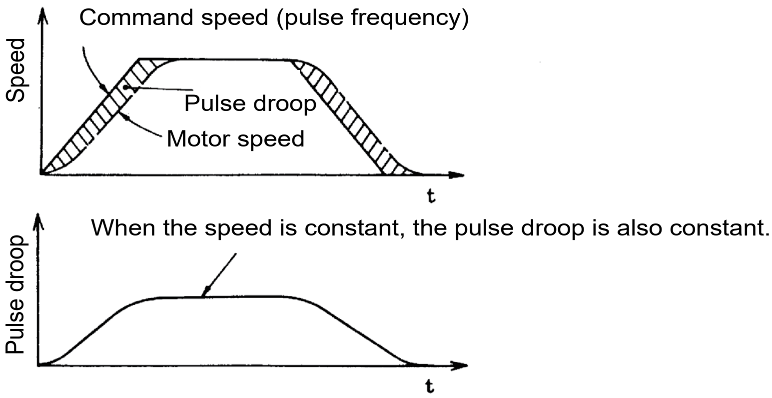
(2) Control circuit section

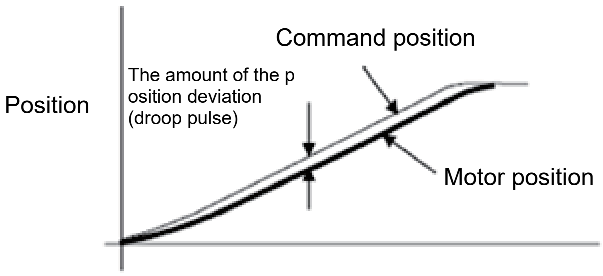
This section calculates the control amount (position, speed, and current) from the command value (target value) and current value very quickly and accurately using a microcomputer, achieving a high-response and accurate servo control. Monitoring of the controlled items and protection of the unit are performed as well. The following explains the brief summary of the controlled items.

(a) Position control

Pulse trains are used to control the motor speed and rotation direction and to execute high-accuracy positioning.







In the positioning section, the motor moves with a slight delay to the command even when the command pulses are input. The pulses equivalent to the delay are accumulated and retained in the deviation counter, and the said pulses are called the droop pulses. The droop pulses are then output to the speed control section as the speed command.

(b) Speed control

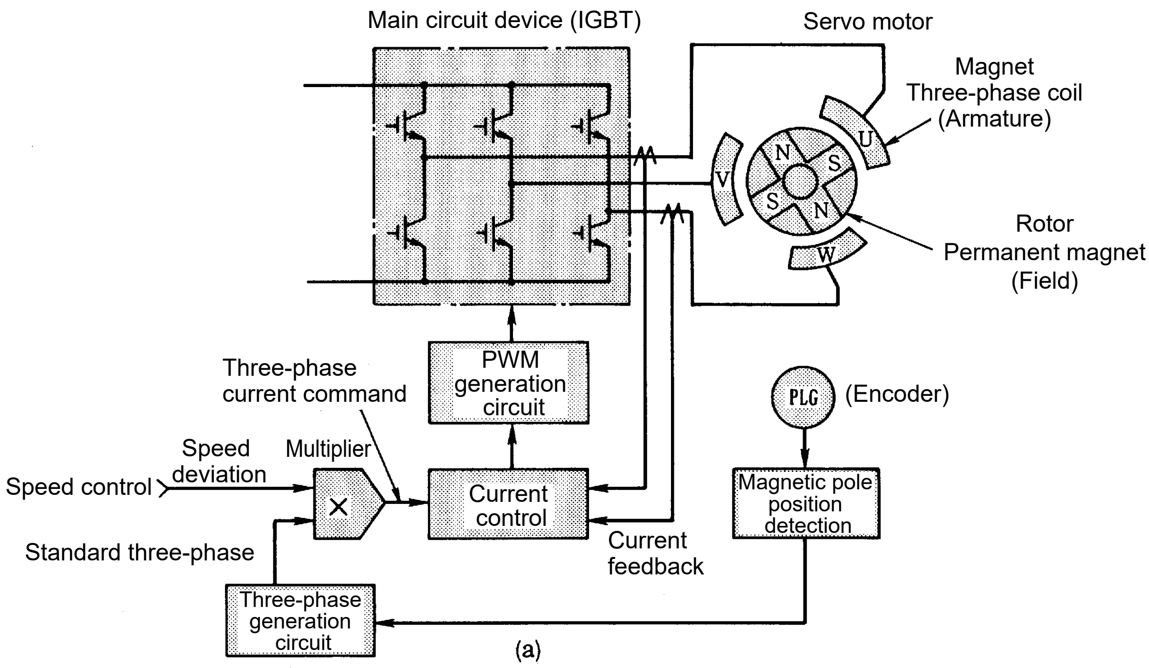
The output from the deviation counter in the position control section is in proportion to the command speed, and thus this output is used as the speed command. The speed command section outputs the deviation between the speed command and motor speed as the current command.

Note that the control signal and analog voltage (0 to ±10V) are input as the speed command from an external device when the motor is operated in the speed control mode.

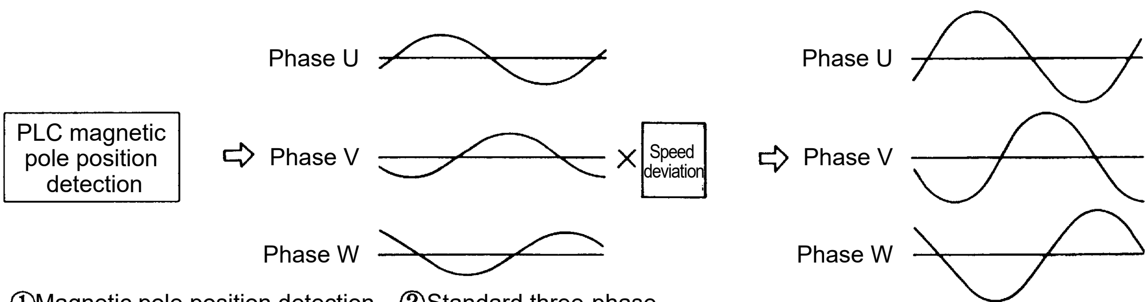
(c) Current control/3-phase generating circuit

The current control section uses the inverter of the main circuit to control the current of the motor so that the motor operates in accordance with the position command or speed command.

For this current control, the phase of the 3-phase AC is determined in accordance with the motor field (which is determined by the position of the permanent magnet of the rotor), then a current corresponding to the speed deviation is applied.



(a)



①Magnetic pole position detection ②Standard three-phase ③Three-phase current command

(b)

Figure 1.8 Current control principle

When a synchronous motor is being used, the phase of the motor current needs to match the position of the field system (magnetic pole position).
Therefore, the motor detector has a signal to detect the magnetic pole position, constantly feeding the position data back to the servo amplifier. With this signal, the servo amplifier generates a reference 3-phase current in the 3-phase generating circuit section. The current control section generates a 3-phase current command by multiplying the reference 3-phase current by the speed deviation to control the PWM circuit.
Note)Induction-type servo motors do not have their own field system. Therefore, they do not need magnetic pole position detection.

The PWM method is the method that generates switching pulses several times per cycle, then changes their pulse widths to change the output voltage. The number of the switching pulses generated per second is called the carrier frequency. When the PWM method is being used, motor vibration and noise of the frequency component in proportion to this carrier frequency will occur.

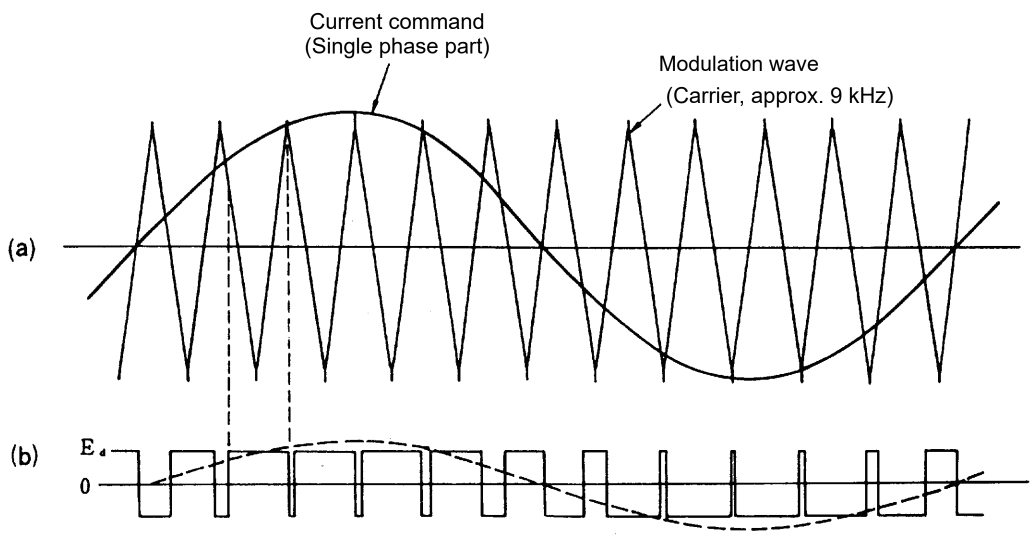


Figure 1.9 PWM control principle

1.4.2 AC servo motor features and operating principle

(1) Features

The output torque of the servo motor is in proportion to the current applied to the motor.
As the servo amplifier controls the servo motor by constantly detecting the motor speed to apply a current in accordance with the speed deviation, the servo motor can be operated with a constant torque from low speed to high speed.
The torque characteristics vary depending on the servo motor model.
The figure in the right shows the torque characteristics of the HK-KT053W.

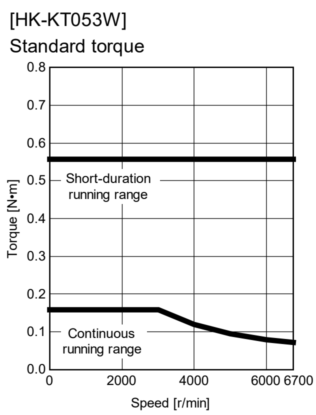
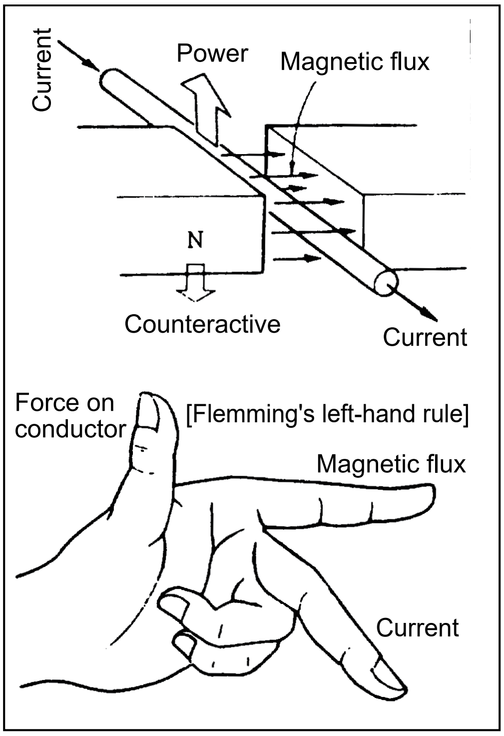
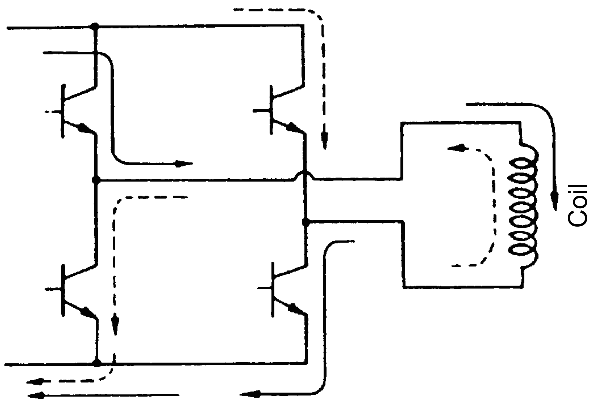


Figure 1.10 The HK-KT053W torque characteristics example

(2) Operating principles
Regardless of the types and sizes, all the motors are operated by the common operating principle which generates torque as indicated by the "Fleming's left hand rule". It simplifies the way of working out the direction of motion where a force acts on a conductor in the magnetic field when a current is applied to the conductor. An SM type (synchronous type) AC servo motor has a permanent magnet in the rotor and windings around the magnet to which a current is applied. It applies a current to the magnet windings in an amount corresponding to the motion of the rotor (rotation speed/direction and output torque).



Motor torque generating principle



SM type AC servo motor operating principle

A current is applied to the winding of the motor windings which is orthogonal to the magnetic flux from the rotor magnet by turning on and off the servo amplifier transistor. The applied voltage is switched at several kHz, and the flowing current is smoothed into a sine wave by the reactance of the winding. The section + and - of the winding voltage are discriminated by the magnetic pole position detection signal output from the detector directly connected to the motor shaft. Moreover, the magnetic flux and current are controlled so that they are always orthogonal to each other. Thus, the SM type AC servo motor does not step out like the general synchronous motors.

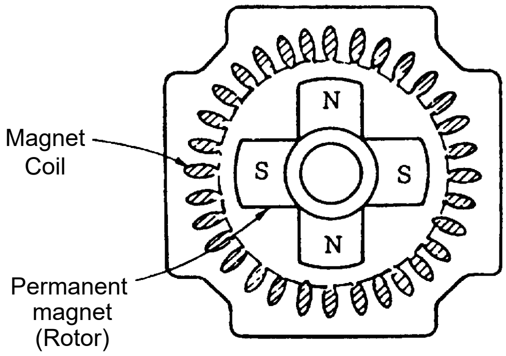


Figure 1.11 Cross-section of an SM type AC servo motor

(3) IM type (induction type) motor (vector control inverter) principle

An induction motor generates torque under the same principle as the synchronous motor.
However, an induction motor does not have a permanent magnet on the rotor side as shown in the cross-section in the right, thus the current Ia and magnetic flux Φ cannot be supplied separately.
Therefore, a current is applied to the magnet winding, then torque is generated using the current that flows in the rotor slits resulting from magnetic induction and the magnetic flux generated by the magnet winding current.
Thus, both the torque current and magnetic flux current are applied to the magnetic windings, and the relation between the currents is as indicated in the expression (1-1).

$I_1 = I_a + I_b$ ·· (1-1)

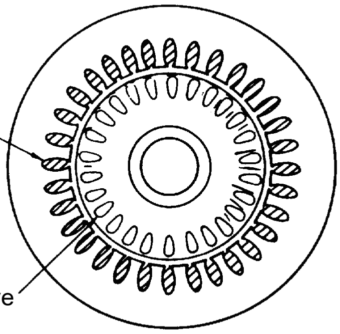


Figure 1.12 Cross-section of an IM type motor

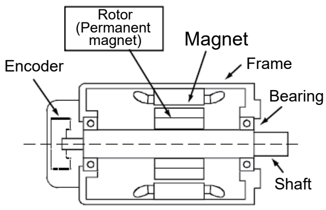
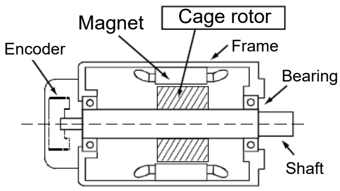
I_1: Magnet winding current I^a: Torque current I^b: Magnetic flux current
* The above expression indicates the vectorial sum, not arithmetical.

Therefore, an IM motor needs to control the two types of currents separately, and this control is called the vector control.
An IM type motor with the vector control has the same torque characteristics as a servo motor.

(4) Servo motor types and features

Servo motors are classified into AC servo and DC servo. The AC servo is further classified into an SM type (synchronous motor) and IM type (induction motor). Table 1.2 shows the servo motor structure and features.

Table 1.2

Type	Structure	Feature	
		Advantage	Disadvantage
SM type AC servo motor		●Maintenance-free ●Good environmental durability ●Capable of large-torque operation ●Capable of dynamic braking at a power failure ●Small-sized and lightweight ●High power rate	●Its servo amplifier is rather more complicated than for a DC motor. ●One motor requires one servo amplifier. ●The magnet may be demagnetized.
IM type motor		●Maintenance-free ●Good environmental durability ●Capable of high-speed and large-torque operation ●Efficient for large-capacity models ●Sturdy structure	●Its servo amplifier is rather more complicated than for a DC motor. ●Braking at a power failure is unavailable. ●Variable characteristics depending on the temperature ●One motor requires one servo amplifier.

1.4.3 Encoder functions and operating principle

Servo control feeds back the actual value (motor speed and position) relative to the command value to reduce the deviation between these values.
Therefore, a detector is an essential element of a servo system.

(1) Encoder structure
The following shows the structure of an encoder that is mainly used as a detector.

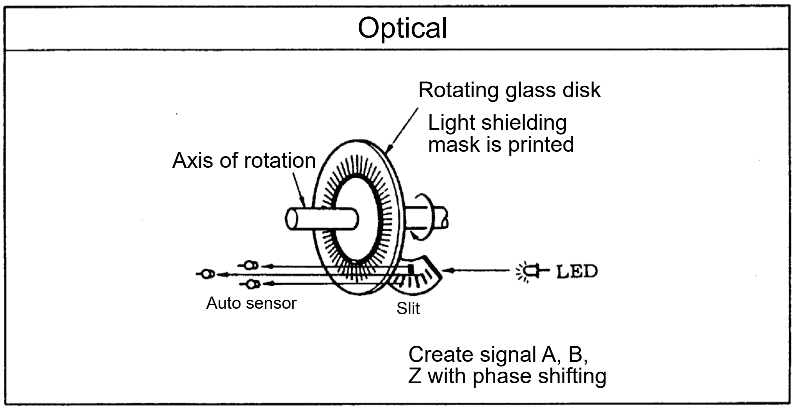


Figure 1.13 Encoder structure

(2) Encoder functions and signal types
The functions of an encoder installed in a servo motor are roughly classified into three categories as follows:

1) Detecting motor position (including rotation direction)
2) Detecting motor speed (including rotation direction)
3) Detecting motor magnetic pole position (unnecessary for an IM type motor and a DC servo motor)

1) and 2) of the above functions use 2-phase pulses which are output incrementally as the motor rotates.

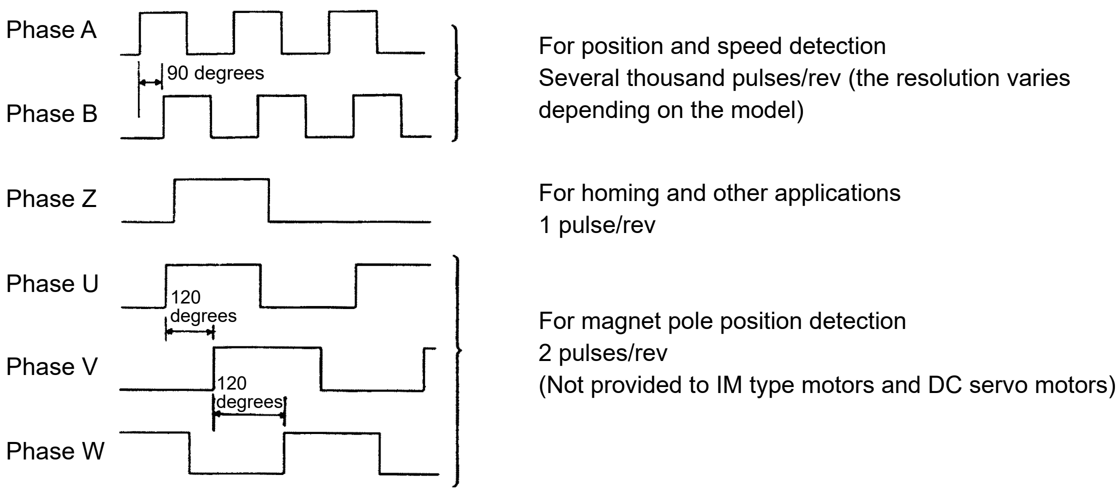
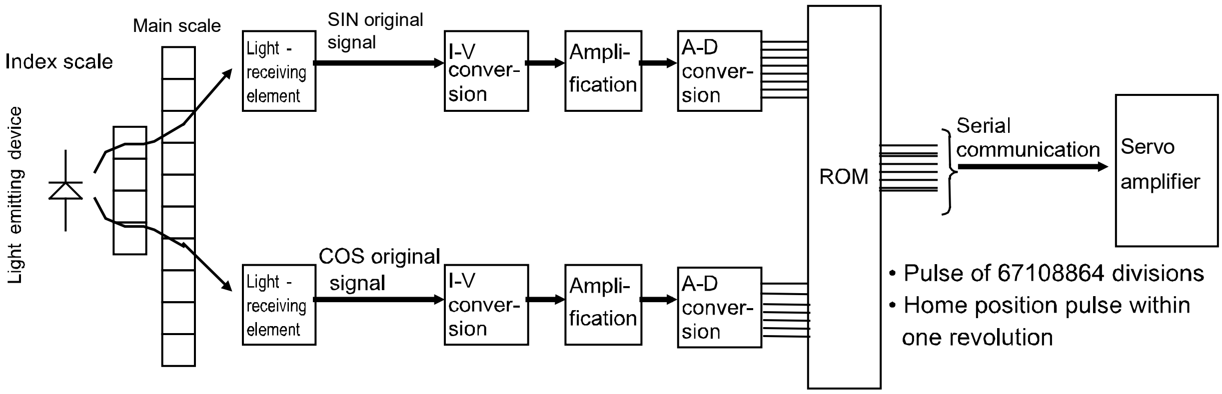
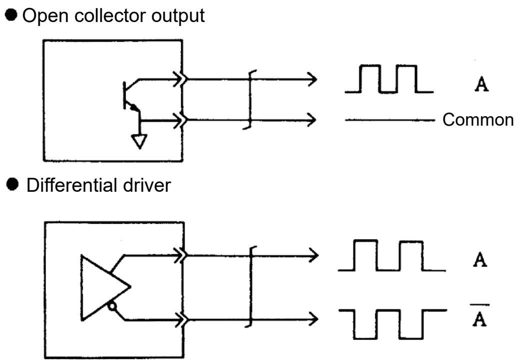


Figure 1.14 Encoder signal

Encoders installed in recent models of AC servo motors generate pulses of 67108864 divisions and home position pulses within one revolution using the SIN original signal and COS original signal as shown below. Then, the data of the generated pulses are transferred using the serial communication method, which transfers data to the servo amplifier via serial communication.



(3) Encoder signal interface
While the encoder signal from the servo motor to the servo amplifier is serialized, the encoder signal from the servo amplifier is pulsed to be output.
There are two types of encoder output signal interfaces as shown below. The recent mainstream is the differential driver output method which performs secure signal transfer. Refer to section 5.4 "Positioning Command Interface" for details.



At a long-distance transfer, susceptible to noise and the waveform is easy to get rounded.

Capable of transfer at a high-frequency. Robust to noise.

Figure 1.15 Types of interfaces

(4) Absolute position encoder

An absolute position encoder is often installed in the motor recently to configure an absolute position detection system which does not require homing after a power failure, for purposes such as improving the takt time. When an absolute position detection system is being used, the rotation position at power-on needs to be found. Thus, as shown in the figure in the right, the absolute position signal (7-bit signal for the case shown in the figure) is output in addition to the incremental signals (A and B) mentioned in section (2). When an absolute position detection system is being used, the rotation position at power-on needs to be found. Thus, as shown in the figure in the right, the absolute position signal (7-bit signal for the case shown in the figure) is output in addition to the incremental signals (A and B) mentioned in section (2).

The block diagram of an absolute position detection system is shown below.

* Besides the increment signals (A and B) mentioned above, the memory of the absolute position detector backs up the data of an absolute position within one revolution and the counter for the motor rotation amount from the home position. Therefore, once the position is determined by homing, the servo amplifier and controller can always find the motor position even if the power is turned off. This allows position and speed control to be executed without homing when the power is turned on for the second time or later

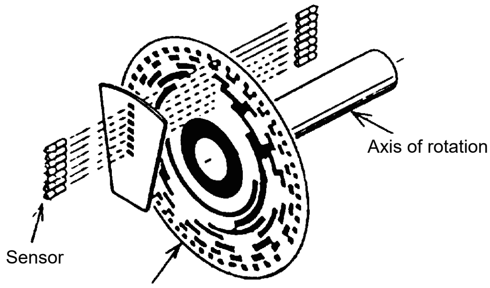


Figure 1.16 Structure example of an absolute position encoder

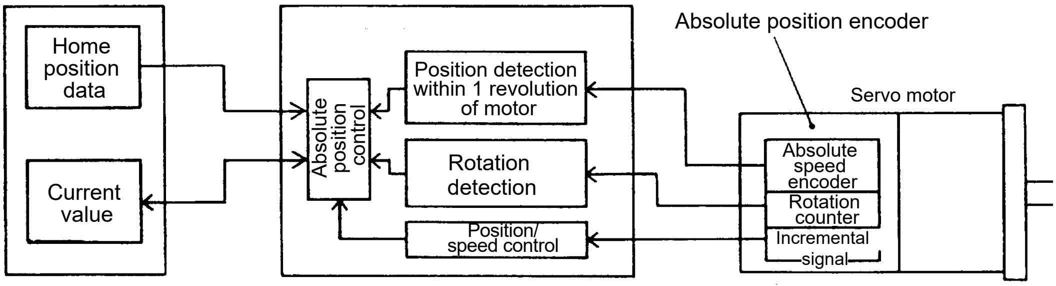


Figure 1.17 Block diagram of an absolute position detection system

(5) Adopting higher resolution encoders

26-bit (67, 108, and 864) absolute position encoders are adopted to the MELSERVO-J5 series servo motors with any capacity as the standard encoders.

Adopting higher resolution encoders enables improvement in various conditions such as response frequency, speed feedback accuracy at a low speed, position accuracy, and smoothness of movement relative to the commands.

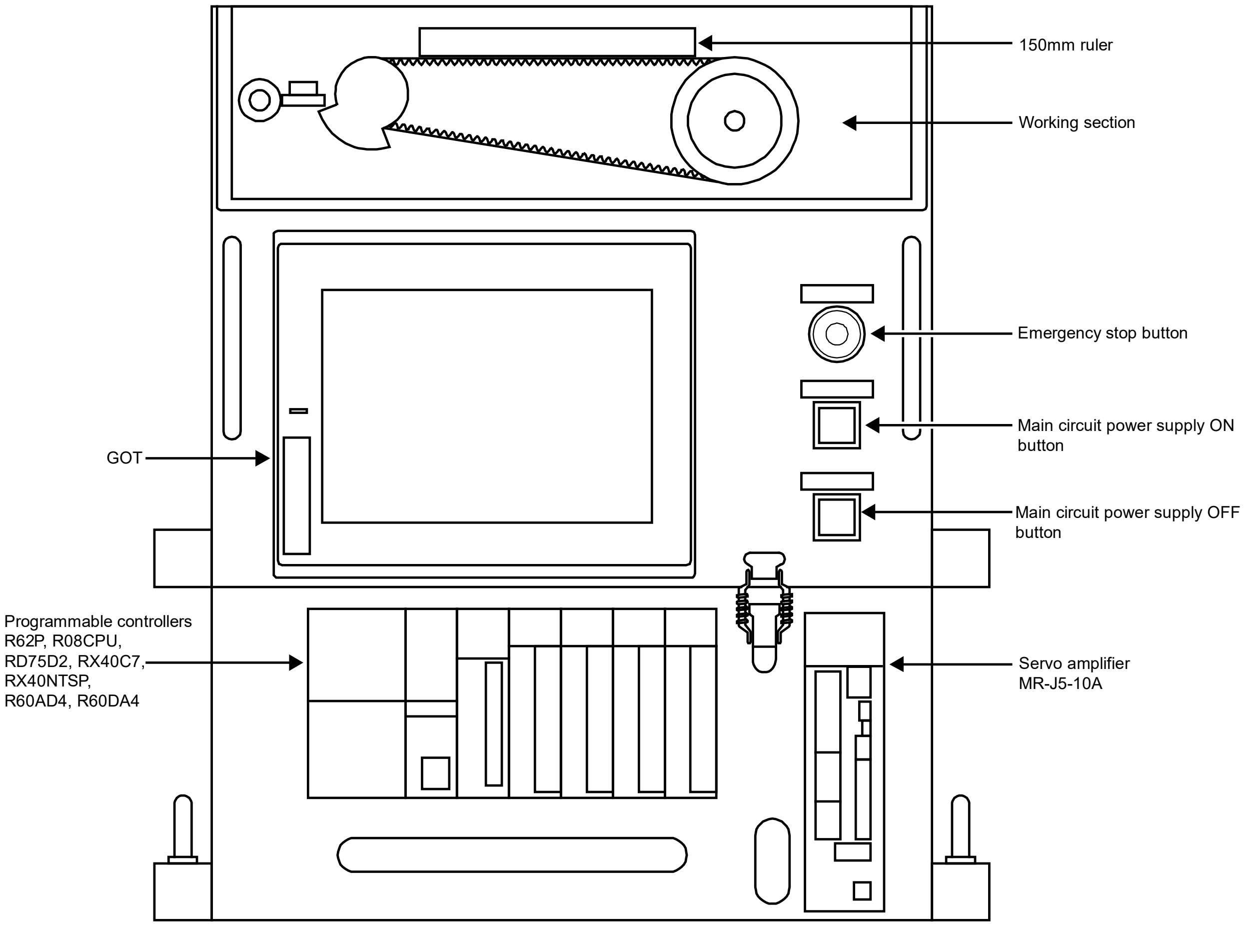
■Standardizing higher resolution encoders 13bit(8192), 14bit(16384) ⇒ 17bit(131072) ⇒ 18bit(262144) ⇒ 22bit(4194304) ⇒ 26bit(67108864)

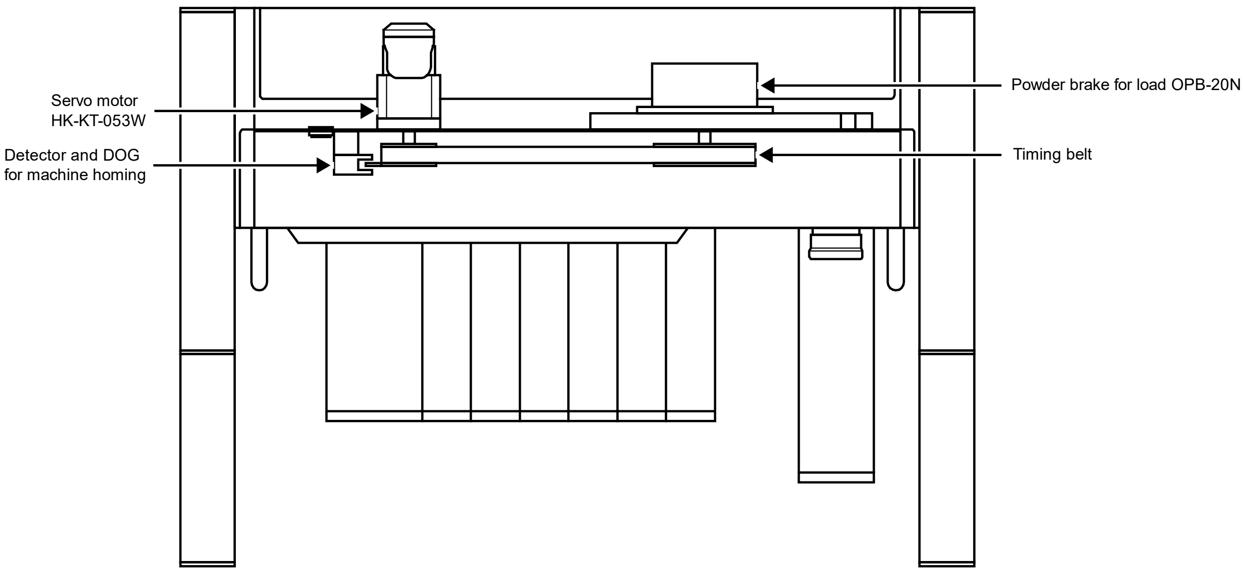
Memo

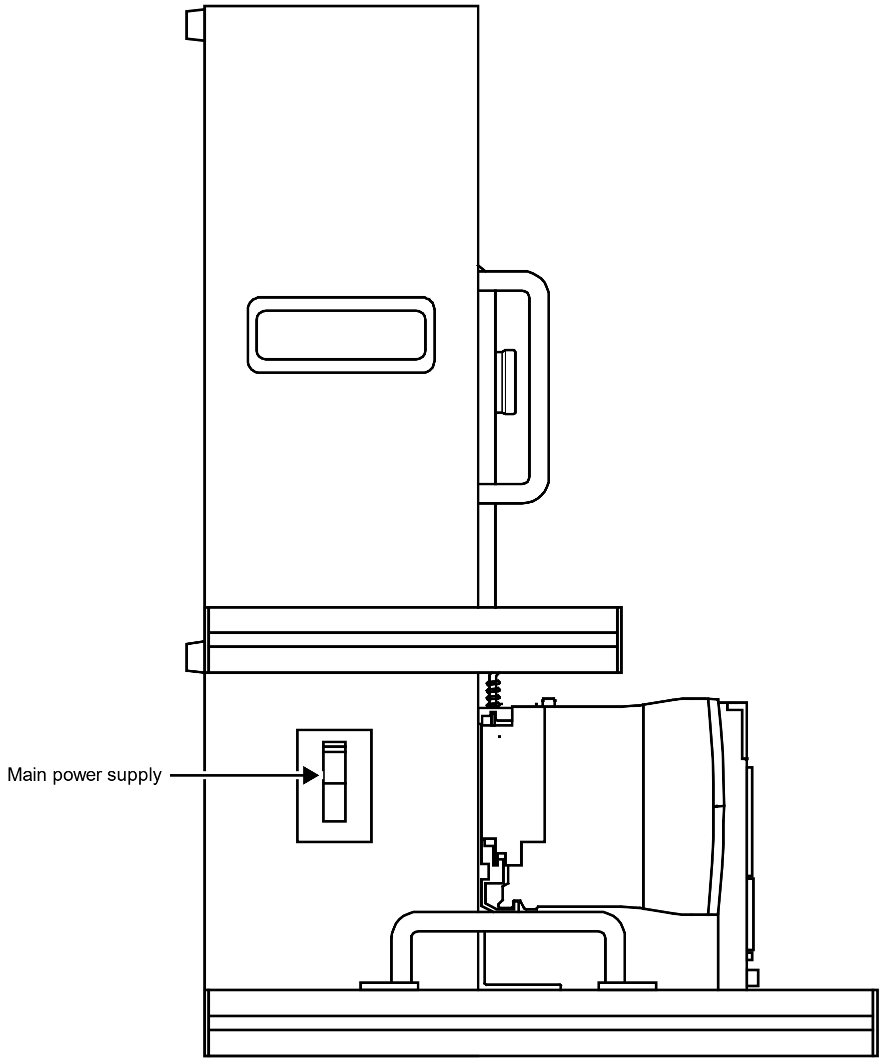
2 MELSERVO-J5 BASICS

2.1 Outline of AC Servo Training Apparatus

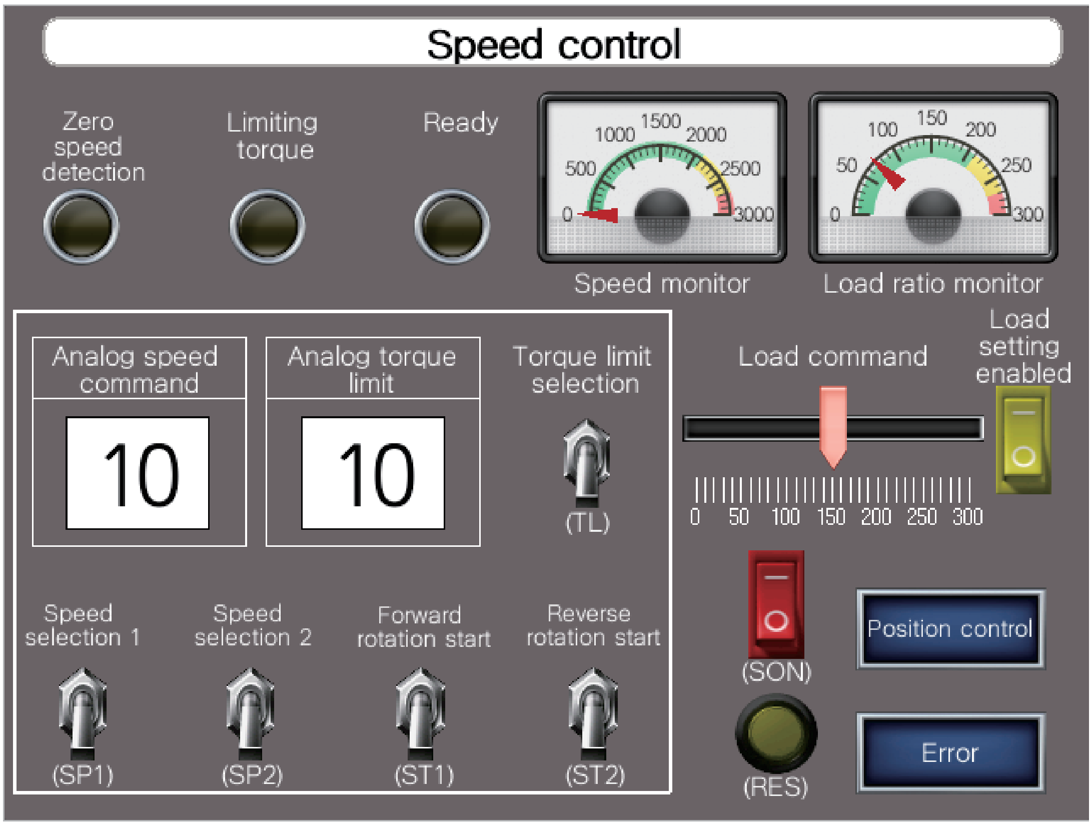
2.1.1 Demonstration machine appearance and architecture

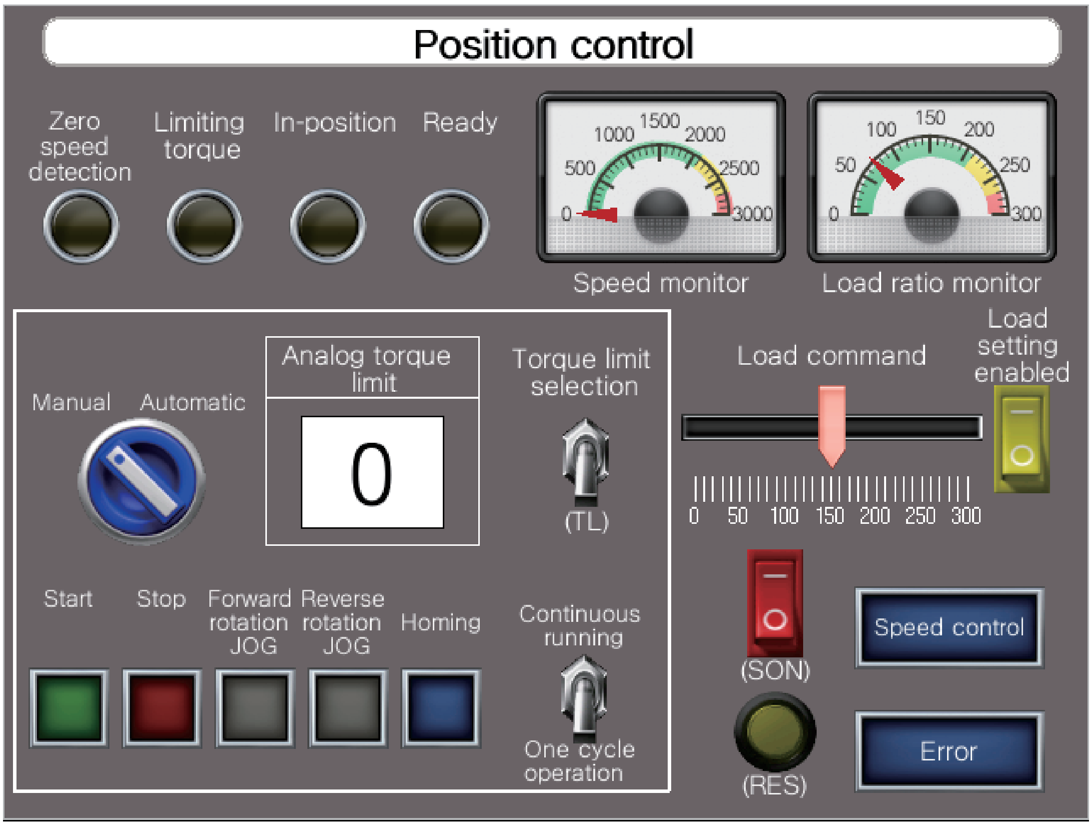





Main power supply

2.1.2 GOT display

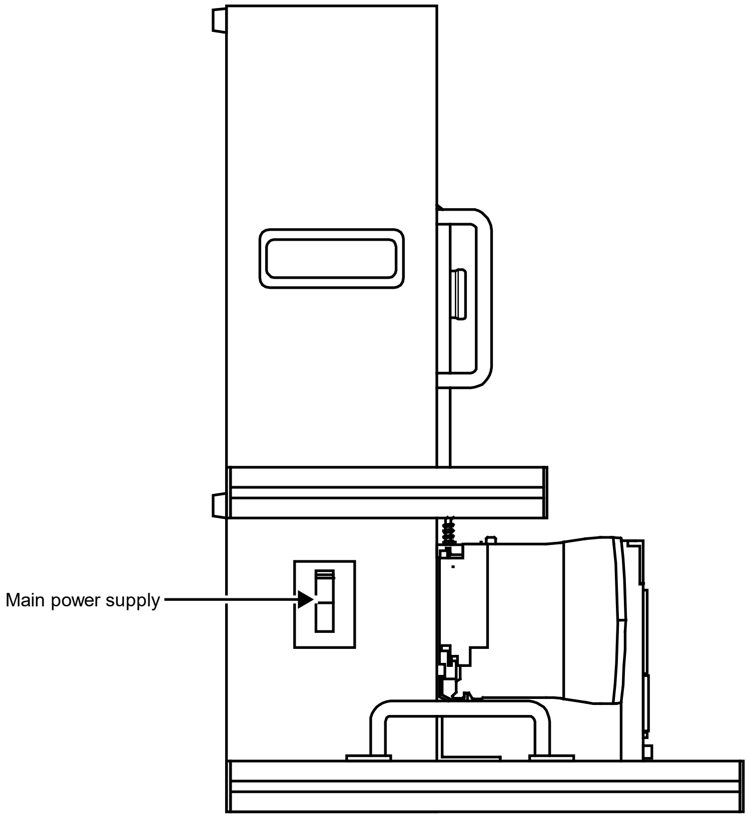




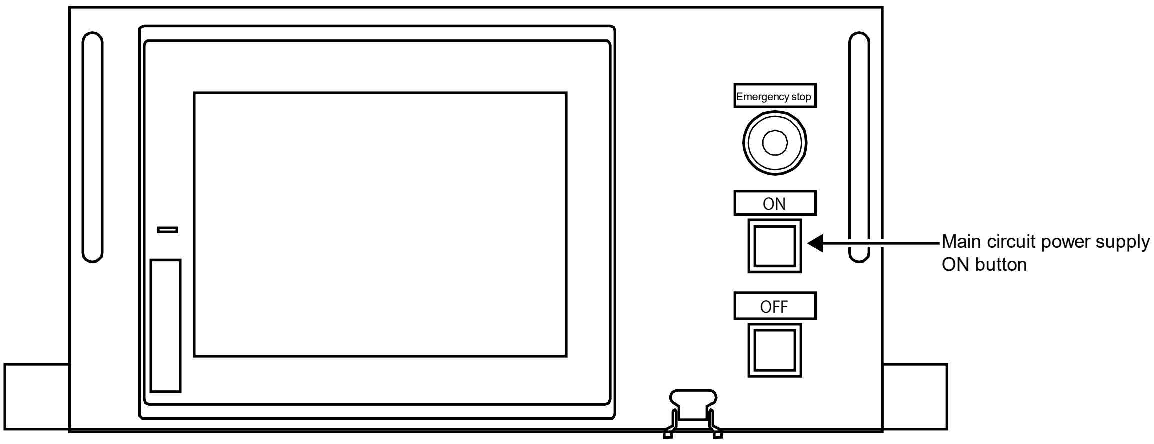
2.1.3 Power-on

1. Connect the supplied 100V AC cable to the socket in accordance with the shape of the socket (two-pole parallel or two-pole parallel with grounding).

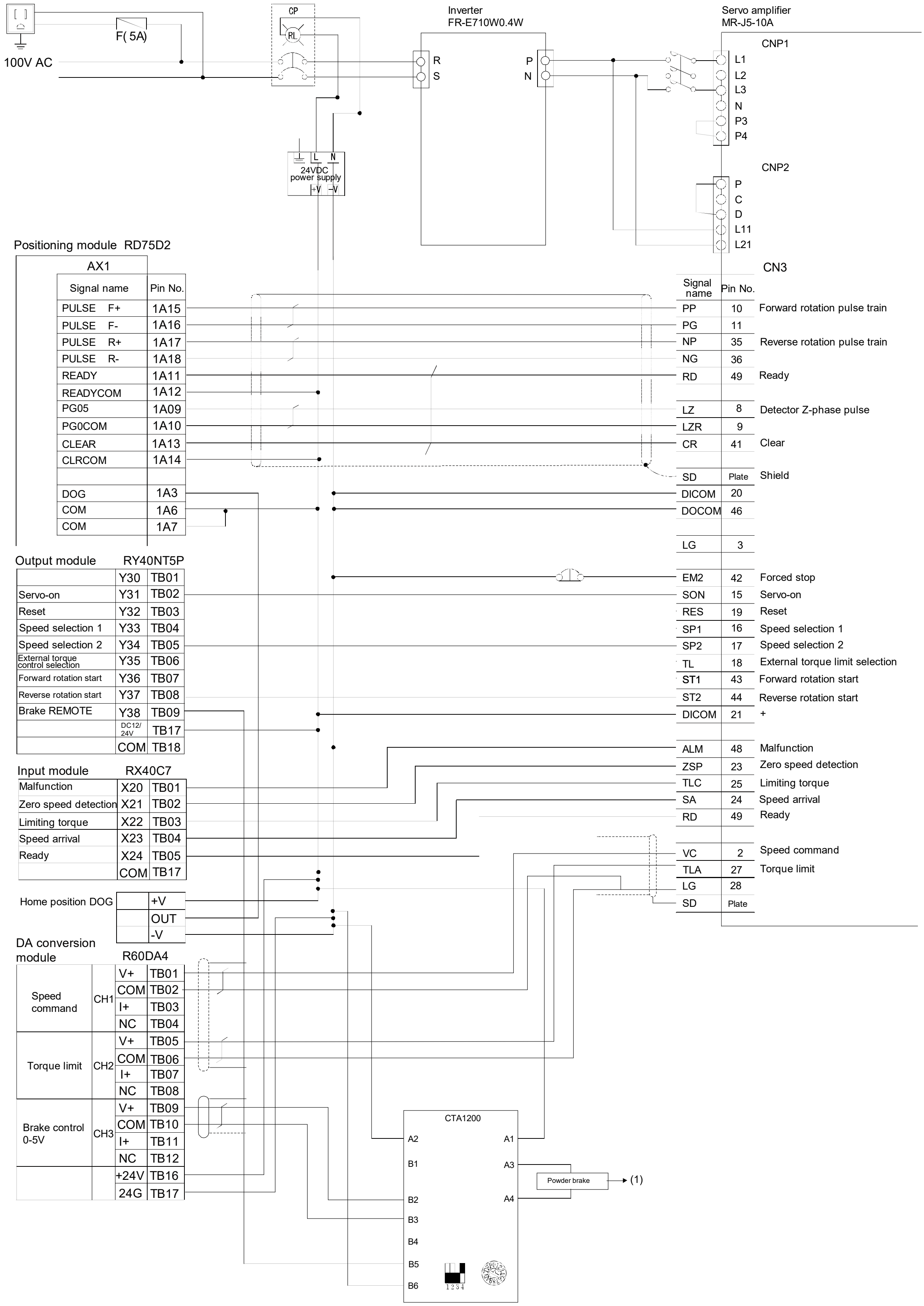
2. Turn on the main power.

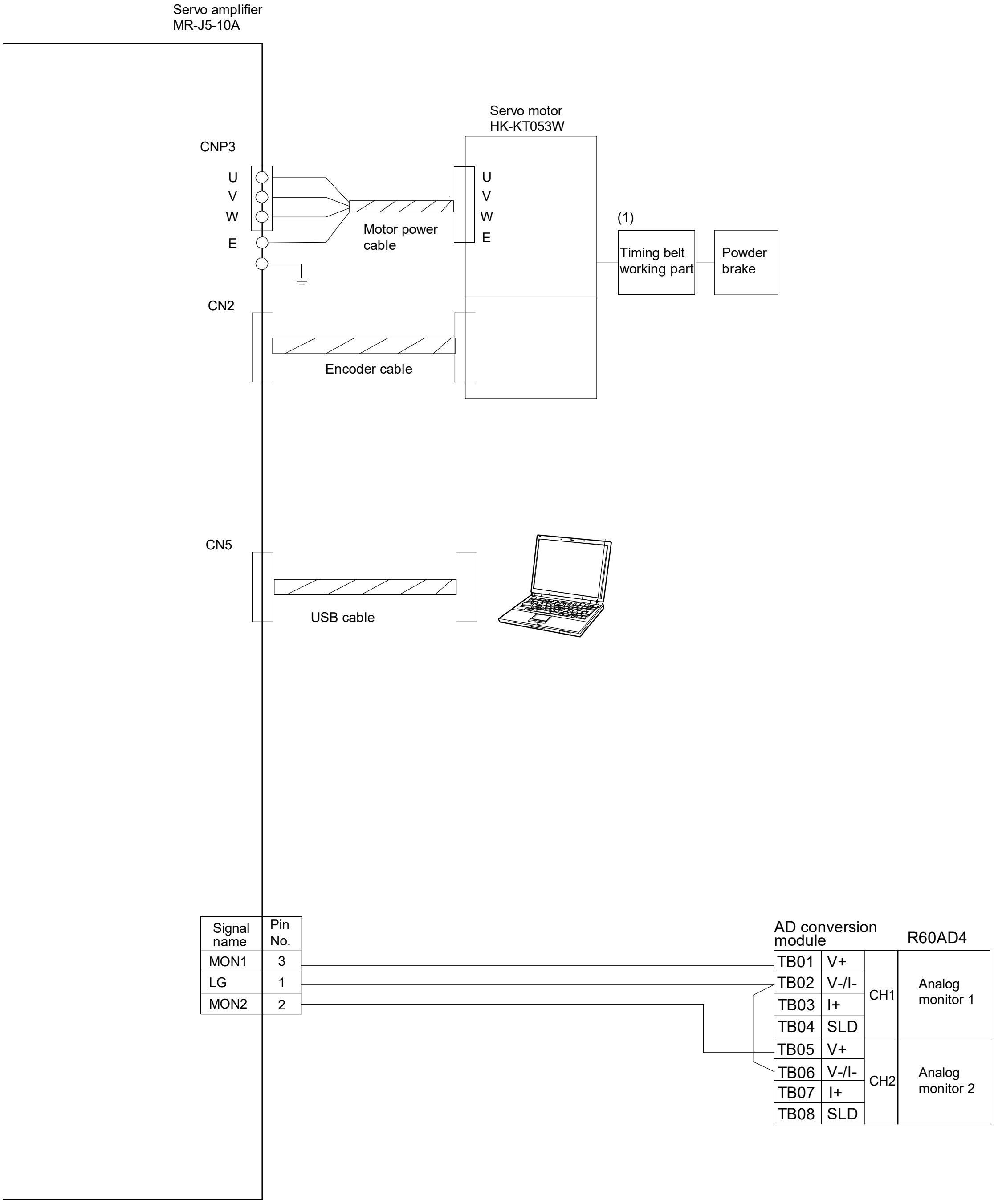


3. Press the main circuit power supply ON button. Power will be supplied to the main circuit of the servo amplifier.



2.1.4 Demonstration machine connections




Servo amplifier
MR-J5-10A
CNP3
U
V
W
E
Motor power cable
Servo motor
HK-KT053W
U
V
W
E
(1)
Timing belt working part
Powder brake
CN2
Encoder cable
CN5
USB cable
Signal name
Pin No.
MON1
3
LG
1
MON2
2
AD conversion module
R60AD4
TB01 V+
TB02 V-/I-
TB03 I+
TB04 SLD
CH1
Analog monitor 1
TB05 V+
TB06 V-/I-
TB07 I+
TB08 SLD
CH2
Analog monitor 2

2.2 Function List

The following tables list the functions of the MR-J5-A.

(1) Control mode

Subcategory	Function	Description	Supported software version
Pulse/analog/ DI command	Position control mode (P) (Pulse train input)	This function operates the servo motor in the position control mode by the pulse train input.	A0
	Speed control mode (S) (Internal speed/analog speed command)	This function operates the servo motor in the speed control mode by the internal speed command or analog speed command.	A0
	Torque control mode (T) (Analog torque command)	This function operates the servo motor in the torque control mode by the analog torque command.	A0
Test operation	Test operation mode	This function requires MR Configurator2 for JOG operation, positioning operation, motor-less operation, DO forced output and program operation.	A0

(2) Drive motor

Subcategory	Function	Description	Supported software version
Universal drive	Linear servo motor	Using the linear servo motor and linear encoder enables the linear servo system to be configured.	A0
	Direct drive motor	Using this function enables the direct drive servo system to be configured to drive the direct drive motor.	A0
Encoder	High-resolution encoder	A 67108864 pulses/rev high-resolution encoder is used for the encoder of the rotary servo motor.	A0
	Batteryless absolute position encoder	The rotation position of the servo motor can be backed up without the battery. Using the servo motor with this encoder enables an absolute value detection system to be configured without battery.	A0

(3) Position detection

Subcategory	Function	Description	Supported software version
Control method	Semi closed loop system	This function uses the servo motor encoder to configure semi closed loop systems.	A0
	Fully closed loop system	This function uses the load-side encoder to configure fully closed loop systems.	A5
Absolute position	Absolute position detection system	This function does not require homing at every power-on as long as homing is performed once.	A0

(4) Operation function

Subcategory	Function	Description	Supported software version
Stop function	Stroke limit function	This function uses LSP (Forward rotation stroke end) and LSN (Reverse rotation stroke end) to limit the travel interval of the servo motor.	A0
Command generation	Command pulse selection	The command pulse train input form can be selected from among three different types.	A0
	Rotation/travel direction selection	This function sets the rotation direction of the servo motor without changing the command polarity.	A0
	Electronic gear	This function performs positioning control with the value obtained by multiplying the position command from the upper controller by a set electronic gear ratio.	A0
	Acceleration/deceleration function	This function sets acceleration and deceleration time constants.	A0
	S-pattern acceleration/deceleration time constants	This function performs smooth acceleration and deceleration.	A0
	Torque limit	This function limits the servo motor torque.	A0
	Speed limit	This function limits the servo motor speed in the torque control mode.	A0

(5) Control function

Subcategory	Function	Description	Supported software version
Vibration suppression	Advanced vibration suppression control II	This function suppresses vibration and residual vibration at an arm end.	A0
	Machine resonance suppression filter	This function decreases the gain of the specific frequency to suppress the resonance of the mechanical system.	A0
	Shaft resonance suppression filter	When driving the servo motor with a load mounted to the servo motor shaft, resonance due to shaft torsion may generate high frequency mechanical vibration. The shaft resonance suppression filter suppresses this vibration.	A0
	Robust filter	This function improves disturbance response when response performance cannot be increased because of a large load to motor inertia ratio, such as a roll feed axis.	A0
	Slight vibration suppression control	This function suppresses vibration of ±1 pulse generated at each servo motor stop.	A0
Tracking control	Lost motion compensation function	This function reduces the response delay generated when the machine moving direction is reversed.	A0
	Super trace control	This function reduces the droop pulses at the rated speed and at the uniform acceleration/deceleration to almost zero.	A5
	Path tracking model adaptive control	This function reduces tracking errors in reciprocation.	A0

(6) Adjustment function

Subcategory	Function	Description	Supported software version
Automatic adjustment	Quick tuning	This function automatically adjusts the gain at servo-on in a short time without acceleration/deceleration operation of the servo motor. Response without overshoot is possible, saving gain adjustment time.	A0
	Auto tuning	This function automatically adjusts the gain to an optimum value even if the load applied to the servo motor shaft varies.	A0
	One-touch tuning	Gain adjustment is performed with this function just by pressing buttons on the servo amplifier or by clicking a button once on MR Configurator2.	A0
Custom adjustment	Model adaptive control	This function enables stable and highly responsive control according to the ideal model. This is a two-degrees-of-freedom model and can adjust responses to commands and disturbances separately. This function can also be disabled.	A0
	Gain switching function	This function switches gains during rotation and during stop, and uses an input device to switch gains during operation. It supports the gain switching by rotation direction and the 3-step gain switching. Therefore, more detailed gain switching is available.	A0
Adjustment support	Machine analyzer	This function analyzes the frequency characteristic of the mechanical system by simply connecting the servo amplifier with an MR Configurator2 installed personal computer.	A0

(7) I/O, monitor

Subcategory	Function	Description	Supported software version
DI/DO	Input signal selection (device selection)	This function assigns input devices such as LSP (Forward rotation stroke end) to certain pins of the connector.	A0
	Output signal selection (device setting)	This function assigns output devices such as MBR (Electromagnetic brake interlock) to certain pins of the connector.	A0
	Output signal (DO) forced output	This function forcibly switches the output signals on and off regardless of the servo status. Use this function for purposes such as checking output signal wiring.	A0
	External I/O signal display	This function shows the on/off status of external I/O signals on the display.	A0
	A/B/Z-phase output	This function outputs the positions of the encoder and linear encoder in the A/B/Z-phase signal.	A0
LED	Status display	This function shows the servo status on the 7-segment LED display.	A0
Analog input/output	Analog command input automatic offset	Voltage is automatically offset to stop the servo motor if it does not come to a stop when an analog input such as VC (Analog speed command) or VLA (Analog speed limit) is 0V.	A0
	High-resolution analog input	When using the MR-J5-A-RJ, the analog input resolution is 16 bits.	A0
	Analog monitor	This function outputs the servo status in voltage in real time.	A0
Monitor	Power monitoring function	This function calculates the running power and the regenerative power from the data in the servo amplifier such as speed and current. The power consumption and other values are displayed on MR Configurator2.	A0

(8) Option

Subcategory	Function	Description	Supported software version
Regenerative capacity enhancement	Simple converter	This function enables servo amplifiers to be used in a common bus connection. Utilizing the regenerative power contributes to energy-conservation. In addition, it decreases the number of circuit breakers and magnetic contactors.	A0
	Regenerative option	Use this function if the built-in regenerative resistor of the servo amplifier does not have sufficient regenerative capacity for the generated regenerative power.	A0

(9) Engineering tool

Subcategory	Function	Description	Supported software version
Setup software	MR Configurator2	This function performs settings (such as servo parameter settings), test operation, and monitoring with a personal computer.	A0

(10) Protective functions

Subcategory	Function	Description	Supported software version
Alarm	Alarm function	This function displays an alarm or warning when an error occurs during operation. If an alarm occurs, ALM (Malfunction) turns off and stops the servo motor. If a warning occurs, WNG (Warning) will turn on. The servo motor may stop or continue operation depending on the warning.	A0
	Alarm history clear	This function clears alarm history.	A0
Power error detection	Disconnection detection function	This function detects a disconnection in the main circuit power supply input and the servo motor power supply output.	A0
Coasting distance reduction	Forced stop deceleration function	This function decelerates the servo motor to a stop at EM2 off or when there is an alarm.	A0
Drop protection	Electromagnetic brake interlock function	This function operates the electromagnetic brake at servo off and error occurrence, and prevents the vertical axis from dropping.	A0
	Vertical axis freefall prevention function	This function moves the axis up by the mechanical backlash amount of the electromagnetic brake to prevent damage to machines.	A0
Braking protection	Dynamic brake	During the power shut-off and alarm occurrence, this function shorts between U, V, and W phases and operates the brake.	A0

(11) Functional safety

Subcategory	Function	Description	Supported software version
Single servo amplifier function	STO function	This servo amplifier supports the STO function for functional safety as per IEC/EN61800-5-2. This allows a safety system to be easily configured for the equipment.	A0

(12) Instantaneous power failure measures

Subcategory	Function	Description	Supported software version
Tough drive	SEMI-F47 function	This function uses the electrical energy charged in the capacitor to avoid triggering [AL.010 Undervoltage] in case that an instantaneous power failure occurs during operation. Use a 3-phase power supply for the input power supply of the servo amplifier. Using a 1-phase 200V AC for the input power supply will not comply with SEMI-F47 standard.	A0
	Tough drive function	This function makes the equipment continue operating even under conditions where an alarm would normally occur. There are two types of tough drive function: the vibration tough drive and the instantaneous power failure tough drive.	A0

(13) Diagnosis

Subcategory	Function	Description	Supported software version
Drive data diagnosis	Drive recorder	This function continuously monitors the servo status and records the state transition before and after an alarm for a fixed period of time. The recorded data can be checked by the Waveform-Display button in the drive recorder window of MR Configurator2 being clicked. However, the drive recorder is not available when: • The graph function of MR Configurator2 is being used. • The machine analyzer function is being used. • [Pr.PF21] is set to "-1". • The controller is not connected (except the test operation mode). • The long-term sampling is supported at an occurrence of a controller-related alarm, and various alarms can be handled.	A0
	Graph function	This function obtains the servo status in the graph.	A0
Failure diagnosis	Encoder communication diagnosis function	This function diagnoses with MR Configurator2 whether the encoder communication error is caused by the circuit malfunction of the servo amplifier or by the malfunction of the cables/encoder.	A0
Service life diagnosis	Servo amplifier life diagnosis function	This function enables checking of the cumulative energization time, the number of times the inrush relay has been turned on/off, and the number of times the dynamic brake has been used. It gives an indication of the replacement time for parts on the servo amplifier with a service life (such as the capacitor and the relay) before they malfunction. MR Configurator2 is required for this function.	A0
	Motor life diagnosis function	This function predicts failures of the equipment and the servo motor based on the machine total travel distance. It gives an indication of the replacement time for the servo motor.	A0
	Machine diagnosis function	This function uses the data in the servo amplifier to estimate the friction and vibrational component of the drive system in the equipment and to recognize an error in machine parts such as ball screws and bearings.	A0
		This function automatically sets the threshold used for detecting the error of machine parts such as ball screws and bearings. It outputs the warning when the friction, vibrational component, and total revolution of the servo motor are out of the set threshold. The error in the machine parts such as ball screws and bearings can be detected automatically.	A0
		This function estimates the friction of gear and loosening of belt drive function (decrease in the belt tension), and detects errors in the gear and belt.	A0
System diagnosis	System configuration information	This function uses MR Configurator2 to monitor the servo amplifier model, connected servo motor, encoder, and other information.	A0

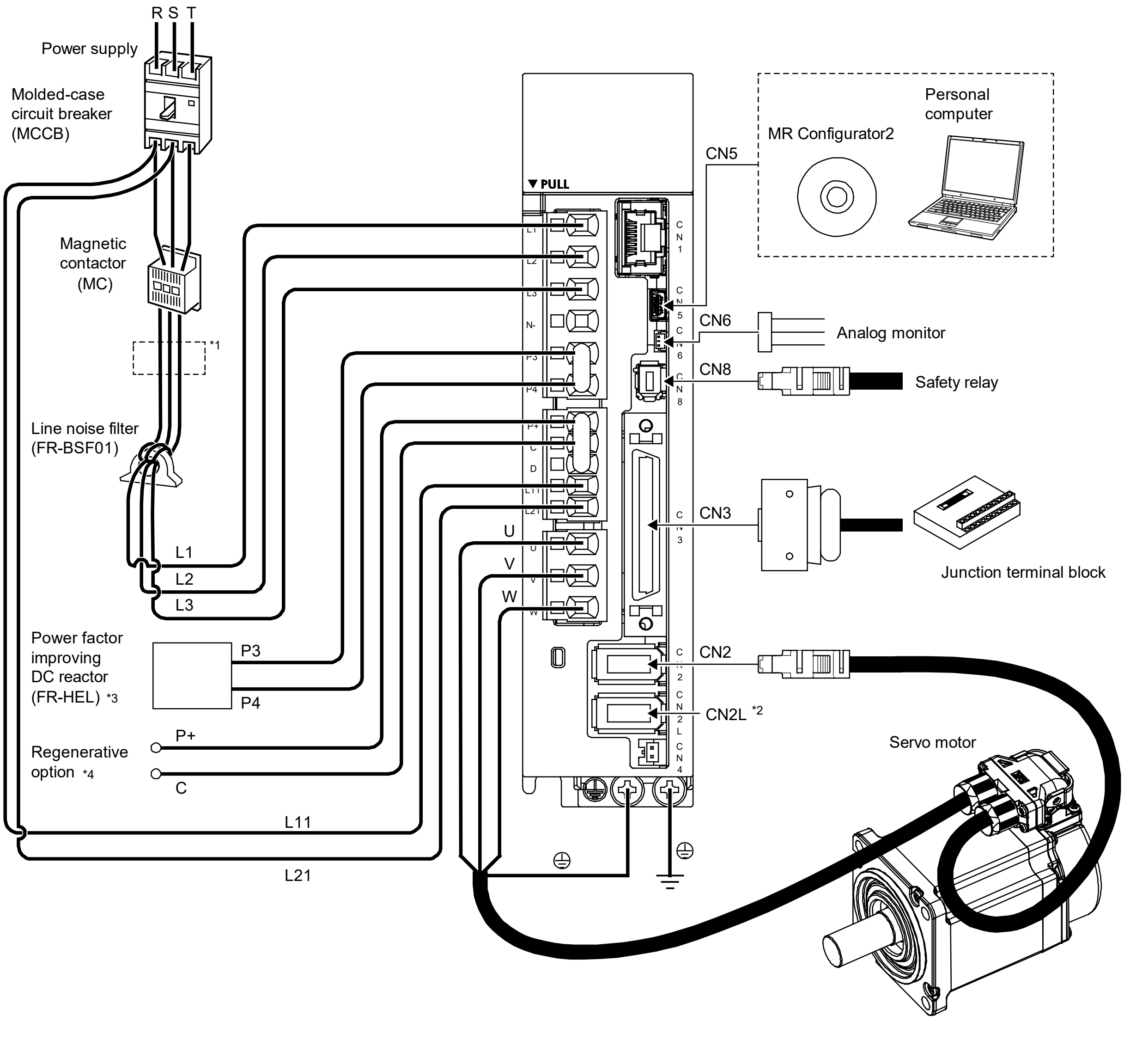
(14) History

Subcategory	Function	Description	Supported software version
−	Alarm history	This function saves information of the alarm that occurred in the servo amplifier. The information is saved in chronological order and used for occasions such as identifying the cause of the alarm.	A0

2.3 Configuration Including Peripheral Equipment

The MR-J5 series servo amplifiers are designed so that all the operations such as connection with external devices, monitoring/diagnosis, and parameter settings can be performed at the front of the servo amplifiers. Thus, the said operations are possible even if servo amplifiers are installed in the cabinet.

The following is an example using the MR-J5-20A-RJ.



*1. The power factor improving AC reactor can also be used. In this case, the power factor improving DC reactor cannot be used.

*2. This is for the MR-J5-_A-RJ servo amplifier. The MR-J5-_A servo amplifier does not have a CN2L connector. If using the MR-J5-_A-RJ servo amplifier in a linear servo system or a fully closed loop system, connect an external encoder to this connector. Refer to "Parts identification" in the MR-J5 User's Manual (Introduction) for the compatible external encoders.

*3. P3 and P4 are connected from the factory. Remove the short-circuit bar between P3 and P4 before connecting a power factor improving DC reactor. Additionally, the power factor improving DC reactor and a power factor improving AC reactor cannot be used together. Refer to section 9.3.3 (1) Power factor improving DC reactor for details.

*4. Connect P+ and D terminals. P+ and D are connected from the factory. Refer to "Regenerative option" in the MR-J5 User's Manual (Hardware) when using a regenerative option.

2.4 Installation and Wiring

Precautions

- Before starting operation, check each parameter. Depending on the machine, an unexpected operation may occur.
- The radiator and regenerative resistor of the servo amplifier, servo motor, and other parts may become hot while the power is turned on and for a while after the power is turned off. Take safety measures such as providing covers to prevent operators' hands or components (such as cables) from accidentally touching the hot area. Not doing so may cause a burn injury and component damages.
- Never touch the rotor of the servo motor during operation. Doing so may cause an injury.

2.4.1 Turning on servo amplifier for the first time

When turning on the servo amplifier for the first time, follow the steps below.

Installation and wiring	Install and wire the servo amplifier and servo motor.
↓	
Test operation of the servo motor alone in test operation mode	With the servo motor disconnected from the machine, operate the servo motor at the lowest speed possible, and check whether the servo motor operates correctly.
↓	
Equipment configuration settings	Set each servo parameter according to the equipment configuration.
↓	
Controller-related settings	Perform necessary settings according to commands from the controller.
↓	
Operation by controller command	Operate the servo motor at the lowest speed possible by giving commands to the servo amplifier from the controller, and check whether the servo motor operates correctly.
↓	
Actual operation	

2.4.2 Installation

Precautions

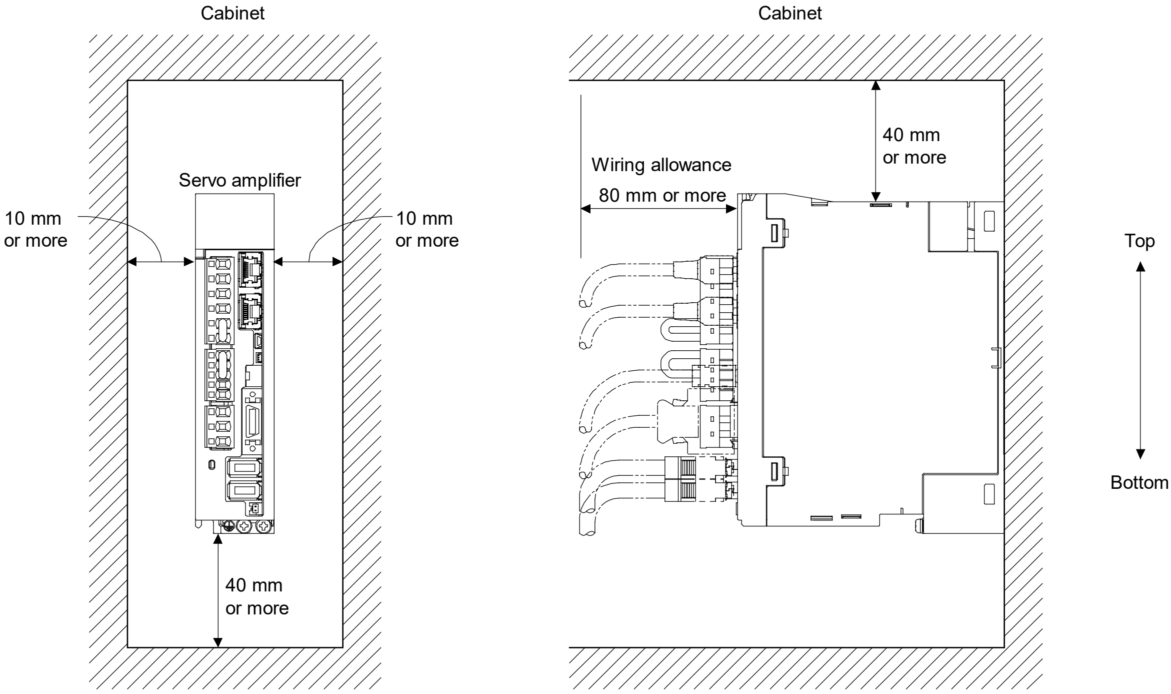
- Install the servo amplifier and regenerative resistor on incombustible material. Installing them either directly on or near combustibles may lead to smoke or a fire. In addition, the servo amplifier must be installed in a metal cabinet.
- Provide an adequate protection to prevent the following matter from entering the servo amplifier: conductive matter such as screws and metal fragments, and combustible matter such as oil.
- Devices such as the servo amplifier regenerative resistor and servo motor may become hot. Take safety measures such as providing covers.
- Do not stack in excess of the specified number of product packages.
- Do not carry the servo amplifier by the front cover, cables, or connectors. Doing so may cause the servo amplifier to drop.
- To prevent a malfunction, do not drop the servo amplifier or servo motor or subject them to impacts.
- Install the servo amplifier and servo motor in a place that can support their weight as stated in the MR-J5 user's manuals.
- Do not get on the equipment or put a heavy load on it.
- Do not install or operate any servo amplifier that is missing parts or is damaged.
- To prevent a malfunction, do not block the intake and exhaust areas of the servo amplifier.
- Do not subject connectors to impacts. Doing so may cause a connection failure, malfunction, or other failures.
- Use the product within the specified environment. For the environment, refer to "Servo amplifier standard specifications" in the MR-J5 User's Manual (Introduction).
- To prevent a fire or injury from occurring in the event of an earthquake or other natural disaster, securely install, mount, and wire the servo amplifier as stated in the MR-J5 user's manuals.
- When the product has been stored for an extended period of time, contact your local sales office.
- When handling the servo amplifier, be careful with the edges of the servo amplifier.
- Fumigants that are used to disinfect and protect wooden packaging from insects contain halogens (such as fluorine, chlorine, bromine, and iodine) cause damage if they enter our products. Please take necessary precautions to ensure that any residual materials from fumigants do not enter our products, or perform disinfection and pest control using a method other than fumigation, such as heat treatment. Perform disinfection and pest control on the wooden packaging materials before packing the products.
- Provide an external emergency stop circuit to stop the operation and shut-off the power immediately.
- For equipment in which the moving part of the machine may collide against the load side, install a limit switch or stopper to the end of the moving part.

(1) Mounting direction and clearances

Precautions
● The servo amplifier must be installed in the specified direction. ● To prevent a malfunction, maintain the specified clearances between the servo amplifier and cabinet walls or other equipment. ● When using the servo amplifier at an ambient temperature exceeding 55°C and up to 60°C, circulate air so that the air at the top and bottom of the servo amplifier does not stagnate.

(a) Installation clearances for the servo amplifier

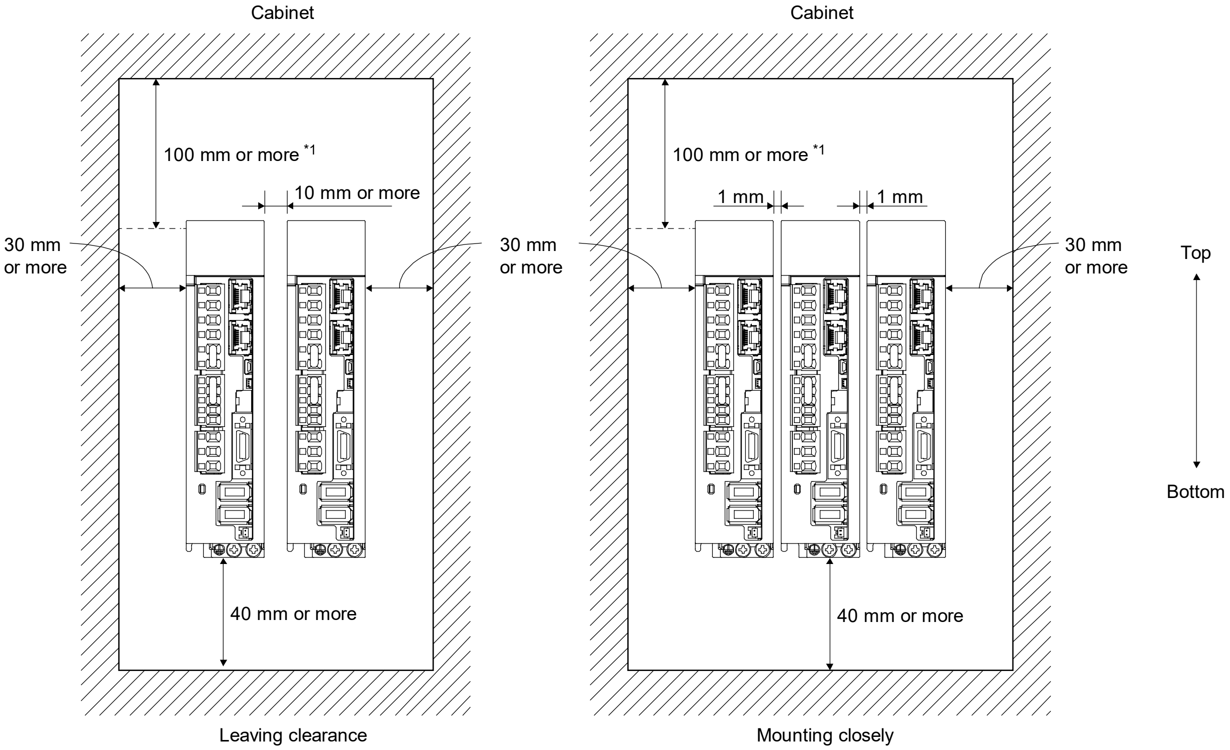
1) Installation of one servo amplifier



2) Installation of two or more servo amplifiers

Precautions
● For the availability of close mounting, refer to "Servo amplifier standard specifications" in the MR-J5 User's Manual (Introduction). ● When closely mounting multiple servo amplifiers, the servo amplifier on the right must have a larger depth than that on the left. Otherwise, the CNP1, CNP2, and CNP3 connectors cannot be removed.

Maintain a large clearance above the servo amplifiers and install a cooling fan to prevent the temperature inside the cabinet from exceeding the temperature specified in the environmental conditions.
When closely mounting the servo amplifiers, leave a clearance of 1mm between the adjacent servo amplifiers in consideration of mounting tolerances.
When mounting servo amplifiers in this manner, keep the ambient temperature within 0°C to 45°C, or use the servo amplifiers with 75% or less of the effective load ratio.



*1. Leave a clearance of 100mm or more above the fan units.

(b) Other precautions
When using heat generating equipment such as the regenerative option, install it with full consideration of heat eneration so that the servo amplifier is not affected.
Mount the servo amplifier on a perpendicular wall in the correct vertical direction.

(2) Keeping out foreign materials
- When drilling the cabinet for assembly, prevent drill chips and wire fragments from entering the servo amplifier.
- Prevent foreign matter such as oil, water, and metallic dust from entering the servo amplifier through openings in the cabinet or through a cooling fan installed on the ceiling.
- When installing the cabinet in a place where toxic gas, dirt, and dust exist, conduct an air purge (force clean air into the cabinet from outside to make the internal pressure higher than the external pressure) to prevent such materials from entering the cabinet.

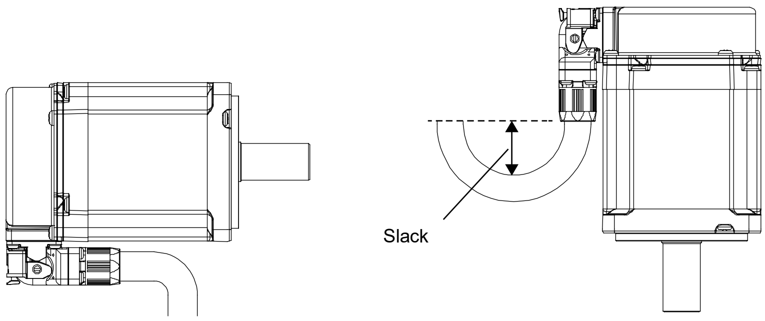
(3) Mounting direction

(a) Rotary servo motor

The mounting direction of the rotary servo motor is shown in the table below.

Rotary servo motor series	Mounting direction
HK-KT, HK-ST	Any direction

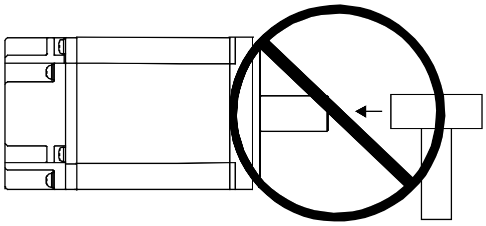
It is recommended to set the connector section downward if the rotary servo motor is mounted horizontally. Examine the cable clamping method, and give a gentle slack to the connection cable, to prevent excessive load from being applied to the connector and cable connection part.



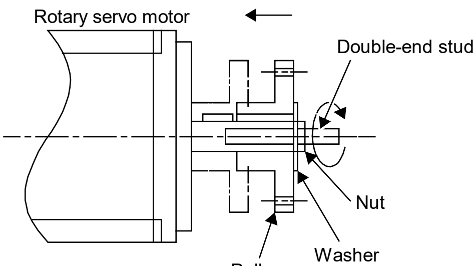
(b) Rotary servo motor with an electromagnetic brake

The rotary servo motor with an electromagnetic brake can also be mounted in the same directions as the one without an electromagnetic brake. When the servo motor with an electromagnetic brake is mounted with the shaft end upward, the brake plate may generate sliding sound but it is not a fault.

(4) Load mounting/dismounting precautions

Precautions
● To prevent a malfunction on the encoder, the shaft end must not be hammered during assembly.  ● Do not process the shaft to avoid damage to the encoder and bearing.

• When mounting a pulley to the rotary servo motor with a keyed shaft, use the screw hole in the shaft end. To fit the pulley, first insert a double-end bolt into the screw hole of the shaft, put a washer against the end face of the coupling, and insert and tighten a nut to force the pulley in.



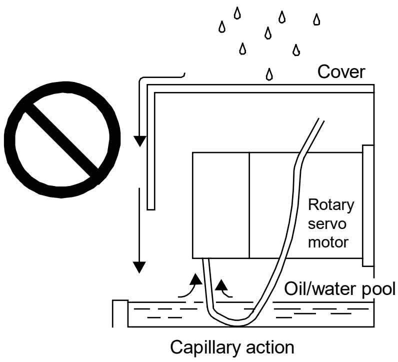
• For the shaft without a key, use a friction coupling or the like.
• When removing the pulley, use a pulley remover to protect the shaft from excessive load and impact.
• To ensure safety, fit a protective cover or the like on the rotary area, such as the pulley, mounted to the shaft.
• When a threaded shaft end part is needed to mount a pulley on the shaft, please contact your local sales office.
• The direction of the encoder on the rotary servo motor cannot be changed.
• When mounting the rotary servo motor, use spring washers or similar parts and fully tighten the bolts so that they do not become loose due to vibration.

(5) Permissible load for the shaft
For the permissible load for the shaft specific to the rotary servo motor, refer to Rotary Servo Motor User's Manual (HK series).
- Use a flexible coupling and adjust the misalignment of the shaft to less than the permissible radial load.
- When using a pulley, sprocket, or timing belt, keep the radial load within the permissible value.
- Exceeding the permissible load can cause deterioration of the bearing and damage to the shaft.
- The load indicated as the permissible load for the shaft is a static load in a single direction and does not include eccentric loads. To prevent the rotary servo motor being damaged, make eccentric loads as small as possible.

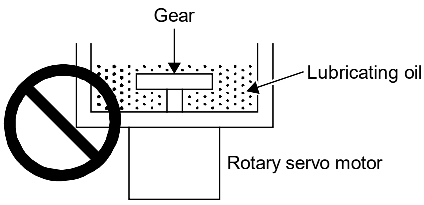
Precautions

- Do not use a rigid coupling as it may apply excessive bending load to the shaft of the rotary servo motor, leading the shaft to break and the bearing to wear out.

(6) Protection from oil and water
Provide adequate protection to prevent foreign matter, such as oil from entering the rotary servo motor shaft.
When installing the rotary servo motor, consider the following items:
- Do not use the rotary servo motor with its cable soaked in oil or water.



- When the servo motor is to be installed with the shaft end upward, provide measures so that it is not exposed to oil and water entering from the machine side, gear box, etc.



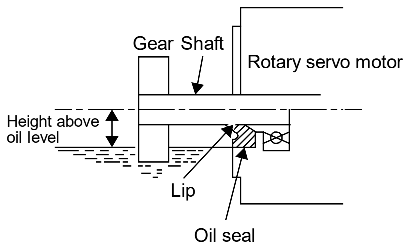
- If oil such as cutting oil splashes on the servo motor, the sealant, packing, cable, and other parts may be affected depending on the oil type.
- In the environment where the rotary servo motor is exposed to oil mist, oil, or water, the rotary servo motor of the standard specifications may not be usable. Please contact your local sales office.

(7) Cable
The power supply and encoder cables routed from the rotary servo motor should be fixed to the rotary servo motor to keep them unmovable. Otherwise, the cable may be disconnected. In addition, do not modify the connectors, terminals, and other areas at the ends of the cables.

Precautions
● The cables should not be damaged, stressed, loaded, or pinched.

(8) Servo motors with an oil seal
For rotary servo motors with an oil seal, the oil seal prevents the entry of oil into the rotary servo motor. Make sure to install it in accordance with the descriptions below.
Even if the oil seal on the rotary servo motor makes noises during operation, it does not indicate a problem with the functions.

(a) Pressure and oil level
Install the rotary servo motor horizontally, and set the oil level in the gear box to be always lower than the oil seal lip. If the oil level is higher than the oil seal lip, the oil enters the rotary servo motor and may cause a malfunction. Refer to Rotary Servo Motor User's Manual (HK series) for the height above oil level.



High pressure against the oil seal causes abrasion, which shortens the service life of the product. Keep constant internal pressure by equipping a ventilator to the gear box.

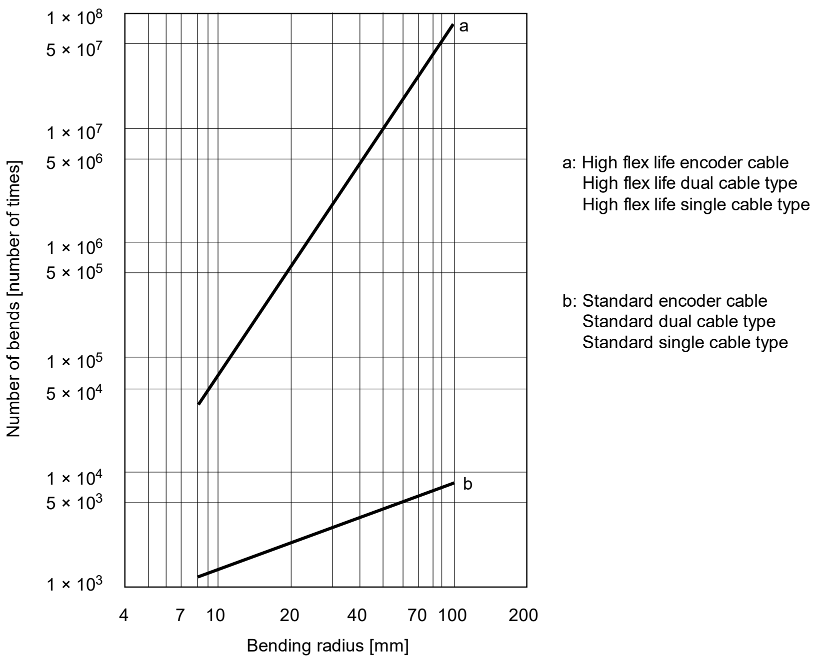
(b) Temperature
If the oil seal lip reaches a high temperature, the service life of the oil seal will be shortened. The maximum applicable temperature of material of the oil lip is 100˚C, and the temperature of the oil lip increases by 10˚C to 15˚C at maximum rotation. Keep high-temperature oil away from the oil lip.

(9) Cable stress

- The method used to clamp the cable must be fully examined so that bending stress and cable's own weight stress are not applied to the cable connection.
- When used for applications where the servo motor moves, fix the cable (encoder, power supply, brake) with gentle slack from the connecting part of the connector to prevent stress from being applied to the connecting part of the servo motor connector. Use the optional motor cable/encoder cable within the flex life range.
- Prevent the cable insulator from being cut by sharp chips or from touching and rubbing against the machine corners.
- Prevent the cables from getting stepped on by workers or run over by vehicles.
- If installing the servo motor that moves on a machine, make the bend radius as large as possible. Refer to "(10) Cable flex life" in this section for the flex life.

(10) Cable flex life

The flex life of the cables is shown below. This graph shows calculated values. Since they are not guaranteed values, provide a slight allowance for these values.



2.4.3 Wiring and sequence

(1) Power-on procedure

Point
● The voltage of analog monitor output, the output signal, or other conditions may be unstable at power-on.

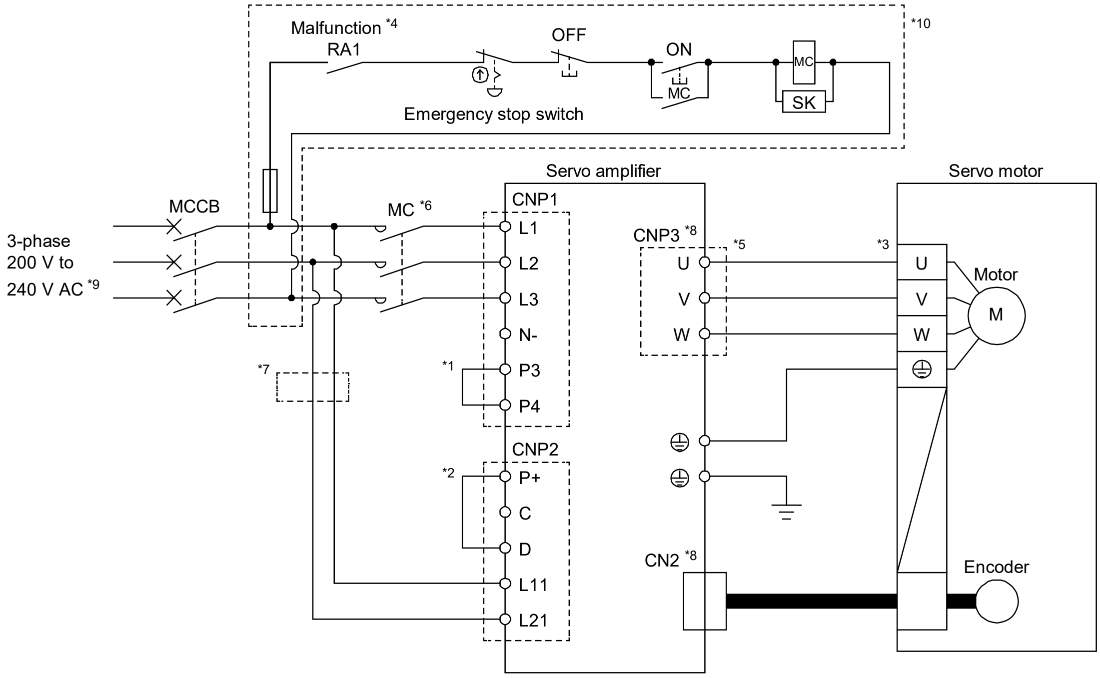
1) Wire the power supply using a magnetic contactor between the power supply and the main circuit power supply (L1/L2/L3) of a servo amplifier by referring to (2) in this section. Switch off the magnetic contactor as soon as an alarm occurs.

2) Switch on the control circuit power supply (L11 and L21) simultaneously with the main circuit power supply or before switching on the main circuit power supply. If the main circuit power supply is not on, the display shows the corresponding warning. However, the warning will disappear and the servo amplifier will operate properly if the main circuit is powered on.

3) The servo amplifier receives SON (Servo-on) 2.5s to 3.5s after the main circuit power supply is powered on.

4) Once RES (Reset) is turned on, the base circuit is shut off and the servo motor shaft coasts.

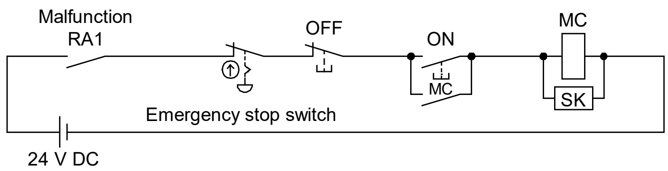
(2) Connection example
Wire the power supply and main circuit so that the power shuts off when an alarm is detected and SON (Servo-on) turns off at the same time. Refer to section 3.1.2 "Standard connection diagram" and 6.1.2 "Standard connection diagram" for details of the wiring.
Always connect a magnetic contactor between a power supply and the main circuit power supply (L1/L2/L3) of a servo amplifier to configure a circuit that shuts off the power supply on the servo amplifier side.



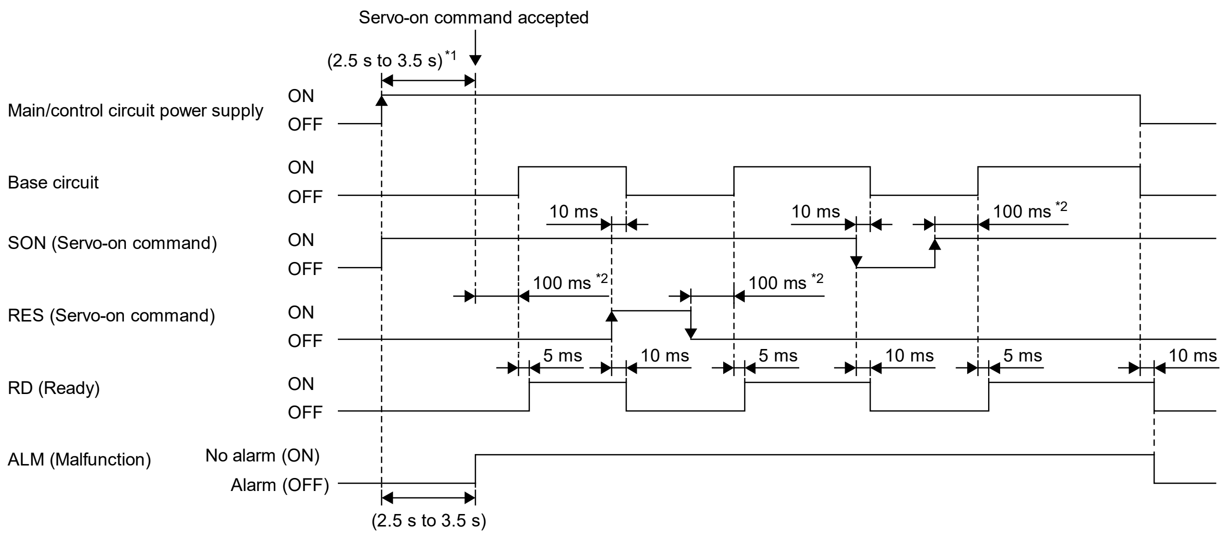
Wiring of the power supply and the main circuit (for the MR-J5-10A to MR-J5-350A with 3-phase 200 to 240V AC)

*1. P3 and P4 are connected from the factory. Remove the short-circuit bar between P3 and P4 before connecting a power factor improving DC reactor. Additionally, the power factor improving DC reactor and a power factor improving AC reactor cannot be used together. Refer to section 9.3.3 (1) Power factor improving DC reactor for details.
*2. Connect P+ and D terminals. P+ and D are connected from the factory. Refer to "Regenerative option" in the MR-J5 User's Manual (Hardware) when using a regenerative option.
*3. Option cables are recommended for servo motor power cables and encoder cables. Refer to Rotary Servo Motor User's Manual (HK series) for selecting cables.
*4. If ALM (Malfunction) output is disabled with a servo parameter, configure a power circuit which switches off a magnetic contactor after detection of an alarm occurrence on the controller side.
*5. Refer to Rotary Servo Motor User's Manual (HK series) for connecting servo motor power cables.
*6. Use the magnetic contactor with an operation delay time (interval between current being applied to the coil until closure of contacts) of 80ms or less. The bus voltage may drop depending on the main circuit power supply voltage and operation pattern, causing a dynamic brake deceleration during a forced stop deceleration. If dynamic brake deceleration is not required, delay the time to turn off the magnetic contactor.
*7. If wires used for L11 and L21 are thinner than wires used for L1, L2, and L3, use a molded-case circuit breaker. Refer to "Molded-case circuit breakers, fuses, magnetic contactors" in the MR-J5 User's Manual (Hardware) for details.
*8. Connecting the servo motor for an incorrect axis to U, V, W, or CN2 of the servo amplifier may cause a malfunction.

*9. For 1-phase 200 to 240V AC power supply, connect the power supply to L1 and L3. Leave L2 open.
*10. If operating the on switch and off switch of the main circuit power supply with a DC power supply, do not share the 24V DC power supply for interface with the magnetic contactor. Use the power supply designed exclusively for the magnetic contactor. Refer to "Driving on/off of main circuit power supply with DC power supply [G] [A]" in the MR-J5 User's Manual (Hardware) for the available magnetic contactors.
Operating the on switch and off switch with the DC power supply meets IEC/EN 60204-1 requirements. Also, change the configuration of the part inside the dotted line as follows.



(3) Timing chart



Timing chart at power-on

*1. For a linear servo system, this is "4.5s to 5.5s".
*2. The time will be longer in the magnetic pole detection of a linear servo motor and direct drive motor.

(4) Timing chart at alarm occurrence

This function displays an alarm or warning when an error occurs during operation. When an alarm occurs, ALM (Malfunction) turns off and the servo motor stops. When a warning occurs, the servo motor may not stop for each warning number.
The stop method changes depending on whether the forced stop deceleration function is enabled or disabled. However, even if the forced stop deceleration function is enabled, the forced stop deceleration may not be effective and the servo motor may stop with the dynamic brake or other methods, depending on the alarm that has occurred.
After deactivating the alarm or warning, resume the operation. Refer to the MR-J5 User's Manual (Troubleshooting) for the details of alarms and warnings.

Point
● When an alarm occurs, remove its cause, check that the operation signal is not being inputted, ensure safety, and deactivate the alarm before restarting the operation. ● In the torque control mode, the forced stop deceleration function cannot be used.

The following table shows how to deactivate the alarm.

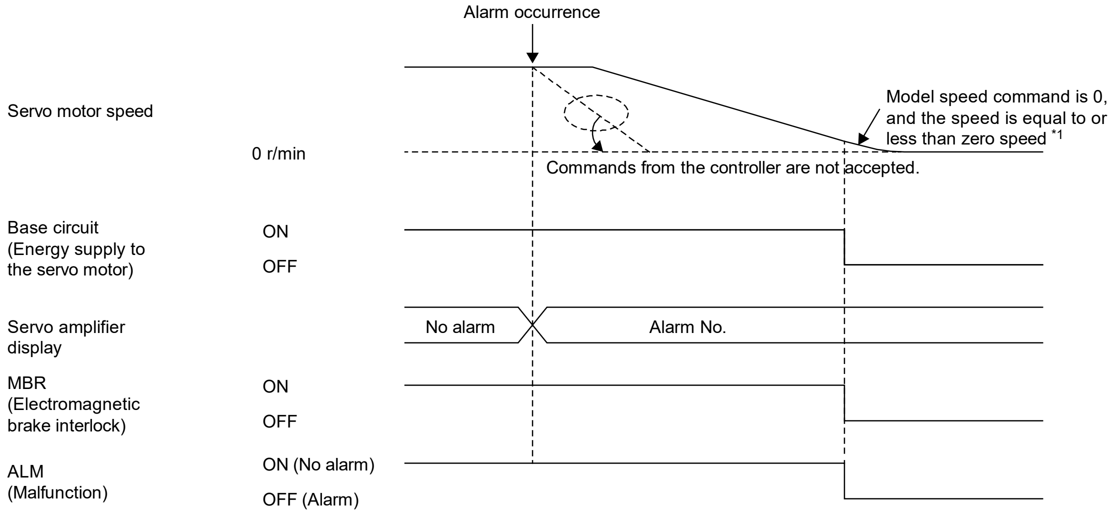
Alarm deactivation	Explanation
Alarm reset	• The controller sends an error reset command. • Click "Occurred Alarm Reset" in the "Alarm Display" window of MR Configurator2. • Turn on RES (Reset) with an input device. • Push the "SET" button while the display of the servo amplifier is in the current alarm display mode.
Power cycling	• Cycle the power. • Perform the software reset with commands from the controller and MR Configurator2. Refer to the step 6 in section 3.1.8 (2) "Parameter settings using MR Configurator2 (setup software)" for how to reset the software.

(a) When using the forced stop deceleration function

Point
● When [Pr.PA04.3 Forced stop deceleration function selection] is set to "2" (Forced stop deceleration function enabled).

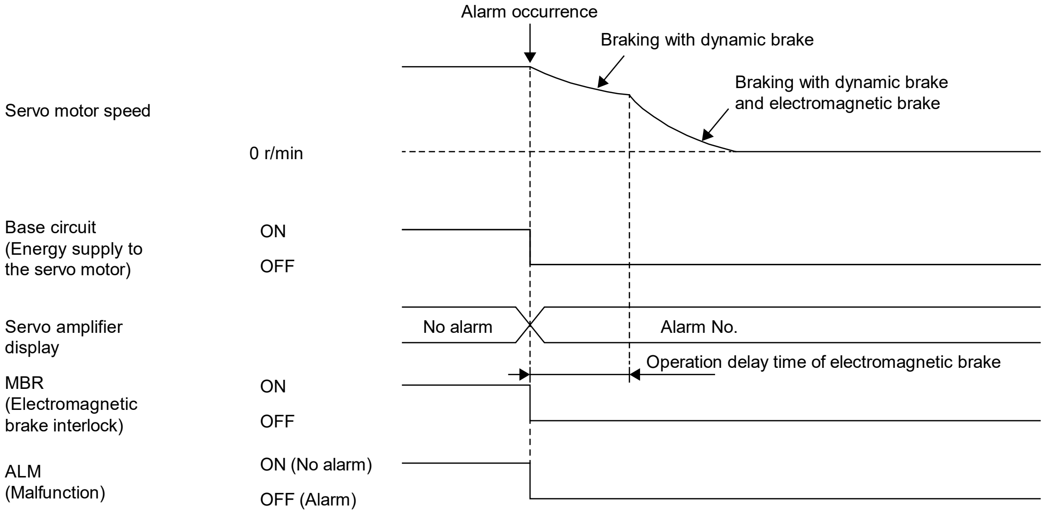
1) Stopping with forced stop deceleration function

When an alarm is detected, the servo motor stops using forced stop deceleration and MBR and ALM are turned off.



*1. The model speed command is a speed command generated in the servo amplifier for forced stop deceleration of the servo motor.

2) Stopping with dynamic brake
When an alarm is detected, MRB and ALM are turned off, and the servo motor stops using the dynamic brake and electromagnetic brake.



(b) When the forced stop deceleration function is not used

Point
● When [Pr.PA04.3 Forced stop deceleration function selection] is set to "0" (Forced stop deceleration function disabled).

The operation status during an alarm occurrence or network communication shut-off is the same as "2) Stopping with dynamic brake" in section 2.4.3 (4) (a).

2.4.4 Startup preparation

(1) Checking

Check the installation and wiring performed in sections 2.4.2 and 2.4.3 thoroughly again before turning on the power.

(a) Installation ······· Check the installation condition in accordance with section 2.4.2. Specifically, check the influence of the heating element inside the cabinet upon the servo amplifier ambient temperature, whether the heating element is contacting the cables, and the waterproof/oil prevention measures of the servo motor.

(b) Wiring ············· Check the wiring in accordance with section 2.4.3. The wiring must be carefully checked because an incorrect wiring of the main circuit may damage the module.

The items to be checked are shown below. Refer to each instruction guide or instruction manual for model-specific details that are not mentioned here.

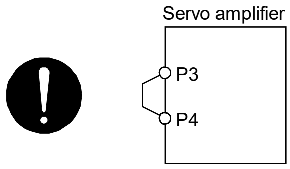
(2) Wiring

Before switching on the main circuit and control circuit power supplies, check the following items.

(a) Power supply system wiring

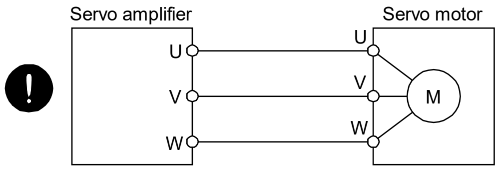
1) Power supply system wiring

- Check that the power supplied to the power input terminals (L1/L2/L3/L11/L21) of the servo amplifier satisfies the defined specifications. For the power supply specifications, refer to "Servo amplifier standard specifications" in the MR-J5 User's Manual (Introduction).
- If the power factor improving DC reactor is not used, check that P3 and P4 are connected.

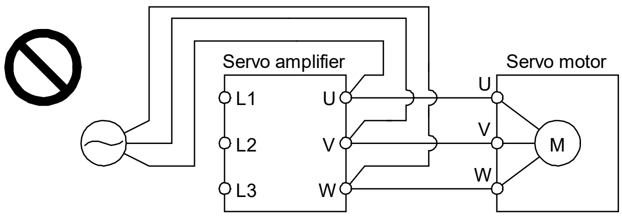


2) Connecting the servo amplifier and the servo motor

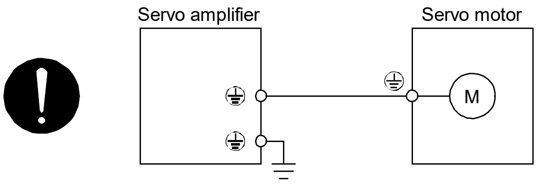
- Check that the phases (U/V/W) of the servo amplifier power outputs and the phases (U/V/W) of the servo motor power inputs match with each other.



- Check that the power to be supplied to the servo amplifier is not connected to the power outputs (U/V/W) as doing so will cause the servo amplifier and the servo motor to malfunction.



• Check that the grounding terminal of the servo motor is connected to the PE terminal of the servo amplifier.



• Check that the CN2 connector of the servo amplifier is securely connected to the encoder of the servo motor using a motor cable or encoder cable.

3) Using options or peripheral equipment

a) Regenerative option

• Check that the lead wire between terminal P+ and terminal D has been removed.
• Check that the wire of the regenerative option is connected to terminal P+ and terminal C.
• Check that twisted wires have been used for connecting the regenerative option to the servo amplifier.

Refer to "Connection of regenerative option" in the MR-J5 User's Manual (Hardware) for details.

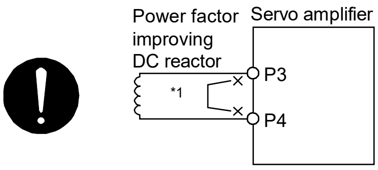
b) Simple converter

Refer to "Example of configuration including peripheral equipment" in the MR-J5 User's Manual (Hardware) for details.

c) Power factor improving DC reactor

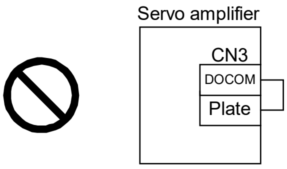
• Check that a power factor improving DC reactor is connected between P3 and P4.

Refer to section 9.3.3 (1) Power factor improving DC reactor for details.



(b) I/O signal wiring

• Check that I/O signals are connected correctly.
If the DO forced output mode is used, the pins of the CN3 connector can be forcibly switched on/off. This mode is used to check the wiring. In this case, switch on the control circuit power supply only. Refer to "Example I/O signal connections" in the MR-J5 User's Manual (Hardware) for details of the I/O signal connections.
• Check that a voltage exceeding 24V DC has not been applied to the pins of the CN3 connector.
• Check that the plate and DOCOM of the CN3 connector have not been shorted.



(3) Surrounding environment

Check the following items about the environment surrounding the servo amplifier and servo motor.

(a) Handling cables

- Check that the wiring cables have not been stressed.
- Check that the encoder cable has been used within its flex life.
  Refer to "(10) Cable flex life" in section 2.4.2 for details.
- Check that the connector of the servo motor has not been stressed.

(b) Environment

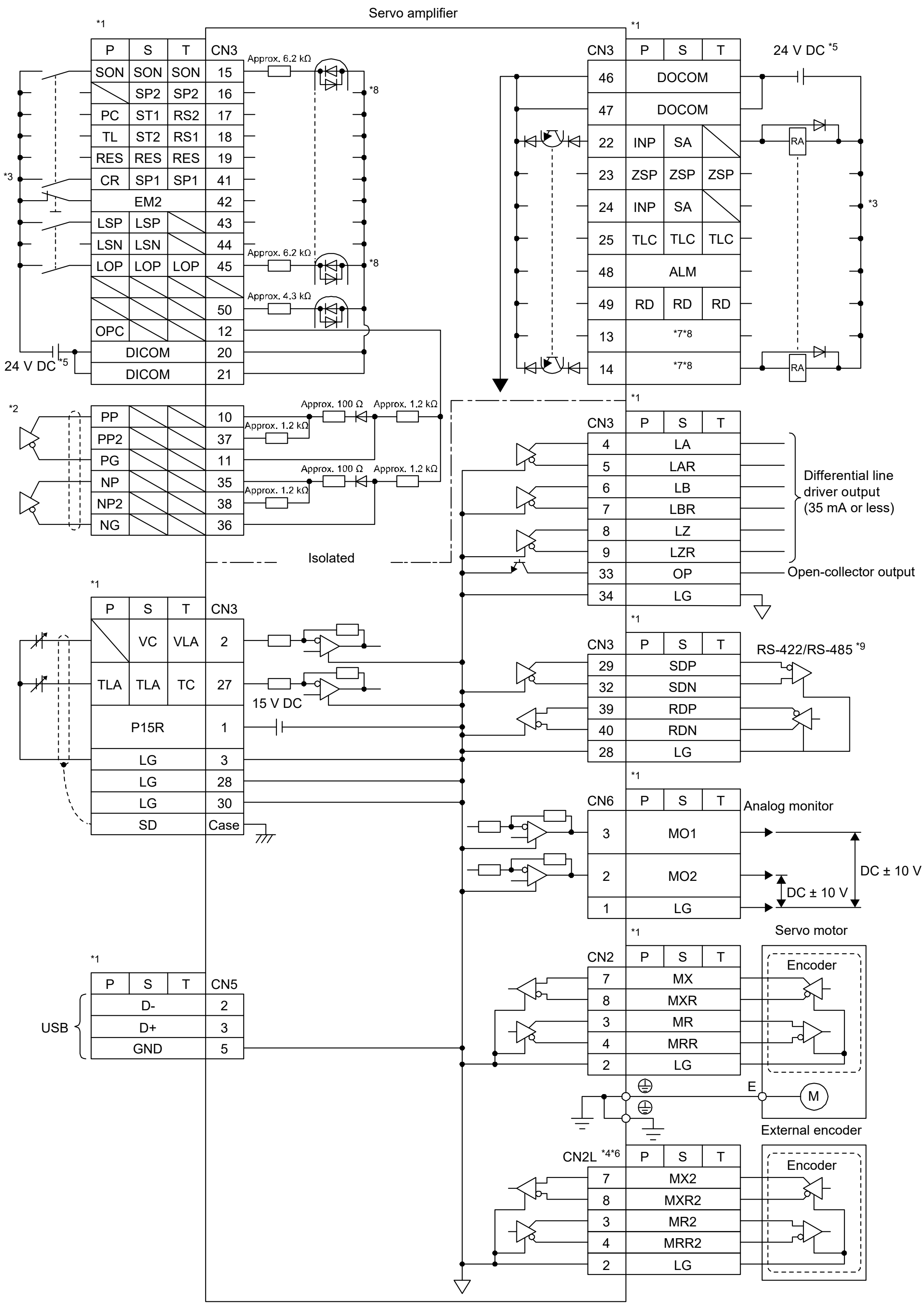
Check that signal cables and power cables have not been shorted primarily by wire offcuts and metallic dust.

3 FUNCTIONS AND OPERATION OF MELSERVO (SPEED CONTROL)

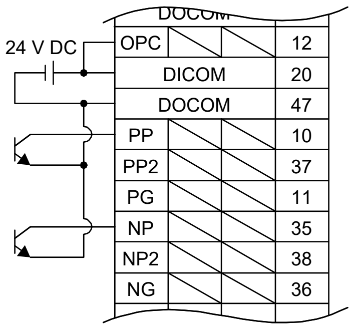
3.1 From Startup to Operation

3.1.1 Wiring and sequences

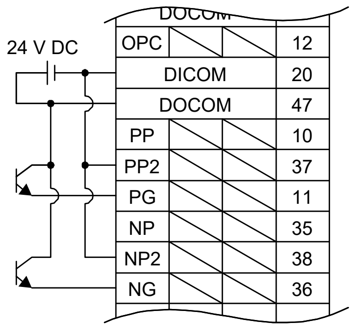
(1) Connection diagram inside the interface



*1. P: Position control mode, S: Speed control mode, T: Torque control mode
*2. This is for the differential line driver pulse train input. For the open-collector pulse train input, connect as follows.



For sink input interface

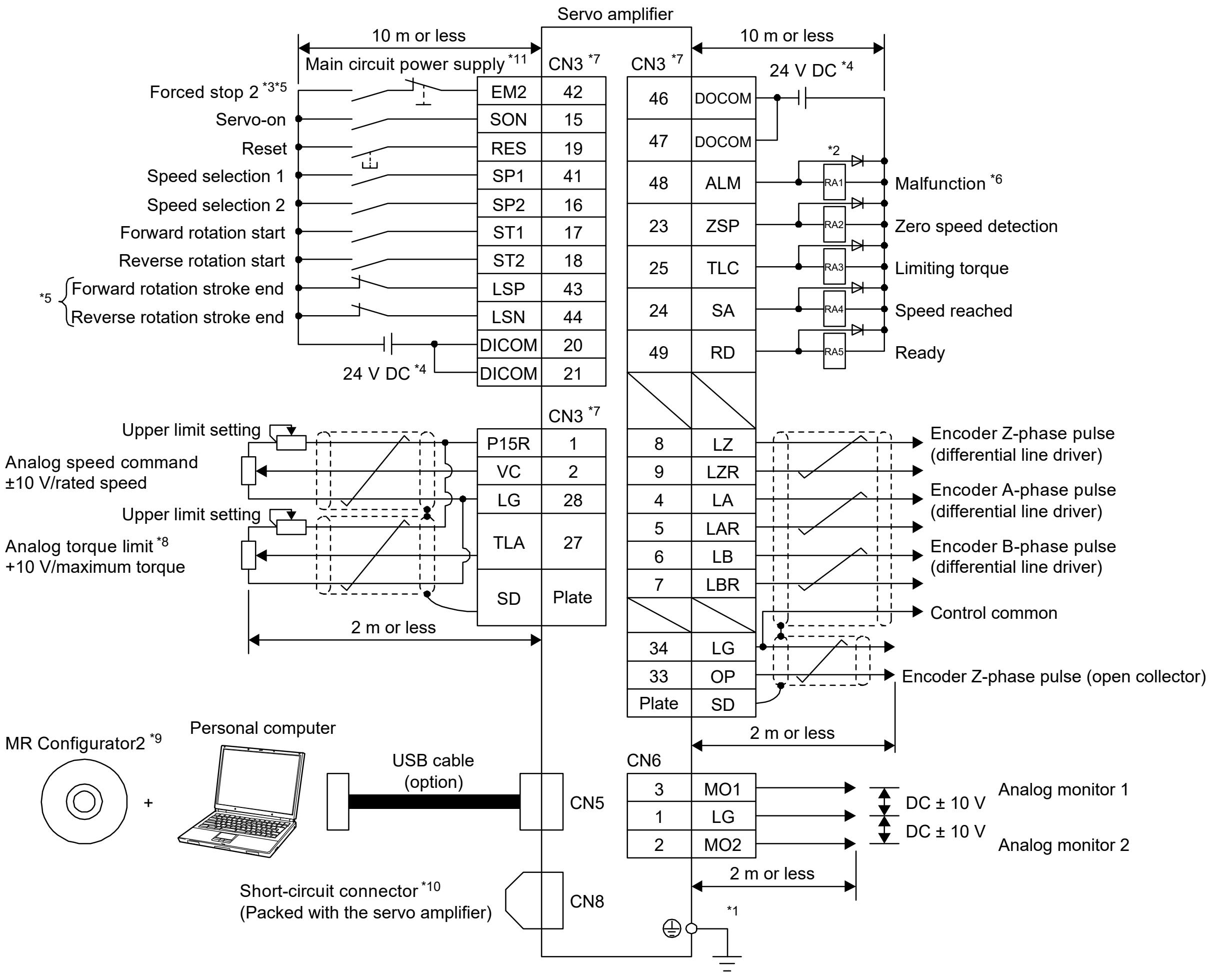


For source input interface

*3. This diagram shows a sink I/O interface. Refer to "Source I/O interface" in the MR-J5 User's Manual (Hardware) for source I/O interfaces.
*4. This is for the MR-J5-_A_-RJ_ servo amplifier. The MR-J5-_A_ servo amplifier does not have the CN2L connector.
*5. Although the diagram shows the input signal and the output signal each using a separate 24V DC power supply for illustrative purposes, the system can be configured to use a single 24V DC power supply.
*6. Refer to "Parts identification" in the MR-J5 User's Manual (Introduction) for connecting an external encoder.
*7. Output devices are not assigned by default. Assign the output devices with [Pr.PD47] as necessary.
*8. If the MR-J5-_A_-RJ_ is used, the values in the CN3-16 pin and the CN3-45 pin are approximately 4.3kΩ.
*9. RS-422 and RS-485 are not supported.

3.1.2 Standard connection diagram

(1) Sink I/O interface



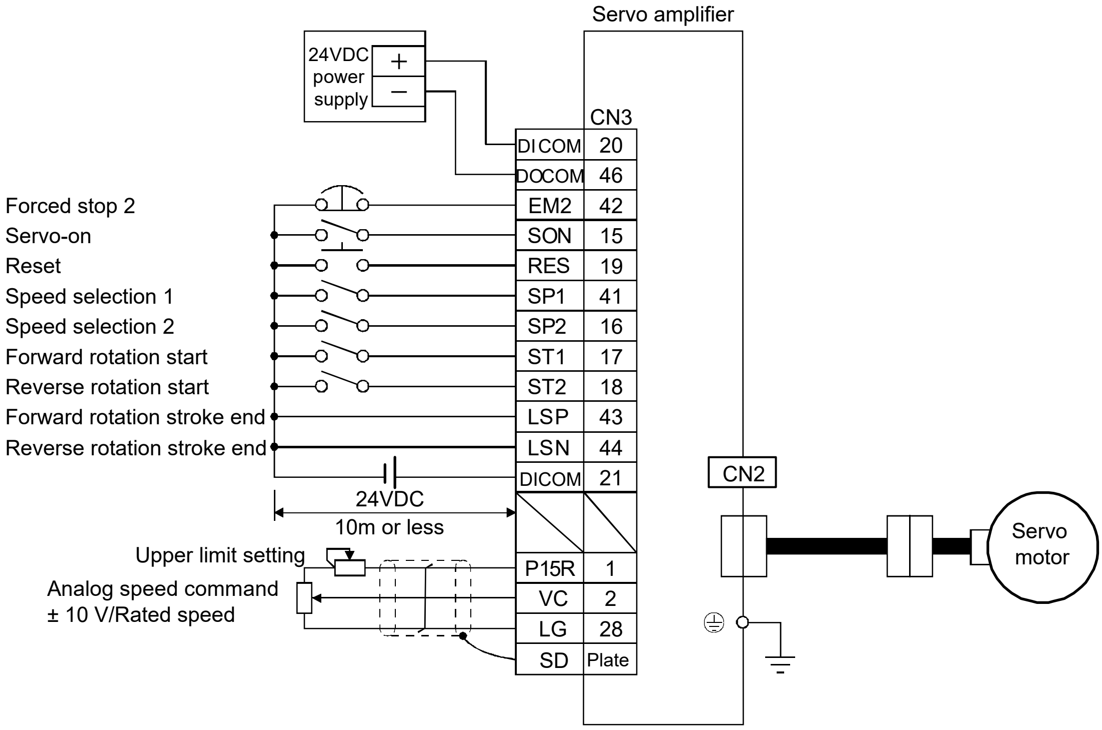
Connection I in speed control

*1. To prevent an electric shock, connect the protective earth (PE) terminal (the terminal marked with the ⏚ symbol) of the servo amplifier to the protective earth (PE) of the cabinet.
*2. Connect the diode in the correct direction. If it is connected reversely, the servo amplifier may malfunction and not output signals, disabling protective circuits such as EM2 (Forced stop 2).
*3. Install a forced stop switch (normally closed contact).
*4. Supply 24V DC ± 10% to interfaces from an external source. The total current capacity of these power supplies is 500mA maximum. The amperage will not exceed 500mA when all the I/O signals are used. Reducing the number of I/O points decreases the current capacity. Refer to "Digital input interface DI-1" in the MR-J5 User's Manual (Hardware) for the current required for the interfaces.
Although the diagram shows the input signal and the output signal each using a separate 24V DC power supply for illustrative purposes, the system can be configured to use a single 24V DC power supply.
*5. When starting operation, turn on EM2 (Forced stop 2), LSP (Forward rotation stroke end), and LSN (Reverse rotation stroke end) (normally closed contact).
*6. If no alarm is occurring, ALM (Malfunction) is on (normally closed contact).
*7. The pins with the same signal name are connected in the servo amplifier.
*8. TLA will be available when TL (External torque limit selection) is enabled with servo parameters ([Pr.PD03] to [Pr.PD22]). For details, refer to the MR-J5 User's Manual (Function).
*9. Use the SW1DNC-MRC2-_.
*10. If not using the STO function, attach the short-circuit connector that came with the servo amplifier.
*11. To prevent an unexpected restart of the servo amplifier, configure a circuit that turns off EM2 when the main circuit power supply is turned off.
*12. For source interfaces, the polarity (positive or negative) of the power supply is reversed as compared with sink interfaces.

(a) Connecting minimum necessary I/O signals

Motor operation requires at least the following signals. The output signal does not need to be connected with the motor.

1) Servo-on ············ Needs to be turned on before operation as this is a signal to activate the main circuit.
Turning on this signal makes a servo-lock state.
2) Speed selection 1 and 2 ········ Selects whether to set the speed command to the parameter setting value or the external analog setting value.
The figure below is for the external analog speed command.
3) Forward/reverse rotation start ·· Used as the start signals.
4) Reset ············ Cancels alarms. This is not an indispensable signal as alarms can also be canceled by turning off the control circuit power supply.
In addition,turning on the reset signal releases the servo-lock state, and the servo motor coasts.
5) Forced stop 2 ············ When EM2 is turned off (open between commons), the servo motor decelerates to a stop with commands.
The forced stop will be deactivated if EM2 is turned on (short between commons) while in the forced stop state.



Connection II in speed control

[Supplementary explanation] Speed command circuit configuration

1) SP1 (Speed selection 1)/SP2 (Speed selection 2) and speed command value
The speed command can be selected with SP1 (Speed selection 1) and SP2 (Speed selection 2).

Input devices *1		Speed command value
SP2	SP1	
0	0	VC (Analog speed command)
0	1	[Pr.PC05 Internal speed 1]
1	0	[Pr.PC06 Internal speed 2]
1	1	[Pr.PC07 Internal speed 3]

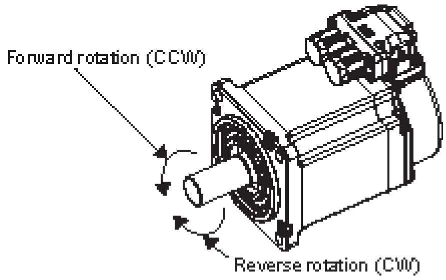
*1. 0: OFF
1: ON

When SP3 (Speed selection 3) is enabled with the settings of [Pr.PD03 Input device selection 1] to [Pr.PD22 Input device selection 10], internal speed 4 to 7 can be selected.

Input devices *1			Speed command value
SP3	SP2	SP1	
0	0	0	VC (Analog speed command)
0	0	1	[Pr.PC05 Internal speed 1]
0	1	0	[Pr.PC06 Internal speed 2]
0	1	1	[Pr.PC07 Internal speed 3]
1	0	0	[Pr.PC08 Internal speed 4]
1	0	1	[Pr.PC09 Internal speed 5]
1	1	0	[Pr.PC10 Internal speed 6]
1	1	1	[Pr.PC11 Internal speed 7]

*1. 0: OFF
1: ON

2) ST1 (Forward rotation start)/ST2 (Reverse rotation start)
The motor starts and stops by ST1 (Forward rotation start) and ST2 (Reverse rotation start). Turning off or on both ST1 and ST2 decelerates the motor to a stop, then makes a servo-lock state.
When the speed setting is configured using an external analog voltage,the relations between the motor rotation direction and the current polarity or start signal are as shown in the following table.



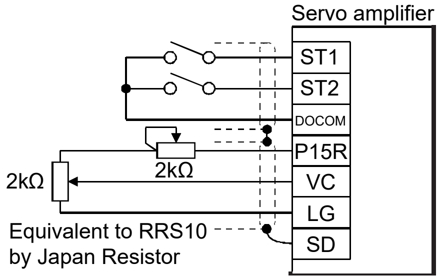
Input devices [*1]		Rotation direction [*2]			
ST2	ST1	VC (Analog speed command)			Internal speed
		Polarity: +	0V	Polarity: -	
0	0	Stop (Servo-lock)	Stop (Servo-lock)	Stop (Servo-lock)	Stop (Servo-lock)
0	1	CCW	Stop (No servo-lock)	CW	CCW
1	0	CW		CCW	CW
1	1	Stop (Servo-lock)	Stop (Servo-lock)	Stop (Servo-lock)	Stop (Servo-lock)

*1. 0: OFF
1: ON
*2. If the torque limit is canceled during servo-lock, the servo motor may suddenly rotate, depending on the amount of the position deviation from the command position.

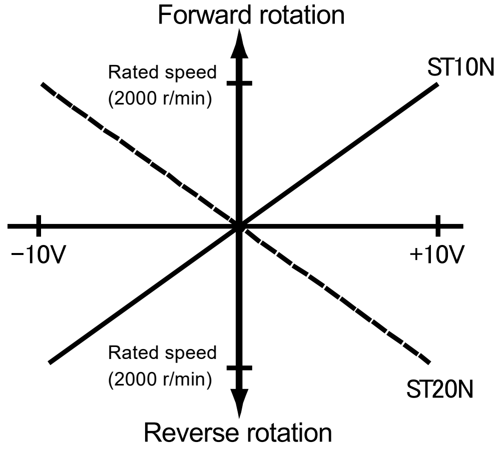
3) External wiring example

The following shows a configuration of a speed command circuit using an external analog voltage.

a) When operating the motor in forward/reverse directions using only ⊕ of the analog voltage polarity



Speed command circuit configuration I



4) Torque limit

The torque limit function limits the torque generated by the servo motor.

The following torque limit can be set. The torque limit function can be used by switching the following limit vales.

Item	Outline
Internal torque limit	The maximum torque is limited by the values of [Pr.PA11 Forward rotation torque limit] and [Pr.PA12 Reverse rotation torque limit].
Internal torque limit 2	The generated torque is limited by the value of [Pr.PC35 Internal torque limit 2].
External analog torque limit	The maximum torque is limited by the value input to the TLA (analog torque limit).

3.1.3 Power-on

Perform operation in accordance with the instructions shown in this chapter.

(1) Startup of the speed control mode

(a) Instructions for power-on

Turn on the power using the following procedure. Always follow this procedure when turning on the power. Refer to "Instructions for power-on" in the MR-J5 User's Manual (Introduction) as well for instructions for power-on.

1) Turn off SON (Servo-on).
2) Make sure that ST1 (Forward rotation start) and ST2 (Reverse rotation start) are off.
3) Turn on the main circuit power supply and control circuit power supply.
Data is displayed 2s after "r" (Servo motor speed) is displayed.

(b) Instructions on power shut-off

1) Turn off ST1 (Forward rotation start) and ST2 (Reverse rotation start).
2) Turn off SON (Servo-on).
3) Shut off the main circuit power supply and control circuit power supply.

(2) Instructions for startup

Precautions

- When the absolute position detection system is used with a rotary servo motor, [AL.025 Absolute position erased] occurs at first power-on and the servo motor cannot be changed to servo-on status. Shut off the power once, then cycle the power to deactivate the alarm.
- If the power is turned on while the servo motor is being rotated by an external force, an alarm may occur. Make sure that the servo motor is not operating before turning on the power. In addition, refer to the manual for the servo motor or encoder being used.

(a) Stop

If any of the following situations occur, the servo amplifier suspends and stops the operation of the servo motor.

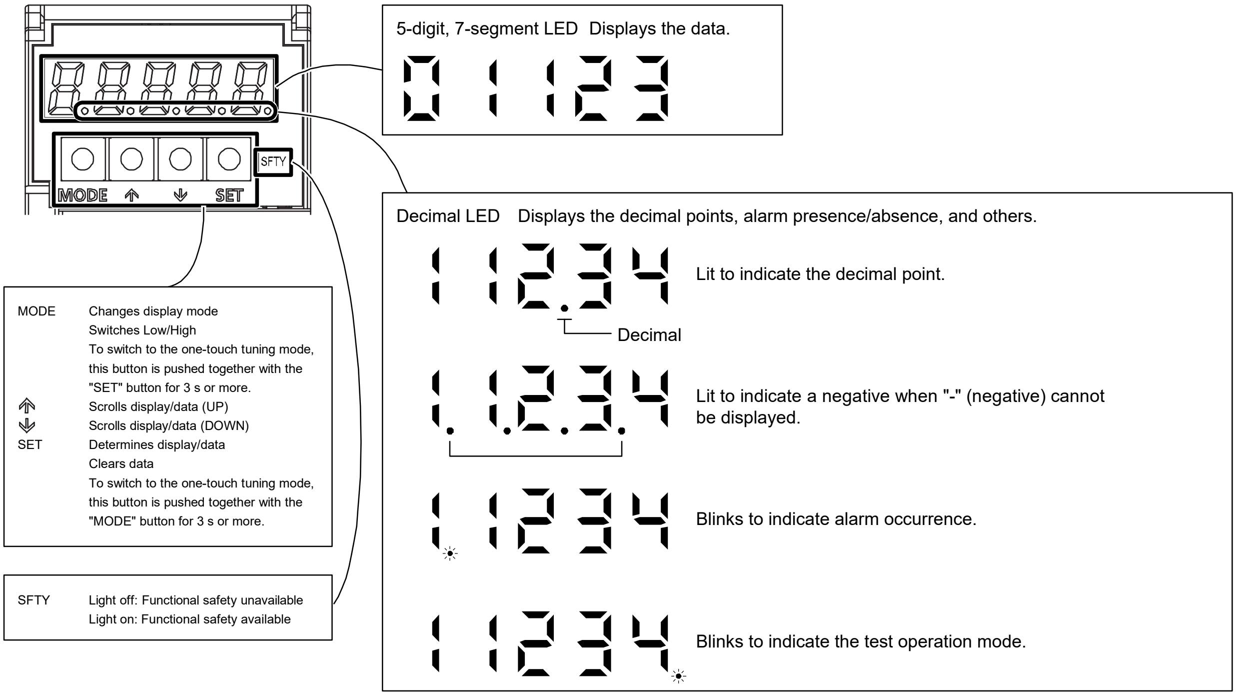
Operation/command	Stopping condition
Alarm occurrence	The servo motor decelerates to a stop. There are also alarms that activate the dynamic brake and stop the servo motor.
EM2 (Forced stop 2) off	The servo motor decelerates to a stop. [AL.0E6 Servo forced stop warning] occurs. In the torque mode, EM2 functions the same as EM1.
STO (STO1 and STO2) off	The base circuit is shut off and the dynamic brake operates to stop the servo motor.
Limit switch off	When LSP (Forward rotation stroke end) or LSN (Reverse rotation stroke end) is turned off, the servo motor comes to a quick stop and activates the servo-lock. Operation in the opposite direction is possible.

For use with training machine

3.1.4 Display/diagnosis function

(1) Outline

The MR-J5-_A_ servo amplifier has the display section (5-digit, 7-segment LED) and operation section (4 push buttons) for servo amplifier status display, alarm display, servo parameter settings, etc.
Push the "MODE" and "SET" buttons at the same time for 3s or longer to switch to the one-touch tuning mode.

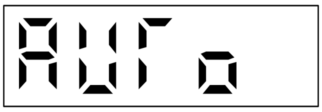
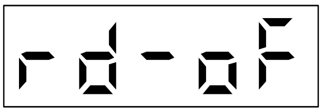
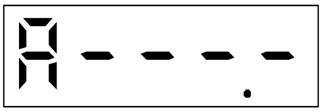
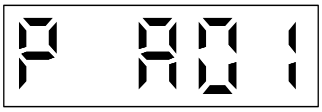
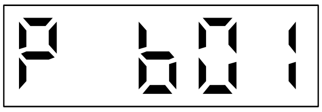
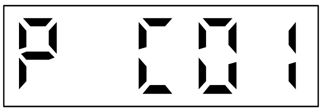
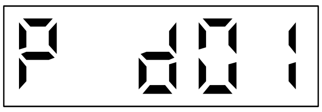
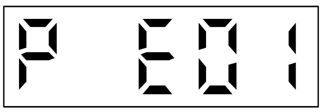
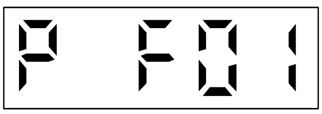
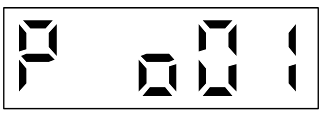
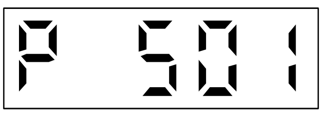
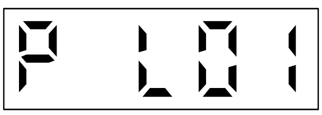


For use with training machine

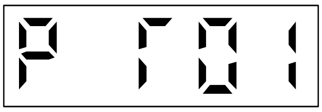
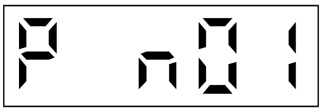
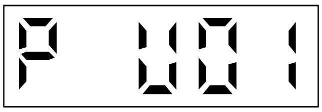
(2) Display sequence

Press the "MODE" button once to shift to the next display mode.

Use the basic setting parameters [Pr.PA19 Parameter writing prohibited] to refer to and operate the gain/filter parameters, extension setting parameters, and I/O setting parameters.

Display mode transition	Initial screen	Function
Status display		The servo status is displayed. The display at power-on differs depending on each operation mode. *1
One-touch tuning		Select this when performing the one-touch tuning.
Diagnostics		The status display of each servo amplifier such as sequence display and external I/O signal display and test operation are enabled.
Alarm		The current alarm, alarm history, and servo parameter error No. are displayed.
Basic setting servo parameters		The basic setting parameters can be displayed and set.
Gain/filter servo parameters		The gain/filter parameters can be displayed and set.
Extension setting servo parameters		The extension setting parameters can be displayed and set.
I/O setting servo parameters		The I/O setting parameters can be displayed and set.
Extension setting 2 servo parameters		The extension setting 2 parameters can be displayed and set.
Extension setting 3 servo parameters		The extension setting 3 parameters can be displayed and set.
For manufacturer setting		This is for manufacturer setting.
For manufacturer setting		This is for manufacturer setting.
Motor extension setting servo parameters		The motor extension setting parameters can be displayed and set.

For use with training machine

Display mode transition	Initial screen	Function
For manufacturer setting		This is for manufacturer setting.
For manufacturer setting		This is for manufacturer setting.
For manufacturer setting		This is for manufacturer setting.

*1. When the axis name is set to the servo amplifier using MR Configurator2, the servo status is displayed after the axis name is displayed.

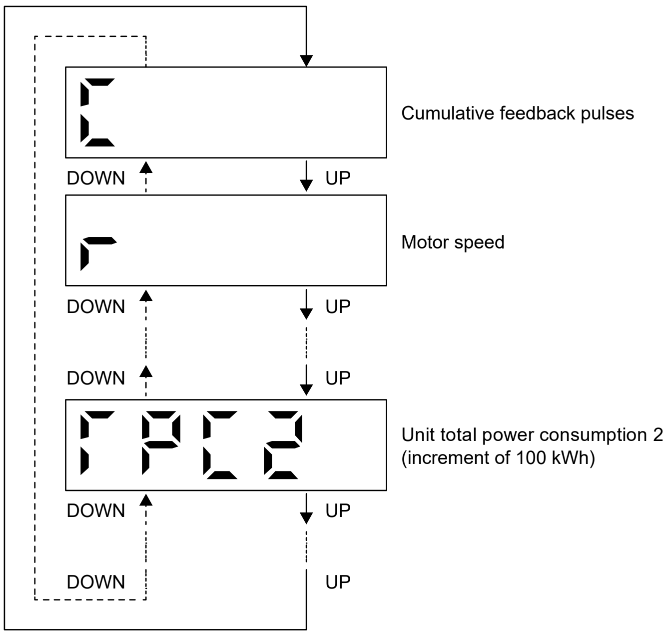
(3) Status display

The servo status during operation is shown on the 5-digit, 7-segment LED display. Press "UP" or "DOWN" to change display data as desired. When the servo status is selected, the corresponding symbol is displayed. Press "SET" to display its data. Only at power-on, the symbol of the status display selected with [Pr.PC36] is displayed for 2s, and then the data is displayed.

(a) Display transition

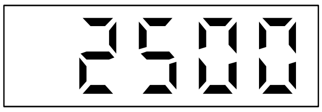
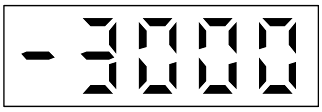
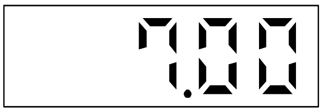
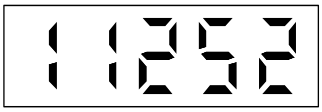
After selecting the status display mode by pressing "MODE", pressing "UP" or "DOWN" button changes the display as follows.

The status that can be displayed differs depending on the operation mode or control mode. Refer to (4) "Status display list" in this section for the status display list.



For use with training machine

(b) Display examples

Item	Status	Display method
Servo motor speed	2500r/min in the forward rotation	
	3000r/min in the reverse rotation	
Load to motor inertia ratio	7.00 times	
ABS counter	11252rev	
	-12566rev	 The decimal points in the upper four digits are lit for a negative value.

For use with training machine

(4) Status display list

The following table shows the servo status that can be displayed.

Table3.1(1/6)

Status display	Symbol	Unit	Description	Control mode *1 P	Control mode *1 S	Control mode *1 T	Operation mode *2 Semi closed	Operation mode *2 Fully closed
Cumulative feedback pulses	C	pulse	The feedback pulses from a servo motor encoder are counted and displayed. The values in excess of ±99999 can be counted. However, the counter shows only the lower five digits of the actual value because the servo amplifier display is five digits. Press the "SET" button to reset the display value to "0". The decimal points in the upper four digits are lit for a negative value.	○	○	○	○	○
Servo motor speed/linear servo motor speed	r	r/min or mm/s	The servo motor speed is displayed. It is displayed rounding off 0.1r/min (0.1mm/s) unit.	○	○	○	○	○
Droop pulses	E	pulse	The number of droop pulses in the deviation counter is displayed. The decimal points in the upper four digits are lit for reverse rotation pulses. The values in excess of ±99999 can be counted. However, the counter shows only the lower five digits of the actual value because the servo amplifier display is five digits. The number of pulses is displayed in the units of encoder pulses.	○	○	○	○	○
Cumulative command pulses	P	pulse	Position command input pulses are counted and displayed. As the value before being multiplied by the electronic gear (CMX/CDV) is displayed, the value may not match the indicated cumulative feedback pulses. The values in excess of ±99999 can be counted. However, the counter shows only the lower five digits of the actual value because the servo amplifier display is five digits. Press the "SET" button to reset the display value to "0". When the servo motor is rotating in the reverse direction, the decimal points in the upper four digits are lit.	○	○	○	○	○

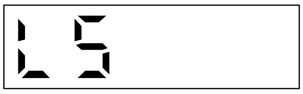
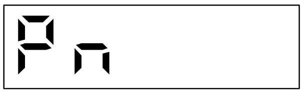
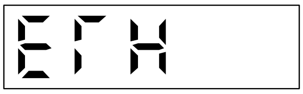
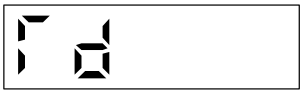
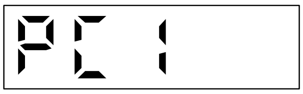
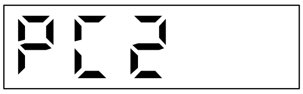
For use with training machine

Table3.1(2/6)

Status display	Symbol	Unit	Description	Control mode *1			Operation mode *2	
				P	S	T	Semi closed	Fully closed
Command pulse frequency	n	kpulse/s	The frequency of the position command input pulses is displayed. The value before being multiplied by the electronic gear (CMX/CDV) is displayed.	○	○	○	○	○
Analog speed limit voltage	F	V	The input voltage of VLA (Analog speed limit) is displayed.	×	×	○	○	×
Analog speed command voltage			The input voltage of VC (Analog speed command) is displayed.	×	○	×	○	×
Analog torque limit voltage	U	V	The voltage of TLA (Analog torque limit) is displayed.	○	○	×	○	○
Analog torque command voltage			The voltage of TC (Analog torque command) is displayed.	×	×	○	○	×
Regenerative load ratio	L	%	The ratio of regenerative power to permissible regenerative power is displayed in percentage.	○	○	○	○	○
Effective load ratio	J	%	The continuous effective load current is displayed. The effective value in the past 15s is displayed in relation to the rated current (= 100%).	○	○	○	○	○
Peak load ratio	b	%	The maximum generated torque is displayed. The highest value in the past 15s is displayed in relation to the rated torque (= 100%).	○	○	○	○	○
Instantaneous torque	T	%	The instantaneous torque is displayed. The rated torque is displayed as 100%. The value of the generated torque is displayed in real time.	○	○	○	○	○
Position within one-revolution (1 pulse unit)	Cy1	pulse	The position within one-revolution is displayed in the encoder pulse unit. The values in excess of ±99999 can be counted. However, the counter shows only the lower five digits of the actual value because the servo amplifier display is five digits. When the servo motor rotates in the CCW direction, the value is added.	○	○	○	○	○
Position within one-revolution (1000 pulses unit)	Cy2	1000 pulses	The position within one-revolution is displayed by increments of 1000 pulses unit of the encoder. When the servo motor rotates in the CCW direction, the value is added.	○	○	○	○	○

For use with training machine

Table3.1(3/6)

Status display	Symbol	Unit	Description	Control mode *1			Operation mode *2	
				P	S	T	Semi closed	Fully closed
ABS counter		rev	The travel distance from the home position is displayed as multi-revolution counter value of the absolution position encoder in the absolution position detection system.	○	○	○	○	○
Load to motor inertia ratio		Multiplier	The estimated ratio of the load inertia moment to the servo motor inertia moment is displayed.	○	○	○	○	○
Bus voltage		V	The voltage of main circuit converter (between P+ and N-) is displayed.	○	○	○	○	○
Internal temperature of encoder		°C	The internal temperature detected by the encoder is displayed. If the internal temperature of encoder cannot be obtained, such case as the linear servo motor or others, "9999" is displayed.	○	○	○	○	○
Settling time		ms	The settling time is displayed. When the settling time exceeds 1000ms, "1000" is displayed.	○	○	○	○	○
Oscillation detection frequency		Hz	The frequency at the time of oscillation detection is displayed.	○	○	○	○	○
Number of tough drive operations		times	The number of times the tough drive function has activated is displayed.	○	○	○	○	○
Unit power consumption 1 (1W unit)		W	The unit power consumption by increment of 1W is displayed. The positive value indicates power running, and negative value indicates regeneration. The values in excess of ±99999 can be counted. However, the counter shows only the lower five digits of the actual value because the servo amplifier display is five digits.	○	○	○	○	○
Unit power consumption 2 (1kW unit)		kW	The unit power consumption by increment of 1kW is displayed. The positive value indicates power running, and negative value indicates regeneration.	○	○	○	○	○

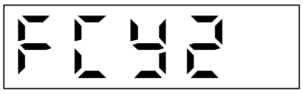
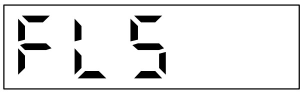
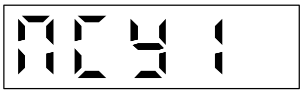
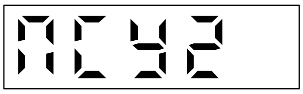
For use with training machine

Table3.1(4/6)

Status display	Symbol	Unit	Description	Control mode *1			Operation mode *2	
				P	S	T	Semi closed	Fully closed
Unit total power consumption 1 (1Wh unit)	rPC 1	Wh	The unit total power consumption by increment of 1Wh is displayed. The positive value is accumulated during power running, while negative value is accumulated during regeneration. The values in excess of ±99999 can be counted. However, the counter shows only the lower five digits of the actual value because the servo amplifier display is five digits.	○	○	○	○	○
Unit total power consumption 2 (100kWh unit)	rPC2	100kWh	The unit total power consumption by increment of 100kWh is displayed. The positive value is accumulated during power running, while negative value is accumulated during regeneration.	○	○	○	○	○
Cumulative feedback pulses from load-side encoder *3	FC	pulse	The feedback pulses from the load-side encoder are counted and displayed. The values in excess of ±99999 can be counted. However, the counter shows only the lower five digits of the actual value because the servo amplifier display is five digits. Press the "SET" button to reset the display value to 0. The decimal points in the upper four digits are lit for a negative value.	○	○	○	×	○
Load-side encoder droop pulses *3	FE	pulse	Droop pulses in the deviation counter, which are the pulse differences between a load-side encoder and a command, are displayed. When the count exceeds ±99999, it starts from 0. The decimal points in the upper four digits are lit for a negative value.	○	○	○	×	○
Load-side encoder information 1 (1pulse unit) *3	FCY 1	pulse	The Z-phase counter of the load-side encoder is displayed in the encoder pulse unit. For an incremental linear encoder, the Z-phase counter is displayed. The value is counted up from 0 based on the home position (reference mark). For absolute position linear encoders, the absolute position of encoder is displayed. When the count exceeds ±99999, it starts from 0.	○	○	○	×	○

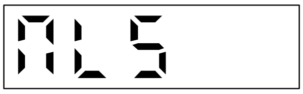
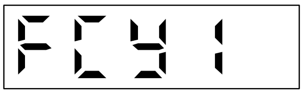
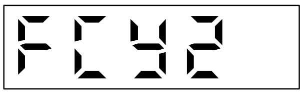
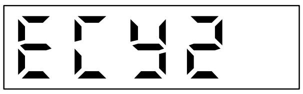
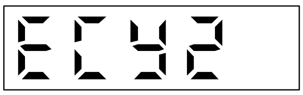
For use with training machine

Table3.1(5/6)

Status display	Symbol	Unit	Description	Control mode *1			Operation mode *2	
				P	S	T	Semi closed	Fully closed
Load-side encoder information 1 (100000pulses unit) *3		100000 pulses	The Z-phase counter of the load-side encoder is displayed in 100000 pulses unit. For an incremental linear encoder, the Z-phase counter is displayed. The value is counted up from 0 based on the home position (reference mark). For absolute position linear encoders, the absolute position of encoder is displayed. When the count exceeds ±99999, it starts from 0.	○	○	○	×	○
Load-side encoder information 2 *3		rev	If an incremental linear encoder is used as the load-side encoder, "0" is displayed. If an absolute position linear encoder is used as the load-side encoder, "0" is displayed. If a rotary encoder is used as the load-side encoder, the multi-revolution counter value of the encoder is displayed.	○	○	○	×	○
Motor-side encoder information 1 (1pulse unit) *3		pulse	The position within one revolution of the motor-side encoder is displayed in the encoder pulse unit. For an incremental linear encoder, the Z-phase counter is displayed. The value is counted up from 0 based on the home position (reference mark). For absolute position linear encoders, the absolute position of encoder is displayed. When the count exceeds ±99999, it starts from 0.	○	○	○	×	○
Motor-side encoder information 1 (100000pulses unit) *3		100000 pulses	The position within one revolution of the motor-side encoder is displayed in 100000 pulses unit. For an incremental linear encoder, the Z-phase counter is displayed. The value is counted up from 0 based on the home position (reference mark). For absolute position linear encoders, the absolute position of encoder is displayed. When the count exceeds ±99999, it starts from 0.	○	○	○	×	○

For use with training machine

Table3.1(6/6)

Status display	Symbol	Unit	Description	Control mode *1			Operation mode *2	
				P	S	T	Semi closed	Fully closed
Motor-side encoder information 2 *3		rev	If an incremental linear encoder is used as the motor-side encoder, "0" is displayed. If an absolute position linear encoder is used as the motor-side encoder, "0" is displayed. If a rotary encoder is used as the motor-side encoder, the multi-revolution counter value of the encoder is displayed.	○	○	○	×	○
Z-phase counter low		pulse	The Z-phase counter is displayed in the encoder pulse unit. For an incremental linear encoder, the Z-phase counter is displayed. The value is counted up from 0 based on the home position (reference mark). For absolute position linear encoders, the absolute position of encoder is displayed. When the count exceeds ±99999, it starts from 0. This is displayed only when the linear servo motor is used.	○	○	○	○	×
Z-phase counter high		100000 pulses	The Z-phase counter is displayed by increments of 100000 pulses of the encoder. For an incremental linear encoder, the Z-phase counter is displayed. The value is counted up from 0 based on the home position (reference mark). For absolute position linear encoders, the absolute position of encoder is displayed. When the count exceeds ±99999, it starts from 0. This is displayed only when the linear servo motor is used.	○	○	○	○	×
Electrical angle low		pulse	The servo motor electrical angle is displayed. This is displayed only when the linear servo motor is used.	○	○	○	○	×
Electrical angle high		100000 pulses	The servo motor electrical angle is displayed by increments of 100000 pulses. This is displayed only when the linear servo motor is used.	○	○	○	○	×

*1. P: Position control mode
S: Speed control mode
T: Torque control mode

*2. Semi closed: Semi closed loop control mode
Fully closed: Fully closed loop control mode

*3. Available on servo amplifiers with software version A5 or later.

For use with training machine

(5) Changing the status display screen

The status display on the servo amplifier at power-on can be changed with [Pr.PC36].

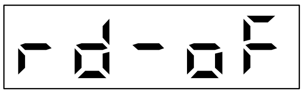
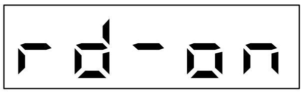
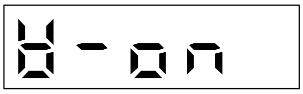
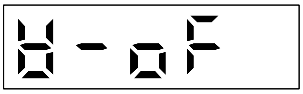
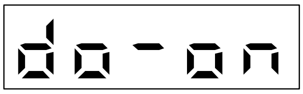
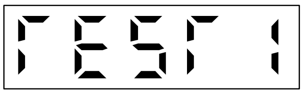
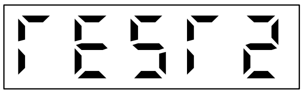
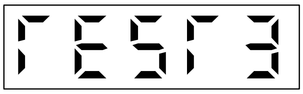
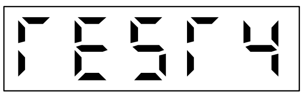
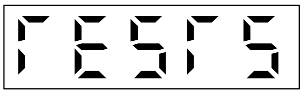
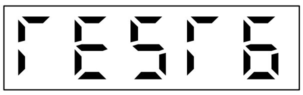
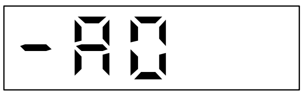
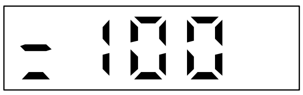
For each control mode, the status display in the initial status changes as follows.

Control mode	Displayed items
Position	Cumulative feedback pulses
Position/speed	Cumulative feedback pulses/servo motor speed
Speed	Servo motor speed
Speed/torque	Servo motor speed/analog torque command voltage
Torque	Analog torque command voltage
Torque/position	Analog torque command voltage/cumulative feedback pulses

For use with training machine

(6) Diagnostic mode

This mode is used to check the status of external sequences, etc.

Name		Display	Description
Sequence			Not ready Indicates that the servo amplifier is being initialized or an alarm has occurred.
			Ready Indicates that initialization is completed, and the servo amplifier is in servo-on state and ready to operate.
Drive recorder enabled/disabled display			The drive recorder is enabled. When an alarm occurs in this state, the drive recorder operates, and records the status at the alarm occurrence.
			The drive recorder is disabled. The drive recorder does not operate in the following conditions. The graph function of MR Configurator2 is being used. The machine analyzer function is being used. [Pr.PF21] is set to "-1".
External I/O signal display		Refer to section 3.1.7 "Checking external I/O signal"	Indicates the on/off status of the external I/O signal. The upper segments correspond to the input signals, and the lower segments correspond to the output signals.
Output signal (DO) forced output			Allows digital output signal to be switched on/off forcibly.
Test operation mode	JOG operation		The JOG operation can be performed without commands from an external controller. Refer to section 3.1.8 (3) (b) "JOG operation" for details.
	Positioning operation		The positioning operation can be performed without commands from an external controller. MR Configurator2 is required to perform the positioning operation. Refer to section 6.1.5 (7) "Positioning operation" for details.
	Motor-less operation		Without connecting the servo motor, output signals can be provided, and the status display can be monitored for the input devices as if the servo motor is actually running. Refer to section 6.1.5 (9) "Motor-less operation" for details.
	Machine analyzer operation		Merely connecting a servo amplifier allows the resonance point of the mechanical system to be measured. MR Configurator2 is required to perform the machine analyzer operation. For details, refer to Help of MR Configurator2.
	For manufacturer adjustment		This is for manufacturer adjustment.
	For manufacturer adjustment		This is for manufacturer adjustment.
Software version lower			Indicates the version of the software.
Software version upper			Indicates the system number of the software.

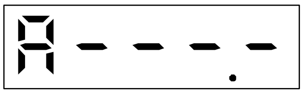
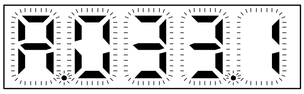
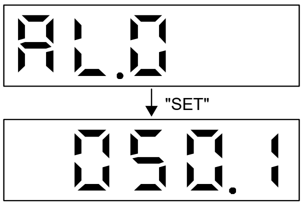
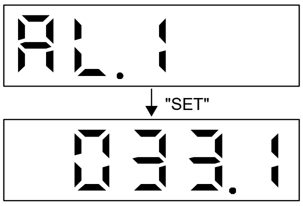
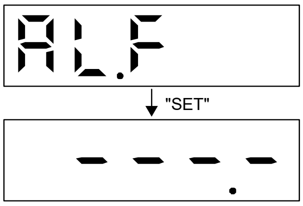
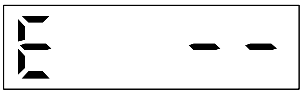
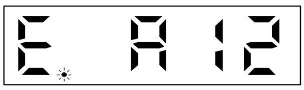
For use with training machine

Name	Display	Description
Analog command input 1 automatic offset	H1 0	The analog command input 1 offset voltage can be adjusted automatically. VC (Analog speed command)/VLA (Analog speed limit) is set as the initial value. Zero-adjustment of the offset voltage is performed automatically when the offset voltage of the internal and external analog circuits of the servo amplifier causes the servo motor to operate slowly, even though VC (Analog speed command) or VLA (Analog speed limit) is set to 0V. When using this function, enable it in the following procedure. When it is enabled, the value of [Pr.PC37] changes to the automatically adjusted offset voltage. 1) Press "SET" once. 2) Set the number in the first digit to 1 with "UP"/"DOWN". 3) Press "SET". This function cannot be used if the input voltage of VC or VLA is -0.4V or less, or +0.4V or more. Even if the analog command input 1 automatic offset is performed and 0V is input, the servo motor may not stop completely due to an internal error. To completely stop the servo motor, switch off ST1 or ST2 and stop.
Servo motor series ID	H2 0	Press the "SET" button to display the series ID of the servo motor currently connected. Refer to "Rotary servo motor ID codes" in Rotary Servo Motor User's Manual (HK series) for the description of each display.
Servo motor type ID	H3 0	Push "SET" to show the servo motor type ID of the servo motor currently connected. Refer to "Rotary servo motor ID codes" in Rotary Servo Motor User's Manual (HK series) for the description of each display.
Servo motor encoder ID	H4 0	Push "SET" to show the encoder ID of the servo motor currently connected. Refer to "Rotary servo motor ID codes" in Rotary Servo Motor User's Manual (HK series) for the description of each display.
For manufacturer adjustment	H5 0	This is for manufacturer adjustment.
For manufacturer adjustment	H6 0	This is for manufacturer adjustment.

For use with training machine

(7) Alarm mode

The current alarm, past alarm history, and parameter error are displayed. The lower 3 digits on the display indicate the number of the alarm that has occurred or the servo parameter No. in error.

Name	Display	Description
Current alarm		Indicates no occurrence of an alarm.
	 (Blinking)	Indicates the occurrence of [AL.033.1 Main circuit voltage error]. Blinks at alarm occurrence.
Alarm history		Indicates that the last alarm is [AL.050.1 Thermal overload error 1 during operation]. When an alarm is recorded in the alarm history, the 2-digit decimal point is lit. Press "SET" to display the alarm No.
		Indicates the second last alarm is [AL.033.1 Main circuit voltage error]. When an alarm is recorded in the alarm history, the 2-digit decimal point is lit. Press "SET" to display the alarm No.
	…	…
		Indicates that there is no sixteenth alarm in the past. When no alarm history exists, the display is as shown in the left column.
Servo parameter error No.		Indicates no occurrence of [AL.037 Parameter error].
	 (The decimal point of the five digit blinks.)	The setting value of [Pr.PA12 Reverse rotation torque limit] is incorrect.

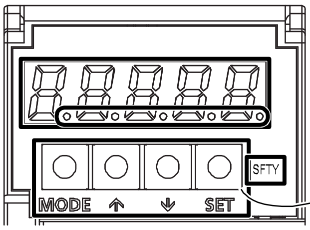
(a) Functions at alarm occurrence

- The current alarm is displayed in any mode.
- Even during alarm occurrence, the other screen can be viewed by pressing the button in the operation area. At this time, the decimal point in the fifth digit remains blinking.
- Remove the cause of the alarm and clear the alarm in any of the following methods.
  Cycle the power.
  Press "SET" on the current alarm display.
  Turn on RES (Reset).
- Clear the alarm history with [Pr.PC18].
- Press "UP" or "DOWN" to move to the next history.

For use with training machine

(8) Display operation

Settings of the display and parameters are performed using the display section (5-digit, 7-segment LED) and operation section (4 push buttons) on the front of the servo amplifier. The operation procedure is as follows.



MODE	Display mode change Low/High switching Press this item for 3 sec or more at the same time as "SET" to switch the mode to the one-touch tuning mode.
⇑	Display/data transition (UP)
⇓	Display/data transition (DOWN)
SET	Display/data confirmation Data clear Press this item for 3 sec or more at the same time as "MODE" to switch the mode to the one-touch tuning mode.

(a) Power-on

• Turn off the servo-on signal (SON).

• Turning the power on displays "C" (Cumulative feedback pulses) on the display. (For position control mode)

Point

● The initial display at power-on varies depending on the control mode.
- For position control mode: C (Cumulative feedback pulses)
- For speed control mode: r (Servo motor speed)
- For torque control mode: U (Analog torque command)

The status display on the servo amplifier at power-on can also be changed with [Pr.PC36].

(b) Turning on the SON signal

Turning on the servo-on signal (SON) makes the servo amplifier the operation-ready state and locks the servo motor shaft. (Servo-lock state)

If the servo-lock is not performed, the servo amplifier is not in the servo-on state. Check the external sequence by the diagnosis display.

Confirmation method

Power-on

↓

C — Press the <MODE> button twice.

↓

rd-oF

↓ Turn on SON.

rd-on ……The display on the left is displayed when the servo-on is performed.

For use with training machine

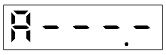
(c) Status display

The initial display of the status display varies depending on the control mode. For the positioning control mode, the display initially shows the status "Cumulative feedback pulses". Pressing the <UP> button changes the display to the status shown in the table in section 3.1.4 (4) "Status display list" in order from the top to the bottom of the list. Press the <DOWN> button to move back to the previous display.
To display a desired content on the initial display, select the applicable value in [Pr.PC36].

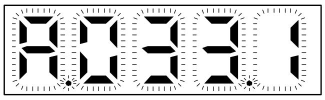
(d) Diagnosis display

Pressing the <MODE> button twice in the status display mode shifts the mode to the diagnosis display mode. Change the display as desired with the <UP> and <DOWN> buttons.

(e) Alarm display

Pressing the <MODE> button again in the diagnosis display mode displays the current alarm code for the description and history of the alarm.
If no alarm is currently occurring,  will be displayed.
Pressing the <UP> button displays the last alarm code, allowing the histories of up to sixteenth alarms to be browsed.
The alarm history will be stored even after the power is turned off.
When an alarm is recorded in the alarm history, the 2-digit decimal point is lit. Press and hold "SET" to display the alarm No.

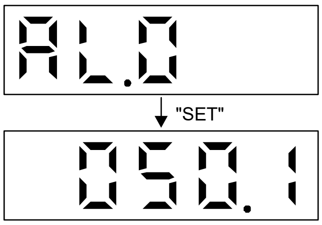
Current alarm



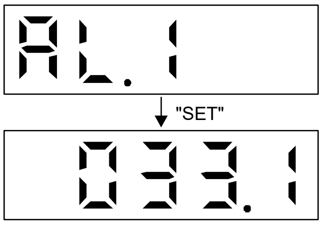
(Blinking)

* The display blinks.

Last alarm



Second last alarm



(f) At alarm occurrence during operation

If an alarm occurs during an operation, the current alarm will immediately be displayed regardless of the display mode.

3.1.5 Parameter

Digital servos use parameters to perform settings required for analog servos such as gain adjustment and offset adjustment of the analog I/O signals. In addition, the digital servos select a control mode from the position/speed/torque modes and switch the functions. The parameter lists of MR-J5 model servo amplifier are shown in the following.

(1) Lists of servo parameter supported modes

When using this servo in the position control mode, setting mainly the basic setting parameters allows the basic parameters to be set at installation.

(a) Explanation of the lists

The following shows the meaning of each abbreviation used in the lists. "○" indicates the modes that can be used, and "-" indicates the modes that cannot be used or modes that are not used even if set.

Mode	Abbreviation	Meaning
Operation mode	Standard	Standard control mode
	Linear	Linear servo motor control mode
	DD	Direct drive motor control mode
	Semi closed	Semi closed loop control mode
	Fully closed	Fully closed loop control mode
Control mode	P	Position control mode
	S	Speed control mode
	T	Torque control mode

(b) Lists of supported control modes

1) Basic setting servo parameters group ([Pr.PA_ _])

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PA01	PA01.0	○	○	○	○	○	○	○	○
	PA01.1	○	○	○	○	○	○	○	○
	PA01.4	○	–	○	○	○	○	–	–
PA02	PA02.0-1	○	○	○	○	○	○	○	○
	PA02.4	○	○	○	○	○	○	○	○
	PA02.5	○	○	○	○	○	○	○	○
PA03	PA03.0	○	○	○	○	○	○	–	–
	PA03.1	○	–	–	○	–	–	–	–
PA04	PA04.3	○	○	○	○	○	○	○	–
PA05	–	○	–	○	–	–	○	–	–
PA06	–	○	○	○	○	○	○	–	–
PA07	–	○	○	○	○	○	○	–	–
PA08	PA08.0	○	○	○	○	○	○	○	–
	PA08.4	○	○	○	○	○	○	○	–
	PA08.5	○	○	○	○	○	○	○	–
	PA08.6	○	○	○	○	○	○	○	–
PA09	–	○	○	○	○	○	○	○	–
PA10	–	○	○	○	○	○	○	–	–
PA11	–	○	○	○	○	○	○	○	○
PA12	–	○	○	○	○	○	○	○	○
PA13	PA13.0	○	○	○	○	○	○	–	–
	PA13.1	○	○	○	○	○	○	–	–
	PA13.2	○	○	○	○	○	○	–	–
PA14	–	○	○	○	○	○	○	–	–
PA15	–	○	○	○	○	○	○	○	○
PA16	–	○	○	○	○	○	○	○	○
PA17	–	–	○	○	–	○	○	○	○
PA18	PA18.0-3	–	○	○	–	○	○	○	○
PA19	–	○	○	○	○	○	○	○	○
PA20	PA20.1	○	○	○	○	○	○	○	–
	PA20.2	○	○	○	○	○	○	○	○
PA21	PA21.0	○	○	○	○	○	○	○	–
	PA21.3	○	○	○	○	○	○	–	–
PA22	PA22.1	○	○	○	○	○	○	–	–
PA23	PA23.0-1	○	○	○	○	○	○	○	○
	PA23.2-4	○	○	○	○	○	○	○	○
PA24	PA24.0	○	○	○	○	○	○	○	–
PA25	–	○	○	○	○	○	○	–	–
PA26	PA26.0	○	○	○	○	○	○	○	–
PA28	PA28.4	○	○	○	○	○	○	○	○
PA34	–	○	○	○	○	○	○	○	○

2) Gain/filter setting servo parameters group ([Pr.PB _ _])

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PB01	PB01.0	○	○	○	○	○	○	○	○
	PB01.3	○	○	○	○	○	○	○	–
PB02	PB02.0	○	○	○	○	○	○	–	–
	PB02.1	○	○	○	○	○	○	–	–
PB03	–	○	○	○	○	○	○	–	–
PB04	–	○	○	○	○	○	○	–	–
PB06	–	○	○	○	○	○	○	○	–
PB07	–	○	○	○	○	○	○	○	–
PB08	–	○	○	○	○	○	○	–	–
PB09	–	○	○	○	○	○	○	○	–
PB10	–	○	○	○	○	○	○	○	–
PB11	–	○	○	○	○	○	○	○	–
PB12	–	○	○	○	○	○	○	–	–
PB13	–	○	○	○	○	○	○	○	○
PB14	PB14.1	○	○	○	○	○	○	○	○
	PB14.2	○	○	○	○	○	○	○	○
PB15	–	○	○	○	○	○	○	○	○
PB16	PB16.0	○	○	○	○	○	○	○	○
	PB16.1	○	○	○	○	○	○	○	○
	PB16.2	○	○	○	○	○	○	○	○
PB17	PB17.0-1	○	○	○	○	○	○	○	○
	PB17.2	○	○	○	○	○	○	○	○
PB18	–	○	○	○	○	○	○	○	–
PB19	–	○	○	○	○	○	○	–	–
PB20	–	○	○	○	○	○	○	–	–
PB21	–	○	○	○	○	○	○	–	–
PB22	–	○	○	○	○	○	○	–	–
PB23	PB23.0	○	○	○	○	○	○	○	○
	PB23.1	○	○	○	○	○	○	○	–
	PB23.3	○	○	○	○	○	○	○	○
PB24	PB24.0	○	○	○	○	○	○	–	–
PB25	PB25.0	○	○	○	○	○	○	○	–
	PB25.1	○	○	○	○	○	○	–	–
PB26	PB26.0	○	○	○	○	○	○	○	–
	PB26.1	○	○	○	○	○	○	○	–
	PB26.2	○	○	○	○	○	○	○	–
	PB26.4	○	○	○	○	○	○	○	–
	PB26.5	○	○	○	○	○	○	–	–
PB27	–	○	○	○	○	○	○	○	–
PB28	–	○	○	○	○	○	○	○	–
PB29	–	○	○	○	○	○	○	○	–
PB30	–	○	○	○	○	○	○	–	–
PB31	–	○	○	○	○	○	○	○	–
PB32	–	○	○	○	○	○	○	○	–
PB33	–	○	○	○	○	○	○	–	–
PB34	–	○	○	○	○	○	○	–	–
PB35	–	○	○	○	○	○	○	–	–
PB36	–	○	○	○	○	○	○	–	–
PB45	PB45.0-1	○	○	○	○	○	○	–	–
	PB45.2	○	○	○	○	○	○	–	–
PB46	–	○	○	○	○	○	○	○	○

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PB47	PB47.0	○	○	○	○	○	○	○	○
	PB47.1	○	○	○	○	○	○	○	○
	PB47.2	○	○	○	○	○	○	○	○
PB48	–	○	○	○	○	○	○	○	○
PB49	PB49.0	○	○	○	○	○	○	○	○
	PB49.1	○	○	○	○	○	○	○	○
	PB49.2	○	○	○	○	○	○	○	○
PB50	–	○	○	○	○	○	○	○	○
PB51	PB51.0	○	○	○	○	○	○	○	○
	PB51.1	○	○	○	○	○	○	○	○
	PB51.2	○	○	○	○	○	○	○	○
PB52	–	○	○	○	○	○	○	–	–
PB53	–	○	○	○	○	○	○	–	–
PB54	–	○	○	○	○	○	○	–	–
PB55	–	○	○	○	○	○	○	–	–
PB56	–	○	○	○	○	○	○	–	–
PB57	–	○	○	○	○	○	○	–	–
PB58	–	○	○	○	○	○	○	–	–
PB59	–	○	○	○	○	○	○	–	–
PB60	–	○	○	○	○	○	○	○	–
PB65	–	○	○	○	○	○	○	○	–
PB66	–	○	○	○	○	○	○	○	–
PB67	–	○	○	○	○	○	○	○	–
PB68	–	○	○	○	○	○	○	–	–
PB69	–	○	○	○	○	○	○	○	–
PB70	–	○	○	○	○	○	○	○	–
PB71	–	○	○	○	○	○	○	–	–
PB72	–	○	○	○	○	○	○	–	–
PB73	–	○	○	○	○	○	○	–	–
PB74	–	○	○	○	○	○	○	–	–
PB75	–	○	○	○	○	○	○	–	–
PB76	–	○	○	○	○	○	○	–	–
PB77	–	○	○	○	○	○	○	–	–
PB78	–	○	○	○	○	○	○	–	–
PB79	–	○	○	○	○	○	○	○	–
PB81	PB81.4	○	○	○	○	○	○	–	–
PB82	–	○	○	○	○	○	○	–	–

3) Extension setting servo parameters group ([Pr.PC_ _])

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PC01	–	○	○	○	–	–	–	○	○
PC02	–	○	○	○	–	–	–	○	○
PC03	–	○	○	○	–	–	–	○	○
PC04	–	○	○	○	–	–	–	–	○
PC05	–	○	○	○	–	–	–	○	○
PC06	–	○	○	○	–	–	–	○	○
PC07	–	○	○	○	–	–	–	○	○
PC08	–	○	○	○	–	–	–	○	○
PC09	–	○	○	○	–	–	–	○	○
PC10	–	○	○	○	–	–	–	○	○
PC11	–	○	○	○	–	–	–	○	○
PC12	–	○	○	○	–	–	–	○	○
PC13	–	○	○	○	–	–	–	–	○
PC14	PC14.0-1	○	○	○	○	○	○	○	○
PC15	PC15.0-1	○	○	○	○	○	○	○	○
PC16	–	○	○	○	○	○	○	○	○
PC17	–	○	○	○	○	○	○	○	○
PC18	PC18.0	○	○	○	○	○	○	○	○
PC19	PC19.0	○	○	○	○	○	○	○	○
	PC19.1	○	○	○	○	○	○	○	○
	PC19.2	○	○	○	○	○	○	–	–
PC22	PC22.3	○	○	○	○	○	○	○	○
PC23	PC23.0	○	○	○	–	–	–	○	–
	PC23.2	○	○	○	–	–	–	○	○
	PC23.3	○	○	○	–	–	–	–	○
PC24	PC24.0	○	○	○	○	○	○	–	–
	PC24.3	○	○	○	○	○	○	–	–
PC26	PC26.0	○	○	○	○	○	○	○	–
	PC26.4	○	○	○	○	○	○	○	○
	PC26.6	○	○	○	○	○	○	○	○
PC27	PC27.2	○	○	○	○	○	○	○	○
	PC27.4	○	○	○	○	○	○	○	○
PC28	PC28.3	–	○	–	–	–	○	○	○
PC29	PC29.0	○	–	–	○	–	○	○	○
	PC29.3	○	○	○	○	○	○	○	○
	PC29.4	○	○	○	○	○	○	○	○
PC30	–	○	○	○	–	–	–	○	○
PC31	–	○	○	○	–	–	–	○	○
PC32	–	○	○	○	○	○	○	–	–
PC33	–	○	○	○	○	○	○	–	–
PC34	–	○	○	○	○	○	○	–	–
PC35	–	○	○	○	○	○	○	○	○
PC36	PC36.0-1	○	○	○	○	○	○	○	○
	PC36.2	○	○	○	○	○	○	○	○
PC37	–	○	○	○	○	○	○	○	○
PC38	–	○	○	○	○	○	○	○	○
PC39	–	○	○	○	○	○	○	○	○
PC40	–	○	○	○	○	○	○	○	○
PC43	–	○	○	○	○	○	○	–	–
PC44	PC44.3	○	○	○	○	○	○	–	–
PC45	PC45.0	○	○	○	○	○	○	○	○
	PC45.2	○	○	○	○	○	○	○	○

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PC50	PC50.0	○	○	○	○	○	○	○	○
	PC50.1	○	○	○	–	–	–	–	○
PC51	–	○	○	○	○	○	○	○	–
PC54	–	○	○	○	○	○	○	–	–
PC60	PC60.0	○	–	–	–	–	○	○	○
	PC60.1	○	○	○	○	○	○	○	○
	PC60.4	○	○	○	○	○	○	○	○
PC73	–	○	○	○	○	○	○	–	–
PC90	–	○	○	○	○	○	○	–	–

4) I/O setting servo parameters group ([Pr.PD_ _])

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PD01	PD01.0-7	○	○	○	○	○	○	○	○
PD03	PD03.0-1	○	○	○	○	○	○	–	–
	PD03.2-3	○	○	○	–	–	–	○	–
PD04	PD04.0-1	○	○	○	–	–	–	–	○
PD05	PD05.0-1	○	○	○	○	○	○	–	–
	PD05.2-3	○	○	○	–	–	–	○	–
PD06	PD06.0-1	○	○	○	–	–	–	–	○
PD07	PD07.0-1	○	○	○	○	○	○	–	–
	PD07.2-3	○	○	○	–	–	–	○	–
PD08	PD08.0-1	○	○	○	–	–	–	–	○
PD09	PD09.0-1	○	○	○	○	○	○	–	–
	PD09.2-3	○	○	○	–	–	–	○	–
PD10	PD10.0-1	○	○	○	–	–	–	–	○
PD11	PD11.0-1	○	○	○	○	○	○	–	–
	PD11.2-3	○	○	○	–	–	–	○	–
PD12	PD12.0-1	○	○	○	–	–	–	–	○
PD13	PD13.0-1	○	○	○	○	○	○	–	–
	PD13.2-3	○	○	○	–	–	–	○	–
PD14	PD14.0-1	○	○	○	–	–	–	–	○
PD17	PD17.0-1	○	○	○	○	○	○	–	–
	PD17.2-3	○	○	○	–	–	–	○	–
PD18	PD18.0-1	○	○	○	–	–	–	–	○
PD19	PD19.0-1	○	○	○	○	○	○	–	–
	PD19.2-3	○	○	○	–	–	–	○	–
PD20	PD20.0-1	○	○	○	–	–	–	–	○
PD21	PD21.0-1	○	○	○	○	○	○	–	–
	PD21.2-3	○	○	○	–	–	–	○	–
PD22	PD22.0-1	○	○	○	–	–	–	–	○
PD23	PD23.0-1	○	○	○	○	○	○	○	○
PD24	PD24.0-1	○	○	○	○	○	○	○	○
PD25	PD25.0-1	○	○	○	○	○	○	○	○
PD26	PD26.0-1	○	○	○	○	○	○	○	○
PD28	PD28.0-1	○	○	○	○	○	○	○	○
PD29	PD29.0	○	○	○	○	○	○	○	○
	PD29.1	○	○	○	○	○	○	○	○
	PD29.2	○	○	○	○	○	○	–	–
PD30	PD30.0	○	○	○	○	○	○	○	–
	PD30.1	○	○	○	○	○	○	○	○
	PD30.3	○	○	○	○	○	○	○	○
PD31	PD31.2	○	○	○	○	○	○	–	–

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PD32	PD32.0	○	○	○	○	○	○	–	–
PD33	PD33.2	○	○	○	○	○	○	○	○
PD34	PD34.1	○	○	○	○	○	○	○	○
PD43	PD43.0-1	○	○	○	○	○	○	–	–
	PD43.2-3	○	○	○	–	–	–	○	–
PD44	PD44.0-1	○	○	○	–	–	–	–	○
PD45	PD45.0-1	○	○	○	○	○	○	–	–
	PD45.2-3	○	○	○	–	–	–	○	–
PD46	PD46.0-1	○	○	○	–	–	–	–	○
PD47	PD47.0-1	○	○	○	○	○	○	○	○
	PD47.2-3	○	○	○	○	○	○	○	○
PD60	PD60.0-7	○	○	○	○	○	○	○	○

5) Extension setting 2 servo parameters group ([Pr.PE_ _])

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PE01	PE01.0	○	–	○	○	○	○	–	–
PE03	PE03.0	○	–	○	○	○	○	–	–
	PE03.1	○	–	○	○	○	○	–	–
	PE03.3	○	–	○	○	○	○	–	–
PE04	–	○	–	○	○	○	○	–	–
PE05	–	○	–	○	○	○	○	–	–
PE06	–	○	–	○	○	○	○	–	–
PE07	–	○	–	○	○	○	○	–	–
PE08	–	○	–	○	○	○	○	–	–
PE10	PE10.1	○	–	○	○	○	○	–	–
PE41	PE41.0	○	○	○	○	○	○	○	○
	PE41.6	○	○	○	○	○	○	○	○
PE44	–	○	○	○	○	○	○	–	–
PE45	–	○	○	○	○	○	○	–	–
PE46	–	○	○	○	○	○	○	–	–
PE47	–	○	○	○	○	○	○	○	○
PE48	PE48.0	○	○	○	○	○	○	–	–
	PE48.1	○	○	○	○	○	○	–	–
PE49	–	○	○	○	○	○	○	–	–
PE50	–	○	○	○	○	○	○	–	–

6) Extension setting 3 servo parameters group ([Pr.PF_ _])

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PF02	PF02.4	○	○	○	○	○	–	–	–
	PF02.5	○	○	○	○	○	–	–	–
PF09	PF09.0	○	–	–	○	–	○	○	○
	PF09.1	○	○	○	○	○	○	○	○
PF15	–	○	–	–	○	–	○	○	○
PF18	–	○	○	○	○	○	○	○	○
PF21	–	○	○	○	○	○	○	○	○
PF23	–	○	○	○	○	○	○	○	–
PF24	PF24.0	○	○	○	○	○	○	○	○
PF25	–	○	○	○	○	○	○	○	○
PF31	–	○	○	○	○	○	○	○	○
PF32	–	○	○	○	○	○	○	○	–
PF49	–	○	○	○	○	○	○	○	○

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PF50	–	○	○	○	○	○	○	○	○
PF51	PF51.0	○	○	○	○	○	○	○	○
	PF51.1	○	○	○	○	○	○	○	○
	PF51.2	○	○	○	○	○	○	○	○
	PF51.5	○	○	○	○	○	○	○	○
	PF51.6	○	○	○	○	○	○	○	○
PF52	PF52.0	○	○	○	○	○	○	○	○
	PF52.1	○	○	○	○	○	○	○	○
	PF52.2	○	○	○	○	○	○	○	○
	PF52.4	○	○	○	○	○	○	○	○
	PF52.5	○	○	○	○	○	○	○	○
PF53	–	○	○	○	○	○	○	○	○
PF54	–	○	○	○	○	○	○	○	○
PF55	–	○	○	○	○	○	○	○	○
PF56	–	○	○	○	○	○	○	○	○
PF57	–	○	○	○	○	○	○	○	○
PF58	–	○	○	○	○	○	○	○	○
PF66	PF66.0-3	○	–	○	○	○	○	○	–
	PF66.4-7	○	–	○	○	○	○	○	–
PF67	–	○	–	○	○	○	○	○	–
PF68	–	○	–	○	○	○	○	○	–
PF69	–	○	○	○	○	○	○	○	○
PF70	–	○	○	○	○	○	○	○	○
PF71	PF71.0	○	○	○	○	○	○	○	○
	PF71.1	○	○	○	○	○	○	○	○
PF72	–	○	–	○	○	○	○	○	○
PF73	–	○	–	○	○	○	○	○	○
PF74	–	○	–	○	○	○	○	○	○
PF75	–	○	–	○	○	○	○	○	○
PF76	–	○	–	○	○	○	○	○	○
PF80	PF80.0	○	○	○	○	○	○	○	○
	PF80.2-3	○	○	○	○	○	○	○	○
PF81	PF81.0	○	○	○	○	○	○	○	○
PF82	PF82.0	○	○	○	○	○	○	○	○
	PF82.1	○	○	○	○	○	○	○	○
	PF82.2	○	○	○	○	○	○	○	○
	PF82.3	○	○	○	○	○	○	○	○
PF84	PF84.0-1	○	○	○	○	○	○	○	○
	PF84.2-3	○	○	○	○	○	○	○	○
	PF84.4-5	○	○	○	○	○	○	○	○
PF85	–	○	○	○	○	○	○	○	○
PF86	–	○	○	○	○	○	○	○	○
PF87	PF87.0-2	○	○	○	○	○	○	○	○
	PF87.4-6	○	○	○	○	○	○	○	○
PF88	PF88.0-2	○	○	○	○	○	○	○	○
	PF88.4-6	○	○	○	○	○	○	○	○
PF89	PF89.0-2	○	○	○	○	○	○	○	○
	PF89.4-6	○	○	○	○	○	○	○	○
PF90	PF90.0-2	○	○	○	○	○	○	○	○
PF91	PF91.0-3	○	○	○	○	○	○	○	○
	PF91.4-7	○	○	○	○	○	○	○	○
PF92	PF92.0-3	○	○	○	○	○	○	○	○
	PF92.4-7	○	○	○	○	○	○	○	○
PF93	PF93.0-3	○	○	○	○	○	○	○	○
	PF93.4-7	○	○	○	○	○	○	○	○

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PF94	PF94.0-3	○	○	○	○	○	○	○	○
	PF94.4-7	○	○	○	○	○	○	○	○
PF95	PF95.0	○	○	○	○	○	○	○	○

7) Motor extension setting servo parameters group ([Pr.PL_ _])

No.	Detail No.	Operation mode					Control mode		
		Semi closed			Fully closed				
		Standard	Linear	DD	Standard	DD	P	S	T
PL01	PL01.0	–	○	○	–	○	○	○	○
	PL01.2	–	○	–	–	–	○	○	○
PL02	–	–	○	–	–	–	○	○	○
PL03	–	–	○	–	–	–	○	○	○
PL04	PL04.0	–	○	○	–	○	○	○	○
	PL04.3	–	○	○	–	○	○	○	○
PL05	–	–	○	○	–	○	○	–	–
PL06	–	–	○	○	–	○	○	○	–
PL07	–	–	○	○	–	○	○	○	○
PL08	PL08.0	–	○	○	–	○	○	○	○
	PL08.2	–	○	○	–	○	○	○	○
PL09	–	–	○	○	–	○	○	○	○
PL17	PL17.0	–	○	○	–	○	○	○	○
	PL17.1	–	○	○	–	○	○	○	○
PL18	–	–	○	○	–	○	○	○	○

(2) Lists of servo parameter initial values
Abbreviated parameters prefixed with * or ** are enabled after the power is cycled or a software reset is performed.

(a) Basic setting servo parameters group ([Pr.PA_ _])

No.	Symbol	Initial value	Unit
PA01	**STY	10003000h	–
PA02	**REG	00000000h	–
PA03	*ABS	00000000h	–
PA04	*AOP1	00002000h	–
PA05	*FBP	10000	pulse
PA06	CMX	1	–
PA07	CDV	1	–
PA08	ATU	00000001h	–
PA09	RSP	16	–
PA10	INP	400	*1
PA11	TLP	1000.0	%
PA12	TLN	1000.0	%
PA13	*PLSS	00000100h	–
PA14	*POL	0	–
PA15	*ENR	4000	pulse/rev
PA16	*ENR2	1	–
PA17	**MSR	00000000h	–
PA18	**MTY	00000000h	–
PA19	*BLK	000000ABh	–
PA20	*TDS	00000000h	–
PA21	*AOP3	00000001h	–
PA22	**PCS	00000000h	–
PA23	DRAT	00000000h	–
PA24	AOP4	00000000h	–
PA25	OTHOV	0	%
PA26	*AOP5	00000000h	–
PA27	For manufacturer setting	00000000h	–
PA28	**AOP6	00000000h	–
PA29	For manufacturer setting	0	–
PA30	For manufacturer setting	0	–
PA31	For manufacturer setting	0	–
PA32	For manufacturer setting	00000000h	–
PA33	For manufacturer setting	0.0	–
PA34	QDIS	0	0.1rev, mm
PA35	For manufacturer setting	00000000h	–
PA36	For manufacturer setting	00000000h	–
PA37	For manufacturer setting	00000000h	–
PA38	For manufacturer setting	00000000h	–
PA39	For manufacturer setting	00000000h	–
PA40	For manufacturer setting	00000000h	–
PA41	For manufacturer setting	00000000h	–
PA42	For manufacturer setting	00000000h	–
PA43	For manufacturer setting	00000000h	–
PA44	For manufacturer setting	00000000h	–

*1. Refer to section 3.1.5 10) [Pr.PA10_In-position range (INP)].

(b) Gain/filter setting servo parameters group ([Pr.PB _ _])

No.	Symbol	Initial value	Unit
PB01	FILT	00000000h	–
PB02	VRFT	00000000h	–
PB03	PST	0	ms
PB04	FFC	0	%
PB05	For manufacturer setting	500	–
PB06	GD2	7.00	Multiplier
PB07	PG1	15.0	rad/s
PB08	PG2	37.0	rad/s
PB09	VG2	823	rad/s
PB10	VIC	33.7	ms
PB11	VDC	980	–
PB12	OVA	0	%
PB13	NH1	4500	Hz
PB14	NHQ1	00000000h	–
PB15	NH2	4500	Hz
PB16	NHQ2	00000000h	–
PB17	NHF	00000000h	–
PB18	LPF	3141	rad/s
PB19	VRF11	100.0	Hz
PB20	VRF12	100.0	Hz
PB21	VRF13	0.00	–
PB22	VRF14	0.00	–
PB23	VFBF	00001000h	–
PB24	*MVS	00000000h	–
PB25	*BOP1	00000000h	–
PB26	*CDP	00000000h	–
PB27	CDL	10	*1
PB28	CDT	1	ms
PB29	GD2B	7.00	Multiplier
PB30	PG2B	0.0	rad/s
PB31	VG2B	0	rad/s
PB32	VICB	0.0	ms
PB33	VRF11B	0.0	Hz
PB34	VRF12B	0.0	Hz
PB35	VRF13B	0.00	–
PB36	VRF14B	0.00	–
PB37	For manufacturer setting	1600	–
PB38	For manufacturer setting	0.000	–
PB39	For manufacturer setting	0.000	–
PB40	For manufacturer setting	0.000	–
PB41	For manufacturer setting	00000000h	–
PB42	For manufacturer setting	00000000h	–
PB43	For manufacturer setting	00000000h	–
PB44	For manufacturer setting	0.00	–
PB45	CNHF	00000000h	–
PB46	NH3	4500	Hz
PB47	NHQ3	00000000h	–
PB48	NH4	4500	Hz
PB49	NHQ4	00000000h	–
PB50	NH5	4500	Hz
PB51	NHQ5	00000000h	–
PB52	VRF21	100.0	Hz
PB53	VRF22	100.0	Hz
PB54	VRF23	0.00	–
PB55	VRF24	0.00	–

No.	Symbol	Initial value	Unit
PB56	VRF21B	0.0	Hz
PB57	VRF22B	0.0	Hz
PB58	VRF23B	0.00	–
PB59	VRF24B	0.00	–
PB60	PG1B	0.0	rad/s
PB61	For manufacturer setting	0.0	–
PB62	For manufacturer setting	00000000h	–
PB63	For manufacturer setting	00000000h	–
PB64	For manufacturer setting	00000000h	–
PB65	CDL2	10	*1
PB66	CDT2	1	ms
PB67	GD2C	7.00	Multiplier
PB68	PG2C	0.0	rad/s
PB69	VG2C	0	rad/s
PB70	VICC	0.0	ms
PB71	VRF11C	0.0	Hz
PB72	VRF12C	0.0	Hz
PB73	VRF13C	0.00	–
PB74	VRF14C	0.00	–
PB75	VRF21C	0.0	Hz
PB76	VRF22C	0.0	Hz
PB77	VRF23C	0.00	–
PB78	VRF24C	0.00	–
PB79	PG1C	0.0	rad/s
PB80	For manufacturer setting	177.0	–
PB81	*CFIL	00000001h	–
PB82	PFT	0.0	ms
PB83	For manufacturer setting	00000000h	–
PB84	For manufacturer setting	00000000h	–
PB85	For manufacturer setting	00000000h	–
PB86	For manufacturer setting	00000000h	–
PB87	For manufacturer setting	00000000h	–
PB88	For manufacturer setting	00000000h	–
PB89	For manufacturer setting	00000000h	–
PB90	For manufacturer setting	00000000h	–
PB91	For manufacturer setting	00000000h	–
PB92	For manufacturer setting	00000000h	–

*1. Refer to the MR-J5 User's Manual (Parameters).

(c) Extension setting servo parameters group ([Pr.PC _ _])

No.	Symbol	Initial value	Unit
PC01	STA	0	ms
PC02	STB	0	ms
PC03	STC	0	ms
PC04	TQC	0	ms
PC05	SC1	100.00	r/min, mm/s
PC06	SC2	500.00	r/min, mm/s
PC07	SC3	1000.00	r/min, mm/s
PC08	SC4	200.00	r/min, mm/s
PC09	SC5	300.00	r/min, mm/s
PC10	SC6	500.00	r/min, mm/s
PC11	SC7	800.00	r/min, mm/s
PC12	VCM	0	r/min, mm/s
PC13	TLC	100.0	%
PC14	MOD1	00000000h	–
PC15	MOD2	00000001h	–
PC16	MBR	0	ms

No.	Symbol	Initial value	Unit
PC17	ZSP	50	r/min, mm/s
PC18	*BPS	00000000h	–
PC19	*ENRS	00000000h	–
PC20	For manufacturer setting	0	–
PC21	For manufacturer setting	00000000h	–
PC22	**COP1	00000000h	–
PC23	*COP2	00000000h	–
PC24	*COP3	00000000h	–
PC25	For manufacturer setting	00000000h	–
PC26	*COP5	00000000h	–
PC27	*COP6	00000000h	–
PC28	*COP7	00000000h	–
PC29	*COP8	00000120h	–
PC30	STA2	0	ms
PC31	STB2	0	ms
PC32	CMX2	1	–
PC33	CMX3	1	–
PC34	CMX4	1	–
PC35	TL2	1000.0	%
PC36	*DMD	00000000h	–
PC37	VCO	0	mV
PC38	TPO	0	mV
PC39	MO1	0	mV
PC40	MO2	0	mV
PC41	For manufacturer setting	0	–
PC42	For manufacturer setting	0	–
PC43	ERZ	0	rev, mm
PC44	**COP9	00000050h	–
PC45	**COPA	00000000h	–
PC46	For manufacturer setting	0	–
PC47	For manufacturer setting	0	–
PC48	For manufacturer setting	0	–
PC49	For manufacturer setting	0	–
PC50	**COPB	00000001h	–
PC51	RSBR	100	ms
PC52	For manufacturer setting	0	–
PC53	For manufacturer setting	0	–
PC54	RSUP1	0	0.0001rev, 0.01mm
PC55	For manufacturer setting	0	–
PC56	For manufacturer setting	100	–
PC57	For manufacturer setting	00000000h	–
PC58	For manufacturer setting	0	–
PC59	For manufacturer setting	00000000h	–
PC60	**COPD	00000000h	–
PC61	For manufacturer setting	00000000h	–
PC62	For manufacturer setting	00000000h	–
PC63	For manufacturer setting	00000000h	–
PC64	For manufacturer setting	00000000h	–
PC65	For manufacturer setting	00000000h	–
PC66	For manufacturer setting	0	–
PC67	For manufacturer setting	00000000h	–
PC68	For manufacturer setting	0	–
PC69	For manufacturer setting	00000000h	–
PC70	For manufacturer setting	0	–
PC71	For manufacturer setting	00000040h	–
PC72	For manufacturer setting	00000000h	–
PC73	ERW	0	rev, mm

No.	Symbol	Initial value	Unit
PC74	For manufacturer setting	00000000h	–
PC75	For manufacturer setting	00C00000h	–
PC76	For manufacturer setting	00000000h	–
PC77	For manufacturer setting	10	–
PC78	For manufacturer setting	0	–
PC79	For manufacturer setting	00000000h	–
PC80	For manufacturer setting	00000000h	–
PC81	For manufacturer setting	0.0	–
PC82	For manufacturer setting	0.0	–
PC83	For manufacturer setting	50.00	–
PC84	For manufacturer setting	10	–
PC85	For manufacturer setting	400	–
PC86	For manufacturer setting	10	–
PC87	For manufacturer setting	20.00	–
PC88	For manufacturer setting	10	–
PC89	For manufacturer setting	00000000h	–
PC90	PLFT	0	pulse/s
PC91	For manufacturer setting	00000000h	–
PC92	For manufacturer setting	0	–
PC93	For manufacturer setting	00000000h	–
PC94	For manufacturer setting	00000000h	–
PC95	For manufacturer setting	00000000h	–
PC96	For manufacturer setting	00000000h	–
PC97	For manufacturer setting	00000000h	–
PC98	For manufacturer setting	00000000h	–
PC99	For manufacturer setting	00000000h	–

(d) I/O setting servo parameters group ([Pr.PD_ _])

No.	Symbol	Initial value	Unit*1
PD01	*DIA1	00000000h	–
PD02	For manufacturer setting	00000000h	–
PD03	*DI1L	00000202h	–
PD04	*DI1H	00000202h	–
PD05	*DI2L	00002100h	–
PD06	*DI2H	00002021h	–
PD07	*DI3L	00000704h	–
PD08	*DI3H	00000707h	–
PD09	*DI4L	00000805h	–
PD10	*DI4H	00000808h	–
PD11	*DI5L	00000303h	–
PD12	*DI5H	00003803h	–
PD13	*DI6L	00002006h	–
PD14	*DI6H	00003920h	–
PD15	For manufacturer setting	000C0C0Ch	–
PD16	For manufacturer setting	00000C0Ch	–
PD17	*DI8L	000A0A0Ah	–
PD18	*DI8H	00000A00h	–
PD19	*DI9L	000B0B0Bh	–
PD20	*DI9H	00000B00h	–
PD21	*DI10L	002B2323h	–
PD22	*DI10H	00002B23h	–
PD23	*DO1	00000004h	–
PD24	*DO2	0000000Ch	–
PD25	*DO3	00000004h	–
PD26	*DO4	00000007h	–
PD27	For manufacturer setting	00000003h	–
PD28	*DO6	00000002h	–

No.	Symbol	Initial value	Unit*1
PD29	*DIF	00000007h	–
PD30	*DOP1	00000000h	–
PD31	*DOP2	00000000h	–
PD32	*DOP3	00000000h	–
PD33	*DOP4	00000000h	–
PD34	*DOP5	00000000h	–
PD35	For manufacturer setting	00000000h	–
PD36	For manufacturer setting	00000000h	–
PD37	For manufacturer setting	00000000h	–
PD38	For manufacturer setting	0	–
PD39	For manufacturer setting	0	–
PD40	For manufacturer setting	0	–
PD41	For manufacturer setting	00000000h	–
PD42	*DIA4	00000000h	–
PD43	*DI11L	00000000h	–
PD44	*DI11H	00003A00h	–
PD45	*DI12L	00000000h	–
PD46	*DI12H	00003B00h	–
PD47	*DO7	00000000h	–
PD48	For manufacturer setting	00000000h	–
PD49	For manufacturer setting	00000000h	–
PD50	For manufacturer setting	00000000h	–
PD51	For manufacturer setting	00000000h	–
PD52	For manufacturer setting	00110001h	–
PD53	For manufacturer setting	0	–
PD54	For manufacturer setting	0	–
PD55	For manufacturer setting	0	–
PD56	For manufacturer setting	00000000h	–
PD57	For manufacturer setting	00000000h	–
PD58	For manufacturer setting	00000000h	–
PD59	For manufacturer setting	00000000h	–
PD60	*DIP	00000000h	–
PD61	For manufacturer setting	00000000h	–
PD62	For manufacturer setting	00000000h	–
PD63	For manufacturer setting	00000000h	–
PD64	For manufacturer setting	00000000h	–
PD65	For manufacturer setting	00000000h	–
PD66	For manufacturer setting	00000000h	–
PD67	For manufacturer setting	00000000h	–
PD68	For manufacturer setting	00000000h	–
PD69	For manufacturer setting	00000000h	–
PD70	For manufacturer setting	00000000h	–
PD71	For manufacturer setting	00000000h	–
PD72	For manufacturer setting	00000000h	–

(e) Extension setting 2 servo parameters group ([Pr.PE_ _])

No.	Symbol	Initial value	Unit
PE01	**FCT1	00000000h	–
PE02	For manufacturer setting	00000000h	–
PE03	*FCT2	00000003h	–
PE04	**FBN	1	–
PE05	**FBD	1	–
PE06	BC1	400	r/min
PE07	BC2	100	kpulse
PE08	DUF	10	rad/s
PE09	For manufacturer setting	00000000h	–
PE10	FCT3	00000000h	–

No.	Symbol	Initial value	Unit
PE11	For manufacturer setting	00000000h	–
PE12	For manufacturer setting	00000000h	–
PE13	For manufacturer setting	00000000h	–
PE14	For manufacturer setting	00000111h	–
PE15	For manufacturer setting	20	–
PE16	For manufacturer setting	00000000h	–
PE17	For manufacturer setting	00000100h	–
PE18	For manufacturer setting	00000000h	–
PE19	For manufacturer setting	00000000h	–
PE20	For manufacturer setting	00000000h	–
PE21	For manufacturer setting	00000000h	–
PE22	For manufacturer setting	00000000h	–
PE23	For manufacturer setting	00000000h	–
PE24	For manufacturer setting	00000000h	–
PE25	For manufacturer setting	00000000h	–
PE26	For manufacturer setting	00000000h	–
PE27	For manufacturer setting	00000000h	–
PE28	For manufacturer setting	00000000h	–
PE29	For manufacturer setting	00000000h	–
PE30	For manufacturer setting	00000000h	–
PE31	For manufacturer setting	00000000h	–
PE32	For manufacturer setting	00000000h	–
PE33	For manufacturer setting	00000000h	–
PE34	For manufacturer setting	1	–
PE35	For manufacturer setting	1	–
PE36	For manufacturer setting	0.0	–
PE37	For manufacturer setting	0.00	–
PE38	For manufacturer setting	0.00	–
PE39	For manufacturer setting	20	–
PE40	For manufacturer setting	00000000h	–
PE41	EOP3	00000000h	–
PE42	For manufacturer setting	0	–
PE43	For manufacturer setting	0.0	–
PE44	LMCP	0	0.01%
PE45	LMCN	0	0.01%
PE46	LMFLT	0	0.1ms
PE47	TOF	0	0.01%
PE48	*LMOP	00000000h	–
PE49	LMCD	0	0.1ms
PE50	LMCT	0	pulse, kpulse
PE51	For manufacturer setting	00000000h	–
PE52	For manufacturer setting	00000000h	–
PE53	For manufacturer setting	00000000h	–
PE54	For manufacturer setting	00000000h	–
PE55	For manufacturer setting	00000000h	–
PE56	For manufacturer setting	00000000h	–
PE57	For manufacturer setting	00000000h	–
PE58	For manufacturer setting	00000000h	–
PE59	For manufacturer setting	00000000h	–
PE60	For manufacturer setting	00000000h	–
PE61	For manufacturer setting	0.000	–
PE62	For manufacturer setting	0.000	–
PE63	For manufacturer setting	0.000	–
PE64	For manufacturer setting	0.000	–
PE65	For manufacturer setting	0.0	–
PE66	For manufacturer setting	0.0	–
PE67	For manufacturer setting	0.0	–

No.	Symbol	Initial value	Unit
PE68	For manufacturer setting	00000000h	–
PE69	For manufacturer setting	00000000h	–
PE70	For manufacturer setting	00000000h	–
PE71	For manufacturer setting	00000000h	–
PE72	For manufacturer setting	00000000h	–
PE73	For manufacturer setting	00000000h	–
PE74	For manufacturer setting	00000000h	–
PE75	For manufacturer setting	00000000h	–
PE76	For manufacturer setting	00000000h	–
PE77	For manufacturer setting	00000000h	–
PE78	For manufacturer setting	0	–
PE79	For manufacturer setting	0	–
PE80	For manufacturer setting	00000000h	–
PE81	For manufacturer setting	00000000h	–
PE82	For manufacturer setting	00000000h	–
PE83	For manufacturer setting	00000000h	–
PE84	For manufacturer setting	00000000h	–
PE85	For manufacturer setting	00000000h	–
PE86	For manufacturer setting	00000000h	–
PE87	For manufacturer setting	00000000h	–
PE88	For manufacturer setting	00000000h	–

(f) Extension setting 3 servo parameters group ([Pr.PF _ _])

No.	Symbol	Initial value	Unit
PF01	For manufacturer setting	00000000h	–
PF02	*FOP2	00000000h	–
PF03	For manufacturer setting	00000000h	–
PF04	For manufacturer setting	0	–
PF05	For manufacturer setting	0	–
PF06	For manufacturer setting	00000000h	–
PF07	For manufacturer setting	1	–
PF08	For manufacturer setting	1	–
PF09	*FOP5	00000013h	–
PF10	For manufacturer setting	00000000h	–
PF11	For manufacturer setting	00000000h	–
PF12	For manufacturer setting	65535	–
PF13	For manufacturer setting	100	–
PF14	For manufacturer setting	100	–
PF15	DBT	2000	ms
PF16	For manufacturer setting	00000000h	–
PF17	For manufacturer setting	10	–
PF18	**STOD	10	s
PF19	For manufacturer setting	00000000h	–
PF20	For manufacturer setting	00000000h	–
PF21	DRT	0	s
PF22	For manufacturer setting	200	–
PF23	OSCL1	20	%
PF24	*FOP9	00000000h	–
PF25	CVAT	200	ms
PF26	For manufacturer setting	0	–
PF27	For manufacturer setting	0	–
PF28	For manufacturer setting	0	–
PF29	For manufacturer setting	00000000h	–
PF30	For manufacturer setting	0	–
PF31	FRIC	0	r/min, mm/s
PF32	*VIBT	50	100ms
PF33	For manufacturer setting	00000000h	–

No.	Symbol	Initial value	Unit
PF34	For manufacturer setting	00000000h	–
PF35	For manufacturer setting	00000000h	–
PF36	For manufacturer setting	00000000h	–
PF37	For manufacturer setting	00000000h	–
PF38	For manufacturer setting	00000000h	–
PF39	For manufacturer setting	00000000h	–
PF40	For manufacturer setting	0	–
PF41	For manufacturer setting	0	–
PF42	For manufacturer setting	0	–
PF43	For manufacturer setting	0	–
PF44	For manufacturer setting	0	–
PF45	For manufacturer setting	00000000h	–
PF46	For manufacturer setting	0	–
PF47	For manufacturer setting	00000000h	–
PF48	For manufacturer setting	00000000h	–
PF49	TSL	0	0.0001%/°C
PF50	TIC	0	0.1%
PF51	*MFP	00000000h	–
PF52	MFPP	00000000h	–
PF53	FPMT	0	10rev, m
PF54	PAV	0	0.1%
PF55	PSD	0	0.1
PF56	VAV	0	0.1%
PF57	VSD	0	0.1%
PF58	TMO	0	10rev, m
PF59	For manufacturer setting	00000000h	–
PF60	For manufacturer setting	00000000h	–
PF61	For manufacturer setting	00000000h	–
PF62	For manufacturer setting	00000000h	–
PF63	For manufacturer setting	00000000h	–
PF64	For manufacturer setting	00000000h	–
PF65	For manufacturer setting	00000000h	–
PF66	BLG	00000000h	–
PF67	BLN	0	0.01degree
PF68	BLTT	0	0.1
PF69	SPAV2	0	0.1%
PF70	SPSD2	0	0.1%
PF71	BFP	00000000h	–
PF72	SBT	0	0.1N
PF73	ABT	0	0.1N
PF74	SSF	0	0.1%
PF75	ASF	0	0.1%
PF76	BTS	0	0.1%
PF77	For manufacturer setting	00000000h	–
PF78	For manufacturer setting	00000000h	–
PF79	For manufacturer setting	00110010h	–
PF80	DRMC	00000000h	–
PF81	DRMS	00000000h	–
PF82	DRTM	00000000h	–
PF83	For manufacturer setting	00000000h	–
PF84	DRTC	005A8101h	–
PF85	DRTL1	0	–
PF86	DRTL2	0	–
PF87	DRAC1	00020201h	–
PF88	DRAC2	02040003h	–
PF89	DRAC3	02090205h	–
PF90	DRAC4	0000020Ch	–

No.	Symbol	Initial value	Unit
PF91	DRDC1	00120000h	–
PF92	DRDC2	80058010h	–
PF93	DRDC3	8000800Ah	–
PF94	DRDC4	801D8015h	–
PF95	**DRCLR	00000000h	–
PF96	For manufacturer setting	00000000h	–
PF97	For manufacturer setting	00000000h	–
PF98	For manufacturer setting	00000000h	–
PF99	For manufacturer setting	00000000h	–

(g) Motor extension setting servo parameters group ([Pr.PL_ _])

No.	Symbol	Initial value	Unit
PL01	**LIT1	00000301h	–
PL02	**LIM	1000	μm
PL03	**LID	1000	μm
PL04	*LIT2	00000003h	–
PL05	LB1	0	mm, 0.01rev
PL06	LB2	0	mm/s, r/min
PL07	LB3	100	%
PL08	*LIT3	00001010h	–
PL09	LPWM	30	%
PL10	For manufacturer setting	5	–
PL11	For manufacturer setting	100	–
PL12	For manufacturer setting	500	–
PL13	For manufacturer setting	00000000h	–
PL14	For manufacturer setting	00000000h	–
PL15	For manufacturer setting	20	–
PL16	For manufacturer setting	0	–
PL17	LTSTS	00000000h	–
PL18	IDLV	0	%
PL19	For manufacturer setting	0	–
PL20	For manufacturer setting	0	–
PL21	For manufacturer setting	0	–
PL22	For manufacturer setting	0	–
PL23	For manufacturer setting	00000000h	–
PL24	For manufacturer setting	0	–
PL25	For manufacturer setting	0	–
PL26	For manufacturer setting	00000000h	–
PL27	For manufacturer setting	00000000h	–
PL28	For manufacturer setting	00000000h	–
PL29	For manufacturer setting	00000000h	–
PL30	For manufacturer setting	00000000h	–
PL31	For manufacturer setting	00000000h	–
PL32	For manufacturer setting	00000000h	–
PL33	For manufacturer setting	00000000h	–
PL34	For manufacturer setting	00000000h	–
PL35	For manufacturer setting	00000000h	–
PL36	For manufacturer setting	00000000h	–
PL37	For manufacturer setting	00000000h	–
PL38	For manufacturer setting	00000000h	–
PL39	For manufacturer setting	00000000h	–
PL40	For manufacturer setting	00000000h	–
PL41	For manufacturer setting	00000000h	–
PL42	For manufacturer setting	00000000h	–
PL43	For manufacturer setting	00000000h	–
PL44	For manufacturer setting	00000000h	–
PL45	For manufacturer setting	00000000h	–

No.	Symbol	Initial value	Unit
PL46	For manufacturer setting	00000000h	–
PL47	For manufacturer setting	00000000h	–
PL48	For manufacturer setting	00000000h	–
PL49	For manufacturer setting	00000000h	–
PL50	For manufacturer setting	00000000h	–
PL51	For manufacturer setting	00000000h	–
PL52	For manufacturer setting	00000000h	–
PL53	For manufacturer setting	0	–
PL54	For manufacturer setting	00000000h	–
PL55	For manufacturer setting	00000000h	–
PL56	For manufacturer setting	00000000h	–
PL57	For manufacturer setting	00000000h	–
PL58	For manufacturer setting	00000000h	–
PL59	For manufacturer setting	00000000h	–
PL60	For manufacturer setting	00000000h	–
PL61	For manufacturer setting	00000000h	–
PL62	For manufacturer setting	00000000h	–
PL63	For manufacturer setting	00000000h	–
PL64	For manufacturer setting	00000000h	–
PL65	For manufacturer setting	00000000h	–
PL66	For manufacturer setting	00000000h	–
PL67	For manufacturer setting	00000000h	–
PL68	For manufacturer setting	00000000h	–
PL69	For manufacturer setting	00000000h	–
PL70	For manufacturer setting	00000000h	–
PL71	For manufacturer setting	00000000h	–
PL72	For manufacturer setting	00000000h	–

(3) Servo parameter details

Restrictions

- Settable servo parameters and values depend on the controller model, servo amplifier software version, and MR Configurator2 software version. For details, refer to the MR-J5 User's Manual. Refer to the Mitsubishi Electric FA site for the latest software version of MR Configurator2. In addition, the software version of the servo amplifier can be checked with MR Configurator2 or by other means.

Precautions

- Never make a drastic adjustment or change to the servo parameter values as doing so will make the operation unstable.
- Do not change the servo parameter settings as described below. Doing so may cause an unexpected condition, such as failing to start up the servo amplifier.
  - Changing the values of the servo parameters for manufacturer setting
  - Setting a value outside the range
  - Changing the fixed value in each servo parameter
- When writing servo parameters with the controller, make sure that the control axis No. of the servo amplifier is set correctly. Failure to do so may cause the servo parameter settings of another axis to be written and result in the servo amplifier being in an unexpected condition.
- Some servo parameters are adjusted automatically. For example, auto tuning automatically adjusts gain servo parameters.

(a) Explanation of servo parameters

For how to interpret the servo parameter numbers, refer to "Interpreting servo parameter numbers" in the MR-J5 User's Manual (Introduction).

The following explains how to read the details of servo parameters.

<table>
<tr><th>Item</th><th colspan="2">Explanation</th></tr>
<tr><td>No.</td><td>Indicates the servo parameter No., which can be identified by the servo parameter group and number.</td><td rowspan="3">Servo parameter No., symbols, and names are indicated as follows.
[Pr. PA01_Operation mode (**STY)]
Symbol
Name
No./Detail No.</td></tr>
<tr><td>Symbol</td><td>Indicates the abbreviation of the servo parameter.
"*" added to abbreviations means the following.
* or **: After setting, cycle the power or reset the software.</td></tr>
<tr><td>Name</td><td>Indicates the name of the servo parameter.</td></tr>
<tr><td>Initial value</td><td colspan="2">Indicates the servo parameter initial value at factory setting.
When there is a unit in the servo parameter, the unit is shown with [ ].</td></tr>
<tr><td>Setting range</td><td colspan="2">Indicates the setting range of the servo parameter.</td></tr>
<tr><td>Supported</td><td colspan="2">Indicates the supported software version of the servo amplifier. The servo parameter is available on servo amplifiers with the software version or later.</td></tr>
</table>

(b) Parameters necessary to be set or checked before operation

If the settings of the parameters introduced in this section are incorrectly configured, the motor will not operate or an alarm will occur. Be sure to check the parameters before operation and change the settings as necessary. Refer to the MR-J5 User's Manual (Parameters) for details of other parameters.

1) [Pr.PA01_Operation mode (**STY)]

Initial value	Setting range	Supported software version
10003000h	10003000h to 10013085h	Refer to the relevant detail No.

• [Pr.PA01.0_Control mode selection]

Initial value	Setting range	Supported software version
0h	0h to 5h	A0

Select a control mode.
0: Position control mode (P)
1: Position control mode and speed control mode (P/S)
2: Speed control mode (S)
3: Speed control mode and torque control mode (S/T)
4: Torque control mode (T)
5: Torque control mode and position control mode (T/P)

• [Pr.PA01.1_Operation mode selection]

Initial value	Setting range	Supported software version
0h	0h to 8h	A0

0: Standard control mode
4: Linear servo motor control mode
6: Direct drive motor control mode

• [Pr.PA01.4_Fully closed loop operation mode selection]

Initial value	Setting range	Supported software version
0h	0h to 1h	A5

Select whether to enable or disable the fully closed loop control mode.
The external encoder communication method of four-wire type cannot be used in the fully closed loop control mode on the MR-J5-_A_. In that case, use the MR-J5-_A_-RJ.
When this servo parameter is set to "1" in the linear servo motor control mode, [AL.037 Parameter error] occurs.
0: Disabled (semi closed loop control mode)
1: Enabled (fully closed loop control mode)

2) [Pr.PA02_Regenerative option (**REG)]

Initial value	Setting range	Supported software version
00000000h	00000000h to 001100FFh	Refer to the relevant detail No.

• [Pr.PA02.0-1_Regenerative option selection]

Initial value	Setting range	Supported software version
00h	00h to FFh	A0

Select a regenerative option.
Incorrect setting may cause the regenerative option to burn.
If a selected regenerative option is not for use with the servo amplifier, [AL.037 Parameter error] occurs.
00: Regenerative option is not used.
- No regenerative resistors are used on servo amplifiers with a capacity of 100W.
- Built-in regenerative resistors are used on servo amplifiers with a capacity of 0.2kW to 3.5kW.

02: MR-RB032
03: MR-RB12
04: MR-RB32
05: MR-RB30
06: MR-RB50 (A cooling fan is required.)
0B: MR-RB3N
0C: MR-RB5N (A cooling fan is required.)

• [Pr.PA02.4_Simple converter selection]

Initial value	Setting range	Supported software version
0h	0h to 1h	A0

When using the simple converter, set this servo parameter.
The simple converter and external regenerative option can be used together. When using an external regenerative option, set the regenerative option to be used with [Pr.PA02.0-1].
0: Simple converter is not used
1: MR-CM3K

• [Pr.PA02.5_Excessive regeneration warning enabled/disabled selection]

Initial value	Setting range	Supported software version
0h	0h to 1h	A0

When the simple converter is used, whether to enable or disable the detection of [AL.0E0.1 Excessive regeneration warning] is selectable with this servo parameter.
When [Pr.PA02.4] is set to "0" (simple converter is not used), setting this servo parameter to "1" (disabled) triggers [AL.037 Parameter error].
0: Enabled
1: Disabled

3) [Pr.PA03_Absolute position detection system (*ABS)]

Initial value	Setting range	Supported software version
00000000h	00000000h to 00000011h	Refer to the relevant detail No.

• [Pr.PA03.0_Absolute position detection system selection]

Initial value	Setting range	Supported software version
0h	0h to 1h	A0

Set this servo parameter when using the absolute position detection system in the position control mode. If the absolute position detection system is switched to the incremental system, the home position is erased. Execute homing again when the absolute position detection system is enabled.
0: Disabled (incremental system)
1: Enabled (absolute position detection system by DIO)
The absolute position detection system cannot be used when an incremental type encoder is used or when the semi closed/fully closed loop control switching is enabled. At this time, enabling the absolute position detection system triggers [AL.037 Parameter error].

• [Pr.PA03.1_Servo motor replacement preparation]

Initial value	Setting range	Supported software version
0h	0h to 1h	A0

To replace an in-use batteryless absolute position encoder equipped servo motor while the absolute position detection system is in enabled status, set this servo parameter to "enabled".
Selecting "1" (enabled) enables servo motor replacement. After completing the servo motor replacement preparation, the value automatically changes to "0" (disabled).
After replacing the servo motor, the home position is erased. Execute homing again.
After setting this servo parameter to "1" (enabled), cycle the power and then deactivate [AL.01A.5 Servo motor combination error 3].
0: Disabled
1: Enabled

4) [Pr.PA04_Function selection A-1 (*AOP1)]

Initial value	Setting range	Supported software version
00002000h	00000000h to 00002000h	Refer to the relevant detail No.

• [Pr.PA04.3_Forced stop deceleration function selection]

Initial value	Setting range	Supported software version
2h	0h to 2h	A0

0: Forced stop deceleration function disabled (EM1 is used)
2: Forced stop deceleration function enabled (EM2 is used)

Setting value		Selecting EM2 or EM1	Deceleration method	
[Pr.PA04.3]	[Pr.PA04.2] *1		EM2 or EM1 is off	Alarm occurrence
0	0	EM1	MBR (Electromagnetic brake interlock) turns off without the forced stop deceleration.	MBR (Electromagnetic brake interlock) turns off without the forced stop deceleration.
2	0	EM2	MBR (Electromagnetic brake interlock) turns off after the forced stop deceleration.	MBR (Electromagnetic brake interlock) turns off after the forced stop deceleration.
0	1	Neither EM2 nor EM1 is used.	–	MBR (Electromagnetic brake interlock) turns off without the forced stop deceleration.
2	1	Neither EM2 nor EM1 is used.	–	MBR (Electromagnetic brake interlock) turns off after the forced stop deceleration.

*1. For the MR-J5-_A_ servo amplifier, the setting value of this servo parameter is fixed to "0". To disable forced stop, change the setting value of [Pr.PD01.3].

5) [Pr.PA05_Number of command input pulses per revolution (*FBP)]

Initial value	Setting range	Supported software version
10000[pulse]	1000 to 1000000	A0

The servo motor rotates once as per command input pulse that has been set.
The setting value of this servo parameter is enabled when [Pr.PA21.3 Electronic gear compatibility selection] is set to "1" (number of command input pulses per revolution). In the linear servo motor control mode or fully closed loop control mode, [Pr.PA21.3] cannot be set to "1".

6) [Pr.PA06_Electronic gear numerator (CMX)]

Initial value	Setting range	Supported software version
1	1 to 2147483647	A0

Set the electronic gear numerator.
This servo parameter is enabled in the following condition: [Pr.PA21.3 Electronic gear compatibility selection] is "0" (electronic gear), "2" (J3 electronic gear setting value compatibility mode), "3" (J2S electronic gear setting value compatibility mode), or "4" (J4 electronic gear setting value compatibility mode).
The condition range of the electronic gear is shown in the table below. If the set value is outside this range, noise may be generated during acceleration/deceleration, or operation may not be performed at the preset speed and/or acceleration/deceleration time constants. In addition, if the electric gear numerator exceeds "2147483647" by combining this servo parameter and [Pr.PA21.3], the electric gear numerator is limited to "2147483647".

Encoder resolution [pulse]	Setting range (CMX/CDV)
67108864	1/10 < CMX/CDV < 64000

7) [Pr.PA07_Electronic gear denominator (CDV)]

Initial value	Setting range	Supported software version
1	1 to 2147483647	A0

Set the electronic gear denominator.
This servo parameter is enabled in the following condition: [Pr.PA21.3 Electronic gear compatibility selection] is "0" (electronic gear), "2" (J3 electronic gear setting value compatibility mode), "3" (J2S electronic gear setting value compatibility mode), or "4" (J4 electronic gear setting value compatibility mode).
Refer to section 4.5.1 "Electronic gear function" for details.

8) [Pr.PA08_Auto tuning mode (ATU)]

Initial value	Setting range	Supported software version
00000001h	00000000h to 01110006h	Refer to the relevant detail No.

• [Pr.PA08.0_Gain adjustment mode selection]

Initial value	Setting range	Supported software version
1h	0h to 6h	A0

Select the gain adjustment mode.
0: 2 gain adjustment mode 1 (interpolation mode)
1: Auto tuning mode 1
2: Auto tuning mode 2
3: Manual mode
4: 2 gain adjustment mode 2
5: Quick tuning mode
6: Load to motor inertia ratio monitor mode
Refer to the following table for details.

Setting value of [Pr.PA08.0]	Gain adjustment mode	Servo parameter adjusted automatically
0	2 gain adjustment mode 1 (interpolation mode)	[Pr.PB06 Load to motor inertia ratio/load to motor mass ratio] [Pr.PB08 Position control gain] [Pr.PB09 Speed control gain] [Pr.PB10 Speed integral compensation]
1	Auto tuning mode 1	[Pr.PB06 Load to motor inertia ratio/load to motor mass ratio] [Pr.PB07 Model control gain] [Pr.PB08 Position control gain] [Pr.PB09 Speed control gain] [Pr.PB10 Speed integral compensation]
2	Auto tuning mode 2	[Pr.PB07 Model control gain] [Pr.PB08 Position control gain] [Pr.PB09 Speed control gain] [Pr.PB10 Speed integral compensation]
3	Manual mode	–
4	2 gain adjustment mode 2	[Pr.PB08 Position control gain] [Pr.PB09 Speed control gain] [Pr.PB10 Speed integral compensation]
5	Quick tuning mode	[Pr.PB07 Model control gain] [Pr.PB08 Position control gain] [Pr.PB09 Speed control gain] [Pr.PB10 Speed integral compensation] [Pr.PB13 Machine resonance suppression filter 1] [Pr.PB14 Notch shape selection 1] [Pr.PB15 Machine resonance suppression filter 2] [Pr.PB16 Notch shape selection 2] [Pr.PB18 Low-pass filter setting] [Pr.PB23 Low-pass filter selection] [Pr.PB50 Machine resonance suppression filter 5] [Pr.PB51 Notch shape selection 5] [Pr.PE41 Function selection E-3]
6	Load to motor inertia ratio monitor mode	[Pr.PB06 Load to motor inertia ratio/load to motor mass ratio]

• [Pr.PA08.4_Quick tuning - Load to motor inertia ratio setting]

Initial value	Setting range	Supported software version
0h	0h to 1h	A0

Set the load to motor inertia ratio at quick tuning. If the load connected to the servo motor is equal to or larger than the load to motor inertia ratio set in the servo parameter, an overshoot may occur in positioning operation after quick tuning.
0: Load to motor inertia ratio of 30 times or less
1: Load to motor inertia ratio of 100 times or less

• [Pr.PA08.5_Quick tuning - Execution selection]

Initial value	Setting range	Supported software version
0h	0h to 1h	A0

Set when to execute quick tuning.
0: At initial servo-on after cycling the power
1: At every servo-on

• [Pr.PA08.6_Quick tuning - Restore selection]

Initial value	Setting range	Supported software version
0h	0h to 1h	A0

Set whether to return servo parameters to the values they had set before quick tuning was executed.
0: Disabled
1: Enabled
By setting "1" (enabled), the following servo parameters return to the values they had set before quick tuning was executed. If quick tuning has never been performed after power on or software reset, setting "1" (enabled) only keeps the current servo parameter values.

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

9) [Pr.PA09_Auto tuning response (RSP)]

Initial value	Setting range	Supported software version
16	1 to 40	A0

Set the auto tuning response.

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

10) [Pr.PA10_In-position range (INP)]

Initial value	Setting range	Supported software version
400 [Refer to the text below for the unit.]	0 to 16777215	A0

Set the in-position range in the command pulse unit.
With the setting of [Pr.PC24.0 In-position range unit selection], the unit can be changed to the servo motor encoder pulse unit.

In-position range setting

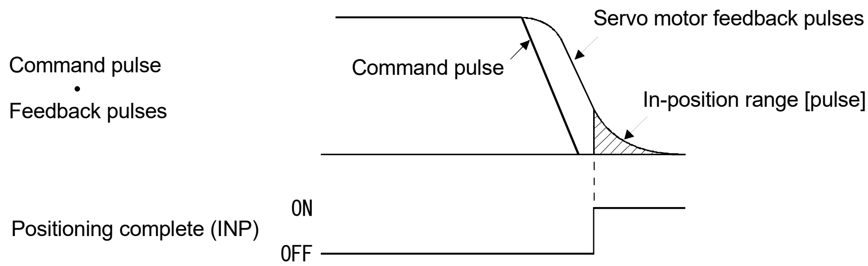
Control mode [Pr.PA01]	In-position setting range
Position, speed, and torque control modes	Range where positioning completion (INP) is output

Selecting a control side for the in-position range

[Pr.PA01.4 Fully closed loop operation mode selection]	In-position range unit
"0" (semi closed loop system)	Command resolution unit (motor-side encoder)
"1" (fully closed loop system)	Command resolution unit (load-side encoder)

In-position range unit

[Pr.PA01.0 Control mode selection]	[Pr.PC24.0 In-position range unit selection]	Unit
Position, speed, and torque control modes	0 (command unit)	pulse
"1" (fully closed loop system)	1 (servo motor encoder pulse unit)	pulse



11) [Pr.PA11_Forward rotation torque limit (TLP)]

Initial value	Setting range	Supported software version
1000.0[%]	0.0 to 1000.0	A0

The torque or thrust generated by the servo motor can be limited.
Set servo parameters in relation to the rated torque or continuous thrust as 100.0 [%]. Set the servo parameter when limiting the torque of the servo motor for CCW power running or CW regeneration, or when limiting the thrust of the linear servo motor for positive direction power running or negative direction regeneration. If this servo parameter is set to "0.0", the servo motor does not generate torque or thrust.
When [Pr.PC50.0 Torque limit unit change] is set to "0" (maximum torque unit), set the servo parameter in relation to the maximum torque or maximum thrust (= 100.0%).
If a value larger than the maximum torque or maximum thrust of the servo motor is set, the value will be limited to the maximum torque or maximum thrust of the servo motor.
When torque (thrust) is output with the analog monitor output, the larger value of either [Pr.PA11 Forward rotation torque limit] or [Pr.PA12 Reverse rotation torque limit] is applied to the torque (thrust) at the maximum output voltage.

12) [Pr.PA12_Reverse rotation torque limit (TLN)]

Initial value	Setting range	Supported software version
1000.0[%]	0.0 to 1000.0	A0

The torque or thrust generated by the servo motor can be limited.
Set servo parameters in relation to the rated torque or continuous thrust as 100.0 [%]. Set the servo parameter to limit the torque of the servo motor for CW power running or CCW regeneration, or to limit the thrust of the linear servo motor for negative direction power running or positive direction regeneration. If this servo parameter is set to "0.0", the servo motor does not generate torque or thrust.
When [Pr.PC50.0 Torque limit unit change] is set to "0" (maximum torque unit), set the servo parameter in relation to the maximum torque or maximum thrust (= 100.0%).
If a value larger than the maximum torque or maximum thrust of the servo motor is set, the value will be limited to the maximum torque or maximum thrust of the servo motor.
When torque (thrust) is output with the analog monitor output, the larger value of either [Pr.PA11 Forward rotation torque limit] or [Pr.PA12 Reverse rotation torque limit] is applied to the torque (thrust) at the maximum output voltage.

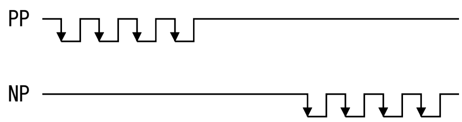
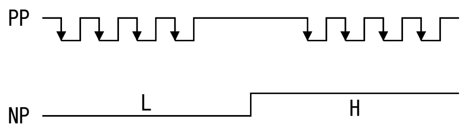
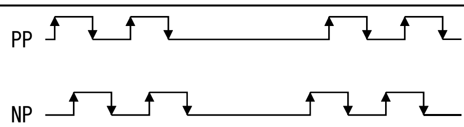
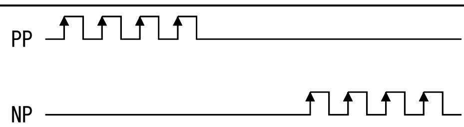
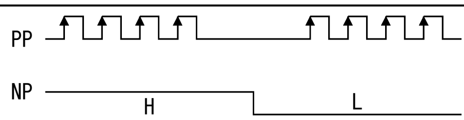
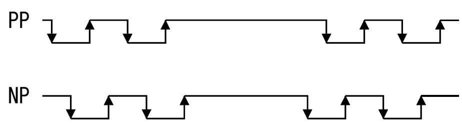
13) [Pr.PA13_Command pulse input form (*PLSS)]

Initial value	Setting range	Supported software version
00000100h	00000000h to 00000412h	Refer to the relevant detail No.

• [Pr.PA13.0_Command input pulse train form selection]

Initial value	Setting range	Supported software version
0h	0h to 2h	A0

0: Forward/reverse rotation pulse train
1: Signed pulse train
2: A-phase/B-phase pulse train (the servo amplifier multiplies the input pulse by 4, and captures the multiplied input pulses.)
Refer to the following table for setting values.

[Pr.PA13.1]	[Pr.PA13.0]	Pulse train form		Forward rotation (positive direction) command	Reverse rotation (negative direction) command
1	0	Negative logic	Forward rotation pulse train (positive direction pulse train) Reverse rotation pulse train (negative direction pulse train)		
1	1		Positive pulse train		
1	2		A-phase pulse train B-phase pulse train		
0	0	Positive logic	Forward rotation pulse train (positive direction pulse train) Reverse rotation pulse train (negative direction pulse train)		
0	1		Positive pulse train		
0	2		A-phase pulse train B-phase pulse train		

Arrows in the table indicate the timing of importing pulse trains. A-phase/B-phase pulse trains are imported after they have been multiplied by 4.

• [Pr.PA13.1_Pulse train logic selection]

Initial value	Setting range	Supported software version
0h	0h to 1h	A0

0: Positive logic
1: Negative logic
Match the logic of the command pulse train received from the connected controller.
Refer to [Pr.PA13.0_Command input pulse train form selection] for setting values.

• [Pr.PA13.2_Command input pulse train filter selection]

Initial value	Setting range	Supported software version
1h	0h to 3h	A0

Selecting the appropriate filter for the command pulse frequency can increase noise tolerance.
0: Command input pulse train is 4Mpulses/s or less
1: Command input pulse train is 1Mpulse/s or less
2: Command input pulse train is 500kpulses/s or less
3: Command input pulse train is 200kpulses/s or less
"1" can be set for commands up to 1Mpulse/s. When inputting commands exceeding 1Mpulse/s and up to 4Mpulses/s, set "0".
To prevent the following malfunctions, set a correct value in accordance with the command pulse frequency.
Setting a value higher than the actual command value will decrease noise tolerance.
Setting a value lower than the actual command will cause a position mismatch.

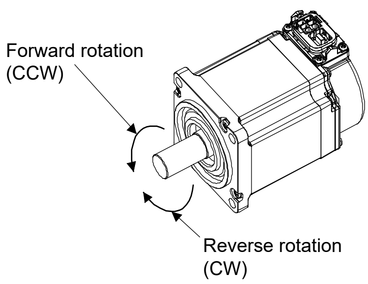
14) [Pr.PA14_Travel direction selection (*POL)]

Initial value	Setting range	Supported software version
0	0 to 1	A0

Select the servo motor rotation direction or linear servo motor travel direction for the command input pulse.

• For position control mode
With the setting value of [Pr.PA14 Travel direction selection], the rotation and travel direction can be changed without reversing the forward/reverse rotation pulse inputs for the input pulse train.

• For speed and torque control modes
The rotation and travel direction cannot be changed with the servo parameter.
The servo motor rotation direction is as follows.



15) [Pr.PA19_Servo parameter writing prohibited (*BLK)]

Initial value	Setting range	Supported software version
000000ABh	00000000h to 0000FFFFh	A0

Settings of all the parameters can be changed on this servo amplifier in the factory setting. The settings of [Pr.PA19] can prohibit writing to prevent unnecessary changes.
The following table shows the parameters that can be referred to and written to by the settings of [Pr.PA19]. Parameters with "○" in their columns are to be modified by [Pr.PA19].

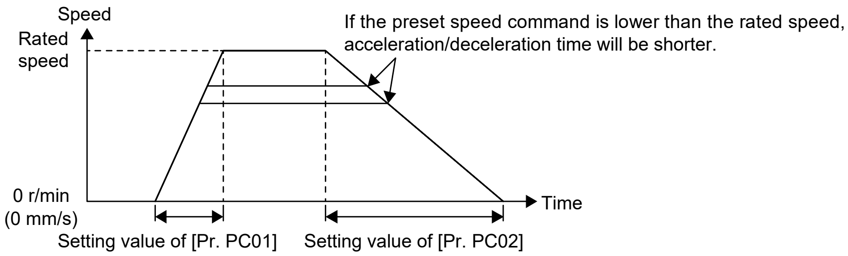
[Pr.PA19]	Setting value operation	PA	PB	PC	PD	PE	PF	PO	PS	PL, PU	PT, PV	PN
Setting values not listed below	Readable	○	×	×	×	×	×	×	×	×	×	×
	Writable	○	×	×	×	×	×	×	×	×	×	×
0000000A	Readable	19 only	×	×	×	×	×	×	×	×	×	×
	Writable	19 only	×	×	×	×	×	×	×	×	×	×
0000000B	Readable	○	○	○	×	×	×	×	×	×	×	×
	Writable	○	○	○	×	×	×	×	×	×	×	×
0000000C	Readable	○	○	○	○	×	×	×	×	×	×	×
	Writable	○	○	○	○	×	×	×	×	×	×	×
0000000D	Readable	○	○	○	○	×	×	×	○	×	×	×
	Writable	○	○	○	○	×	×	×	○	×	×	×
0000000E	Readable	○	○	○	○	×	×	○	○	×	×	×
	Writable	○	○	○	○	×	×	○	○	×	×	×
0000000F	Readable	○	○	○	○	○	×	○	○	○	×	×
	Writable	○	○	○	○	○	×	○	○	○	×	×
000000AA	Readable	○	○	○	○	○	○	×	×	×	×	×
	Writable	○	○	○	○	○	○	×	×	×	×	×
000000AB (Initial value)	Readable	○	○	○	○	○	○	○	○	○	○	○
	Writable	○	○	○	○	○	○	○	○	○	○	○
0000100B	Readable	○	×	×	×	×	×	×	×	×	×	×
	Writable	19 only	×	×	×	×	×	×	×	×	×	×
0000100C	Readable	○	○	○	○	×	×	×	×	×	×	×
	Writable	19 only	×	×	×	×	×	×	×	×	×	×
0000100D	Readable	○	○	○	○	×	×	×	○	×	×	×
	Writable	19 only	×	×	×	×	×	×	×	×	×	×
0000100E	Readable	○	○	○	○	×	×	○	○	×	×	×
	Writable	19 only	×	×	×	×	×	×	×	×	×	×
0000100F	Readable	○	○	○	○	○	×	○	○	○	×	×
	Writable	19 only	×	×	×	×	×	×	×	×	×	×
000010AA	Readable	○	○	○	○	○	○	×	×	×	×	×
	Writable	19 only	×	×	×	×	×	×	×	×	×	×
000010AB	Readable	○	○	○	○	○	○	○	○	○	○	○
	Writable	19 only	×	×	×	×	×	×	×	×	×	×

16) [Pr.PC01_Speed acceleration time constant (STA)]

Initial value	Setting range	Supported software version
0[ms]	0 to 50000	A0

In the speed control mode or torque control mode, set the acceleration time required to reach the rated speed from 0r/min for VC (Analog speed command) and [Pr.PC05 Internal speed 1] to [Pr.PC11 Internal speed 7].

For example for the servo motor of 3000r/min rated speed, set 3000 (3s) to increase speed from 0r/min to 1000r/min in 1s.



17) [Pr.PC02_Speed deceleration time constant (STB)]

Initial value	Setting range	Supported software version
0[ms]	0 to 50000	A0

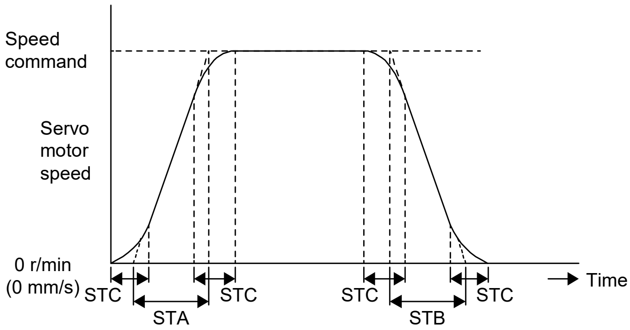
When using the servo amplifier in the speed control mode or torque control mode, set VC (Analog speed command) and [Pr.PC05 Internal speed 1] to [Pr.PC11 Internal speed 7] to the rated speed or the deceleration time which it takes for the motor from the rated speed to a stop.

This function is enabled in the speed control mode and torque control mode.

18) [Pr.PC03_S-pattern acceleration/deceleration time constants (STC)]

Initial value	Setting range	Supported software version
0[ms]	0 to 5000	A0

Set the time of the arc part for S-pattern acceleration/deceleration.
By setting "0", linear acceleration/deceleration is performed.



STA: Speed acceleration time constant ([Pr.PC01])
STB: Speed deceleration time constant ([Pr.PC02])
STC: S-pattern acceleration/deceleration time constant ([Pr.PC03])
If a large value is set to STA (speed acceleration time constant) or STB (speed deceleration time constant), the actual operation time for the arc part may differ from the setting value of the S-pattern acceleration deceleration time constant.
The upper limit of the actual time for the arc part is limited to $\frac{2000000}{STA}$ during acceleration and $\frac{2000000}{STB}$ during deceleration.

(Example) At the setting of STA = 20000, STB = 5000, and STC = 200, the actual time for the arc part is as follows:

During acceleration: 100[ms] (The time is limited to 100[ms] because there is a limitation $\frac{2000000}{20000} = 100[ms] < 200[ms]$)

During deceleration: 200[ms] (The time is limited to 200[ms] because there is a limitation $\frac{2000000}{5000} = 400[ms] > 200[ms]$)

19) [Pr.PC05_Internal speed 1 (SC1)]

Initial value	Setting range	Supported software version
100.00 [r/min], [mm/s]	0.00 to 65535.00	A0

Set a value within the range between 0 and the maximum speed. When changing the speed to the permissible speed, set the speed in [Pr.PA28.4 Speed range limit selection].
• When using the speed control mode, set the speed 1 of internal speed commands.
• When using the torque control mode, set the speed 1 of internal speed limit.

20) [Pr.PC06_Internal speed 2 (SC2)]

Initial value	Setting range	Supported software version
500.00 [r/min], [mm/s]	0.00 to 65535.00	A0

Set a value within the range between 0 and the maximum speed. When changing to the permissible speed, set the speed in [Pr.PA28.4].
• When using the speed control mode, set the speed 2 of internal speed commands.
• When using the torque control mode, set the speed 2 of internal speed limit.

21) [Pr.PC07_Internal speed 3 (SC3)]

Initial value	Setting range	Supported software version
1000.00 [r/min], [mm/s]	0.00 to 65535.00	A0

Set a value within the range between 0 and the maximum speed. When changing to the permissible speed, set the speed in [Pr.PA28.4].
• When using the speed control mode, set the speed 3 of internal speed commands.
• When using the torque control mode, set the speed 3 of internal speed limit.

22) [Pr.PC08_Internal speed 4 (SC4)]

Initial value	Setting range	Supported software version
200.00 [r/min], [mm/s]	0.00 to 65535.00	A0

Set a value within the range between 0 and the maximum speed. When changing to the permissible speed, set the speed in [Pr.PA28.4].
• When using the speed control mode, set the speed 4 of internal speed commands.
• When using the torque control mode, set the speed 4 of internal speed limit.

23) [Pr.PC09_Internal speed 5 (SC5)]

Initial value	Setting range	Supported software version
300.00 [r/min], [mm/s]	0.00 to 65535.00	A0

Set a value within the range between 0 and the maximum speed. When changing to the permissible speed, set the speed in [Pr.PA28.4].
• When using the speed control mode, set the speed 5 of internal speed commands.
• When using the torque control mode, set the speed 5 of internal speed limit.

24) [Pr.PC10_Internal speed 6 (SC6)]

Initial value	Setting range	Supported software version
500.00 [r/min], [mm/s]	0.00 to 65535.00	A0

Set a value within the range between 0 and the maximum speed. When changing to the permissible speed, set the speed in [Pr.PA28.4].
• When using the speed control mode, set the speed 6 of internal speed commands.
• When using the torque control mode, set the speed 6 of internal speed limit.

25) [Pr.PC11_Internal speed 7 (SC7)]

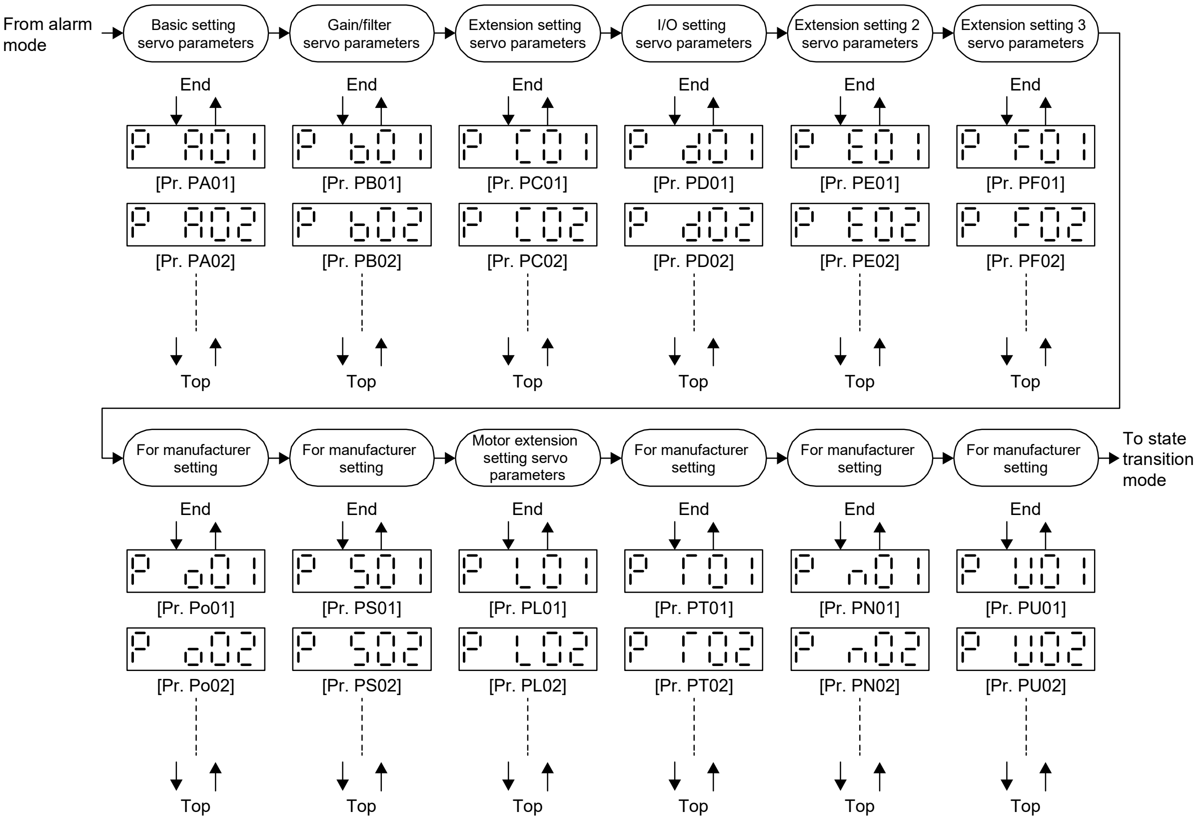
Initial value	Setting range	Supported software version
800.00 [r/min], [mm/s]	0.00 to 65535.00	A0

Set a value within the range between 0 and the maximum speed. When changing to the permissible speed, set the speed in [Pr.PA28.4].
• When using the speed control mode, set the speed 7 of internal speed commands.
• When using the torque control mode, set the speed 7 of internal speed limit.

3.1.6 Parameter settings

After turning on the power, configure initial settings of the parameter values as necessary for the operation conditions. Set the parameters mentioned in section 3.1.5 in accordance with the design specifications.
In particular, be sure to confirm the parameters mentioned in section 3.1.5 (3) (b) "Parameters necessary to be set or checked before operation".

[Parameter mode transition]
After selecting the corresponding parameter mode with "MODE" button, pressing the "UP" or "DOWN" button changes the display as follows.

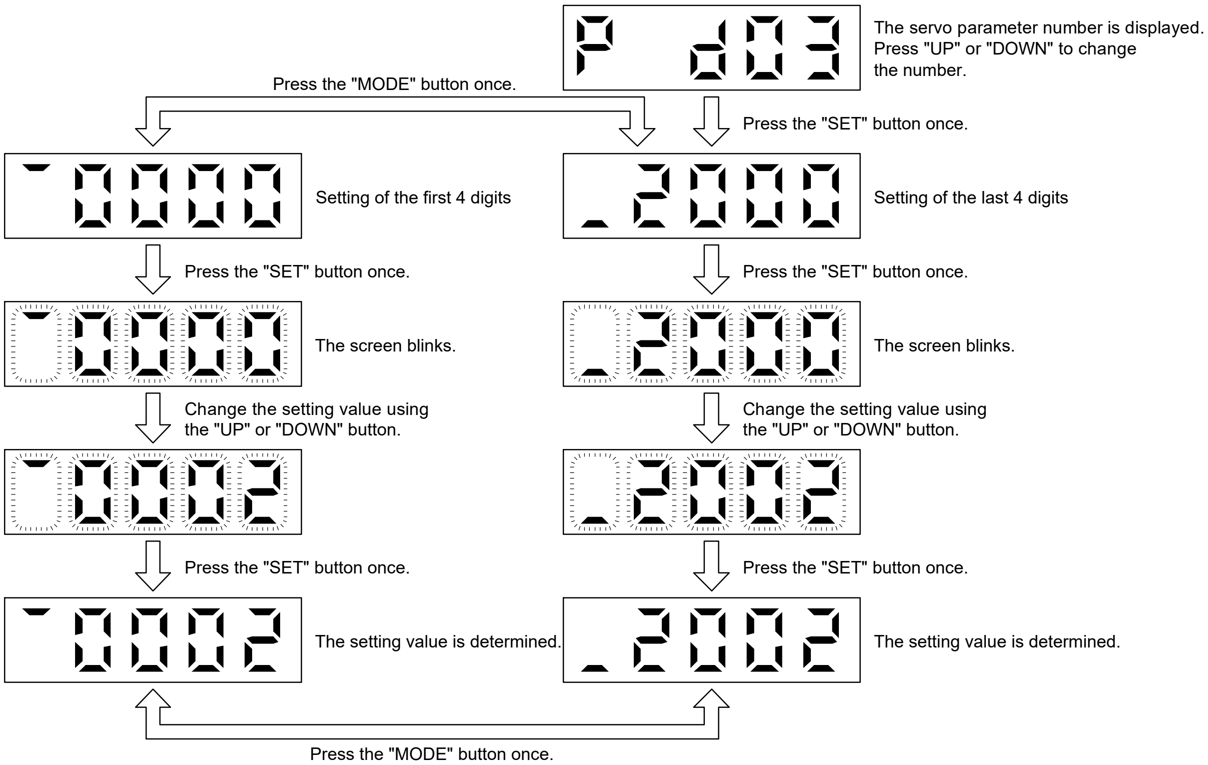


[Operation method]

• Servo parameter in hexadecimal

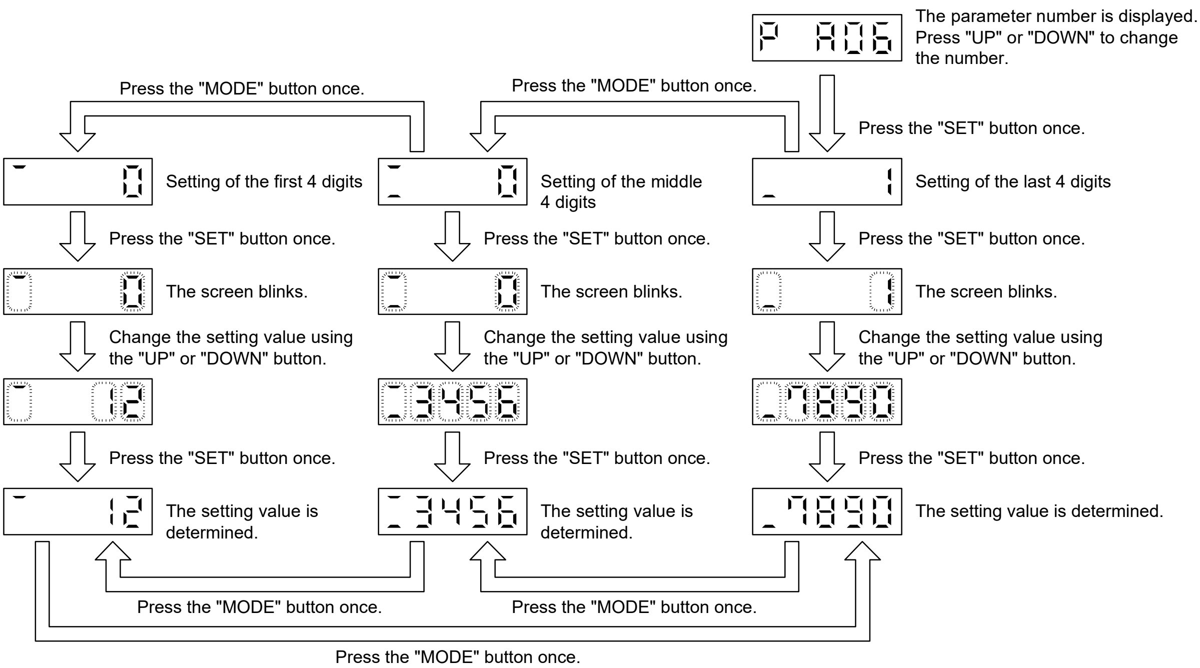
The operation method example is shown below when [Pr.PD03 Input device selection 1L] is set to "00022002".

Press "MODE" to switch to the basic setting parameter screen.

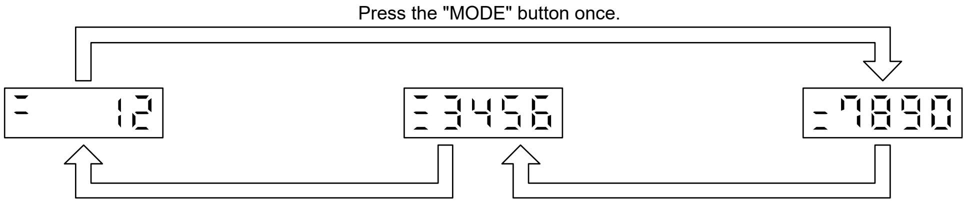


• Servo parameter in decimal

The following example gives the operation procedure to change [Pr.PA06 Electronic gear numerator] to "1234567890".



When the value of the servo parameter is negative, a minus is displayed in the first digit. The example for in the case of "-1234567890" is displayed.

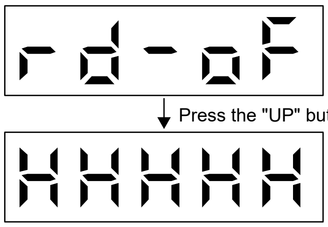


3.1.7 Checking external I/O signal

Before starting operation, check if the operation panel, peripheral relays, etc. are connected with the servo amplifier I/O signal in accordance with the connection diagram.
This section explains how to diagnose the ON/OFF of the servo amplifier I/O signal which can be checked with the servo amplifier display.

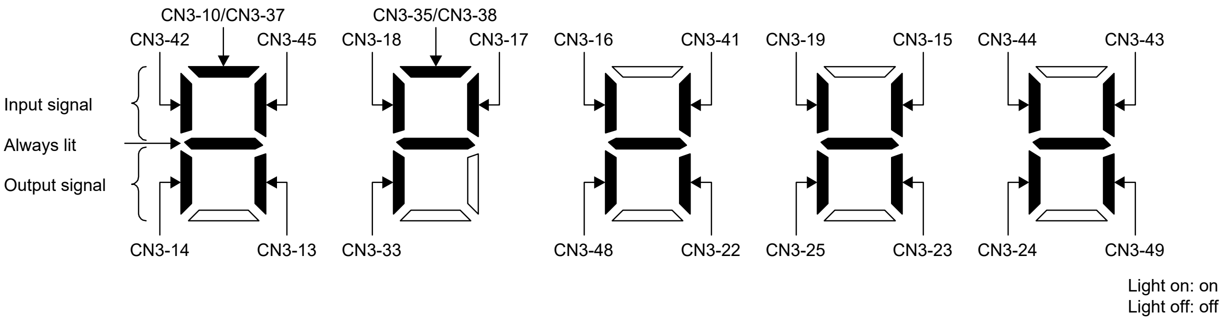
(1) Operation

The display screen after power-on is shown. Press "MODE" to display the diagnostic screen.



(2) Display content

The 7-segment LED segments and CN3 connector pins correspond as shown below. The CN3-13 pin and CN3-14 pin can be used on the MR-J5-_A-RJ servo amplifiers.



The LED segments corresponding to the pins are lit to indicate on, and are extinguished to indicate off. For pin signals in each control mode, refer to "Connectors and pin assignments" in the MR-J5 User's Manual (Hardware).

3.1.8 Speed control

Perform a test operation before an actual operation to check if the machine operates properly.

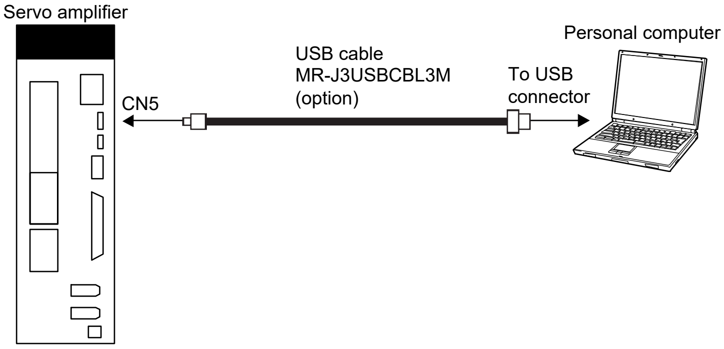
(1) Power-on

Turn on the power in accordance with section 3.1.3 "Power-on".

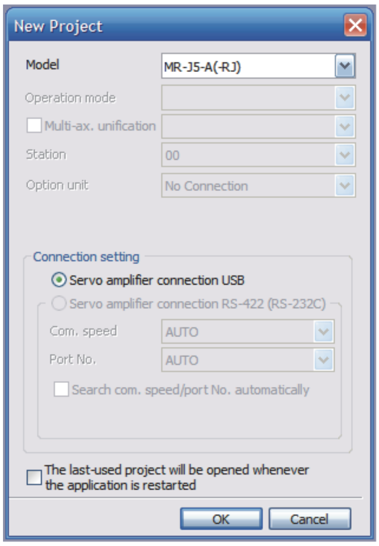
(2) Parameter settings using MR Configurator2 (setup software)

MR Configurator2 is the software used for purposes such as servo parameter settings, graph measurement/display, and test operation. This section describes the startup procedure of the servo amplifier when the servo amplifier is connected to a personal computer which has MR Configurator2 installed. To learn more about using MR Configurator2, refer to Help in MR Configurator2.

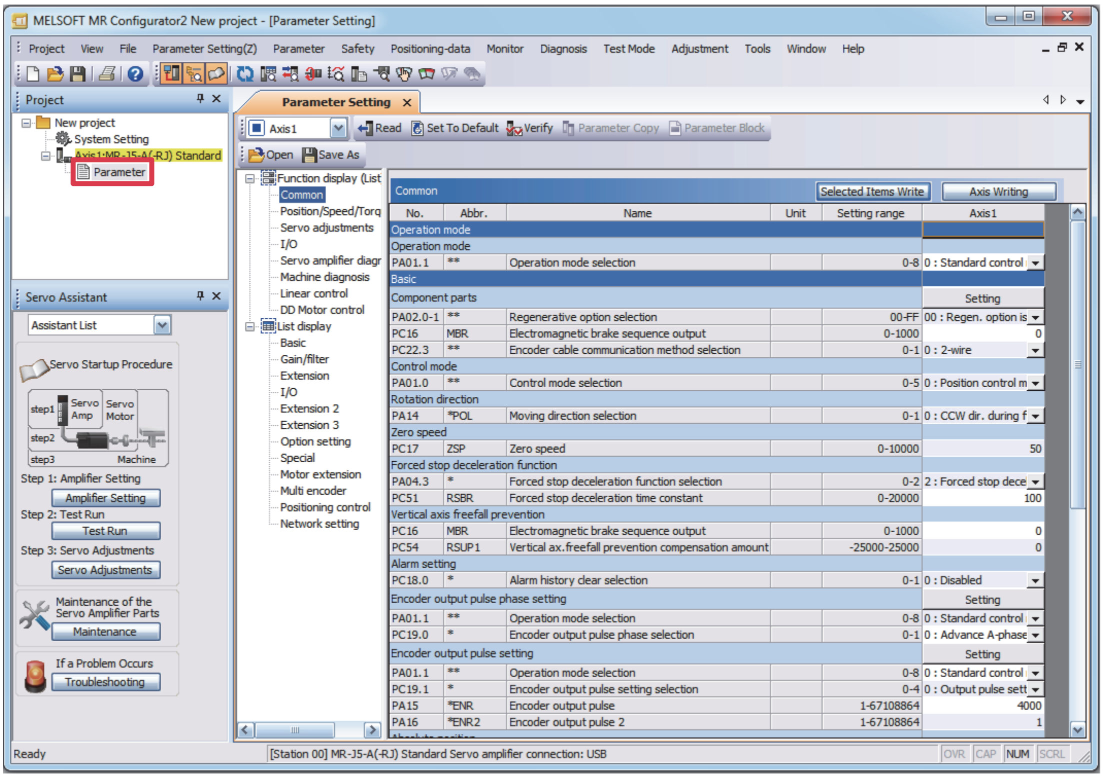
1. Connect the servo amplifier and the personal computer with a USB cable. Turn on the servo amplifier control circuit power supply.



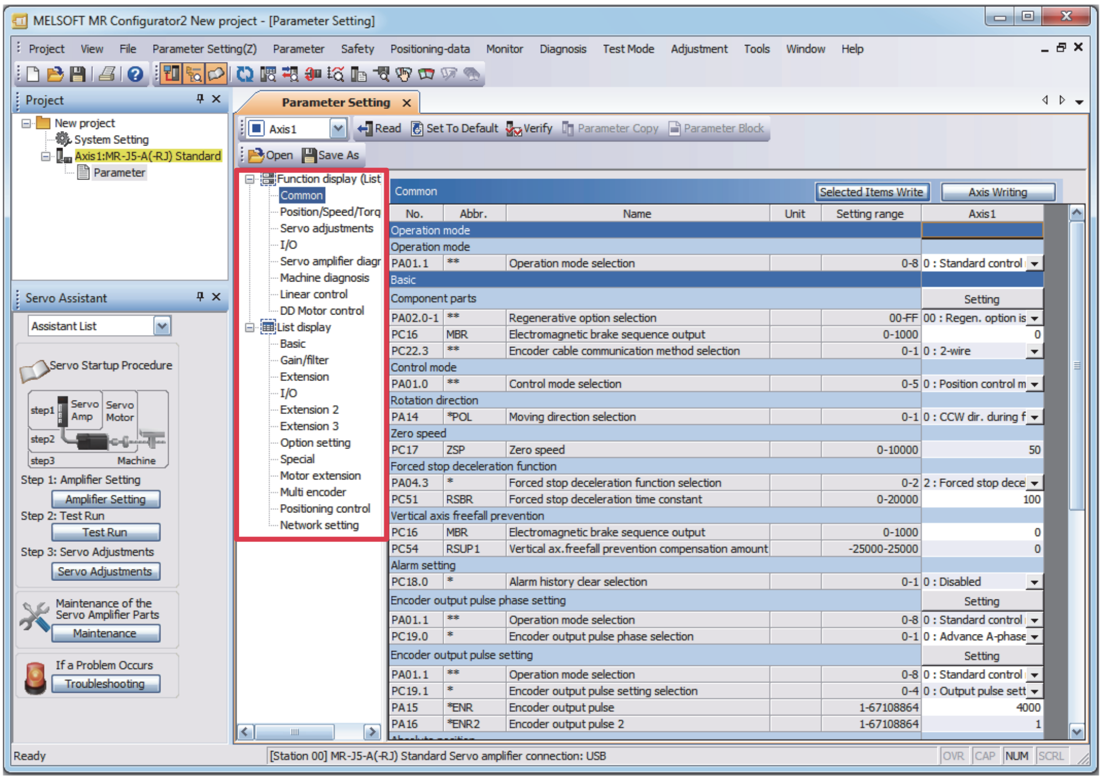
2. Start MR Configurator2 and create a new project. For the connection setting, select USB. Select a servo amplifier model and an operation mode.



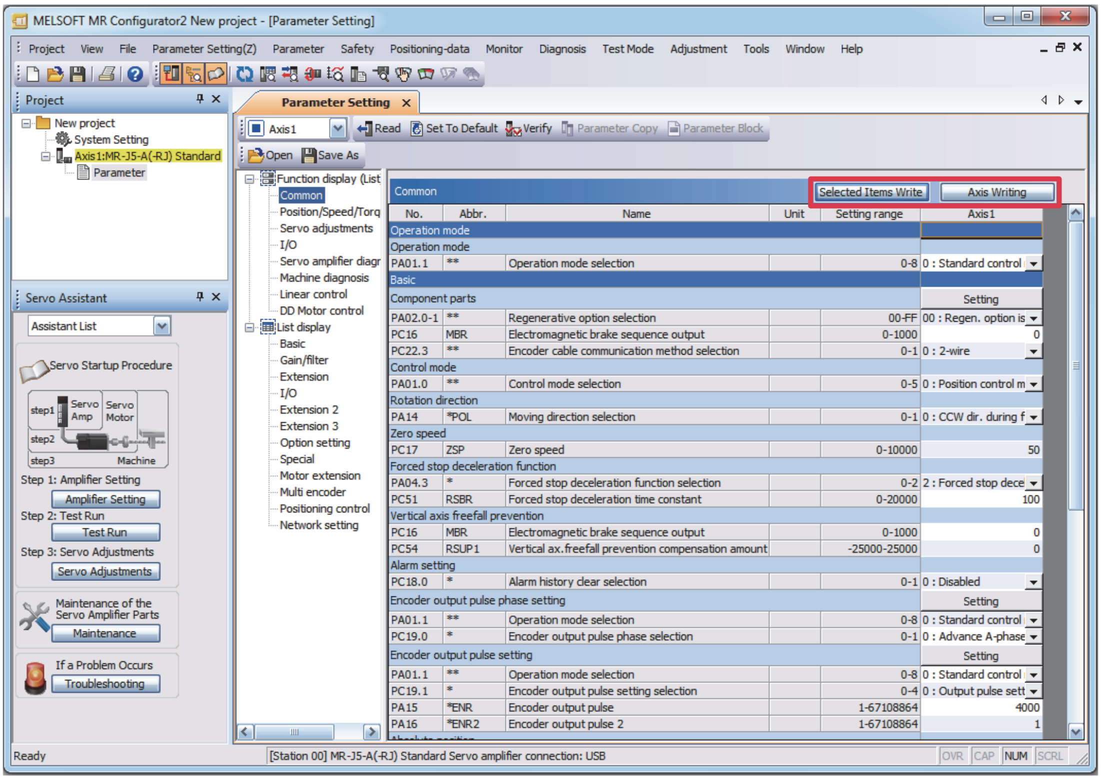
3. Selecting "Parameter" from the project tree opens the "Parameter Setting" window.



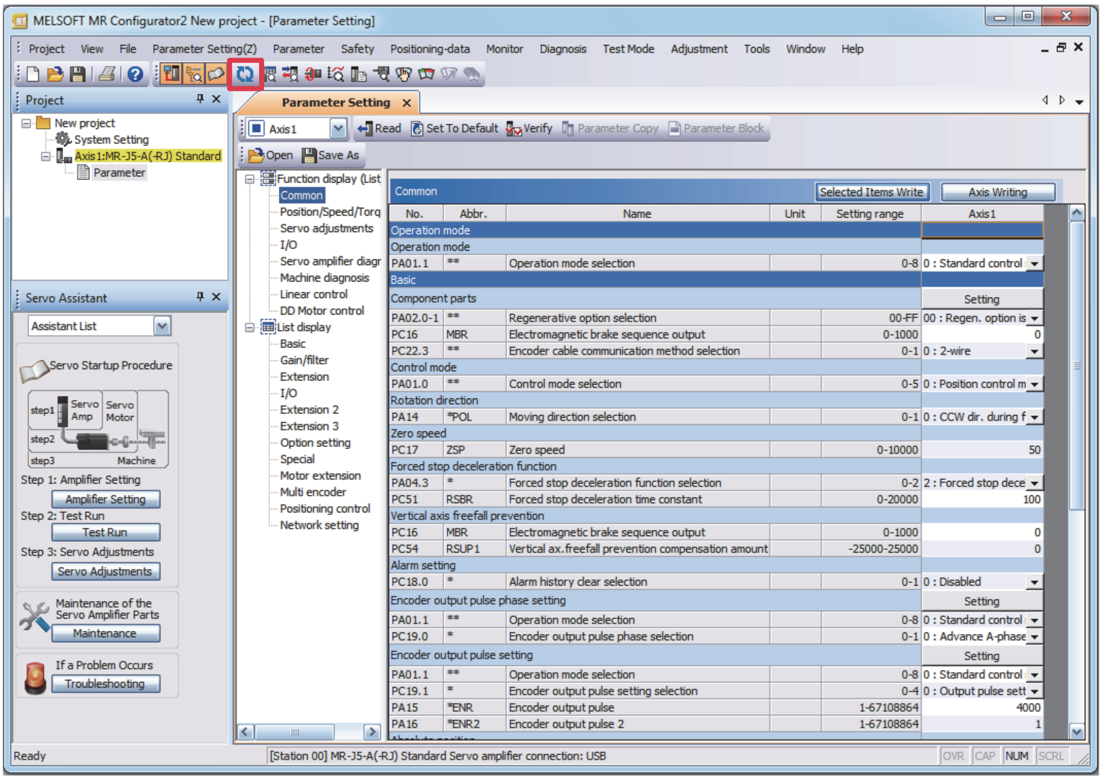
4. Select a group of servo parameters in the selection tree of the "Parameter Setting" window to display and configure the settings.



5. After changing the servo parameter, click "Selected Items Write" or "Axis Writing".



6. Abbreviated servo parameters prefixed with * and servo parameters marked with ** are enabled after the power is cycled or a software reset is performed. Click "Software Reset" in MR Configurator2 to perform the software reset.



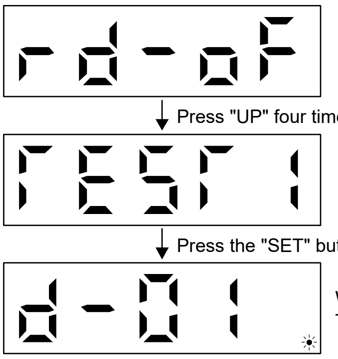
(3) Test operation mode

Precautions

- The test operation mode is designed for checking servo operation. Do not use it for an actual operation.
- If the servo motor operates abnormally, stop the servo motor with EM2 (Forced stop 2).
- The test operation mode cannot be used in the absolute position detection system by DIO ([Pr.PA03.0 Absolute position detection system selection] set to "1" (enabled (absolute position detection system by DIO))). To perform the test operation, select the incremental system in [Pr.PA03].
- MR Configurator2 is required to perform the positioning operation.
- The test operation cannot be performed unless SON (servo-on) is turned off.

(a) Mode switching

The display screen after power-on is shown. Select JOG operation or motor-less operation in the following procedure. Press "MODE" to display the diagnostic screen.



Press "UP" four times.

Press the "SET" button for 2 s or more.

When this screen appears, JOG operation can be performed.
The decimal point of the last digit blinks.

(b) JOG operation

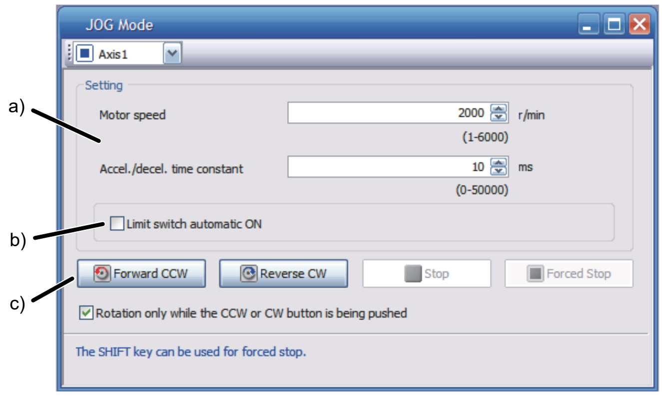
The JOG operation can be performed when there is no command from the controller. The motor can be operated at the specified speed. Operate the motor using the JOG Mode screen of MR Configurator2.

Precautions

- When performing the JOG operation, turn on EM2, LSP and LSN. LSP and LSN can be set to automatic on by setting [Pr.PD01.2] to "C".

1) Operation/drive

A servo motor operates while holding down "UP" or "DOWN". The servo motor stops operating by releasing the button. Operation conditions can be changed by using MR Configurator2. Use the JOG operation screen of MR Configurator2.



a) Motor operation setting

Set the motor speed and acceleration/deceleration time constants for JOG operation. When changing the speed to the permissible speed, set the speed in [Pr.PA28.4 Speed range limit selection].

b) Limit switch automatic ON

JOG operation can be performed without connecting the limit switch. Be sure to avoid causing a collision while performing the operation.

c) Operation

The servo motor can be started (CCW/CW), paused, stopped, or forcibly stopped. Clicking "Start" starts the operation. When "Rotation only while the CCW or CW button is being pushed" is selected, clicking "Forward CCW" or "Reverse CW" will perform operation until "Stop" or "Forced Stop" is clicked.

If operating conditions are not changed in MR Configurator2, operate the servo motor under the following conditions.

Item	Setting range
Servo motor speed [r/min]	200
Acceleration/deceleration time constants [ms]	1000

Starting operation and stop of a servo motor can be done by the buttons. Operate it as follows.

Button	Description
UP	Press to start CCW rotation. Release to stop.
DOWN	Press to start CW rotation. Release to stop.

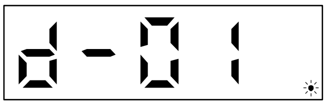
2) Status display

Press "MODE" in the JOG operation-ready status to call the status display screen. When the JOG operation is performed by pressing "UP" or "DOWN", the servo status during the JOG operation is displayed. Every time "MODE" is pressed, the next status display screen appears. When one cycle of the screen display is complete, it returns to the JOG operation-ready status screen. Refer to section 3.1.4 (3) "Status display" for details of status display.

Note that the status display screen cannot be changed by "UP" or "DOWN" during the JOG operation.

3) Termination of JOG operation

To end the JOG operation, shut the power off once, or press "MODE" to switch to the next screen, and then hold down "SET" for 2s or longer.



(4) Equipment configuration setting

Set the servo parameters for each function according to the equipment configuration. For details, refer to the MR-J5 User's Manual (Function).

Item	Description
Rotation/travel direction selection	To change the rotation/travel direction (POL), change the servo parameter.
Stroke limit function	Limit switches can be used to limit travel intervals of the servo. Configure the settings according to the connection method of the limit switch.
In-position setting	Positioning completion status can be checked with in-position. Set this as necessary.
Forced stop deceleration function	Stops the servo motor at EM2 (Forced stop 2) off. Perform settings such as the deceleration time constant.
Vertical axis freefall prevention function	For vertical axes, this function pulls up the shaft slightly. When using a servo motor with an electromagnetic brake for a vertical axis, perform settings as required.

(5) Controller-related setting

Set the servo parameters according to the control mode to be used from the controller. For details, refer to the MR-J5 User's Manual (Function).

Set each servo parameter that is necessary for the operation using controller commands.

Item	Description
Command unit selection function	The unit of torque command can be selected from the controller.
Electronic gear setting	Perform the settings related to the controller command unit and amplifier command unit.

(6) Operation by controller command

In this section, check that the servo motor correctly rotates as slowly as possible under the commands from the controller.

Use the following procedure to check if the servo motor rotates.

(a) Operation by command

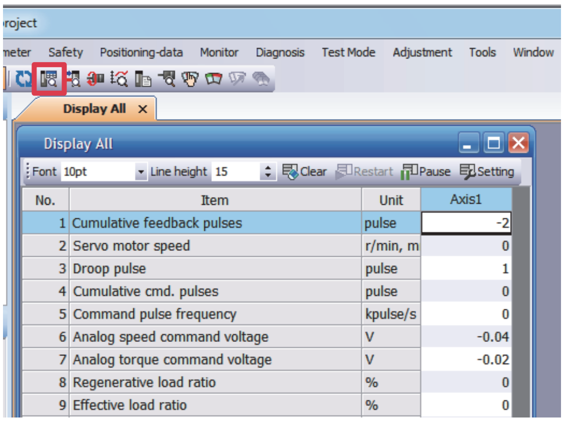
1) Turn on EM2 (Forced stop 2) and SON (Servo-on). When the servo amplifier is in servo-on status, RD (Ready) turns on.
2) Turn on LSP (Forward rotation stroke end) and LSN (Reverse rotation stroke end).
3) When VC (Analog speed command) is input from the controller and ST1 (Forward rotation start) or ST2 (Reverse rotation start) is turned on, the servo motor starts operating. Give a low speed command at first to check the servo motor operations such as the rotation direction. If the servo motor does not operate in the intended direction, check the input signal.
4) Check the operation status.

Refer to (b) "Checking the operation status" in this section.

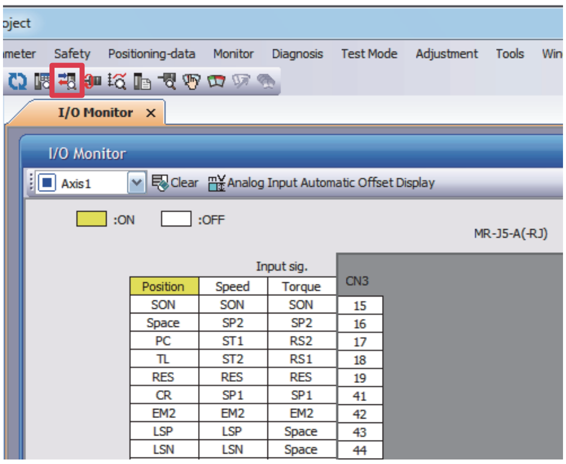
(b) Checking the operation status

After the operation by controller command, confirm that the servo motor can be operated properly in accordance with the following procedure.

1. Display the Display All window in MR Configurator2. Confirm that there is no error in the items such as servo motor speed and load ratio.



2. Display the I/O Monitor window. Confirm that there is no error in the I/O signal.



(7) Parameter settings

Before operating the demonstration machine, set the parameters to the demonstration machine setting values (speed control) shown in the table below.

Refer to section 3.1.6 "Parameter settings" for how to set the parameters.

Point
● Abbreviated parameters prefixed with * are enabled by cycling the power after setting.

(a) Basic setting servo parameters group ([Pr. PA_ _])

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PA01	**STY	10003000h	–	10003000	10003002
PA02	**REG	00000000h	–	00000000	00000000
PA03	*ABS	00000000h	–	00000000	00000000
PA04	*AOP1	00002000h	–	00002000	00002000
PA05	*FBP	10000	pulse	10000	10000
PA06	CMX	1	–	67108864	67108864
PA07	CDV	1	–	10000	10000
PA08	ATU	00000001h	–	00000004	00000004
PA09	RSP	16	–	32	32
PA10	INP	400	pulse	400	400
PA11	TLP	1000.0	%	1000.0	1000.0
PA12	TLN	1000.0	%	1000.0	1000.0
PA13	*PLSS	00000100h	–	00000100	00000100
PA14	*POL	0	–	0	0
PA15	*ENR	4000	pulse/rev	4000	4000
PA16	*ENR2	1	–	1	1
PA17	**MSR	00000000h	–	00000000	00000000
PA18	**MTY	00000000h	–	00000000	00000000
PA19	*BLK	000000ABh	–	000000AB	000000AB
PA20	*TDS	00000000h	–	00000000	00000000
PA21	*AOP3	00000001h	–	00000001	00000001
PA22	**PCS	00000000h	–	00000000	00000000
PA23	DRAT	00000000h	–	00000000	00000000
PA24	AOP4	00000000h	–	00000000	00000000
PA25	OTHOV	0	%	0	0
PA26	*AOP5	00000000h	–	00000000	00000000
PA27	For manufacturer setting	00000000h	–	00000000	00000000
PA28	**AOP6	00000000h	–	00000000	00000000
PA29	For manufacturer setting	0	–	0	0
PA30	For manufacturer setting	0	–	0	0
PA31	For manufacturer setting	0	–	0	0
PA32	For manufacturer setting	00000000h	–	00000000	00000000
PA33	For manufacturer setting	0.0	–	0.0	0.0
PA34	QDIS	0	0.1rev, mm	0	0
PA35	For manufacturer setting	00000000h	–	00000000	00000000
PA36	For manufacturer setting	00000000h	–	00000000	00000000

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PA37	For manufacturer setting	00000000h	–	00000000	00000000
PA38	For manufacturer setting	00000000h	–	00000000	00000000
PA39	For manufacturer setting	00000000h	–	00000000	00000000
PA40	For manufacturer setting	00000000h	–	00000000	00000000
PA41	For manufacturer setting	00000000h	–	00000000	00000000
PA42	For manufacturer setting	00000000h	–	00000000	00000000
PA43	For manufacturer setting	00000000h	–	00000000	00000000
PA44	For manufacturer setting	00000000h	–	00000000	00000000

(b) Gain/filter setting servo parameters group ([Pr.PB_ _])

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PB01	FILT	00000000h	–	00000000	00000000
PB02	VRFT	00000000h	–	00000000	00000000
PB03	PST	0	ms	0	0
PB04	FFC	0	%	0	0
PB05	For manufacturer setting	500	–	500	500
PB06	GD2	7.00	Multiplier	7.43	7.43
PB07	PG1	15.0	rad/s	338.0	338.0
PB08	PG2	37.0	rad/s	249.0	249.0
PB09	VG2	823	rad/s	5397	5397
PB10	VIC	33.7	ms	5.0	5.0
PB11	VDC	980	–	980	980
PB12	OVA	0	%	99	99
PB13	NH1	4500	Hz	4500	4500
PB14	NHQ1	00000000h	–	00000000	00000000
PB15	NH2	4500	Hz	480	480
PB16	NHQ2	00000000h	–	00000011	00000011
PB17	NHF	00000000h	–	0000012B	0000012B
PB18	LPF	3141	rad/s	32000	32000
PB19	VRF11	100.0	Hz	100.0	100.0
PB20	VRF12	100.0	Hz	100.0	100.0
PB21	VRF13	0.00	–	0.00	0.00
PB22	VRF14	0.00	–	0.00	0.00
PB23	VFBF	00001000h	–	00001001	00001001
PB24	*MVS	00000000h	–	00000000	00000000
PB25	*BOP1	00000000h	–	00000000	00000000
PB26	*CDP	00000000h	–	00000000	00000000
PB27	CDL	10	pulse	10	10
PB28	CDT	1	ms	1	1
PB29	GD2B	7.00	Multiplier	7.00	7.00
PB30	PG2B	0.0	rad/s	0.0	0.0
PB31	VG2B	0	rad/s	0	0
PB32	VICB	0.0	ms	0.0	0.0
PB33	VRF11B	0.0	Hz	0.0	0.0
PB34	VRF12B	0.0	Hz	0.0	0.0
PB35	VRF13B	0.00	–	0.00	0.00
PB36	VRF14B	0.00	–	0.00	0.00
PB37	For manufacturer setting	1600	–	1600	1600
PB38	For manufacturer setting	0.000	–	0.000	0.000
PB39	For manufacturer setting	0.000	–	0.000	0.000
PB40	For manufacturer setting	0.000	–	0.000	0.000
PB41	For manufacturer setting	00000000h	–	00000000	00000000
PB42	For manufacturer setting	00000000h	–	00000000	00000000
PB43	For manufacturer setting	00000000h	–	00000000	00000000
PB44	For manufacturer setting	0.00	–	0.00	0.00
PB45	CNHF	00000000h	–	00000000	00000000
PB46	NH3	4500	Hz	4500	4500

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PB47	NHQ3	00000000h	–	00000000	00000000
PB48	NH4	4500	Hz	4500	4500
PB49	NHQ4	00000000h	–	00000000	00000000
PB50	NH5	4500	Hz	4500	4500
PB51	NHQ5	00000000h	–	00000000	00000000
PB52	VRF21	100.0	Hz	100.0	100.0
PB53	VRF22	100.0	Hz	100.0	100.0
PB54	VRF23	0.00	–	0.00	0.00
PB55	VRF24	0.00	–	0.00	0.00
PB56	VRF21B	0.0	Hz	0.0	0.0
PB57	VRF22B	0.0	Hz	0.0	0.0
PB58	VRF23B	0.00	–	0.00	0.00
PB59	VRF24B	0.00	–	0.00	0.00
PB60	PG1B	0.0	rad/s	0.0	0.0
PB61	For manufacturer setting	0.0	–	0.0	0.0
PB62	For manufacturer setting	00000000h	–	00000000	00000000
PB63	For manufacturer setting	00000000h	–	00000000	00000000
PB64	For manufacturer setting	00000000h	–	00000000	00000000
PB65	CDL2	10	pulse	10	10
PB66	CDT2	1	ms	1	1
PB67	GD2C	7.00	Multiplier	7.00	7.00
PB68	PG2C	0.0	rad/s	0.0	0.0
PB69	VG2C	0	rad/s	0	0
PB70	VICC	0.0	ms	0.0	0.0
PB71	VRF11C	0.0	Hz	0.0	0.0
PB72	VRF12C	0.0	Hz	0.0	0.0
PB73	VRF13C	0.00	–	0.00	0.00
PB74	VRF14C	0.00	–	0.00	0.00
PB75	VRF21C	0.0	Hz	0.0	0.0
PB76	VRF22C	0.0	Hz	0.0	0.0
PB77	VRF23C	0.00	–	0.00	0.00
PB78	VRF24C	0.00	–	0.00	0.00
PB79	PG1C	0.0	rad/s	0.0	0.0
PB80	For manufacturer setting	177.0	–	177.0	177.0
PB81	*CFIL	00000001h	–	00000001	00000001
PB82	PFT	0.0	ms	0	0
PB83	For manufacturer setting	00000000h	–	00000000	00000000
PB84	For manufacturer setting	00000000h	–	00000000	00000000
PB85	For manufacturer setting	00000000h	–	00000000	00000000
PB86	For manufacturer setting	00000000h	–	00000000	00000000
PB87	For manufacturer setting	00000000h	–	00000000	00000000
PB88	For manufacturer setting	00000000h	–	00000000	00000000
PB89	For manufacturer setting	00000000h	–	00000000	00000000
PB90	For manufacturer setting	00000000h	–	00000000	00000000

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PB91	For manufacturer setting	00000000h	–	00000000	00000000
PB92	For manufacturer setting	00000000h	–	00000000	00000000

(c) Extension setting servo parameters group ([Pr. PC_ _])

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PC01	STA	0	ms	0	0
PC02	STB	0	ms	0	0
PC03	STC	0	ms	0	0
PC04	TQC	0	ms	0	0
PC05	SC1	100.00	r/min, mm/s	100.00	100.00
PC06	SC2	500.00	r/min, mm/s	500.00	500.00
PC07	SC3	1000.00	r/min, mm/s	1000.00	1000.00
PC08	SC4	200.00	r/min, mm/s	200.00	200.00
PC09	SC5	300.00	r/min, mm/s	300.00	300.00
PC10	SC6	500.00	r/min, mm/s	500.00	500.00
PC11	SC7	800.00	r/min, mm/s	800.00	800.00
PC12	VCM	0	r/min, mm/s	0	0
PC13	TLC	100.0	%	100.0	100.0
PC14	MOD1	00000000h	–	00000002	00000002
PC15	MOD2	00000001h	–	00000001	00000001
PC16	MBR	0	ms	0	0
PC17	ZSP	50	r/min, mm/s	50	50
PC18	*BPS	00000000h	–	00000000	00000000
PC19	*ENRS	00000000h	–	00000000	00000000
PC20	For manufacturer setting	0	–	0	0
PC21	For manufacturer setting	00000000h	–	00000000	00000000
PC22	**COP1	00000000h	–	00000000	00000000
PC23	*COP2	00000000h	–	00000000	00000000
PC24	*COP3	00000000h	–	00000000	00000000
PC25	For manufacturer setting	00000000h	–	00000000	00000000
PC26	*COP5	00000000h	–	00000000	00000000
PC27	*COP6	00000000h	–	00000000	00000000
PC28	*COP7	00000000h	–	00000000	00000000
PC29	*COP8	00000120h	–	00000120	00000120
PC30	STA2	0	ms	0	0
PC31	STB2	0	ms	0	0
PC32	CMX2	1	–	1	1
PC33	CMX3	1	–	1	1
PC34	CMX4	1	–	1	1
PC35	TL2	1000.0	%	1000.0	1000.0
PC36	*DMD	00000000h	–	00000000	00000000
PC37	VCO	0	mV	-4	-4
PC38	TPO	0	mV	0	0
PC39	MO1	0	mV	0	0
PC40	MO2	0	mV	0	0
PC41	For manufacturer setting	0	–	0	0

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PC42	For manufacturer setting	0	–	0	0
PC43	ERZ	0	rev, mm	0	0
PC44	**COP9	00000050h	–	00000050	00000050
PC45	**COPA	00000000h	–	00000000	00000000
PC46	For manufacturer setting	0	–	0	0
PC47	For manufacturer setting	0	–	0	0
PC48	For manufacturer setting	0	–	0	0
PC49	For manufacturer setting	0	–	0	0
PC50	**COPB	00000001h	–	00000000	00000000
PC51	RSBR	100	ms	100	100
PC52	For manufacturer setting	0	–	0	0
PC53	For manufacturer setting	0	–	0	0
PC54	RSUP1	0	0.0001rev, 0.01mm	0	0
PC55	For manufacturer setting	0	–	0	0
PC56	For manufacturer setting	100	–	100	100
PC57	For manufacturer setting	00000000h	–	00000000	00000000
PC58	For manufacturer setting	0	–	0	0
PC59	For manufacturer setting	00000000h	–	00000000	00000000
PC60	**COPD	00000000h	–	00000000	00000000
PC61	For manufacturer setting	00000000h	–	00000000	00000000
PC62	For manufacturer setting	00000000h	–	00000000	00000000
PC63	For manufacturer setting	00000000h	–	00000000	00000000
PC64	For manufacturer setting	00000000h	–	00000000	00000000
PC65	For manufacturer setting	00000000h	–	00000000	00000000
PC66	For manufacturer setting	0	–	0	0
PC67	For manufacturer setting	00000000h	–	00000000	00000000
PC68	For manufacturer setting	0	–	0	0
PC69	For manufacturer setting	00000000h	–	00000000	00000000
PC70	For manufacturer setting	0	–	0	0
PC71	For manufacturer setting	00000040h	–	00000040	00000040
PC72	For manufacturer setting	00000000h	–	00000000	00000000

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PC73	ERW	0	rev, mm	0	0
PC74	For manufacturer setting	00000000h	–	00000000	00000000
PC75	For manufacturer setting	00C00000h	–	00C00000	00C00000
PC76	For manufacturer setting	00000000h	–	00000000	00000000
PC77	For manufacturer setting	10	–	10	10
PC78	For manufacturer setting	0	–	0	0
PC79	For manufacturer setting	00000000h	–	00000000	00000000
PC80	For manufacturer setting	00000000h	–	00000000	00000000
PC81	For manufacturer setting	0.0	–	0.0	0.0
PC82	For manufacturer setting	0.0	–	0.0	0.0
PC83	For manufacturer setting	50.00	–	50.00	50.00
PC84	For manufacturer setting	10	–	10	10
PC85	For manufacturer setting	400	–	400	400
PC86	For manufacturer setting	10	–	10	10
PC87	For manufacturer setting	20.00	–	20.00	20.00
PC88	For manufacturer setting	10	–	10	10
PC89	For manufacturer setting	00000000h	–	00000000	00000000
PC90	PLFT	0	pulse/s	00000000	00000000
PC91	For manufacturer setting	00000000h	–	00000000	00000000
PC92	For manufacturer setting	0	–	00000000	00000000
PC93	For manufacturer setting	00000000h	–	00000000	00000000
PC94	For manufacturer setting	00000000h	–	00000000	00000000
PC95	For manufacturer setting	00000000h	–	00000000	00000000
PC96	For manufacturer setting	00000000h	–	00000000	00000000
PC97	For manufacturer setting	00000000h	–	00000000	00000000
PC98	For manufacturer setting	00000000h	–	00000000	00000000
PC99	For manufacturer setting	00000000h	–	00000000	00000000

(d) I/O setting servo parameters group ([Pr. PD _ _])

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PD01	*DIA1	00000000h	–	00000C00	00000C00
PD02	For manufacturer setting	00000000h	–	00000000	00000000
PD03	*DI1L	00000202h	–	00000202	00000202
PD04	*DI1H	00000202h	–	00000202	00000202
PD05	*DI2L	00002100h	–	00002000	00002000
PD06	*DI2H	00002021h	–	00002021	00002021
PD07	*DI3L	00000704h	–	00002104	00002104
PD08	*DI3H	00000707h	–	00000707	00000707
PD09	*DI4L	00000805h	–	00000505	00000505
PD10	*DI4H	00000808h	–	00000808	00000808
PD11	*DI5L	00000303h	–	00000303	00000303
PD12	*DI5H	00003803h	–	00003803	00003803
PD13	*DI6L	00002006h	–	00002006	00002006
PD14	*DI6H	00003920h	–	00003920	00003920
PD15	For manufacturer setting	000C0C0Ch	–	000C0C0C	000C0C0C
PD16	For manufacturer setting	00000C0Ch	–	00000C0C	00000C0C
PD17	*DI8L	000A0A0Ah	–	000A707	000A0707
PD18	*DI8H	00000A00h	–	00000A00	00000A00
PD19	*DI9L	000B0B0Bh	–	000B0808	000B0808
PD20	*DI9H	00000B00h	–	00000B00	00000B00
PD21	*DI10L	002B2323h	–	002B2323	002B2323
PD22	*DI10H	00002B23h	–	00002B23	00002B23
PD23	*DO1	00000004h	–	00000004	00000004
PD24	*DO2	0000000Ch	–	0000000C	0000000C
PD25	*DO3	00000004h	–	00000004	00000004
PD26	*DO4	00000007h	–	00000007	00000007
PD27	For manufacturer setting	00000003h	–	00000003	00000003
PD28	*DO6	00000002h	–	00000002	00000002
PD29	*DIF	00000007h	–	00000007	00000007
PD30	*DOP1	00000000h	–	00000000	00000000
PD31	*DOP2	00000000h	–	00000000	00000000
PD32	*DOP3	00000000h	–	00000000	00000000
PD33	*DOP4	00000000h	–	00000000	00000000
PD34	*DOP5	00000000h	–	00000000	00000000
PD35	For manufacturer setting	00000000h	–	00000000	00000000
PD36	For manufacturer setting	00000000h	–	00000000	00000000
PD37	For manufacturer setting	00000000h	–	00000000	00000000
PD38	For manufacturer setting	0	–	0	0
PD39	For manufacturer setting	0	–	0	0
PD40	For manufacturer setting	0	–	0	0
PD41	For manufacturer setting	00000000h	–	00000000	00000000
PD42	*DIA4	00000000h	–	00000000	00000000
PD43	*DI11L	00000000h	–	00000000	00000000
PD44	*DI11H	00003A00h	–	00003A00	00003A00
PD45	*DI12L	00000000h	–	00000000	00000000

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PD46	*DI12H	00003B00h	–	00003B00	00003B00
PD47	*DO7	00000000h	–	00000000	00000000
PD48	For manufacturer setting	00000000h	–	00000000	00000000
PD49	For manufacturer setting	00000000h	–	00000000	00000000
PD50	For manufacturer setting	00000000h	–	00000000	00000000
PD51	For manufacturer setting	00000000h	–	00000000	00000000
PD52	For manufacturer setting	00110001h	–	00110001	00110001
PD53	For manufacturer setting	0	–	0	0
PD54	For manufacturer setting	0	–	0	0
PD55	For manufacturer setting	0	–	0	0
PD56	For manufacturer setting	00000000h	–	00000000	00000000
PD57	For manufacturer setting	00000000h	–	00000000	00000000
PD58	For manufacturer setting	00000000h	–	00000000	00000000
PD59	For manufacturer setting	00000000h	–	00000000	00000000
PD60	*DIP	00000000h	–	00000000	00000000
PD61	For manufacturer setting	00000000h	–	00000000	00000000
PD62	For manufacturer setting	00000000h	–	00000000	00000000
PD63	For manufacturer setting	00000000h	–	00000000	00000000
PD64	For manufacturer setting	00000000h	–	00000000	00000000
PD65	For manufacturer setting	00000000h	–	00000000	00000000
PD66	For manufacturer setting	00000000h	–	00000000	00000000
PD67	For manufacturer setting	00000000h	–	00000000	00000000
PD68	For manufacturer setting	00000000h	–	00000000	00000000
PD69	For manufacturer setting	00000000h	–	00000000	00000000
PD70	For manufacturer setting	00000000h	–	00000000	00000000
PD71	For manufacturer setting	00000000h	–	00000000	00000000
PD72	For manufacturer setting	00000000h	–	00000000	00000000

(e) Extension setting 2 servo parameters group ([Pr.PE_ _])

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PE01	**FCT1	00000000h	–	00000000	00000000
PE02	For manufacturer setting	00000000h	–	00000000	00000000
PE03	*FCT2	00000003h	–	00000003	00000003
PE04	**FBN	1	–	1	1
PE05	**FBD	1	–	1	1
PE06	BC1	400	r/min	400	400
PE07	BC2	100	kpulse	100	100
PE08	DUF	10	rad/s	10	10
PE09	For manufacturer setting	00000000h	–	00000000	00000000
PE10	FCT3	00000000h	–	00000000	00000000
PE11	For manufacturer setting	00000000h	–	00000000	00000000
PE12	For manufacturer setting	00000000h	–	00000000	00000000
PE13	For manufacturer setting	00000000h	–	00000000	00000000
PE14	For manufacturer setting	00000111h	–	00000111	00000111
PE15	For manufacturer setting	20	–	20	20
PE16	For manufacturer setting	00000000h	–	00000000	00000000
PE17	For manufacturer setting	00000100h	–	00000100	00000100
PE18	For manufacturer setting	00000000h	–	00000000	00000000
PE19	For manufacturer setting	00000000h	–	00000000	00000000
PE20	For manufacturer setting	00000000h	–	00000000	00000000
PE21	For manufacturer setting	00000000h	–	00000000	00000000
PE22	For manufacturer setting	00000000h	–	00000000	00000000
PE23	For manufacturer setting	00000000h	–	00000000	00000000
PE24	For manufacturer setting	00000000h	–	00000000	00000000
PE25	For manufacturer setting	00000000h	–	00000000	00000000
PE26	For manufacturer setting	00000000h	–	00000000	00000000
PE27	For manufacturer setting	00000000h	–	00000000	00000000
PE28	For manufacturer setting	00000000h	–	00000000	00000000
PE29	For manufacturer setting	00000000h	–	00000000	00000000
PE30	For manufacturer setting	00000000h	–	00000000	00000000
PE31	For manufacturer setting	00000000h	–	00000000	00000000
PE32	For manufacturer setting	00000000h	–	00000000	00000000
PE33	For manufacturer setting	00000000h	–	00000000	00000000

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PE34	For manufacturer setting	1	–	1	1
PE35	For manufacturer setting	1	–	1	1
PE36	For manufacturer setting	0.0	–	0.0	0.0
PE37	For manufacturer setting	0.00	–	0.00	0.00
PE38	For manufacturer setting	0.00	–	0.00	0.00
PE39	For manufacturer setting	20	–	20	20
PE40	For manufacturer setting	00000000h	–	00000000	00000000
PE41	EOP3	00000000h	–	00000001	00000001
PE42	For manufacturer setting	0	–	0	0
PE43	For manufacturer setting	0.0	–	0.0	0.0
PE44	LMCP	0	0.01%	0	0
PE45	LMCN	0	0.01%	0	0
PE46	LMFLT	0	0.1ms	0	0
PE47	TOF	0	0.01%	0	0
PE48	*LMOP	00000000h	–	00000000	00000000
PE49	LMCD	0	0.1ms	0	0
PE50	LMCT	0	pulse, kpulse	0	0
PE51	For manufacturer setting	00000000h	–	00000000	00000000
PE52	For manufacturer setting	00000000h	–	00000000	00000000
PE53	For manufacturer setting	00000000h	–	00000000	00000000
PE54	For manufacturer setting	00000000h	–	00000000	00000000
PE55	For manufacturer setting	00000000h	–	00000000	00000000
PE56	For manufacturer setting	00000000h	–	00000000	00000000
PE57	For manufacturer setting	00000000h	–	00000000	00000000
PE58	For manufacturer setting	00000000h	–	00000000	00000000
PE59	For manufacturer setting	00000000h	–	00000000	00000000
PE60	For manufacturer setting	00000000h	–	00000000	00000000
PE61	For manufacturer setting	0.000	–	0.000	0.000
PE62	For manufacturer setting	0.000	–	0.000	0.000
PE63	For manufacturer setting	0.000	–	0.000	0.000
PE64	For manufacturer setting	0.000	–	0.000	0.000
PE65	For manufacturer setting	0.0	–	0.0	0.0
PE66	For manufacturer setting	0.0	–	0.0	0.0
PE67	For manufacturer setting	0.0	–	0.0	0.0

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PE68	For manufacturer setting	00000000h	–	00000000	00000000
PE69	For manufacturer setting	00000000h	–	00000000	00000000
PE70	For manufacturer setting	00000000h	–	00000000	00000000
PE71	For manufacturer setting	00000000h	–	00000000	00000000
PE72	For manufacturer setting	00000000h	–	00000000	00000000
PE73	For manufacturer setting	00000000h	–	00000000	00000000
PE74	For manufacturer setting	00000000h	–	00000000	00000000
PE75	For manufacturer setting	00000000h	–	00000000	00000000
PE76	For manufacturer setting	00000000h	–	00000000	00000000
PE77	For manufacturer setting	00000000h	–	00000000	00000000
PE78	For manufacturer setting	0	–	0	0
PE79	For manufacturer setting	0	–	0	0
PE80	For manufacturer setting	00000000h	–	00000000	00000000
PE81	For manufacturer setting	00000000h	–	00000000	00000000
PE82	For manufacturer setting	00000000h	–	00000000	00000000
PE83	For manufacturer setting	00000000h	–	00000000	00000000
PE84	For manufacturer setting	00000000h	–	00000000	00000000
PE85	For manufacturer setting	00000000h	–	00000000	00000000
PE86	For manufacturer setting	00000000h	–	00000000	00000000
PE87	For manufacturer setting	00000000h	–	00000000	00000000
PE88	For manufacturer setting	00000000h	–	00000000	00000000

(f) Extension setting 3 servo parameters group ([Pr.PF _ _])

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PF01	For manufacturer setting	00000000h	–	00000000	00000000
PF02	*FOP2	00000000h	–	00000000	00000000
PF03	For manufacturer setting	00000000h	–	00000000	00000000
PF04	For manufacturer setting	0	–	0	0
PF05	For manufacturer setting	0	–	0	0
PF06	For manufacturer setting	00000000h	–	00000000	00000000
PF07	For manufacturer setting	1	–	1	1
PF08	For manufacturer setting	1	–	1	1
PF09	*FOP5	00000013h	–	00000013	00000013
PF10	For manufacturer setting	00000000h	–	00000000	00000000
PF11	For manufacturer setting	00000000h	–	00000000	00000000
PF12	For manufacturer setting	65535	–	65535	65535
PF13	For manufacturer setting	100	–	100	100
PF14	For manufacturer setting	100	–	100	100
PF15	DBT	2000	ms	2000	2000
PF16	For manufacturer setting	00000000h	–	00000000	00000000
PF17	For manufacturer setting	10	–	10	10
PF18	**STOD	10	s	10	10
PF19	For manufacturer setting	00000000h	–	00000000	00000000
PF20	For manufacturer setting	00000000h	–	00000000	00000000
PF21	DRT	0	s	0	0
PF22	For manufacturer setting	200	–	200	200
PF23	OSCL1	20	%	20	20
PF24	*FOP9	00000000h	–	00000000	00000000
PF25	CVAT	200	ms	200	200
PF26	For manufacturer setting	0	–	0	0
PF27	For manufacturer setting	0	–	0	0
PF28	For manufacturer setting	0	–	0	0
PF29	For manufacturer setting	00000000h	–	00000000	00000000
PF30	For manufacturer setting	0	–	0	0
PF31	FRIC	0	r/min, mm/s	0	0
PF32	*VIBT	50	100ms	50	50
PF33	For manufacturer setting	00000000h	–	00000000	00000000
PF34	For manufacturer setting	00000000h	–	00000000	00000000

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PF35	For manufacturer setting	00000000h	–	00000000	00000000
PF36	For manufacturer setting	00000000h	–	00000000	00000000
PF37	For manufacturer setting	00000000h	–	00000000	00000000
PF38	For manufacturer setting	00000000h	–	00000000	00000000
PF39	For manufacturer setting	00000000h	–	00000000	00000000
PF40	For manufacturer setting	0	–	0	0
PF41	For manufacturer setting	0	–	0	0
PF42	For manufacturer setting	0	–	0	0
PF43	For manufacturer setting	0	–	0	0
PF44	For manufacturer setting	0	–	0	0
PF45	For manufacturer setting	00000000h	–	00000000	00000000
PF46	For manufacturer setting	0	–	0	0
PF47	For manufacturer setting	00000000h	–	00000000	00000000
PF48	For manufacturer setting	00000000h	–	00000000	00000000
PF49	TSL	0	0.0001%/°C	0	0
PF50	TIC	0	0.1%	0	0
PF51	*MFP	00000000h	–	00000000	00000000
PF52	MFPP	00000000h	–	00000000	00000000
PF53	FPMT	0	10rev, m	0	0
PF54	PAV	0	0.1%	0	0
PF55	PSD	0	0.1	0	0
PF56	VAV	0	0.1%	0	0
PF57	VSD	0	0.1%	0	0
PF58	TMO	0	10rev, m	0	0
PF59	For manufacturer setting	00000000h	–	00000000	00000000
PF60	For manufacturer setting	00000000h	–	00000000	00000000
PF61	For manufacturer setting	00000000h	–	00000000	00000000
PF62	For manufacturer setting	00000000h	–	00000000	00000000
PF63	For manufacturer setting	00000000h	–	00000000	00000000
PF64	For manufacturer setting	00000000h	–	00000000	00000000
PF65	For manufacturer setting	00000000h	–	00000000	00000000
PF66	BLG	00000000h	–	00000000	00000000
PF67	BLN	0	0.01degree	0	0
PF68	BLTT	0	0.1	0	0
PF69	SPAV2	0	0.1%	0	0
PF70	SPSD2	0	0.1%	0	0
PF71	BFP	00000000h	–	00000000h	00000000h
PF72	SBT	0	0.1N	0	0

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PF73	ABT	0	0.1N	0	0
PF74	SSF	0	0.1%	0	0
PF75	ASF	0	0.1%	0	0
PF76	BTS	0	0.1%	0	0
PF77	For manufacturer setting	00000000h	–	00000000	00000000
PF78	For manufacturer setting	00000000h	–	00000000	00000000
PF79	For manufacturer setting	00110010h	–	00110010	00110010
PF80	DRMC	00000000h	–	00000000	00000000
PF81	DRMS	00000000h	–	00000000	00000000
PF82	DRTM	00000000h	–	00000000	00000000
PF83	For manufacturer setting	00000000h	–	00000000	00000000
PF84	DRTC	005A8101h	–	005A8101	005A8101
PF85	DRTL1	0	–	0	0
PF86	DRTL2	0	–	0	0
PF87	DRAC1	00020201h	–	00020201	00020201
PF88	DRAC2	02040003h	–	02040003	02040003
PF89	DRAC3	02090205h	–	02090205	02090205
PF90	DRAC4	0000020Ch	–	0000020C	0000020C
PF91	DRDC1	00120000h	–	00120000	00120000
PF92	DRDC2	80058010h	–	80058010	80058010
PF93	DRDC3	8000800Ah	–	8000800A	8000800A
PF94	DRDC4	801D8015h	–	801D8015	801D8015
PF95	**DRCLR	00000000h	–	00000000	00000000
PF96	For manufacturer setting	00000000h	–	00000000	00000000
PF97	For manufacturer setting	00000000h	–	00000000	00000000
PF98	For manufacturer setting	00000000h	–	00000000	00000000
PF99	For manufacturer setting	00000000h	–	00000000	00000000

(g) Motor extension setting servo parameters group ([Pr.PL_ _])

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PL01	**LIT1	00000301h	–	00000301	00000301
PL02	**LIM	1000	μm	1000	1000
PL03	**LID	1000	μm	1000	1000
PL04	*LIT2	00000003h	–	00000003	00000003
PL05	LB1	0	mm, 0.01rev	0	0
PL06	LB2	0	mm/s, r/min	0	0
PL07	LB3	100	%	100	100
PL08	*LIT3	00001010h	–	00001010	00001010
PL09	LPWM	30	%	30	30
PL10	For manufacturer setting	5	–	5	5
PL11	For manufacturer setting	100	–	100	100
PL12	For manufacturer setting	500	–	500	500
PL13	For manufacturer setting	00000000h	–	00000000	00000000
PL14	For manufacturer setting	00000000h	–	00000000	00000000
PL15	For manufacturer setting	20	–	20	20
PL16	For manufacturer setting	0	–	0	0
PL17	LTSTS	00000000h	–	00000000	00000000
PL18	IDLV	0	%	0	0
PL19	For manufacturer setting	0	–	0	0
PL20	For manufacturer setting	0	–	0	0
PL21	For manufacturer setting	0	–	0	0
PL22	For manufacturer setting	0	–	0	0
PL23	For manufacturer setting	00000000h	–	00000000	00000000
PL24	For manufacturer setting	0	–	0	0
PL25	For manufacturer setting	0	–	0	0
PL26	For manufacturer setting	00000000h	–	00000000	00000000
PL27	For manufacturer setting	00000000h	–	00000000	00000000
PL28	For manufacturer setting	00000000h	–	00000000	00000000
PL29	For manufacturer setting	00000000h	–	00000000	00000000
PL30	For manufacturer setting	00000000h	–	00000000	00000000
PL31	For manufacturer setting	00000000h	–	00000000	00000000
PL32	For manufacturer setting	00000000h	–	00000000	00000000
PL33	For manufacturer setting	00000000h	–	00000000	00000000
PL34	For manufacturer setting	00000000h	–	00000000	00000000

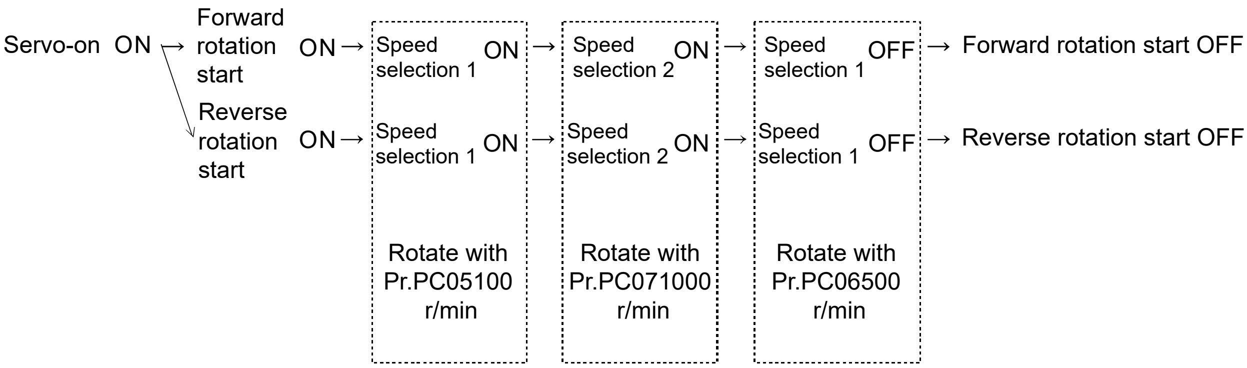
No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PL35	For manufacturer setting	00000000h	–	00000000	00000000
PL36	For manufacturer setting	00000000h	–	00000000	00000000
PL37	For manufacturer setting	00000000h	–	00000000	00000000
PL38	For manufacturer setting	00000000h	–	00000000	00000000
PL39	For manufacturer setting	00000000h	–	00000000	00000000
PL40	For manufacturer setting	00000000h	–	00000000	00000000
PL41	For manufacturer setting	00000000h	–	00000000	00000000
PL42	For manufacturer setting	00000000h	–	00000000	00000000
PL43	For manufacturer setting	00000000h	–	00000000	00000000
PL44	For manufacturer setting	00000000h	–	00000000	00000000
PL45	For manufacturer setting	00000000h	–	00000000	00000000
PL46	For manufacturer setting	00000000h	–	00000000	00000000
PL47	For manufacturer setting	00000000h	–	00000000	00000000
PL48	For manufacturer setting	00000000h	–	00000000	00000000
PL49	For manufacturer setting	00000000h	–	00000000	00000000
PL50	For manufacturer setting	00000000h	–	00000000	00000000
PL51	For manufacturer setting	00000000h	–	00000000	00000000
PL52	For manufacturer setting	00000000h	–	00000000	00000000
PL53	For manufacturer setting	0	–	0	0
PL54	For manufacturer setting	00000000h	–	00000000	00000000
PL55	For manufacturer setting	00000000h	–	00000000	00000000
PL56	For manufacturer setting	00000000h	–	00000000	00000000
PL57	For manufacturer setting	00000000h	–	00000000	00000000
PL58	For manufacturer setting	00000000h	–	00000000	00000000
PL59	For manufacturer setting	00000000h	–	00000000	00000000
PL60	For manufacturer setting	00000000h	–	00000000	00000000
PL61	For manufacturer setting	00000000h	–	00000000	00000000
PL62	For manufacturer setting	00000000h	–	00000000	00000000
PL63	For manufacturer setting	00000000h	–	00000000	00000000
PL64	For manufacturer setting	00000000h	–	00000000	00000000

No.	Symbol	Initial value	Unit	Demonstration machine setting value	
				Position control	Speed control
PL65	For manufacturer setting	00000000h	–	00000000	00000000
PL66	For manufacturer setting	00000000h	–	00000000	00000000
PL67	For manufacturer setting	00000000h	–	00000000	00000000
PL68	For manufacturer setting	00000000h	–	00000000	00000000
PL69	For manufacturer setting	00000000h	–	00000000	00000000
PL70	For manufacturer setting	00000000h	–	00000000	00000000
PL71	For manufacturer setting	00000000h	–	00000000	00000000
PL72	For manufacturer setting	00000000h	–	00000000	00000000

(8) Operation

(a) Internal three-speed operation

1) Operate the servo motor with the procedure below to check if the motor rotates in the forward and reverse directions at the speed specified by Internal speed command 1 to 3 (Pr.PC05 to Pr.PC07).
The speed can be checked with the display (5-digit, 7-segment display) on the front of the servo amplifier or with the monitor of MR Configurator2 installed on the computer.



2) Change the value in Internal speed command 1 to 3 (Pr.PC05 to Pr.PC07), then check the operation.

* Set Pr.PC05 and Pr.PC06 to desired values and Pr.PC07 to 3000.

(b) Analog speed command (VC) operation
Turning off the internal three-speed (speed selection 1 and speed selection 2) enables operation using the VC input.

1) Turn on the forward rotation start or reverse rotation start switch, then check if the speed can be changed by the numerical value input of the analog speed command as desired.

* If the motor rotates even when the speed command is 0, the rotation is caused by an input offset of the external speed command signal. This does not occur when the motor is operated by the internal speed command.
Such motor rotation can be stopped using the method in section 3.1.8 (8) (c) 4) "Adjusting VC offset".

(c) Checking settings of each parameter (refer to section 3.1.5 "Parameter" for details of the parameters.)

1) Checking acceleration/deceleration time constants
Set the speed acceleration time constant (Pr.PC01) and speed deceleration time constant (Pr.PC02), then check the operation.
Setting examples·········Pr.PC01: 0 → 3000 (3 seconds)
Pr.PC02: 0 → 5000 (5 seconds)

2) Checking S-pattern acceleration/deceleration time constants
Set the speed acceleration time constant (Pr.PC01), speed deceleration time constant (Pr.PC02), and S-pattern acceleration/deceleration time constants (Pr.PC03), then check the operation.
Setting examples·········Pr.PC03: 0 → 500 (0.5 second)
Refer to section 3.1.5 (3) (b) 18) "[Pr.PC03_S-pattern acceleration/deceleration time constants (STC)]" for details.
* After checking the operation, set all of Pr.PC01 to Pr.PC03 to 0.

3) Checking torque limit value
Set Internal torque limit (Pr.PA11 and PA12).
Setting example ··········Forward rotation torque limit (Pr.PA11): 100.0% → 28.5%
(The torque will be limited to one-third of the maximum torque to disable the torque output of the rated torque or more.)
Turning on the torque limit selection switch enables numerical value input of the analog torque limit.

4) Adjusting VC offset
Set Analog command input 1 offset (Pr.PC37) so that the motor does not rotate when the command speed voltage is 0V.
Setting example ··········Analog command input 1 offset (Pr.PC37): 0mV → □□mV
(If the motor rotates in the CCW direction when Forward rotation start is turned on, set the parameter to a negative value.)

5) Adjusting analog monitor offset
Set Analog monitor 1 offset (Pr.PC39) to compensate the monitor output meter.

6) Setting monitor output
The contents of the monitor output can be changed by setting Analog monitor 1 output (Pr.PC14).
Setting examples·········00000002: Motor speed (+8V/maximum speed)
00000003: Generated torque (+8V/maximum torque)

7) Setting status display
Set Status display selection (Pr.PC36) to select the status display shown at power-on.
Setting examples·········00000100: Cumulative feedback pulses
00000101: Servo motor speed

8) Checking each status display
a) Enable the load settings during motor operation, then move the load command slider to check the displayed contents such as the peak load ratio and effective load ratio.
b) Set Analog speed command - Maximum speed (Pr.PC12) for a 10V command to 0 then to 2000, then check the output of speed command F, rotation speed r, and GOT speed meter (deflection of the indicator).

4 POSITIONING CONTROL USING AC SERVOS
4.1 Positioning Method and Stop Accuracy
4.1.1 Positioning types

- Positioning
  - Mechanical
  - Electrical
    - Speed
    - Position

A moving part can be stopped at a specified position within a specified accuracy either mechanically or electrically. In general, there are two mechanical stopping methods: 1. Pressing the moving part against a stopper (stopper type control of the inverter and torque limit of the AC servo are used until the moving part contacts the stopper). 2. Sandwiching the moving part between objects such as cylinders to forcibly perform positioning, but the stopping position is restricted. On the other hand, the electrical stopping method allows easy positioning at a number of desired positions by providing position sensors.
There are variations in the electrical stopping method in terms of types of position detection and control, which are roughly classified into the speed control method and position control method as follows.

(1) Speed control method: As motors do not have a signal output device required for positioning, the machine side has devices such as limit switches to back up positioning.
(2) Position control method: As the machine side does not have a position detection device, the detector on the servo motor side performs position control with high accuracy.

Table 4.1 shows the summary of the above description.

4.1.2 Positioning control and stop precision (for speed control method)

(1) Limit switch method
To automatically stop the moving part operated by the motor, its position is generally detected by devices such as limit switches, then their signals stop the motor (the brake is often activated at the same time). Figure 4.1 shows the relation between the time and speed of the moving part. As the horizontal axis indicates the time [sec] and the vertical axis indicates the speed [mm/sec], the area within the speed pattern is the travel distance [mm].

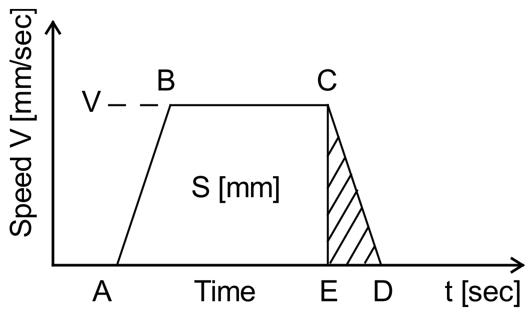


Figure 4.1 Operation (speed) pattern

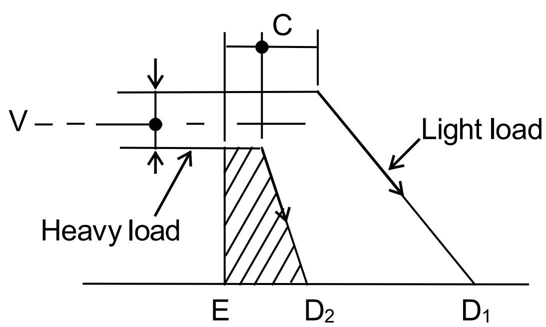


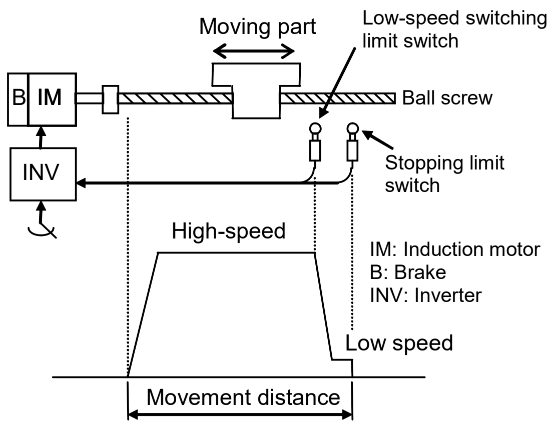
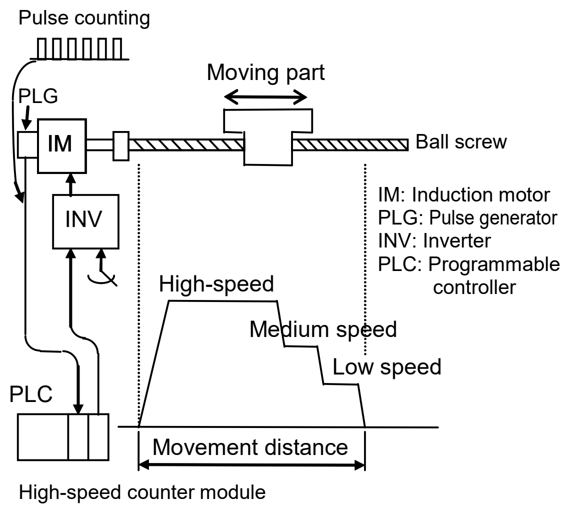
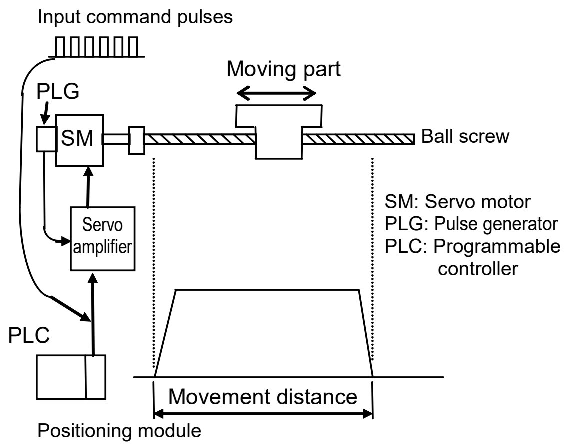
Figure 4.2 Coasting distance variation

The coasting distance after activating the limit switch corresponds to the area CDE, indicating the variation of the stop accuracy. The factors that affect the stop accuracy (the factors that may change the area CDE) in this condition are shown in Figure 4.2, specifically as follows: the variation of the stop time (ED) (variation of the load torque or the brake torque), the speed change of the moving part at the point C, the variation of the sensor activating position of the point C, and the variation of the delay time from the sensor activates until the motor actually starts decelerating.
These variations of the said characters are of course required to be minimized as much as possible, but decreasing the speed V is the most effective to stabilize the stop accuracy. Therefore, when the stop accuracy is not satisfied by stopping from an ordinary speed, generally the motor is first decelerated to a low speed with the limit switch for low-speed switching as shown in table 4.1, then the motor is brought to a stop. This method is widely adopted as it is easy and improves the accuracy. However, it also has a disadvantage that the positioning time is long for the following reasons: The speed at passing through the stopping limit switch is unstable due to factors such as load fluctuation if the time at a low speed (which is called a creep speed) is insufficient.
In addition, as the number of stop positions increases, more sensors are required.

(2) Pulse count method
The pulse count method is the method which is improved from the limit switch method. As stop positions can be selected as desired with this method, decelerating points can also be made as many as desired. Therefore, the time to travel short distance can be reduced. Although the stop accuracies of the limit switch method and pulse count method are equivalent, the pulse count method enables easier position compensation in such conditions as when the moving part goes past the stop position because the current position of the moving part is constantly detected.
However, the stop accuracy itself should not be expected to improve because the same disadvantage as the limit switch method will affect the stop accuracy.

(3) Pulse command method
The positioning method using the servo improves the disadvantages mentioned above. The pulse command method always detects the position of the moving part just as the pulse count method, and continuously decelerates the motor without a creep speed from a high speed directly to the target stop position, then stops the motor within the desired accuracy. This method is called the position control method as opposed to the speed control method.

Table 4.1 Positioning method comparison table

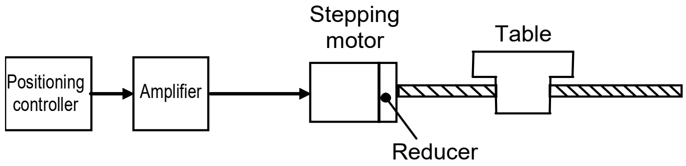
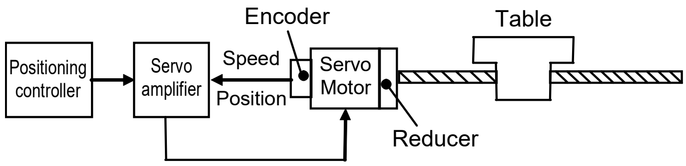
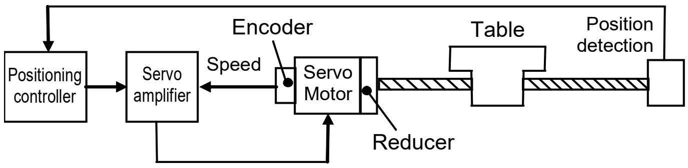
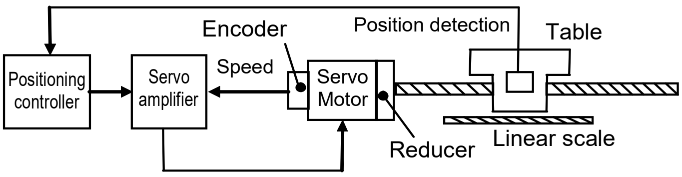
Category	Method	Description	Outline explanation diagram
Speed control method	Limit switch method	Sets limit switches at the points where the moving part passes through. The moving part activates the switches, then their signal stops the servo motor. The method generally uses two switches. The first switch decelerates the motor to a low speed, then the second switch turns off the motor and activates the brake to stop the moving part. An additional positioning device is not required and the system can be configured with a simple control at a reasonable price. (Guideline for stop accuracy Approximately v0.5 to 5.0mm) *1	
	Pulse count method	Sets a position detector (such as a pulse encoder) on the motor and the rotation shaft which drives the object, and counts the number of generated pulses with a high-speed counter. This method stops the moving part by outputting the stop signal when the counter reaches the specified value since the pulse is in proportion to the travel distance. Devices such as limit switches can be omitted in this method, and thus changing positions becomes easier. (Devices such as a high-speed counter module can be used.) (Guideline for stop accuracy Approximately ±0.5 to 5.0mm) *1	
Position control method	Pulse command method	An AC servo motor that rotates in proportion to the number of input pulses is used as the drive motor. High-speed positioning in proportion to the number of pulses can be performed by inputting the number of pulses corresponding to the travel distance to the servo amplifier of the AC servo motor. (Devices such as a positioning module can be used.) (Guideline for stop accuracy Approximately ±0.001 to 0.05mm)	

*1. The stop accuracy for when the slow speed is 10[mm/sec] to 100[mm/sec] is indicated.

4.1.3 Position control method types

The position control by the servo is a method which constantly feeds back the detected position, and the detecting method has the types as shown in table 4.2. (The open loop method, which is not a servo control, is shown as a comparison to the closed loop method.)

Table 4.2 Position control method types

Loop method		System architecture	Feature
Open loop			• This is not defined as a servo because it does not give a feedback. • The operation stops at overload. • It has small capacity models only.
Semi closed loop	Motor shaft detection		• Easily configured. • The fastest response. • Stable control system which allows secure operation. • Requires backlash compensation of the gear reducer.
	Feed screw-side detection		• Configuration is rather complicated (an additional detector is required). • Control is liable to become unstable under influence of the gear reducer and feed screws. • Backlash compensation of the gear reducer is not required.
Fully closed loop			• An expensive position detector is required. • Control is liable to become unstable under influence of the gears and feed screws, and a response at a high level cannot be obtained. • Backlash compensation of the gear reducer is not required.

The AC servo MELSERVO series has introduced the semi closed loop control using the motor shaft detection method as its control system is stable and is easy for users to handle. In addition, the MELSERVO-J5 supports the fully closed loop control as the standard specification.

4.2 Basics of Positioning Control Using AC Servos

This section explains the positioning control using the pulse command method.

4.2.1 Position detection and number of pulses per motor revolution

As mentioned in section 4.1.3 Position control method types, the AC servo MELSERVO series has introduced the semi closed loop control method which detects the motor rotating position, that is the machine position, using the encoder directly connected with the motor shaft. (The MELSERVO-J5 can select the fully closed loop control as the standard specification.)

The encoder outputs a pulse signal corresponding to the motor rotation angle, then the servo amplifier captures the pulse signal to perform positioning control. (Refer to section 1.4.3 "Encoder functions and operating principle" for details of the encoders.)

The feedback pulses are the reference for the steps of movement of the machine connected with the motor (resolution). Accuracy of the positioning control improves as the number of pulses per motor revolution increases. The resolution of the HK series servo motors is 67108864 pulses (represented as 67108864 pulses/rev). (Refer to section 1.3.4 "Model series and features of servo motors" for details of the motors.)

4.2.2 Idea of positioning servos

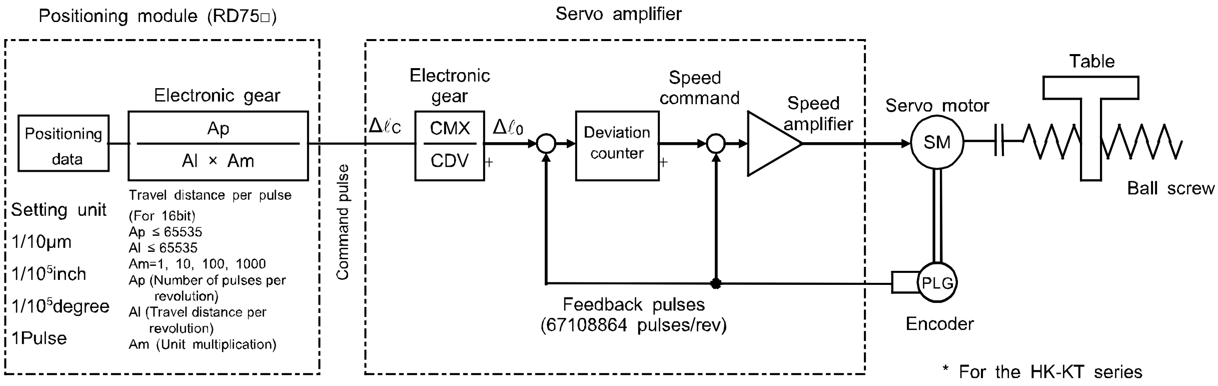


Figure 4.3 Positioning servo configuration

As the positioning command module inputs the command pulses, the servo amplifier captures the command pulses and the feedback pulses corresponding to the number of motor revolutions into its deviation counter. Positioning using servo motors is to control the motor so that there is no differences between the command pulses and the feedback pulses.

Therefore, the servo motors can perform exact positioning using the command pulses.

One of the bases of the positioning control using servos is the movement of a motor shaft (machine) per pulse of the command to the servo amplifier, and the others are as follows:

(a) The feed length of the machine is in proportion to the total number of the command pulses
(b) The machine speed is in proportion to the speed of the command pulse train (pulse frequency)
(c) Positioning completes within the area of the last ±1 pulse, and the position is retained in the servo-lock state unless there is a subsequent position command

(1) Deviation counter and motor rotation amount
In the deviation counter, the command pulses from the positioning command module are added together, and at the same time the values of the counter are subtracted as feedback pulses are returned. When the value of the deviation counter (droop pulses) is large, a large speed command is output to rotate the motor at a high speed. The command pulses decrease as the position comes close to the target stop position, decreasing the output of the deviation counter to slow down the motor speed. When the value of the deviation counter (droop pulses) becomes zero, the speed command also becomes zero and the motor stops. In sum, the output of the deviation counter has the function that automatically controls the number of feedback pulses (the motor rotation amount) and command pulses so that both the numbers are the same.
For example, to make a half revolution of the MELSERVO-J5 series servo motor HK-KT which has feedback pulses of 67108864p/rev, an input of 33554432 pulses needs to be given from a positioning command module.

(2) Motor speed
With the control by the deviation counter, the motor rotation speed is in proportion to the command pulse train speed since the motor rotation angle is in proportion to the command pulse amount.
For example, to operate the HK-KT series motor at 3000r/min, command pulses of 3000 revolutions × 67108864 pulses = 201326.592×10^6pulses per minute ($201326.592 \times 10^6/60 = 3355443.2 \times 10^3$pulses per second) (expressed as 3355443.2×10^3PPS = 3355443.2kpps) are required to be input from the positioning command module.

(3) Positioning completion and servo-lock
When the output of the deviation counter (droop pulses) becomes zero, which means that the number of command pulses and feedback pulses matches, the positioning completes. After the positioning completion, if the servo motor is rotated by an external force, feedback pulses will be input from the encoder to the deviation counter to output a speed command. This command corrects the motor rotation to a direction which constantly makes the droop pulses zero so that the moving part remains at a specified position. This function is called servo-lock.

4.3 Positioning accuracy

4.3.1 Machine feed length per pulse

The machine feed length per pulse is the minimum unit of the machine movement. Figure 4.4 Expression (4-1) describes the machine feed length per pulse $\Delta\ell_0$ for when the mechanical system has a ball screw without a gear reducer as shown in section (1). If the mechanical system has a device other than a ball screw or the system has a gear reducer, calculate the machine feed length per pulse based on the machine feed length ΔS per motor revolution. The feed length per pulse $\Delta\ell_0$ can be obtained by substituting the feed length per motor revolution shown in Figure 4.5 for ΔS in expression (4-1).

$$\Delta\ell_0 = \frac{\Delta S}{P_{fo}} = \frac{\Delta S}{67108864} \text{ [mm/pulse]} \cdots\cdots (4\text{-}1)$$

Note that Pf_o is the number of feedback pulses per motor revolution.
The value of Pf_o is equal to the encoder resolution, which varies depending on the motor type.
The resolution of each motor type is as follows: the HC-PQ is 4000 [pulses/rev], the HC-SFS is 131072 [pulses/rev], all the MELSERVO-J3 series motors are 262144 [pulses/rev], all the MELSERVO-J4 series motors are 4194304 [pulses/rev], and all the MELSERVO-J5 series motors are 67108864 [pulses/rev]. (Refer to section 1.3.4 "Model series and features of servo motors" for details of the motors.)

Figure 4.4 shows the mechanical system examples and the expression of ΔS.

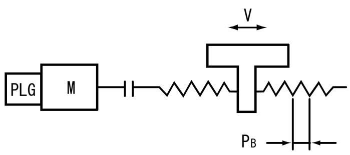
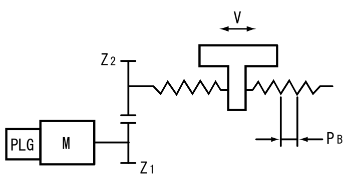
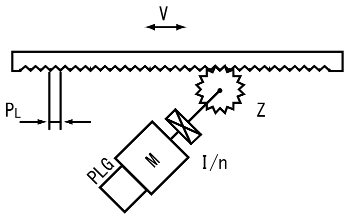
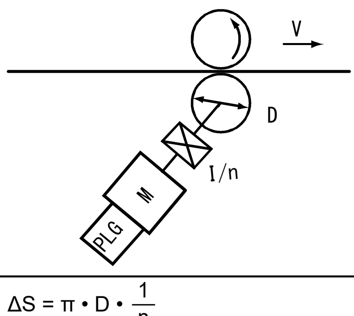
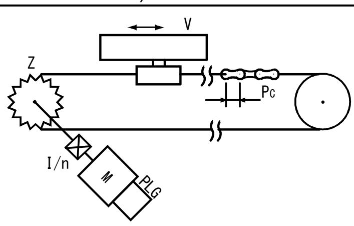
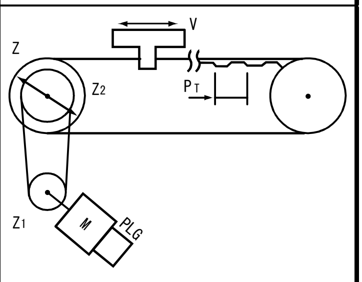
Driving method	(1) Ball screw (directly connected)	(2) Ball screw (connected with gears)	(3) Rack and pinion
			
Feed length per motor revolution	$\Delta S = P_B$	$\Delta S = P_B \cdot \frac{Z_1}{Z_2} = P_B \cdot \frac{1}{n}$	$\Delta S = P_L \cdot Z \cdot \frac{1}{n}$ Z: Number of pinion teeth
Driving method	(4) Roll feed	(5) Driving by chains (directly connected)	(6) Driving by chains and timing belts
			
Feed length per motor revolution	$\Delta S = \pi \cdot D \cdot \frac{1}{n}$	$\Delta S = P_C \cdot Z \cdot \frac{1}{n}$ Z: Number of sprocket teeth	$\Delta S = P_T \cdot Z \cdot \frac{Z_1}{Z_2} = P_T \cdot Z \cdot \frac{1}{n}$ Z: Number of pulley teeth

Figure 4.1 Feed length per motor revolution of each mechanical system (ΔS)

4.3.2 Machine total accuracy and electrical side accuracy

The machine total accuracy $\Delta\varepsilon$ is obtained by adding the machine side accuracy and electrical side accuracy together.
The machine side accuracy is to be considered by the machine manufacturer.
The electrical side accuracy depends on the feed length per pulse on the machine shaft $\Delta\ell_0$ [mm/pulse].
The Mitsubishi MELSERVO series eventually stops the moving part within the area of ±one pulse of the electronic gear output pulse ($\pm\Delta\ell_0$ with being converted into the machine axis), then the servo will be set to a servo-lock state. The servo-lock state will be maintained until a subsequent command pulse is sent. Therefore, the electrical side accuracy $\Delta\ell_0$ is generally set to satisfy the following expression so that the machine total accuracy $\Delta\varepsilon$ will not be affected by the electrical side accuracy.

$$\Delta\ell_0 \leq \left(\frac{1}{5} \text{ to } \frac{1}{10}\right) \times \Delta\varepsilon \cdots\cdots (4\text{-}2)$$

<Reference> Machine total accuracy $\Delta\varepsilon$ and feed length per pulse $\Delta\ell_0$ The feed length per pulse $\Delta\ell_0$ can be obtained with the machine total accuracy $\Delta\varepsilon$ taken into account.

4.4 Motor Speed in Relation to the Maximum Machine Speed

When the mechanical system is operated with gear shift and the ball screw as shown in Figure 4.4, the motor speed N [r/min] in relation to the machine speed V [mm/min] will be as shown in expression (4-3).

$$\text{Motor speed} = \frac{\text{Machine speed}}{\text{Ball screw lead}} \times \frac{1}{\text{Reduction ratio}} \cdots\cdots (4\text{-}3)$$

Therefore, the expression will be as shown in (4-4) for the ball screw lead P_B [mm] and the reduction ratio 1/n.

$$N = \frac{V}{\Delta S} = \frac{V}{P_B} \cdot n \text{ [r/min]} \cdots\cdots (4\text{-}4)$$

If the maximum machine speed V_0 is determined, setting the motor speed to a value that is as close to the rated speed Nr [r/min] as possible without exceeding it enables high accuracy in positioning and thus the power of the motor can be used effectively.

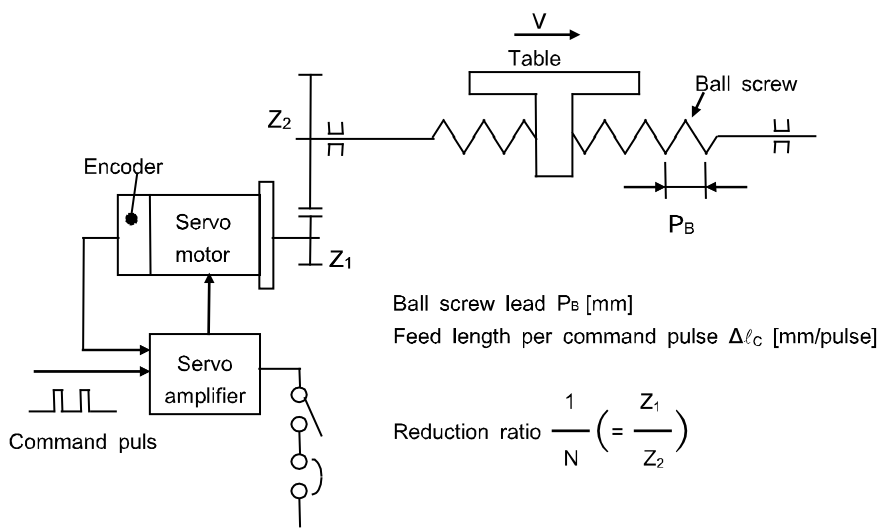


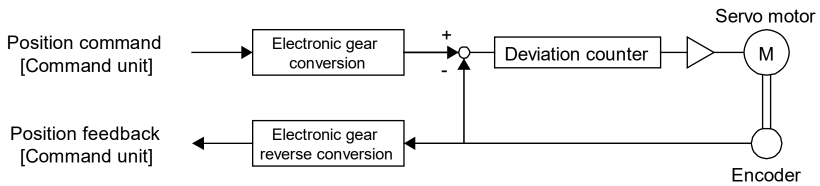
Figure 4.2 Relation between machine speed and motor speed

4.5 Command pulse

In the positioning servo, the machine moves by the number of feedback pulses with the same amount of the number of pulses input from the positioning command module, and the motor is operated at a speed that matches the command pulses with the feedback pulses during a steady operation. Therefore, you need to check if the relation between the minimum command unit for positioning and machine feed length per pulse (section 4.3.1 Machine feed length per pulse) is consistent and if the pulse frequency at the maximum machine speed satisfies the operation conditions of both the positioning command module and servo amplifier.

4.5.1 Electronic gear function

Both the positioning command module and the servo amplifier have the electronic gear function. This section explains the electronic gear on the servo amplifier side.
The electronic gear function is a function that multiplies the electronic gear ratio to the position command, and sets the ratio of the rotation amount/travel distance of the servo motor to the rotation amount/travel distance of the command unit as desired. For the position feedback, the inverse number of the electronic gear ratio is multiplied.



Restrictions

- Set the electronic gear within the range of conditions. If a value out of the range is set, [AL.037 Parameter error] occurs.

Precautions

- To prevent unexpected operation, set the electronic gear correctly.
- In the position control mode, ensure that the electronic gear is in servo-off status before setting the gear so as to prevent unexpected operation due to incorrect setting.
- If an excessive command pulse frequency is input from the controller in the position control mode, [AL.031 Overspeed] may occur, depending on the value of the electronic gear ratio.

(1) Setting method

(a) Setting with servo parameters

Set the electronic gear numerator in [Pr.PA06 Electronic gear numerator], and electronic gear denominator in [Pr.PA07 Electronic gear denominator]. When using the electronic gear in the command input pulses per revolution, set [Pr.PA05 Number of command input pulses per revolution]. Set the servo parameter of the electronic gear and the electronic gear setting compatibility mode to be used in "Electronic gear compatibility selection" of [Pr.PA21].

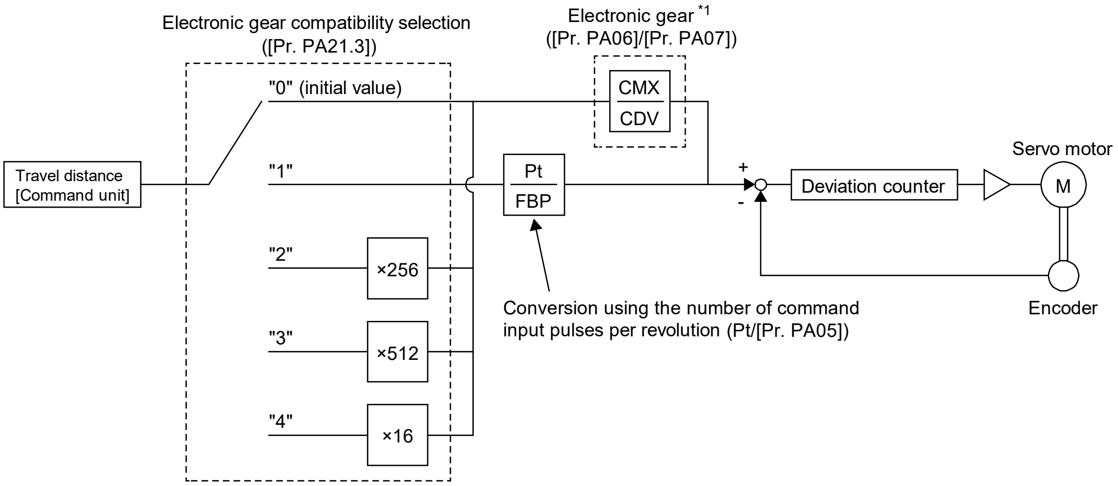
Servo parameter	Symbol	Name	Description
PA05	*FBP	Number of command input pulses per revolution	Set the number of command input pulses per revolution. Initial value: 10000 [pulses]
PA06	CMX	Electronic gear numerator	Set the electronic gear numerator. Initial value: 1
PA07	CDV	Electronic gear denominator	Set the electronic gear denominator. Initial value: 1
PA21.3	*AOP3	Electronic gear compatibility selection	Select the electronic gear, and set the electronic gear setting compatibility mode. 0: Electronic gear (initial value) 1: Number of command input pulses per revolution 2: J3 electronic gear setting value compatibility mode 3: J2S electronic gear setting value compatibility mode 4: J4 electronic gear setting value compatibility mode
PC32	CMX2	Command input pulse multiplication numerator 2	Set the electronic gear numerator at switching with CM1 (Electronic gear selection 1) and CM2 (Electronic gear selection 2) of the input device. Initial value: 1
PC33	CMX3	Command input pulse multiplication numerator 3	
PC34	CMX4	Command input pulse multiplication numerator 4	

(2) Setting example

The electronic gears on the position command side are illustrated in the function block diagrams. The inverse number of the electronic gear ratio is multiplied to the position feedback side.

(a) For position control mode

Adjust [Pr.PA06 Electronic gear numerator] and [Pr.PA07 Electronic gear denominator] so that the travel distance set in the controller matches the travel distance on the machine. When the value is converted with [Pr.PA05 Number of command input pulses per revolution], the numerator of the electronic gear ratio is the encoder resolution, and the denominator is the setting value in [Pr.PA05].



*1. With CM1 (Electric gear selection 1) and CM2 (Electric gear selection 2) of the input device, the setting value of CMX can be selected from [Pr.PA06], [Pr.PC32], [Pr.PC33], or [Pr.PC34].

P_t: Servo motor encoder resolution [pulses/rev]
ΔS: Travel distance per servo motor revolution [command unit/rev]
CMX: Electronic gear numerator
CDV: Electronic gear denominator
$CMX/CDV = P_t/\Delta S$
The following setting example shows how to calculate the electronic gear.

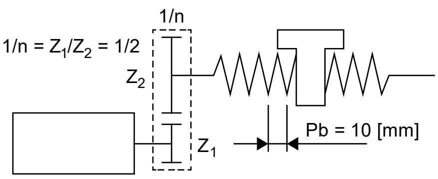
Precautions

- The following specification symbols are necessary for calculation of the electronic gear.
  Pb: Ball screw lead [mm]
  1/n: Reduction ratio
  P_t: Servo motor encoder resolution [pulses/rev]
  ΔL_0: Travel distance per command pulse [mm/pulse]
  ΔS: Travel distance per servo motor revolution [mm/rev]
  Δθ°: Angle per pulse [°/pulse]
  Δθ: Angle per revolution [°/rev]

1) Setting example for a ball screw

The following shows an example where the ball screw is moved at 10μm per pulse.

Machine specifications



Ball screw lead Pb = 10 [mm]

Reduction ratio: $1/n = Z_1/Z_2 = 1/2$

Z_1: Number of gear teeth on servo motor side

Z_2: Number of gear teeth on load gear

Servo motor encoder resolution: P_t = 67108864 [pulses/rev]

$$\frac{CMX}{CDV} = \Delta L_0 \bullet \frac{P_t}{\Delta S} \quad \Delta L_0 \bullet \frac{P_t}{1/n \bullet Pb} = 10 \times 10^{-3} \bullet \frac{67108864}{1/2 \bullet 10} = \frac{67108864}{500} = \frac{16777216}{125}$$

Therefore, set CMX = 16777216 and CDV = 125.

2) Setting example for conveyors

The following shows the example of when the conveyor is rotated at 0.01° per pulse.

Machine specifications

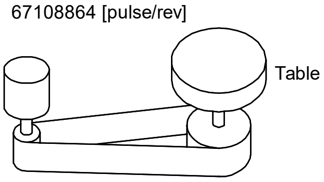


Table: 360°/rev

Reduction ratio: 1/n = 625/12544

Servo motor encoder resolution: P_t = 67108864 [pulses/rev]

$$\frac{CMX}{CDV} = \Delta\theta° \bullet \frac{P_t}{\Delta S} = 0.01 \bullet \frac{67108864}{625/12544 \bullet 360} = \frac{841813590016}{22500000} = \frac{26306674688}{703125}$$

At this point, as CMX is outside of the setting range (2147483647 or less), the value needs to be reduced. After reducing CMX to the setting range or less, round off the value to the nearest whole number.

$$\frac{CMX}{CDV} = \frac{26306674688}{703125} = \frac{1753778312.53}{46875} \approx \frac{1753778313}{46875}$$

Therefore, set CMX = 1753778313 and CDV = 46875.

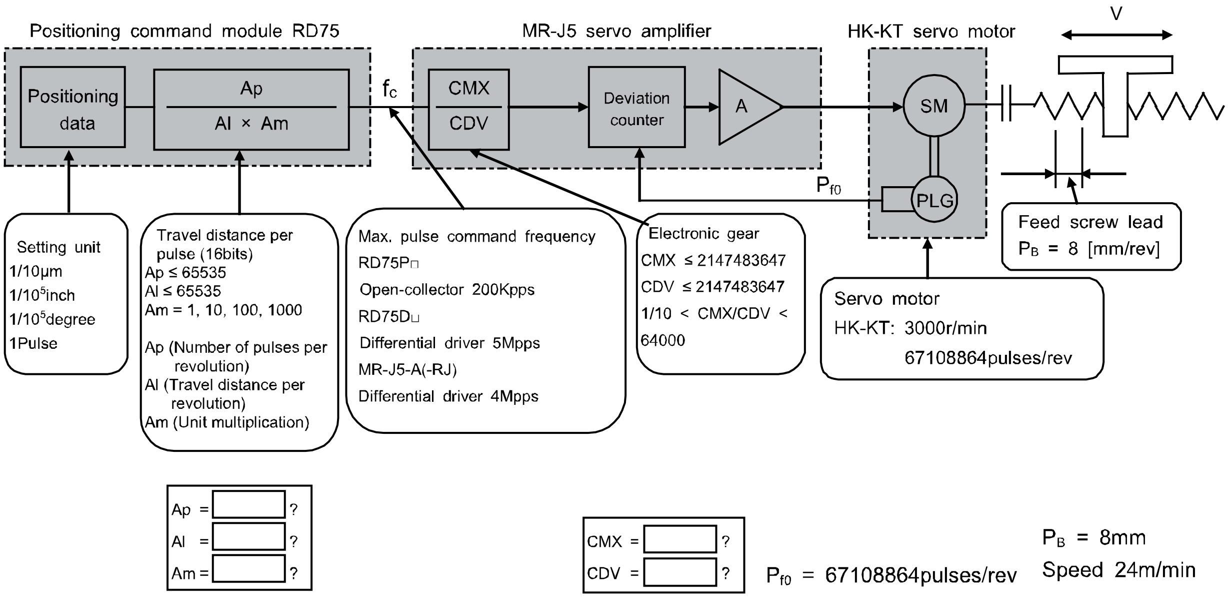
Point

- If the servo motor rotates in one direction endlessly on systems such as an index table, the error in rounding off accumulates, resulting in the index position mismatch.
  For example, even if 36000 pulses are input for the command in the previous example, the following result is obtained for the table. Therefore, a positioning to the same position cannot be performed on the table.

  $$36000 \cdot \frac{1753778313}{46875} \cdot \frac{1}{67108864} \cdot \frac{625}{12544} \cdot 360° = 360.0000001°$$

  Reduce the value so that the calculated values before and after reduction are as close as possible.

Exercise 4.1



Calculate on the assumption that a differential driver is used.

Q1. Find the machine travel distance per feedback pulse $\Delta\ell_0$.

Q2. Find the electronic gear ratio K on the servo amplifier side. Assume that the electronic gear on the RD75 side is 1/1 and the machine travel distance $\Delta\ell_c$ is 0.05 [μm/pulse].

Q3. Find the command pulse frequency fc assuming the motor speed is 3000 [r/min], using K obtained in the question 2.

Q4. Find the electronic gear ratio K on the servo amplifier side assuming the command pulse frequency is 4Mpps.

Q1.

$$\Delta\ell_0 = \frac{P_B}{P_{fo}} = \frac{8}{67108864} \approx 0.12 \times 10^{-6} \text{ [mm/pulse]}$$

* When positioning for 300mm, the calculation is as follows: 300 ÷ 0.12 × 10^{-6} = 2500000000pulses

Q2.

Calculate the electronic gear ratio to control the servo motor with travel distance per feedback pulse of the servo motor (0.12 × 10^{-6} [mm/pulse]) using the machine travel distance of the positioning device (0.05 × 10^{-3} [mm/pulse]).

$$K = \frac{CMX}{CDV} = \Delta\ell c \bullet \frac{P_{fo}}{P_B} = 0.05 \times 10^{-3} \times \frac{67108864}{8} = \frac{1}{20000} \times \frac{67108864}{8} = \frac{262144}{625}$$

$\Delta\ell_C$ will be as follows when the electronic gear above is substituted in the expression.

$$\Delta\ell_C = \frac{P_B}{P_{fo}} \times \frac{CMX}{CDV} = \frac{8}{67108864} \times \frac{262144}{625} = 0.00005 \text{ [mm/pulse]}$$

* When positioning for 300mm, the calculation is as follows, generating no fractions: 300 ÷ 0.00005 = 6000000pulses
* The electronic gear ratio obtained in the expression above needs to be checked if it exceeds 4Mpps which is the maximum command frequency for the combination mentioned above.

Q3.

$$f_{c1} = P_{fo} \times \frac{N}{60} = 67108864 \times \frac{3000}{60} = 3355443200 \text{ [pps]}$$

$$f_c = \frac{625}{262144} \bullet f_{c1} = \frac{CMX}{CDV} \times 3355443200 = 8000000 = 8 \text{ [Mpps]}$$

* The control cannot be performed because the command pulse frequency exceeds the RD75D□'s maximum command pulse frequency 5Mpps and the MR-J5-A's maximum command pulse frequency 4Mpps.
(Therefore, find the electronic gear on the servo amplifier side at 4Mpps which is the maximum command pulse frequency that can be used with the combination described above.)

Q4.

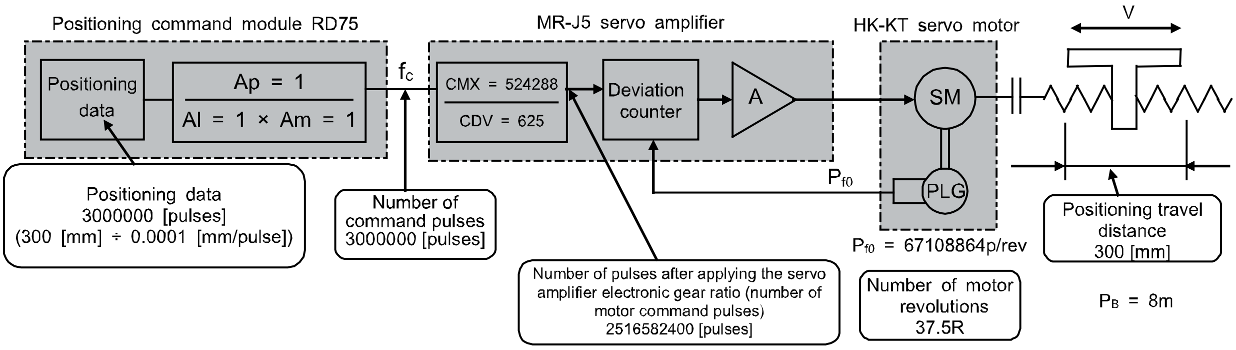
The following is obtained by calculating the electronic gear ratio from the relationship between f_c and f_{c1}.

$$f_c = \frac{CDV}{CMX} \bullet f_{c1} \Rightarrow \frac{CMX}{CDV} = \frac{f_{c1}}{f_c} = \frac{3355443200}{4 \times 10^6} = \frac{524288}{625}$$

Check the positioning accuracy $\Delta\ell_C$ when the electronic gear above is substituted in the expression.

$$\Delta\ell_C = \frac{P_B}{P_{fo}} \times \frac{CMX}{CDV} = \frac{8}{67108864} \times \frac{524288}{625} = 0.0001 \text{ [mm/pulse]}$$

Summary of the exercise 4.1
Assume positioning for 300mm.



4.5.2 Maximum input pulse frequency

The maximum servo amplifier input frequency is defined by the following conditions:

(1) The MR-J5 series selects the electronic gear value so that the servo motor can be operated at a speed up to the rated speed with the maximum input pulse frequency (open collector: 200kpps, differential driver: 4Mpps).
The total maximum input pulse frequency including the command device is the maximum frequency that satisfies the operation conditions of both the said servo amplifier and command device.

Exercise 4.2
(1) What is the maximum input pulse frequency of the MR-J5 (3000r/min) series with open collector input in kpps?
(2) Find the range of the electronic gear value K on the MR-J5 when it is operated at the rated speed with the maximum input pulse frequency or less.
(3) What is the maximum input pulse frequency in total for the MR-J5 and RD75 with open collector input in kpps?

(1) It is 200kpps.
(2) The range of the electronic gear value K is as follows:

$$f_{c1} = P_{f0} \times \frac{3000}{60} = 67108864 \times \frac{3000}{60} = 3355443.2 \times 10^3 \text{pps}$$

$$4000 > K \geq \frac{f_{c1}}{f_c} = \frac{3355443.2 \times 10^3}{200 \times 10^3} = \frac{2097152}{125}$$

(3) The frequency that satisfies the operation conditions of both the MR-J5 and RD75 is 200kpps.

Exercise 4.3
(1) What is the maximum input pulse frequency of the MR-J5 (3000r/min) series with differential driver input in kpps?
(2) Find the range of the electronic gear value K on the MR-J5 when it is operated at the rated speed with the maximum input pulse frequency or less.
(3) What is the maximum input pulse frequency in total for the MR-J5 and RD75 with differential driver input in kpps?

(1) It is 4Mpps.
(2) The range of the electronic gear value K is as follows:

$$f_{c1} = P_{f0} \times \frac{3000}{60} = 67108864 \times = \frac{3000}{60} \; 3355443.2 \times 10^3 \text{pps}$$

$$64000 > K \geq \frac{f_{c1}}{f_c} = \frac{3355443.2 \times 10^3}{4 \times 10^6} = \frac{8388608}{10000}$$

(3) The frequency that satisfies the operation conditions of both the MR-J5 and RD75 is 4Mpps.

4.6 Speed Patterns and Stop Settling Time

4.6.1 Speed patterns and behavior of droop pulses

Droop pulses are the difference between the command pulses and feedback pulses in the deviation counter of the servo amplifier. Their behavior is shown in Figure 4.6.

(1) Behavior from t_0 to t_2

The feedback pulses from the encoder are delayed because of the servo motor acceleration delay to the command pulses, generating the droop pulses ε.

$$\varepsilon = \frac{f_{c1}}{PG1} = \frac{K \bullet f_c}{PG1} \text{ [pulse]} \cdots\cdots (4\text{-}5)$$

PG1: Model control gain

K: $\frac{CMX}{CDV}$

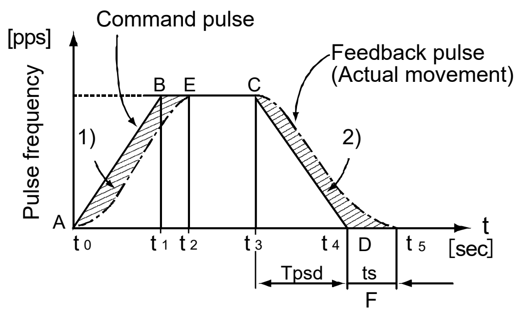


Figure 4.6 Speed pattern and droop pulses

(2) Behavior from t_2 to t_3

The motor operates synchronizing the command pulses and servo motor speed while retaining the delay for the droop pulses of the expression in (4-5).

(3) Behavior from t_3 to t_4

The motor operates to catch up the position delay of the expression in (4-5). The motor does not arrive at the command position even at t_4 (the point where the command pulses finish), and the motor still rotates even after the command pulses run out.

(4) Behavior from t_4 to t_5

The motor operates to clear all the remaining droop pulses. The time between t_4 and t_5 is defined as the stop settling time ts.

(5) Motor behavior

The actual motor speed and droop pulses behave exponentially.

In the end, the motor settles by clearing all the droop pulses, then becomes a servo-lock state.

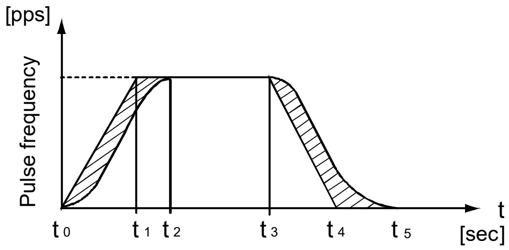
Therefore, the motor behavior can be described as follows:

The command amount of the command pulses (area ABCD) = the actual feed length (area AECF)

and

The amount of pulses accumulated at acceleration 1) (area ABEA) = the amount of pulses that decrease at deceleration 2) (area CFDC)

Exercise 4.4



Assuming PG1 = 36 [sec^{-1}] in the figure on the left, find the droop pulses ε with the deviation counter input indicated below.
f_{c1} = K • f_c = 180k, 18k, 0.9k, 72 [pps]
Moreover, assuming $\Delta\ell_0$ = 0.01 [mm/pulse], convert the obtained droop pulses into a feed length.
Note that an MR-J5 motor is assumed to be used.
(Electronic gear ratio K = 1/16)

Since ε = K • f_c /PG1 [pulse], each result is as follows:
For K • f_c = 180kpps (1318r/min)

$\varepsilon = \frac{180000}{36}$ = 5000 [pulses], converted into the feed length as 5000 × 0.01 = 50 [mm]

For K • f_c = 18kpps (132r/min)

$\varepsilon = \frac{180000}{36}$ = 500 [pulses], converted into the feed length as 500 × 0.01 = 5 [mm]

For K • f_c = 0.9kpps (6.6r/min)

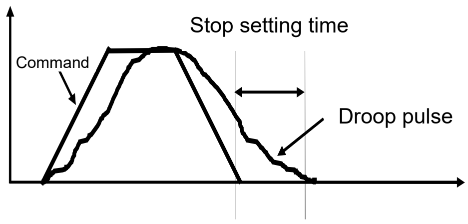
$\varepsilon = \frac{900}{36}$ = 25 [pulses], converted into the feed length as 25 × 0.01 = 0.25 [mm]

For K • f_c = 72pps (0.53r/min)

$\varepsilon = \frac{72}{36}$ = 2 [pulses], converted into the feed length as 2 × 0.01 = 0.02 [mm]

4.6.2 Stop settling time ts

The stop settling time is the time from the end of a command output until the positioning finishes. This settling time determines the takt time for parts mounting machines such as inserters and mounters, thus shortening time is highly important.

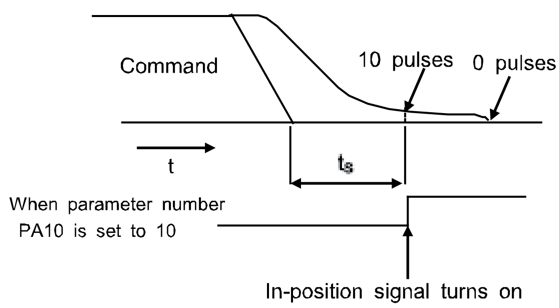


The value of the stop settling time can be roughly calculated using Position loop gain 1 (PG1) on the model side in the model adaptive control. However, the value of Position loop gain 1 is highly susceptible to the machine conditions and the value of the load moment of inertia. Therefore, the mechanical system needs to be taken into account when a high-frequency operation feed or high-response stop settling is requested.
The stop settling time until the pulses are reduced to approximately 10 or less is empirically obtained from the following expression.

$$ts \approx \frac{3}{PG1} \text{ (sec)}$$

When the droop pulses are within the accuracy demanded by the machine, the servo motor is regarded as to be at a stop even if it rotates, and an in-position signal is output.

The stop settling time has an influence on the cycle time of high-frequency positioning.



4.7 Relation between Mechanical Systems and Responsiveness Settings

4.7.1 Responsiveness settings

The conventional control methods needed to adjust the servo positioning loop gain and speed loop gain in accordance with the conditions of the machine. In particular, the load to motor inertia ratio and rigidity often required a long time for adjustment because these factors had to be understood well about how they related to each loop of the servo system.
As the models such as the MELSERVO-J5 series perform the model adaptive control and real-time auto tuning, both the ideal model section and actual loop section can be adjusted automatically to the optimum gain just by setting the auto tuning response to a value that matches with the machine rigidity.
The auto tuning response can be set using the parameter.
Refer to the following table for the settings on the MR-J5.

Table 4.3 MR-J5 parameter Pr.PA09

Setting value	Auto tuning response	Guidelines for machinery
1 to 13	Low response	Applicable to low mechanical rigidity. Specifically for machines such as belt-driving machines, chain-driving machines, and machines with large backlash.
14 to 18	Low to middle response	Applicable to the average rigidity level of general-purpose machines. Specifically for machines such as belt-driving machines, chain-driving machines, and rack and pinion-driving machines. It is the setting from the factory.
19 to 23	Middle response	Applicable to a rather high level of mechanical rigidity. Specifically when the responsiveness needs to be improved on devices such as ball screws and timing belts with high rigidity.
24 to 28	Middle to high response	Applicable to high mechanical rigidity and very frequent positioning.
29 to 40	High response	Applicable to very high mechanical rigidity and extremely frequent positioning.

* Decrease the setting value if hunting or large gear noise occurs on the machine.
Increase the setting value to shorten the stop settling time or other purposes to improve the performance.

4.7.2 Real-time auto tuning

By setting a value of the auto tuning response in the parameter and rotating the servo motor, the load moment of inertia at this point is automatically adjusted. Then, each control loop gain (position and speed) is set to the optimum value in accordance with the set response value.
At this time, if the setting value of the auto tuning response for the mechanical system is inapplicable, vibration occurs or the operation will be unstable. Check the setting value of the auto tuning response again.
The results of the adjusted load to motor inertia ratio can be checked on the load to motor inertia ratio of the status display monitor.
The recommended load to motor inertia ratio has restrictions such as responsiveness, regenerative energy, and dynamic brake.

The load to motor inertia ratio is usually recommended to be 30 times or less of the servo motor as a guideline. (Refer to each catalog for details.)
Although settings can be configured by real-time auto tuning on most of the machines, adjust the gain manually when it needs to be adjusted to its limit.

<Reference> Manual gain adjustment method
Adjust the gains manually when the load moment of inertia is excessive, a normal tuning cannot be obtained because the unbalanced load on the vertical axis is extremely large, or the auto tuning response settings cannot be used on the machine being used. Refer to section 6.2.3 "Auto tuning" for details.

5 IDEA OF POSITIONING

5.1 Dividing Functions between Servo and Positioning Command Module

AC servos perform positioning control by dividing the functions between the positioning command module that generates command pulse trains and servo amplifier as follows.

5.1.1 Functions on the positioning command module side

(1) Outputting the command pulses equivalent to the machine feed length
(2) Determining the machine speed (command pulse frequency)
(3) Determining the operation pattern (acceleration/deceleration time constants)
(4) Storing the theoretical machine position

5.1.2 Functions on the servo amplifier side

(1) Performing position control for a command position in accordance with the pulse train from the positioning command module
(2) Servo-lock function
(3) In-position signal outputting function

5.2 Classification and System Architecture of Positioning Command Modules

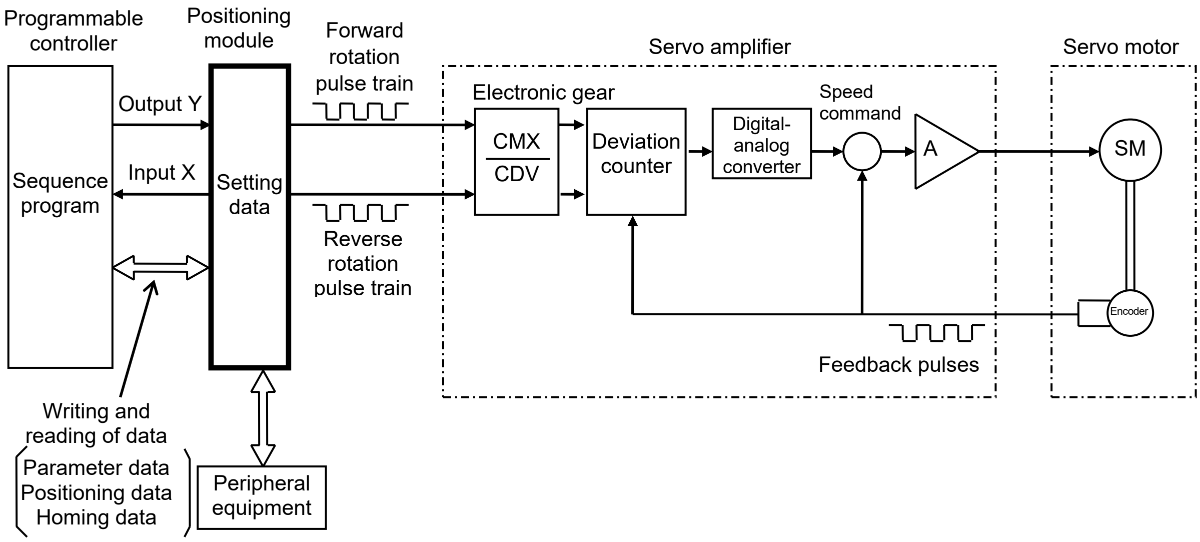


Figure 5.1 Positioning system architecture

(a) The pulse train output from the positioning module is integrated in the deviation counter, and the amount of the droop pulses is converted into DC analog voltage by digital-analog conversion. The converted droop pulses are the speed command.
(b) The speed command rotates the motor and at the same time the feedback pulses return from PLG to the deviation counter, reducing the droop pulses.
(c) As the pulse train output from the positioning module becomes a deceleration command, the droop pulses in the deviation counter are cleared, then the motor stops.

While servo motors have been used for various purposes and their systematization with upper controllers has been advancing, so many models of positioning modules for servo motors have also been proposed and developed into products.
Therefore, selecting a positioning command module appropriate for the purpose is very important to improve the efficiency and cost-effectiveness of the servo system, as well as selecting a servo motor.
Based on the above perspective, the categories and functions of positioning controllers are explained as follows.

(1) System methods
The table below shows the servo system methods including the positioning command modules and servo amplifiers.

(2) Number of control axes
The term explains how many servo motors/servo amplifiers can usually be controlled simultaneously with one positioning command module.
If the positioning command device has multiple control axes, the control method is either synchronous control or independent control.

	Programmable controller series	Communication method	Model ("n" and "□" indicate the number of control axes)	Maximum number of control axes								Linear interpolation	Circular interpolation	Synchronous interpolation	Remark
				64	32	16	8	4	3	2	1				
Multi-axis controller system (Motion controller)	MELSEC iQ-R	SSCNET III(/H)	RnMTCPU	●	●	●						●	●	●	
	MELSEC Q	SSCNET III(/H)	Q173/172DSCPU		●	●						●	●	●	32 axes for the Q173, and 16 axes for the Q172
		SSCNET III(/H)	Q170MSCPU(-S1)			●						●	●	●	Stand-alone motion controller
		SSCNET III	Q173/172DCPU		●	●						●	●	●	32 axes for the Q173, and 16 axes for the Q172
		SSCNET III	Q170MCPU			●						●	●	●	Stand-alone motion controller
		SSCNET III	Q173/172HCPU(-T)		●		●					●	●	●	Ended production in September 2018, 8-axis is compatible for the Q172
		SSCNET	Q173/172CPU(N)(-T)		●		●					●	●	●	Ended production in September 2018, 8-axis is compatible for the Q172
Programmable controller family type (Positioning module) (Simple Motion module) (Motion module)	MELSEC iQ-R	CC-Link IE TSN	RD78G□	●	●	●	●	●				●	●	●	
		CC-Link IE Field	RD77GF□		●	●	●	●				●	●	●	
		SSCNET III(/H)	RD77MS□			●	●	●		●		●	●	●	
		Open collector	RD75P□					●		●		●	●	−	
		Differential driver	RD75D□					●		●		●	●	−	
	MELSEC Q	CC-Link IE Field	QD77GF□			●	●	●				●	●	●	
		SSCNET III(/H)	QD77MS□			●		●		●		●	●	●	
		SSCNET III	QD74MH□			●	●					●	−	−	Ended production in December 2019
		SSCNET III	QD75MH□					●		●	●	●	●	−	Ended production in September 2018
		SSCNET	QD75M□					●		●	●	●	●	−	Ended production in September 2018
		Open collector	QD75P□(N)					●		●	●	●	●	−	
		Differential driver	QD75D□(N)					●		●	●	●	●	−	
		Open collector	QD70P□				●	●				−	−	−	
		Differential driver	QD70D□				●	●				−	−	−	
		Open collector	QD72P3C3						●			Note	−	−	Counter function built-in type
		Analog output	QD73A1								●	−	−	−	
	MELSEC L	SSCNET III(/H)	LD77MS□			●		●		●		●	●	●	
		SSCNET III	LD77MH□			●		●				●	●	●	Ended production in September 2015
		Open collector	LD75P□					●		●	●	●	●	−	
		Differential driver	LD75D□					●		●	●	●	●	−	
		Differential driver	L CPU							●		−	−	−	CPU built-in positioning
	MELSEC iQ-F	SSCNET III(/H)	FX5-80/40SSC-S				●	●				●	●	●	8 axes for the 80SS-C, and 4 axes for the 40SS-C
		Open collector	FX5-20PG-P							●		●	●	−	
		Open collector	FX5U/5UC CPU					●				Note	−	−	CPU built-in positioning
	MELSEC F	SSCNET III	FX3U-20SSC-H							●		−	−	−	
		Open collector	FX3U-1PG								●	−	−	−	
		Open collector	FX2N-10PG								●	−	−	−	
		Open collector	FX2N-1PG(-E)								●	−	−	−	Ended production in December 2015
		Open collector	FX2N-20GM							●		●	●	−	
		Open collector	FX2N-10GM								●	−	−	−	
		Open collector	FX3U/3UC CPU						●			−	−	−	CPU built-in positioning
Stand-alone type (Amplifier with built-in positioning function) (Point table compatible)	Servo amplifier	CC-Link IE Field	MR-J4-GF(-RJ) (All capacities)								●	−	−	−	(Motion mode can be used by switching)
		External input signal	MR-J4-A-RJ (All capacities)								●	−	−	−	Program compatible (pulse trains can be used by switching)
		CC-Link	MR-J3-T (All capacities)								●	−	−	−	Ended production in May 2019
		External input signal	MR-J2S-CP (All capacities)								●	−	−	−	Ended production in August 2015
		External input signal	MR-J2S-CL (All capacities)								●	−	−	−	Ended production in August 2015, program compatible
		External input signal	MR-J2-C (All capacities)								●	−	−	−	Ended production in December 2005
		CC-Link IE TSN	MR-J5□-G(-RJ) (All capacities)						●			−	−	−	Number of axes differs depending on the model
		External input signal	MR-J5-A(-RJ) (All capacities)								●	−	−	−	

* Pseudo linear interpolation by synchronous start

(3) Synchronous control/independent control

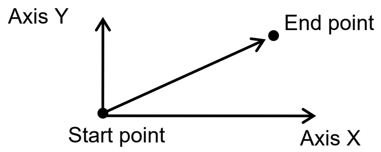
(a) Synchronous control ···· A function to control multiple axes simultaneously on a positioning command module that has two or more control axes.
The control for multiple axes is made by a single program, and the operation modes (automatic, manual, homing, etc.) and start/stop are performed simultaneously. On top of these said functions, interpolation control is also available on an increasing number of recent models.

(b) Independent control ····· A function to control each axis independently on a positioning command module that has two or more control axes.
The control for each axis is made by an individual program separately, and the operation modes (automatic, manual, homing, etc.) and start/stop can also be performed separately.

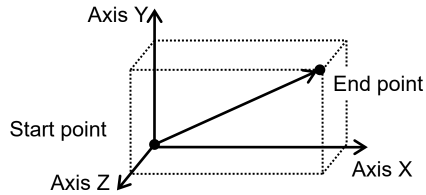
(4) Interpolation control

This is a function that controls multiple axes by having them relate to each other. This function usually has the linear interpolation and circular interpolation.

(a) Linear interpolation ······ Controls multiple axes by connecting the start point and the end point (target position) via the shortest distance. This is called the linear interpolation as paths in this method become linear. It usually has the two-axis linear interpolation, three-axis linear interpolation, and four-axis linear interpolation.
The linear interpolation can be used on models that are available with two axes or more within their maximum number of control axes (two to four-axis interpolation).



1) 2-axis linear interpolation



2) 3-axis linear interpolation

Figure 5.2 Linear interpolation movement

Applicable models
- 2-axis linear interpolation ········ RD75P2, RD75D2
- 4-axis linear interpolation ········ RD78G□, RD77GF□, RD77MS, RD75P4, RD75D4 (2-axis/3-axis linear interpolation are also available)

(b) Circular interpolation ···· Controls multiple axes by connecting the start point and the end point (target position) in a circular arc. Since there are countless possible circular paths connecting the two points, set additional information, such as an auxiliary point which the circular arc passes through, radius and center position of the circular arc, and the rotation direction, on the program.
The two-axis interpolation of the circular interpolation can be used on models that can operate two or more axes.

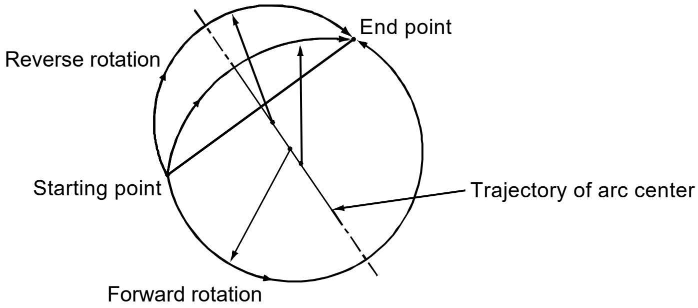


Figure 5.3 Circular interpolation movement

Applicable models ——— RD78G□, RD77GF□, RD77MS, RD75P□, RD75D□

(5) Absolute position detection

With the absolute position detector installed on the servo motor, the positioning command module backs up the machine position without executing homing after a power-off. This system enables resumption of positioning control from the backed-up position.

A motor with an absolute position detector, compatible servo amplifier, and positioning command module are required to configure an absolute position detection system.

Command interface	Positioning command module	Servo amplifier	Motor
CC-Link IE TSN	RD78G	MR-J5-□G series	• HK-KT • HK-ST
CC-Link IE Field	RD77GF	MR-J4-□GF series	• HG-KR • HG-MR • HG-JR • HG-RR • HG-UR • HG-SR
SSCNETNET III/H	• RnMTCPU • RD77MS	MR-J4-□B series	

(As of May 2020)

(6) Types of positioning programs

The types of programs are compared between their supporting models as follows.

Sequence program
- Sequence program (SSCNET III/H) ····· RD77MS, QD77MS, LD77MS, FX5-40SSC-S, FX5-80SSC-S
- Sequence program (CC-Link IE Field Network) ···· RD77GF, QD77GF
- Sequence program (CC-Link IE TSN) ·· RD78G
- Motion SFC ·········· R16MTCPU, R32MTCPU, R64MTCPU, Q172DSCPU, Q173DSCPU, Q170MSCPU
- C language (CC-Link IE Field Network) ····· MR-EM340GFT

POINT

- SSCNET: An abbreviation for Servo System Controller NETwork
  Mitsubishi-dedicated servo network method

5.3 Data for Positioning Command Module Settings

This section explains the data for the positioning command module RD75D□ settings.

5.3.1 Basic setting

Item		Setting range
Basic parameter 1	Unit setting	• 0: mm • 1: inch • 2: degree • 3: pulse (default value)
	Electronic gear selection	• 0: 16bits (default value) • 1: 32bits
	Number of pulses per revolution (16bit)	1 to 65535pulses (default value: 20000)
	Travel distance per revolution (16bit)	Setting values using engineering tools (default value: 20000) • 0.1 to 6553.5 (μm) • 0.00001 to 0.65535 (inches) • 0.00001 to 0.65535 (degrees) • 1 to 65535 (pulses)
		Setting values using programs *1 (default value: 20000) • 1 to 65535 (× 10^{-1}μm) • 1 to 65535 (× 10^{-5}inches) • 1 to 65535 (× 10^{-5}degrees) • 1 to 65535 (pulses)
	Number of pulses per revolution (32bits)	1 to 200000000pulses (default value: 20000)
	Travel distance per revolution (32bits)	Setting values using engineering tools (default value: 20000) • 0.1 to 20000000.0 (μm) • 0.00001 to 2000.00000 (inches) • 0.00001 to 2000.00000 (degrees) • 1 to 200000000 (pulses)
		Setting values using programs *1 (default value: 20000) • 1 to 200000000 (× 10^{-1}μm) • 1 to 200000000 (× 10^{-5}inches) • 1 to 200000000 (× 10^{-5}degrees) • 1 to 200000000 (pulses)
	Unit multiplication	• 1: 1 time (default value) • 10: 10 times • 100: 100 times • 1000: 1000 times
	Pulse output mode	• 0: PULSE/SIGN mode • 1: CW/CCW mode (default value) • 2: A-phase/B-phase (4 multiplication) • 3: A-phase/B-phase (1 multiplication)
	Rotation direction settings	• 0: Increases the current value with forward rotation pulse output (default value) • 1: Increases the current value with reverse rotation pulse output

Item		Setting range
Basic parameter 1	Offset speed at starting	Setting values using engineering tools (Default value: 0) • 0 to 20000000.00 (mm/min) • 0 to 2000000.000 (inches/min) • 0 to 3000000.000 (degrees/min) • 0 to 5000000 (pulses/s)
		Setting values using programs *1 (default value: 0) • 0 to 2000000000 (× 10^{-2}mm/min) • 0 to 2000000000 (× 10^{-3}inches/min) • 0 to 3000000000 (× 10^{-3}degrees/min) • 0 to 5000000 (pulses/s)
Basic parameter 2	Speed limit value	Setting values using engineering tools (Default value: 200000) • 0.01 to 20000000.00 (mm/min) • 0.001 to 2000000.000 (inches/min) • 0.001 to 3000000.000 (degrees/min) • 1 to 5000000 (pulses/s)
		Setting values using programs *1 (default value: 200000) • 1 to 2000000000 (× 10^{-2}mm/min) • 1 to 2000000000 (× 10^{-3}inches/min) • 1 to 3000000000 (× 10^{-3}degrees/min) • 1 to 5000000 (pulses/s)
	Acceleration time 0	1 to 8388608ms (default value: 1000)
	Deceleration time 0	
Detail parameter 1	Backlash compensation amount	Setting values using engineering tools (Default value: 0) • 0 to 6553.5 (μm) • 0 to 0.65535 (inches) • 0 to 0.65535 (degrees) • 0 to 65535 (pulses)
		Setting values using programs *1 (default value: 0) • 0 to 65535 (× 10^{-1}μm) • 0 to 65535 (× 10^{-5}inches) • 0 to 65535 (× 10^{-5}degrees) • 0 to 65535 (pulses)
	Software stroke limit Upper limit value	Setting values using engineering tools (Default value: 2147483647) • -214748364.8 to 214748364.7 (μm) • -21474.83648 to 21474.83647 (inches) • 0 to 359.99999 (degrees) • -2147483648 to 2147483647 (pulses)
		Setting values using programs *1 (Default value: 2147483647) • -2147483648 to 2147483647 (× 10^{-1}μm) • -2147483648 to 2147483647 (× 10^{-5}inches) • 0 to 35999999 (× 10^{-5}degrees) • -2147483648 to 2147483647 (pulses)

Item		Setting range
Detail parameter 1	Software stroke limit Lower limit value	Setting values using engineering tools (Default value: 2147483647) • -214748364.8 to 214748364.7 (μm) • -21474.83648 to 21474.83647 (inches) • 0 to 359.99999 (degrees) • -2147483648 to 2147483647 (pulses)
		Setting values using programs *1 (Default value: 2147483647) • -2147483648 to 2147483647 (× 10^{-1}μm) • -2147483648 to 2147483647 (× 10^{-5}inches) • 0 to 35999999 (× 10^{-5}degrees) • -2147483648 to 2147483647 (pulses)
	Software stroke limit selection	• 0: Applying software limit to the feed current value (default value) • 1: Applying software limit to the feed machine value
	Software stroke limit Enable/disable setting	• 0: Enabled (default value) • 1: Disabled
	Command in-position range	Setting values using engineering tools (Default value: 100) • 0.1 to 214748364.7 (μm) • 0.00001 to 21474.83647 (inches) • 0.00001 to 21474.83647 (degrees) • 1 to 2147483647 (pulses)
		Setting values using programs *1 (default value: 100) • 1 to 2147483647 (× 10^{-1}μm) • 1 to 2147483647 (× 10^{-5}inches) • 1 to 2147483647 (×10^{-5}degrees) • 1 to 2147483647 (pulses)
	Torque limit setting value	1 to 5000 (default value: 300)
	M code-ON signal output timing	• 0: WITH mode (default value) • 1: AFTER mode
	Speed switching mode	• 0: Standard speed switching mode (default value) • 1: Front-load speed switching mode
	Interpolation speed specifying method	• 0: Composite speed (default value) • 1: Reference axis speed
	Feed current value at speed control	• 0: The feed current value is not updated (default value) • 1: The feed current value is updated • 2: The feed current value is cleared to 0
	Input signal logic selection: Lower limit signal	• 0: Negative logic (default value) • 1: Positive logic
	Input signal logic selection: Upper limit signal	
	Input signal logic selection: Drive unit ready signal	
	Input signal logic selection: Stop signal	
	Input signal logic selection: External command signal	
	Input signal logic selection: Zero-point signal	
	Input signal logic selection: Proximity dog signal	
	Input signal logic selection: Manual pulse generator input	
	Output signal logic selection: Command pulse signal	• 0: Negative logic (default value) • 1: Positive logic
	Output signal logic selection: Deviation counter clear	

<table>
<tr><th colspan="2">Item</th><th>Setting range</th></tr>
<tr><td rowspan="2">Detail parameter 1</td><td>Manual pulse generator input selection</td><td>• 0: A-phase/B-phase (4 multiplication) (default value)
• 1: A-phase/B-phase (2 multiplication)
• 2: A-phase/B-phase (1 multiplication)
• 3: PULSE/SIGN</td></tr>
<tr><td>Speed/position function selection</td><td>• 0: Speed/position switching control (INC mode) (default value)
• 2: Speed/position switching control (ABS mode)</td></tr>
<tr><td rowspan="22">Detail parameter 2</td><td>Acceleration time 1</td><td rowspan="6">1 to 8388608ms
(default value: 1000)</td></tr>
<tr><td>Acceleration time 2</td></tr>
<tr><td>Acceleration time 3</td></tr>
<tr><td>Deceleration time 1</td></tr>
<tr><td>Deceleration time 2</td></tr>
<tr><td>Deceleration time 3</td></tr>
<tr><td rowspan="2">JOG speed limit value</td><td>Setting values using engineering tools
(Default value: 20000)
• 0.01 to 20000000.00 (mm/min)
• 0.001 to 2000000.000 (inches/min)
• 0.001 to 3000000.000 (degrees/min)
• 1 to 5000000 (pulses/s)</td></tr>
<tr><td>Setting values using programs *1
(default value: 20000)
• 1 to 2000000000 (× 10^{-2}mm/min)
• 1 to 2000000000 (× 10^{-3}inches/min)
• 1 to 3000000000 (× 10^{-3}degrees/min)
• 1 to 5000000 (pulses/s)</td></tr>
<tr><td>JOG operation acceleration time selection</td><td>• 0: Acceleration time 0 (default value)
• 1: Acceleration time 1
• 2: Acceleration time 2
• 3: Acceleration time 3</td></tr>
<tr><td>JOG operation deceleration time selection</td><td>• 0: Deceleration time 0 (default value)
• 1: Deceleration time 1
• 2: Deceleration time 2
• 3: Deceleration time 3</td></tr>
<tr><td>Acceleration/deceleration process selection</td><td>• 0: Trapezoid acceleration/deceleration process (default value)
• 1: S-pattern acceleration/deceleration process</td></tr>
<tr><td>S-pattern ratio</td><td>1 to 100% (default value: 100)</td></tr>
<tr><td>Quick stop deceleration time</td><td>1 to 8388608ms (default value: 1000)</td></tr>
<tr><td>Stop group 1 quick stop selection</td><td rowspan="3">• 0: Ordinary deceleration stop (default value)
• 1: Quick stop</td></tr>
<tr><td>Stop group 2 quick stop selection</td></tr>
<tr><td>Stop group 3 quick stop selection</td></tr>
<tr><td>In-position signal outputting time</td><td>0 to 65535ms (default value: 300)</td></tr>
<tr><td rowspan="2">Circular interpolation error permissible range</td><td>Setting values using engineering tools
(Default value: 100)
• 0 to 10000.0 (μm)
• 0 to 1.00000 (inch)
• 0 to 1.00000 (degrees)
• 0 to 100000 (pulses)</td></tr>
<tr><td>Setting values using programs *1
(default value: 100)
• 0 to 100000 (× 10^{-1}μm)
• 0 to 100000 (× 10^{-5}inches)
• 0 to 100000 (× 10^{-5}degrees)
• 0 to 100000 (pulses)</td></tr>
<tr><td>External command function selection</td><td>• 0: External positioning start (default value)
• 1: External speed change request
• 2: Speed⇔position control switching request
• 3: Skip request</td></tr>
<tr><td>Start adjusting time</td><td>0.00 to 10000.00ms (default value: 0.00)</td></tr>
</table>

Item		Setting range
Homing basic parameter	Homing methods	• 0: Proximity dog method (default value) • 1: Stopper method 1 • 2: Stopper method 2 • 3: Stopper method 3 • 4: Count method 1 • 5: Count method 2 • 6: Data set method • 7: Limit switch combined method
	Homing direction	• 0: Positive direction (address increasing direction) (default value) • 1: Negative direction (address decreasing direction)
	Home position address	Setting values using engineering tools (Default value: 0) • -214748364.8 to 214748364.7 (μm) • -21474.83648 to 21474.83647 (inches) • 0 to 359.99999 (degrees) • -2147483648 to 2147483647 (pulses)
		Setting values using programs [*1] (default value: 0) • -2147483648 to 2147483647 (× 10^{-1}μm) • -2147483648 to 2147483647 (× 10^{-5}inches) • 0 to 35999999 (× 10^{-5}degrees) • -2147483648 to 2147483647 (pulses)
	Homing speed	Setting values using engineering tools (Default value: 1) • 0.01 to 20000000.00 (mm/min) • 0.001 to 2000000.000 (inches/min) • 0.001 to 3000000.000 (degrees/min) • 1 to 5000000 (pulses/s)
		Setting values using programs [*1] (default value: 1) • 1 to 2000000000 (× 10^{-2}mm/min) • 1 to 2000000000 (× 10^{-3}inches/min) • 1 to 3000000000 (× 10^{-3}degrees/min) • 1 to 5000000 (pulses/s)
	Creep speed	Setting values using engineering tools (default value: 1) • 0.01 to 20000000.00 (mm/min) • 0.001 to 2000000.000 (inches/min) • 0.001 to 3000000.000 (degrees/min) • 1 to 5000000 (pulses/s)
		Setting values using programs [*1] (default value: 1) • 1 to 2000000000 (× 10^{-2}mm/min) • 1 to 2000000000 (× 10^{-3}inches/min) • 1 to 3000000000 (× 10^{-3}degrees/min) • 1 to 5000000 (pulses/s)
	Homing retry	• 0: Homing retry using the limit switch is not performed (default value) • 1: Homing retry using the limit switch is performed

Item		Setting range
Homing detail parameter	Homing dwell time	0 to 65535ms (default value: 0)
	Travel distance settings after proximity dog ON	Setting values using engineering tools (Default value: 0) • 0 to 214748364.7 (μm) • 0 to 21474.83647 (inches) • 0 to 21474.83647 (degrees) • 0 to 2147483647 (pulses)
		Setting values using programs *1 (default value: 0) • 0 to 2147483647 (× 10^{-1}μm) • 0 to 2147483647 (× 10^{-5}inches) • 0 to 2147483647 (× 10^{-5}degrees) • 0 to 2147483647 (pulses)
	Homing acceleration time selection	• 0: Acceleration time 0 (default value) • 1: Acceleration time 1 • 2: Acceleration time 2 • 3: Acceleration time 3
	Homing deceleration time selection	• 0: Deceleration time 0 (default value) • 1: Deceleration time 1 • 2: Deceleration time 2 • 3: Deceleration time 3
	Home position shift distance	Setting values using engineering tools (Default value: 0) • -214748364.8 to 214748364.7 (μm) • -21474.83648 to 21474.83647 (inches) • -21474.83648 to 21474.83647 (degrees) • -2147483648 to 2147483647 (pulses)
		Setting values using programs *1 (default value: 0) • -2147483648 to 2147483647 (× 10^{-1}μm) • -2147483648 to 2147483647 (× 10^{-5}inches) • -21474.83648 to 21474.83647 (× 10^{-5}degrees) • -2147483648 to 2147483647 (pulses)
	Homing torque limit value	1 to 3000 (default value: 300)
	Deviation counter clear signal outputting time	1 to 65535ms (default value: 11)
	Speed specification at home position shift	• 0: Homing speed (default value) • 1: Creep speed
	Dwell time at homing retry	0 to 65535ms (default value: 0)
	Operation settings at homing incomplete	• 0: Positioning control is not performed (default value) • 1: Positioning control is performed
Basic parameter 3 *2	Operation mode	• Q-compatible mode (default value) • High-speed start mode
	Extension parameter storage settings	• CPU (default value) • Positioning module

*1. When the settings are performed using programs, calculations are performed in the RD75 to convert the values into each unit. Take the value after unit conversion into account to perform settings.
*2. Basic parameter 3 can be set only by engineering tools.

5.3.2 Positioning data

(1) Operation pattern

Operation patterns specify whether a positioning corresponding to a data No. is to finish only with the data No. or to continue on the following data No.

Operation pattern	Setting value	Description
Positioning complete	00	Performs positioning to the specified address, then finishes positioning.
Consecutive positioning control	01	Performs positioning consecutively in order of the data No. by one start signal. The motor stops once at each positioning data.
Consecutive tracking control	11	Performs positioning consecutively in order of the data No. by one start signal. The motor does not stop at each positioning data.

(2) Control method

Set "control method" for when positioning control is performed. The control methods that can be set are as follows.

Control method	Setting value
ABS1: Straight-line control of one axis (ABS)	01H
INC1: Straight-line control of one axis (INC)	02H
FEED1: Fixed length feed control of one axis	03H
VF1: Speed control of one axis (forward rotation)	04H
VR1: Speed control of one axis (reverse rotation)	05H
VPF: Speed/position switching control (forward rotation)	06H
VPR: Speed/position switching control (reverse rotation)	07H
PVF: Position/speed switching control (forward rotation)	08H
PVR: Position/speed switching control (reverse rotation)	09H
ABS2: Linear interpolation control of two axes (ABS)	0AH
INC2: Linear interpolation control of two axes (INC)	0BH
FEED2: Fixed length feed control by linear interpolation of two axes	0CH
ABS ⌒: Circular interpolation control with specified auxiliary points (ABS)	0DH
INC ⌒: Circular interpolation control with specified auxiliary points (INC)	0EH
ABS . : Circular interpolation control with a specified center point (ABS, CW)	0FH
ABS . : Circular interpolation control with a specified center point (ABS, CCW)	10H
INC . : Circular interpolation control with a specified center point (INC, CW)	11H
INC . : Circular interpolation control with a specified center point (INC, CCW)	12H
VF2: Speed control of two axes (forward rotation)	13H
VR2: Speed control of two axes (reverse rotation)	14H
ABS3: Linear interpolation control of three axes (ABS)	15H
INC3: Linear interpolation control of three axes (INC)	16H
FEED3: Fixed length feed control by linear interpolation of three axes	17H
VF3: Speed control of three axes (forward rotation)	18H
VR3: Speed control of three axes (reverse rotation)	19H
ABS4: Linear interpolation control of four axes (ABS)	1AH
INC4: Linear interpolation control of four axes (INC)	1BH
FEED4: Fixed length feed control by linear interpolation of four axes	1CH
VF4: Speed control of four axes (forward rotation)	1DH
VR4: Speed control of four axes (reverse rotation)	1EH
ABSH ⌒: Helical interpolation control with specified auxiliary points (ABS)	20H

Control method	Setting value
INCH ⌒: Helical interpolation control with specified auxiliary points (INC)	21H
ABSH . : Helical interpolation control with a specified center point (ABS, CW)	22H
ABSH . : Helical interpolation control with a specified center point (ABS, CCW)	23H
INCH . : Helical interpolation control with a specified center point (INC, CW)	24H
INCH . : Helical interpolation control with a specified center point (INC, CCW)	25H
NOP: NOP command	80H
POS: Current value change	81H
JUMP: JUMP command	82H
LOOP: Beginning of LOOP to LEND	83H
LEND: End of LOOP to LEND	84H

Restrictions

- When the control method is set to "JUMP command", the setting contents of "[Da.9] Dwell time" and "[Da.10] M code" are different from the other control methods.
- When the control method is set to "LOOP", the setting contents of "[Da.10] M code" are different from the other control methods.
- When "[Pr.1] Unit setting" is set to "degree", circular interpolation control and helical interpolation control with three axes cannot be performed. If attempted, circular interpolation failed (error code: 199FH) occurs.

(3) Acceleration time No.

Set any of "Acceleration time 0 to 3" as the acceleration time at positioning.

Acceleration time No.	Setting value	Description
Acceleration time 0	00	Uses the value set in "[Pr.9] Acceleration time 0".
Acceleration time 1	01	Uses the value set in "[Pr.25] Acceleration time 1".
Acceleration time 2	10	Uses the value set in "[Pr.26] Acceleration time 2".
Acceleration time 3	11	Uses the value set in "[Pr.27] Acceleration time 3".

(4) Deceleration time No.

Set any of "Deceleration time 0 to 3" as the deceleration time at positioning.

Deceleration time No.	Setting value	Description
Deceleration time 0	00	Uses the value set in "[Pr.10] Deceleration time 0".
Deceleration time 1	01	Uses the value set in "[Pr.28] Deceleration time 1".
Deceleration time 2	10	Uses the value set in "[Pr.29] Deceleration time 2".
Deceleration time 3	11	Uses the value set in "[Pr.30] Deceleration time 3".

(5) Interpolation object axis

Set an "Interpolation object axis" (partner axis) to perform interpolation operation with two axes.

Interpolation object axis	Setting value	Description
Axis 1 specification	00	Specifies Axis 1 as the interpolation object axis (partner axis).
Axis 2 specification	01	Specifies Axis 2 as the interpolation object axis (partner axis).
Axis 3 specification	10	Specifies Axis 3 as the interpolation object axis (partner axis).
Axis 4 specification	11	Specifies Axis 4 as the interpolation object axis (partner axis).

(6) Positioning address/travel distance

Set the address to be the target value of the positioning control. The setting range differs depending on "[Da.2] Control method".

(a) When "[Pr.1] Unit setting" is set to "mm"

Setting of "[Da.2] Control method" *1	Setting values using engineering tools	Setting values using programs
ABS linear 1: 01H ABS linear 2: 0AH ABS linear 3: 15H ABS linear 4: 1AH Current value change: 81H	Sets the address. -214748364.8 to 214748364.7 (μm)	Sets the address. -2147483648 to 2147483647 (× 10^{-1}μm)
INC linear 1: 02H INC linear 2: 0BH INC linear 3: 16H INC linear 4: 1BH Fixed length feed 1: 03H Fixed length feed 2: 0CH Fixed length feed 3: 17H Fixed length feed 4: 1CH	Sets the travel distance. -214748364.8 to 214748364.7 (μm)	Sets the travel distance. -2147483648 to 2147483647 (× 10^{-1}μm)
Forward rotation speed/position: 06H Reverse rotation speed/position: 07H Forward rotation position/speed: 08H Reverse rotation position/speed: 09H	Sets the travel distance. 0 to 214748364.7 (μm)	Sets the travel distance. 0 to 2147483647 (× 10^{-1}μm)
ABS circular interpolation control: 0DH ABS circular interpolation control clockwise: 0FH ABS circular interpolation control counterclockwise: 10H	Sets the address. -214748364.8 to 214748364.7 (μm)	Sets the address. -2147483648 to 2147483647 (× 10^{-1}μm)
INC circular interpolation control: 0EH INC circular interpolation control clockwise: 11H INC circular interpolation control counterclockwise: 12H	Sets the travel distance. -214748364.8 to 214748364.7 (μm)	Sets the travel distance. -2147483648 to 2147483647 (× 10^{-1}μm)
ABS helical interpolation control: 20H ABS helical interpolation control clockwise: 22H ABS helical interpolation control counterclockwise: 23H	Sets the address. -214748364.8 to 214748364.7 (μm)	Sets the address. -2147483648 to 2147483647 (× 10^{-1}μm)
INC helical interpolation control: 21H INC helical interpolation control clockwise: 24H INC helical interpolation control counterclockwise: 25H	Sets the travel distance. -214748364.8 to 214748364.7 (μm)	Sets the travel distance. -2147483648 to 2147483647 (× 10^{-1}μm)

*1. The settings of positioning address/travel distance are not required for the control methods that are not mentioned here.

(b) When "[Pr.1] Unit setting" is set to "degree"

Setting of "[Da.2] Control method" *2	Setting values using engineering tools	Setting values using programs
ABS linear 1: 01H ABS linear 2: 0AH ABS linear 3: 15H ABS linear 4: 1AH Current value change: 81H	Sets the address. 0 to 359.99999 (degrees)	Sets the address. 0 to 35999999 (× 10^{-5}degrees)
INC linear 1: 02H INC linear 2: 0BH INC linear 3: 16H INC linear 4: 1BH Fixed length feed 1: 03H Fixed length feed 2: 0CH Fixed length feed 3: 17H Fixed length feed 4: 1CH	Sets the travel distance. -21474.83648 to 21474.83647 (degrees)	Sets the travel distance. -2147483648 to 2147483647 (× 10^{-5}degrees)
Forward rotation speed/position: 06H Reverse rotation speed/position: 07H	Sets the travel distance in the INC mode. 0 to 21474.83647 (degrees)	Sets the travel distance in the INC mode. 0 to 2147483647 (× 10^{-5}degrees)
	Sets the address in the ABS mode. 0 to 359.99999 (degrees)	Sets the address in the ABS mode. 0 to 35999999 (× 10^{-5}degrees)
Forward rotation position/speed: 08H Reverse rotation position/speed: 09H	Sets the travel distance. 0 to 21474.83647 (degrees)	Sets the travel distance. 0 to 2147483647 (× 10^{-5}degrees)
ABS helical interpolation control: 20H *3 ABS helical interpolation control clockwise: 22H *3 ABS helical interpolation control counterclockwise: 23H *3	Sets the address. 0 to 359.99999 (degrees)	Sets the address. 0 to 35999999 (× 10^{-5}degrees)
INC helical interpolation control: 21H *3 INC helical interpolation control clockwise: 24H *3 INC helical interpolation control counterclockwise: 25H *3	Sets the travel distance. -21474.83648 to 21474.83647 (degrees)	Sets the travel distance. -2147483648 to 2147483647 (× 10^{-5}degrees)

*2. The settings of positioning address/travel distance are not required for the control methods that are not mentioned here.
*3. In helical interpolation control with three axes, "degree" can be set only on linear interpolation axes.

(c) When "[Pr.1] Unit setting" is set to "pulse"

Setting of "[Da.2] Control method" *4	Setting values using engineering tools	Setting values using programs
ABS linear 1: 01H ABS linear 2: 0AH ABS linear 3: 15H ABS linear 4: 1AH Current value change: 81H	Sets the address. -2147483648 to 2147483647 (pulses)	Sets the address. -2147483648 to 2147483647 (pulses)
INC linear 1: 02H INC linear 2: 0BH INC linear 3: 16H INC linear 4: 1BH Fixed length feed 1: 03H Fixed length feed 2: 0CH Fixed length feed 3: 17H Fixed length feed 4: 1CH	Sets the travel distance. -2147483648 to 2147483647 (pulses)	Sets the travel distance. -2147483648 to 2147483647 (pulses)
Forward rotation speed/position: 06H Reverse rotation speed/position: 07H Forward rotation position/speed: 08H Reverse rotation position/speed: 09H	Sets the travel distance. 0 to 2147483647 (pulses)	Sets the travel distance. 0 to 2147483647 (pulses)
ABS circular interpolation control: 0DH ABS circular interpolation control clockwise: 0FH ABS circular interpolation control counterclockwise: 10H	Sets the address. -2147483648 to 2147483647 (pulses)	Sets the address. -2147483648 to 2147483647 (pulses)

Setting of "[Da.2] Control method" *4	Setting values using engineering tools	Setting values using programs
INC circular interpolation control: 0EH INC circular interpolation control clockwise: 11H INC circular interpolation control counterclockwise: 12H	Sets the travel distance. -2147483648 to 2147483647 (pulses)	Sets the travel distance. -2147483648 to 2147483647 (pulses)
ABS helical interpolation control: 20H ABS helical interpolation control clockwise: 22H ABS helical interpolation control counterclockwise: 23H	Sets the address. -2147483648 to 2147483647 (pulses)	Sets the address. -2147483648 to 2147483647 (pulses)
INC helical interpolation control: 21H INC helical interpolation control clockwise: 24H INC helical interpolation control counterclockwise: 25H	Sets the travel distance. -2147483648 to 2147483647 (pulses)	Sets the travel distance. -2147483648 to 2147483647 (pulses)

*4. The settings of positioning address/travel distance are not required for the control methods that are not mentioned here.

(d) When "[Pr.1] Unit setting" is set to "inch"

Setting of "[Da.2] Control method" *5	Setting values using engineering tools	Setting values using programs
ABS linear 1: 01H ABS linear 2: 0AH ABS linear 3: 15H ABS linear 4: 1AH Current value change: 81H	Sets the address. -21474.83648 to 21474.83647 (inches)	Sets the address. -2147483648 to 2147483647 ($\times 10^{-5}$inches)
INC linear 1: 02H INC linear 2: 0BH INC linear 3: 16H INC linear 4: 1BH Fixed length feed 1: 03H Fixed length feed 2: 0CH Fixed length feed 3: 17H Fixed length feed 4: 1CH	Sets the travel distance. -21474.83648 to 21474.83647 (inches)	Sets the travel distance. -2147483648 to 2147483647 ($\times 10^{-5}$inches)
Forward rotation speed/position: 06H Reverse rotation speed/position: 07H Forward rotation position/speed: 08H Reverse rotation position/speed: 09H	Sets the travel distance. 0 to 21474.83647 (inches)	Sets the travel distance. 0 to 2147483647 ($\times 10^{-5}$inches)
ABS circular interpolation control: 0DH ABS circular interpolation control clockwise: 0FH ABS circular interpolation control counterclockwise: 10H	Sets the address. -21474.83648 to 21474.83647 (inches)	Sets the address. -2147483648 to 2147483647 ($\times 10^{-5}$inches)
INC circular interpolation control: 0EH INC circular interpolation control clockwise: 11H INC circular interpolation control counterclockwise: 12H	Sets the travel distance. -21474.83648 to 21474.83647 (inches)	Sets the travel distance. -2147483648 to 2147483647 ($\times 10^{-5}$inches)
ABS helical interpolation control: 20H ABS helical interpolation control clockwise: 22H ABS helical interpolation control counterclockwise: 23H	Sets the address. -21474.83648 to 21474.83647 (inches)	Sets the address. -2147483648 to 2147483647 ($\times 10^{-5}$inches)
INC helical interpolation control: 20H INC helical interpolation control clockwise: 22H INC helical interpolation control counterclockwise: 23H	Sets the travel distance. -21474.83648 to 21474.83647 (inches)	Sets the travel distance. -2147483648 to 2147483647 ($\times 10^{-5}$inches)

*5. The settings of positioning address/travel distance are not required for the control methods that are not mentioned here.

(7) Circular address

The circular address is data required only when circular interpolation control or helical interpolation control with three axes is performed.

- For circular interpolation with specified auxiliary points, set the addresses of the auxiliary points (points to be passed) as the circular address.
- For circular interpolation with a specified center point, set the address of the center point as the circular address.

The setting range differs depending on the settings of "[Pr.1] Unit setting" and "[Da.2] Control method".

(a) When "[Pr.1] Unit setting" is set to "mm"

Setting of "[Da.2] Control method"	Setting values using engineering tools	Setting values using programs
ABS circular interpolation control: 0DH ABS circular interpolation control clockwise: 0FH ABS circular interpolation control counterclockwise: 10H	Sets the address. -214748364.8 to 214748364.7 (μm)	Sets the address. -2147483648 to 2147483647 ($\times 10^{-1}$μm)
INC circular interpolation control: 0EH INC circular interpolation control clockwise: 11H INC circular interpolation control counterclockwise: 12H	Sets the travel distance. -214748364.8 to 214748364.7 (μm) *1	Sets the travel distance. -2147483648 to 2147483647 ($\times 10^{-1}$μm) *1
ABS helical interpolation control: 20H ABS helical interpolation control clockwise: 22H ABS helical interpolation control counterclockwise: 23H	Sets the address. -214748364.8 to 214748364.7 (μm)	Sets the address. -2147483648 to 2147483647 ($\times 10^{-1}$μm)
INC helical interpolation control: 21H INC helical interpolation control clockwise: 24H INC helical interpolation control counterclockwise: 25H	Sets the travel distance. -214748364.8 to 214748364.7 (μm) *1	Sets the travel distance. -2147483648 to 2147483647 ($\times 10^{-1}$μm) *1

*1. Although the values can be input within the ranges shown here as the circular addresses, note that the maximum radius for circular interpolation control is 536870912.

(b) When "[Pr.1] Unit setting" is set to "degree"

Circular addresses are not available for any control method when the unit setting is set to "degree".

(c) When "[Pr.1] Unit setting" is set to "pulse"

Setting of "[Da.2] Control method"	Setting values using engineering tools	Setting values using programs
ABS circular interpolation control: 0DH ABS circular interpolation control clockwise: 0FH ABS circular interpolation control counterclockwise: 10H	Sets the address. -2147483648 to 2147483647 (pulses)	Sets the address. -2147483648 to 2147483647 (pulses)
INC circular interpolation control: 0EH INC circular interpolation control clockwise: 11H INC circular interpolation control counterclockwise: 12H	Sets the travel distance. -2147483648 to 2147483647 (pulses) *2	Sets the travel distance. -2147483648 to 2147483647 (pulses) *2
ABS helical interpolation control: 20H ABS helical interpolation control clockwise: 22H ABS helical interpolation control counterclockwise: 23H	Sets the address. -2147483648 to 2147483647 (pulses)	Sets the address. -2147483648 to 2147483647 (pulses)
INC helical interpolation control: 21H INC helical interpolation control clockwise: 24H INC helical interpolation control counterclockwise: 25H	Sets the travel distance. -2147483648 to 2147483647 (pulses) *2	Sets the travel distance. -2147483648 to 2147483647 (pulses) *2

*2. Although the values can be input within the ranges shown here as the circular addresses, note that the maximum radius for circular interpolation control is 536870912.

(d) When "[Pr.1] Unit setting" is set to "inch"

Setting of "[Da.2] Control method"	Setting values using engineering tools	Setting values using programs
ABS circular interpolation control: 0DH ABS circular interpolation control clockwise: 0FH ABS circular interpolation control counterclockwise: 10H	Sets the address. -21474.83648 to 21474.83647 (inches)	Sets the address. -2147483648 to 2147483647 (× 10^{-5}inches)
INC circular interpolation control: 0EH INC circular interpolation control clockwise: 11H INC circular interpolation control counterclockwise: 12H	Sets the travel distance. -21474.83648 to 21474.83647 (inches) *3	Sets the travel distance. -2147483648 to 2147483647 (× 10^{-5}inches) *3
ABS helical interpolation control: 20H ABS helical interpolation control clockwise: 22H ABS helical interpolation control counterclockwise: 23H	Sets the address. -21474.83648 to 21474.83647 (inches)	Sets the address. -2147483648 to 2147483647 (× 10^{-5}inches)
INC helical interpolation control: 21H INC helical interpolation control clockwise: 24H INC helical interpolation control counterclockwise: 25H	Sets the travel distance. -21474.83648 to 21474.83647 (inches) *3	Sets the travel distance. -2147483648 to 2147483647 (× 10^{-5}inches) *3

*3. Although the values can be input within the ranges shown here as the circular addresses, note that the maximum radius for circular interpolation control is 536870912.

(8) Command speed

Set the command speed at positioning.

- When the command speed exceeds "[Pr.8] Speed limit value", perform positioning with the speed limit value.
- When the command speed is set to "-1", perform positioning control using the current speed (the setting speed of the previous positioning data No.).

The current speed is used on occasions such as when consecutive tracking control is performed. By setting the succeeding positioning data to "-1" then changing the speed, the change also applies to the speed of the following consecutive data. Note that if the positioning data for the first positioning control is set to "-1" at a positioning start, "no command speed" (error code: 1A12H) occurs and the positioning does not start.

The setting range differs depending on the setting of "[Pr.1] Unit setting".

Setting of "[Pr.1] Unit setting"	Setting values using engineering tools	Setting values using programs *1
0: mm	0.01 to 20000000.00 (mm/min)	1 to 2000000000 (× 10^{-2}mm/min)
1: inch	0.001 to 2000000.000 (inches/min)	1 to 2000000000 (× 10^{-3}inches/min)
2: degree	0.001 to 3000000.000 (degrees/min)	1 to 3000000000 (× 10^{-3}degrees/min)
3: pulse	1 to 5000000 (pulses/s)	1 to 5000000 (pulses/s)

*1. When the settings are performed using programs, calculations are performed in the RD75 to convert the values into each unit. Take the value after unit conversion into account to perform settings.

(9) Dwell time

Set "Dwell time" or "Positioning data No." in accordance with "[Da.2] Control method".

- When "[Da.2] Control method" is set to other than "JUMP command", set "Dwell time" in the unit of ms.
- When "[Da.2] Control method" is set to "JUMP command", set "Positioning data No." of the JUMP destination excepting the current position.

Dwell time is the time from when a command pulse output is complete until when the in-position signal turns on. It is set to absorb the delay of the mechanical system to commands, such as the delay of the servo system (deviation).

Setting of "[Da.2] Control method"	Setting value	Setting details
JUMP command: 82H	1 to 600	Positioning data No.
Other than JUMP command	0 to 65535 (ms)	Dwell time

(10) M code

Set "M code", "number of pitches", "condition data No.", or "number of LOOP to LEND repeats" in accordance with "[Da.2] Control method".

- When "[Da.2] Control method" is set to other than "JUMP command" or "LOOP", set "M code". If not outputting "M code", set "0" (default value).
- When "[Da.2] Control method" is set to "Helical interpolation control with three axes", set the number of pitches for the linear interpolation axis. Set the number of revolutions used in the circular interpolation as the number of pitches.
- When "[Da.2] Control method" is set to other than "JUMP command", set "condition data No." for JUMP. If 0 is set, JUMP is performed to the positioning data set in "[Da.9] Dwell time" under any conditions. If any of 1 to 10 is set, JUMP is performed in accordance with the corresponding condition data No.1 to 10.
- When "[Da.2] Control method" is set to "LOOP", set the "number of repeats" of LOOP to LEND. If 0 is set, "Control method LOOP setting error" (error code: 1A33H) occurs.

The setting range differs depending on the setting of "[Da.2] Control method".

Setting of "[Da.2] Control method"	Setting value	Setting details
JUMP command: 82H	0 to 10	Condition data No.
LOOP: 83H	1 to 65535	Number of repeats
Helical interpolation: 20H to 25H	0 to 999	Number of pitches
Settings not listed above	0 to 65535	M code

Positioning data setting examples

Data No.	Operation pattern	Control method *1	Interpolation object axis	Acceleration time No.	Deceleration time No.	Positioning address	Circular address	Command speed	Dwell time	M-code
1	0: Positioning complete	01H: ABS1 Straight-line control of one axis (ABS)	-	0: Acceleration time 0	0: Deceleration time 0	50000.0 [µm]	-	2000.00 [mm/min]	-	-
2	0: Positioning complete	01H: ABS1 Straight-line control of one axis (ABS)	-	0: Acceleration time 0	0: Deceleration time 0	75000.0 [µm]	-	2000.00 [mm/min]	-	-
3	0: Positioning complete	01H: ABS1 Straight-line control of one axis (ABS)	-	0: Acceleration time 0	0: Deceleration time 0	100000.0 [µm]	-	2000.00 [mm/min]	-	-
4	0: Positioning complete	01H: ABS1 Straight-line control of one axis (ABS)	-	0: Acceleration time 0	0: Deceleration time 0	150000.0 [µm]	-	2000.00 [mm/min]	-	-
5	0: Positioning complete	01H: ABS1 Straight-line control of one axis (ABS)	-	0: Acceleration time 0	0: Deceleration time 0	200000.0 [µm]	-	2000.00 [mm/min]	-	-
6	0: Positioning complete	01H: ABS1 Straight-line control of one axis (ABS)	-	0: Acceleration time 0	0: Deceleration time 0	25000.0 [µm]	-	2000.00 [mm/min]	-	-
7	0: Positioning complete	-	-	0: Acceleration time 0	0: Deceleration time 0	0.0 [µm]	-	0.00 [mm/min]	-	-
8	0: Positioning complete	-	-	0: Acceleration time 0	0: Deceleration time 0	0.0 [µm]	-	0.00 [mm/min]	-	-
9	0: Positioning complete	-	-	0: Acceleration time 0	0: Deceleration time 0	0.0 [µm]	-	0.00 [mm/min]	-	-
10	0: Positioning complete	-	-	0: Acceleration time 0	0: Deceleration time 0	0.0 [µm]	-	0.00 [mm/min]	-	-

5.4 Positioning Command Interface

In conventional methods, generally pulse trains have been used as positioning commands that output from a positioning command module to a servo amplifier. However, as each unit becomes software-controlled and digitized with microprocessors (CPUs) recently, methods that connect the bus lines of the CPUs of the positioning command module and servo amplifier have been introduced as an ultimate figure. Thus, more accurate and advanced systems can be configured.

As there are various types of interface for the pulse train method itself, the supported models and their features are introduced in the following table.

Servo amplifier series	Resolution	Interface								
		General-purpose interface (Pulse train input) *1	Positioning command module	Bus connection interface (SSCNET) *2		Positioning command module	Network communication method		Positioning command module	Contact method Stand-alone type (With built-in point table/ program)
MR-J2 (Ended production in December 2005)	8192 pls/rev (13bits)	A	RD75D/P□ QD75D/P□(N) QD70P/D□ LD75D/P□ FX5-20PG-P FX3U-1PG FX2N-10PG FX2N-1PG FX2N-20/10GM, etc.	B	SSCNET (5.6Mbps *4) Metal cable	Q173/172 (N)(-T) QD75M□, etc.	-	-	-	C
MR-J2S (Ended production in August 2015)	16384 pls/rev (14bits)	A		B	SSCNET (5.6Mbps *4) Metal cable		-	-	-	CP/CL
MR-J3 (Ended production in May 2019)	262144 pls/rev (18bits)	A		B	SSCNET III (50Mbps *4) Optical cable	Q173/172D Q170M Q173/172H (-T) QD75MH□ QD74MH□ LD77MH□ FX3U-20SSC-H, etc.*3	-	-	-	T(CC-Link)
MR-J4	4194304 pls/rev (22bits)	A		B	SSCNET III/H (150Mbps *4) Optical cable	RnMT Q173172DS Q170MS (-S1) RD77MS□ QD77MS□ LD77MS□ FX5-80/40SSC-S	GF	CC-Link IE Field CC-Link IE Field Basic *4	RD77GF□ QD77GF□	A-RJ *4 GF (CC-Link IE Field) *4
MR-J5	67108864 pls/rev (26bits)	A		-	-	-	GF	CC-Link IE TSN *5	RD78G□	A-RJ

(As of May 2020)

*1. <Open-collector type: 200Kpps>, <differential driver type: 4Mpps>
*2. When configuring an absolute position detection system, a servo motor with an ABS encoder and installation of battery are required.
*3. Models supporting SSCNET III/H also support SSCNET III.
*4. Refer to Instruction Manuals for supported software versions of servo amplifiers and MR Configurator2.
*5. When configuring an absolute position detection system using a servo motor with a batteryless encoder, battery does not need to be installed.

[Pulse train input interface types]

(a) Forward/reverse rotation pulse train method and pulse train/direction discrimination signal method

As the methods using pulse trains to specify the motor rotation direction, the pulse trains are input from separate terminals in accordance with the rotation direction or the rotation direction is switched by the rotation direction discrimination signal.

In addition, when the pulse trains are directly input from the synchronous encoder, the two-phase pulse train method is used.

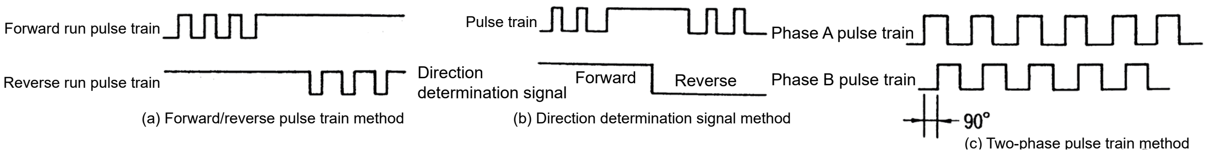


Figure 5.4 Rotation direction command method

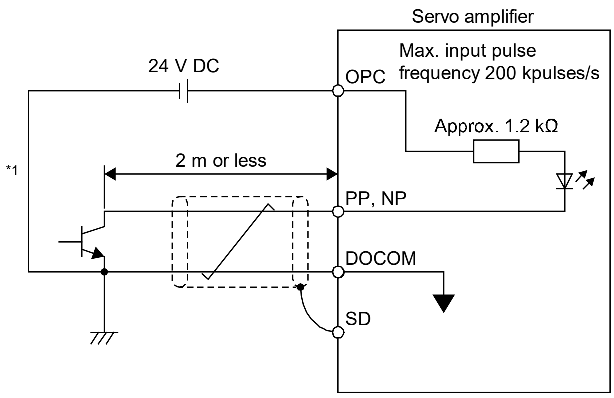
(b) Open-collector output type and differential driver output type

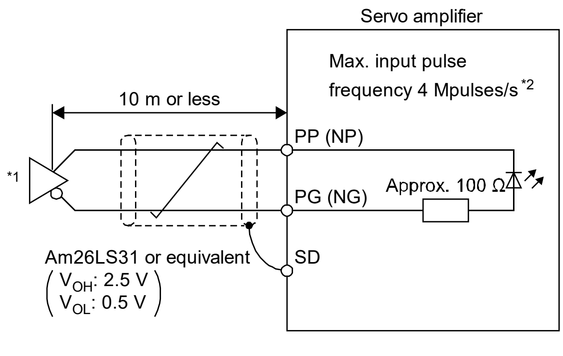
There are two types of interface hardware available. Although open-collector output type went mainstream for its ease of use, the differential driver output type interfaces have been more common recently as their speed and noise tolerance of pulse trains have been improved.

The RD75D is differential driver output type and the RD75P is open-collector output type.

[Hardware configuration example]

(a) Open-collector output type (maximum 200kpps) (b) Differential driver output type (maximum 5Mpps)





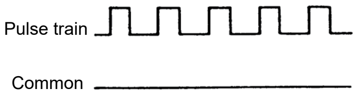
* A maximum output pulse frequency of 4Mpps satisfies the operation conditions of both the RD75D and MR-J5-A.

Figure 5.5 Pulse train example for each hardware type

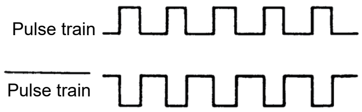
*1. A photocoupler is used as the pulse train input interface. Therefore, this circuit does not operate properly due to reduction in current if a resistor is connected to the pulse train signal line.

*2. Set [Pr.PA13.2] to "0" to use the input pulse frequency of 4Mpulses/s.

[Pulse train form]



(a) Open-collector type



(b) Differential driver

Figure 5.6 Pulse train form

5.5 Basics of Positioning Control Using Positioning Command Module

5.5.1 Machine travel direction and servo motor rotation direction

The forward rotation of the servo motor is counterclockwise when viewed from the load-side.
The machine travel direction in the address increasing direction is generally defined as the forward direction.
The servo motor rotation direction needs to match with the machine travel direction. Change the rotation direction by such means as using parameters of the positioning command module as necessary. Rotation direction change by switching the phase sequence of the servo motor terminals cannot be performed as it causes an abnormal operation.
The rotation direction changing methods apply to on any model of positioning command modules.
In addition, the rotation directions are to be checked using functions such as the JOG operation mode.

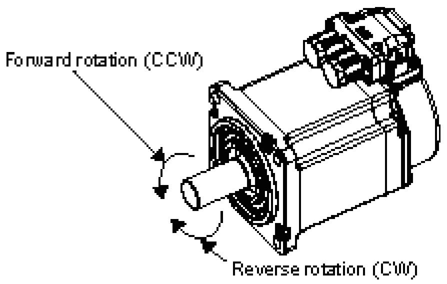


Figure 5.7 Servo motor rotation direction

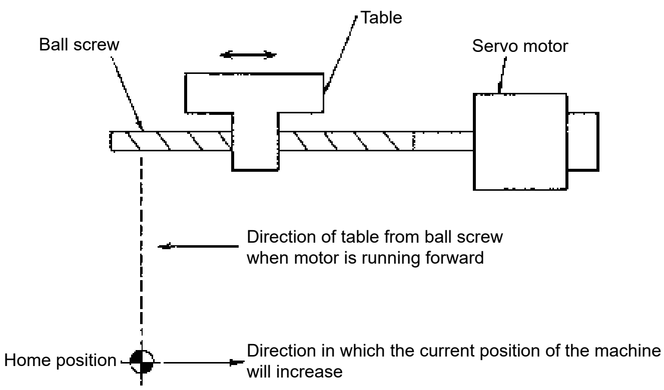


Figure 5.8 Rotation direction setting example

For the machine shown in Figure 5.3, the machine travels in the address decreasing direction (negative direction) as the servo motor rotates in the forward direction. Therefore, set the servo motor rotation direction as the negative direction on the position command module in this case.

Point
● Forward rotation CCW: Abbreviation for counterclockwise Reverse rotation CW: Abbreviation for clockwise

5.5.2 Types of homing

(1) Types of homing

"Homing control" performs positioning towards a position that is set as the reference for positioning control (= home position). It is used to return the mechanical system to the home position, such as when the RD75 requests "homing request" at power-on or after a positioning stop.

On the RD75, the two controls shown below are defined as "homing control" in accordance with the homing operation process. To execute these two homing controls, perform settings of "homing parameters", set "positioning start No.9001" and "positioning start No.9002" to "[Cd.3] Positioning start No." in the RD75, then turn on the positioning start signal.

Homing methods	Operation of homing methods
Machine homing (positioning start No.9001)	Performs homing operation to set the home position of the machine. This method sets up the home position at homing completion, then performs succeeding positioning control based on the home position. Machine homing is required when the machine home position has not been set (the current value monitor of the RD75 and the actual machine position do not match) in such conditions as a system power-on.
High-speed homing (positioning start No.9002)	Performs positioning towards the home position set by machine homing. As high-speed homing is performed by specifying "positioning start No.9002" and starting operation, positioning data settings are not required to perform positioning back to the home position.

Homing control can also be performed by setting the start number of the dedicated instruction GP.PSTRT□ to 9001 and 9002.

Refer to "MELSEC iQ-R Programming Manual (Module Dedicated Instructions)" for details of the dedicated instructions.

"Machine homing" needs to be performed in advance to execute "high-speed homing".

Restrictions

- If the following conditions are met, the RD75 needs to turn on "homing request flag" ([Md.31] Status: b3) and execute machine homing.
  - At power-on
  - At turning off of the drive unit ready signal ([Md.30] External I/O signal: b2)
  - At turning on of the programmable controller ready signal [YO]
- While "homing request flag" is on, the address information stored in the RD75 cannot be ensured. Executing and finishing machine homing properly turns off "homing request flag", then "homing completion flag" ([Md.31] Status: b4) turns on.

(2) Types of homing method

There are eight types of machine homing methods as follows:

[Pr.43] Homing methods	Operation
Proximity dog method	Starts deceleration by turning on the proximity dog. (The speed decelerates to "[Pr.47] Creep speed".) After the proximity dog turns off, the motor stops with the first zero-point signal *1, then machine homing finishes at the time when deviation counter clear output finishes. This position is set as the home position.
Stopper method 1	The stopper position is set as the home position. Starts deceleration by turning on the proximity dog, then stops the moving part by pressing it against the stopper at the speed of "[Pr.47] Creep speed". After stop, "[Pr.49] Homing dwell time" passes, then machine homing completes at the time when deviation counter clear output finishes.
Stopper method 2	The stopper position is set as the home position. Starts deceleration by turning on the proximity dog, then stops the moving part by pressing it against the stopper at the speed of "[Pr.47] Creep speed". After stop, the zero-point signal *1 is detected, then machine homing completes at the time when deviation counter clear output finishes.
Stopper method 3	The stopper position is set as the home position. Starts operation with "[Pr.47] Creep speed" from the beginning, then stops the moving part by pressing it against the stopper at the speed of "[Pr.47] Creep speed". After stop, the zero-point signal *1 is detected, then machine homing completes at the time when deviation counter clear output finishes.
Count method 1	The moving part travels the distance set in "[Pr.50] Travel distance setting after turning on proximity dog" from the position where the proximity dog turns on, then stops with the first zero-point signal *1. This position is set as the home position. Starts deceleration by turning on the proximity dog, then the moving part travels at the speed of "[Pr.47] Creep speed". The moving part travels the distance set in "[Pr.50] Travel distance setting after turning on proximity dog" from the position where the proximity dog turns on. Then the moving part stops with the first zero-point signal *1, and machine homing completes at the time when deviation counter clear output finishes.
Count method 2	The moving part travels the distance set in "[Pr.50] Travel distance setting after turning on proximity dog" from the position where the proximity dog turns on. This position is set as the home position. Starts deceleration by turning on the proximity dog, then the moving part travels at the speed of "[Pr.47] Creep speed". The moving part stops after it travels in the distance set in "[Pr.50] Travel distance setting after turning on proximity dog" from the position where the proximity dog turns on, then machine homing completes.
Data set method	The position where machine homing is performed is set as the home position. After deviation counter clear output finishes, the feed current value and feed machine value are rewritten to the home position address, then machine homing completes.
Limit switch combined method	After starting operation, the moving part travels toward the homing position followed by deceleration to a stop as the limit switch turns off, then travels in the opposite direction at the speed of "[Pr.47 Creep speed]". The motor stops with the first zero-point signal *1 from the position where the limit switch turns on, then machine homing completes at the time when deviation counter clear output finishes.

*1. The following signals are input as the zero-point signal of the RD75 for each homing method.
Proximity dog method, count method 1, and limit switch combined method:
Signals that output one pulse per motor revolution. (Such as the Z-phase signal output from the drive unit)
Stopper stop methods 2 and 3:
Signals that are output when the moving part comes into contact with the stopper. (Input from an external device)

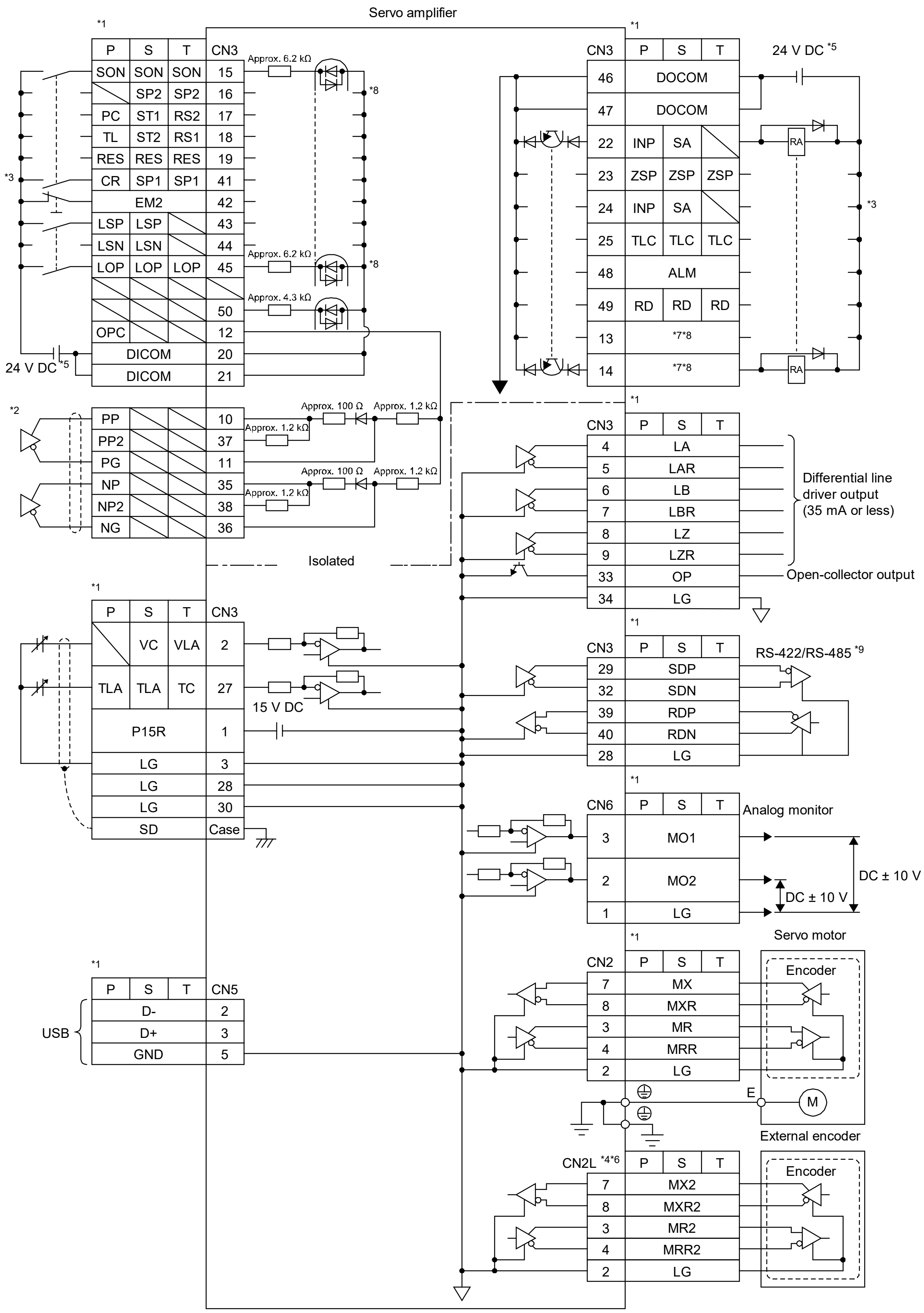
Memo

6 FUNCTIONS AND OPERATION OF MELSERVO (POSITION CONTROL)

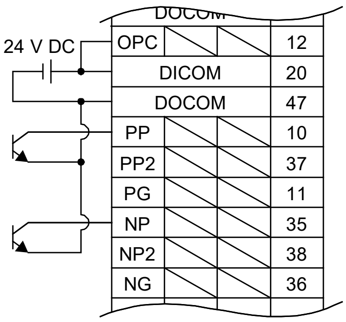
6.1 From Startup to Operation

6.1.1 Wiring and sequences

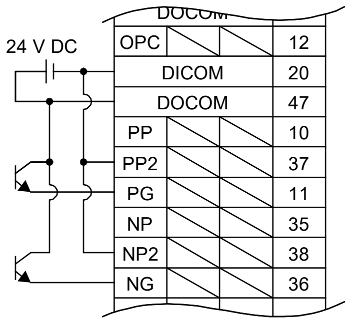
(1) Connection diagram inside the interface



*1. P: Position control mode, S: Speed control mode, T: Torque control mode
*2. This is for the differential line driver pulse train input. For the open-collector pulse train input, connect as follows.



For sink input interface

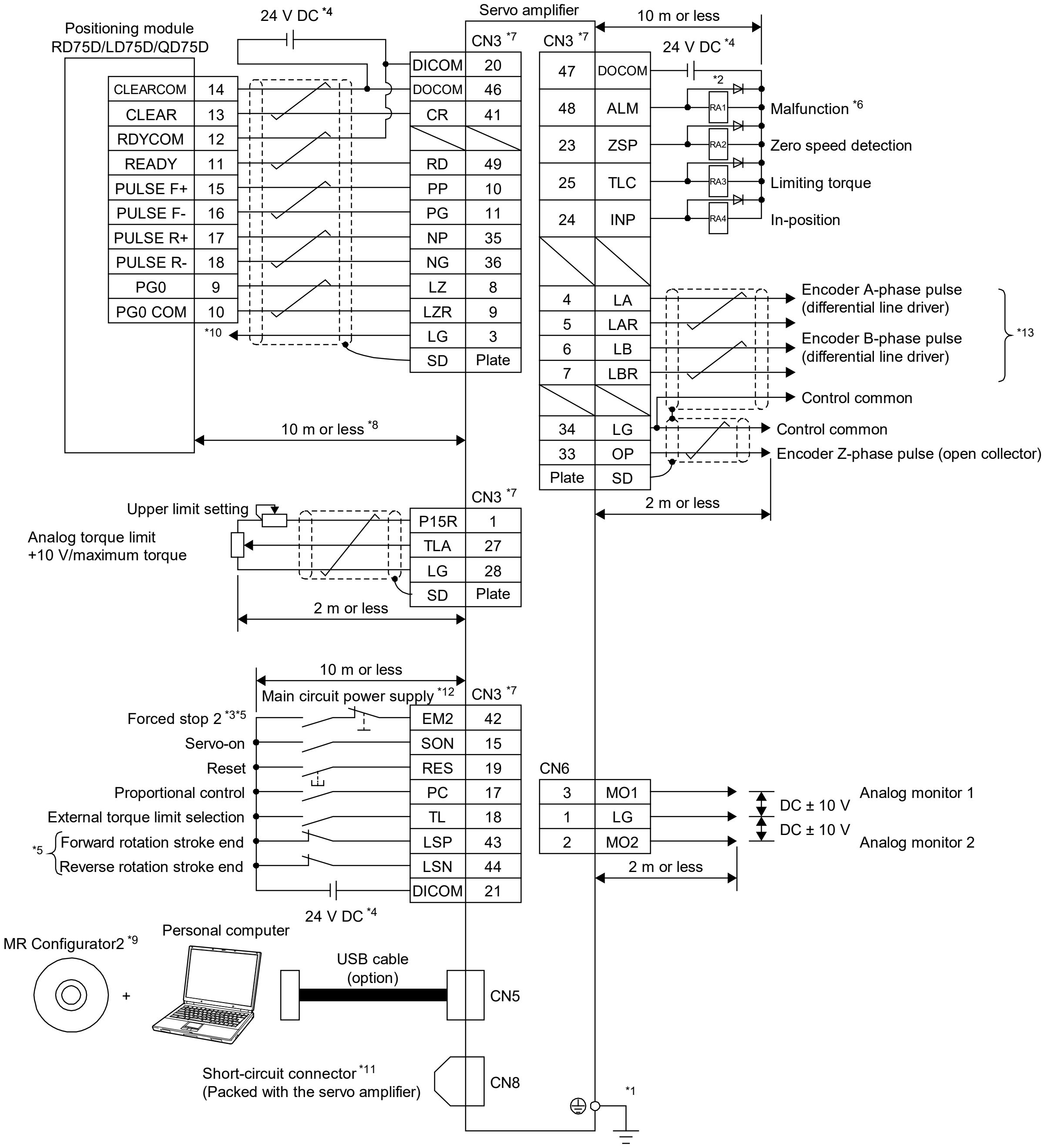


For source input interface

*3. This diagram shows a sink I/O interface. Refer to "Source I/O interface" in the MR-J5 User's Manual (Hardware) for source I/O interfaces.
*4. This is for the MR-J5-_A_-RJ_ servo amplifier. The MR-J5-_A_ servo amplifier does not have the CN2L connector.
*5. Although the diagram shows the input signal and the output signal each using a separate 24V DC power supply for illustrative purposes, the system can be configured to use a single 24V DC power supply.
*6. Refer to "Parts identification" in the MR-J5 User's Manual (Introduction) for connecting an external encoder.
*7. Output devices are not assigned by default. Assign the output devices with [Pr.PD47] as necessary.
*8. If the MR-J5-_A_-RJ_ is used, the values in the CN3-16 pin and the CN3-45 pin are approximately 4.3kΩ.
*9. RS-422 and RS-485 are not supported.

6.1.2 Standard connection diagram

(1) Sink I/O interface



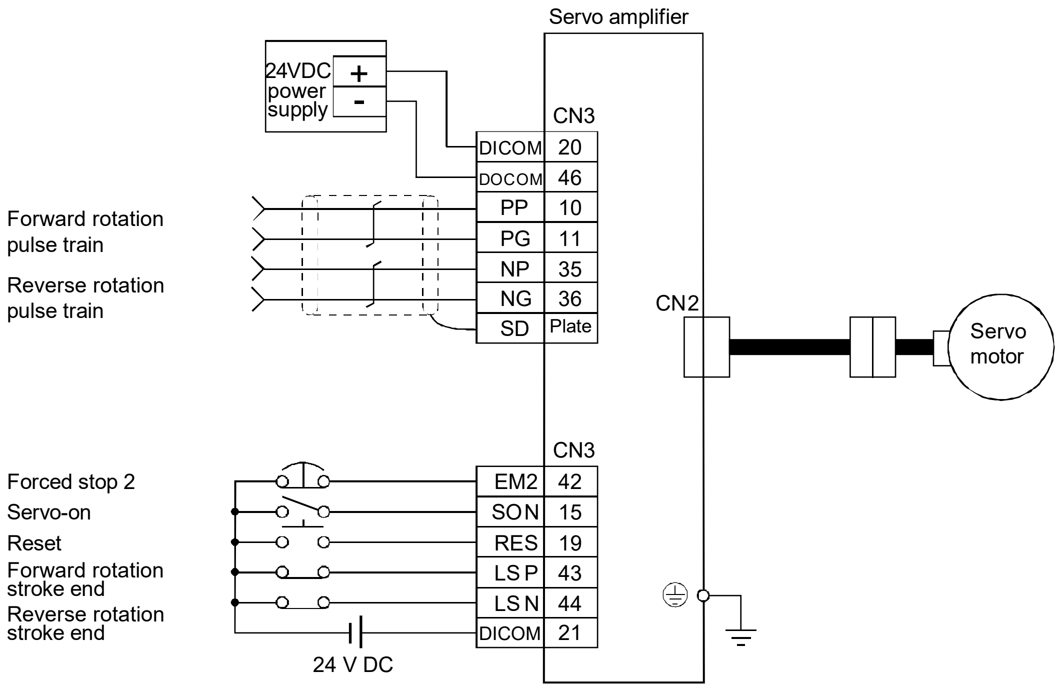
Connection I in position control

*1. To prevent an electric shock, connect the protective earth (PE) terminal (the terminal marked with the ⏚ symbol) of the servo amplifier to the protective earth (PE) of the cabinet.
*2. Connect the diode in the correct direction. If it is connected reversely, the servo amplifier may malfunction and not output signals, disabling protective circuits such as EM2 (Forced stop 2).
*3. Install a forced stop switch (normally closed contact).
*4. Supply 24V DC ± 10% to interfaces from an external source. The total current capacity of these power supplies is 500mA maximum. The amperage will not exceed 500mA when all the I/O signals are used. Reducing the number of I/O points decreases the current capacity. Refer to "Digital input interface DI-1" in the MR-J5 User's Manual (Hardware) for the current required for the interfaces.
Although the diagram shows the input signal and the output signal each using a separate 24V DC power supply for illustrative purposes, the system can be configured to use a single 24V DC power supply.
*5. When starting operation, turn on EM2 (Forced stop 2), LSP (Forward rotation stroke end), and LSN (Reverse rotation stroke end) (normally closed contact).
*6. If no alarm is occurring, ALM (Malfunction) is on (normally closed contact). If an alarm occurs, stop programmable controller's signals with a sequence program.
*7. The pins with the same signal name are connected in the servo amplifier.
*8. This length applies when the command pulse train input is the differential line driver type. For the open-collector type, connect them within 2m.
*9. Use the SW1DNC-MRC2-_.
*10. This connection is not required when the positioning module is RD75D, LD75D, or QD75D. However, to enhance noise tolerance, it is recommended to connect LG of the servo amplifier and control common.
*11. If not using the STO function, attach the short-circuit connector that came with the servo amplifier.
*12. To prevent an unexpected restart of the servo amplifier, configure a circuit that turns off EM2 when the main circuit power supply is turned off.
*13. Noise or disconnection of the command cable connected to the controller may cause a position mismatch. To avoid the position mismatch, check the encoder A-phase pulse and encoder B-phase pulse on the controller side.
*14. For source interfaces, the positive and negative outputs of the power supply are reversed as compared with sink interfaces.
*15. For source interfaces, CLEAR and CLEARCOM are reversed as compared with sink interfaces.

(a) Connecting minimum necessary I/O signals

Motor operation requires at least the following signals. The output signal does not need to be connected with the motor.

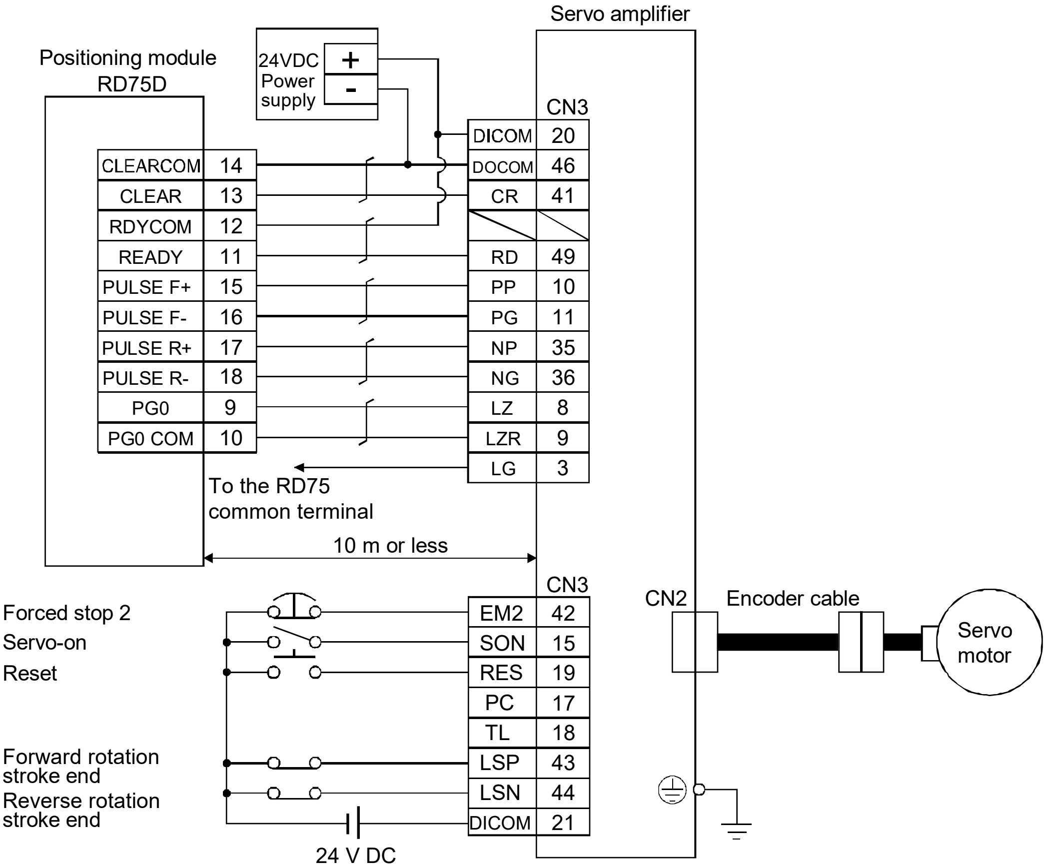
1) Servo-on ·········· Needs to be turned on before operation as this is a signal to activate the main circuit. Turning on this signal makes a servo-lock state.
2) Forward/reverse rotation stroke end ·· Connects with limit switches that are normally installed on the machine side. Turning off either of these signals disables the motor to rotate in the corresponding direction. The motor can be rotated in the opposite direction. For devices which do not have machine-side limit switches such as a roll feed, always short between DOCOM and terminals of the forward/reverse rotation stroke ends.
3) Forward/reverse rotation pulse train ·· When the pulse train is input, the motor rotates in accordance with the number of pulses and pulse frequency. When no pulse trains are input, the motor stops and becomes a servo-lock state.
4) Reset Cancels alarms. ·········· This is not an indispensable signal as alarms can also be canceled by turning off the control circuit power supply. In addition, turning on the reset signal releases the servo-lock state, and the servo motor coasts.
5) Forced stop 2 ·········· When EM2 is turned off (open between commons), the servo motor decelerates to a stop with commands. The forced stop will be deactivated if EM2 is turned on (short between commons) while in the forced stop state.



Connection II in position control

(b) Connecting minimum necessary I/O signals for operation with the RD75D

1) Servo-on
2) Forward/reverse rotation stroke end
3) Forward/reverse rotation pulse train ·· Connects with the terminal of the RD75D as shown in the diagram below.
4) Reset
5) Clear ···· Clears the counter at homing.
6) Zero pulse ···· Used as the home position signal at homing.
7) Ready ···· Outputs the servo-on state to the RD75D to use this signal as the interlock signal.
8) Forced stop 2 ···· When EM2 is turned off (open between commons), the servo motor decelerates to a stop with commands. The forced stop will be deactivated if EM2 is turned on (short between commons) while in the forced stop state.



* Refer to the RD75 manual for details of connections relating to the RD75.

Connection III in position control

[Supplementary explanation]

1) Types of pulse train input

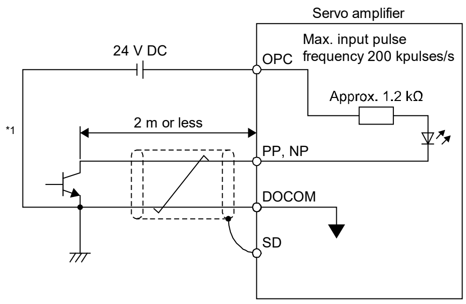
The command pulses are generally input using forward/reverse rotation pulse trains in either of the open-collector type or differential type,and the RD75P and RD75D also use this method.
To support pulse trains of the various command modules besides the RD75P and RD75D, the MR-J5 series servo amplifiers are compatible with the pulse trains shown in (i) [Pr.PA13_Command pulse input form (*PLSS)] by switching the parameter settings.

a) Types of pulse train form

Refer to section6.1.4 (i) [Pr.PA13_Command pulse input form (*PLSS)] for command pulse input form.

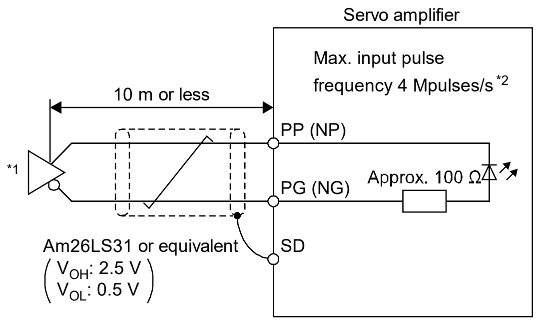
b) Types of hardware

Applicable configuration can be selected from the following in accordance with the hardware of the command module.



*1. A photocoupler is used as the pulse train input interface. Therefore this circuit may not operate properly due to reduction in current if a resistor is connected to the pulse train signal line.

Open-collector type



*1. A photocoupler is used as the pulse train input interface. Therefore this circuit may not operate properly due to reduction in current if a resistor is connected to the pulse train signal line.
*2. Set [Pr.PA13.2] to "0" to use the input pulse frequency of 4Mpulses/s.

Differential line driver type

2) Torque limit

The torque limit function limits the torque generated by the servo motor.
The following torque limit can be set. The torque limit function can be used by switching the following limit values.

Item	Outline
Internal torque limit	The maximum torque is limited by the values of [Pr.PA11 Forward rotation torque limit] and [Pr.PA12 Reverse rotation torque limit].
Internal torque limit 2	The generated torque is limited by the value of [Pr.PC35 Internal torque limit 2].
External analog torque limit	The maximum torque is limited by the value input to the TLA (analog torque limit).

6.1.3 Power-on

Perform operation in accordance with the instructions shown in this chapter.

(1) Startup of the position control mode

(a) Instructions for power-on

Turn on the power using the following procedure. Always follow this procedure when turning on the power. Refer to "Turning on servo amplifier for the first time" in the MR-J5 User's Manual (Introduction) as well for instructions for power-on.

1) Turn off SON (Servo-on).
2) Make sure that a command pulse train is not input.
3) Turn on the main circuit power supply and control circuit power supply.

Data is displayed 2s after "C" (Cumulative feedback pulses) is displayed.

(b) Instructions for power shut-off

1) Make sure that a command pulse train is not input.
2) Turn off SON (Servo-on).
3) Shut off the main circuit power supply and control circuit power supply.

(2) Instructions for startup

Precautions

- When the absolute position detection system is used with a rotary servo motor, [AL.025 Absolute position erased] occurs at first power-on and the servo motor cannot be changed to servo-on status. Shut off the power once, then cycle the power to deactivate the alarm.
- If the power is turned on while the servo motor is being rotated by an external force, an alarm may occur. Make sure that the servo motor is not operating before turning on the power. In addition, refer to the manual for the servo motor or encoder being used.

(a) Stop

If any of the following situations occur, the servo amplifier suspends and stops the operation of the servo motor.

Operation/command	Stopping condition
Alarm occurrence	The servo motor decelerates to a stop. There are also alarms that activate the dynamic brake and stop the servo motor.
EM2 (Forced stop 2) off	The servo motor decelerates to a stop. [AL.0E6 Servo forced stop warning] occurs. In the torque mode, EM2 functions the same as EM1.
STO (STO1 and STO2) off	The base circuit is shut off and the dynamic brake operates to stop the servo motor.
Limit switch off	When LSP (Forward rotation stroke end) or LSN (Reverse rotation stroke end) is turned off, the servo motor comes to a quick stop and activates the servo-lock. Operation in the opposite direction is possible.

6.1.4 Parameter

(1) Parameters necessary to be set or checked before operation

If the settings of the parameters introduced in this section are incorrectly configured, the motor will not operate or an alarm will occur. Be sure to check the parameters before operation and change the settings as necessary. Refer to the MR-J5 User's Manual (Parameters) for details of other parameters.

(a) [Pr.PA03_Absolute position detection system (*ABS)]

Initial setting	Setting range	Supported software version
00000000h	00000000h to 00000011h	Refer to the relevant detail No.

• [Pr.PA03.0_Absolute position detection system selection]

Initial setting	Setting range	Supported software version
0h	0h to 1h	A0

Set this servo parameter when using the absolute position detection system in the position control mode. If the absolute position detection system is switched to the incremental system, the home position is erased.
Execute homing again when the absolute position detection system is enabled.
0: Disabled (incremental system)
1: Enabled (absolute position detection system by DIO)
The absolute position detection system cannot be used when an incremental type encoder is used or when the semi closed/fully closed loop control switching is enabled. At this time, enabling the absolute position detection system triggers [AL.037 Parameter error].

• [Pr.PA03.1_Servo motor replacement preparation]

Initial setting	Setting range	Supported software version
0h	0h to 1h	A0

To replace an in-use batteryless absolute position encoder equipped servo motor while the absolute position detection system is in enabled status, set this servo parameter to "enabled".
Selecting "1" (enabled) enables servo motor replacement. After completing the servo motor replacement preparation, the value automatically changes to "0" (disabled).
After replacing the servo motor, the home position is erased. Execute homing again.
After setting this servo parameter to "1" (enabled), cycle the power and deactivate [AL.01A.5 Servo motor combination error 3].
0: Disabled
1: Enabled

(b) [Pr.PA04_Function selection A-1 (*AOP1)]

Initial setting	Setting range	Supported software version
00002000h	00000000h to 00002000h	Refer to the relevant detail No.

• [Pr.PA04.3_Forced stop deceleration function selection]

Initial setting	Setting range	Supported software version
2h	0h to 2h	A0

0: Forced stop deceleration function disabled (EM1 is used)
2: Forced stop deceleration function enabled (EM2 is used)

Setting value		Selecting EM2 or EM1	Deceleration method	
[Pr.PA04.3]	[Pr.PA04.2] *1		EM2 or EM1 is off	Alarm occurrence
0	0	EM1	MBR (Electromagnetic brake interlock) turns off without the forced stop deceleration.	MBR (Electromagnetic brake interlock) turns off without the forced stop deceleration.
2	0	EM2	MBR (Electromagnetic brake interlock) turns off after the forced stop deceleration.	MBR (Electromagnetic brake interlock) turns off after the forced stop deceleration.
0	1	Neither EM2 nor EM1 is used.	–	MBR (Electromagnetic brake interlock) turns off without the forced stop deceleration.
2	1	Neither EM2 nor EM1 is used.	–	MBR (Electromagnetic brake interlock) turns off after the forced stop deceleration.

*1. For the MR-J5-_A_ servo amplifier, the setting value of this servo parameter is fixed to "0". To disable forced stop, change the setting value of [Pr.PD01.3].

(c) [Pr.PA05_Number of command input pulses per revolution (*FBP)]

Initial setting	Setting range	Supported software version
10000[pulse]	1000 to 1000000	A0

The servo motor rotates once as per command input pulse that has been set.
The setting value of this servo parameter is enabled when [Pr.PA21.3 Electronic gear compatibility selection] is set to "1" (number of command input pulses per revolution). In the linear servo motor control mode or fully closed loop control mode, [Pr.PA21.3] cannot be set to "1".

(d) [Pr.PA06_Electronic gear numerator (CMX)]

Initial setting	Setting range	Supported software version
1	1 to 2147483647	A0

Set the electronic gear numerator.
This servo parameter is enabled in the following condition: [Pr.PA21.3 Electronic gear compatibility selection] is "0" (electronic gear), "2" (J3 electronic gear setting value compatibility mode), "3" (J2S electronic gear setting value compatibility mode), or "4" (J4 electronic gear setting value compatibility mode).
The condition range of the electronic gear is shown in the table below. If the set value is outside this range, noise may be generated during acceleration/deceleration, or operation may not be performed at the preset speed and/or acceleration/deceleration time constants. In addition, if the electric gear numerator exceeds "2147483647" by combining this servo parameter and [Pr.PA21.3], the electric gear numerator is limited to "2147483647".

Encoder resolution [pulse]	Setting range (CMX/CDV)
67108864	1/10 < CMX/CDV < 64000

(e) [Pr.PA07_Electronic gear denominator (CDV)]

Initial setting	Setting range	Supported software version
1	1 to 2147483647	A0

Set the electronic gear denominator.
This servo parameter is enabled in the following condition: [Pr.PA21.3 Electronic gear compatibility selection] is "0" (electronic gear), "2" (J3 electronic gear setting value compatibility mode), "3" (J2S electronic gear setting value compatibility mode), or "4" (J4 electronic gear setting value compatibility mode).
Refer to section 4.5.1 "Electronic gear function" for details.

(f) [Pr.PA08_Auto tuning mode (ATU)]

Initial setting	Setting range	Supported software version
00000001h	00000000h to 01110006h	Refer to the relevant detail No.

• [Pr.PA08.0_Gain adjustment mode selection]

Initial setting	Setting range	Supported software version
1h	0h to 6h	A0

Select the gain adjustment mode.
0: 2 gain adjustment mode 1 (interpolation mode)
1: Auto tuning mode 1
2: Auto tuning mode 2
3: Manual mode
4: 2 gain adjustment mode 2
5: Quick tuning mode
6: Load to motor inertia ratio monitor mode
Refer to the following table for details.

Setting value of [Pr.PA08.0]	Gain adjustment mode	Servo parameter adjusted automatically
0	2 gain adjustment mode 1 (interpolation mode)	[Pr.PB06 Load to motor inertia ratio/load to motor mass ratio] [Pr.PB08 Position control gain] [Pr.PB09 Speed control gain] [Pr.PB10 Speed integral compensation]
1	Auto tuning mode 1	[Pr.PB06 Load to motor inertia ratio/load to motor mass ratio] [Pr.PB07 Model control gain] [Pr.PB08 Position control gain] [Pr.PB09 Speed control gain] [Pr.PB10 Speed integral compensation]
2	Auto tuning mode 2	[Pr.PB07 Model control gain] [Pr.PB08 Position control gain] [Pr.PB09 Speed control gain] [Pr.PB10 Speed integral compensation]
3	Manual mode	–
4	2 gain adjustment mode 2	[Pr.PB08 Position control gain] [Pr.PB09 Speed control gain] [Pr.PB10 Speed integral compensation]
5	Quick tuning mode	[Pr.PB07 Model control gain] [Pr.PB08 Position control gain] [Pr.PB09 Speed control gain] [Pr.PB10 Speed integral compensation] [Pr.PB13 Machine resonance suppression filter 1] [Pr.PB14 Notch shape selection 1] [Pr.PB15 Machine resonance suppression filter 2] [Pr.PB16 Notch shape selection 2] [Pr.PB18 Low-pass filter setting] [Pr.PB23 Low-pass filter selection] [Pr.PB50 Machine resonance suppression filter 5] [Pr.PB51 Notch shape selection 5] [Pr.PE41 Function selection E-3]
6	Load to motor inertia ratio monitor mode	[Pr.PB06 Load to motor inertia ratio/load to motor mass ratio]

• [Pr.PA08.4_Quick tuning - Load to motor inertia ratio setting]

Initial setting	Setting range	Supported software version
0h	0h to 1h	A0

Set the load to motor inertia ratio at quick tuning. If the load connected to the servo motor is equal to or larger than the load to motor inertia ratio set in the servo parameter, an overshoot may occur in positioning operation after quick tuning.
0: Load to motor inertia ratio of 30 times or less
1: Load to motor inertia ratio of 100 times or less

• [Pr.PA08.5_Quick tuning - Execution selection]

Initial setting	Setting range	Supported software version
0h	0h to 1h	A0

Set when to execute quick tuning.
0: At initial servo-on after cycling the power
1: At every servo-on

• [Pr.PA08.6_Quick tuning - Restore selection]

Initial setting	Setting range	Supported software version
0h	0h to 1h	A0

Set whether to return servo parameters to the values they had set before quick tuning was executed.
0: Disabled
1: Enabled
By setting "1" (enabled), the following servo parameters return to the values they had set before quick tuning was executed. If quick tuning has never been performed after power on or software reset, setting "1" (enabled) only keeps the current servo parameter values.

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

(g) [Pr.PA09_Auto tuning response (RSP)]

Initial setting	Setting range	Supported software version
16	1 to 40	A0

Set the auto tuning response.

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

(h) [Pr.PA10_In-position range (INP)]

Initial setting	Setting range	Supported software version
400 [Refer to the text below for the unit.]	0 to 16777215	A0

Set the in-position range in the command pulse unit.
With the setting of [Pr.PC24.0 In-position range unit selection], the unit can be changed to the servo motor encoder pulse unit.

In-position range setting

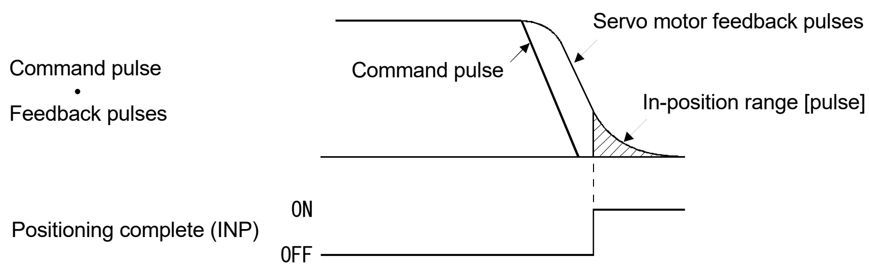
Control mode [Pr.PA01]	In-position setting range
Position, speed, and torque control modes	Range where positioning completion (INP) is output

Selecting a control side for the in-position range

[Pr.PA01.4 Fully closed loop operation mode selection]	In-position range unit
"0" (semi closed loop system)	Command resolution unit (motor-side encoder)
"1" (fully closed loop system)	Command resolution unit (load-side encoder)

In-position range unit

[Pr.PA01.0 Control mode selection]	[Pr.PC24.0 In-position range unit selection]	Unit
Position, speed, and torque control modes	0 (command unit)	pulse
"1" (fully closed loop system)	1 (servo motor encoder pulse unit)	pulse



(i) [Pr.PA11_Forward rotation torque limit (TLP)]

Initial setting	Setting range	Supported software version
1000.0[%]	0.0 to 1000.0	A0

The torque or thrust generated by the servo motor can be limited.
Set servo parameters in relation to the rated torque or continuous thrust as 100.0 [%]. Set the servo parameter when limiting the torque of the servo motor for CCW power running or CW regeneration, or when limiting the thrust of the linear servo motor for positive direction power running or negative direction regeneration. If this servo parameter is set to "0.0", the servo motor does not generate torque or thrust.
When [Pr.PC50.0 Torque limit unit change] is set to "0" (maximum torque unit), set the servo parameter in relation to the maximum torque or maximum thrust (= 100.0%).
If a value larger than the maximum torque or maximum thrust of the servo motor is set, the value will be limited to the maximum torque or maximum thrust of the servo motor.
When torque (thrust) is output with the analog monitor output, the larger value of either [Pr.PA11 Forward rotation torque limit] or [Pr.PA12 Reverse rotation torque limit] is applied to the torque (thrust) at the maximum output voltage.

(j) [Pr.PA12_Reverse rotation torque limit (TLN)]

Initial setting	Setting range	Supported software version
1000.0[%]	0.0 to 1000.0	A0

The torque or thrust generated by the servo motor can be limited.
Set servo parameters in relation to the rated torque or continuous thrust as 100.0 [%]. Set the servo parameter to limit the torque of the servo motor for CW power running or CCW regeneration, or to limit the thrust of the linear servo motor for negative direction power running or positive direction regeneration. If this servo parameter is set to "0.0", the servo motor does not generate torque or thrust.
When [Pr.PC50.0 Torque limit unit change] is set to "0" (maximum torque unit), set the servo parameter in relation to the maximum torque or maximum thrust (= 100.0%).
If a value larger than the maximum torque or maximum thrust of the servo motor is set, the value will be limited to the maximum torque or maximum thrust of the servo motor.
When torque (thrust) is output with the analog monitor output, the larger value of either [Pr.PA11 Forward rotation torque limit] or [Pr.PA12 Reverse rotation torque limit] is applied to the torque (thrust) at the maximum output voltage.

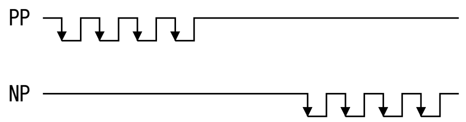
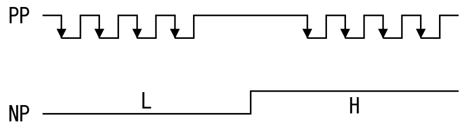
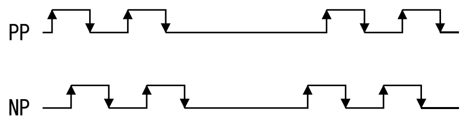
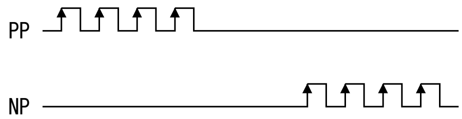
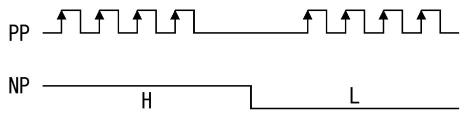
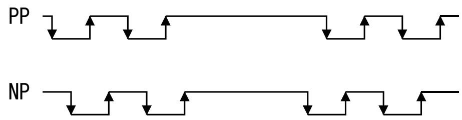
(k) [Pr.PA13_Command pulse input form (*PLSS)]

Initial setting	Setting range	Supported software version
00000100h	00000000h to 00000412h	Refer to the relevant detail No.

• [Pr.PA13.0_Command input pulse train form selection]

Initial setting	Setting range	Supported software version
0h	0h to 2h	A0

0: Forward/reverse rotation pulse train
1: Signed pulse train
2: A-phase/B-phase pulse train (the servo amplifier multiplies the input pulse by 4, and captures the multiplied input pulses.)
Refer to the following table for setting values.

[Pr.PA13.1]	[Pr.PA13.0]	Pulse train form		Forward rotation (positive direction) command	Reverse rotation (negative direction) command
1	0	Negative logic	Forward rotation pulse train (positive direction pulse train) Reverse rotation pulse train (negative direction pulse train)		
1	1		Positive pulse train		
1	2		A-phase pulse train B-phase pulse train		
0	0	Positive logic	Forward rotation pulse train (positive direction pulse train) Reverse rotation pulse train (negative direction pulse train)		
0	1		Positive pulse train		
0	2		A-phase pulse train B-phase pulse train		

Arrows in the table indicate the timing of importing pulse trains. A-phase/B-phase pulse trains are imported after they have been multiplied by 4.

• [Pr.PA13.1_Pulse train logic selection]

Initial setting	Setting range	Supported software version
0h	0h to 1h	A0

0: Positive logic
1: Negative logic
Match the logic of the command pulse train received from the connected controller.
Refer to [Pr.PA13.0_Command input pulse train form selection] for setting values.

• [Pr.PA13.2_Command input pulse train filter selection]

Initial setting	Setting range	Supported software version
1h	0h to 3h	A0

Selecting the appropriate filter for the command pulse frequency can increase noise tolerance.
0: Command input pulse train is 4Mpulses/s or less
1: Command input pulse train is 1Mpulse/s or less
2: Command input pulse train is 500kpulses/s or less
3: Command input pulse train is 200kpulses/s or less
"1" can be set for commands up to 1Mpulse/s. When inputting commands exceeding 1Mpulse/s and up to 4Mpulses/s, set "0".
To prevent the following malfunctions, set a correct value in accordance with the command pulse frequency.
Setting a value higher than the actual command value will decrease noise tolerance.
Setting a value lower than the actual command will cause a position mismatch.

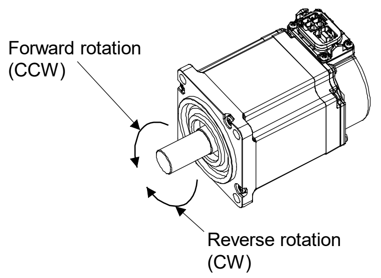
(l) [Pr.PA14_Travel direction selection (*POL)]

Initial setting	Setting range	Supported software version
0	0 to 1	A0

Select the servo motor rotation direction or linear servo motor travel direction for the command input pulse.

• For position control mode
With the setting value of [Pr.PA14 Travel direction selection], the rotation and travel direction can be changed without reversing the forward/reverse rotation pulse inputs for the input pulse train.

• For speed and torque control modes
The rotation and travel direction cannot be changed with the servo parameter.
The servo motor rotation direction is as follows.



(m) [Pr.PA15_Encoder output pulses (*ENR)]

Initial setting	Setting range	Supported software version
4000[pulse/rev]	1 to 67108864	A0

Set the encoder output pulses that are output from the servo amplifier, by using the number of output pulses per revolution, dividing ratio, or electronic gear ratio. (after multiplication by 4)
Selecting "1" (dividing ratio setting) in [Pr.PC19.1 Encoder output pulse setting selection] will divide the travel distance [pulse] by the setting value.
Set a numerator for the electronic gear for the A/B-phase pulse output when selecting "3" (A-phase/B-phase pulse electronic gear setting) in [Pr.PC19.1].
The maximum output frequency is 4.6Mpulses/s. Set the value within the range.
For details of the relation to PC19, refer to the MR-J5 User's Manual (Function).

6.1.5 Position control

Perform a test operation before an actual operation to check that the machine operates properly.

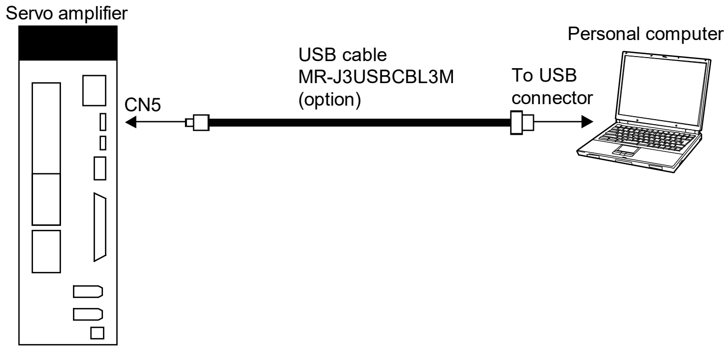
(1) Power-on

Turn on the power in accordance with section 6.1.3 "Power-on".

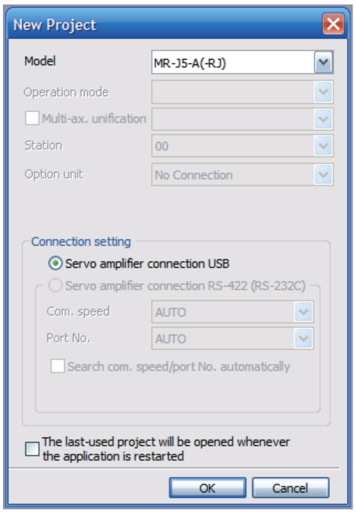
(2) Parameter settings using MR Configurator2 (setup software)

MR Configurator2 is the software used for purposes such as servo parameter settings, graph measurement/display, and test operation. This section describes the startup procedure of the servo amplifier when the servo amplifier is connected to a personal computer which has MR Configurator2 installed. To learn more about using MR Configurator2, refer to Help in MR Configurator2.

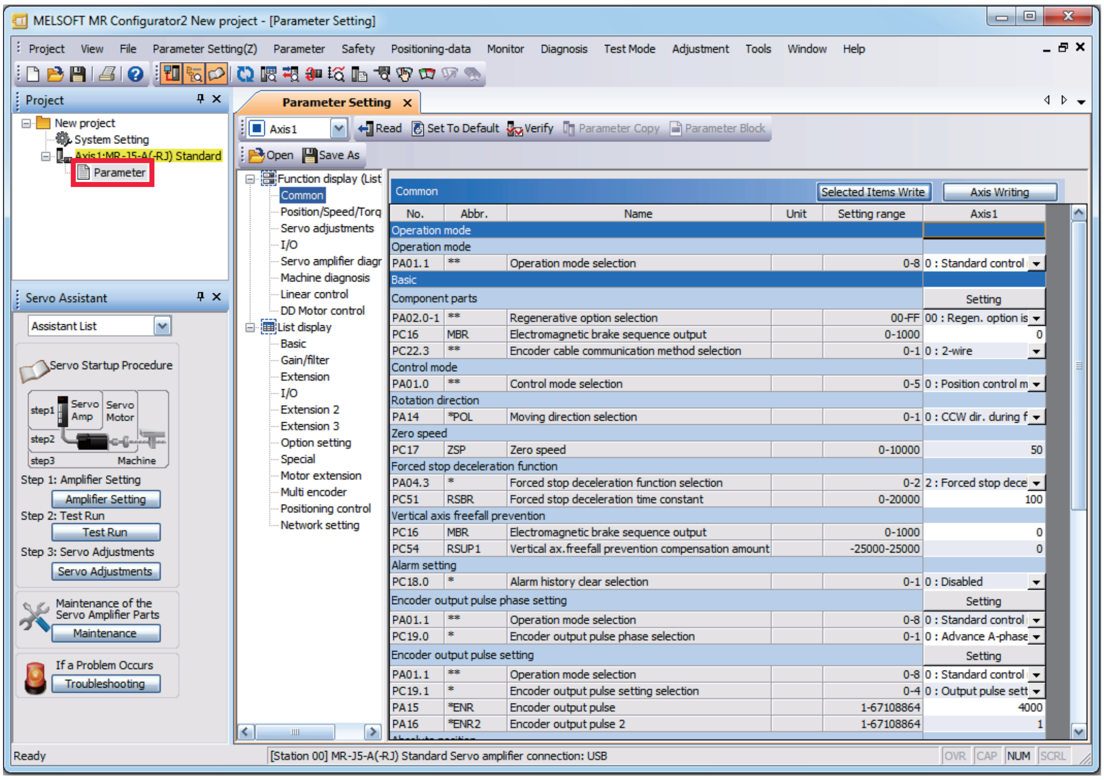
1. Connect the servo amplifier and the personal computer with a USB cable. Turn on the servo amplifier control circuit power supply.



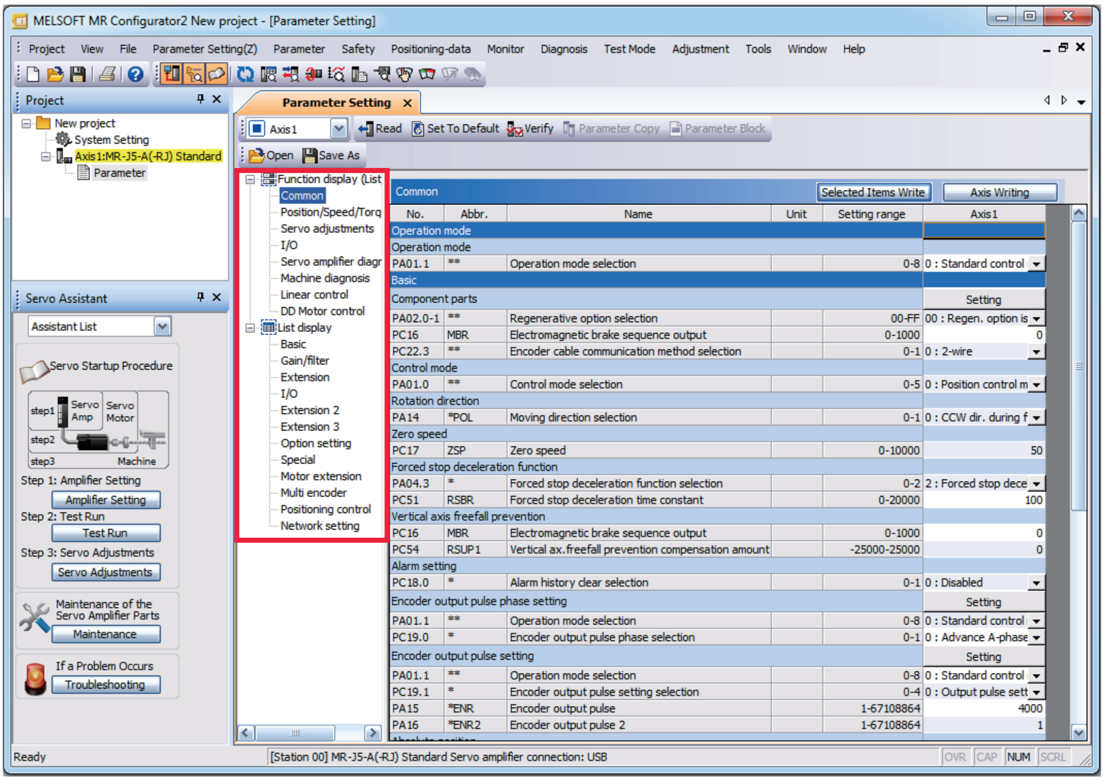
2. Start MR Configurator2 and create a new project. For the connection setting, select USB. Select a servo amplifier model and an operation mode.



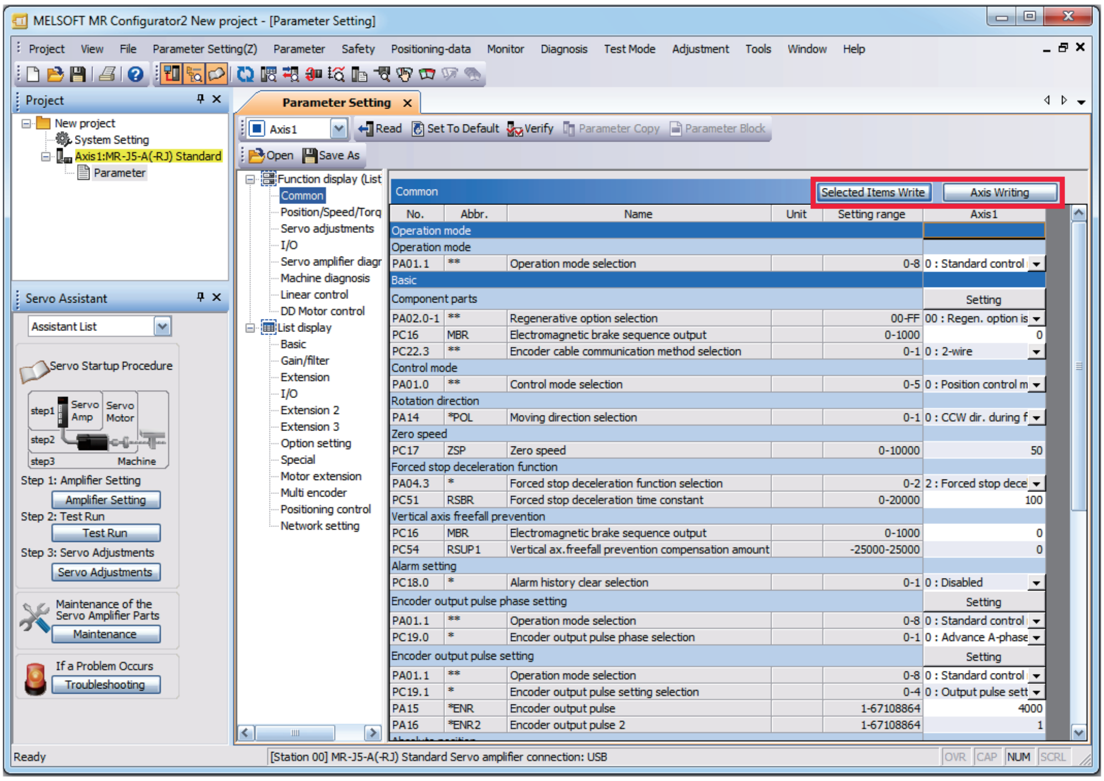
3. Selecting "Parameter" from the project tree opens the "Parameter Setting" window.



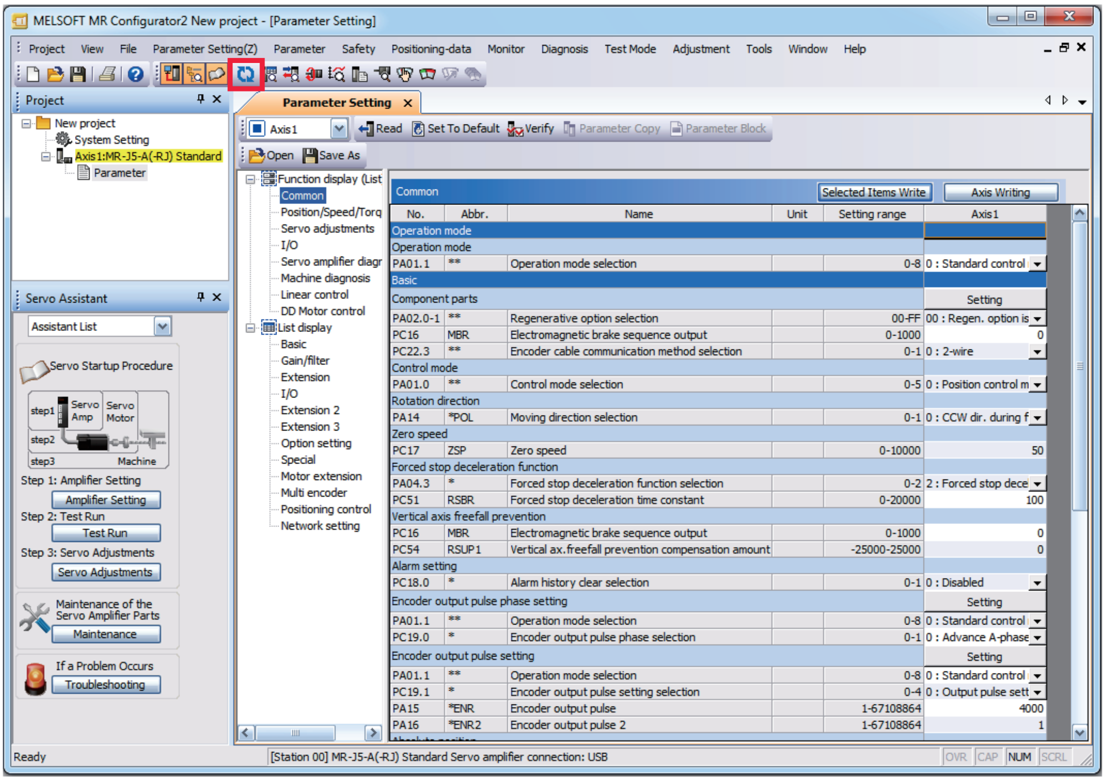
4. Select a group of servo parameters in the selection tree of the "Parameter Setting" window to display and configure the settings.



5. After changing the servo parameter, click "Selected Items Write" or "Axis Writing".



6. Abbreviated servo parameters prefixed with * and servo parameters marked with ** are enabled after the power is cycled or a software reset is performed. Click "Software Reset" in MR Configurator2 to perform the software reset.



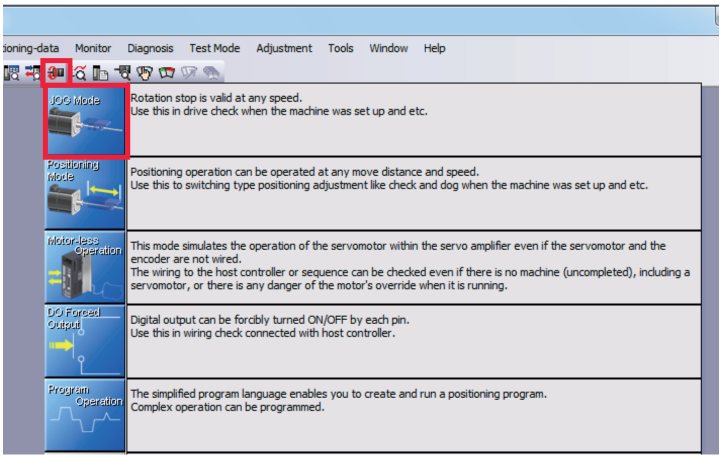
(3) Test operation of the servo motor alone in test operation mode

Point
● If the servo motor operates in an unintended manner, stop the servo motor with EM2 (Forced stop 2).

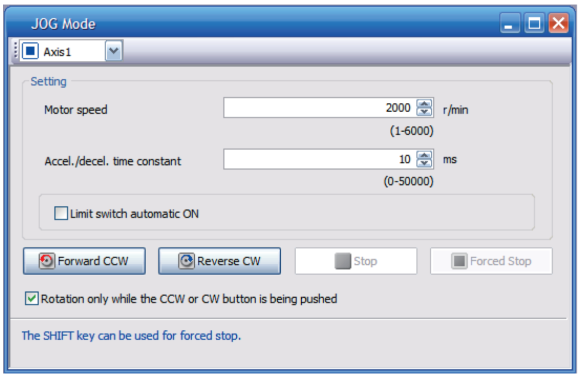
Check that the servo amplifier and servo motor operate normally. With the servo motor disconnected from the machine, use the test operation mode and check whether the servo motor operates correctly. This section describes how to check the servo motor operation in the JOG operation. The test operation also includes the positioning operation and program operation. Refer to section 3.1.8 (3) "Test operation mode" for details.

1. Turn on the power.

2. Open the "JOG Mode" screen of MR Configurator2.



3. To operate the servo motor, input the motor speed and acceleration/deceleration time constants, then click "Forward CCW" or "Reverse CW". The servo motor operates only while the button is being clicked. Give a low speed command at first and check the operation.



4. After the test operation is completed, turn off the power.

(4) Equipment configuration setting

Set the servo parameters for each function according to the equipment configuration. For details, refer to the MR-J5 User's Manual (Function).

Item	Description
Rotation/travel direction selection	To change the rotation/travel direction (POL), change the servo parameter.
Stroke limit function	Limit switches can be used to limit travel intervals of the servo motor. Configure the settings according to the connection method of the limit switch.
In-position setting	Positioning completion status can be checked with in-position. Set this as necessary.
Forced stop deceleration function	Stops the servo motor at EM2 (Forced stop 2) off. Perform settings such as the deceleration time constant.
Vertical axis freefall prevention function	For vertical axes, this function pulls up the shaft slightly. When using a servo motor with an electromagnetic brake for a vertical axis, perform settings as required.

(5) Controller-related setting

Set the servo parameters according to the control mode to be used from the controller. For details, refer to the MR-J5 User's Manual (Function).

Set each servo parameter that is necessary for the operation using controller commands.

Item	Description
Command unit selection function	The unit of torque command can be selected from the controller.
Electronic gear setting	Perform the settings related to the controller command unit and amplifier command unit.

(6) Operation by controller command

In this section, check that the servo motor correctly rotates as slowly as possible under the commands from the controller.

Use the following procedure to check that the servo motor rotates.

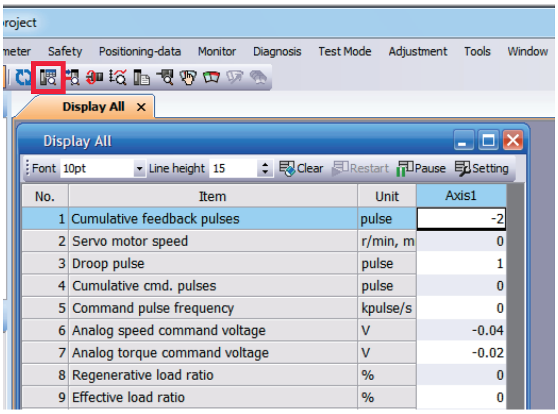
(a) Operation by command

1) Turn on EM2 (Forced stop 2) and SON (Servo-on). When the servo amplifier is in servo-on status, RD (Ready) turns on.
2) Turn on LSP (Forward rotation stroke end) and LSN (Reverse rotation stroke end).
3) When VC (Analog speed command) is input from the controller and ST1 (Forward rotation start) or ST2 (Reverse rotation start) is turned on, the servo motor starts operating. Give a low speed command at first to check the servo motor operations such as the rotation direction. If the servo motor does not operate in the intended direction, check the input signal.
4) Check the operation status.
   Refer to (b) "Checking the operation status" in this section.

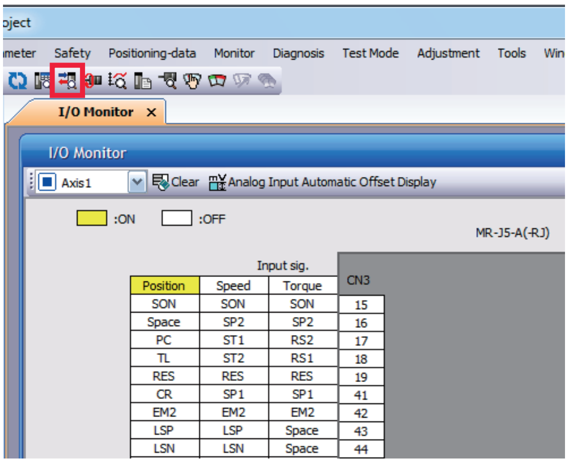
(b) Checking the operation status

After the operation by controller command, confirm that the servo motor can be operated properly in accordance with the following procedure.

1. Display the Display All window in MR Configurator2. Confirm that there is no error in the items such as servo motor speed and load ratio.

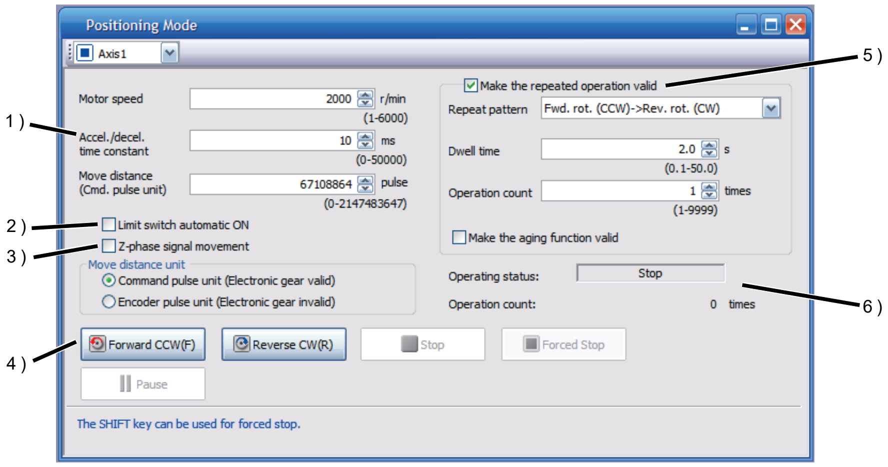


2. Display the I/O Monitor window. Confirm that there is no error in the I/O signal.



(7) Positioning operation

Positioning operation can be performed when there is no command from the controller. Operate the motor using the Positioning Mode screen of MR Configurator2.



1) Motor operation setting

Set the motor speed, acceleration/deceleration time constants, and travel distance in the positioning operation mode. When changing the speed to the permissible speed, set the speed in [Pr.PA28.4 Speed range limit selection].

2) Limit switch

Select "Limit switch automatic ON" to perform the positioning operation when the limit switch is not connected. Be sure to avoid causing a collision while performing the operation.

3) Z-phase signal movement

When "Z-phase signal movement" is selected, the servo motor moves until the first Z-phase signal after positioning operation.

4) Operation

The servo motor can be started (CCW/CW), paused, stopped, or forcibly stopped. Clicking "Operation Start" starts the operation in the specified operation condition.

5) Repeated operation

Selecting "Make the repeated operation valid" enables the repeated operation. Selecting "Make the aging function valid" enables the continuous operation until clicking "Stop" or "Forced Stop". Set the repeat pattern, the dwell time, and the number of operations.

6) Operation status

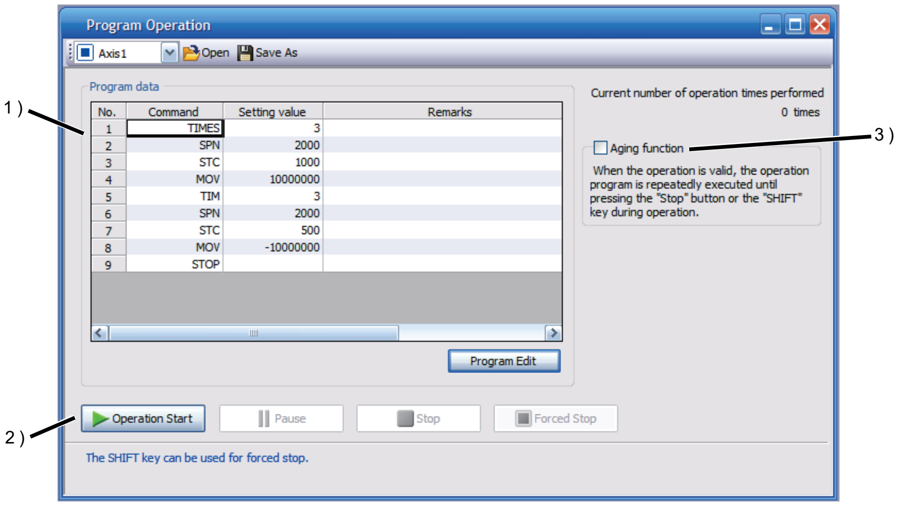
The operation status during the repeat operation and the number of operations are displayed.

The status display can be checked in the display section during positioning operation. Press "MODE" in the positioning operation-ready status to call the status display screen.

(8) Program operation

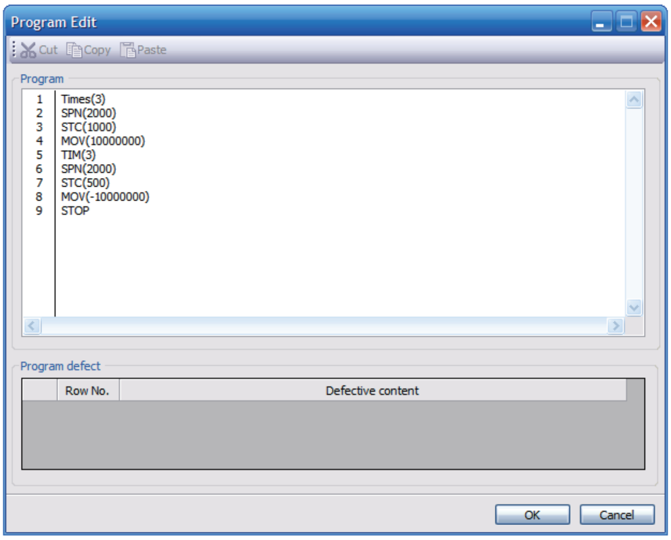
Positioning operation using multiple operation patterns can be performed without a controller. Operate the motor using the Program Operation screen of MR Configurator2. For details, refer to Help of MR Configurator2.

1. Open the Program Operation screen of MR Configurator2.



No.	Item	Screen operation
1)	Program display	Displays the program. To edit the display item, click "Program Edit".
2)	Operation	The servo motor can be started (CCW/CW), paused, stopped, or forcibly stopped. Clicking "Operation Start" starts the operation according to the program.
3)	Repeat execution	Displays the number of execution times. Selecting "Aging function" enables the repeated operation of the operation program.

2. Clicking "Program Edit" in the program operation screen opens the Program Edit screen. Input the program and click "OK". For program commands, refer to Help of MR Configurator2.



(9) Motor-less operation

Point
● The motor-less operation cannot be used in the linear servo motor control mode or direct drive motor control mode.

Without connecting a servo motor to the servo amplifier, output signals or status displays can be provided in response to the controller commands as if the servo motor is actually running. This operation can be used to check the sequence of a controller. Use this operation after the forced stop has been released. Use this operation with the servo amplifier connected to the controller.
To perform the motor-less operation, set [Pr.PC60.0 Motor-less operation selection] to "1" (enabled). To terminate the motor-less operation, set [Pr.PC60.0] to "0" (disabled).

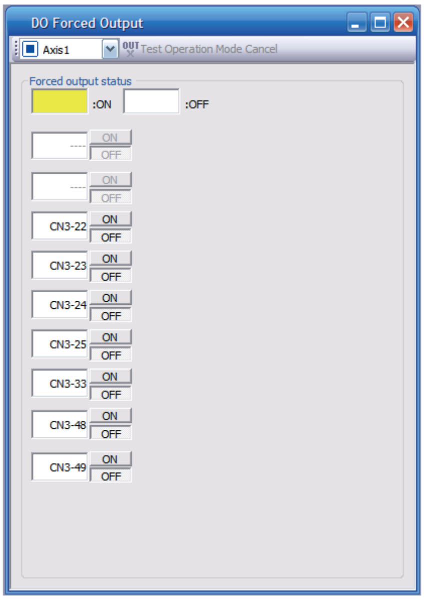
(a) Load conditions
The operation is performed in the following conditions. Note that the conditions may differ from those of actual machines.

Load item	Conditions
Load torque	0
Load to motor inertia ratio	[Pr.PB06 Load to motor inertia ratio/load to motor mass ratio]

(b) Alarm
In the motor-less operation, some alarms and warnings are not generated. The following are examples of alarms which do not occur.
• [AL.016 Encoder initial communication error 1]
• [AL.01E Encoder initial communication error 2]
• [AL.01F Encoder initial communication error 3]
• [AL.020 Encoder normal communication error 1]
• [AL.021 Encoder normal communication error 2]
• [AL.025 Absolute position erased]
• [AL.092 Battery cable disconnection warning]
• [AL.09F Battery warning]

(10) Output signal (DO) forced output

This function forcibly switches the output signals on and off regardless of the servo status. Use this function for purposes such as checking output signal wiring. Operate this function on the DO Forced Output screen of MR Configurator2.



Each output signal can be turned on/off by clicking the ON/OFF button next to its name. After checking, click "Test Operation Mode Cancel" and terminate the output signal (DO) forced output.

(11) Parameter settings

Before operating the demonstration machine, set the parameters to the demonstration machine setting values (position control) shown in section 3.1.8 (7) "Parameter settings".

(12) Operation

(a) Servo-on

Turn on servo-on (SON) to make the servo-on state.

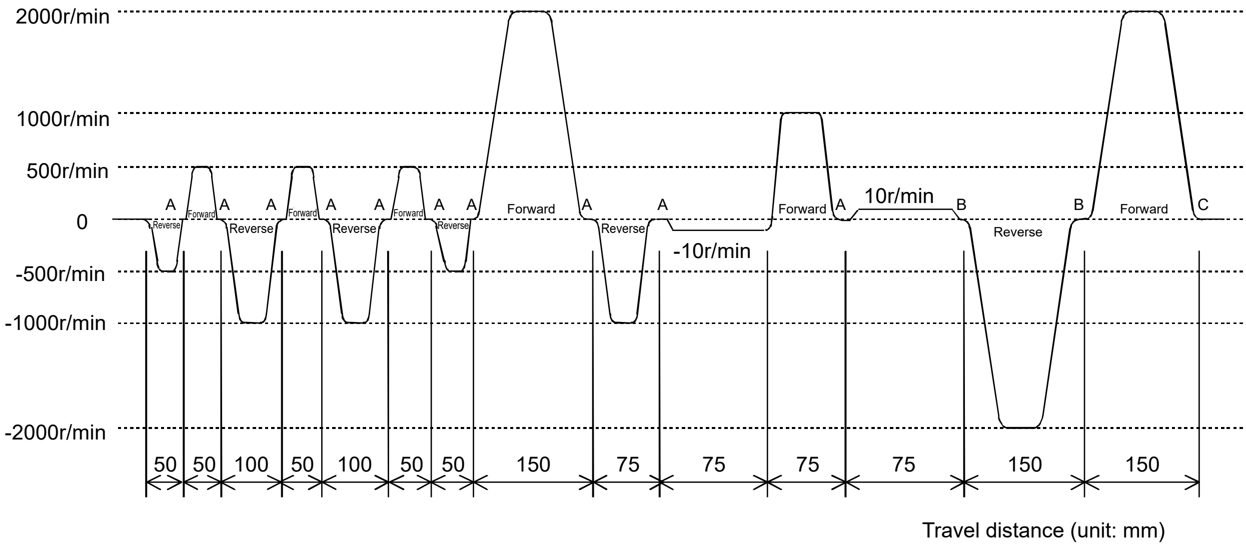
(b) JOG operation

1. Switch the manual/automatic select switch to the manual side.
2. Turn on the forward rotation JOG button to rotate the motor in the forward rotation direction (counterclockwise). (Only when the button is turned on)
3. Turn on the reverse rotation JOG button to rotate the motor in the reverse rotation direction (clockwise). (Only when the button is turned on)

(c) Automatic operation

Perform homing before automatic operation.

1. Switch the manual/automatic select switch to the manual side.
2. Turn on the homing button to make the motor perform homing.
   Refer to section 5.5.2 "Types of homing" for the homing operation.
   To perform automatic operation, switch the manual/automatic select switch to the automatic side.
3. Switch the continuous/one-cycle operation switch to one-cycle operation then press the start button to perform operation once in the pattern shown in the figure below.
   Press the stop button to pause the operation.
4. Switch the continuous/one-cycle operation switch to continuous operation then press the start button to perform operation repeatedly in the pattern shown in the figure below.
   Press the stop button to pause the operation.



(Note) A, B, and C indicate the dwell time. A=500ms, B=1s, C=2s

(d) Timing belt working section and home position setting operation

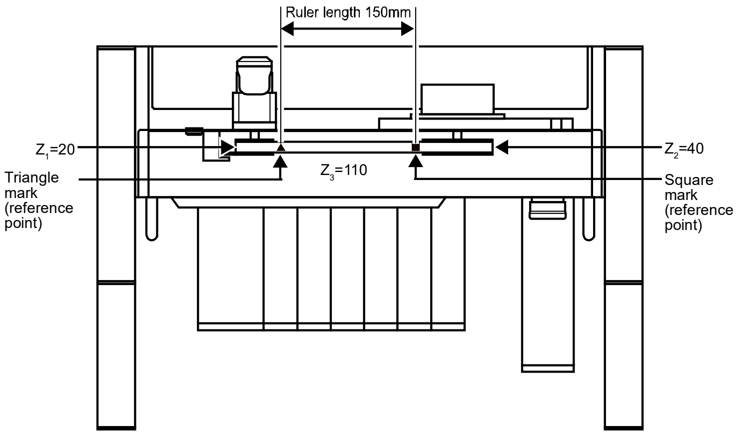
The specifications of the mechanical section (timing working section) of this demonstration machine are as follows.

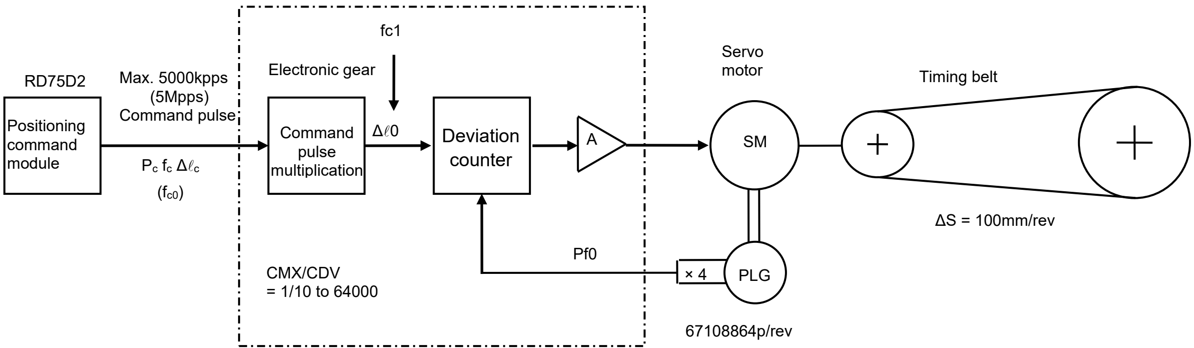
1) Timing belt working part specifications

No.	Item	Specifications
1	Belt length	L=550mm (one circle)
2	Number of pulley teeth on the servo motor side	Z_1=20
3	Number of pulley teeth on the powder brake side	Z_2=40
4	Number of belt teeth	Z_3=110
5	Inertia moment of the powder brake itself	Ja=0.358kg • m^2
6	Inertia moment of the servo motor itself	J_M = 0.0394 × 10^{-4}kg • m^2
7	Belt travel distance per motor rotation	ΔS = 100mm
8	Motor feedback pulses	P_{f0} = 67108864P/rev

2) When the home position is set at the reference position as shown in the right figure, if the homing button is turned on for consecutive eleven times, the home position will be set at the reference position again.
In other words, the home position is set at the reference position once in eleven times as shown in the right figure.

$$n = \frac{L}{\Delta S} = \frac{550}{100} = \frac{11}{2}$$





(e) Checking operations using each parameter setting (refer to section 0 "Parameter" for details of the parameters.)

1) Settings and idea of electronic gear (Pr.PA06 and Pr.PA07)

Consider if the setting is possible in the unit of the belt travel distance per pulse $\Delta\ell_c$ = 0.001mm (1μm).

$$\text{Electronic gear ratio } \frac{CMX}{CDV} = \frac{\text{Motor feedback pulse } P_{f0} \times \text{belt travel distance per pulse } \Delta\ell_c}{\text{Belt travel distance per motor rotation } \Delta S}$$

$$= \frac{67108864 \times 0.001}{100} = \frac{8388608}{12500} = \frac{2097152}{3125}$$

2) Find the value of fc for a motor speed of 3000r/min when the electronic gear ratio is 2097152/3125.

Consider if the setting is possible in the unit of the belt travel distance per pulse $\Delta\ell_c$ = 0.001mm (1μm).

$$N = \frac{f_c \times 60 \times CMX/CDV}{P_{f0}} = \frac{f_c \times 60 \times 2097152/3125}{67108864} = 3000\text{r/min}$$

$$f_c = \frac{67108864 \times 3000}{60 \times 2097152/3125} = 5000\text{kpps} \geq 5000\text{kpps}$$

The maximum command frequency of the positioning module RD75D2 is 5000kpps (5Mpps). This setting is possible because fc matches with the maximum command frequency.

3) Consider if the setting is possible in the unit of the belt travel distance per pulse $\Delta\ell_c$ = 0.05mm (50μm).

$$\text{Electronic gear ratio } \frac{CMX}{CDV} = \frac{67108864 \times 0.05}{100} = \frac{83886080}{2500} = \frac{4194304}{125}$$

Find the value of fc for a motor speed of 3000r/min when the electronic gear ratio is 4194304/125.

$$f_c = \frac{67108864 \times 3000}{60 \times 4194304/125} = 100\text{kpps} < 5000\text{kpps}$$

The maximum command frequency of the positioning module RD75D2 is 5000kpps (5Mpps). The setting does not have any problem as the frequency is 200kpps < 5000Kpps even at 6000r/min which is within the maximum command frequency.

* The feed length per pulse on this demonstration machine has been set to 0.01mm.

$$\frac{CMX}{CDV} = \frac{67108864 \times 0.01}{100} = \frac{67108864}{10000}$$

Perform settings as follows.
Command pulse multiplication numerator (Pr.PA06): 67108864
Command pulse multiplication denominator (Pr.PA07): 10000

4) Set "In-position range setting" (Pr.PA10).

5) Set "Model control gain" and "Position control gain" (Pr.PB07 and Pr.PB08).

6.1.6 Functions useful for startup and diagnosis

The MR-J5-A servo amplifier has functions useful for startup and diagnosis other than "Checking external I/O signal" in section 3.1.7 and "Operation mode" in section 3.1.8 (3). The main items are as follows.

1) One-touch tuning ··························· Gain adjustment is performed with this function just by pressing buttons on the servo amplifier or by clicking a button once on MR Configurator2.

2) Auto tuning ································· Servo gain is automatically adjusted in accordance with the load to motor inertia. The servo gain can be selected from high, middle, and low depending on the machine conditions.

3) Analog command input automatic offset·· Offsets of analog input signals such as a speed command are automatically compensated.

4) Stop cause display ························ When the motor is at a stop, the stop cause is displayed with the segment of the display. This function is useful for troubleshooting.

5) DO forced output ·························· The digital output signal of the amplifier is forcibly output. This function is useful for startup as the external relay and lamps can be checked.

6.2 Adjusting Operation Conditions

6.2.1 Adjusting the servo amplifier alone

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

(1) Gain adjustment mode explanation

(a) Functions to automatically adjust machine stability

Adjustment function	Outline
Quick tuning	Use this function to prioritize reduction of the overshoot over shortening the settling time. An adjustment is enabled without the positioning operation.
Auto tuning mode 1	Use this function to adjust the machine while checking the response waveform when the load to motor inertia ratio of the device is unknown. Also use this function when the load to motor inertia ratio of a machine varies during operation.
Auto tuning mode 2	Use this function to adjust the machine while checking the response waveform when the load to motor inertia ratio of the device is known.
2 gain adjustment mode 1	Use this function for auto tuning a machine that requires path accuracy improvement, such as an XY table or a tandem mechanism, and to suppress interference between axes.
2 gain adjustment mode 2	Use this function to adjust settling time and overshoot amount after quick tuning or one-touch tuning.

(b) Adjustment functions to suppress vibration and to obtain a high level of responsiveness

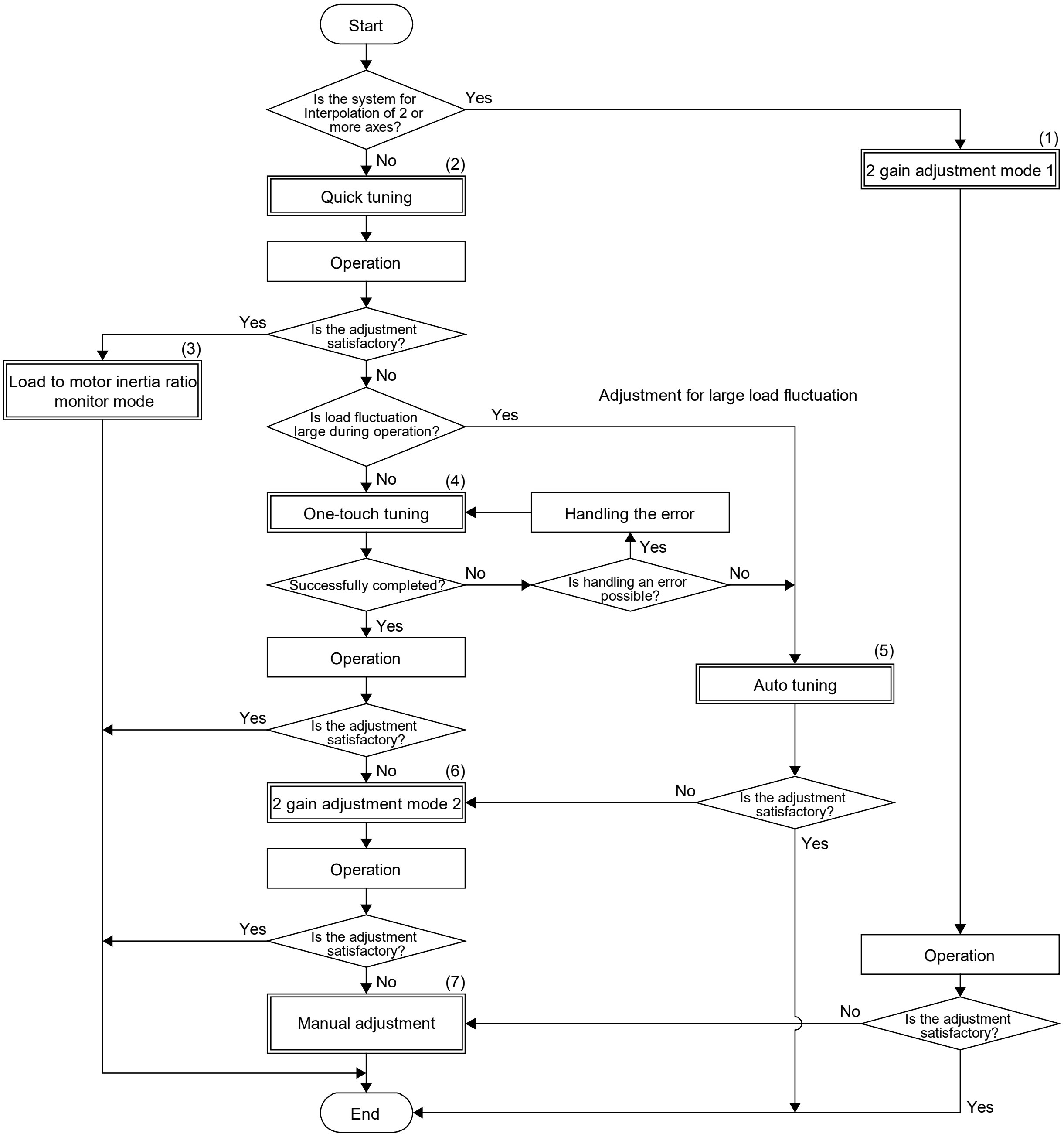
Adjustment function	Outline
One-touch tuning	Use this function to reduce settling time within the designated in-position range.
Machine resonance suppression filter	Use this function if machine resonance occurs when the response level is increased in auto tuning or manual mode.
Adaptive filter II	Use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

(c) Manual adjustment functions to obtain the maximum performance

Adjustment function	Outline
Manual mode	Use this function if the performance of quick tuning, one-touch tuning, and auto tuning is not satisfactory.
Gain switching function	Use this function for: 1) Reducing the settling time 2) Increasing the gain during servo-lock while suppressing vibration noise during rotation 3) When load fluctuation is too large
Speed feed forward	Use this function to improve path accuracy by decreasing droop pulses at the constant speed.
Overshoot suppression function	Use this function to decrease the overshoot.
Slight vibration suppression function	Use this function to suppress vibration at a servo motor stop.
Unbalanced torque offset	Use this function to prevent free fall of a vertical axis when turning on servo-on.
Path tracking model adaptive control	Use this function to suppress overshoot in path control.
Super trace control	Use this function to improve the trackability at acceleration/deceleration in path control.
Lost motion compensation function	Use this function to suppress quadrant projections at speed switching in path control.

(2) Order of adjustment and proper use of adjustment modes

Adjust the servo amplifier using the following procedure.



No.	Instructions
(1)	Set [Pr.PA08.0 Gain adjustment mode selection] to "0". Use this mode to set the same setting value in [Pr.PB07 Model control gain] to all axes when performing interpolation such as path control or tandem drive for a system with 2 axes or more. This mode is not used for other purposes generally. For details, refer to "2 gain adjustment mode 1" in the MR-J5 User's Manual (Adjustment).
(2)	This mode can adjust the servo amplifier without driving the servo motor. Adjust the servo amplifier with this mode when not executing interpolation control. For details, refer to "Quick tuning" in the MR-J5 User's Manual (Adjustment).
(3)	Change the mode to the load to motor inertia ratio monitor mode if no problem appears in the adjustment result of quick tuning. For details, refer to "Quick tuning" in the MR-J5 User's Manual (Adjustment).
(4)	Use one-touch tuning if the conditions for quick tuning are not fulfilled. One-touch tuning offers a higher response level than quick tuning that enables quicker positioning. Refer to section 6.2.2 "One-touch tuning" for details.
(5)	Set [Pr.PA08.0 Gain adjustment mode selection] to "1" or "2". Refer to section 6.2.3 (1) "Auto tuning mode 1" for details.
(6)	[Pr.PA08.0 Gain adjustment mode selection] is automatically set to "4" (2 gain adjustment mode 2) once one-touch tuning is complete. Refer to section 6.2.2 "One-touch tuning" for details.
(7)	Set [Pr.PA08.0 Gain adjustment mode selection] to "3". Use the manual adjustment for fast settling or high accuracy path control. Refer to section 6.2.4"Manual mode" for details.

6.2.2 One-touch tuning

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

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

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

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

(1) Restrictions on one-touch tuning
One-touch tuning cannot be performed in the following cases.

(a) Common restrictions on user command method and amplifier command method
• When [Pr.PA21.0 One-touch tuning function selection] is "0" (disabled)
• In the torque mode
• When an alarm or a warning which disrupts the motor driving occurs
• In output signal (DO) forced output and motor-less operation

(b) Restrictions on user command method
• One-touch tuning using the user command method cannot be performed at servo-off.

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

(2) Instructions for one-touch tuning

(a) Instructions for amplifier command method

- Once one-touch tuning using the amplifier command method is performed, control by commands from a controller will not be available. To enable control from the controller again, reset the controller, cycle the power of the servo amplifier, or reset software.
- Set a permissible travel distance that avoids collision with the machine. In addition, the permissible travel distance may be exceeded because of an overshoot during one-touch tuning. Therefore, set the permissible travel distance with a margin to avoid exceeding the range of a limit switch.
- When the manual mode is selected in [Pr.PA08.0 Gain adjustment mode selection], a load to motor inertia ratio is not estimated. Optimum acceleration/deceleration commands are generated by [Pr.PB06 Load to motor inertia ratio/load to motor mass ratio] at the start of one-touch tuning. When the load to motor inertia ratio is not accurate, optimum acceleration/deceleration commands may not be generated, causing the tuning to fail.
- When one-touch tuning is started with a USB communication, both the servo motor and the tuning will stop if communication between MR Configurator2 and the servo amplifier is interrupted during the tuning. In addition, the servo parameters return to the status they had at the start of one-touch tuning.
- When one-touch tuning is started during velocity mode, the mode is switched to position mode automatically. As a result, the tuning result may differ from the results obtained by using the speed command.

(3) One-touch tuning procedure

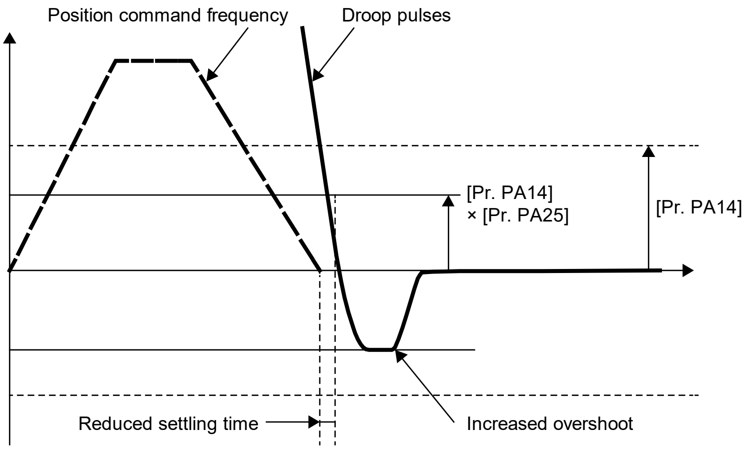
(a) One-touch tuning using the user command method in MR Configurator2

Perform one-touch tuning using the following procedure.

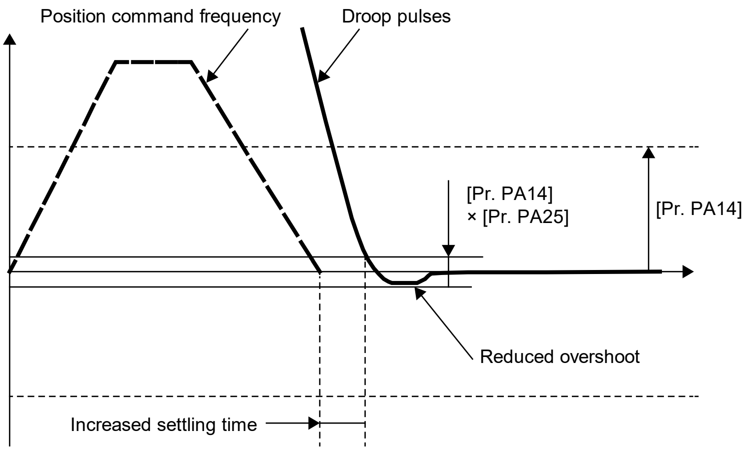
Start	
Overshoot permissible level setting	Set the overshoot permissible level for one-touch tuning in [Pr.PA25 One-touch tuning - Overshoot permissible level].
Operation	Rotate the servo motor using the controller. In the user command method, one-touch tuning cannot be performed during a servo motor stop.
One-touch tuning start, command method selection	Select "One-touch Tuning" from the Adjustment tab of MR Configurator2. Select "User command method".
Response mode selection	Select the response mode (High mode/Basic mode/Low mode) in the one-touch tuning window of MR Configurator2.
One-touch tuning execution	Click "Start" during servo motor driving.
One-touch tuning in progress	Gains and filters are adjusted automatically. During the process of the tuning, the progress status is displayed in % on MR Configurator2.
One-touch tuning complete	Once one-touch tuning is complete, the parameters will be set automatically. If tuning did not complete properly, a tuning error will be displayed. Refer to section 6.2.2 (6) "One-touch tuning error" for details.
Tuning result check	Check the tuning results. If the tuning result is not satisfactory, the servo parameters can be returned to the values they had set before one-touch tuning or the initial value. Refer to section 6.2.2 (7) "Initializing one-touch tuning" for details.
End	

1) Overshoot permissible level setting
Set the overshoot permissible level for one-touch tuning in [Pr.PA25 One-touch tuning - Overshoot permissible level]. One-touch tuning adjusts the settling time to be as short as possible within the range of the overshoot permissible level. Therefore, when the value set in [Pr.PA25] is too large, reduction of the settling time is prioritized. When the value set in [Pr.PA25] is too small, then reduction of the overshoot is prioritized.

• When the overshoot permissible level is too high

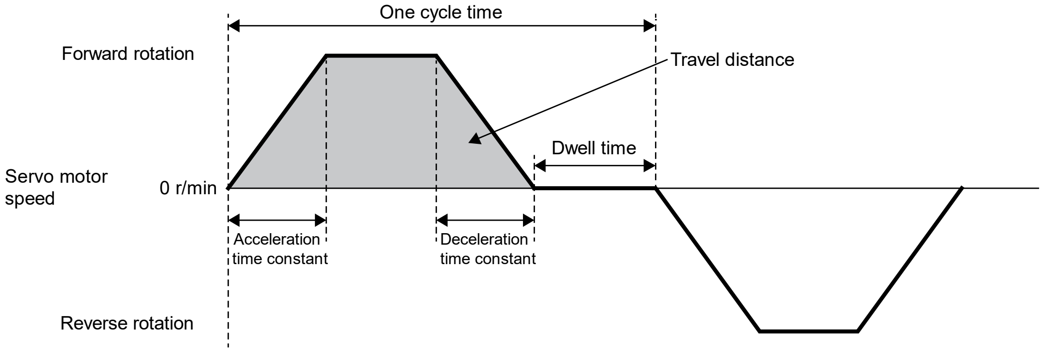


• When the overshoot permissible level is too low



2) Operation

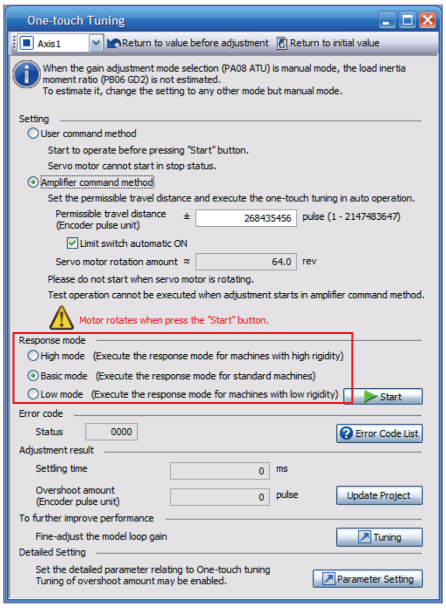
Inputting commands to the servo amplifier that satisfy the following conditions is recommended. A one-touch tuning error may occur if one-touch tuning is performed for a servo amplifier that has commands inputted which do not satisfy these conditions.



Item	Description
Travel distance	Set 100pulses or more in the encoder pulse unit. Setting less than 100pulses causes the one-touch tuning error "C_04".
Servo motor speed	Set to 50r/min (mm/s) or higher. Setting less than 50r/min may cause the one-touch tuning error "C_05".
Acceleration time constant/deceleration time constant	Set the time to reach 2000r/min (mm/s) to 5s or less. Set an acceleration time constant/deceleration time constant so that the acceleration/deceleration torque is 10% or more of the rated torque. The estimation accuracy of the load to motor inertia ratio improves as the acceleration/deceleration torque is larger, and the one-touch tuning result is closer to the optimum value.
Dwell time	Set to 200ms or more. If the value is too small, the one-touch tuning error "C_04" may occur.
One cycle time	Set to 30s or less. Setting over 30s causes the one-touch tuning error "C_04".

3) Command method and response mode selection

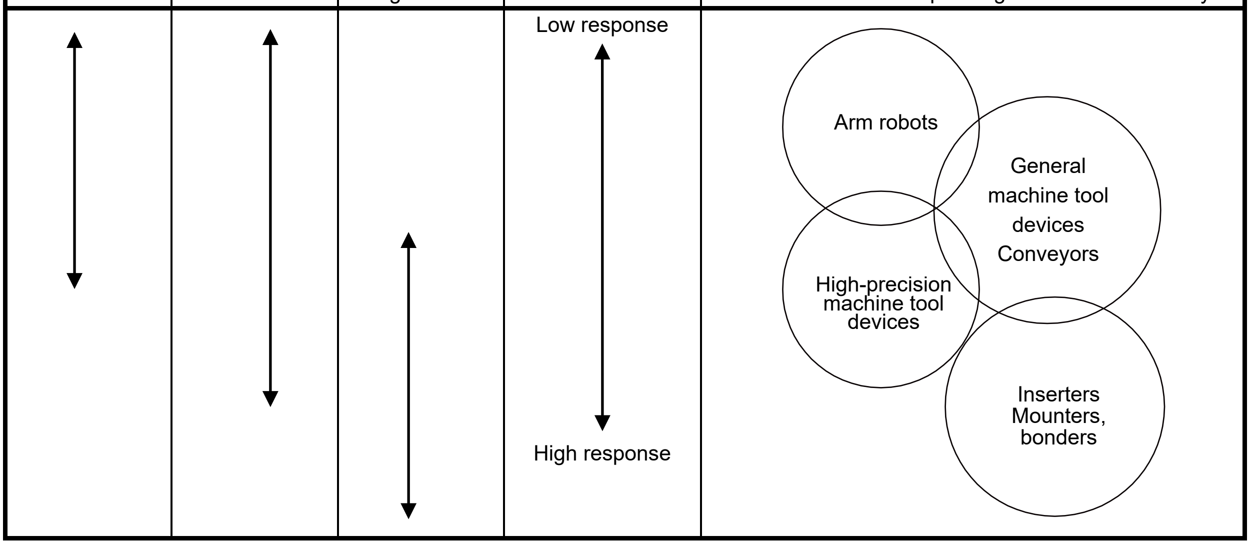
Select the user command method in the one-touch tuning window of MR Configurator2, then select a response mode from three modes. If no vibration noise occurs during tuning, perform one-touch tuning again in the high response mode.



Item	Description
High mode	This mode is for a system with high rigidity.
Basic mode	This mode is for a standard system.
Low mode	This mode is for a system with low rigidity.

Refer to the following table for selecting a response mode.

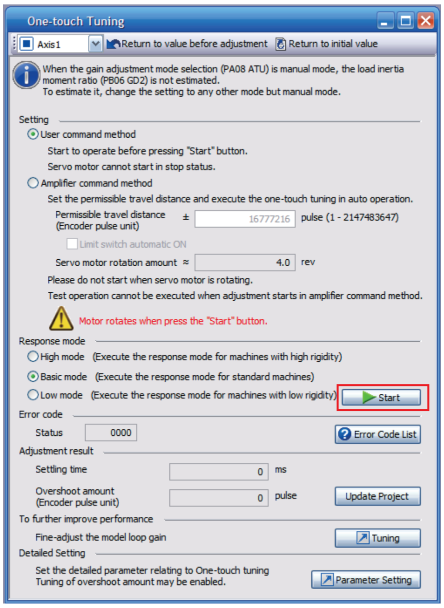
Response mode			Responsiveness	Machine characteristic
Low mode	Basic mode	High mode		Guidelines for corresponding mode and machinery



4) One-touch tuning execution

Clicking "Start" after selecting the response mode starts one-touch tuning in the user command method. Refer to (3) (a) 3) "Command method and response mode selection" in this section for details.

For one-touch tuning in the user command method, clicking "Start" during a servo motor stop causes "C_02" or "C_04" to appear in the error code status. (Refer to (6) "One-touch tuning error" in this section for the error codes.)



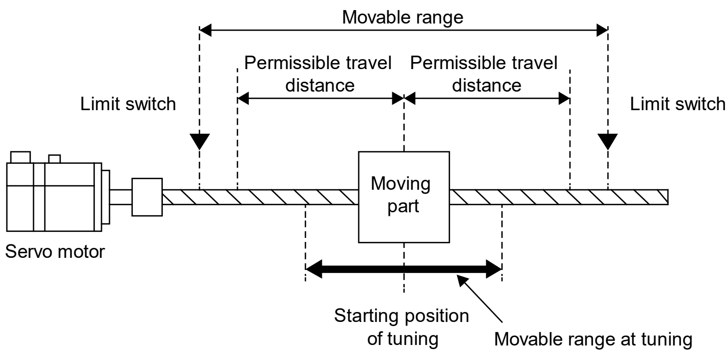
(b) One-touch tuning using the amplifier command method in MR Configurator2

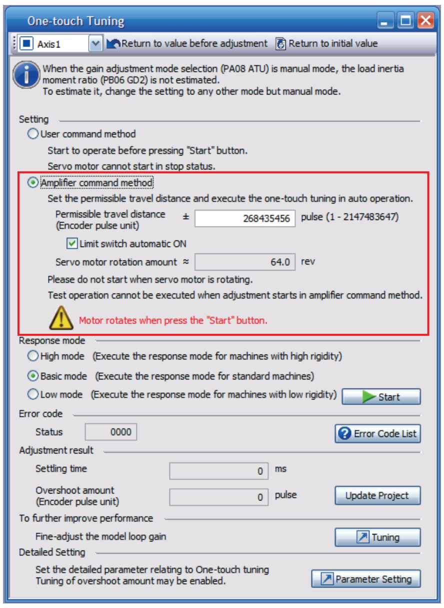
Perform one-touch tuning using the following procedure.

Start	
↓	
Moving to tuning start position	Move the movable part to the center of the movable range.
↓	
Overshoot permissible level setting	Set the overshoot permissible level for one-touch tuning in [Pr.PA25 One-touch tuning - Overshoot permissible level].
↓	
One-touch tuning start, command method selection	Select "One-touch Tuning" from the Adjustment tab of MR Configurator2. Select "Amplifier command method".
↓	
Permissible travel distance input	In the one-touch tuning window of MR Configurator2, input a maximum travel distance to move the movable part at one-touch tuning.
↓	
Response mode selection	Select the response mode (High mode/Basic mode/Low mode) in the one-touch tuning window of MR Configurator2.
↓	
One-touch tuning execution	Click the "Start" button during a servo motor stop to start one-touch tuning. Once tuning starts, the servo motor reciprocates automatically. Performing one-touch tuning during a servo motor rotation causes an error. Once performed, one-touch tuning using the amplifier command method cannot be controlled by commands from the controller.
↓	
One-touch tuning in progress	Gains and filters are adjusted automatically. During the process of the tuning, the progress status is displayed in % on MR Configurator2.
↓	
One-touch tuning complete	Once one-touch tuning is complete, the parameters will be set automatically. If tuning did not complete properly, a tuning error will be displayed. Refer to the servo parameters that are to be adjusted in section 6.2.2 (6) "One-touch tuning error" for details.
↓	
Tuning result check	Check the tuning results. If the tuning result is not satisfactory, the servo parameters can be returned to the values they had set before one-touch tuning or the initial value. Refer to section 6.2.2 (7) "Initializing one-touch tuning" for details.
↓	
Controller reset Servo amplifier power cycling	To use controller control after executing one-touch tuning, reset the controller or cycle the power of the servo amplifier.
↓	
End	

1) Overshoot permissible level setting
Refer to (3) (a) 1) "Overshoot permissible level setting" in this section for the settings of the overshoot permissible level.

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

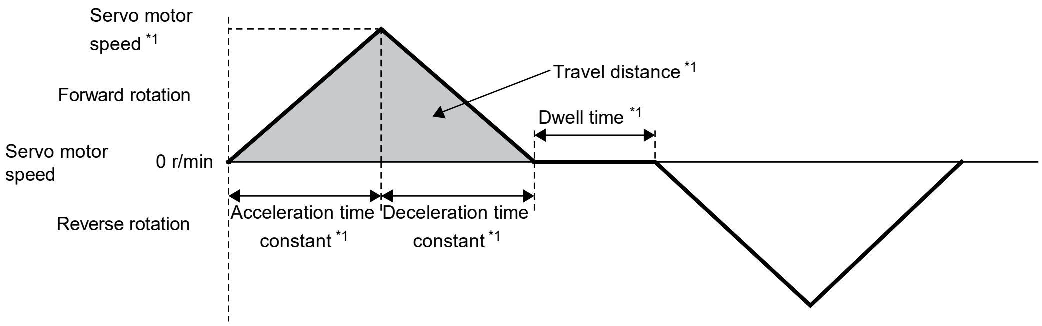




3) Response mode selection
Refer to (3) (a) 3) "Command method and response mode selection" in this section for the response mode.

4) One-touch tuning execution

Clicking "Start" after selecting a response mode starts the one-touch tuning in the amplifier command method. Refer to (3) (a) 3) "Command method and response mode selection" in this section for details. Clicking "Start" for one-touch tuning using the amplifier command method while in the servo-off state automatically turns on servo-on and starts one-touch tuning. For one-touch tuning using the amplifier command method, an optimum tuning command like the one shown below is generated inside the servo amplifier after servo-on. After that, one-touch tuning is performed with the servo motor reciprocating.



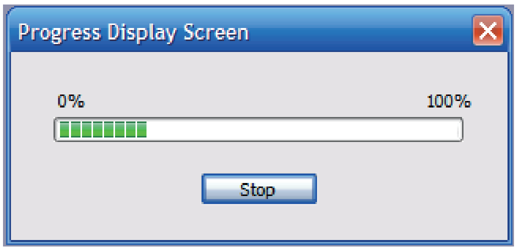
*1. These items are automatically generated in the servo amplifier.

Item	Description
Travel distance	An optimum travel distance is automatically set in the range not exceeding the user-input permissible travel distance with MR Configurator2.
Servo motor speed	A speed that does not exceed the overspeed alarm detection level and also does not exceed 1/2 of the rated speed is automatically set.
Acceleration time constant Deceleration time constant	An acceleration time constant/deceleration time constant is automatically set so as not to exceed 60% of the rated torque and the torque limit value set at the start of one-touch tuning using the amplifier command method.
Dwell time	A dwell time in which the one-touch tuning error "C_04" does not occur will be automatically set.

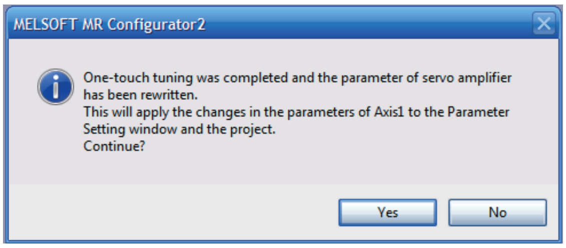
5) Progress display during one-touch tuning

Clicking "Start" for one-touch tuning using the amplifier command method while in the servo-off state automatically turns on servo-on and starts one-touch tuning. For one-touch tuning using the amplifier command method, an optimum tuning command is generated inside the servo amplifier after servo-on. After that, one-touch tuning is performed with the servo motor reciprocating. After tuning is completed or canceled, the servo amplifier is automatically switched to servo-off state. For the MR-J5-_A_ servo amplifiers, the servo amplifiers stay in servo-on state if the servo-on command is input from outside.

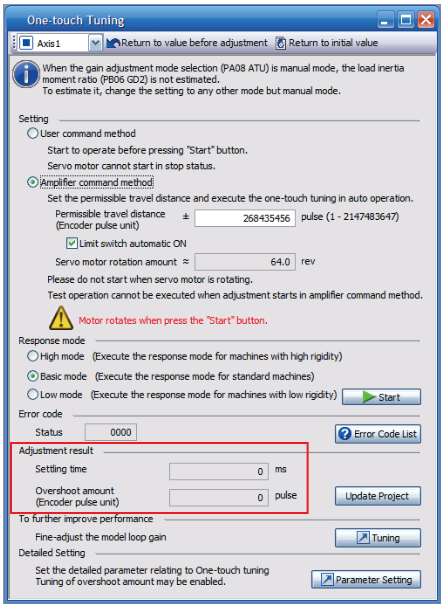
During one-touch tuning, the progress status is displayed in the progress window as follows. One-touch tuning completes when the progress reaches 100%.



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



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



(c) One touch adjustment procedure with push button

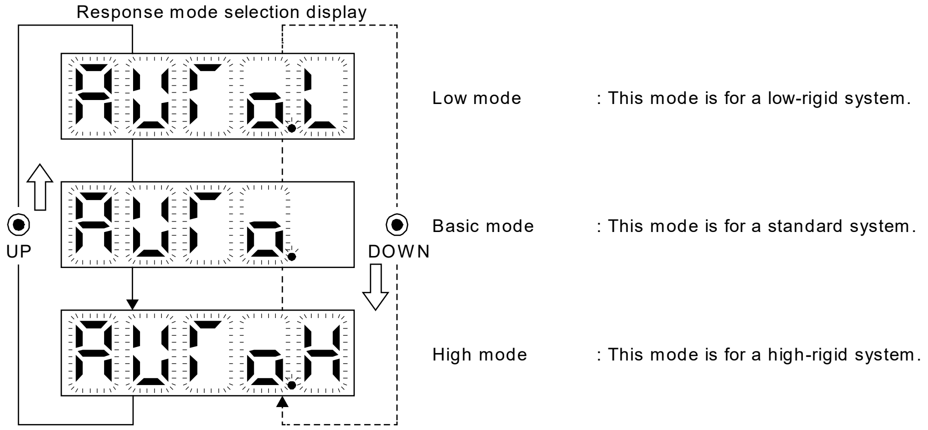
Perform one-touch tuning using the following procedure.

Start	
↓	
Overshoot permissible level setting	Set the in-position range for one-touch tuning in [Pr.PA25 One-touch tuning - Overshoot permissible level].
↓	
Operation	Rotate the servo motor using the controller. In the user command method, one-touch tuning cannot be performed during a servo motor stop.
↓	
Switching to one-touch tuning mode	Push "MODE" during motor driving to switch to the initial screen ("AUTO.") of one-touch tuning. While "AUTO" is being displayed, push the "SET" button for 2s or more to switch to the response mode selection ("AUTO."). By pushing "MODE" and "SET" at the same time for 3s or more, switching to the response mode selection ("AUTO.") can be done without going through the initial display of one-touch tuning ("AUTO").
↓	
Response mode selection	Push "UP" or "DOWN", and select the response mode from "AUTO.H" (High mode), "AUTO." (Basic mode), and "AUTO.L" (Low mode).
↓	
One-touch tuning execution	Push "SET" to start one-touch tuning. Push "SET" during servo motor driving.
↓	
One-touch tuning in progress	Gains and filters are adjusted automatically. During the process of tuning, the progress status is displayed in % on the display (five-digit, seven-segment LED).
↓	
One-touch tuning complete	Once one-touch tuning is complete, the parameters will be set automatically. If tuning did not complete properly, a tuning error will be displayed. Refer to section 6.2.2 (7) "Initializing one-touch tuning" for details.
↓	
Tuning result check	Check the tuning results. If the tuning result is not satisfactory, the servo parameters can be returned to the values they had set before one-touch tuning or the initial value. Refer to section 6.2.2 (7) "Initializing one-touch tuning" for details.
↓	
End	

1) Overshoot permissible level setting
Refer to (3) (a) 1) "Overshoot permissible level setting" in this section for the settings of the overshoot permissible level.

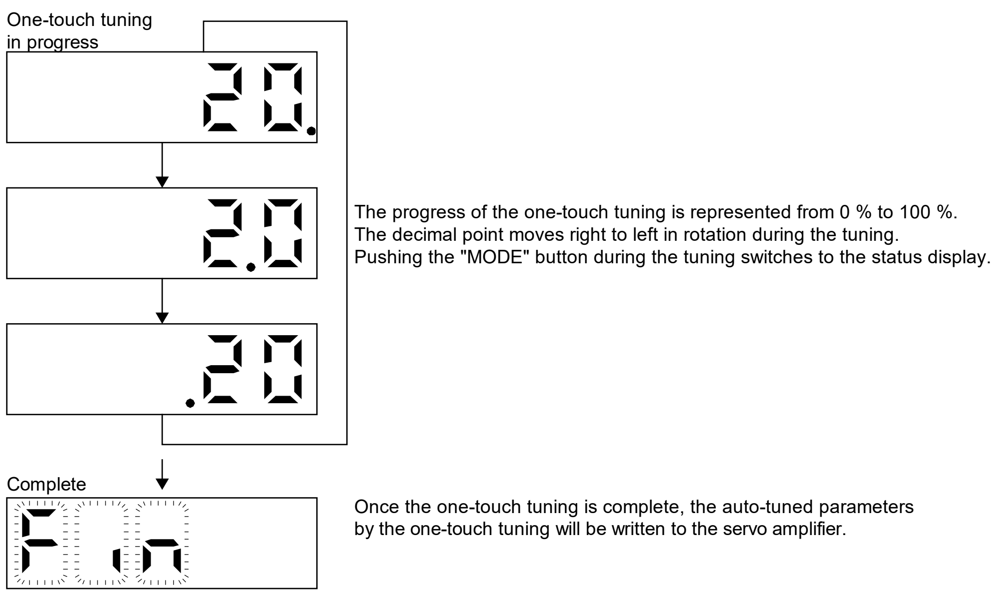
2) Operation
Refer to (3) (a) 2) "Operation" in this section for operation.

3) Response mode selection
Select a response mode for one-touch tuning from three modes with the "UP" button or the "DOWN" button. Refer to (3) (a) 3) "Command method and response mode selection" in this section for guidelines of the response mode.



4) One-touch tuning execution
After the response mode is selected, pushing "SET" starts one-touch tuning.
Refer to (3) (a) 4) "One-touch tuning execution" in this section for details.

5) Progress display during one-touch tuning
The following are displayed during one-touch tuning.



(4) Servo parameters adjusted with one-touch tuning

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

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

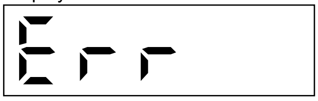
(5) One-touch tuning stop method

(a) On MR Configurator2

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

(b) With push buttons

Stop symbol



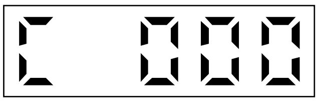
Once the one-touch tuning mode is in progress, the one-touch tuning mode can be stopped by pushing the "SET" button regardless of what is displayed on the screen.

2 s interval

The stop symbol and error code "C 000" (cancel during tuning) will be displayed by turns with 2 s interval.

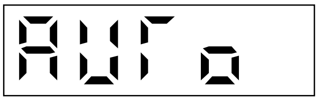
After the one-touch tuning is stopped, the servo parameters are restored to the values at the start of the one-touch tuning.

Error code



Pushing the "SET" button will switch to the initial screen.

Initial screen



When performing the one-touch tuning again, stop the servo motor once.

(6) One-touch tuning error

(a) On MR Configurator2

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

Display	Name	Error description	Handling example
C000	Tuning canceled	The "Stop" button was clicked during one-touch tuning.	–
C_01	Overshoot exceeded	The overshoot amount is larger than the value set in [Pr.PA10 In-position range] and [Pr.PA25 One-touch tuning - Overshoot permissible level].	Increase the in-position range or the overshoot permissible level.
C_02	Servo-off during tuning	One-touch tuning using the user command method was attempted during servo-off. The servo amplifier was set to servo-off state during one-touch tuning.	Perform one-touch tuning using the user command method in servo-on state. Do not allow the servo amplifier to enter servo-off state during one-touch tuning.
C_03	Control mode error	One-touch tuning was attempted when torque mode was selected as the control mode.	Select position mode or velocity mode as the control mode, then perform one-touch tuning without control switching.
		Control switching from the position mode to the speed mode was attempted during one-touch tuning.	
C_04	Time-out	One cycle time during the operation exceeds 30s.	Set one cycle time during the operation (time from the command start to the next command start) to 30s or less.
		The command speed is too slow.	Set the servo motor speed to 100r/min (mm/s) or higher. An error is less likely to occur if the command speed is higher.
		The dwell time during continuous operation (stop time between commands) is too short.	Set the dwell time to 200ms or more. An error is less likely to occur as the setting time is longer.
C_05	Load inertia moment ratio misestimated	The estimation of the load to motor inertia ratio at one-touch tuning has failed.	Drive the servo motor under the following conditions: • Time to reach 2000r/min (mm/s) is the acceleration/deceleration time constant of 5s or less. • Speed is 50r/min (mm/s) or higher. • The load to motor inertia ratio to the servo motor is 100 times or less. • The acceleration/deceleration torque is 10% or more of the rated torque.
		The load to motor inertia ratio cannot be estimated due to the effect of oscillation, etc.	Set [Pr.PA08.0 Gain adjustment mode selection] to "3" (manual mode), and set the correct value of load to motor inertia ratio to [Pr.PB06 Load to motor inertia ratio], then execute one-touch tuning.
C_06	Amplifier command start error	One-touch tuning using the amplifier command method was attempted under the following speed conditions. Servo motor speed: 20[r/min] or higher	Perform one-touch tuning using the amplifier command method when the servo motor is at a stop.

Display	Name	Error description	Handling example
C_07	Amplifier command generation error	One-touch tuning (amplifier command) was performed with a permissible travel distance of 100[pulses] or less in the encoder pulse unit, or with a permissible travel distance that limited the servo motor speed to less than 50[r/min] (for direct drive motors, less than 15[r/min]) when estimating the load to motor inertia ratio.	Execute one-touch tuning using the amplifier command method after setting the permissible travel distance to be 100[pulses] or more in the encoder pulse unit, or setting the distance so that the servo motor speed is 50[r/min] or more (15[r/min] or more for direct drive motors) at the load to motor inertia ratio estimation. The permissible travel distance required for estimating the load to motor inertia ratio is two or more rotations as a guide value. If [Pr.PA08.0 Gain adjustment mode selection] is set to "3" (manual mode) at the start of one-touch tuning, the load to motor inertia ratio estimation is not performed. If the servo motor speed cannot be set to 50[r/min (mm/s)] or more (15[r/min] or more for direct drive motors) because the permissible travel distance is too short, execute one-touch tuning using the amplifier command method while manual mode is set ("3" in [Pr.PA08.0]).
		The overspeed alarm detection level is set where the servo motor speed becomes 50[r/min] or less (for direct drive motors, 15[r/min] or less) at the time of load to motor inertia ratio estimation.	When estimating the load to motor inertia ratio, set the overspeed alarm detection level to be 50[r/min] or more (for direct drive motors, 15[r/min] or more).
		The torque limit value has been set to 0.	Set the torque limit to a value greater than 0.
C_08	Stop signal	LSP and LSN were turned off during one-touch tuning using the amplifier command method. EM2 was turned off during one-touch tuning using the amplifier command method.	Review the start position and the permissible travel distance for the amplifier command method. After ensuring safety, turn EM2 on.
C_09	Parameter	Servo parameter for manufacturer setting has been changed.	Restore the servo parameters for manufacturer setting to the initial values.
C_0A	Alarm	One-touch tuning using the amplifier command method was attempted while there was an alarm or a warning. An alarm or a warning occurred during one-touch tuning using the amplifier command method.	Start one-touch tuning using the amplifier command method when there is no alarm or warning. Ensure that an alarm or a warning does not occur during one-touch tuning using the amplifier command method.
C00F	One-touch tuning Disabled	[Pr.PA21.0 One-touch tuning function selection] is set to "0" (disabled).	Set [Pr.PA21.0 One-touch tuning function selection] to "1" (enabled).

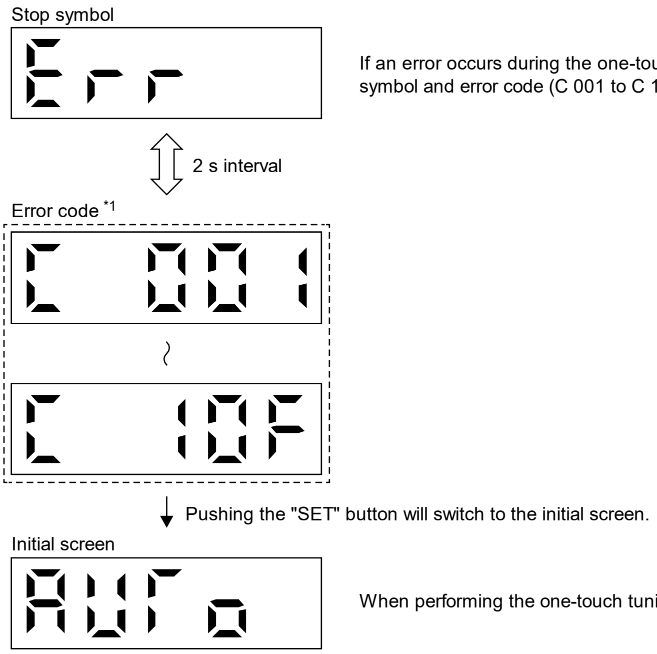
The following table shows servo parameter statuses after a one-touch tuning error has occurred.

Error code	Servo parameter after the one-touch tuning error occurrence
C0_ _	A servo parameter is returned to the value it had at the start of one-touch tuning.
C1_ _	The following servo parameters retain the values they had during one-touch tuning. Other servo parameters return to the values they had at the start of one-touch tuning. • [Pr.PA08 Auto tuning mode (ATU)] • [Pr.PA09 Auto tuning response (RSP)] • [Pr.PB01 Adaptive tuning mode (adaptive filter II) (FILT)] • [Pr.PB03 Position command speed adjustment time constant (position smoothing) (PST)] • [Pr.PB06 Load to motor inertia ratio/load to motor mass ratio (GD2)] • [Pr.PB08 Position control gain (PG2)] • [Pr.PB09 Speed control gain (VG2)] • [Pr.PB10 Speed integral compensation (VIC)] • [Pr.PB13 Machine resonance suppression filter 1 (NH1)] • [Pr.PB14 Notch shape selection 1 (NHQ1)] • [Pr.PB15 Machine resonance suppression filter 2 (NH2)] • [Pr.PB16 Notch shape selection 2 (NHQ2)] • [Pr.PB17 Shaft resonance suppression filter (NHF)] • [Pr.PB18 Low-pass filter setting (LPF)] • [Pr.PB23 Low-pass filter selection (VFBF)] • [Pr.PB46 Machine resonance suppression filter 3 (NH3)] • [Pr.PB47 Notch shape selection 3 (NHQ3)] • [Pr.PB48 Machine resonance suppression filter 4 (NH4)] • [Pr.PB49 Notch shape selection 4 (NHQ4)] • [Pr.PB51 Notch shape selection 5 (NHQ5)] • [Pr.PE41 Function selection E-3 (EOP3)]

If the error code is C1_ _, [Pr.PB07 Model control gain] returns the servo parameters to the value they had at the start of one-touch tuning. If the response from the gain after error code C1_ _ was output is not satisfactory, adjust [Pr.PB07 Model control gain] manually.

(b) With push buttons

If a tuning error occurs during the tuning, one-touch tuning is stopped. At this time, an error code is sent to the servo amplifier. Check the cause of the tuning error. Stop the servo motor before executing one-touch tuning again. In addition, perform one-touch tuning after the movable part is returned to the tuning start position. Refer to (6) (a) "On MR Configurator2" in this section for the causes of one-touch tuning error, and the servo parameters after the error.



If an error occurs during the one-touch tuning, the tuning will be forcibly terminated and the stop symbol and error code (C 001 to C 10F) will be displayed by turns with 2 s interval.

When performing the one-touch tuning again, stop the servo motor once.

*1. Refer to (6) (a) "On MR Configurator2" in this section for the causes of one-touch tuning error, and the servo parameters after the error.

(7) Initializing one-touch tuning

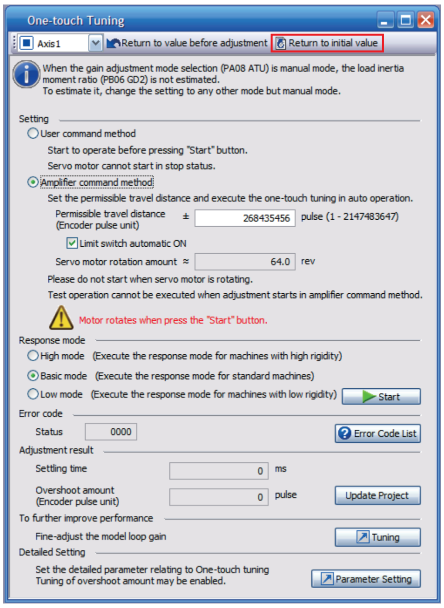
(a) Servo parameters to be initialized

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

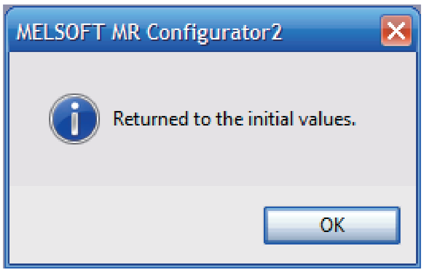
Servo parameter	Symbol	Name	Remark
PA08	ATU	Auto tuning mode	[Pr.PA08.0] is set to "1" (auto tuning mode 1).
PA09	RSP	Auto tuning response	–
PA24	AOP4	Function selection A-4	–
PB01	FILT	Adaptive tuning mode (Adaptive filter II)	–
PB02	VRFT	Vibration suppression control tuning mode	–
PB03	PST	Position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

(b) On MR Configurator2

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



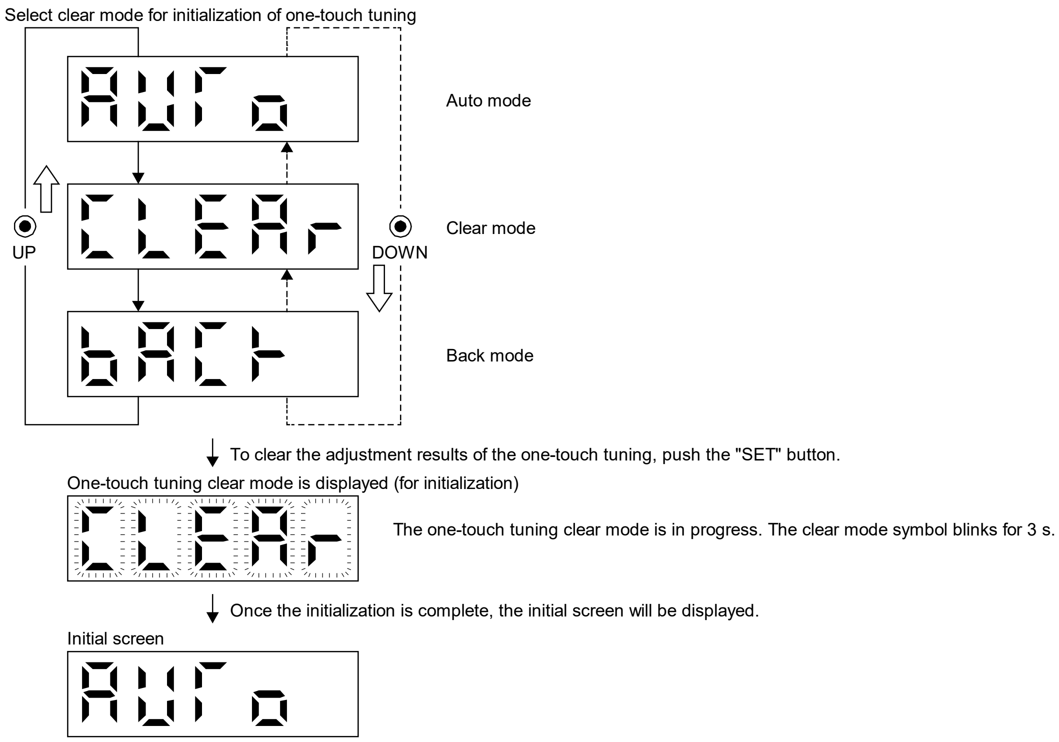
Once initialization of one-touch tuning is complete, the following window will be displayed. (When returning servo parameters to the initial value.)



(c) With push buttons

In the clear mode, the one-touch tuning result can be rewritten to the factory setting of the servo parameter. In the back mode, the one-touch tuning result can be returned to the value that was set before one-touch tuning. The setting value of the returned servo parameter is stored in the non-volatile memory.

1. Press the "MODE" button to switch to "AUTO", the initial display for one-touch tuning.
2. Select the clear mode or back mode with the "UP" and "DOWN" buttons.



6.2.3 Auto tuning

(1) Auto tuning mode 1

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

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

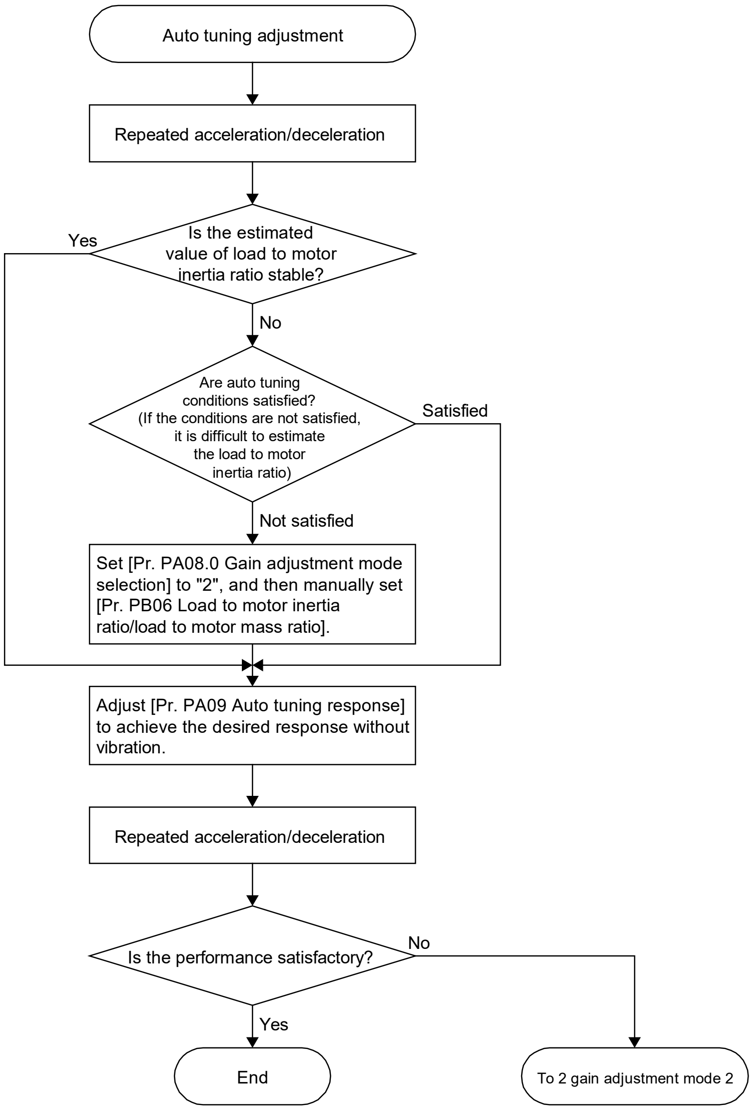
Restrictions

- All of the following conditions should be satisfied to use auto tuning mode 1.
  - The time until the acceleration/deceleration time constant reaches 2000r/min (mm/s) is 5s or less.
  - The servo motor speed is 50r/min (mm/s) or higher.
  - The load to servo motor (mass of linear servo motor primary-side or direct drive motor) inertia ratio is 100 times or less.
  - The acceleration/deceleration torque is 10% or more of the rated torque.
- The auto tuning may not function properly under operating conditions where sudden disturbance torque is applied during acceleration/deceleration, or in machines with low rigidity. In such cases, use auto tuning mode 2 or manual mode to adjust the gain.

Precautions

- If sudden disturbance torque is applied during operation, the load to motor inertia ratio may be miscalculated temporarily. In such a case, set [Pr.PA08.0 Gain adjustment mode selection] to "2" (auto tuning mode 2), and then set the accurate load to motor inertia ratio in [Pr.PB06 Load to motor inertia ratio/load to motor mass ratio].
- When auto tuning mode 1 is changed to manual mode, the current control gains and the load to motor inertia ratio estimation value are saved in the non-volatile memory.

(a) Adjustment procedure by auto tuning mode 1
The adjustment procedure is as follows.



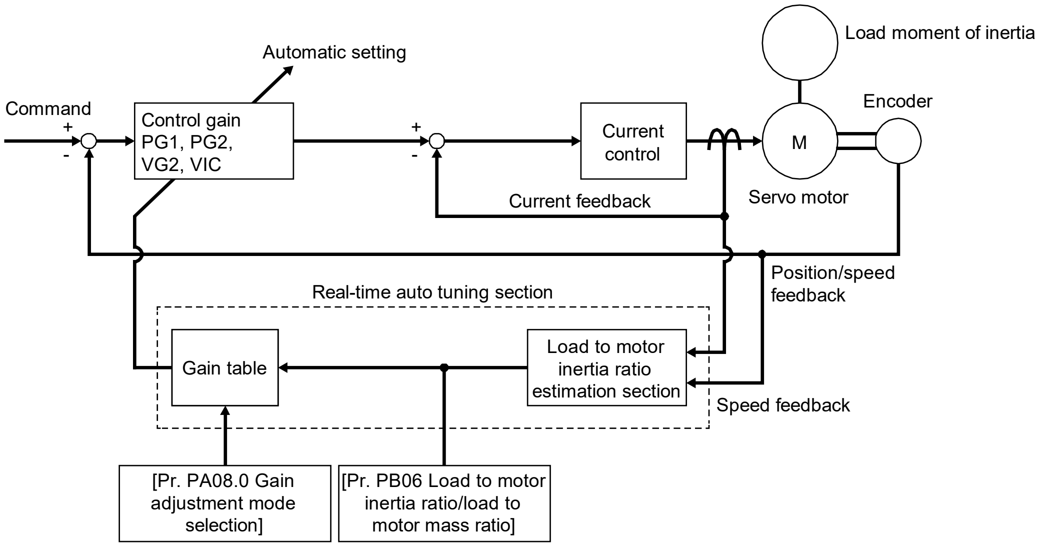
(b) Responsiveness setting in auto tuning mode 1
Set the response level for the entire servo system with [Pr.PA09]. As the responsiveness setting increases, the trackability to the command improves and the settling time becomes shorter, but vibration is more likely to occur. Therefore, set a value to obtain the desired response within the vibration-free range.
If the response level cannot be increased up to the desired level because of machine resonance beyond 100Hz, the filter tuning mode selection in [Pr.PB01.0] or machine resonance suppression filter in [Pr.PB13] to [Pr.PB16], and [Pr.PB46] to [Pr.PB51] can be used to suppress machine resonance. Suppressing machine resonance may allow the response level to be increased. Refer to section 7.1.1 (1) "Machine resonance suppression filter" and (2) "Adaptive filter II" for settings of the adaptive tuning mode and the machine resonance suppression filter.

[Pr. PA09]

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

(c) Operation of auto tuning mode 1

The block diagram for auto tuning mode 1 is shown below.



When a servo motor is accelerated/decelerated, the load to motor inertia ratio estimation section always estimates the load to motor inertia ratio from the current and speed of the servo motor. The results of estimation are written to [Pr.PB06 Load to motor inertia ratio/load to motor mass ratio]. These results can be confirmed on the status display screen of MR Configurator2.

If the value of the load to motor inertia ratio is known in advance or the estimation has failed, set [Pr.PA08.0 Gain adjustment mode selection] to "2" (auto tuning mode 2), and after stopping the estimation of the load to motor inertia ratio, set the load to motor inertia ratio ([Pr.PB06]) manually.

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

The servo parameters that are automatically adjusted in auto tuning mode 1 are shown in the table below.

Servo parameter	Symbol	Name
PB06	GD2	Load to motor inertia ratio/load to motor mass ratio
PB07	PG1	Model control gain
PB08	PG2	Position control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation

(2) Auto tuning mode 2

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

Precautions

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

(a) Adjustment procedure by auto tuning mode 2

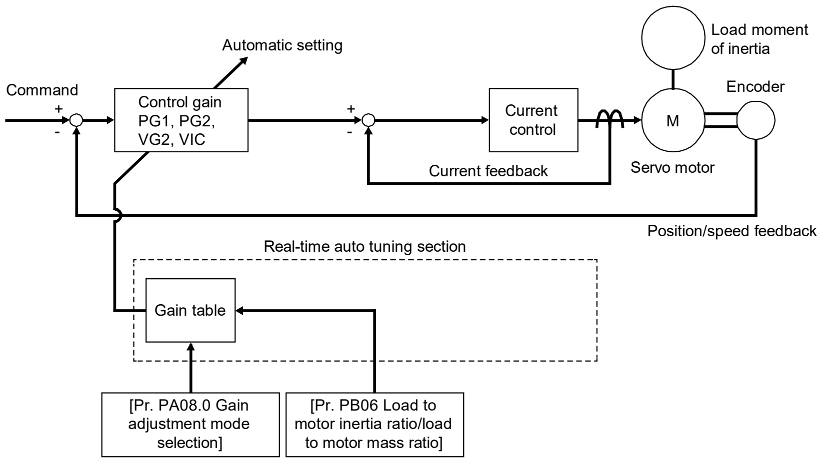
Refer to (1) (a) "Adjustment procedure by auto tuning mode 1" in this section.

(b) Responsiveness setting in auto tuning mode 2

Refer to (1) (b) "Responsiveness setting in auto tuning mode 1" in this section.

(c) Operation of auto tuning mode 2

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



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

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

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

Servo parameter	Symbol	Name
PB07	PG1	Model control gain
PB08	PG2	Position control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation

6.2.4 Manual mode

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

Precautions

- If machine resonance occurs, [Pr.PB01.0 Filter tuning mode selection] or machine resonance suppression filter in [Pr.PB13] to [Pr.PB16] and [Pr.PB46] to [Pr.PB51] can be used to suppress machine resonance. Refer to section 7.1.1 (1) "Machine resonance suppression filter" and (2) "Adaptive filter II".

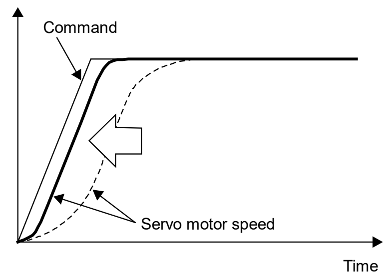
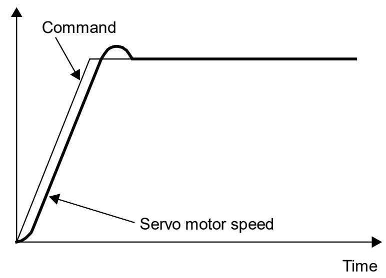
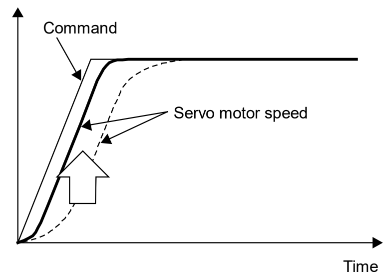
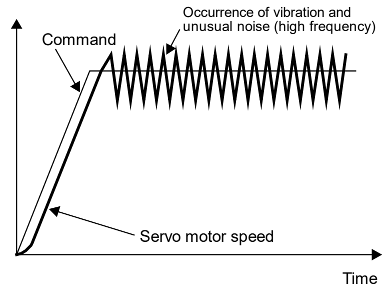
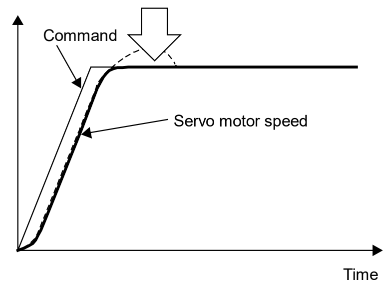
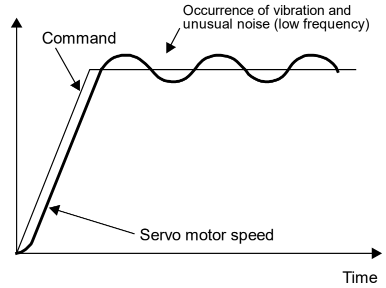
(1) Adjustment procedure for velocity mode

(a) Servo parameters

The following servo parameters are used for gain adjustment.

Servo parameter	Symbol	Name
PB06	GD2	Load to motor inertia ratio/load to motor mass ratio
PB07	PG1	Model control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation

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

<table>
<tr><th>Explanation on servo parameter</th><th>Effect when increasing the responsiveness</th><th>Operating status when increase in responsiveness is excessive</th></tr>
<tr><td>[Pr.PB07 Model control gain]
This servo parameter determines the responsiveness. Increasing the value improves trackability to a position command, but the servo motor speed is likely to be higher than the command.</td><td>
</td><td>
</td></tr>
<tr><td>[Pr.PB09 Speed control gain]
This servo parameter determines the responsiveness of the speed control loop. Increasing the value improves the responsiveness to the load disturbance, but mechanical vibration is more likely to occur.</td><td>
</td><td>
</td></tr>
<tr><td>[Pr.PB10 Speed integral compensation]
This servo parameter determines the time constant for proportional integral control of speed control loop. Decreasing the value improves the responsiveness. If the moment of inertia ratio is large or the mechanical system contains vibratory element, the mechanical system is liable to vibrate unless the value is increased to some degree.</td><td>
</td><td>
</td></tr>
</table>

(b) Adjustment procedure

Procedure	Operation	Description
1	Perform approximate adjustment with the auto tuning. Refer to section 6.2.3 (1) "Auto tuning mode 1" for details. The control gain obtained by the auto tuning is the reference value.	–
2	Change [Pr.PA08.0 Gain adjustment mode selection] to "3" (manual mode).	–
3	Set an estimated value in the load to motor inertia ratio/load to motor mass ratio. (If the estimated value by auto tuning is correct, setting change is not required.)	–
4	Set a small value to the model control gain. Set a large value to the speed integral compensation.	–
5	Increase the speed control gain within the range where vibration or unusual noise is not generated, and decrease it slightly if vibration occurs.	Increase the speed control gain.
6	Decrease the speed integral compensation within the vibration-free range. If vibration occurs, increase the value until the vibration stops.	Decrease the time constant of the speed integral compensation.
7	Increase the model control gain, and decrease it slightly if an overshoot occurs.	Increase the model control gain.
8	If the desired responsiveness cannot be achieved because of mechanical system resonance or the like which stops the gains from being increased, suppressing the resonance with adaptive tuning mode or the machine resonance suppression filter and then following steps 3 to 7 may increase the responsiveness.	Suppression of machine resonance Refer to section 7.1.1 (1) "Machine resonance suppression filter" and (2) "Adaptive filter II" for details.
9	While checking the motor status, fine-adjust each gain.	Fine adjustment

(c) Servo parameter adjustment method

1) [Pr.PB07 Model control gain]

As a guide, this servo parameter can be calculated with the following formula.

$$\text{Model control gain guideline} = \frac{\text{Speed control gain}}{(1 + \text{Load to motor inertia ratio})} \times \left(\frac{1}{4} \text{ to } \frac{1}{8}\right)$$

2) [Pr.PB09 Speed control gain]

The actual response frequency of the speed loop can be calculated with the following formula.

$$\text{Speed loop response frequency [Hz]} = \frac{\text{Speed control gain}}{(1 + \text{Load to motor inertia ratio}) \times 2\pi}$$

When adjusting [Pr.PB09 Speed control gain], increase the value gradually. Increasing the setting value causes vibration and resonance. At this time, check the value of [Pr.PB09 Speed control gain]. 70% to 80% of the value at which vibration and resonance occurred should be set as the limit value of [Pr.PB09 Speed control gain] in consideration of factors such as variations and margins between devices.

3) [Pr.PB10 Speed integral compensation]

As a guide, this servo parameter can be calculated with the following formula.

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

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

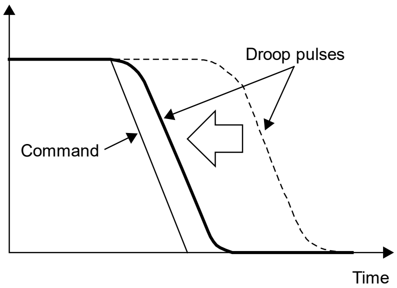
(2) Adjustment procedure for position mode

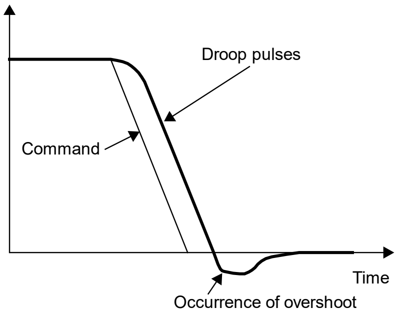
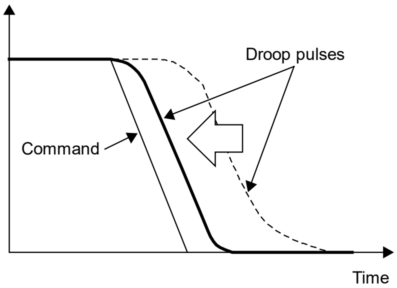
(a) Servo parameters

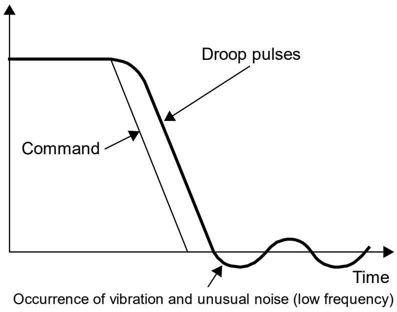
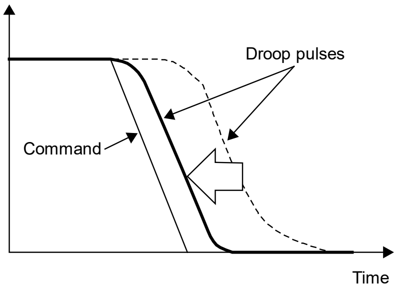
The following servo parameters are used for gain adjustment.

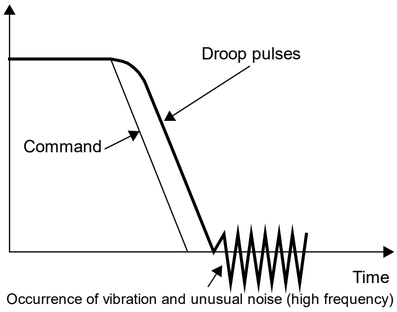
Servo parameter	Symbol	Name
PB06	GD2	Load to motor inertia ratio/load to motor mass ratio
PB07	PG1	Model control gain
PB08	PG2	Position control gain
PB09	VG2	Speed control gain
PB10	VIC	Speed integral compensation

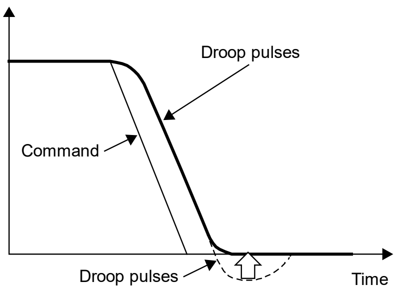
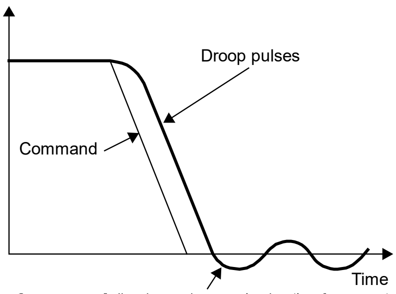
For the effect of each servo parameter, refer to the following diagram.

<table>
<tr><th>Explanation on servo parameter</th><th>Effect when increasing the responsiveness</th><th>Operating status when increase in responsiveness is excessive</th></tr>
<tr><td>[Pr.PB07 Model control gain]
This servo parameter determines the responsiveness. Increasing the value improves trackability to a position command, but an overshoot is likely to occur.</td><td>

Effect on reducing the settling time</td><td>
</td></tr>
<tr><td>[Pr.PB08 Position control gain]
This parameter is set for increasing the position response to load disturbance. Increasing the value improves the responsiveness, but vibration and noise are more likely to occur.</td><td>

Effect on reducing the settling time</td><td>
</td></tr>
<tr><td>[Pr.PB09 Speed control gain]
This servo parameter determines the responsiveness of the speed control loop. Increasing the value improves the responsiveness to the load disturbance, but mechanical vibration is more likely to occur.</td><td>

Effect on reducing the settling time</td><td>
</td></tr>
</table>

Explanation on servo parameter	Effect when increasing the responsiveness	Operating status when increase in responsiveness is excessive
[Pr.PB10 Speed integral compensation] This servo parameter determines the time constant for proportional integral control of speed control loop. Decreasing the value improves the responsiveness. If the moment of inertia ratio is large or the mechanical system contains vibratory element, the mechanical system is liable to vibrate unless the value is increased to some degree.	 	

(b) Adjustment procedure

Procedure	Operation	Description
1	Perform approximate adjustment with the auto tuning. Refer to section 6.2.3 (1) "Auto tuning mode 1" for details. The control gain obtained by the auto tuning is the reference value.	–
2	Change [Pr.PA08.0 Gain adjustment mode selection] to "3" (manual mode).	–
3	Set an estimated value in the load to motor inertia ratio/load to motor mass ratio. (If the estimated value by auto tuning is correct, setting change is not required.)	–
4	Set a small value to the model control gain and the position control gain. Set a large value to the speed integral compensation.	–
5	Increase the speed control gain within the range where vibration or unusual noise is not generated, and decrease it slightly if vibration occurs.	Increase the speed control gain.
6	Decrease the speed integral compensation within the vibration-free range. If vibration occurs, increase the value until the vibration stops.	Decrease the time constant of the speed integral compensation.
7	Increase the position control gain, and decrease it slightly if vibration occurs.	Increase the position control gain.
8	Increase the model control gain, and decrease it slightly if an overshoot occurs.	Increase the model control gain.
9	If the desired responsiveness cannot be achieved because of mechanical system resonance or the like which stops the gains from being increased, suppressing the resonance with adaptive tuning mode or the machine resonance suppression filter and then following steps 3 to 8 may increase the responsiveness.	Suppression of machine resonance Refer to section 7.1.1 (1) "Machine resonance suppression filter" and (2) "Adaptive filter II" for details.
10	While checking the settling characteristic and the motor status, fine-adjust each gain.	Fine adjustment

(c) Servo parameter adjustment method

1) [Pr.PB07 Model control gain]

As a guide, this servo parameter can be calculated with the following formula.

$$\text{Model control gain guideline} = \frac{\text{Speed control gain}}{(1 + \text{Load to motor inertia ratio})} \times \left(\frac{1}{4} \text{ to } \frac{1}{8}\right)$$

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

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

Position command frequency differs depending on the operation mode.

• For rotary servo motors and direct drive motors

$$\text{Position command frequency} = \frac{\text{Servo motor speed [r/min]}}{60} \times \text{Encoder resolution (number of pulses per servo motor revolution)}$$

• For linear servo motors

Position command frequency = Speed[mm/s] ÷ Encoder resolution (travel distance per pulse)

2) [Pr.PB08 Position control gain]

As a guide, this servo parameter can be calculated with the following formula.

$$\text{Position control gain guideline} = \frac{\text{Speed control gain}}{(1 + \text{Load to motor inertia ratio})} \times \left(\frac{1}{4} \text{ to } \frac{1}{8}\right)$$

3) [Pr.PB09 Speed control gain]

The actual response frequency of the speed loop can be calculated with the following formula.

$$\text{Speed loop response frequency [Hz]} = \frac{\text{Speed control gain}}{(1 + \text{Load to motor inertia ratio}) \times 2\pi}$$

When adjusting [Pr.PB09 Speed control gain], increase the value gradually. Increasing the setting value causes vibration and resonance. At this time, check the value of [Pr.PB09 Speed control gain]. 70% to 80% of the value at which vibration and resonance occurred should be set as the limit value of [Pr.PB09 Speed control gain] in consideration of factors such as variations and margins between devices.

4) [Pr.PB10 Speed integral compensation]

As a guide, this servo parameter can be calculated with the following formula.

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

If the setting value is less than the calculated value, oscillation may occur. If the droop pulses vibrate during a stop, increasing the value in [Pr.PB10 Speed integral compensation] is effective.

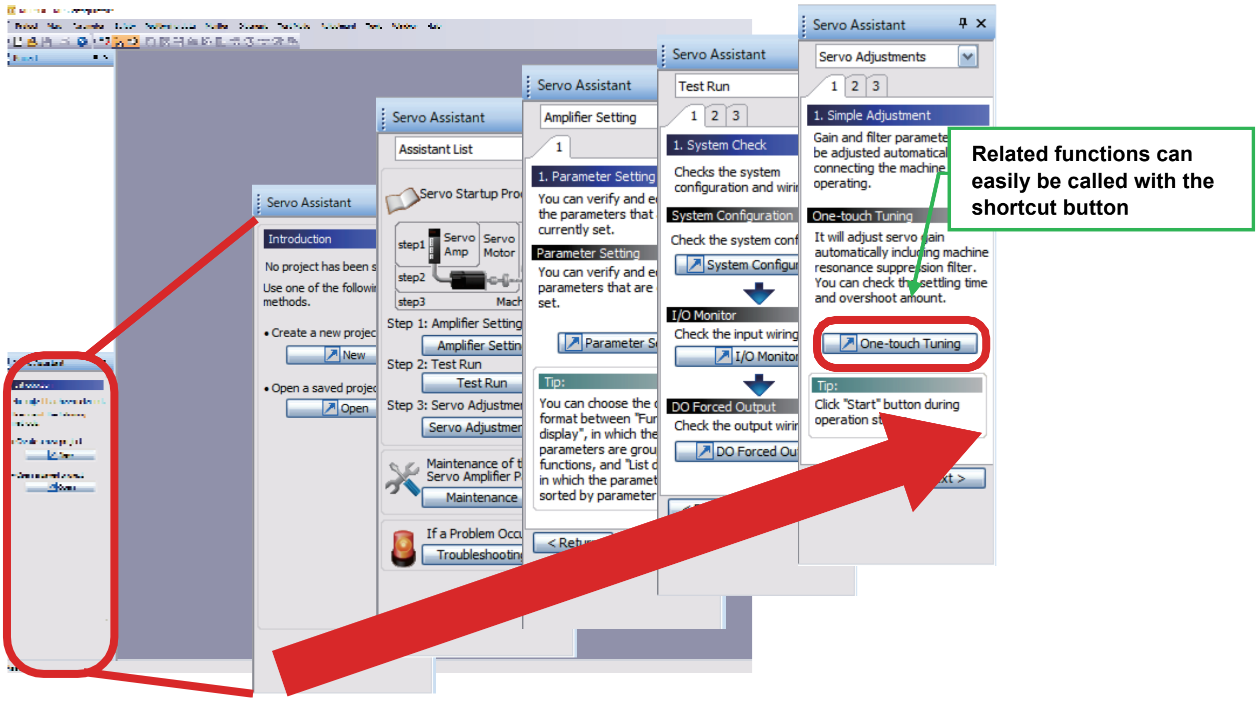
6.2.5 Adjustment using MR Configurator2

(1) Features of MR Configurator2

MR Configurator2 provides an easier-to-use engineering environment, which facilitates the settings, startup adjustment, and maintenance of servo amplifiers.
Following introduces a part of the functions.

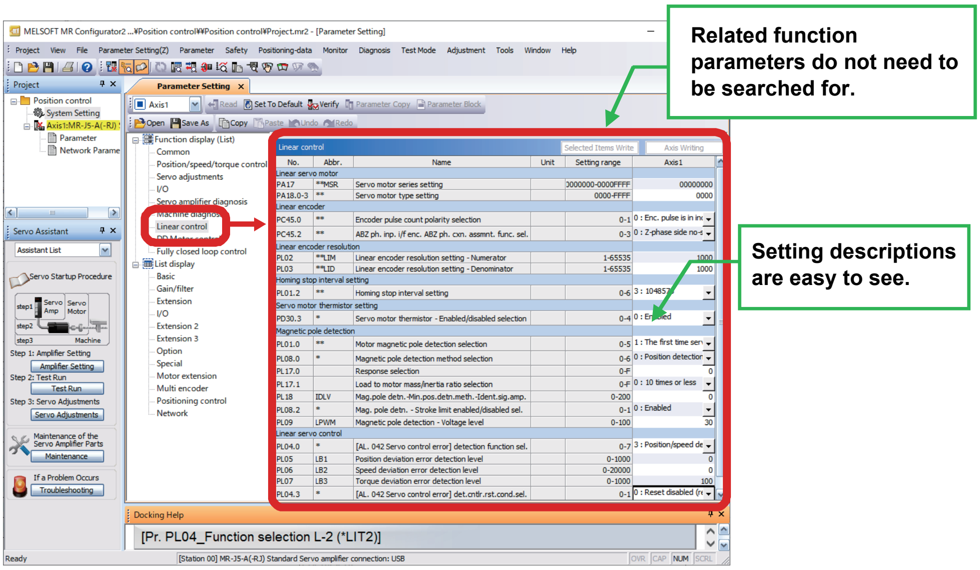
(a) Servo assistant

Servo amplifier setup completes just by following the guidance.



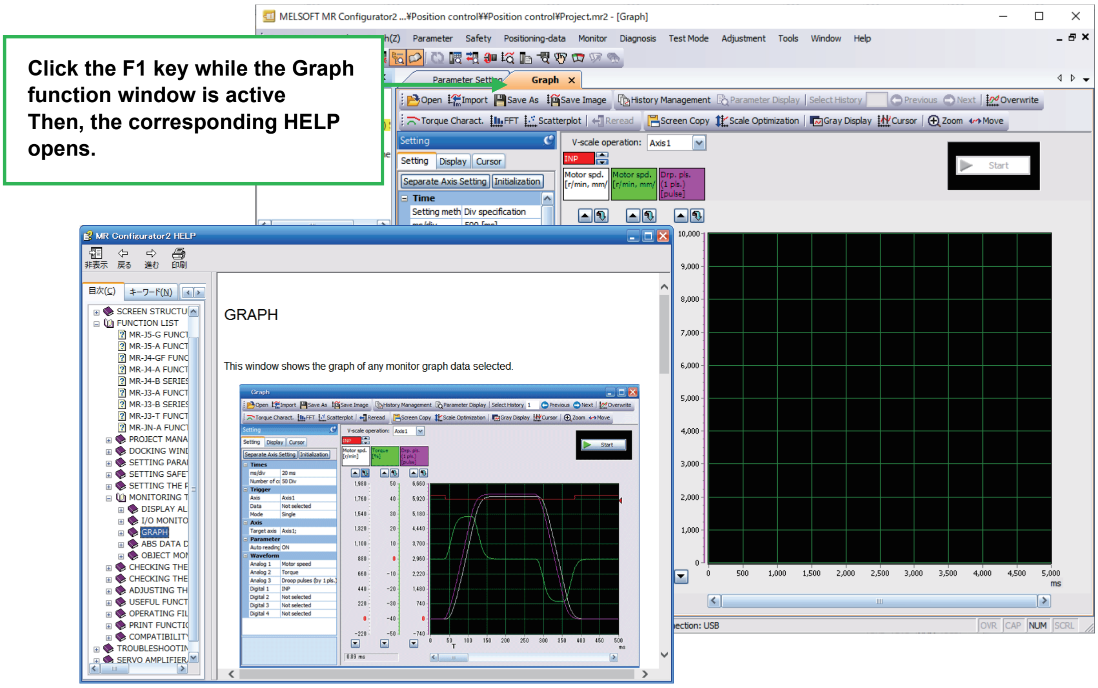
(b) Parameter settings categorized by functions

Settings can easily be configured using the parameter setting window which has contents classified in accordance with the function.



(c) Simple help function

If you have any trouble on the operation, click the F1 key to open HELP.



For usage and details of the new functions and enhanced functions that are not mentioned here, refer to the explanations of HELP/FUNCTION LIST in MR Configurator2.

For the contents changed from the conventional MR Configurator, refer to "COMPATIBILITY WITH PREDECESSORS/CHANGES FROM MR Configurator" of HELP/FUNCTION LIST in MR Configurator2.

(2) Specifications

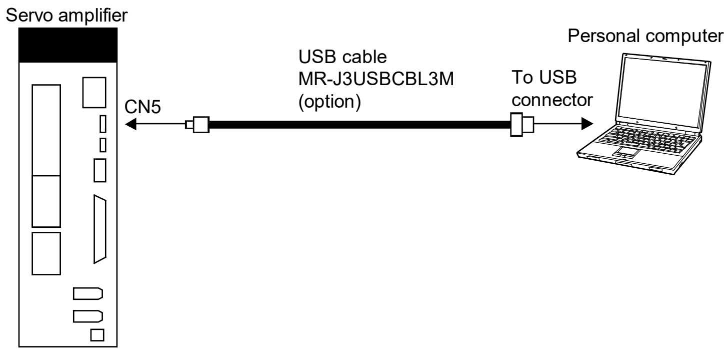
With MR Configurator2 via the communication function of the servo amplifier, operations such as parameter change using a personal computer, graph display, program operation using the simplified language, and test operation can be performed.

With the servo amplifier connected

Item		Supported
Communication channel	USB	○
	RS-422(RS-232C)	–
	Ethernet	–
Parameter	Parameter Setting	○
	Network Parameter	○
	Axis Name Setting	○
	Parameter Converter	–
Safety	Safety Parameter Setting	–
	Change Password	–
	Initialize Password	–
Positioning-data	Point Table	–
	Program	–
	Indirect Addressing	–
	Cam Data	–
Monitor	Display All	○
	I/O Monitor	○
	Graph	○
	ABS Data Display	○
Diagnosis	Alarm Display	○
	Alarm Occurrence Data	○
	Drive Recorder	○
	No Motor Rotation	○
	System Configuration	○
	Life Diagnosis	○
	Machine Diagnosis	○
	Gear Failure Diagnosis	○
	Encoder Communication Circuit Diagnosis	○
	Fully Closed Loop Diagnosis	○ *1
	Linear Diagnosis	○ *2
Test Mode	JOG Mode	○ *3
	Positioning Mode	○
	Motor-less Operation	○ *4
	DO Forced Output	○
	Program Operation	○
	Single-step Feed	–
	Test Mode Information	○
Adjustment	One-touch tuning	○
	Tuning	○
	Multi-axis Tuning	–
	Machine Analyzer	○
	Advanced Gain Search	–
Tools	Update Parameter Setting Range	○
	Machine Unit Conversion Display Setting	–

*1. Available only when the operation mode is set to the fully closed loop control.
*2. Available only when the operation mode is set to the linear servo motor control.
*3. Unavailable when the operation mode is set to the linear servo motor control.
*4. Available only when the operation mode is set to the standard control.

(3) Communication interface
Data such as parameter contents (including gains), monitor-related data (contents that can be displayed on the LED of the servo amplifier such as currents, speed, and droop pulses), input/output signals of the I/O, and alarm display are available via communication.
As information related to the protocols and commands required for communication is accessible, the user can create software for communication.



(4) Functions of MR Configurator2

MR Configurator2 features the following functions.

Initial window

Menu	Command	Main description
Project	New	Creates a new project.
	Open	Call an existing project.
	Close	Closes the currently open project.
	Save	Saves the currently open project.
	Save As	Saves the currently open project under a name.
	Delete	Deletes an MR Configurator2 format project.
	Read Other Format	Calls an MR Configurator format project.
	Write Other Format	Saves a project in the MR Configurator format.
	System Setting	Performs settings for the hardware configuration to be adjusted.
	Print Preview	Displays the print preview.
	Print	Prints the data, including parameter settings, graphs, data displays during alarm, and machine analyzer data.
	Exit MR Configurator2	Exits MR Configurator2.
View	System	Selects whether to display or hide the toolbar for the system that opens a project, prints out data, etc.
	Call Functions	Selects whether to display or hide the toolbar that calls the functions.
	Status Bar	Selects whether to display or hide the status bar.
	Docking Window	Selects whether to display or hide the Project Window, Servo Assistant, and Docking Help functions.
	Switch Display Language	Selects a language to display.
Parameter	Parameter Setting	Displays/edits servo parameters.
	Network Parameter	Displays/edits network parameters.
	Axis name setting	Sets the amplifier axis name.

To the next page

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Menu	Command	Main description
Monitor	Display All	Displays numerical servo status by items.
	I/O monitor display	Displays the status of the I/O signals, analog monitor, and other devices.
	Graph	Displays the servo status in a graph.
	ABS Data Display	Checks the absolute position data in the absolute position detection system.
Diagnosis	Alarm Display	If an alarm or warning occurs in the current servo amplifier, this command displays the details. For the alarms and warnings that occurred in the past servo amplifier, this command displays the history in a list.
	Alarm Occurrence Data	If an alarm or warning occurs in the current servo amplifier, this command displays the monitor data of the alarm occurrence.
	Drive Recorder	Displays the drive recorder.
	No Motor Rotation	Displays the cause that the servo motor fails to rotate.
	System Configuration	Displays the system configuration information.
	Life Diagnosis	Displays the service life diagnosis information.
	Machine diagnosis	Displays the machine diagnosis information.
	Gear Failure Diagnosis	Displays the gear failure diagnosis function.
	Encoder Communication Circuit Diagnosis	Displays the encoder communication circuit diagnosis function.
	Fully Closed Loop Diagnosis	Displays the monitors and parameters regarding the fully closed function.
	Linear Diagnosis	Displays the monitors and parameters regarding the linear function.
Test Mode	JOG Mode	Executes JOG operation.
	Positioning Mode	Executes positioning operation.
	Motor-less Operation	Executes motor-less operation.
	DO Forced Output	Executes DO forced output.
	Program Operation	Executes program operation.
	Test Mode Information	Displays events such as an operation start/end and alarms and warnings during an operation in chronological order.

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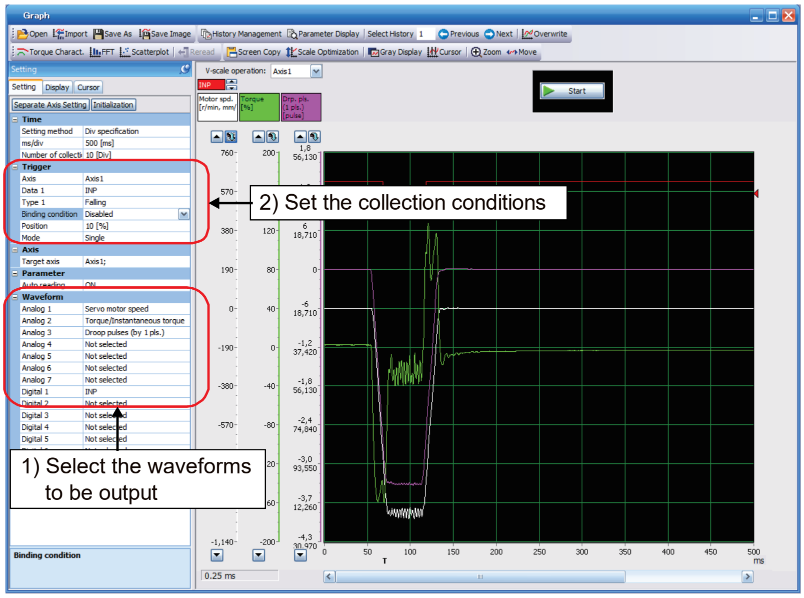
From the previous page

Menu	Command	Main description
Adjustment	One-touch tuning	Executes one-touch tuning.
	Tuning	Performs settings and adjustment of gain parameters.
	Machine Analyzer	Executes machine analyzer.
Tools	Update Parameter Setting Range	Obtains the parameter setting range from the connected servo amplifier, and updates the data file of MR Configurator2.
	Options	Changes the option settings of MR Configurator2.
Window	Cascade	Displays the screens in a cascade format.
	Tile Vertically	Displays the screens in a vertical tiled format.
	Tile horizontally	Displays the screens in a horizontal tiled format.
	Arrange Icons	Minimizes and arranges the screen icons.
	Close All Windows	Closes all the displayed windows.
	Reset Window Layout	Resets the screen size.
Help	MR Configurator2 Help	Displays MR Configurator2 Help.
	Connection to MITSUBISHI ELECTRIC FA Global Website	Displays the home page of the Mitsubishi Electric FA site.
	About MR Configurator2	Displays the version information.

(5) Graph [[Monitor] - [Graph] menu]

In the Graph window, selected monitor graph data is displayed in a graph.



Operation procedure

1) Select a waveform to be output
Set the items as follows:
Analog 1 to Servo motor speed
↓ Analog 2 to Torque/Instantaneous torque
Analog 3 to Droop pulses (in units of pulses)+
Digital 1 to INP

2) Set the collection conditions
↓ Set Trigger to INP Falling

3) Collect waveform data
Set the horizontal axis sampling to 50ms/Div
↓ Click the Start button
Start demonstration machine automatic operation
(Turn on the Start button on the operation panel)

4) Monitor the collected waveforms
↓ Adjust the vertical axis scale

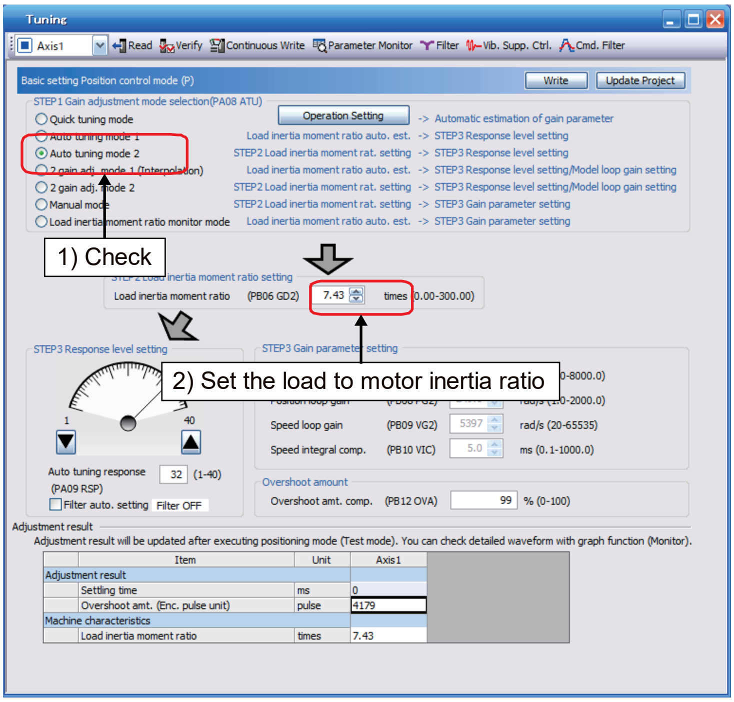
5) Store the waveform data
↓ Click the Save As menu

6) Terminate the graph

* Details can be checked on Help.

(6) Tuning [[Adjustment] - [Tuning] menu]

In the Tuning window, settings are configured by adjusting gain parameters so that the servo motor operates as intended.



Operation procedure

1) Select an auto tuning mode
↓ Select Auto tuning mode 2
2) Set the load to motor inertia ratio
↓ Set it to 7.43 times

* Details can be checked on Help.

(7) Machine analyzer [[Adjustment] - [Machine Analyzer] menu]
The mechanical frequency characteristics are generally expressed by the diagram indicating the relationship between the frequencies of the gain and phase (bode plot).
The gain indicates the amount of the response of the mechanical system to the torque input. The phase indicates the phase delay of the speed response of the mechanical system to the torque input.
If the mechanical system is rigid and does not have a resonance point, the gain will be linear.
In general, a mechanical system has a resonance point of some kind, and thus the machine analyzer can measure the frequency and amount of the resonance.
The figure below shows a monitoring example of when a mechanical system has a resonance point at 323Hz. The gain rises and the response of the machine to the input torque increases at the resonance point, thus the machine becomes more likely to vibrate by the resonance frequency as the speed gain rises.

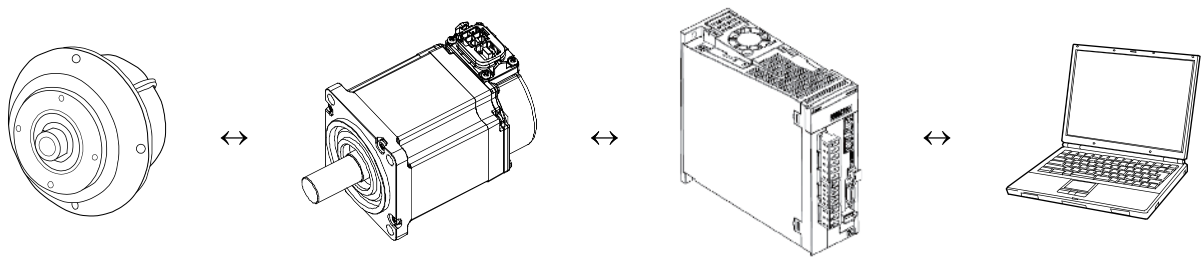
Operation procedure

1) Set Machine Analyzer
↓ Remains default
2) Execute Machine Analyzer
↓ Click the Start button
3) Monitor waveform data
↓ Check the resonance point and antiresonance point
4) Set a filter
↓ Not required if there is no resonance
5) Store the file
↓ Click the Save As menu
6) End

* Details can be checked on Help.

Yellow line: Antiresonance point Red line: Resonance point

If the resonance frequency of the mechanical system can be measured, the frequencies for machine resonance suppression filter (Pr.PB13 and Pr.PB15) can be determined based on the measured result, suppressing the machine resonance when the gain rises.



(8) Test Mode (Positioning Mode) [[Test Mode] - [Positioning Mode] menu]

Each positioning operation can be performed without commands from an external command module.

(a) Operation/drive

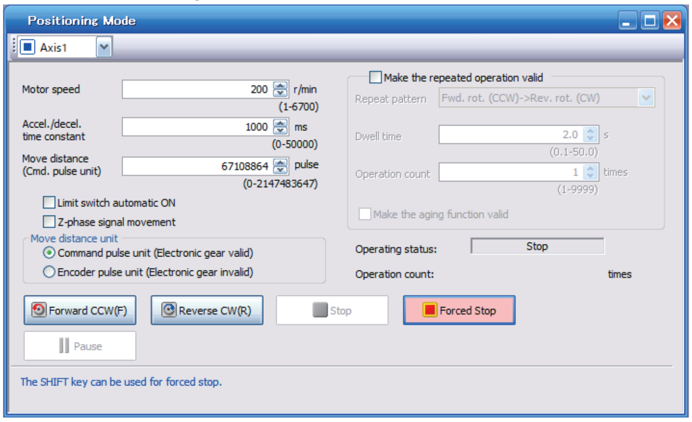
When performing positioning operation, connect between EM2 and DOCOM.

Clicking the "Forward CCW" and "Reverse CW" buttons on MR Configurator2 rotates the servo motor, then the motor stops after traveling the set travel distance. The operation conditions can be changed on MR Configurator2.

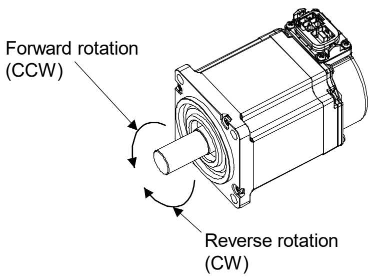
The following table shows the initial conditions and setting ranges of the operation.

Item	Initial setting value	Setting range
Motor speed [r/min]	200	1 to 6900
Acceleration/deceleration time constants [ms]	1000	0 to 50000
Travel distance [pulse]	Value obtained from the servo amplifier	0 to 2147483647

The following table shows the explanations of each button.



Button	Description
"Forward CCW"	Press to start CCW rotation.
"Reverse CW"	Press to start CW rotation.
"Pause"	Press during operation to pause the rotation. Press the "Pause" button again to erase the remaining distance. To resume the operation, press the button that started the rotation.



If the communication cable is disconnected during positioning operation, the servo motor makes a quick stop.

(b) Status display

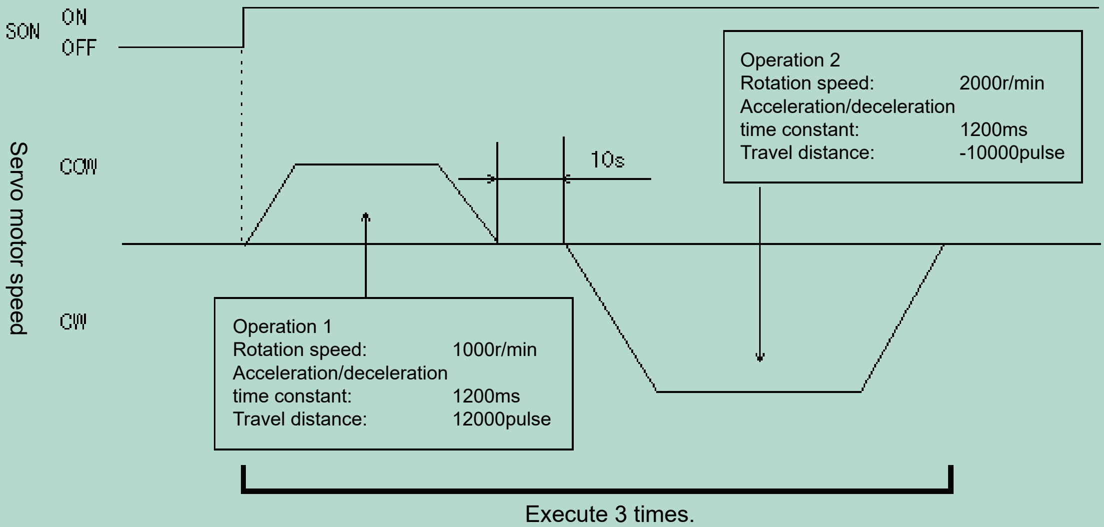
The servo status display can be monitored even while positioning operation is being executed.

Point
● MR Configurator2 is required to perform the positioning operation.

(9) Test Mode (Program Operation) [[Test Mode] - [Program Operation] menu]

(a) Program example

Press the <Start (G)> button to automatically set the SON to ON and start operation simultaneously.



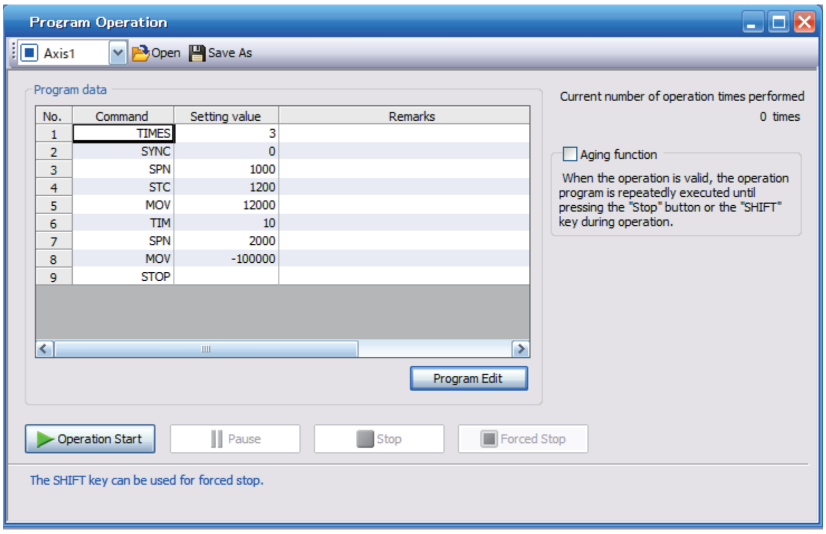
Program

```
TIMES(3) -------------- Repeat the program 3 times up to STOP.
SYNC(0) --------------- Hold the execution of the program until the
                        input signal setting 0 (SON) turns to ON.
SPN(1000) ------------- Set the command rotation speed to 1000 r/min.
STC(1200) ------------- Set the acceleration/deceleration time constant to 1200 ms.   Operation 1
MOV(12000) ------------ Travel 12000 pulses in the CCW direction.
TIM(10) --------------- Wait 10 seconds for the next operation.
SPN(2000) ------------- Set the command rotation speed to 2000 r/min.                 Operation 2
MOV(-100000) ---------- Travel 100000 pulses in the CW direction.
STOP
```

Describe the program in single-byte characters and enter a line break (press the <Enter> key) at the end of the line.

The acceleration/deceleration time constants are the same in Operation 1 and 2. In this case, Operation 2 does not need settings of the acceleration/deceleration time constants. Thus, write only the operation program of the setting values that are to be changed from the previous operation.

(Note) If a program operation is performed while the "Program Operation" window and the other window (such as the "Display All" window of Monitor) are displayed at the same time, the progress of the program may be slow causing the dwell command time to exceed the setting value.



Details of the simplified language for the program operation can be checked on Help.

Memo

7 SPECIAL ADJUSTMENT FUNCTION

7.1 Vibration Suppression Function

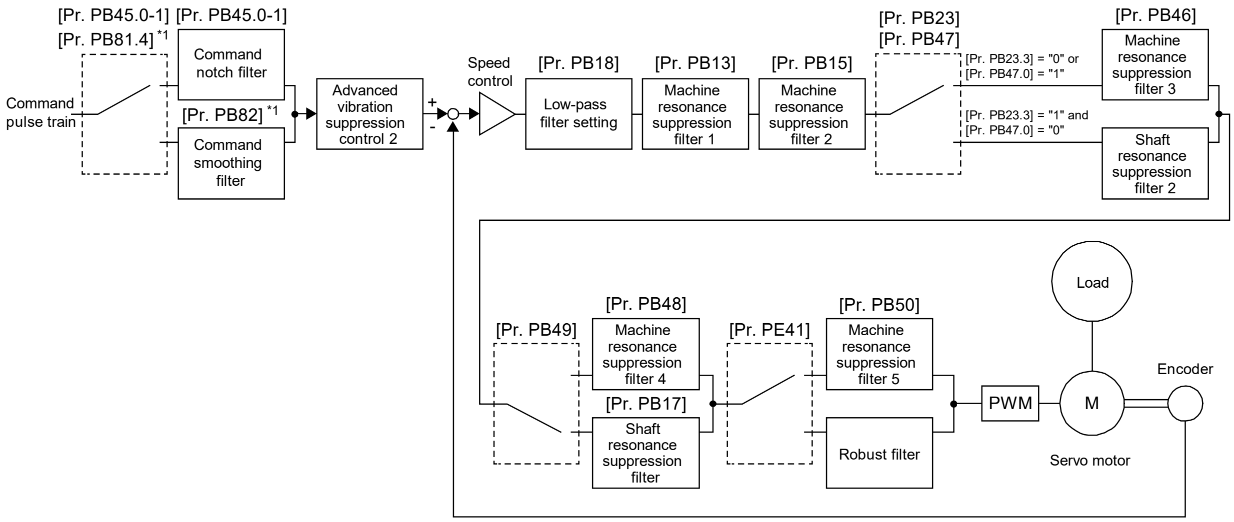
If a mechanical system has a unique resonance point, increasing the servo system response level may cause resonance (vibration or unusual noise) in the mechanical system at that resonance frequency. By using various types of filters, resonance of the mechanical system can be suppressed, improving the responsiveness of the servo system.

Point

- The functions introduced in this section do not need to be used in normal use. Use them when the machine conditions are not satisfied by the adjustment methods described in section 6.2 "Adjusting Operation Conditions".

7.1.1 Filter settings

The following filters are available with this servo amplifier.



*1. Available on servo amplifiers with software version A5 or later.

(1) Machine resonance suppression filter

If a mechanical system has a unique resonance point, increasing the servo system response level may cause resonance (vibration or unusual noise) in the mechanical system at that resonance frequency. Using the machine resonance suppression filter and adaptive tuning can suppress the resonance of the mechanical system. When the mechanical system resonates and does not meet the required performance, use the machine resonance suppression filter.

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

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

Restrictions

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

Precautions

- If the frequency of machine resonance is unknown, decrease the notch frequency from higher to lower. The optimum notch frequency is set at the point where vibration is minimal.
- By using the machine analyzer in MR Configurator2 to understand the mechanical characteristics, the frequency and characteristics of the notch can be determined.
- The machine resonance suppression filter is a delay factor for the servo system. Therefore, vibration may increases if an incorrect resonance frequency is set or the notch characteristics are too deep or too wide.
- A deeper notch has a higher effect on the machine resonance suppression but increases the phase delay, and this may cause a higher vibration.
- A wider notch has a higher effect on the machine resonance suppression, but increases the phase delay and vibration.

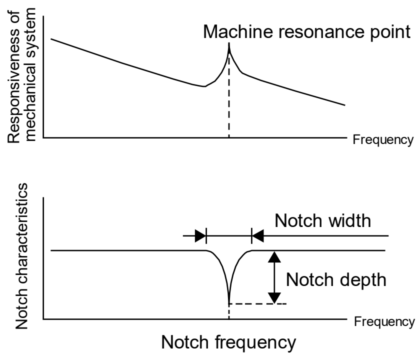
(a) Machine resonance suppression filter setting method

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

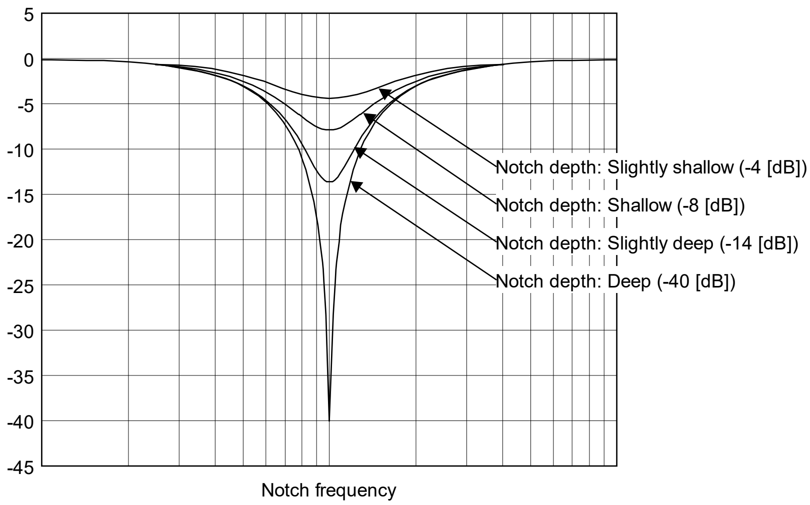
Item	Servo parameter			Remark
	Enable/Disable	Notch frequency	Notch depth, notch width	
Machine resonance suppression filter 1	[Pr.PB01.0 Filter tuning mode selection]	[Pr.PB13 Machine resonance suppression filter 1]	[Pr.PB14.1 Notch depth selection 1] [Pr.PB14.2 Notch width selection 1]	–
Machine resonance suppression filter 2	[Pr.PB16.0 Machine resonance suppression filter 2 selection]	[Pr.PB15 Machine resonance suppression filter 2]	[Pr.PB16.1 Notch depth selection 2] [Pr.PB16.2 Notch width selection 2]	–
Machine resonance suppression filter 3	[Pr.PB47.0 Machine resonance suppression filter 3 selection]	[Pr.PB46 Machine resonance suppression filter 3]	[Pr.PB47.1 Notch depth selection 3] [Pr.PB47.2 Notch width selection 3]	Shaft resonance suppression filter 2 cannot be set when machine resonance suppression filter 3 is enabled.
Machine resonance suppression filter 4	[Pr.PB49.0 Machine resonance suppression filter 4 selection]	[Pr.PB48 Machine resonance suppression filter 4]	[Pr.PB49.1 Notch depth selection 4] [Pr.PB49.2 Notch width selection 4]	Shaft resonance suppression filter cannot be set when machine resonance suppression filter 4 is enabled.
Machine resonance suppression filter 5	[Pr.PB51.0 Machine resonance suppression filter 5 selection]	[Pr.PB50 Machine resonance suppression filter 5]	[Pr.PB51.1 Notch depth selection 5] [Pr.PB51.2 Notch width selection 5]	Machine resonance suppression filter 5 cannot be used when the robust filter is enabled (i.e., when [Pr.PE41.0 Robust filter selection] is set to "1" (enabled)).

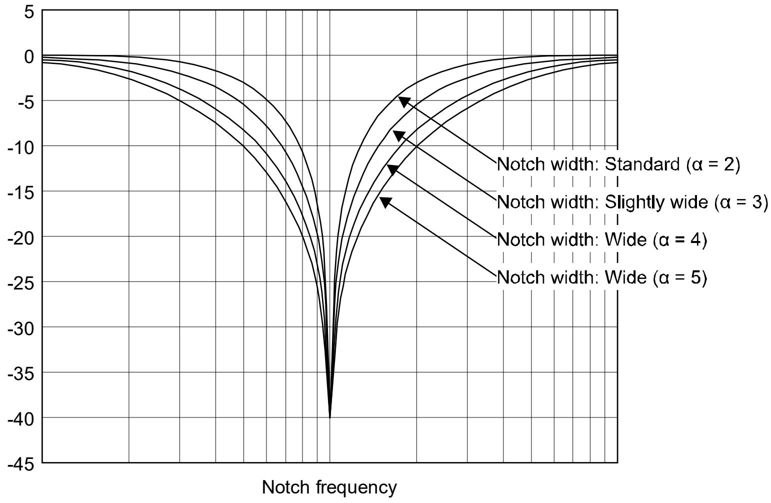
(b) Operation of machine resonance suppression filter

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



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

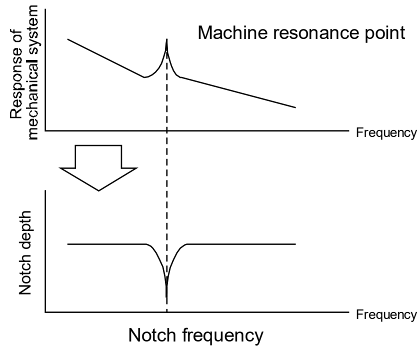




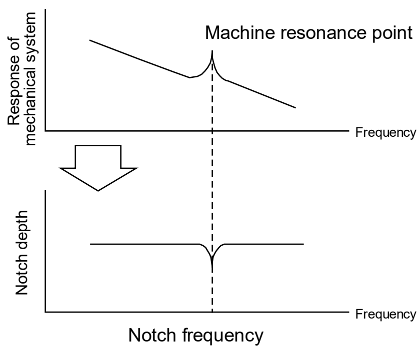
(2) Adaptive filter II

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

• When machine resonance is large and frequency is low



• When machine resonance is small and frequency is high



Restrictions

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

Precautions

- The machine resonance frequency which adaptive filter II (adaptive tuning) can respond to is about 100Hz to 2.25kHz. As for the resonance frequency out of the range, set adaptive filter II manually.
- When adaptive tuning is executed, machine resonance is detected for a maximum of 10s and a filter is generated. After filter generation, the adaptive tuning mode automatically shifts to the manual setting.
- Adaptive tuning generates an optimum filter with the currently set control gain. If vibration occurs when the response setting is increased, execute adaptive tuning again.
- Adaptive tuning generates a filter with an optimum notch depth for the set control gain. To allow a wider range of the resonance frequency for filtering, increase the notch depth in the manual setting.
- Adaptive tuning may be ineffective on a mechanical system with complex resonance characteristics.
- When the adaptive tuning is executed, vibration noise increases as the vibration signal is forcibly added for several seconds.
- In the high-accuracy mode, the frequency is estimated more accurately than in the standard mode, but the noise during adjustment is larger.

(a) How to set adaptive filter II

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

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

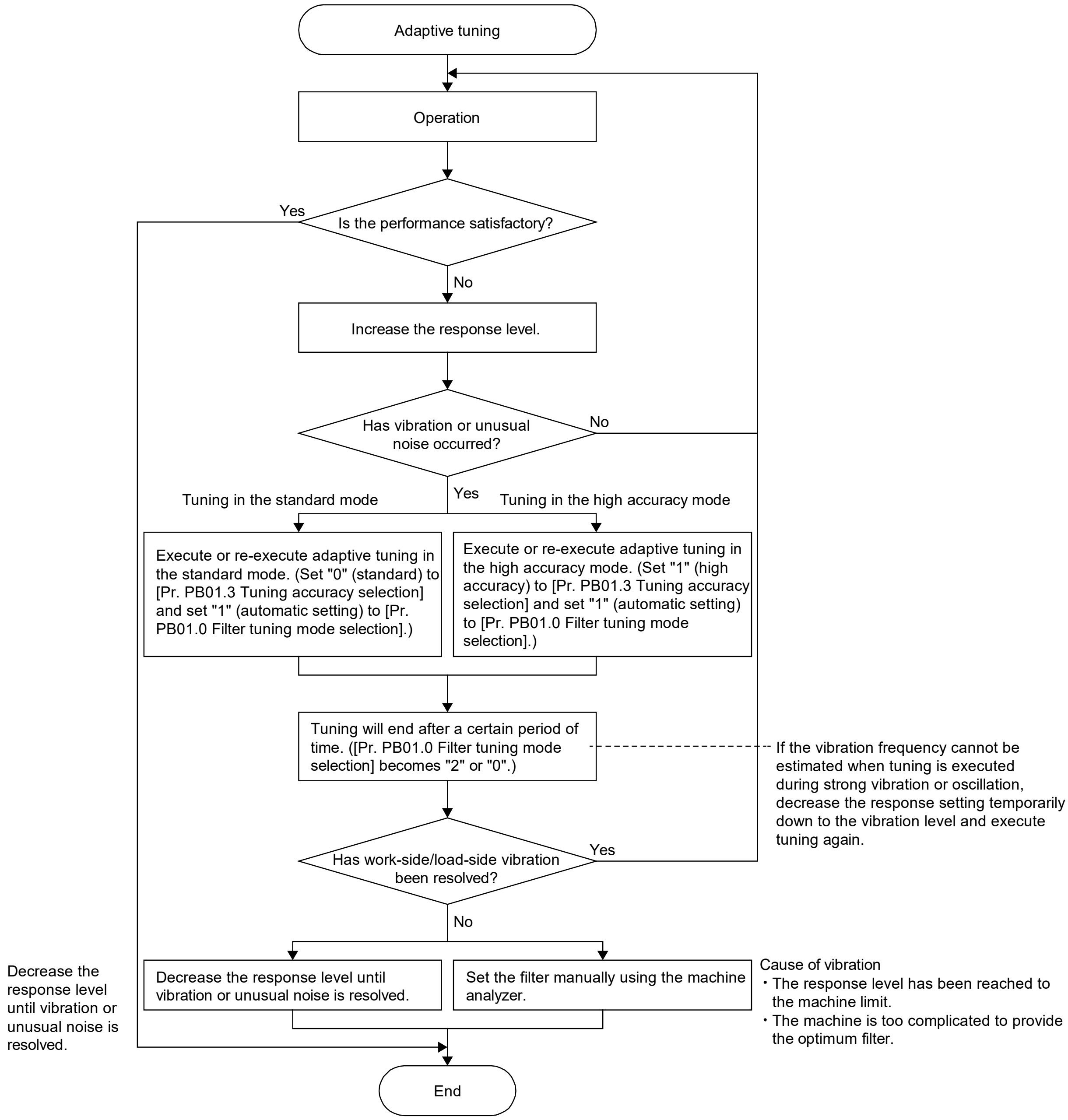
Setting value	Filter tuning mode selection	Automatically set servo parameter
0	Disabled	–
1	Automatic setting	PB13/PB14
2	Manual setting	–

• [Pr.PB01.3 Tuning accuracy selection]

0: Standard

1: High accuracy

(b) Adaptive tuning procedure



(3) Shaft resonance suppression filter

When a load is mounted to the servo motor shaft, resonance by shaft torsion during servo motor drive may generate high frequency mechanical vibration. The shaft resonance suppression filter suppresses this vibration. Selecting "Automatic setting" sets the filter automatically based on the servo motor used and the load to motor inertia ratio. If the resonance frequency is high, disable the setting to increase the responsiveness of the servo amplifier.

Precautions

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

Restrictions

- Shaft resonance suppression filter cannot be set when machine resonance suppression filter 4 is enabled.
- Shaft resonance suppression filter 2 cannot be set when machine resonance suppression filter 3 is enabled.

(a) Shaft resonance suppression filter setting method

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

Servo parameter	Description
PB23.0	Shaft resonance suppression filter selection 0: Automatic setting 1: Manual setting 2: Disabled
PB23.3	Shaft resonance suppression filter 2 selection 0: Disabled 1: Automatic setting

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

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

Setting value	Frequency [Hz]
00	Disabled
01	Disabled
02	4500
03	3000
04	2250
05	1800
06	1500
07	1285
08	1125
09	1000
0A	900
0B	818
0C	750
0D	692
0E	642
0F	600
10	562
11	529

Setting value	Frequency [Hz]
12	500
13	473
14	450
15	428
16	409
17	391
18	375
19	360
1A	346
1B	333
1C	321
1D	310
1E	300
1F	290
20	Disabled
21	Disabled
22	Disabled
23	Disabled
24	Disabled
25	Disabled
26	Disabled
27	Disabled
28	4500
29	4000
2A	3600
2B	3272
2C	3000
2D	2769
2E	2571
2F	2400
30	2250
31	2117
32	2000
33	1894
34	1800
35	1714
36	1636
37	1565
38	1500
39	1440
3A	1384
3B	1333
3C	1285
3D	1241
3E	1200
3F	1161
40	1125
41	1090
42	1058
43	1028
44	1000
45	972
46	947
47	923
48	900
49	878
4A	857

Setting value	Frequency [Hz]
4B	837
4C	818
4D	800
4E	782
4F	765
50	750
51	734
52	720
53	705
54	692
55	679
56	666
57	654
58	642
59	631
5A	620
5B	610
5C	600
5D	590
5E	580
5F	571
60	562
61	553
62	545
63	537
64	529
65	521
66	514
67	507
68	500
69	493
6A	486
6B	480
6C	473
6D	467
6E	461
6F	455
70	450
71	444
72	439
73	433
74	428
75	423
76	418
77	413
78	409
79	404
7A	400
7B	395
7C	391
7D	387
7E	382
7F	378
80	375
81	371
82	367
83	363

Setting value	Frequency [Hz]
84	360
85	356
86	352
87	349
88	346
89	342
8A	339
8B	336
8C	333
8D	330
8E	327
8F	324
90	321
91	318
92	315
93	313
94	310
95	307
96	305
97	302
98	300
99	297
9A	295
9B	292
9C	290
9D	288
9E	285
9F	283

(4) Low-pass filter

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

(a) Low-pass filter setting method

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

Servo parameter	Description
PB23.1	Low-pass filter selection 0: Automatic setting 1: Manual setting 2: Disabled

(b) Operation of low-pass filter

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

$$\text{Filter frequency ([rad/s])} = \frac{\text{VG2}}{1 + \text{GD2}} \times 10$$

(5) Robust filter

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

Restrictions

- Enabling the robust filter disables machine resonance suppression filter 5.

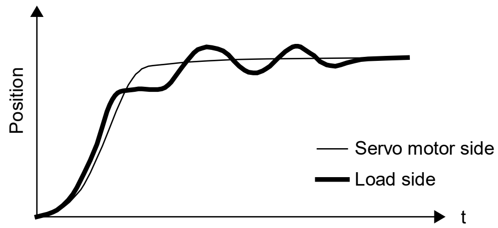
(a) Robust filter setting method

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

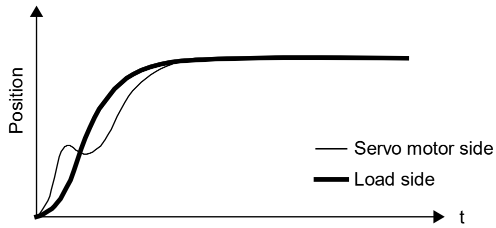
Servo parameter	Description
PE41.0	Robust filter selection 0: Disabled 1: Enabled

(6) Advanced vibration suppression control II

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



Vibration suppression control OFF (normal control)



Vibration suppression control ON

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

Precautions

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

(a) Advanced vibration suppression control restrictions

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

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

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

Vibration suppression control	Usable range	Recommended setting range
Vibration suppression control 1	[Pr.PB19] > 1/2π×(0.9×[Pr.PB07]) [Pr.PB20] > 1/2π×(0.9×[Pr.PB07])	[Pr.PB19] > 1/2π×(1.5×[Pr.PB07]) [Pr.PB20] > 1/2π×(1.5×[Pr.PB07])
Vibration suppression control 2	When [Pr.PB19] < [Pr.PB52] [Pr.PB52] > (5.0+0.1×[Pr.PB07]) [Pr.PB53] > (5.0+0.1×[Pr.PB07]) 1.1 < [Pr.PB52]/[Pr.PB19] < 5.5 [Pr.PB07] < 2π(0.3×[Pr.PB19]+1/8×[Pr.PB52])	When [Pr.PB19] < [Pr.PB52] [Pr.PB52], [Pr.PB53] > 6.25Hz 1.1 < [Pr.PB52]/[Pr.PB19] < 4 [Pr.PB07] < 1/3×(4×[Pr.PB19]+2×[Pr.PB52])

2) When calculating the setting value of [Pr.PB07] by using [Pr.PB19], [Pr.PB20], [Pr.PB52], and [Pr.PB53]
This example shows a case where [Pr.PB19] < [Pr.PB52].

Vibration suppression control	Usable range	Recommended setting range
Vibration suppression control 1	Range that meets all of the following conditions [Pr.PB07] < 2π×[Pr.PB19]/0.9 [Pr.PB07] < 2π×[Pr.PB20]/0.9	Range that meets all of the following conditions [Pr.PB07] < 2π×[Pr.PB19]/1.5 [Pr.PB07] < 2π×[Pr.PB20]/1.5
Vibration suppression control 2	• When [Pr.PB19] < [Pr.PB52] Range that meets all of the following conditions [Pr.PB07] < ([Pr.PB52]–5.0)×10 [Pr.PB07] < ([Pr.PB53]–5.0)×10 1.1 < [Pr.PB52]/[Pr.PB19] < 5.5 [Pr.PB07] < 2π(0.3×[Pr.PB19]+1/8×[Pr.PB52]) • When [Pr.PB52] ≤ [Pr.PB19] Range that meets all of the following conditions [Pr.PB07] < ([Pr.PB19]–5.0)×10 [Pr.PB07] < ([Pr.PB20]–5.0)×10 1.1 < [Pr.PB19]/[Pr.PB52] < 5.5 [Pr.PB07] < 2π(0.3×[Pr.PB52]+1/8×[Pr.PB19])	• When [Pr.PB19] < [Pr.PB52] Range that meets all of the following conditions [Pr.PB52], [Pr.PB53] > 6.25Hz 1.1 < [Pr.PB52]/[Pr.PB19] < 4 [Pr.PB07] < 1/3×(4×[Pr.PB19]+2×[Pr.PB52]) • When [Pr.PB52] ≤ [Pr.PB19] Range that meets all of the following conditions [Pr.PB19], [Pr.PB20] > 6.25Hz 1.1 < [Pr.PB19]/[Pr.PB52] < 4 [Pr.PB07] < 1/3×(4×[Pr.PB52]+2×[Pr.PB19])

The calculation example is shown in the following table.

Vibration suppression control	Servo parameter setting example		Usable range	Recommended setting range
	No.	Value		
Vibration suppression control 1	[Pr.PB19] [Pr.PB20]	20 20	[Pr.PB07] < 139.6	[Pr.PB07] < 83.7
Vibration suppression control 2	[Pr.PB19] [Pr.PB20] [Pr.PB52] [Pr.PB53]	20 20 30 30	[Pr.PB07] < 61.26	[Pr.PB07] < 46.44

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

Precautions

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

(b) Advanced vibration suppression control setting method

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

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

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

Setting value	Vibration suppression control 1 - Tuning mode selection	Automatically set servo parameter
0	Disabled	–
1	Automatic setting	PB19/PB20/PB21/PB22
2	Manual setting	–

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

Setting value	Vibration suppression control 2 - Tuning mode selection	Automatically set servo parameter
0	Disabled	–
1	Automatic setting	PB52/PB53/PB54/PB55
2	Manual setting	–

(c) Advanced vibration suppression control adjustment method

Point

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

The following is a flowchart of vibration suppression control 1. When using vibration suppression control 2, set [Pr.PB02.1 Vibration suppression control 2 tuning mode] to "1" (automatic setting), and execute vibration suppression control tuning.

When adjusting the vibration suppression control manually based on the result of the machine analyzer or the vibration waveform of the load side, set the following parameters. Set the following servo parameters to meet the applicable and recommended range. Refer to (6) (a) "Advanced vibration suppression control restrictions" in this section for value ranges.

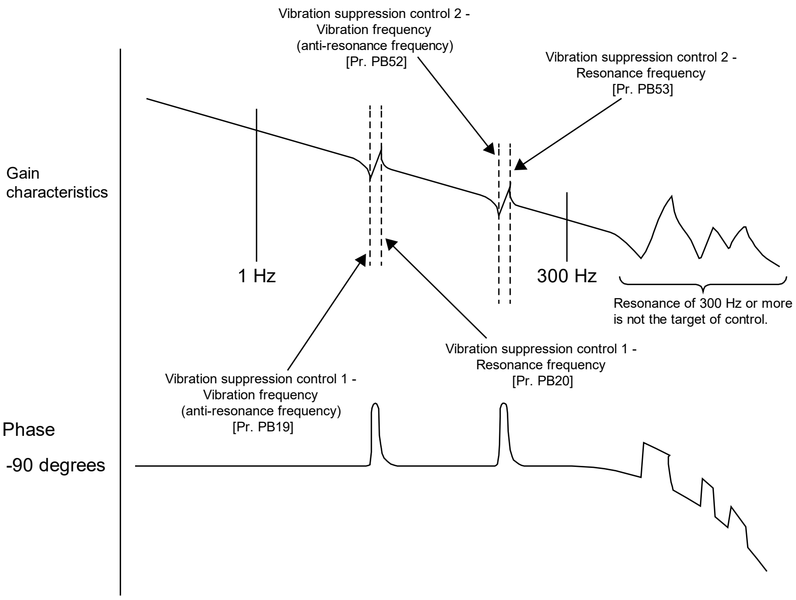
Setting item	Vibration suppression control 1	Vibration suppression control 2
Vibration suppression control - Vibration frequency	[Pr.PB19]	[Pr.PB52]
Vibration suppression control - Resonance frequency	[Pr.PB20]	[Pr.PB53]
Vibration suppression control - Vibration frequency damping	[Pr.PB21]	[Pr.PB54]
Vibration suppression control - Resonance frequency damping	[Pr.PB22]	[Pr.PB55]

The servo parameters are set using the following procedure.

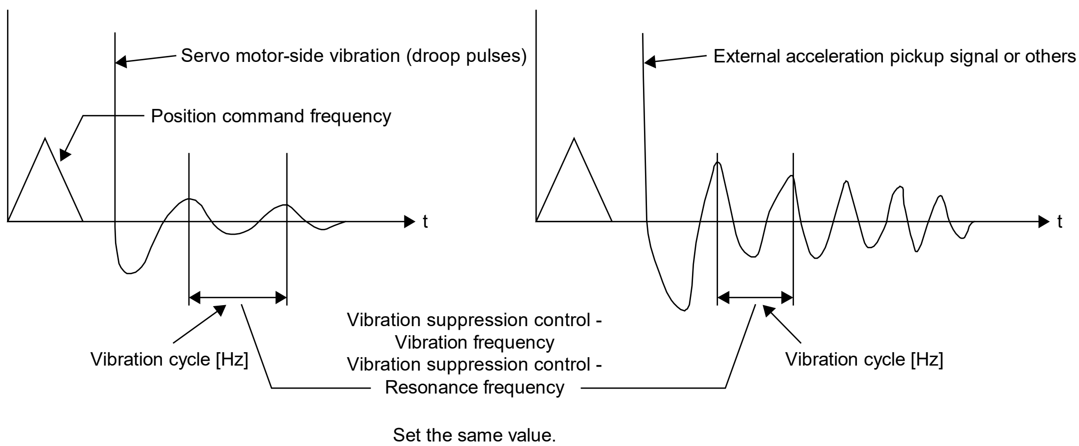
1. Select "2" (manual setting) in [Pr.PB02.0 Vibration suppression control 1 - Tuning mode selection] or [Pr.PB02.1 Vibration suppression control 2 - Tuning mode selection].

2. Set "Vibration frequency for vibration suppression control" and "Resonance frequency for vibration suppression control" as follows.

• When a vibration peak can be checked with machine analyzer in MR Configurator2 or with external measuring equipment
  If the frequency characteristic of the machine can be measured using machine analyzer in MR Configurator2 or external measuring equipment, set the frequency trough of the gain characteristic in the vibration frequency settings, and the frequency crest in the resonance frequency settings.

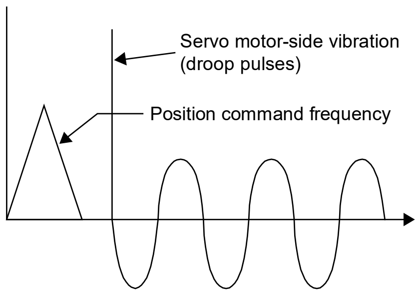


• When vibration can be confirmed using a monitor signal or an external sensor
  If the time waveform of a monitor and an external sensor can be measured, measure the droop pulses, and set the droop pulse vibration cycle of the settling time as the vibration and resonance frequency.

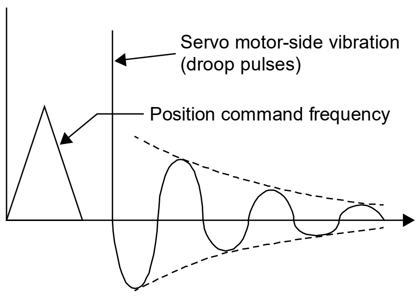


3. Set "Vibration suppression control - Vibration frequency damping" and "Vibration suppression control - Resonance frequency damping".
   The damping settings do not need to be adjusted in most cases. Decrease the damping settings in the following situations: (1) The vibration suppression effect needs to be further enhanced, or (2) The amplitude of the droop pulses at settling time was found to be sustained as a result of measurement of the droop pulses when vibration suppression control was invalid. If the amplitude of the droop pulses is decreasing quickly, increase the damping setting. By setting the damping setting appropriately, the effect of vibration suppression is enhanced.

• If the amplitude of the droop pulses is sustained



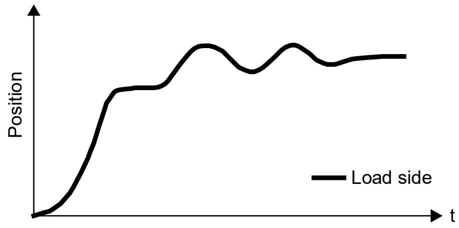
• If the amplitude of the droop pulses is decreasing quickly



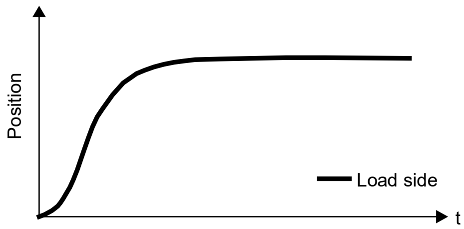
(7) Command notch filter

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

• When command notch filter is disabled



• When command notch filter is enabled



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

Function	Command notch filter	Advanced vibration suppression control II
Servo parameter	[Pr.PB45]	[Pr.PB01] [Pr.PB19] [Pr.PB20] [Pr.PB21] [Pr.PB22] [Pr.PB52] [Pr.PB53] [Pr.PB54] [Pr.PB55]
Automatic estimation	Will not be executed	Will be executed
Restriction on [Pr.PB07 Model control gain]	Will not apply	Will apply

Precautions

- Using advanced vibration suppression control II and the command notch filter can suppress the load-side vibration of three different frequencies.
- The frequency of machine vibration that can be supported by the command notch filter is specifically between 1.12Hz and 2000Hz. Set a frequency close to the machine vibration frequency and within the range.
- When [Pr.PB45 Command notch filter] is changed during the positioning operation, the changed setting is not reflected. The setting value is reflected after waiting for the following time once the servo motor stops (after servo-lock).

Setting frequency for command notch filter before the change	Waiting time for reflection of the change after servo-lock
4.5Hz or more	Approximately 150ms
1.12Hz or more to less than 4.5Hz	Approximately 500ms

(a) Command notch filter setting method

Set [Pr.PB45 Command notch filter] as shown below. For the setting frequency of the command notch filter, set the closest value to the load-side vibration frequency [Hz]. Refer to (6) (c) "Advanced vibration suppression control adjustment method" in this section for the vibration frequency check method of the load side.

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

Setting value	Frequency [Hz]
00	Disabled
01	2000
02	1000
03	666
04	500
06	400
07	333
08	285
09	250
0A	222
0B	200
0C	181
0D	166
0F	153
10	142
11	133
12	125
13	117
14	111
15	105
16	100
17	95
19	90
1A	86
1B	83
1C	80
1D	76
1E	74
1F	71
21	66
22	62
23	58
24	55
25	52
26	50
27	47
29	45
2A	43
2B	41
2C	40
2D	38
2E	37
2F	35
30	34.5
31	33.3
32	31.3
33	29.4
34	27.8
35	26.3

Setting value	Frequency [Hz]
36	25.0
38	23.8
39	22.7
3A	21.7
3B	20.8
3C	20.0
3D	19.2
3E	18.5
3F	17.9
40	17.2
41	16.7
42	15.6
43	14.7
44	13.9
45	13.2
46	12.5
48	11.9
49	11.4
4A	10.9
4B	10.4
4C	10
4D	9.6
4E	9.3
4F	8.9
50	8.6
51	8.3
52	7.8
53	7.4
54	6.9
55	6.6
56	6.3
58	6.0
59	5.7
5A	5.4
5B	5.2
5C	5.0
5D	4.8
5E	4.6
5F	4.5
60	4.31
61	4.17
62	3.91
63	3.68
64	3.47
65	3.29
66	3.13
68	2.98
69	2.84
6A	2.72
6B	2.60
6C	2.50
6D	2.40
6E	2.31
6F	2.23
71	2.08
72	1.95
73	1.84

Setting value	Frequency [Hz]
74	1.74
75	1.64
76	1.56
78	1.49
79	1.42
7A	1.36
7B	1.30
7C	1.25
7D	1.20
7E	1.16
7F	1.12

• [Pr.PB45.2 Notch depth selection]

Setting value	Depth [dB]
0	-40.0
1	-24.1
2	-18.1
3	-14.5
4	-12.0
5	-10.1
6	-8.5
7	-7.2
8	-6.0
9	-5.0
A	-4.1
B	-3.3
C	-2.5
D	-1.8
E	-1.2
F	-0.6

7.1.2 Gain switching function

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

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

Restrictions

- When [Pr.PA08.0 Gain adjustment mode selection] is set to a value other than "3" (manual mode), the gain switching cannot be used.
- Gain switching vibration suppression control ([Pr.PB33] to [Pr.PB36]/[Pr.PB56] to [Pr.PB59]) and [Pr.PB60 Gain switching - Model control gain] can be used with the input device (CDP).
- Gain switching 2 vibration suppression control ([Pr.PB71] to [Pr.PB74]/[Pr.PB75] to [Pr.PB78]) and [Pr.PB79 Gain switching 2 - Model control gain] can be used with the input device (CDP2).
- Gain switching is enabled in the position mode when the direction command is selected for gain switching and gain switching during a stop is enabled.
- Slight vibration suppression control does not allow switching of the load to motor inertia ratio/load to motor mass ratio, the model control gain, the position control gain, the speed control gain, and the speed integral compensation.

Precautions

- If the gain difference is large at gain switching, and the value in [Pr.PB28 Gain switching time constant] is small, the machine may operate unexpectedly at gain switching. In this case, increase the value in [Pr.PB28 Gain switching time constant].
- When the conditions for "Gain switching" and "Gain switching 2" are established at the same time, the servo parameters after "Gain switching 2" are set as the actual gain to be used.

(1) Setting method for gain switching

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

(a) Servo parameters for setting the gain switching condition

Servo parameter	Symbol	Name	Unit	Description
PB26	CDP	Gain switching function	–	Select the switching condition.
PB27	CDL	Gain switching condition	[kpulse/s]/[pulse]/[r/min]	Set the condition values to switch the original gain to the gain for "Gain switching".
PB28	CDT	Gain switching time constant	[ms]	Set the filter time constant for the original gain to be switched to the gain for "Gain switching".
PB65	CDL2	Gain switching 2 condition	[kpulse/s]/[pulse]/[r/min]	Set the condition values to switch the gain to the gain for "Gain switching 2". The setting value is to be larger than in [Pr.PB27 Gain switching condition]. When this setting value is "0", the gain is not switched to the gain for "Gain switching 2".
PB66	CDT2	Gain switching 2 time constant	[ms]	Set the filter time constant for the gain to be switched to the gain for "Gain switching 2".

1) [Pr.PB26 Gain switching function]

Set the conditions for gain switching. Select the switching condition from the first to fifth digits.

Servo parameter	Description
PB26.0	Gain switching selection 0: Disabled 1: Signal (CDP/C_CDP) *1 2: Command frequency 3: Droop pulses 4: Servo motor speed 5: Command direction
PB26.1	Gain switching - Condition selection 0: Gain after "Gain switching" is enabled with the condition value or more for gain switching 1: Gain after "Gain switching" is enabled with the condition value or less for gain switching Refer to "Combination of [Pr.PB26.0] and [Pr.PB26.1]" below for the combination of [Pr.PB26.0] and [Pr.PB26.1].
PB26.2	Gain switching time constant - Disabling condition selection 0: Switching time constant enabled 1: Time constant disabled at switching 2: Time constant disabled at return
PB26.4	Gain switching 2 selection When switching the gain to the gain for gain switching 2, input signals with the control command (C_CDP2) from the controller and with the input device CDP2 (gain switching 2). 0: Disabled 1: Signal (CDP2/C_CDP2) 2: The same condition as [Pr.PB26.0 Gain switching selection]
PB26.5	Gain switching selection during a stop 0: Gain switching 2 during a stop is disabled 1: Gain switching 2 during a stop is enabled This servo parameter is enabled when [Pr.PB26.0 Gain switching selection] is set to "5" (command direction) and [Pr.PB26.4 Gain switching 2 selection] is set to "2" (the same condition as [Pr.PB26.0]). In addition, this function is enabled in the position mode.

*1. Input the signals with the control command (C_CDP) and the input device CDP (Gain switching) from the controller.

• Combination of [Pr.PB26.0] and [Pr.PB26.1]

[Pr.PB26.1 Gain switching - Condition selection]	[Pr.PB26.0 Gain switching selection]				
	1	2	3	4	5
0	Gain after "Gain switching" is enabled with the signal ON	Gain after "Gain switching" is enabled with the condition value or more for gain switching			Gain after "Gain switching" is enabled with the negative direction command
1	Gain after "Gain switching" is enabled with the signal OFF	Gain after "Gain switching" is enabled with the condition value or less for gain switching			Gain after "Gain switching" is enabled with the positive direction command

2) [Pr.PB27 Gain switching condition] and [Pr.PB65 Gain switching 2 condition]
When "2" (command frequency), "3" (droop pulses), or "4" (servo motor speed) is selected in [Pr.PB26.0 Gain switching selection], set [Pr.PB27] for the level to switch the gain to "Gain switching".
In addition, when "2" (the same condition as [Pr.PB26.0]) is selected in [Pr.PB26.4 Gain switching 2 selection], set the level for switching the gain to "Gain switching 2" in [Pr.PB65].
The setting unit is shown in the following table.

Gain switching condition	Unit
Command frequency	[kpulse/s]
Droop pulses	[pulse]
Servo motor speed	[r/min]

3) [Pr.PB28 Gain switching time constant], [Pr.PB66 Gain switching 2 time constant]
The primary delay filter can be set to each gain in gain switching. If the gain difference is too large at gain switching, use these servo parameters to suppress the shock applied to the machine, etc.

(b) Servo parameters that are changeable with the gain switching

Control gain	Before gain switching		After gain switching		After gain switching 2	
	Servo parameter	Symbol	Servo parameter	Symbol	Servo parameter	Symbol
Load to motor inertia ratio/load to motor mass ratio	PB06	GD2	PB29	GD2B	PB67	GD2C
Model control gain	PB07	PG1	PB60	PG1B	PB79	PG1C
Position control gain	PB08	PG2	PB30	PG2B	PB68	PG2C
Speed control gain	PB09	VG2	PB31	VG2B	PB69	VG2C
Speed integral compensation	PB10	VIC	PB32	VICB	PB70	VICC
Vibration suppression control 1 - Vibration frequency	PB19	VRF11	PB33	VRF1B	PB71	VRF1C
Vibration suppression control 1 - Resonance frequency	PB20	VRF12	PB34	VRF2B	PB72	VRF2C
Vibration suppression control 1 - Vibration frequency damping	PB21	VRF13	PB35	VRF3B	PB73	VRF3C
Vibration suppression control 1 - Resonance frequency damping	PB22	VRF14	PB36	VRF4B	PB74	VRF4C
Vibration suppression control 2 - Vibration frequency	PB52	VRF21	PB56	VRF21B	PB75	VRF21C
Vibration suppression control 2 - Resonance frequency	PB53	VRF22	PB57	VRF22B	PB76	VRF22C
Vibration suppression control 2 - Vibration frequency damping	PB54	VRF23	PB58	VRF23B	PB77	VRF23C
Vibration suppression control 2 - Resonance frequency damping	PB55	VRF24	PB59	VRF24B	PB78	VRF24C

1) [Pr.PB06] to [Pr.PB10]
These servo parameters are the same as in the ordinary manual adjustment. Switching the gains enables the values to be switched in load to motor inertia ratio, position control gain, model control gain, speed control gain, and speed integral compensation.

2) [Pr.PB19] to [Pr.PB22]/[Pr.PB52] to [Pr.PB55]
These servo parameters are the same as in the ordinary manual adjustment. During a servo motor stop, by switching the gain with on/off of the input device (CDP) or the control command from the controller, the values are enabled to be switched in the vibration frequency, resonance frequency, vibration frequency damping setting, and resonance frequency damping setting.

3) [Pr.PB29 Load to motor inertia ratio/load to motor mass ratio after gain switching], [Pr.PB67 Load to motor inertia ratio/load to motor mass ratio after gain switching]
Set the load to motor inertia ratio after gain switching. If the load to motor inertia ratio does not change, set the same value as [Pr.PB06 Load to motor inertia ratio].

4) [Pr.PB30 Position control gain after gain switching], [Pr.PB68 Gain switching 2 - Position control gain]
Set the position control gain after gain switching.

5) [Pr.PB31 Speed control gain after gain switching], [Pr.PB69 Gain switching 2 - Speed control gain]
Set the speed control gain after gain switching.

6) [Pr.PB32 Speed integral compensation after gain switching], [Pr.PB70 Gain switching 2 - Speed integral compensation]
Set the speed integral compensation after gain switching.

7) [Pr.PB60 Model control gain after gain switching], [Pr.PB79 Gain switching 2 - Model control gain]
The Model control gain after gain switching and the Gain switching 2 - Model control gain can be used only with on/off of the input device (CDP) and the control command from the controller.

8) Vibration suppression control after gain switching ([Pr.PB33] to [Pr.PB36]/[Pr.PB56] to [Pr.PB59]), and Gain switching 2 - Vibration suppression control ([Pr.PB71] to [Pr.PB79])
Vibration suppression control after gain switching and Gain switching 2 - Vibration suppression control are enabled only with on/off of the input device (CDP) and the control command from the controller.

(2) Examples of gain switching operation

(a) Gain switching by servo motor speed

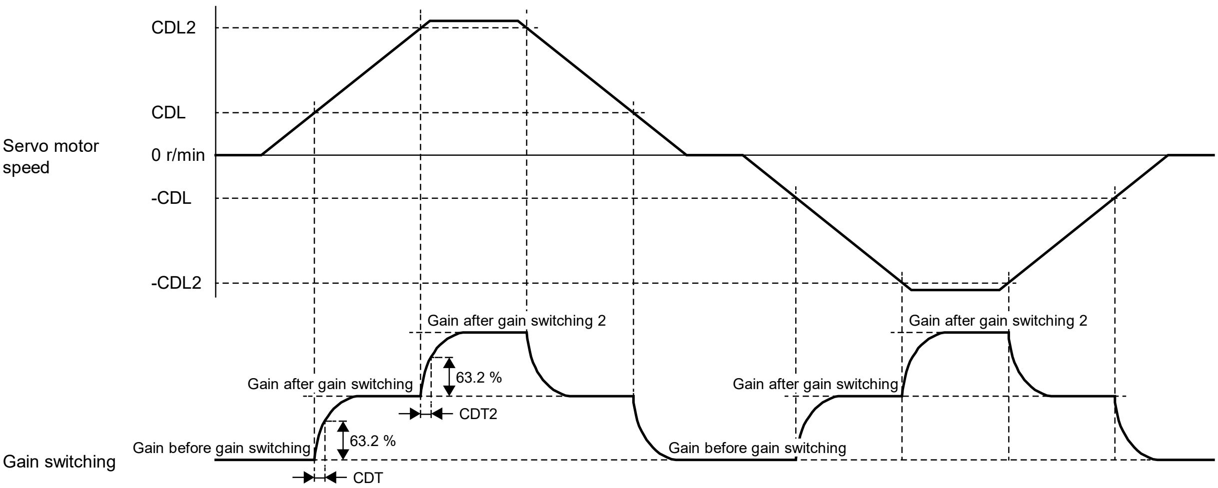
The following illustrates an example where [Pr.PB26.0 Gain switching selection] is set to "4" (servo motor speed) and [Pr.PB26.4 Gain switching 2 selection] is set to "2" (the same condition as [Pr.PB26.0]).

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

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

• When [Pr.PB65] ≥ [Pr.PB27]

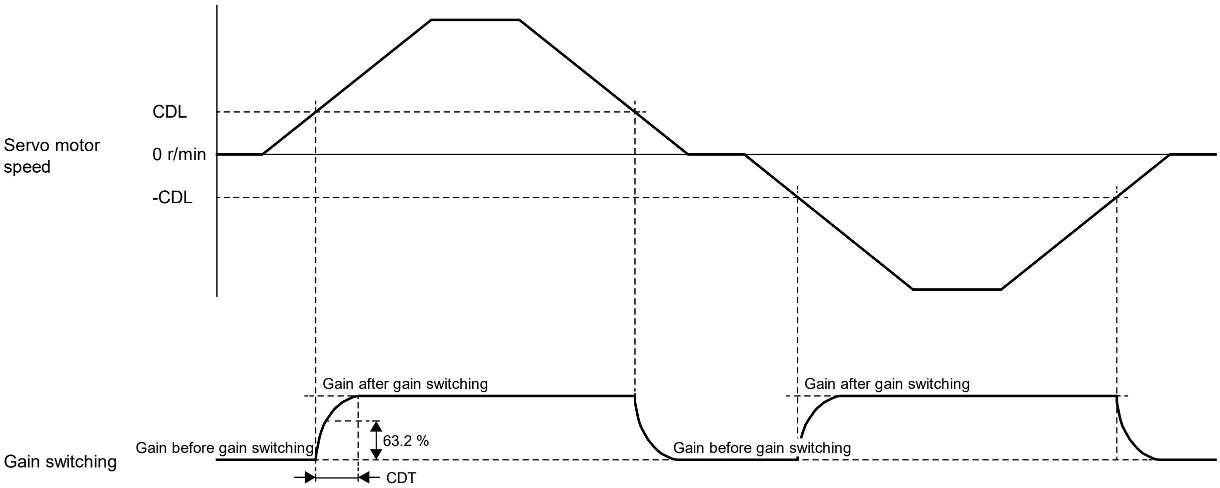
For the case of [Pr.PB65] ≥ [Pr.PB27], the gain switches to "Gain after gain switching" when the absolute value of the servo motor speed exceeds the value of [Pr.PB27]. In addition, when the absolute value of the servo motor speed exceeds the value of [Pr.PB65], the gain switches to "Gain after switching 2".



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	[Pr. PB29]	[Pr. PB67]	[Pr. PB29]	[Pr. PB06]	[Pr. PB29]	[Pr. PB67]	[Pr. PB29]	[Pr. PB06]
Position control gain	[Pr. PB08]	[Pr. PB30]	[Pr. PB68]	[Pr. PB30]	[Pr. PB08]	[Pr. PB30]	[Pr. PB68]	[Pr. PB30]	[Pr. PB08]
Speed control gain	[Pr. PB09]	[Pr. PB31]	[Pr. PB69]	[Pr. PB31]	[Pr. PB09]	[Pr. PB31]	[Pr. PB69]	[Pr. PB31]	[Pr. PB09]
Speed integral compensation	[Pr. PB10]	[Pr. PB32]	[Pr. PB70]	[Pr. PB32]	[Pr. PB10]	[Pr. PB32]	[Pr. PB70]	[Pr. PB32]	[Pr. PB10]

• When [Pr.PB65] is set to "0"

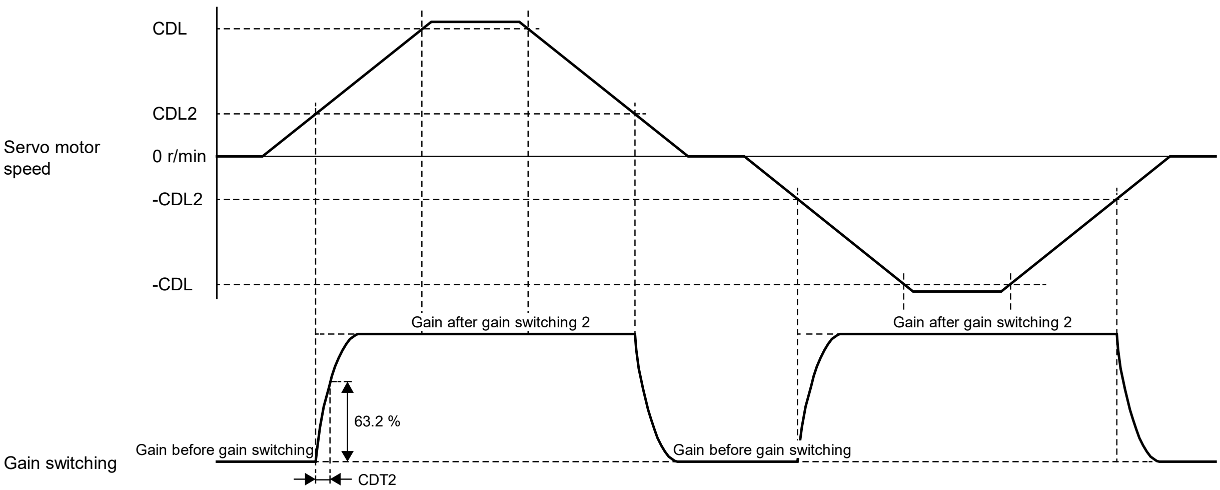
When [Pr.PB65] is set to "0", the gain does not switch to "Gain after gain switching 2". When the absolute value of the servo motor speed exceeds the value of [Pr.PB27], the gain switches.



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	[Pr. PB29]	[Pr. PB06]	[Pr. PB29]	[Pr. PB06]
Position control gain	[Pr. PB08]	[Pr. PB30]	[Pr. PB08]	[Pr. PB30]	[Pr. PB08]
Speed control gain	[Pr. PB09]	[Pr. PB31]	[Pr. PB09]	[Pr. PB31]	[Pr. PB09]
Speed integral compensation	[Pr. PB10]	[Pr. PB32]	[Pr. PB10]	[Pr. PB32]	[Pr. PB10]

• When [Pr.PB65] < [Pr.PB27]

For the case of [Pr.PB65] < [Pr.PB27], the gain does not switch to "Gain after gain switching". When the absolute value of the servo motor speed exceeds the value of [Pr.PB65], the gain switches to "Gain after gain switching 2". However, the gain does not switch to "Gain after gain switching" even when the absolute value exceeds the value of [Pr.PB27].



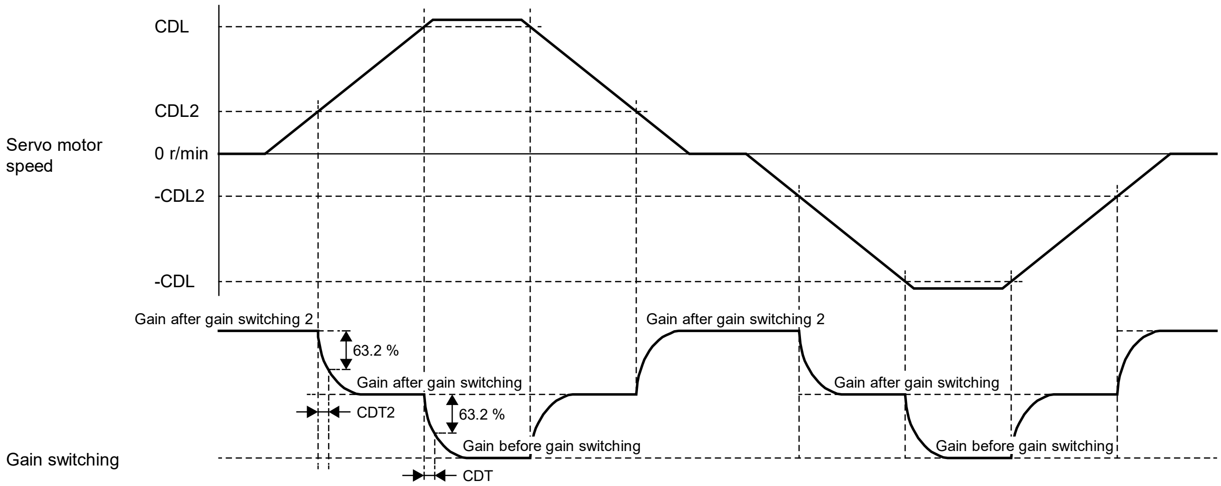
Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	[Pr. PB67]	[Pr. PB06]	[Pr. PB67]	[Pr. PB06]
Position control gain	[Pr. PB08]	[Pr. PB68]	[Pr. PB08]	[Pr. PB68]	[Pr. PB08]
Speed control gain	[Pr. PB09]	[Pr. PB69]	[Pr. PB09]	[Pr. PB69]	[Pr. PB09]
Speed integral compensation	[Pr. PB10]	[Pr. PB70]	[Pr. PB10]	[Pr. PB70]	[Pr. PB10]

2) When [Pr.PB26.1 Gain switching - Condition selection] is set to "1" (enables the gain after gain switching even when the value set in the conditions for gain switching is not reached)

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

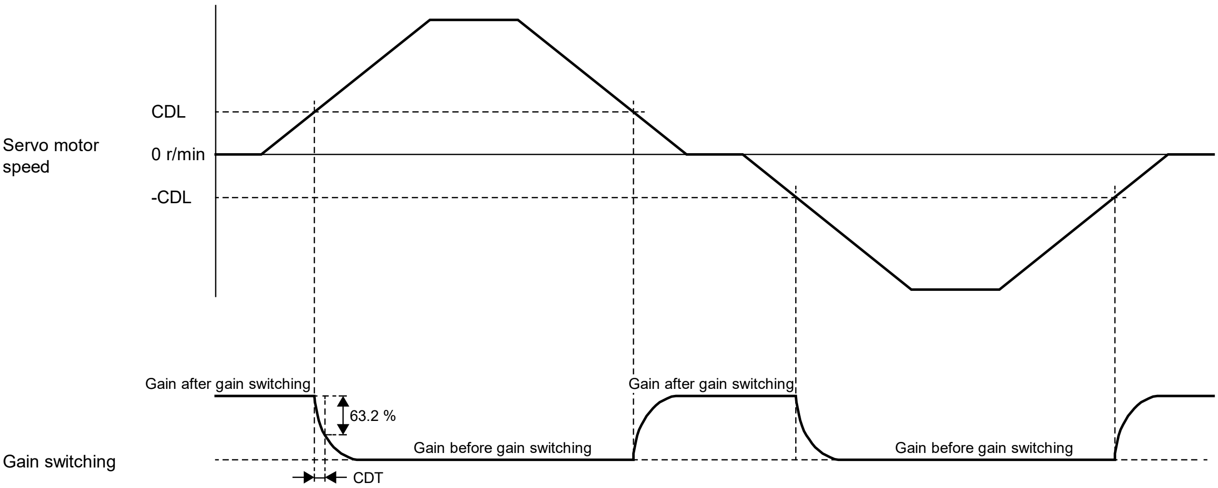
• When [Pr.PB65] ≤ [Pr.PB27]

For the case of [Pr.PB65] ≤ [Pr.PB27], the gain switches to "Gain after gain switching 2" when the absolute value of the servo motor speed is less than the value of [Pr.PB65]. In addition, when the absolute value of the servo motor speed exceeds the value of [Pr.PB65] and less than the value of [Pr.PB27], the gain switches to "Gain after gain switching". When the absolute value of the servo motor speed is equal to or more than the value of [Pr.PB27], "Gain before gain switching" is used.



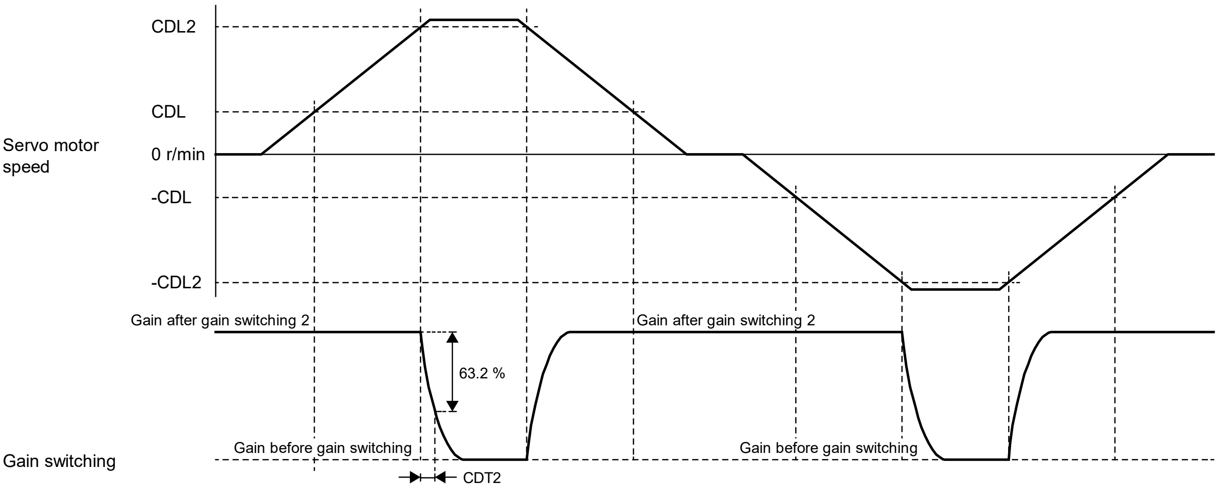
Load to motor inertia ratio/load to motor mass ratio	[Pr. PB67]	[Pr. PB29]	[Pr. PB06]	[Pr. PB29]	[Pr. PB67]	[Pr. PB29]	[Pr. PB06]	[Pr. PB29]	[Pr. PB67]
Position control gain	[Pr. PB68]	[Pr. PB30]	[Pr. PB08]	[Pr. PB30]	[Pr. PB68]	[Pr. PB30]	[Pr. PB08]	[Pr. PB30]	[Pr. PB68]
Speed control gain	[Pr. PB69]	[Pr. PB31]	[Pr. PB09]	[Pr. PB31]	[Pr. PB69]	[Pr. PB31]	[Pr. PB09]	[Pr. PB31]	[Pr. PB69]
Speed integral compensation	[Pr. PB70]	[Pr. PB32]	[Pr. PB10]	[Pr. PB32]	[Pr. PB70]	[Pr. PB32]	[Pr. PB10]	[Pr. PB32]	[Pr. PB70]

• When [Pr.PB65] is set to "0"
When [Pr.PB65] is set to "0", the gain does not switch to "Gain after gain switching 2". When the absolute value of the servo motor speed is less than the value of [Pr.PB27], the gain switches to "Gain after gain switching".



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB29]	[Pr. PB06]	[Pr. PB29]	[Pr. PB06]	[Pr. PB29]
Position control gain	[Pr. PB30]	[Pr. PB08]	[Pr. PB30]	[Pr. PB08]	[Pr. PB30]
Speed control gain	[Pr. PB31]	[Pr. PB09]	[Pr. PB31]	[Pr. PB09]	[Pr. PB31]
Speed integral compensation	[Pr. PB32]	[Pr. PB10]	[Pr. PB32]	[Pr. PB10]	[Pr. PB32]

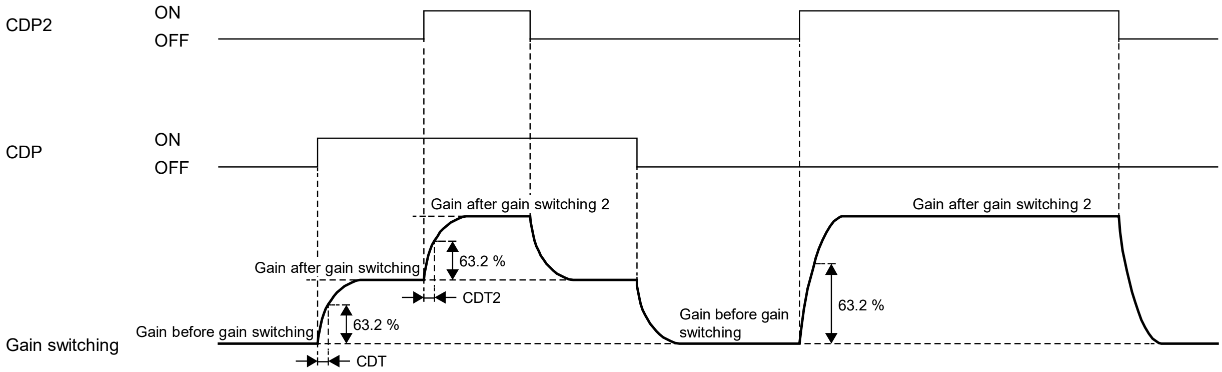
• When [Pr.PB65] > [Pr.PB27]
For the case of [Pr.PB65] > [Pr.PB27], the gain does not switch to "Gain after gain switching". When the absolute value of the servo motor speed is less than the value of [Pr.PB65], the gain switches to "Gain after gain switching 2". However, the gain does not switch to "Gain after gain switching" even when the absolute value is less than the value of [Pr.PB27].



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB67]	[Pr. PB06]	[Pr. PB67]	[Pr. PB06]	[Pr. PB67]
Position control gain	[Pr. PB68]	[Pr. PB08]	[Pr. PB68]	[Pr. PB08]	[Pr. PB68]
Speed control gain	[Pr. PB69]	[Pr. PB09]	[Pr. PB69]	[Pr. PB09]	[Pr. PB69]
Speed integral compensation	[Pr. PB70]	[Pr. PB10]	[Pr. PB70]	[Pr. PB10]	[Pr. PB70]

(b) Gain switching by signals (CDP/C_CDP/CDP2/C_CDP2)
The following illustrates an example where [Pr.PB26.0 Gain switching selection] is set to "1" (signal (CDP/C_CDP)).

1) Gain switching by control commands or input devices



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	[Pr. PB29]	[Pr. PB67]	[Pr. PB29]	[Pr. PB06]	[Pr. PB67]	[Pr. PB06]
Model control gain	[Pr. PB07]	[Pr. PB60]	[Pr. PB79]	[Pr. PB60]	[Pr. PB07]	[Pr. PB79]	[Pr. PB07]
Position control gain	[Pr. PB08]	[Pr. PB30]	[Pr. PB68]	[Pr. PB30]	[Pr. PB08]	[Pr. PB68]	[Pr. PB08]
Speed control gain	[Pr. PB09]	[Pr. PB31]	[Pr. PB69]	[Pr. PB31]	[Pr. PB09]	[Pr. PB69]	[Pr. PB09]
Speed integral compensation	[Pr. PB10]	[Pr. PB32]	[Pr. PB70]	[Pr. PB32]	[Pr. PB10]	[Pr. PB70]	[Pr. PB10]
Vibration suppression control 1 - Vibration frequency	[Pr. PB19]	[Pr. PB33]	[Pr. PB71]	[Pr. PB33]	[Pr. PB19]	[Pr. PB71]	[Pr. PB19]
Vibration suppression control 1 - Resonance frequency	[Pr. PB20]	[Pr. PB34]	[Pr. PB72]	[Pr. PB34]	[Pr. PB20]	[Pr. PB72]	[Pr. PB20]
Vibration suppression control 1 - Vibration frequency/damping coefficient	[Pr. PB21]	[Pr. PB35]	[Pr. PB73]	[Pr. PB35]	[Pr. PB21]	[Pr. PB73]	[Pr. PB21]
Vibration suppression control 1 - Resonance frequency/damping coefficient	[Pr. PB22]	[Pr. PB36]	[Pr. PB74]	[Pr. PB36]	[Pr. PB22]	[Pr. PB74]	[Pr. PB22]
Vibration suppression control 2 - Vibration frequency	[Pr. PB52]	[Pr. PB56]	[Pr. PB75]	[Pr. PB56]	[Pr. PB52]	[Pr. PB75]	[Pr. PB52]
Vibration suppression control 2 - Resonance frequency	[Pr. PB53]	[Pr. PB57]	[Pr. PB76]	[Pr. PB57]	[Pr. PB53]	[Pr. PB76]	[Pr. PB53]
Vibration suppression control 2 - Vibration frequency/damping coefficient	[Pr. PB54]	[Pr. PB58]	[Pr. PB77]	[Pr. PB58]	[Pr. PB54]	[Pr. PB77]	[Pr. PB54]
Vibration suppression control 2 - Resonance frequency/damping coefficient	[Pr. PB55]	[Pr. PB59]	[Pr. PB78]	[Pr. PB59]	[Pr. PB55]	[Pr. PB78]	[Pr. PB55]

(c) Gain switching by command directions

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

The gain switches depending on the command direction of a command pulse frequency and a speed command. A positive direction for the command direction is CCW regardless of the setting in [Pr.PA14 Travel direction selection].

When switching the gain by the command direction, the operation condition varies depending on whether "Gain switching during a stop" is enabled or disabled. However, "Gain switching during a stop" is enabled only in position mode. Refer to the following table for details.

• In the position mode

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

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

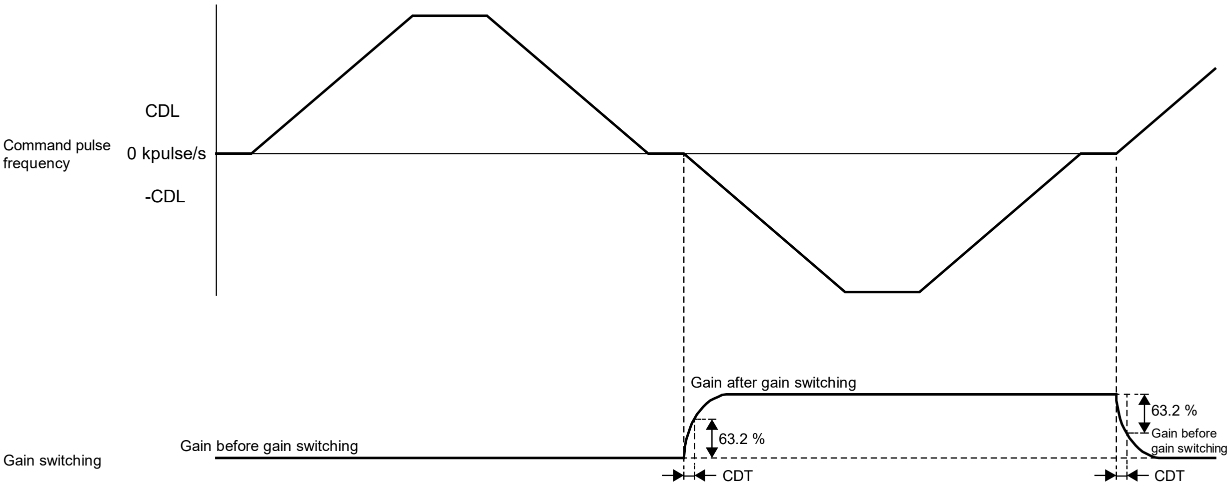
• In velocity mode

[Pr.PB26.5 Gain switching selection during a stop]	Speed command			
	Forward rotation (CCW) or positive direction	0, and ZSP is turned off	0, and ZSP is turned on	Reverse rotation (CW) or negative direction
0	Before gain switching	The current gain value is retained	The current gain value is retained	After gain switching
1	Before gain switching	The current gain value is retained	The current gain value is retained *2	After gain switching

*2. If the mode is switched to the position mode, the gain changes to the "Gain after gain switching 2".

1) When gain switching 2 during a stop is disabled

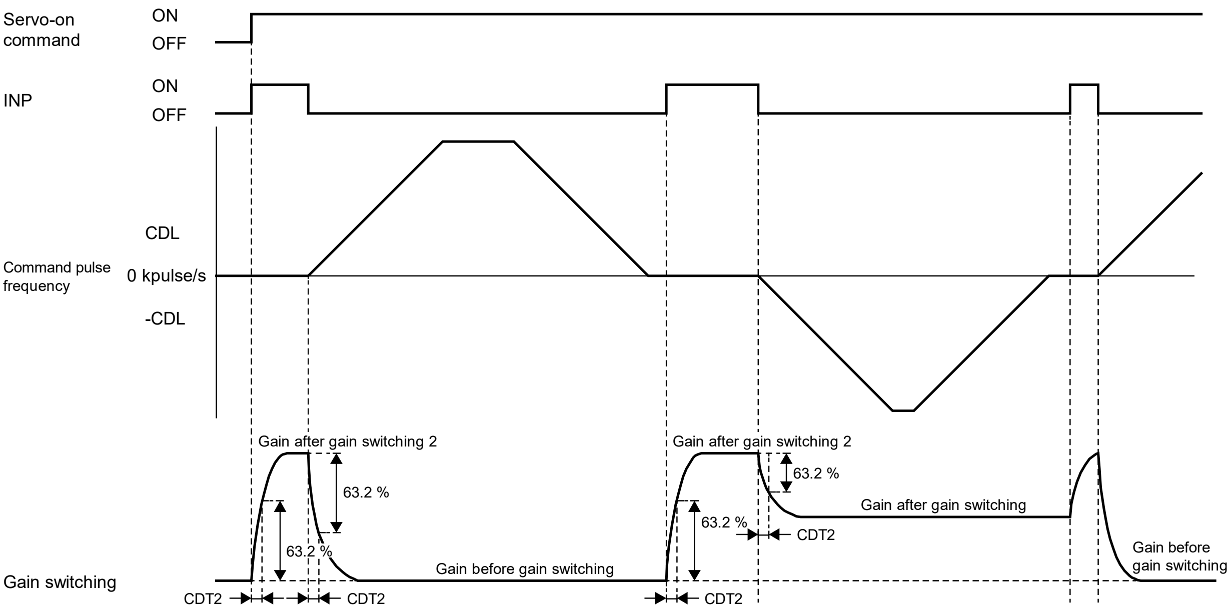
The timing chart of gain switching when the "Gain switching 2 during a stop" is disabled is shown as follows:
In the velocity mode, replace the command pulse frequency with the speed command.



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	[Pr. PB29]	[Pr. PB06]
Position control gain	[Pr. PB08]	[Pr. PB30]	[Pr. PB08]
Speed control gain	[Pr. PB09]	[Pr. PB31]	[Pr. PB09]
Speed integral compensation	[Pr. PB10]	[Pr. PB32]	[Pr. PB10]

2) When gain switching 2 during a stop is enabled

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

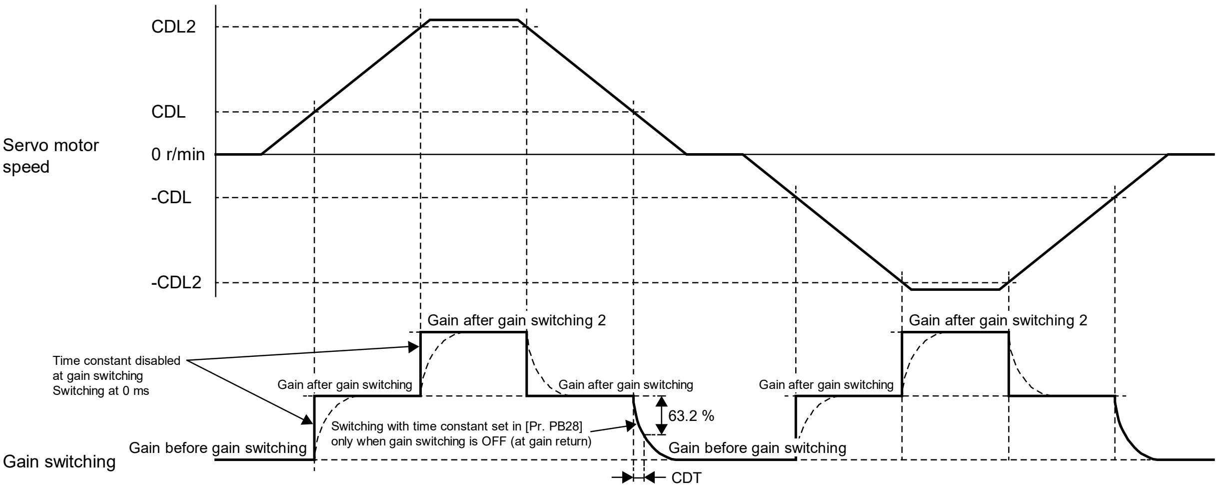


Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	[Pr. PB67]	[Pr. PB06]	[Pr. PB67]	[Pr. PB29]	[Pr. PB06]
Position control gain	[Pr. PB08]	[Pr. PB68]	[Pr. PB08]	[Pr. PB68]	[Pr. PB30]	[Pr. PB08]
Speed control gain	[Pr. PB09]	[Pr. PB69]	[Pr. PB09]	[Pr. PB69]	[Pr. PB31]	[Pr. PB09]
Speed integral compensation	[Pr. PB10]	[Pr. PB70]	[Pr. PB10]	[Pr. PB70]	[Pr. PB32]	[Pr. PB10]

(d) When "Time constant disabled at switching" is selected in "Gain switching time constant - Disabling condition selection"

The time constant is disabled at gain switching. The time constant becomes enabled at gain return.

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

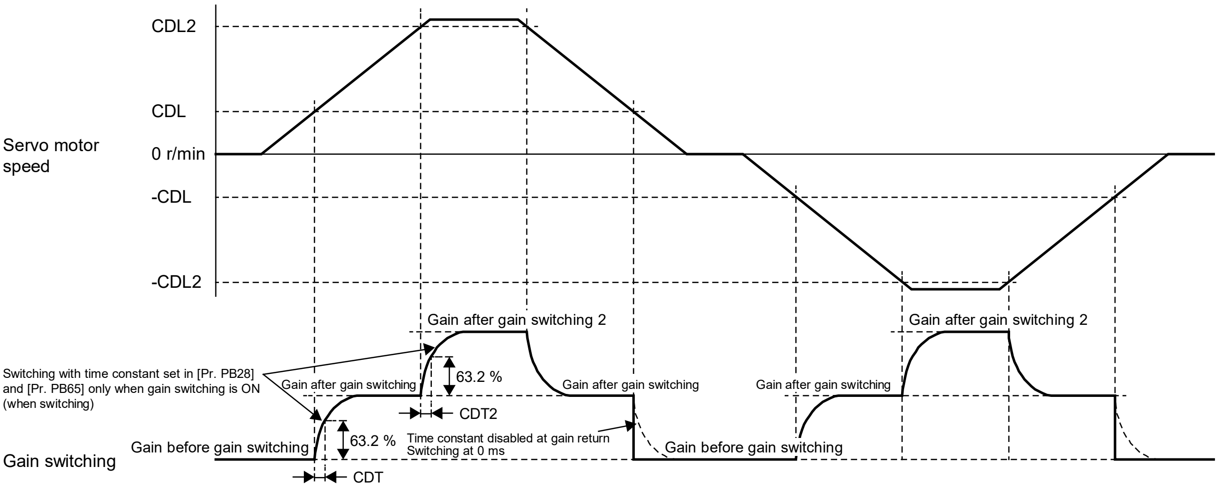


Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	[Pr. PB29]	[Pr. PB67]	[Pr. PB29]	[Pr. PB06]	[Pr. PB29]	[Pr. PB67]	[Pr. PB29]	[Pr. PB06]
Position control gain	[Pr. PB08]	[Pr. PB30]	[Pr. PB68]	[Pr. PB30]	[Pr. PB08]	[Pr. PB30]	[Pr. PB68]	[Pr. PB30]	[Pr. PB08]
Speed control gain	[Pr. PB09]	[Pr. PB31]	[Pr. PB69]	[Pr. PB31]	[Pr. PB09]	[Pr. PB31]	[Pr. PB69]	[Pr. PB31]	[Pr. PB09]
Speed integral compensation	[Pr. PB10]	[Pr. PB32]	[Pr. PB70]	[Pr. PB32]	[Pr. PB10]	[Pr. PB32]	[Pr. PB70]	[Pr. PB32]	[Pr. PB10]

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

The time constant is enabled at gain switching. The time constant becomes disabled at gain return.

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



Load to motor inertia ratio/load to motor mass ratio	[Pr. PB06]	[Pr. PB29]	[Pr. PB67]	[Pr. PB29]	[Pr. PB06]	[Pr. PB29]	[Pr. PB67]	[Pr. PB29]	[Pr. PB06]
Position control gain	[Pr. PB08]	[Pr. PB30]	[Pr. PB68]	[Pr. PB30]	[Pr. PB08]	[Pr. PB30]	[Pr. PB68]	[Pr. PB30]	[Pr. PB08]
Speed control gain	[Pr. PB09]	[Pr. PB31]	[Pr. PB69]	[Pr. PB31]	[Pr. PB09]	[Pr. PB31]	[Pr. PB69]	[Pr. PB31]	[Pr. PB09]
Speed integral compensation	[Pr. PB10]	[Pr. PB32]	[Pr. PB70]	[Pr. PB32]	[Pr. PB10]	[Pr. PB32]	[Pr. PB70]	[Pr. PB32]	[Pr. PB10]

7.1.3 Tough drive function

Point
● Enable or disable the tough drive function with [Pr.PA20 Tough drive setting].

Tough drive function is a function that allows the operation to continue without stopping the device, even when an alarm would occur normally. This function also features the vibration tough drive and the instantaneous power failure tough drive.

(1) Vibration tough drive function

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

(a) Vibration tough drive restrictions

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

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

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

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

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

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

(b) Vibration tough drive setting method

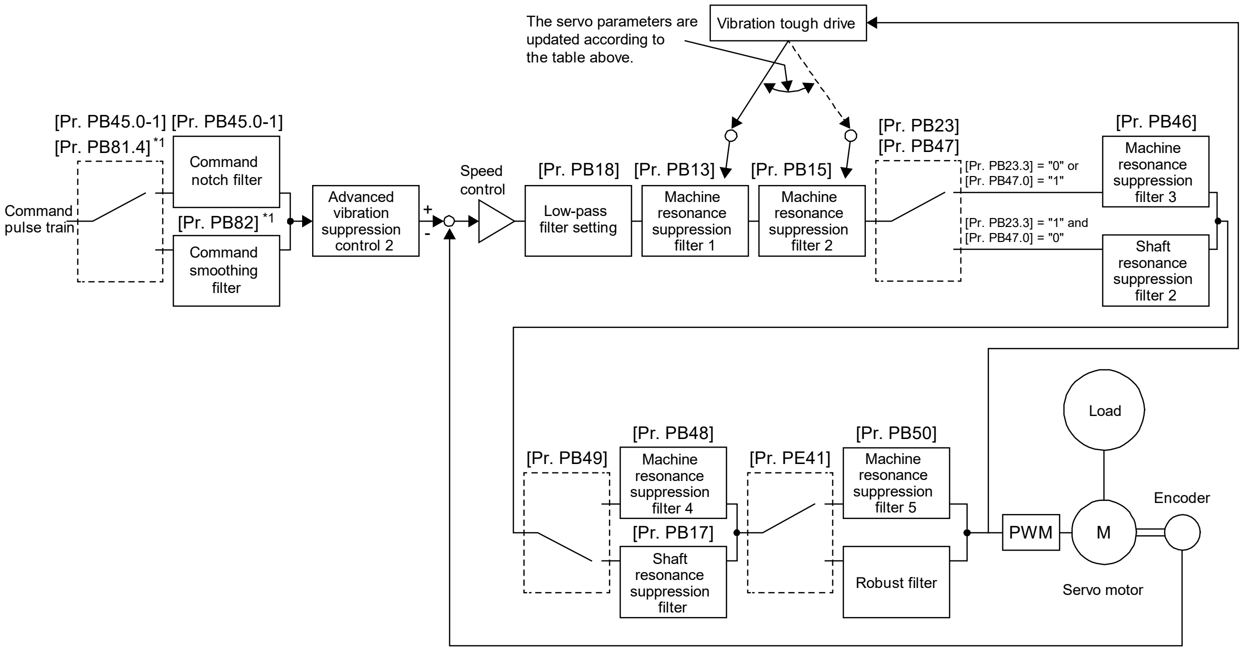
Setting [Pr.PA20.1 Vibration tough drive selection] to "1" (machine resonance suppression filter change mode) or "2" (machine resonance suppression filter automatic setting mode) causes [Pr.PB13 Machine resonance suppression filter 2] and [Pr.PB15 Machine resonance suppression filter 1] to be automatically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

Servo parameter	Description
PA20.1	Vibration tough drive selection 0: Disabled 1: Machine resonance suppression filter change mode enabled 2: Machine resonance suppression filter automatic setting mode When using the vibration tough drive, it is recommended to use "2" (machine resonance suppression filter automatic setting mode).

(c) Operation of vibration tough drive

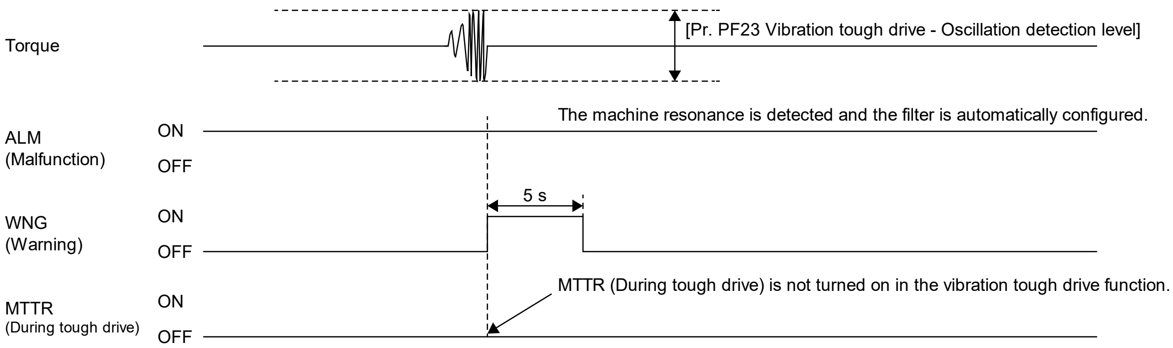
The function block diagram for the vibration tough drive function is shown below. If the oscillation level exceeds the level set in [Pr.PF23 Vibration tough drive - Oscillation detection level], [Pr.PB13 Machine resonance suppression filter 1] and [Pr.PB15 Machine resonance suppression filter 2] will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

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



*1. Available on servo amplifiers with software version A5 or later.

The timing chart of the vibration tough drive is shown as follows:



(2) Instantaneous power failure tough drive function

The instantaneous power failure tough drive function avoids the occurrence of [AL.010 Undervoltage], even when an instantaneous power failure occurs during operation. Operating the system continuously without stopping it is feasible. Once the instantaneous power failure tough drive is activated, the function will increase the tolerance against instantaneous power failure using the electrical energy charged in the capacitor in the servo amplifier and will change an alarm level of [AL.010 Undervoltage] simultaneously. The [AL.010.1 Voltage drop in the control circuit power] detection time for the control circuit power supply can be changed with [Pr.PF25 SEMI-F47 function - Instantaneous power failure detection time (Instantaneous power failure tough drive detection time)]. In addition, [AL.010.2 Voltage drop in the main circuit power] detection level for the bus voltage is changed automatically.

Precautions

- MBR (Electromagnetic brake interlock) is on during the instantaneous power failure tough drive.
- When the load of instantaneous power failure is large, [AL.010.2] caused by the bus voltage drop may occur regardless of the set value of [Pr.PF25 SEMI-F47 function - Instantaneous power failure detection time (Instantaneous power failure tough drive detection time)].
- The external dynamic brake cannot be used when complying with the SEMI-F47 standard. Do not assign DB (Dynamic brake interlock) to the output device. If DB is assigned, the servo amplifier switches to servo-off status when an instantaneous power failure occurs.
- When complying with the SEMI-F47 standard, [Pr.PF25] does not need to be changed from the initial value (200[ms]). When the instantaneous power failure time exceeds 200[ms], and if the instantaneous power failure voltage is less than 70[%] of the rated input voltage, the normal power off may occur even if a value larger than 200[ms] is set in the servo parameter.

(a) Setting method

Set [Pr.PA20.2 SEMI-F47 function selection] to "1" (enabled).

To set the time until the occurrence of [AL.010.1 Voltage drop in the control circuit power], use [Pr.PF25 SEMI-F47 function - Instantaneous power failure detection time (Instantaneous power failure tough drive detection time)].

To extend the time until the occurrence of [AL.010.2 Voltage drop in the main circuit power], set [Pr.PA26.0 Torque limit function selection at instantaneous power failure] to "1" (enabled).

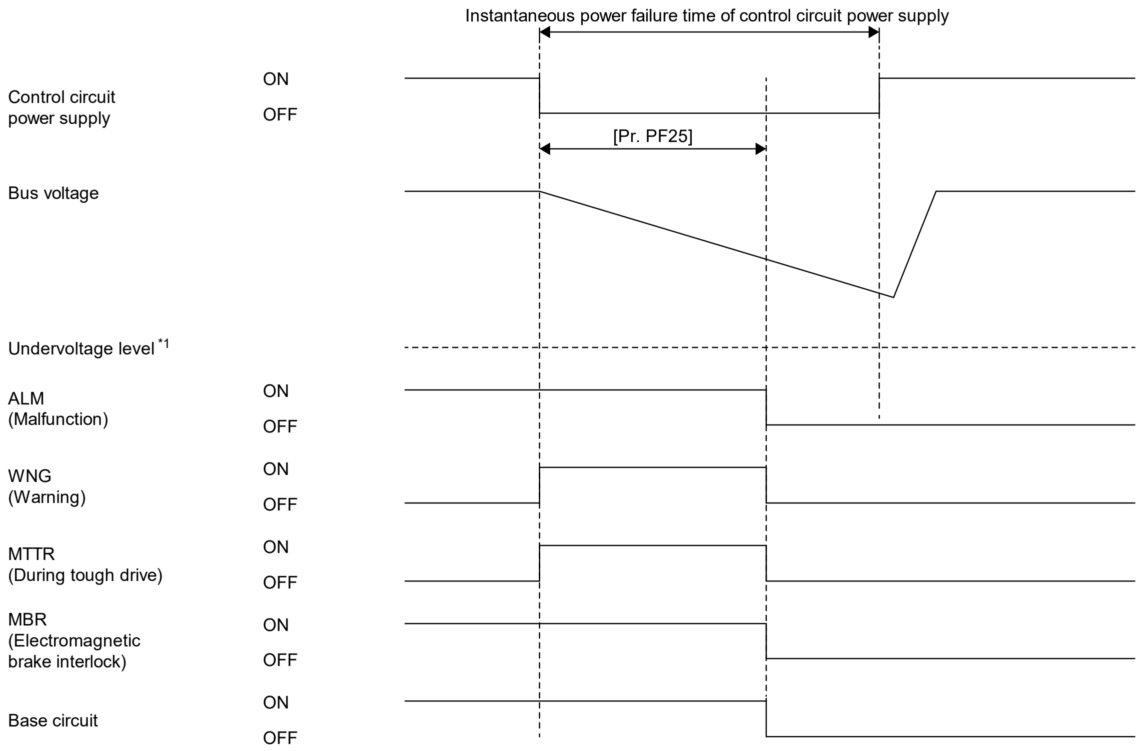
Servo parameter	Symbol	Name	Description
PA20.2	*TDS	SEMI-F47 function selection	Enable or disable the SEMI-F47 function. 0: Disabled (initial value) 1: Enabled
PA26.0	*AOP5	Torque limit function selection at instantaneous power failure	Enable or disable the torque limit function at instantaneous power failure. 0: Disabled (initial value) 1: Enabled
PF25	CVAT	SEMI-F47 function - Instantaneous power failure detection time (Instantaneous power failure tough drive detection time)	Set the time until the occurrence of [AL.010.1 Voltage drop in the control circuit power]. Initial setting: 200[ms]

(b) Timing chart

1) When the instantaneous power failure time of the control circuit power supply > [Pr.PF25 SEMI-F47 function - Instantaneous power failure detection time (Instantaneous power failure tough drive detection time)]

The alarm occurs when the instantaneous power failure time of the control circuit power supply exceeds [Pr.PF25 SEMI-F47 function - Instantaneous power failure detection time (Instantaneous power failure tough drive detection time)]. MTTR (Tough drive in progress) turns on after the instantaneous power failure is detected.

MBR (Electromagnetic brake interlock) turns off when the alarm occurs.

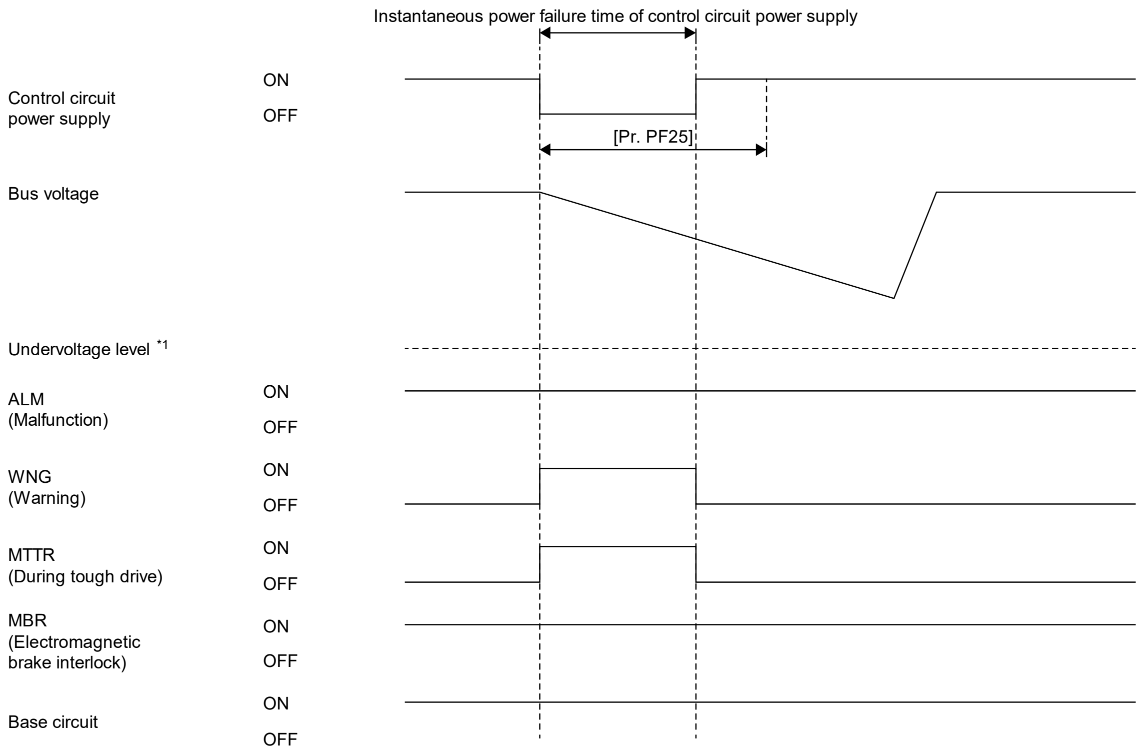


*1. Refer to "Compliance with SEMI-F47 standard" in the MR-J5 User's Manual (Function) for the undervoltage level.

2) When the instantaneous power failure time of the control circuit power supply < [Pr.PF25 SEMI-F47 function - Instantaneous power failure detection time (Instantaneous power failure tough drive detection time)]

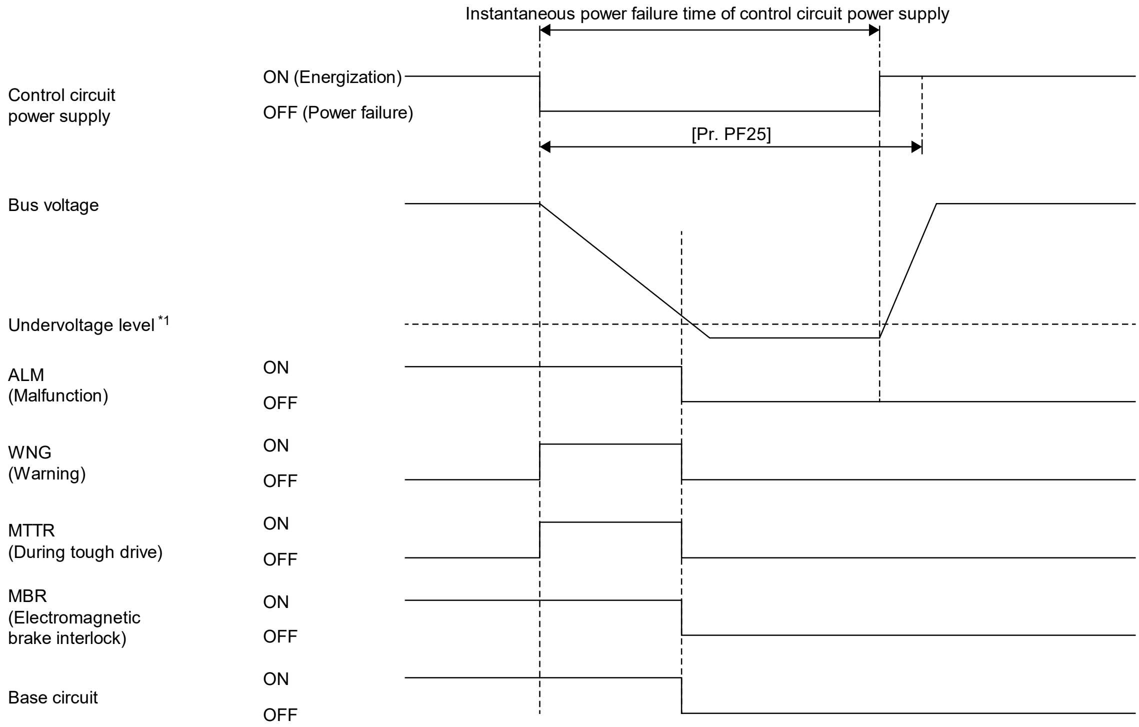
The operation status differs depending on how much the bus voltage decreases.

• When the bus voltage does not decrease to the undervoltage level or lower within the instantaneous power failure time of the control circuit power supply, the operation continues as is without setting off the alarm.



*1. Refer to "Compliance with SEMI-F47 standard" in the MR-J5 User's Manual (Function) for the undervoltage level.

- [AL.010 Undervoltage] occurs regardless of the enabled instantaneous power failure tough drive even if the bus voltage decreases to the undervoltage level or lower within the instantaneous power failure time of the control circuit power supply.



*1. Refer to "Compliance with SEMI-F47 standard" in the MR-J5 User's Manual (Function) for the undervoltage level.

8 SELECTION

8.1 Tentatively Selecting Motor Capacity

The guideline for selecting an AC servo capacity for a machine driving mechanism is roughly calculated as follows.

(1) Guideline for stable control loops
Load moment of inertia J_L ≤ motor rotor inertia moment J_M × recommended load to motor inertia ratio

(2) Margin for load torque
Load torque T_L ≤ motor rated torque T_M × 0.5 to 0.8

8.1.1 Load moment of inertia J_L

It is the moment of inertia on the motor loads, which are the locking devices and driving system of the parts following the coupling connected to the motor output axis. The moment of inertia of the motor electromagnetic brake and gear reducer is also added.
For the AC servo systems, [kg•cm^2] is used as the unit of the load moment of inertia J_L. Table 8.1 shows the expression of the load moment of inertia.

8.1.2 Load torque T_L

It is a force such as thrust, friction force, and unbalanced torque applied to the moving part of the machine which is the motor load.
[N•m] is used as the unit of the load torque T_L. Table 8.2 shows the expression of the load torque.

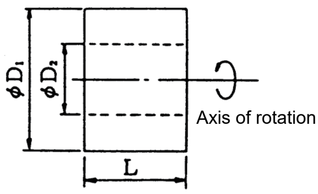
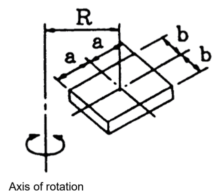
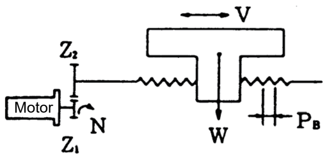
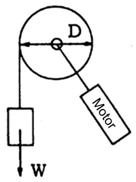
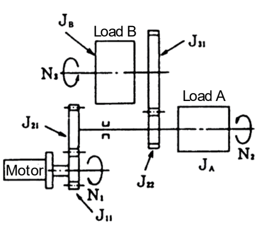
* The specifications symbols introduced in Appendix 1 are used for the expressions in this section.

8.1.3 Expressions of load moment of inertia and load torque

(1) Expressions of load moment of inertia

The expression of a typical load moment of inertia is shown in tabel 8.1.

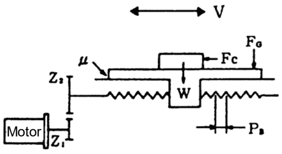
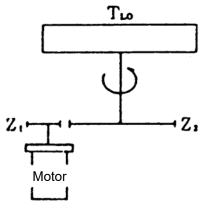
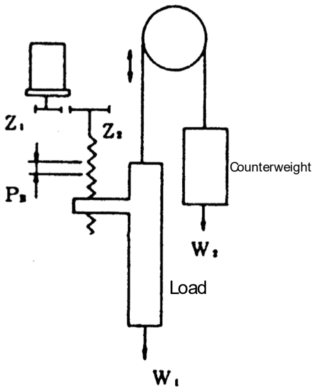
Table 8.1 Calculation of load moment of inertia

Type	Mechanism	Expression
1. Cylinder		$J_L = \frac{\pi \cdot \rho \cdot L}{32} \cdot (D - D_1^4 = \frac{W}{8}{}_2^4 \cdot (D_1^2 + D_2^2)$ ············(8-1) J_L: Load moment of inertia [kg・cm^2] ρ: Material density of the cylinder [kg/cm^3] L: Length of the cylinder [cm] D_1: Outer diameter of the cylinder [cm] D_2: Internal diameter of the cylinder [cm] W: Mass of the cylinder [kg] Reference data Material density Iron ·········· 7.8 • 10-3 [kg/cm^3] Aluminum ···· 2.7 • 10-3 [kg/cm^3] Copper ······· 8.96 • 10-3 [kg/cm^3]
2. Rectangular prism		$J_L = W \left(\frac{a^2 + b^2}{3} + R^2\right)$ ············(8-2) a, b, R: As indicated in the figure on the left [cm]
3. Object which moves linearly		$J_L = W \cdot \left(\frac{V}{600\omega}\right)^2 = W \cdot \left(\frac{1}{2\pi N} \cdot \frac{V}{10}\right)^2 = W \cdot \left(\frac{\Delta S}{20\pi}\right)^2$ ············(8-3) J_L: Load moment of inertia converted into equivalent value on motor shaft [kg•cm^2] V: Speed of the object which moves linearly [mm/min] N: Motor speed [r/min] $\Delta S = P_B \cdot \frac{Z_1}{Z_2}$ Z1, Z2: Number of gear teeth
4. Object to be hung		$J_L = \frac{W}{4} \cdot D^2 + J_P$ ············(8-4) J_P: Pulley moment of inertia [kg•cm^2] D: Pulley diameter [cm]
5. Load moment of inertia converted into equivalent value on motor shaft		$J_L = J_{11} + (J_{21} + J_{22} + J_A) \cdot \left(\frac{N_2}{N_1}\right)^2 + (J_{31} + J_B) \cdot \left(\frac{N_3}{N_1}\right)^2$ ············(8-5) J_A, J_B: Moments of inertia of load A and B [kg•cm^2] J_{11} to J_{31}: Moment of inertia of gear [kg•cm^2] N_1 to N_3: Speed of each shaft [r/min]

(2) Expressions of load torque

The expression of a typical load torque is shown in table 8.2.

Table 8.2 Expressions of load torque

Type	Mechanism	Expression
Linear movement		$T_L = \frac{F}{2 \times 10^3 \pi\eta} \cdot \left(\frac{V}{N}\right) = \frac{F \cdot \Delta S}{2 \times 10^3 \pi\eta}$ ……(8-6) F: Force (thrust) applied in the shaft direction of the machine moving linearly [N] η: Efficiency of the drive system For example, as shown in the figure on the left, the force F to move a table is calculated by the expression below. $F = F_C + \mu (W \cdot g + F_G)$ ……(8-7) F_C: Force (thrust) applied in the axial direction of the moving part [N] F_G: Tightening force of the table guide surface [N] μ: Friction coefficient V: Speed of the object which moves linearly [mm/min] N: Motor speed [r/min] W: Object mass [kg] g: Gravitational acceleration [9.8m/s2] ΔS: Moving object feed length per motor rotation [mm]
Rotary movement		$T_L = \frac{Z_1}{Z_2} \cdot \frac{1}{\eta} \cdot T_{LO} + T_F$ ……(8-8) T_{LO}: Load torque on load shaft [N・m] T_L: Friction load torque converted into equivalent value on motor shaft [N•m] T_F: Friction torque of the moving part [N•m]
Vertical movement		When moving upward $T_L = T_U + T_F$ ……(8-9) When moving downward $T_L = -\eta^2 \cdot T_U + T_F$ ……(8-10) T_U: Unbalanced torque [N•m] T_F: Friction torque of the moving part [N•m] $T_U = \frac{(W_1 - W_2) \cdot g}{2 \times 10^3 \pi\eta} \cdot \left(\frac{V}{N}\right) = \frac{(W_1 - W_2) \cdot g \cdot \Delta S}{2 \times 10^3 \pi\eta}$ ……(8-11) $T_F = \frac{\mu \cdot (W_1 + W_2) \cdot g \cdot \Delta S}{2 \times 10^3 \pi\eta}$ ……(8-12) W_1: Load mass [kg] W_2: Counter weight mass [kg] η: Drive system efficiency μ: Friction coefficient (sheave section)

8.2 Reduction ratio

To bring out the full capability of the servo motor, it is important to derive the servo motor power in the most efficient way and to use the servo system including the machine stably increasing the response.
The reduction ratio between the servo motor and machine is a large element for the said requirements.
The following explains the conditions to select an appropriate reduction ratio.

(1) To derive the maximum motor output (power), select the reduction ratio so that the motor operates at the rated speed when the machine is operated at its maximum speed.
  (a) The servo motor output is maximized (rated output) at the rated speed.
  (b) As the reduction ratio increases, the machine load torque converted into equivalent value on the motor shaft and the machine load moment of inertia converted into equivalent value on motor shaft decrease. This means that the load becomes the lightest to the motor when the reduction ratio is selected so that the motor operates at the rated speed.

(2) To stably increase the response of the servo system, select the reduction ratio and motor capacity so that the load to motor inertia ratio is within twice the recommended load to motor inertia ratio (or 20 times or less for the HK-KT053W motor).

$$\text{Load to motor inertia ratio } m = \frac{\text{Load converted into equivalent value on motor shaft } J_L}{\text{Motor } J_M}$$
$$< \text{recommended load to motor inertia ratio}$$

The smaller the load to motor inertia ratio, the more the response can be increased. Therefore, the reduction ratio must be selected so that the load to motor inertia ratio becomes "(m < 2)", which is the smallest possible value, especially for a high-frequency feed.

(3) A smaller feed length per pulse $\Delta\ell 0$ is more advantageous to secure the positioning accuracy.
The following shows a general guideline for the relationship between the machine accuracy $\Delta\varepsilon$ and $\Delta\ell 0$.

$$\Delta \ell_0 < \left(\frac{1}{5} \text{ to } \frac{1}{10}\right) \times \Delta\varepsilon$$

<Remark>
1. The power at acceleration becomes the smallest when set to m = 1. Therefore, set the reduction ratio as $1 / n = \sqrt{J_M / J_L}$.
   This reduction ratio is generally called the optimum reduction ratio.
2. To use a mechanism such as a spur gear or a pulley for deceleration, be careful when increasing the pulley diameter to increase the reduction ratio as the load moment of inertia may increase resulting from deceleration.

8.3 Operation Patterns and Motor Required Torque

The operation patterns are to be considered generally with the operation divided into the acceleration time Tpsa, constant speed operation time tc, deceleration time Tpsd, stop settling time ts, and stop time tst.
The energy required to accelerate an object that has a moment of inertia (load moment of inertia J_L) is termed the acceleration torque Ta, the energy required to decelerate being the deceleration torque Td.
In addition, the friction load torque TL that is equivalent to the one in constant speed operation operates while decelerating from the constant speed operation to the stop settling time ts.

8.3.1 Acceleration torque Ta

The calculation expression of the acceleration torque Ta is as follows (8-13).

$$Ta = \frac{(J_L + J_M) \cdot No}{9.55 \times 10^4 \cdot Tpsa} \cdot \left(1 - \varepsilon - \frac{Tpsa}{Tp}\right) [N \cdot m] \quad \cdots\cdots (8\text{-}13)$$

The expression (8-14) is used to simplify the calculation.

$$Ta = \frac{(J_L + J_M) \cdot No}{9.55 \times 10^4 \cdot Tpsa} [N \cdot m] \quad \cdots\cdots (8\text{-}14)$$

8.3.2 Deceleration torque Td

The calculation expression of the deceleration torque Td is as follows (8-15).

$$Td = \frac{(J_L + J_M) \cdot No}{9.55 \times 10^4 \cdot Tpsa} \cdot \left(1 - \varepsilon - \frac{Tpsa}{Tp}\right) [N \cdot m] \quad \cdots\cdots (8\text{-}15)$$

The expression (8-16) is used to simplify the calculation.

$$Td = \frac{(J_L + J_M) \cdot No}{9.55 \times 10^4 \cdot Tpsa} [N \cdot m] \quad \cdots\cdots (8\text{-}16)$$

Note that the value of the acceleration torque and deceleration torque is the same (Ta = -(Td)) when Tpsa is equal to Tpsd.

8.3.3 Operation pattern

The description so far is organized as an operation pattern as follows.

(1) The motor torque required at a constant speed is the load torque converted into equivalent value on the motor shaft T_L.

(2) For a system such as a lift, T_L (the load torque converted into equivalent value on the motor shaft) becomes a minus torque depending on the conditions.

(3) The motor torque required at acceleration and deceleration is as follows.
Motor torque required at acceleration T_{Ma} = load torque T_L + acceleration torque T_a
Motor torque required at deceleration T_{Md} = load torque T_L - deceleration torque T_d

(4) When TMd = T_L - T_d > 0, power running deceleration is activated, and the motor decelerates while supplying energy to the machine.

(5) When TMd = T_L - T_d < 0, regenerative braking is activated (the regenerative mode), the motor decelerates while applying a brake to the machine. Then, the regenerative power flows from the motor side to the servo amplifier side.

(6) The deceleration pattern and torque pattern are organized as shown in Figure 8.1.

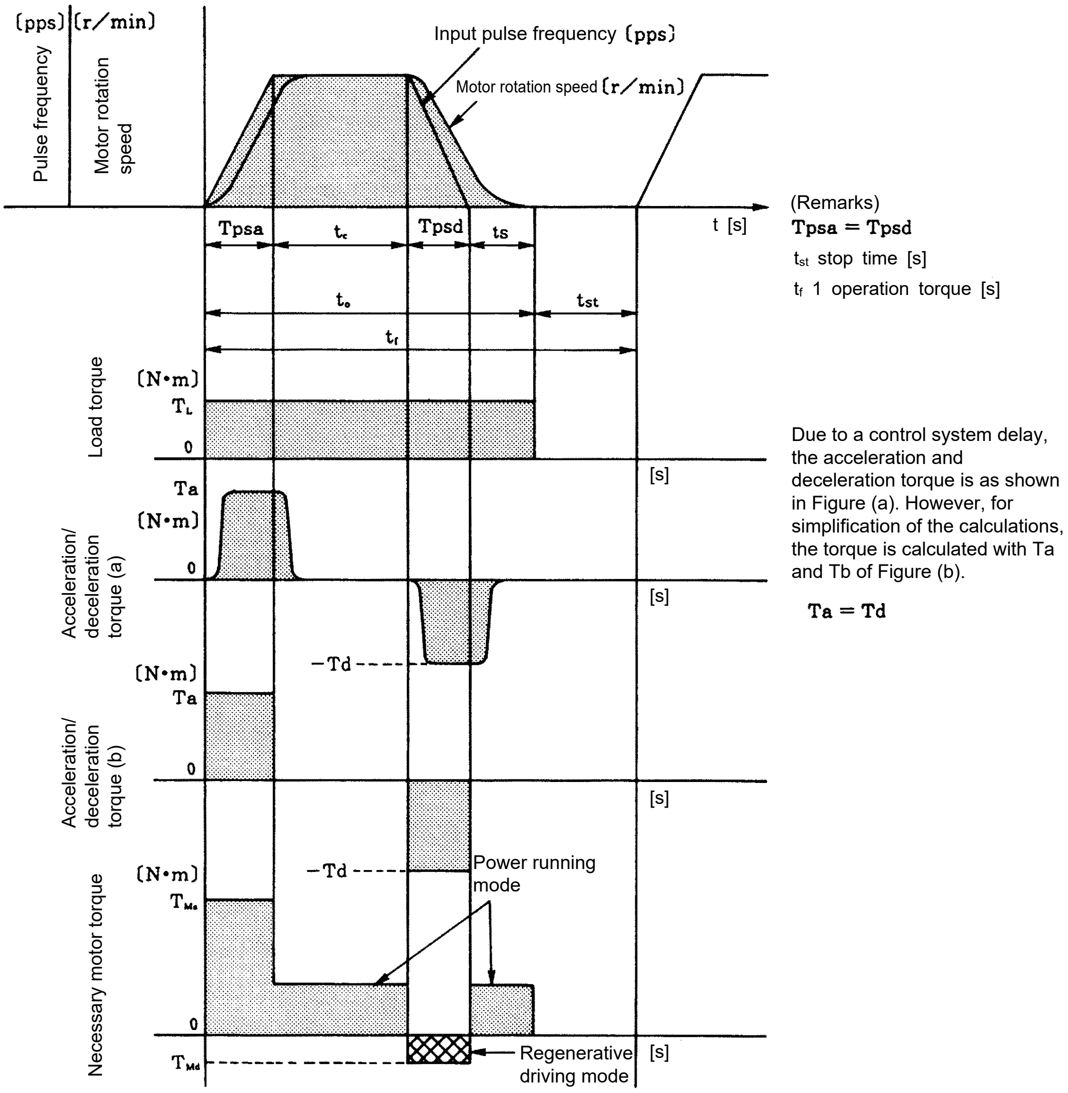


Figure 8.1 Operation pattern and torque pattern per section

8.3.4 Determining motor capacity

Usability of a motor is to be judged primarily by whether the motor can be used with the required motor torque shown in figure 8.1. In addition, the motor temperature rise and heat capacity of the regenerative brake are also required to be considered to use the motor continuously.
The temporarily-selected motor can be used if the following three conditions are satisfied.

(1) Motor torque T_{Ma} required at acceleration shown in figure 8.2
$T_{Ma} = T_L + T_a <$ motor maximum torque T_{Mmax} ······ (8-17)

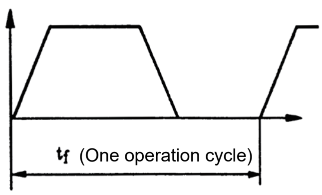
(2) Motor torque TMd required at deceleration shown in figure 8.3
$T_{Md} = T_L - T_d <$ motor maximum torque T_{Mmax} ······ (8-18)

(3) Continuous effective load torque Trms
$T_{rms} \leq$ motor rated torque T_M ······ (8-19)

The continuous effective load torque Trms is a load torque at which the temperature rise of a motor that performs intermittent cycle time operation becomes equivalent if the motor is operated continuously. Therefore, the motor has no problem with the temperature if Trms ≤ T_M.
Trms for figure 8.4 is obtained by the following expression.

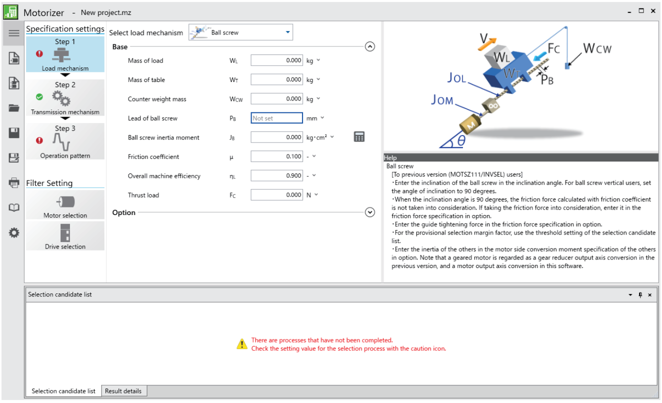
$$\text{Trms} = \sqrt{\frac{T_{Ma}^2 \cdot \text{Tpsa} + T_L^2 \cdot (t_0 - \text{Tpsa} - \text{Tpsd} - \text{Ts}) + T_{Md}^2 \cdot \text{Tpsd}}{t_f}} \text{ [N}\cdot\text{m]} \quad \cdots\cdots \text{(8-20)}$$

If any of the above conditions (1), (2), and (3) is not satisfied, check the machine conditions, operation pattern, motor capacity and other conditions, then consider the motor usability again following the same procedure.
If all of the above conditions (1), (2), and (3) are satisfied, the temporarily-selected motor can be operated properly with the speed pattern and cycle time as planned, having no abnormalities in torque or temperature rise.
Note that, if the torque falls below zero (-) in the torque pattern, the performance of the servo amplifier's regenerative brake needs to be checked.



8.4 Capacity selection Motorizer

Capacity selection Motorizer is software that selects a usable motor by having the machine components, specifications, and operation patterns input. It can select a motor from inverters and sensorless servo motors in addition to the AC servo motors.



(1) Features

(a) Capable of flexibly supporting load mechanisms

Load mechanisms can be selected from typical 12 types, and the inclination of the selected load mechanisms can be set as desired.

In addition, transmission mechanisms such as a coupling can be added.

(b) Capable of selecting multiple axes

The software supports multi-axis servo amplifiers and converters and also allows operation pattern settings for multi axis.

The regenerative option can be set on the multi-axis system.

(c) Selection from multiple candidates

Multiple candidates are displayed in a list. In addition to the motor model names, driver types, and capacities, effective load ratio of each motor and calculation results of specifications such as the motor inertia ratio are displayed at the same time.

(2) Specifications

Item	Description
Types of motors/drives	Servo, inverter, sensorless servo
Types of load mechanisms	Ball screw, rack and pinion, roll feed, rotary table, cart, elevator/hoist, conveyor, fan, pump, generic (rotary), generic (linear), linear servo
Types of transmission mechanisms	Coupling, external gear reducer, V-belt and pulley, belt with teeth/roller chain
Types of operation patterns	Constant speed/pause, acceleration/deceleration, trapezoid, triangle, speed CSV file, MELSOFT GX LogViewer file
Types of moment of inertia input supports	Solid cylinder, hollow cylinder, disc, rectangular parallelepiped, truncated cone, sphere, general-purpose
Selection result	Judgment, motor type, motor, motor capacity, drive, drive capacity, effective torque, torque effective load ratio, peak torque, peak load ratio, effective torque at stop, effective load ratio at stop, motor output, motor output ratio, maximum speed, maximum speed ratio, maximum load moment of inertia, inertia moment ratio, regenerative power, regenerative load ratio, regenerative option, maximally increased torque, rated speed, brake, oil seal, structural specifications, graphs of motor-side speed/motor-side torque/motor output
Result output print	Prints out the load mechanism, transmission mechanism, operation pattern, and selection result
Data storage	Saves the load mechanism, transmission mechanism, operation pattern, motor selection, drive selection, and selection result under a new file name

(3) Operating environment

Item	Description
OS	Microsoft® Windows® 10 (64bit/32bit) Microsoft® Windows® 8.1 (64bit/32bit) Microsoft® Windows® 7 (64bit/32bit) [Service Pack1 or later]
.NET Framework	.NET Framework 4.6 or later
CPU	Desktop-type personal computer: Intel® Celeron® processor 2.4GHz or more recommended Laptop personal computer: Intel® Pentium® processor 1.9GHz or more recommended
Memory	1GB or more recommended (32-bit OS) 2GB or more recommended (64-bit OS)
Disk space	Installation: HD1GB or more Operation: Virtual free space of 512MB or more
Display	Resolution 1024x768 or higher (XGA) Connectable with above personal computers

8.4.1 How to use the capacity selection software

Capacity Selection Software Motorizer can be downloaded for free from Mitsubishi Electric FA site. Use this software to select an AC servo motor.

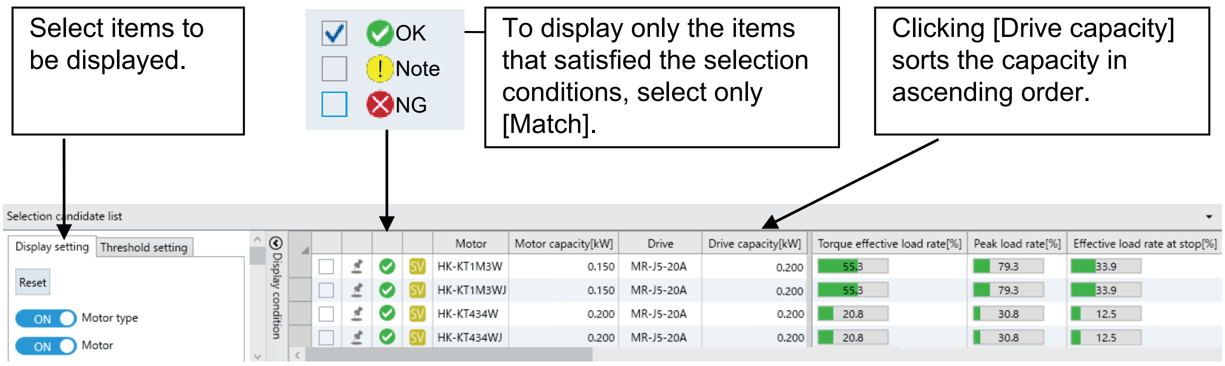
(1) Specifications settings
  (a) Load mechanism (STEP1)
    1) Select a load mechanism from "Select load mechanism". Selecting a load mechanism displays the machine architecture.
    2) Set the base information and option.
  (b) Transmission mechanism (STEP2)
    1) Select [Motor], then toggle Servo to ON in "Motor display".
    2) Select [Transmission mechanism1], then set the inertia moment in "Transmission mechanism1:Coupling".
    3) Select [Transmission mechanism2], then set "Transmission mechanism2:External gear reducer".
  (c) Operation pattern (STEP3)
    1) Click the [Add] button, select an operation pattern, then set the base information and acceleration/deceleration.

(2) Filter setting
  (a) Motor selection
    1) Toggle Servo to ON in "Motor display". (Toggle Inverter and Sensorless servo to off.)
    2) Set "Motor common settings".
    3) Set "Transmission mechanism/motor common settings".
    4) Select a motor from "Motor selection candidate".
  (b) Drive selection
    1) Toggle Servo to ON in "Drive display". (Toggle Inverter and Sensorless servo to off.)
    2) Select a power supply voltage in "Common settings of the motor and drive".
    3) Set "Drive common settings".
    4) Select a drive from "Drive selection candidate".

(3) Selection result

The selection result is displayed in the selection candidate list. The green tick indicates that the motor is "Match", which means it satisfies the selection requirements.

Clicking "Drive capacity" in the selection candidate list sorts the motor in ascending order of capacity.



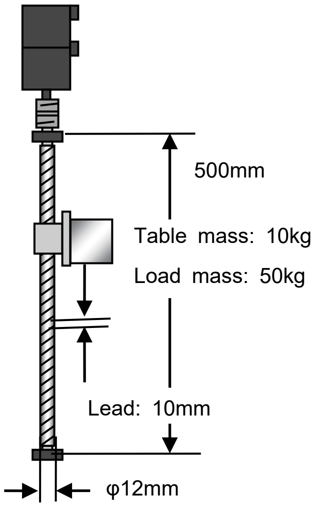
(4) Evaluation criteria for selection results

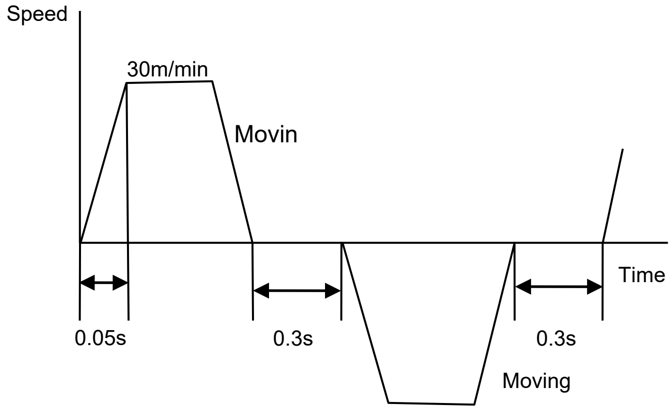
- Inertia moment ratio: Equivalent to or less than the recommended load to motor inertia ratio specified in the catalog. For a motor with a gear reducer, equivalent to or less than the permissible load to motor inertia ratio of the gear reducer specifications.
- Peak torque: Maximum torque or less
- Effective torque: The rated torque or less. For a vertical axis, 60% or less of the rated torque.
- Regenerative load ratio: 80% or less

8.4.2 Selection example

Selection example: Vertical movement on a ball screw

Assume the mechanism moves the travel distance of 200mm in 30m/min. The acceleration/deceleration time is 0.05s, the stop time being 0.3s at both the upper and lower edges.





The drive system efficiency is assumed to be 90%, the friction coefficient being 0.1.

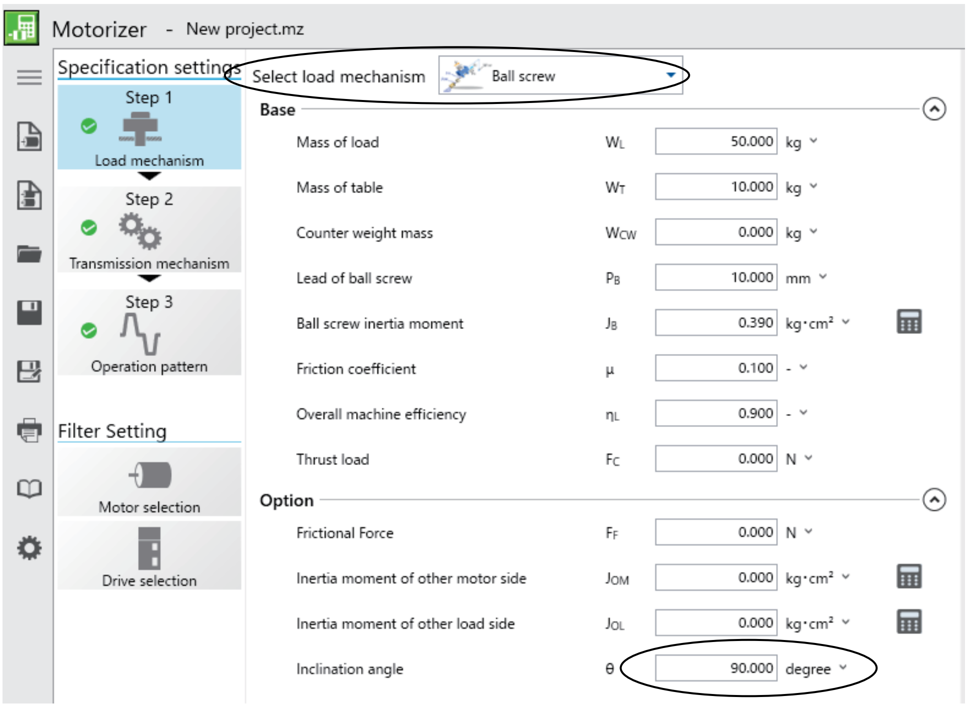
(1) Selecting a ball screw

Select [Step1 Load mechanism], then select the ball screw from "Select load mechanism".

Set the base information and option.

For a vertical system, set the inclination angle to 90 degrees.

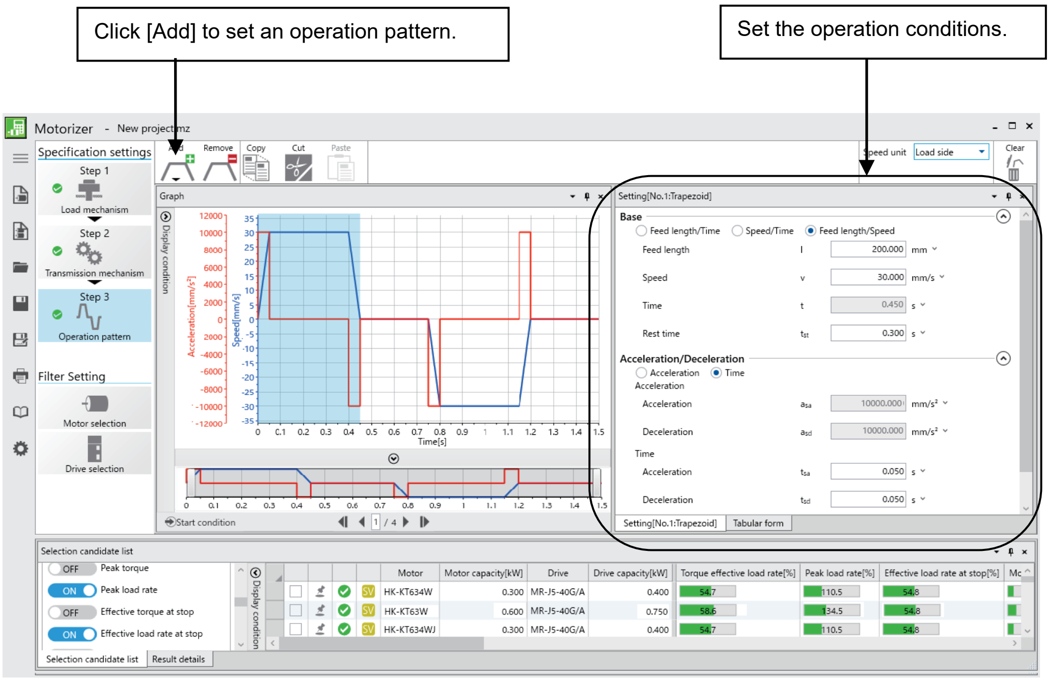
Set the value to zero if the actual value is unknown even when a preset value is indicated in the field.



(2) Setting an operation pattern

Select [Step3 Operation pattern], then click the [Add] button to set an operation pattern.

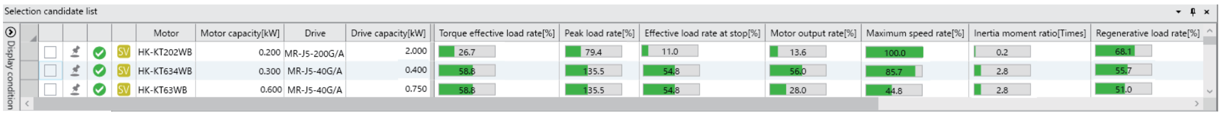
Set the operation conditions.



(3) Calculating the capacity

Confirm that the servo amplifier is the MR-J5 and the motor is the HK-KT. The results are shown in the "Selection candidate list".

It indicates that the selected motors are the HK-KT202WB, HK-KT634WB, and HK-KT63WB for the servo amplifiers MR-J5-200G/A, MR-J5-40G/A, and MR-J5-70G/A, requiring the regenerative option MR-RB12 or MR-RB14.



Selection candidate list

Motor	Motor capacity[kW]	Drive	Drive capacity[kW]	Torque effective load rate[%]	Peak load rate[%]	Effective load rate at stop[%]	Motor output rate[%]	Maximum speed rate[%]	Inertia moment ratio[Times]	Regenerative load rate[%]
HK-KT202WB	0.200	MR-J5-200G/A	2.000	26.7	79.4	11.0	13.6	100.0	0.2	68.1
HK-KT634WB	0.300	MR-J5-40G/A	0.400	58.8	135.5	54.8	56.0	85.7	2.8	55.7
HK-KT63WB	0.600	MR-J5-40G/A	0.750	58.8	135.5	54.8	28.0	44.8	2.8	51.0

(4) Evaluation criteria for selection results

The recommended model is indicated with a green tick. The other models are also applicable as long as the selection result data is indicated with other than a red cross or yellow exclamation point.

(5) Precautions

• Motorizer does not display calculation processes.

Memo

9 NOISE REDUCTION TECHNIQUES, EARTH-LEAKAGE CURRENT BREAKER, HARMONICS SUPPRESSION MEASURES

9.1 Noise Reduction Techniques

Noises are classified into external noises, which enter the servo amplifier to cause it to malfunction, and those radiated by the servo amplifier to cause peripheral equipment to malfunction. Because the servo amplifier is an electronic device that handles weak signals, the following general noise reduction techniques are required.
The servo amplifier can also be a source of noise as its outputs are chopped by high carrier frequencies. If peripheral equipment malfunctions due to noise produced by the servo amplifier, take measures to reduce the noise. The reduction techniques will vary slightly with the routes of noise transmission.

9.1.1 Noise reduction techniques

(1) General reduction techniques

- Avoid bundling power lines (input/output) and signal cables together or running them in parallel to each other. Separate the power lines from the signal cables.
- Use a shielded twisted pair cable for connection with the encoder and for control signal transmission, and connect the external conductor of the cable to the SD terminal.
- Ground the servo amplifier, servo motor, or other devices together at one point.
  For details, refer to the MR-J5 User's Manual (Hardware).

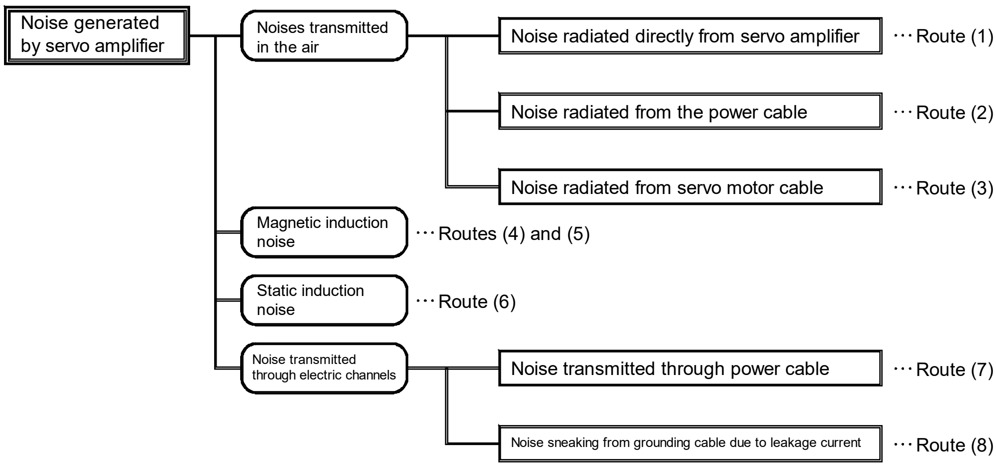
(2) Reduction techniques for external noises that cause the servo amplifier to malfunction

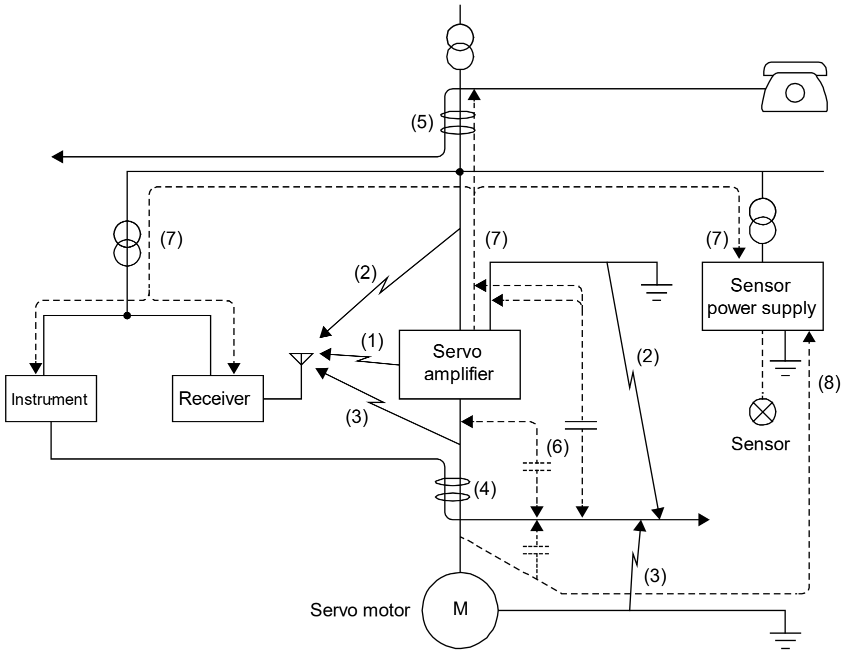
If there are noise sources (such as a magnetic contactor, an electromagnetic brake, and many relays) that make a large amount of noise near the servo amplifier and the servo amplifier may malfunction, the following countermeasures are required.

- Provide surge killers on the noise sources to suppress noise.
- Attach data line filters to the signal cables.
- Ground the shields of the encoder connecting cable and the control signal cables with cable clamp fittings.
- Although a surge absorber is built into the servo amplifier, to protect the servo amplifier and other equipment against large exogenous noise and lightning surge, attaching a varistor to the power input section of the equipment is recommended.

(3) Techniques for noises radiated by the servo amplifier that cause peripheral equipment to malfunction

Noises produced by the servo amplifier are classified into those radiated from the cables connected to the servo amplifier and its main circuits (input/output), those induced electromagnetically or statically by the signal cables of the peripheral equipment located near the main circuit cables, and those transmitted through the power supply cables.





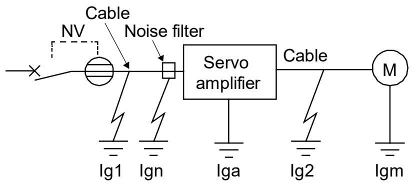
Noise transmission route	Suppression techniques
(1), (2), (3)	A malfunction due to noise transmitted through the air may occur in devices which handle weak signals and are susceptible to noise, such as measuring instruments, receivers and sensors. In addition, a malfunction may also occur when their signal cables are stored in a cabinet together with the servo amplifier or when the signal cables run near the servo amplifier. Take the following measures to prevent a malfunction: • Provide maximum clearance between easily affected devices and the servo amplifier. • Provide maximum clearance between easily affected signal cables and the I/O cables of the servo amplifier. • Avoid wiring the power lines (input/output lines of the servo amplifier) and signal lines side by side or bundling them together. • Insert a line noise filter to the I/O cables or a radio noise filter on the input line to reduce radiated noise from the cables. • Use shielded wires for the signal and power lines, or put the lines in separate metal conduits.
(4), (5), (6)	When power cables and signal cables are laid side by side or bundled together, electromagnetic and static induction noise is transmitted to the signal cables, causing malfunctions. Take the following precautions to protect the signal cables against noise. • Provide maximum clearance between easily affected devices and the servo amplifier. • Provide maximum clearance between easily affected signal cables and the I/O cables of the servo amplifier. • Avoid wiring the power lines (input/output lines of the servo amplifier) and signal lines side by side or bundling them together. • Use shielded wires for the signal and power lines, or put the lines in separate metal conduits.
(7)	When the power supply of peripheral equipment is connected to the power supply of the servo amplifier system, noise produced by the servo amplifier may be transmitted back through the power supply cable, and the equipment may malfunction. The following techniques are required. • Install the radio noise filter (FR-BIF(-H)) on the power lines (input lines) of the servo amplifier. • Install the line noise filter (FR-BSF01/FR-BLF) on the power lines of the servo amplifier.
(8)	If the grounding wires of the peripheral equipment and the servo amplifier make a closed loop circuit, leakage current may flow through, causing the equipment to malfunction. In this case, the malfunction may be prevented by disconnecting the grounding wires from the equipment.

9.2 Earth-Leakage Current Breaker

(1) Selection method

High-frequency chopper currents controlled by pulse width modulation flow in the AC servo circuits. Leakage currents containing harmonic contents are larger than those of the servo motor, which runs on AC power.
Select an earth-leakage current breaker according to the following formula, and ground the servo amplifier, servo motor, etc. securely.
To minimize leakage currents, make the input and output wires as short as possible, and keep a distance of 30cm or longer between the wires and ground.

Rated sensitivity current ≥ 10×{Ig1 + Ign + Iga + K × (Ig2+Igm)} [mA]

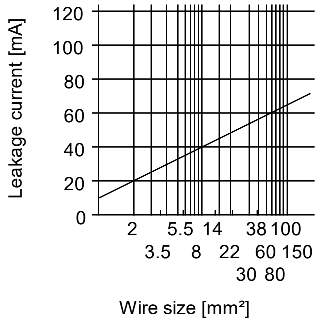


Earth-leakage current breaker		K [*1]
Type	Mitsubishi Electric products	
Models provided with harmonic and surge reduction techniques	NV-SP NV-SW NV-CP NV-CW NV-HW	1
General models	BV-C1 NFB NV-L	3

*1. K: Constant with the harmonics taken into account

Ig1: Leakage current on the electric channel from the earth-leakage current breaker to the input terminals of the servo amplifier (obtained from (a))
Ig2: Leakage current on the electric channel from the output terminals of the servo amplifier to the servo motor (obtained from (a))
Ign: Leakage current when a filter is connected to the input side (4.4mA per FR-BIF(-H))
Iga: Servo amplifier leakage current (obtained from (c))
Igm: Servo motor leakage current (obtained from (b))

(a) Example of leakage current (Ig1, Ig2) per km of CV cable run in metal conduit
• 200V class



(b) Servo motor leakage current example (Igm)

Servo motor output [kW]	Leakage current [mA]
0.05 to 1	0.1
1.2 to 2	0.2
3 to 3.5	0.3

(c) Servo amplifier leakage current example (Iga)

Servo amplifier	Leakage current [mA]
MR-J5-10_ MR-J5-20_ MR-J5-40_ MR-J5-60_ MR-J5-70_ MR-J5-100_	0.16
MR-J5-200_ MR-J5-350_	0.22

(d) Earth-leakage current breaker selection example

Servo amplifier	Rated sensitivity current of earth-leakage current breaker [mA]
MR-J5-10_ to MR-J5-350_	15

Precautions

- Filters in EN standards may be inapplicable in some regions due to their large leakage currents.

(2) Power factor improving DC reactor

The following shows the advantages of using a power factor improving DC reactor.

• It improves the power factor by increasing the form factor of the servo amplifier's input current.

• It decreases the power supply capacity.

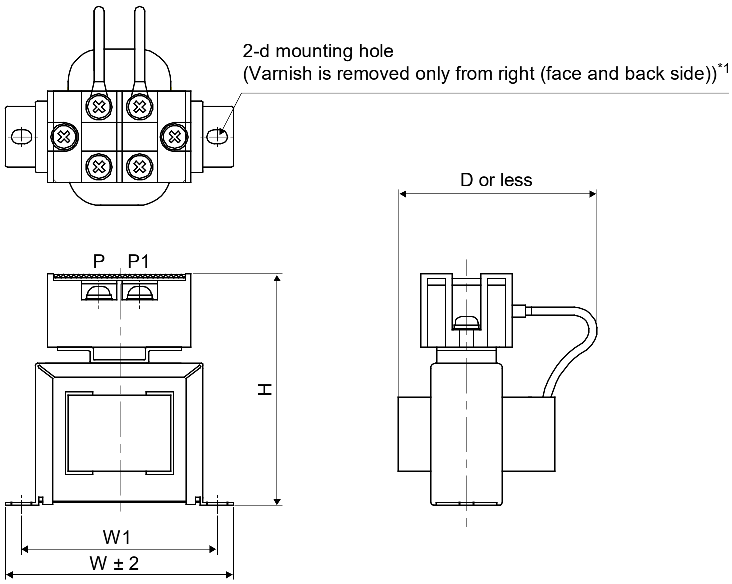
• The input power factor is improved to about 85%.

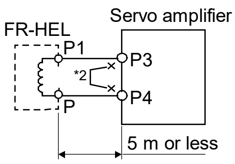
• As compared to the power factor improving AC reactor (FR-HAL-(H)), it decreases the loss.

When connecting the power factor improving DC reactor to the servo amplifier, disconnect P3 and P4. If it remains connected, the effect of the power factor improving DC reactor is not produced.

The power factor improving DC reactor generates heat when it is being used. To dissipate heat, therefore, maintain a minimum clearance of 10cm each at the top and bottom, and 5cm at the sides.

(a) 200V class





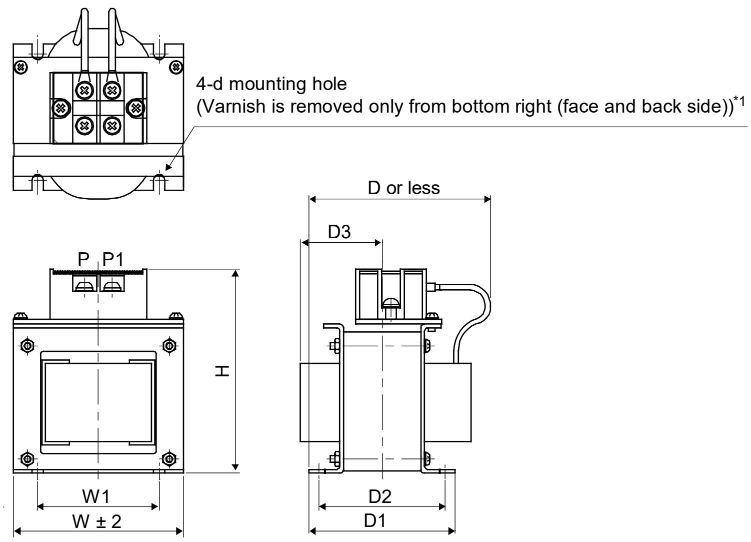
Servo amplifier	Power factor improving DC reactor	Dimensions [mm]								Terminal size	Mass [kg]	Wire [mm2] *4
		W	W1	H	D *3	D1	D2	D3	d			
MR-J5-10_ MR-J5-20_	FR-HEL-0.4K	70	60	71	61	–	21	–	M4	M4	0.4	2(AWG 14)
MR-J5-40_	FR-HEL-0.75K	85	74	81	61		21		M4	M4	0.5	
MR-J5-60_ MR-J5-70_	FR-HEL-1.5K	85	74	81	70		30		M4	M4	0.8	
MR-J5-100_	FR-HEL-2.2K	85	74	81	70		30		M4	M4	0.9	

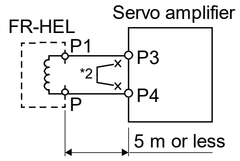
*1 . Use this for grounding.

*2. When using the power factor improving DC reactor, remove the short-circuit bar between P3 and P4.

*3. Maximum dimensions. The dimensions vary depending on the curvature of the input/output lines.

*4. Selection requirements for the wire size are as follows.
Wire type: 600V Grade heat-resistant polyvinyl chloride insulated wire (HIV wire)
Construction requirements: Single wire set in midair





Servo amplifier	Power factor improving DC reactor	Dimensions [mm]								Terminal size	Mass [kg]	Wire [mm2] *4
		W	W1	H	D *3	D1	D2	D3	d			
MR-J5-200_	FR-HEL-3.7K	77	55	92	82	66	57	37	M4	M4	1.5	2(AWG 14)
MR-J5-350_	FR-HEL-7.5K	86	60	113	98	81	72	43	M4	M5	2.5	3.5(AWG 12)

*1. Use this for grounding.
*2. When using the power factor improving DC reactor, remove the short-circuit bar between P3 and P4.
*3. Maximum dimensions. The dimensions vary depending on the curvature of the input/output lines.
*4. Selection requirements for the wire size are as follows.
Wire type: 600V Grade heat-resistant polyvinyl chloride insulated wire (HIV wire)
Construction requirements: Single wire set in midair

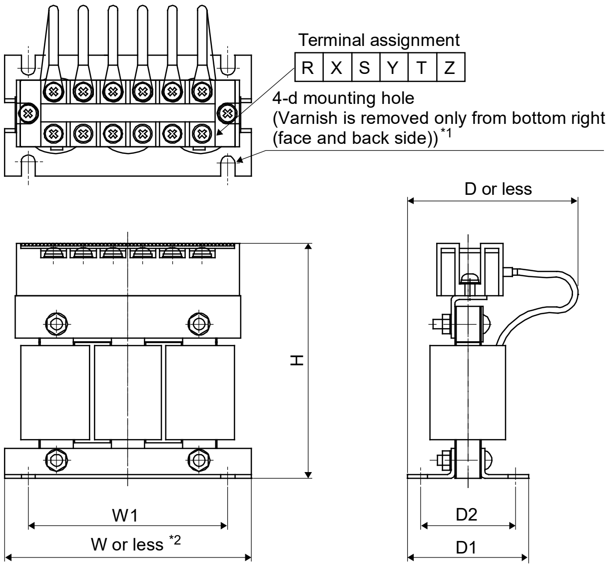
(3) Power factor improving AC reactor

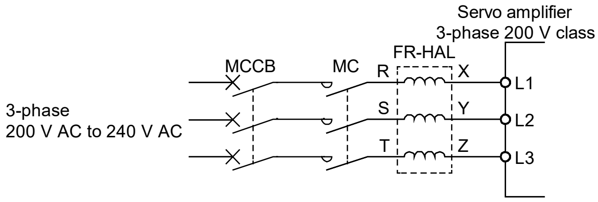
The following shows the advantages of using power factor improving AC reactor.

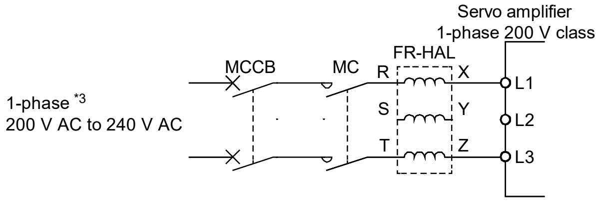
- It improves the power factor by increasing the form factor of the servo amplifier's input current.
- It decreases the power supply capacity.
- The input power factor is improved to about 80%.

When using power factor improving AC reactors for two or more servo amplifiers, connect a power factor improving AC reactor to each servo amplifier. If one power factor improving reactor is used for multiple servo amplifiers, the power factor cannot be improved sufficiently unless all servo amplifiers are operated.

(a) 200V class







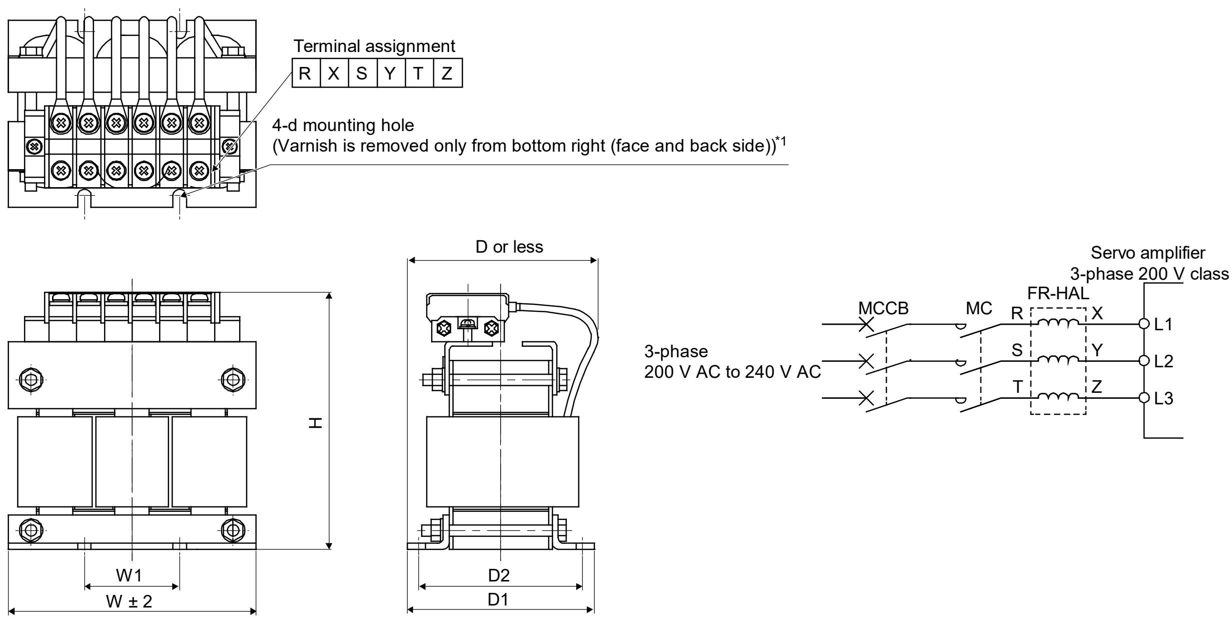
Servo amplifier	Power factor improving AC reactor	Dimensions [mm]							Terminal size	Mass [kg]
		W	W1	H	D *4	D1	D2	d		
MR-J5-10_ MR-J5-20_	FR-HAL-0.4K	104	84	99	72	51	40	M5	M4	0.6
MR-J5-40_	FR-HAL-0.75K	104	84	99	74	56	44	M5	M4	0.8
MR-J5-60_ MR-J5-70_	FR-HAL-1.5K	104	84	99	77	61	50	M5	M4	1.1
MR-J5-100_ (3-phase power supply input)	FR-HAL-2.2K	115 *4	40	115	77	71	57	M6	M4	1.5
MR-J5-100_ (1-phase power supply input) MR-J5-200_ (3-phase power supply input)	FR-HAL-3.7K	115 *4	40	115	83	81	67	M6	M4	2.2
MR-J5-200_ (1-phase power supply input)	FR-HAL-5.5K	115 *4	40	115	83	81	67	M6	M4	2.3

*1. Use this for grounding.

*2. For FR-HAL-0.4K to FR-HAL-1.5K, the W dimension is "W±2".

*3. For 1-phase 200 to 240V AC power supply, connect the power supply to L1 and L3. Leave L2 open.

*4. Maximum dimensions. The dimensions vary depending on the curvature of the input/output lines.



Servo amplifier	Power factor improving AC reactor	Dimensions [mm]							Terminal size	Mass [kg]
		W	W1	H	D [*4]	D1	D2	d		
MR-J5-350_	FR-HEL-7.5K	130	50	135	100	98	86	M6	M5	4.2

*1. Use this for grounding.
*2. Maximum dimensions. The dimensions vary depending on the curvature of the input/output lines.

10 MAINTENANCE, INSPECTION AND PARTS REPLACEMENT

As stationary equipment configured mainly by semiconductor devices, an AC servo amplifier requires daily maintenance to prevent troubles caused by the operating environment such as temperature, humidity, dust, and vibration, and factors such as aging and service life of the components being used.

10.1 Precautions for Maintenance, Inspection and Parts Replacement

The voltage of the smoothing capacitor remains high for a while even after the power supply has been shut off. Before inspecting the inside of an AC servo amplifier, wait until the charge light turns off, and check that the voltage between the main circuit terminals P and N is 0V using a tester or by other means.

10.2 Inspection items

(1) Daily inspection

• Basically, the following items are to be checked during operation:

(a) Whether the motor operates in accordance with the settings
(b) Whether there is any problem in the environment of the area where the servo is installed in
(c) Whether the cooling system has a problem
(d) Whether there is abnormal vibration or noise
(e) Whether there is abnormal heating or discoloration

• The input voltage of the AC servo is to be checked usually using a tester during operation.

(2) Periodic inspection

• Areas where an inspection cannot be performed unless the operation is at a stop and areas requiring periodic inspections are to be checked.

(a) Whether the cooling system has a problem ·········Cleaning conditions of the areas such as air filters
(b) Fastening check and tightening the parts again ····Perform inspection by thoroughly checking the screws and bolts as vibrations, temperature changes and other factors may loosen the fastened parts.
(c) Whether the wire and insulator are decayed or damaged
(d) Checks and replacements of the cooling fans, smoothing capacitors, and relays

Table 10.1 Daily and periodic inspection

Inspection part	Inspection items	What to inspect	Inspection frequency		Inspection method	Determination criteria	Instruments
			Daily	Periodic			
General	Surrounding environment	Check the ambient temperature, humidity, dust, dirt, and other factors	○				Thermometers, hygrometers, recorders
	Storage environment	Check the ambient temperature, humidity, dust, dirt, and other factors	○		By thermometers, hygrometers, and other instruments	(1) Motor: -15˚C to 70˚C (non-freezing) 90%RH or less (non-condensing) Amplifier: -25˚C to 70˚C (non-freezing) 95%RH or less (non-condensing)	Thermometers, hygrometers, recorders
	Whole system	Check if there is abnormal vibration or noise	○		By visual and aural check	No abnormalities	-
	Power supply voltage	Check if the main circuit voltage is at a normal level	○		By measuring voltage of each phase between L1, L2, and L3 of the servo amplifier terminal block	Refer to the standard specifications	Testers and digital multimeters
Main circuit	General	(1) Check if there is looseness in the fastened parts (2) Check if there is any evidence of overheating on each part (3) Cleaning		○ ○	(1) By tightening the parts again (2) By visual check	(1) (2) No abnormalities	
	Bus bar/wire	(1) Whether the bus bar is distorted (2) Whether the wire sheath is damaged		○	(1) (2) By visual check	(1) (2) No abnormalities	
	Terminal block	Check if there is any damage		○	By visual check	No abnormalities	
Main circuit	Smoothing capacitor	(1) Check if there is liquid leakage (2) Check if the safety valve comes out or swells out (3) Measurement of the static capacity		○ ○	(1) (2) By visual check (3) Measured by a capacity measuring instrument	(1) (2) No abnormalities (3) 85% or more of the rated capacity	Farad meter
	Relay	(1) Check if there is chattering sound during operation (2) Check the timer operation time (3) Check if the contact surface is rough		○ ○ ○	(1) By aural check (2) By measuring the time from power-on to relay attraction (3) By visual check	(1) No abnormalities (2) Within 0.1 to 0.15 seconds (3) No abnormalities	Universal counter
	Resistor	(1) Check if there is breakage on the insulator of the resistor (2) Check if there is disconnection		○ ○	(1) By visual check Wire-wound resistors such as a cement resistor (2) By measuring the resistance using a tester after removing the connection on one side	(1) No abnormalities (2) Errors within ±10% of the displayed resistance value	Testers and digital multimeters

Inspection part	Inspection items	What to inspect	Inspection frequency		Inspection method	Determination criteria	Instruments
			Daily	Periodic			
Control circuit/protective circuit	Operation check	(1) Check the balance of output voltage between each phase during operation by the servo alone (without any load) (2) Perform sequence protection operation, then check if there is abnormality in the protective and display circuit		○ ○	(1) By measuring the voltage between each U, V, and W-phase of the servo amplifier output terminal (2) By simulating a short in the servo amplifier protective circuit output	(1) The voltage balance between each phase is 4V or less (2) Error occurrence in the sequence	Digital multimeters Rectifier type voltmeters
Cooling system	Cooling fan	(1) Check if there is abnormal vibration or noise (2) Check if there is looseness in the connected parts	○	○	(1) By rotating the fan by hand with the equipment power off (2) By tightening the parts again	(1) Smooth rotation (2) No abnormalities	
Display	Display	Check if the charge light or 7-segment LED has blown	○		By turning on the light and display on the servo amplifier	The charge light and display are confirmed to turn on properly	
Servo motor	General	(1) Check if there is abnormal vibration or noise (2) Check if there is an unusual odor	○ ○		(1) By aural and visual check and by bodily sensations (2) By abnormal odor check based on factors such as overheating and damage	(1) (2) No abnormalities	
	Detector	Check if there is abnormal vibration or noise	○		By aural check and bodily sensations	No abnormalities	
	Cooling fan	(1) Check if there is abnormal vibration or noise (2) Check if mist, foreign matter, or other substances adhere	○		(1) By rotating the fan by hand with the equipment power off (2) By visual check	(1) Smooth rotation (2) No abnormalities	
	Bearing	Check if there is abnormal vibration or noise	○		By aural check and bodily sensations	No abnormalities	

10.3 Replacement

The service life of the following parts is listed below. In addition, the service life varies depending on the operating methods and environment. If any fault is found in a part, it is necessary to replace it immediately regardless of its service life. For parts replacement, please contact your local sales office.

Part name	Recommended service life
Smoothing capacitor	10 years
Relay	Total number of times of power-on, forced stop by EM1 (Forced stop 1), and sudden stop command from controller: 100,000
Cooling fan	50,000 hours to 70,000 hours (7 to 8 years)
Absolute position battery	Refer to "ABSOLUTE POSITION DETECTION SYSTEM" in the following manual. MR-J5 User's Manual (Hardware)
Bearing	20,000 hours to 30,000 hours
Encoder	20,000 hours to 30,000 hours
Oil seal	5,000 hours
Battery	5 years from date of manufacture

(1) Smoothing capacitor

The characteristic of the smoothing capacitor is deteriorated due to ripple currents or other factors. The service life of the capacitor greatly varies depending on ambient temperature and operating conditions. The service life of the capacitor is 10 years under continuous operation in air-conditioned environments (ambient temperatures of 40°C or less at altitudes of up to 1000m and 30°C or less at altitudes of over 1000m and up to 2000m).

(2) Relays

Contact faults occur due to contact wear arisen from switching currents. A relay will reach the end of its service life if the following actions are performed a total of 100,000 times: powering on the servo amplifier, inputting the EM1 command (Forced stop 1), and inputting the quick stop command from the servo controller. In addition, the service life of a relay may vary depending on the power supply capacity.

(3) Servo amplifier cooling fan

The cooling fan bearings will reach the end of their service life in 50,000 hours to 70,000 hours. Therefore, the cooling fan must be replaced after seven to eight years of continuous operation as a guideline. If unusual noise or vibration is found during inspection, the cooling fan must also be replaced. The service life has been calculated in an environment which contains no corrosive gas, flammable gas, oil mist, or dust. The average annual ambient temperature was 40 ˚C.

(4) Bearings

When the motor is run at rated speed and at rated load, bearings should be changed every 20000 to 30000 hours as a guideline. As this differs depending on the operating conditions, the bearings must also be changed if unusual noise or vibration occurs during inspection.

(5) Oil seal

Oil seals must be changed in 5000 hours of operation at rated speed as a guideline. This differs depending on the operating conditions. The oil seals must also be changed if oil leakage a similar problem is found during inspection.
Even if the oil seal on the rotary servo motor makes noises during operation, it does not indicate a problem with the functions.

(6) Battery

Quality of the batteries degrades by the storage condition. The battery life is 5 years from the production date regardless of the connection status.

10.4 Troubleshooting

Point

- Refer to the MR-J5 User's Manual (Troubleshooting) for the details of alarms and warnings.
- As soon as an alarm occurs, turn off SON (Servo-on), then shut off the power supply.

Precautions

- In the MR-J5 series, the alarm No. and warning No. are shown with three digits, followed by one digit indicating the detail No. This has changed since the MR-J4 series, in which these numbers were shown with two digits and one digit, respectively.

An alarm or warning is displayed when an error occurs during operation. If an alarm or warning occurs, take the appropriate action in accordance with the MR-J5 User's Manual (Troubleshooting). When an alarm occurs, ALM (Malfunction) turns off.
After the cause of the alarm has been removed, the alarm can be deactivated by any of the methods marked "○" in the "Alarm deactivation" column. Warnings will be canceled automatically by removing the causes.
Alarms and warnings which have "SD" in the "Motor stop method" column stop the servo motor with the dynamic brake after forced stop deceleration. Alarms and warnings which have "DB" in the "Motor stop method" column stop the servo motor with the dynamic brake without forced stop deceleration.

10.4.1 List of alarms and warnings

An alarm or warning is displayed when an error occurs during operation. If an alarm or warning occurs, take the appropriate action in accordance with "Handling methods for alarms/warnings" in the MR-J5 User's Manual (Troubleshooting). When an alarm occurs, ALM (Malfunction) turns off.

(1) Alarm No.

No.	Name	Detail No.	Detail name
010	Undervoltage	010.1	Voltage drop in the control circuit power
		010.2	Voltage drop in the main circuit power
011	Switch setting error	011.1	Rotary switch setting error
		011.2	Disabled axis setting error
012	Memory error 1 (RAM)	012.1	RAM error 1
		012.2	RAM error 2
		012.4	RAM error 4
		012.5	RAM error 5
		012.6	RAM error 6
		012.7	RAM error 7
		012.8	RAM error 8
		012.9	RAM error 9
013	CPU error	013.1	CPU error 1
		013.2	CPU error 2
		013.4	CPU error 4
		013.5	CPU error 5
014	Control process error	014.1	Control process error 1
		014.2	Control process error 2
		014.3	Control process error 3
		014.4	Control process error 4
		014.5	Control process error 5
		014.8	Control process error 8
		014.9	Control process error 9
016	Encoder initial communication error 1	016.1	Encoder initial communication - Receive data error 1
		016.2	Encoder initial communication - Receive data error 2
		016.3	Encoder initial communication - Receive data error 3
		016.5	Encoder initial communication - Transmission data error 1
		016.6	Encoder initial communication - Transmission data error 2
		016.7	Encoder initial communication - Transmission data error 3
		016.A	Encoder initial communication - Process error 1
		016.B	Encoder initial communication - Process error 2
		016.C	Encoder initial communication - Process error 3
		016.D	Encoder initial communication - Process error 4
		016.E	Encoder initial communication - Process error 5
		016.F	Encoder initial communication - Process error 6
017	Board error	017.1	Board error 1
		017.3	Board error 2
		017.4	Board error 3
		017.5	Board error 4
		017.6	Board error 5
		017.7	Board error 7
		017.9	Board error 8
019	Memory error 3	019.1	Flash-ROM error 1
		019.2	Flash-ROM error 2
		019.3	Flash-ROM error 3
		019.6	Flash-ROM error 6

No.	Name	Detail No.	Detail name
01A	Servo motor combination error	01A.1	Servo motor combination error 1
		01A.2	Servo motor control mode combination error
		01A.3	Control mode/load-side encoder combination error
		01A.4	Servo motor combination error 2
		01A.5	Servo motor combination error 3
		01A.6	Servo motor combination error 4
01E	Encoder initial communication error 2	01E.1	Encoder malfunction
		01E.2	Load-side encoder malfunction
01F	Encoder initial communication error 3	01F.1	Incompatible encoder
		01F.2	Incompatible load-side encoder
020	Encoder normal communication error 1	020.1	Encoder normal communication - Receive data error 1
		020.2	Encoder normal communication - Receive data error 2
		020.3	Encoder normal communication - Receive data error 3
		020.5	Encoder normal communication - Transmission data error 1
		020.6	Encoder normal communication - Transmission data error 2
		020.7	Encoder normal communication - Transmission data error 3
021	Encoder normal communication error 2	021.1	Encoder data error 1
		021.2	Encoder data update error
		021.3	Encoder data waveform error
		021.4	No encoder signal
		021.5	Encoder hardware error 1
		021.6	Encoder hardware error 2
024	Main circuit error	024.1	Ground fault detected via hardware detection circuit
		024.2	Ground fault detected via software detection processing
025	Absolute position erased	025.1	Servo motor encoder - Absolute position erased
		025.2	Scale measurement encoder - Absolute position erased
027	Initial magnetic pole detection error	027.1	Initial magnetic pole detection - Abnormal termination
		027.2	Initial magnetic pole detection - Time-out error
		027.3	Initial magnetic pole detection - Limit switch error
		027.4	Initial magnetic pole detection - Estimation error
		027.5	Initial magnetic pole detection - Speed deviation error
		027.6	Initial magnetic pole detection - Position deviation error
		027.7	Initial magnetic pole detection - Current error
028	Linear encoder error 2	028.1	Linear encoder environmental error
		028.2	Load-side linear encoder environmental error
02A	Linear encoder error 1	02A.1	Linear encoder error 1-1
		02A.2	Linear encoder error 1-2
		02A.3	Linear encoder error 1-3
		02A.4	Linear encoder error 1-4
		02A.5	Linear encoder error 1-5
		02A.6	Linear encoder error 1-6
		02A.7	Linear encoder error 1-7
		02A.8	Linear encoder error 1-8
02B	Encoder counter error	02B.1	Encoder counter error 1
		02B.2	Encoder counter error 2
030	Regenerative error	030.1	Regenerative heat error
		030.2	Regenerative signal error
		030.3	Regenerative feedback signal error
031	Overspeed	031.1	Servo motor speed error

No.	Name	Detail No.	Detail name
032	Overcurrent	032.1	Overcurrent detected via hardware detection circuit (during operation)
		032.2	Overcurrent detected via software detection processing (during operation)
		032.3	Overcurrent detected via hardware detection circuit (during a stop)
		032.4	Overcurrent detected via software detection processing (during a stop)
033	Overvoltage	033.1	Main circuit voltage error
035	Command frequency error	035.1	Command frequency error
037	Parameter error	037.1	Parameter setting range error
		037.2	Parameter combination error
		037.6	Parameter mismatch error
		037.7	Network parameter setting error
03A	Inrush current suppression circuit error	03A.1	Inrush current suppression circuit error
042	Servo control error	042.1	Servo control error based on position deviation
		042.2	Servo control error based on speed deviation
		042.3	Servo control error based on torque/thrust deviation
		042.8	Fully closed loop control error based on position deviation
		042.9	Fully closed loop control error based on speed deviation
		042.A	Fully closed loop control error based on position deviation during command stop
045	Main circuit device overheat	045.1	Main circuit device overheat error 1
		045.2	Main circuit device overheat error 2
046	Servo motor overheat	046.1	Servo motor temperature error 1
		046.2	Servo motor temperature error 2
		046.3	Thermistor disconnected error
		046.4	Thermistor circuit error
		046.5	Servo motor temperature error 3
		046.6	Servo motor temperature error 4
047	Cooling fan error	047.1	Cooling fan stop error
		047.2	Decreased cooling fan speed error
050	Overload 1	050.1	Thermal overload error 1 during operation
		050.2	Thermal overload error 2 during operation
		050.3	Thermal overload error 4 during operation
		050.4	Thermal overload error 1 during a stop
		050.5	Thermal overload error 2 during a stop
		050.6	Thermal overload error 4 during a stop
051	Overload 2	051.1	Thermal overload error 3 during operation
		051.2	Thermal overload error 3 during a stop

No.	Name	Detail No.	Detail name
052	Excessive error	052.1	Excessive droop pulse 1
		052.3	Excessive droop pulse 2
		052.4	Excessive error during 0 torque limit
		052.5	Excessive droop pulse 3
		052.6	Excessive droop pulse at servo-off
054	Oscillation detection	054.1	Oscillation detection error
056	Forced stop error	056.2	Speed exceeded during forced stop
		056.3	Estimated distance exceeded during forced stop
063	STO timing error	063.1	STO1 off
		063.2	STO2 off
068	STO diagnosis error	068.1	STO signal mismatch error
069	Command error	069.1	Forward rotation-side software limit detection - Command excess error
		069.2	Reverse rotation-side software limit detection - Command excess error
		069.3	Forward rotation stroke end detection - Command excess error
		069.4	Reverse rotation stroke end detection - Command excess error
		069.5	Upper stroke limit detection - Command excess error
		069.6	Lower stroke limit detection - Command excess error
070	Load-side encoder initial communication error 1	070.1	Load-side encoder initial communication - Receive data error 1
		070.2	Load-side encoder initial communication - Receive data error 2
		070.3	Load-side encoder initial communication - Receive data error 3
		070.5	Load-side encoder initial communication - Transmission data error 1
		070.6	Load-side encoder initial communication - Transmission data error 2
		070.7	Load-side encoder initial communication - Transmission data error 3
		070.A	Load-side encoder initial communication - Process error 1
		070.B	Load-side encoder initial communication - Process error 2
		070.C	Load-side encoder initial communication - Process error 3
		070.D	Load-side encoder initial communication - Process error 4
		070.E	Load-side encoder initial communication - Process error 5
		070.F	Load-side encoder initial communication - Process error 6
071	Load-side encoder normal communication error 1	071.1	Load-side encoder normal communication - Receive data error 1
		071.2	Load-side encoder normal communication - Receive data error 2
		071.3	Load-side encoder normal communication - Receive data error 3
		071.5	Load-side encoder normal communication - Transmission data error 1
		071.6	Load-side encoder normal communication - Transmission data error 2
		071.7	Load-side encoder normal communication - Transmission data error 3
072	Load-side encoder normal communication error 2	072.1	Load-side encoder data error 1
		072.2	Load-side encoder data update error
		072.3	Load-side encoder data waveform error
		072.4	No load-side encoder signal
		072.5	Load-side encoder hardware error 1
		072.6	Load-side encoder hardware error 2
086	Network communication error	086.1	Network communication error 1
		086.2	Network communication error 2
		086.3	Network communication error 3
		086.5	Network communication error 5
		086.6	Network communication error 6

No.	Name	Detail No.	Detail name
088/888/ 88888	Watchdog 1	088.1/088/ 888/88888	Watchdog 1-1
		088.2	Watchdog 1-2
		088.4	Watchdog 1-4
		088.8	Watchdog 1-8
08E	Serial communication error	08E.1	Serial communication receive error
		08E.2	Serial communication checksum error
		08E.3	Serial communication character error
		08E.4	Serial communication command error
		08E.5	Serial communication data number error
118	Encoder diagnosis	118.1	Encoder communication circuit diagnosis in progress
119	Memory error 4	119.1	Memory error 4-1
		119.2	Memory error 4-2
		119.3	Memory error 4-3
		119.4	Memory error 4-4
		119.5	Memory error 4-5
		119.6	Memory error 4-6
		119.7	Memory free space error 4-1
		119.8	Memory free space error 4-2
11A	Servo motor constant error	11A.1	Servo motor constant file error
		11A.2	Servo motor constant file extension error
		11A.3	Servo motor constant file amount error
130	Regenerative error 2	130.1	Regenerative heat error
139	Open-phase error	139.1	Input open-phase error
		139.2	Output open-phase error
		139.3	Motor wiring error
168	STO function error	168.1	STO function error
17A	Load-side linear encoder error 1	17A.1	Load-side linear encoder error 1-1
		17A.2	Load-side linear encoder error 1-2
		17A.3	Load-side linear encoder error 1-3
		17A.4	Load-side linear encoder error 1-4
		17A.5	Load-side linear encoder error 1-5
		17A.6	Load-side linear encoder error 1-6
		17A.7	Load-side linear encoder error 1-7
		17A.8	Load-side linear encoder error 1-8
188	Watchdog 2	188.1	Watchdog 2-1
510	Voltage diagnosis error (safety sub-function)	510.1	Power supply voltage diagnosis error A1 (safety sub-function)
		510.2	Power supply voltage diagnosis error A2 (safety sub-function)
		510.7	Power supply voltage diagnosis error A at start-up (safety sub-function)
		510.9	Power supply voltage diagnosis error B1 (safety sub-function)
		510.A	Power supply voltage diagnosis error B2 (safety sub-function)
		510.B	Power supply voltage diagnosis error B3 (safety sub-function)
		510.C	Power supply voltage diagnosis error B4 (safety sub-function)
		510.D	Power supply voltage diagnosis error B5 (safety sub-function)
		510.E	Power supply voltage diagnosis error B6 (safety sub-function)
		510.F	Power supply voltage diagnosis error B at startup (safety sub-function)
512	Memory error 1 (RAM) (safety sub-function)	512.2	RAM diagnosis error A2 (safety sub-function)
		512.3	RAM diagnosis error A3 (safety sub-function)
		512.A	RAM diagnosis error B2 (safety sub-function)
		512.B	RAM diagnosis error B3 (safety sub-function)
514	Control process error (safety sub-function)	514.9	Control process error B (safety sub-function)
517	Board error (safety sub-function)	517.2	Board error A2 (safety sub-function)
		517.9	Board error B1 (safety sub-function)

No.	Name	Detail No.	Detail name
518	Synchronous control error (safety sub-function)	518.2	Synchronous control error A2 (safety sub-function)
		518.A	Synchronous control error B2 (safety sub-function)
519	Memory error 3 (Flash-ROM) (safety sub-function)	519.2	Flash-ROM error A2 (safety sub-function)
		519.A	Flash-ROM error B2 (safety sub-function)
540	Internal diagnosis error 1 (safety sub-function)	540.1	Internal diagnosis error 1 - Data error A1 (safety sub-function)
		540.2	Internal diagnosis error 1 - Data error A2 (safety sub-function)
		540.3	Internal diagnosis error 1 - Data error A3 (safety sub-function)
		540.4	Internal diagnosis error 1 - Data error A4 (safety sub-function)
		540.9	Internal diagnosis error 1 - Data error B1 (safety sub-function)
		540.A	Internal diagnosis error 1 - Data error B2 (safety sub-function)
541	Internal diagnosis error 2 (safety sub-function)	541.1	Internal diagnosis error 2 - Data error A1 (safety sub-function)
		541.2	Internal diagnosis error 2 - Data error A2 (safety sub-function)
		541.3	Internal diagnosis error 2 - Data error A3 (safety sub-function)
		541.4	Internal diagnosis error 2 - Data error A4 (safety sub-function)
		541.5	Internal diagnosis error 2 - Data error A5 (safety sub-function)
		541.9	Internal diagnosis error 2 - Data error B1 (safety sub-function)
		541.A	Internal diagnosis error 2 - Data error B2 (safety sub-function)
		541.B	Internal diagnosis error 2 - Data error B3 (safety sub-function)
		541.C	Internal diagnosis error 2 - Data error B4 (safety sub-function)
		541.D	Internal diagnosis error 2 - Data error B5 (safety sub-function)
542	Internal diagnosis error 3 (safety sub-function)	542.1	Internal diagnosis error 3 - Data error A1 (safety sub-function)
		542.9	Internal diagnosis error 3 - Data error B1 (safety sub-function)
543	Internal diagnosis error 4 (safety sub-function)	543.1	Internal diagnosis error 4 - Data error A1 (safety sub-function)
		543.2	Internal diagnosis error 4 - Data error A2 (safety sub-function)
		543.9	Internal diagnosis error 4 - Data error B1 (safety sub-function)
		543.A	Internal diagnosis error 4 - Data error B2 (safety sub-function)
		543.B	Internal diagnosis error 4 - Data error B3 (safety sub-function)
		543.C	Internal diagnosis error 4 - Data error B4 (safety sub-function)
		543.D	Internal diagnosis error 4 - Data error B5 (safety sub-function)
544	Temperature diagnosis error (safety sub-function)	544.1	Temperature diagnosis error A1 (safety sub-function)
		544.2	Temperature diagnosis error A2 (safety sub-function)
		544.9	Temperature diagnosis error B1 (safety sub-function)
		544.A	Temperature diagnosis error B2 (safety sub-function)
545	Internal diagnosis error 5 (safety sub-function)	545.2	Internal diagnosis error 5 - Data error A2 (safety sub-function)
546	Internal diagnosis error 6 (safety sub-function)	546.1	Internal diagnosis error 6 - Data error A1 (safety sub-function)
		546.2	Internal diagnosis error 6 - Data error A2 (safety sub-function)
		546.9	Internal diagnosis error 6 - Data error B1 (safety sub-function)
		546.A	Internal diagnosis error 6 - Data error B2 (safety sub-function)
547	Internal diagnosis error 7 (safety sub-function)	547.1	Internal diagnosis error 7 - Data error A1 (safety sub-function)
		547.2	Internal diagnosis error 7 - Data error A2 (safety sub-function)
		547.9	Internal diagnosis error 7 - Data error B1 (safety sub-function)
		547.A	Internal diagnosis error 7 - Data error B2 (safety sub-function)
54A	Internal diagnosis error 9 (safety sub-function)	54A.1	Internal diagnosis error 9 - Data error A1 (safety sub-function)
		54A.2	Internal diagnosis error 9 - Data error A2 (safety sub-function)
		54A.3	Internal diagnosis error 9 - Data error A3 (safety sub-function)
		54A.9	Internal diagnosis error 9 - Data error B1 (safety sub-function)
		54A.A	Internal diagnosis error 9 - Data error B2 (safety sub-function)
		54A.B	Internal diagnosis error 9 - Data error B3 (safety sub-function)
54D	Internal diagnosis error 10 (safety sub-function)	54D.1	Internal diagnosis error 10 - Data error A1 (safety sub-function)
		54D.2	Internal diagnosis error 10 - Data error A2 (safety sub-function)
		54D.3	Internal diagnosis error 10 - Data error A3 (safety sub-function)
		54D.4	Internal diagnosis error 10 - Data error A4 (safety sub-function)
		54D.9	Internal diagnosis error 10 - Data error B1 (safety sub-function)

No.	Name	Detail No.	Detail name
54F	Safety software error (safety sub-function)	54F.1	Register setting error A1 (safety sub-function)
550	Internal diagnosis error 11 (safety sub-function)	550.1	Internal diagnosis error 11 - Internal signal error A1 (safety sub-function)
		550.2	Internal diagnosis error 11 - Internal signal error A2 (safety sub-function)
		550.3	Internal diagnosis error 11 - Internal signal error A3 (safety sub-function)
		550.4	Internal diagnosis error 11 - Internal signal error A4 (safety sub-function)
		550.9	Internal diagnosis error 11 - Internal signal error B1 (safety sub-function)
		550.A	Internal diagnosis error 11 - Internal signal error B2 (safety sub-function)
		550.B	Internal diagnosis error 11 - Internal signal error B3 (safety sub-function)
		550.C	Internal diagnosis error 11 - Internal signal error B4 (safety sub-function)
551	Internal diagnosis error 12 (safety sub-function)	551.1	Internal diagnosis error 12 - Internal signal error A1 (safety sub-function)
		551.2	Internal diagnosis error 12 - Internal signal error A2 (safety sub-function)
		551.3	Internal diagnosis error 12 - Internal signal error A3 (safety sub-function)
		551.4	Internal diagnosis error 12 - Internal signal error A4 (safety sub-function)
		551.9	Internal diagnosis error 12 - Internal signal error B1 (safety sub-function)
		551.A	Internal diagnosis error 12 - Internal signal error B2 (safety sub-function)
		551.B	Internal diagnosis error 12 - Internal signal error B3 (safety sub-function)
		551.C	Internal diagnosis error 12 - Internal signal error B4 (safety sub-function)
552	Internal diagnosis error 13 (safety sub-function)	552.1	Internal diagnosis error 13 - Internal signal error A1 (safety sub-function)
		552.9	Internal diagnosis error 13 - Internal signal error B1 (safety sub-function)
554	Input device internal diagnosis error (safety sub-function)	554.1	DI1A internal diagnosis error (safety sub-function)
		554.9	DI1B internal diagnosis error (safety sub-function)
557	Input device mismatch detection (safety sub-function)	557.1	DI1 input mismatch error A (safety sub-function)
		557.9	DI1 input mismatch error B (safety sub-function)

(2) Alarm number

No.	Name	Detail No.	Detail name
090	Homing incomplete warning	090.1	Homing incomplete
		090.2	Homing abnormal termination
		090.5	Z-phase unpassed
091	Servo amplifier overheat warning	091.1	Main circuit device overheat warning
092	Battery cable disconnection warning	092.1	Encoder battery cable disconnection warning
		092.2	Load-side encoder battery cable disconnection warning
		092.3	Battery degradation
093	ABS data transfer warning	093.1	Magnetic pole detection incomplete warning at ABS data transfer request
095	STO warning	095.1	STO1 off detection
		095.2	STO2 off detection
096	Home position setting warning	096.1	In-position warning at homing
		096.2	Command input warning at homing
		096.3	Servo off warning at homing
		096.4	Magnetic pole detection incomplete warning at homing
098	Software position limit warning	098.1	Forward rotation-side software stroke limit reached
		098.2	Reverse rotation-side software stroke limit reached
099	Stroke limit warning	099.1	Forward rotation stroke end off
		099.2	Reverse rotation stroke end off
		099.4	Upper stroke limit off
		099.5	Lower stroke limit off
09B	Excessive error warning	09B.1	Excessive droop pulse 1 warning
		09B.3	Excessive droop pulse 2 warning
		09B.4	Excessive error warning during 0 torque limit
09E	Network warning	09E.2	Communication cycle setting warning
		09E.3	Number of cyclic points warning
		09E.4	Parameter file warning
		09E.5	Cyclic communication setting warning
		09E.6	IP address setting warning
		09E.7	Parameter unreflected warning
		09E.8	Master station error detection warning
		09E.9	Control mode setting warning
		09E.A	Communication cycle setting warning
09F	Battery warning	09F.1	Low battery
		09F.2	Battery degradation warning
0E0	Excessive regenerative error	0E0.1	Excessive regeneration warning
0E1	Overload warning 1	0E1.1	Thermal overload warning 1 during operation
		0E1.2	Thermal overload warning 2 during operation
		0E1.3	Thermal overload warning 3 during operation
		0E1.4	Thermal overload warning 4 during operation
		0E1.5	Thermal overload warning 1 during a stop
		0E1.6	Thermal overload warning 2 during a stop
		0E1.7	Thermal overload warning 3 during a stop
		0E1.8	Thermal overload warning 4 during a stop
0E2	Servo motor overheat warning	0E2.1	Servo motor temperature warning
		0E2.2	Servo motor temperature warning 2
0E3	Absolute position counter warning	0E3.1	Multi-revolution counter travel distance excess warning
		0E3.2	Absolute position counter warning
		0E3.5	Encoder absolute position counter warning
		0E3.6	Scale measurement encoder absolute position counter warning
0E5	ABS time-out warning	0E5.1	Time-out during ABS data transfer
		0E5.2	ABSM off during ABS data transfer
		0E5.3	SON off during ABS data transfer
0E6	Servo forced stop warning	0E6.1	Forced stop warning

No.	Name	Detail No.	Detail name
0E8	Decreased cooling fan speed warning	0E8.1	Decreased cooling fan speed
		0E8.2	Cooling fan stop
0E9	Main circuit off warning	0E9.1	Servo-on signal on during main circuit off
		0E9.2	Bus voltage drop during low speed operation
		0E9.3	Ready-on signal on during main circuit off
0EA	ABS servo-on warning	0EA.1	ABS servo-on warning
0EB	The other axis error warning	0EB.1	The other axis error warning
0EC	Overload warning 2	0EC.1	Overload warning 2
0ED	Output watt excess warning	0ED.1	Output watt excess warning
0F0	Tough drive warning	0F0.1	Instantaneous power failure tough drive warning
		0F0.3	Vibration tough drive warning
0F2	Drive recorder warning	0F2.1	Drive recorder warning 1
		0F2.2	Drive recorder warning 2
		0F2.3	Drive recorder warning 3
		0F2.4	Drive recorder warning 4
		0F2.5	Drive recorder warning 5
		0F2.6	Drive recorder warning 6
0F3	Oscillation detection warning	0F3.1	Oscillation detection warning
0F4	Positioning warning	0F4.6	Acceleration time constant setting range error warning
		0F4.7	Deceleration time constant setting range error warning
		0F4.A	Fully closed loop control - Switching warning
0F7	Machine diagnosis warning	0F7.1	Vibration failure prediction warning
		0F7.2	Friction failure prediction warning
		0F7.3	Servo motor total travel distance failure prediction warning
		0F7.4	Gear failure prediction warning
		0F7.5	Static friction failure prediction warning
		0F7.6	Belt failure prediction warning
19E	Network warning 2	19E.1	Parameter automatic backup setting warning
		19E.2	Control mode setting warning 2
1E9	Open-phase warning	1E9.1	Input open-phase warning
1F8	Memory warning 1	1F8.1	Memory writing frequency warning
		1F8.2	Memory free space warning
59D	Internal diagnosis warning (safety sub-function)	59D.1	Internal diagnosis warning A1 (safety sub-function)
		59D.3	Internal diagnosis warning A3 (safety sub-function)
		59D.6	Internal diagnosis warning A6 (safety sub-function)
		59D.9	Internal diagnosis warning B1 (safety sub-function)
		59D.B	Internal diagnosis warning B3 (safety sub-function)
		59D.E	Internal diagnosis warning B6 (safety sub-function)

10.4.2 Handling methods for alarms/warnings

Precautions

- As soon as an alarm occurs, switch to servo-off status and shut off the main circuit power supply.
- If an abnormality related to overheating occurs, remove the cause of the abnormality and allow a cooling time of approximately 30 minutes.
- The alarm canceling method in [AL.042 Servo control error] can be changed with [Pr.PL04.3 [AL.042 Servo control error] detection controller reset condition selection].
- If an alarm which is related to the communication with the controller occurs, resetting the communication may not cancel the alarm.
- In the alarm list, alarms marked with "○" in the "Safety reset" column must be canceled while all the safety sub-functions have stopped. These alarms cannot be canceled unless all the safety sub-functions have stopped.
- After performing the check/action, cycle the power of the servo amplifier.
- If the alarm remains active even after the check/action of each alarm, the servo amplifier may have malfunctioned. Replace the servo amplifier, then check the repeatability.
- If the same problem continues even after replacing the servo amplifier, there may be a problem with the surrounding environment or with other devices.
- When [AL.025 Absolute position erased] occurs, perform homing again to prevent an unexpected operation.
- When [AL.0E6 Servo forced stop warning], [AL.0E9 Main circuit off warning], [AL.0EA ABS servo-on warning], or [AL.0EB The other axis error warning] occurs, the servo amplifier is changed to servo-off status. If any other warning occurs, the operation can still be continued, but an alarm may occur.
- To prevent malfunctions of the servo amplifier and servo motor, do not deactivate the alarm repeatedly to resume if any of the following alarms occur.Remove the cause of occurrence and allow 30 minutes or more for cooling, then resume the operation.
  - [AL.030 Regenerative error]
  - [AL.045 Main circuit device overheat]
  - [AL.046 Servo motor overheat]
  - [AL.050 Overload 1]
  - [AL.051 Overload 2]
- To prevent malfunctions of the servo amplifier and servo motor, do not cycle the power of the servo amplifier repeatedly to resume if any of the following warnings occur. If the power of the servo amplifier is switched off/on during the warnings, allow more than 30 minutes for cooling before resuming operation.
  - [AL.091 Servo amplifier overheat warning]
  - [AL.0E0 Excessive regeneration warning]
  - [AL.0E1 Overload warning 1]

Refer to "Handling methods for alarms/warnings" in the MR-J5 User's Manual (Troubleshooting) for details of the alarm handling methods.
In addition, remove the causes of alarms in accordance with this manual.
MR Configurator2 can be referenced to find the causes of alarms.

Memo

App. 1 Specification Symbols

Appendix table 1. List of specification symbols

T_a	: Acceleration torque	[N•m]	P_f	: Number of feedback pulses	[pulse/rev]
T_d	: Deceleration torque	[N•m]	f_{c1}	: Electronic gear output pulse frequency	[pps]
T_{Ma}	: Motor torque required at acceleration	[N•m]	f_c	: Electronic gear input pulse frequency	[pps]
T_{Md}	: Motor torque required at deceleration	[N•m]	f_0	: Input pulse frequency at maximum machine speed	[pps]
T_L	: Load torque converted into equivalent value on motor shaft	[N•m]	T_{psa}	: Acceleration time of command pulse frequency	[s]
T_u	: Unbalanced torque	[N•m]	T_{psd}	: Deceleration time of command pulse frequency	[s]
T_F	: Load friction torque	[N•m]	K_p	: Position loop gain	[s^{-1}]
T_{LO}	: Load torque on load shaft	[N•m]	T_p	: Position loop time constant (Tp = 1/Kp)	[s]
T_{rms}	: Continuous effective load torque converted into equivalent value on motor shaft	[N•m]	$\Delta\ell_0$	: Feed length per electronic gear output pulse	[mm/pulse]
T_M	: Motor rated torque	[N•m]	$\Delta\ell_c$	: Feed length per electronic gear input pulse	[mm/pulse]
T_{mmax}	: Motor maximum torque	[N•m]	ℓ	: Length per feed	[mm]
J_L	: Load moment of inertia converted into equivalent value on motor shaft	[kg•cm^2]	P	: Number of command input pulses	[pulse]
J_{LO}	: Load moment of inertia on load shaft	[kg•cm^2]	t_f	: One operation cycle	[s]
J_M	: Rotor inertia moment of motor itself	[kg•cm^2]	t_o	: Positioning time	[s]
Nr	: Motor rated speed	[r/min]	t_{st}	: Stopping time	[s]
No	: Motor speed at maximum machine speed	[r/min]	t_c	: Rated operation time	[s]
N	: Motor speed	[r/min]	t_s	: Stop settling time	[s]
Vo	: Maximum machine speed	[mm/min]	m	: Inertia ratio ($m = J_L/J_M$)	
V	: Machine speed	[mm/min]	ε	: Number of droop pulses	[pulse]
P_B	: Ball screw lead	[mm]	Δε	: Positioning accuracy	[mm]
Z_1	: Number of gear teeth on motor shaft side		ΔS	: Feed length per motor revolution Example on the ball screw When directly coupled $\Delta S = P_B$ When the reduction ratio is 1/n $\Delta S = P_B \cdot 1/n$	[mm]
Z_2	: Number of gear teeth on load shaft side Reduction ratio $1/n = \frac{Z_1}{Z_2}$ Decelerates for 1/n < 1, and accelerates for 1/n > 1				

Note
1. When using GD^2 for the unit of the moment of inertia, the expression will be $GD^2 = 4 \times J$.
2. 1kg•m^2 = 10000kg•cm^2 in the system of measurement
3. These specification symbols are described assuming inputs and outputs of a servo amplifier.
   When assuming the positioning command module to be the main part, substitute the terms as follows.
   Examples: Electronic gear input pulse frequency fc → Command output pulse frequency
   Feed length per electronic gear input pulse $\Delta\ell_c$ → Feed length per command output pulse (command minimum feed unit)

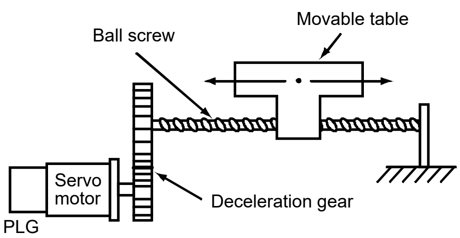
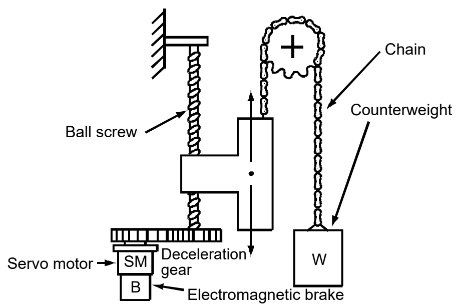
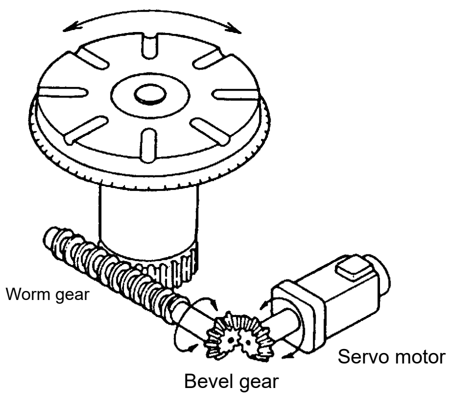
App. 2 Types of Drive Systems

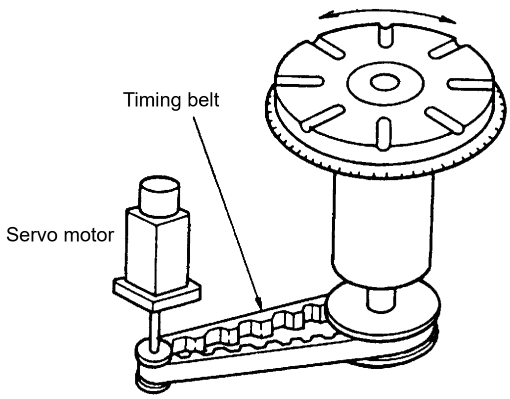
(1) Types of movement directions

The machine driving methods using servo motors have various types, which are to be properly used depending on the purpose (such as the requested accuracy, feed accuracy, travel distance, and machine operation details when working).

First of all, the types of machine movement directions are shown below, which allows you to understand the relations between mechanical parts of a drive system and a servo motor for each classified type. mm is used as the command unit for the linear movement, and angles and the number of resolutions for the rotary movement.

As negative torque will be generated in a vertical movement, the capacity should be carefully considered.

<table>
<tr><th rowspan="2"></th><th colspan="2">Movement direction classification</th></tr>
<tr><th>Horizontal direction</th><th>Vertical direction (ascend and descend)</th></tr>
<tr><td rowspan="2">Linear movement</td><td>
</td><td>
</td></tr>
<tr><td>● It is the most general type of drive system used for the table feed of various machines and conveyors with ball screws, rack and pinions, belts, etc.</td><td>● It is a type of drive systems used for applications such as the vertical axis of a conveyor and robot vertical axis. Counter weights for the load balance are often applied as shown in the figure. Motors with the electromagnetic brake are also used to prevent the load from sliding down at a power failure.</td></tr>
<tr><td>Rotary movement</td><td colspan="2">

[Example 1. Connection with gears]


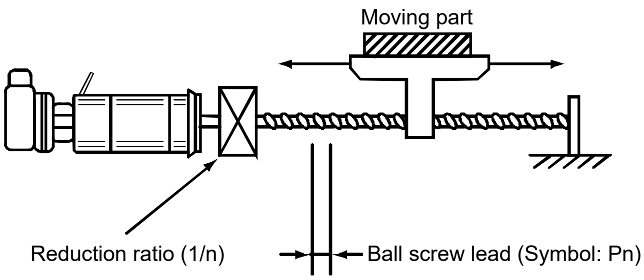
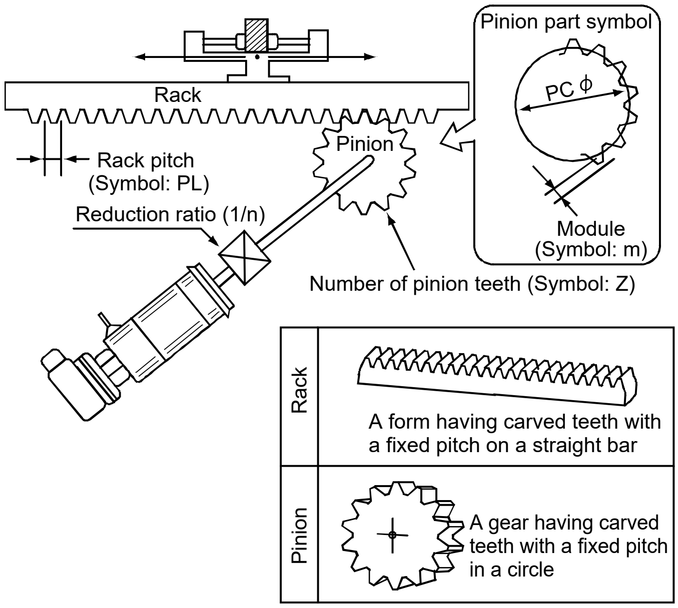
[Example 2. Connection with a belt]
● It is a type of drive systems used for rotation axes such as the index table.
The rotation speed of the load shaft (table rotating shaft) is generally low, and is often reduced by the ratio of the number of gear or pulley teeth.</td></tr>
</table>

Appendix figure 1 Types of movement directions

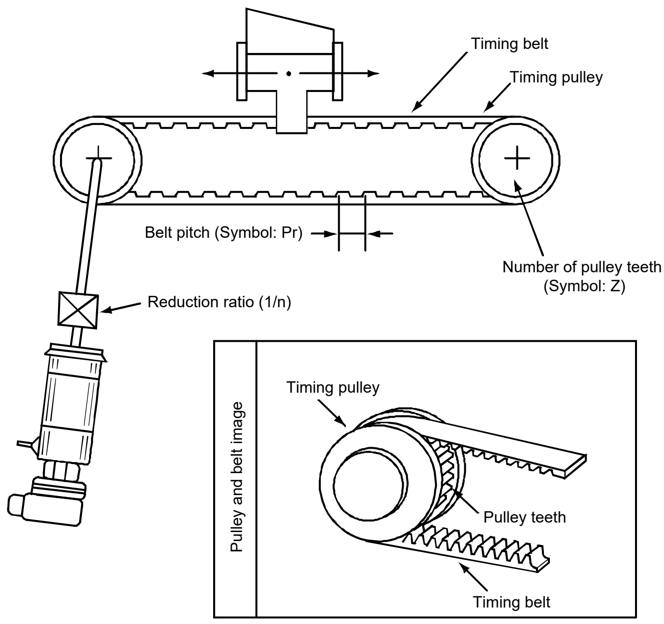
(2) Actual examples of driving methods

When positioning control is performed using a positioning servo, the machine travel distance per pulse is used as the reference. To calculate this travel distance, the machine travel distance per motor revolution (symbol: ΔS, unit: mm) needs to be determined.

The drive systems to be used for the linear movement introduced in (1) are roughly described below, and explained with basic formulas.

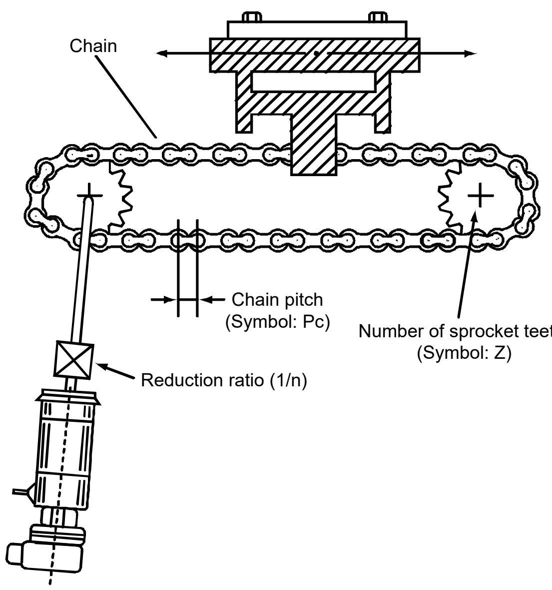
Drive system type		Features and basic formula
1) Ball screws		● It is a typical driving method for high-accuracy positioning in a comparatively short travel distance. ● As the ball screw lead shown in the figure on the left becomes smaller, the accuracy improves and feed speed decreases. (When the same driving servo is used) Basic formula Travel distance per motor revolution ΔS (mm) = Pn (mm) • 1/n For coupling direct connection without the gear reducer ΔS = Pn
2) Rack and pinion		● It is a driving method used for positioning in a comparatively long travel distance. ● Generally in many cases of this method, the rack side moves while the pinion side is fixed, but in some other cases the pinion side moves including the motor area while the rack is fixed. Basic formula ΔS (mm) = P_L (mm) • Z • 1/n or, $\Delta S = PC\varphi \cdot \pi \cdot 1/n$

Appendix figure 2 Driving method (part 2)

<table>
<tr><th colspan="2">Drive system type</th><th>Features and basic formula</th></tr>
<tr><td>3) Timing belt</td><td>
</td><td>

- It is a driving method used in a wide range of fields from large-sized conveyors to precision machinery.
- Unlike the V belts and flat belts frequently used for general motors, this method feeds the work with the teeth of the pulley and belt engaged with each other, eliminating errors due to slippage.
However, careful maintenance is required because the accuracy deteriorates due to aging such as abrasion, depending on the material of the belt.
In addition, the settings of the command pulses and feed length need to be considered carefully because fractions are generated when the belt pitches, which are designed with the inch system, are converted into mm.

Basic formula

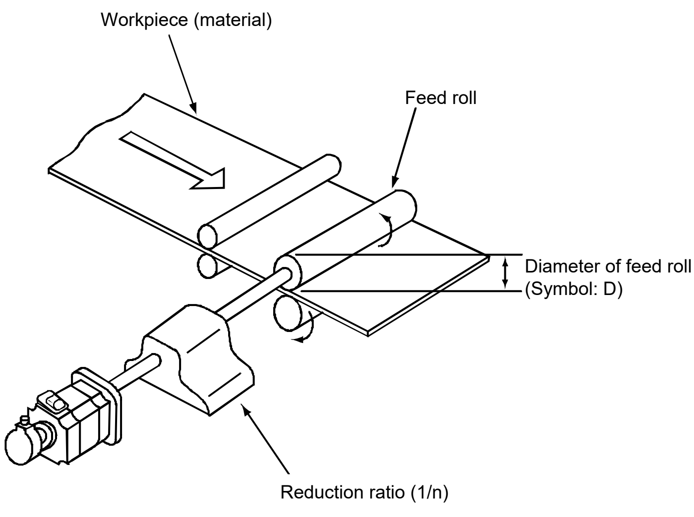
ΔS (mm) = P_T (mm) • Z • 1/n
</td></tr>
<tr><td>4)Chain</td><td>
</td><td>

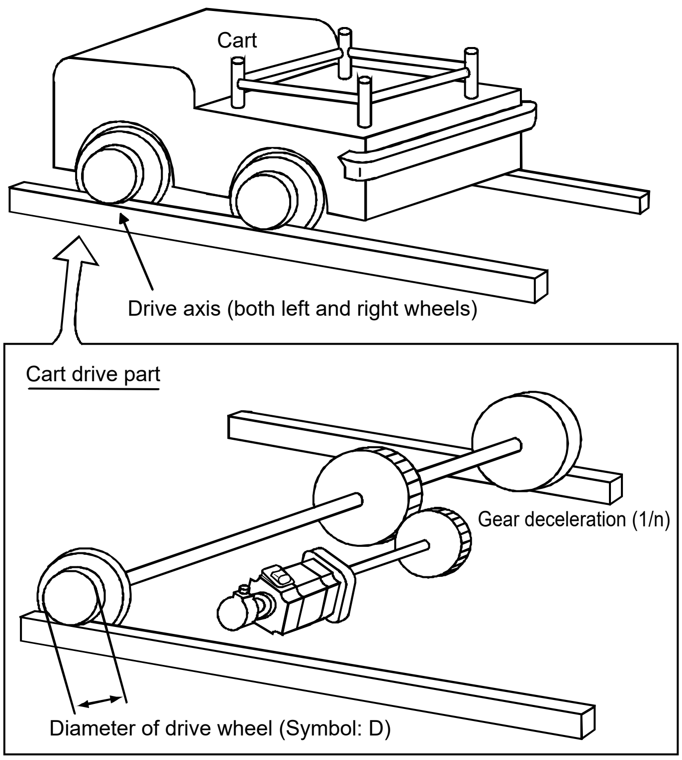
- It is a driving method mainly used for large-sized conveyor systems.
- It is suitable to feed the work at a high speed for a long distance.
- The settings of the feed length require special care because the chain pitches are designed with the inch system just as the timing belt.
In addition, it requires measures against an initial chain stretch affecting the accuracy.

Basic formula

ΔS (mm) = P_C (mm) • Z • 1/n
</td></tr>
</table>

Appendix figure 3 Driving method (part 3)

<table>
<tr><th colspan="2">Drive system type</th><th>Features and basic formula</th></tr>
<tr><td>5) Roll feed</td><td>
</td><td>● It is a method that rotates the roll to feed the work with the friction force.
● It is frequently used for the fixed length feed represented by the roll feeder for press machines and feeds of film sheets, paper, and other materials (in the draw control or with devices such as a cutter).
● To improve the positioning accuracy, slippage between the roll and material needs to be prevented and the roll needs to be machined into a precise circle.
● As π is originally an irrational number, the command pulses and feed length generate fractions at conversion, requiring compensation for the converted values.

Basic formula
ΔS (mm) = $\pi \cdot D$ (mm) • 1/n</td></tr>
<tr><td>6) Cart running</td><td>
</td><td>● It is a method which installs a servo motor on a cart to use the motor to drive the cart.
● This method is generally used to rotate the driving wheels with the servo motor as shown in the figure on the left, and requires special care to prevent a slippage between the wheels and rail.
● As for the other applications than in the figure on the left, this method is also frequently used for mechanisms which uses the rack and pinion to drive the pinion area with the rack fixed.

Basic formula (for the figure on the left)
ΔS (mm) = $\pi \cdot D$ (mm) • 1/n</td></tr>
</table>

Appendix figure 4 Driving method (part 4)

App. 3 Positioning Command Module

	Motion controller *1				
	MELSEC iQ-R	MELSEC Q			
	R64MTCPU R32MTCPU R16MTCPU	Q173DSCPU Q172DSCPU	Q170MSCPU Q170MSCPU-S1	Q173DCPU Q172DCPU	Q170MCPU
Number of control axes	1 to 64 axes	1 to 32 axes	1 to 16 axes	1 to 32 axes	1 to 16 axes
Servo amplifier/servo motor	MR-J4-B(-RJ) MR-J4W_-B			MR-J3-B MR-J3W-B	
Network	SSCNET III (/H)			SSCNET III	
Communication speed [Mbps]	150			50	
Maximum overall cable distance between servo amplifiers [m]	1600			800	
Maximum distance between servo amplifiers [m]	100			50	
Operation cycle [ms]	0.222 or more			0.444 or more	
Absolute position	ABS				
Unlimited feed length	Unlimited feed length				
Acceleration/deceleration pattern	Trapezoid, S-pattern, advanced S-pattern				
Electronic gear	Compatible				
Manual pulse generator operation	Compatible				
Position control/speed control/ torque control	Position control, speed control speed control including position loop torque, continuous operation to torque			Position control, speed control speed control including position loop torque *1	
Interpolation function	Linear interpolation				
	Circular interpolation				
	Helical interpolation				
Synchronous control	Synchronous operation				
	Phase compensation				
Safety sub-function	-	SIK CL 2	-	-	-
Machine control function	Compatible	-	-	-	-
SD memory card	Compatible	-	-	-	-
Batteryless	Compatible	-	-	-	-
Positioning program	Motion SFC, G-code *2, direct positioning start, synchronous control parameter	Motion SFC, mechanical support language, synchronous control parameter		Motion SFC, mechanical support language, G-code *2	
Engineering tool	MELSOFT MT Works2				

* The MR-J5 is not compatible with the Motion controller (as of May 2020).

*1. Torque control requires an operating system software with specified specifications.
*2. G-code control requires a compatible G-code control add-on library (non-free).

	Motion module/Simple Motion module/positioning module			
	MELSEC iQ-R			MELSEC Q
	RD78G	RD77MS	RD77GF	QD77MS
Number of control axes	1 to 64 axes	1 to 16 axes		1 to 16 axes
Servo amplifier/servo motor	MR-J5-_G MR-J5W_-_G	MR-J4-B(-RJ) MR-J4W_-B	MR-J4-GF(-RJ)	MR-J4-B(-RJ) MR-J4W_-B
Network	CC-Link IE TSN	SSCNET III (/H)	CC-Link IE Field	SSCNET III (/H)
Communication speed [Mbps]	1000	150	1000	150
Maximum overall cable distance between servo amplifiers [m]	-	1600	-	1600
Maximum distance between servo amplifiers [m]	100			
Operation cycle [ms]	0.125 or more	0.444 or more	0.5 or more	0.888 or more
Absolute position	ABS			
Unlimited feed length	Unlimited feed length			
Acceleration/deceleration pattern	Trapezoidal acceleration/ deceleration, jerk acceleration/ deceleration, acceleration/ deceleration time constant method	Trapezoid, S-pattern		
Electronic gear	Compatible			
Manual pulse generator operation	Compatible			
Position control/speed control/ torque control	Position control, speed control, speed control including position loop, torque, continuous operation to torque	Position control, speed control, speed control including position loop, torque, continuous operation to torque	Position control, speed control, speed control including position loop, torque	Position control, speed control, speed control including position loop, torque, continuous operation to torque
Interpolation function	Linear interpolation			
	Circular interpolation			
	-	Helical interpolation		-
Synchronous control	Synchronous operation			
	Phase compensation			
Positioning program	ST language	Point table method, synchronous control parameter		
Engineering tool	MELSOFT GX Works3			MELSOFT GX Works 2 (Simple Motion module setting tool)

	Simple Motion module/positioning module			
	MELSEC Q		MELSEC L	MELSEC iQ-F
	QD77GF	QD74MH	LD77MS	FX5-80SSC-S FX5-40SSC-S
Number of control axes	1 to 16 axes	1 to 16 axes	1 to 16 axes	1 to 8 axes:
Servo amplifier/servo motor	MR-J4-GF(-RJ)	MR-J3-B MR-J3W-B	MR-J4-B(-RJ)	MR-J4W_-B
Network	CC-Link IE Field	SSCNET III	SSCNET III (/H)	
Communication speed [Mbps]	1000	50	150	
Maximum overall cable distance between servo amplifiers [m]	1600	800	1600	800
Maximum distance between servo amplifiers [m]	100	50	100	
Operation cycle [ms]	1.0 or more	1.777 or more	0.888 or more	1.777 or more
Absolute position	ABS			
Unlimited feed length	Unlimited feed length	—	Unlimited feed length	
Acceleration/deceleration pattern	Trapezoid, S-pattern			
Electronic gear	Compatible			
Manual pulse generator operation	Compatible	—	Compatible	
Position control/speed control/ torque control	Position control, speed control, speed control including position loop, torque	Position control, speed control, speed control including position loop, torque	Position control, speed control, speed control including position loop, torque, continuous operation to torque	
Interpolation function	Linear interpolation			
	Circular interpolation	—	Circular interpolation	
	—			
Synchronous control	Synchronous operation	—	Synchronization	
	Phase compensation	—	Position compensation	
Positioning program	Point table method, synchronous control parameter	Point table method	Point table method	synchronous control parameter
Engineering tool	MELSOFT GX Works 2 (Simple Motion module setting tool)	QD74MH setting software	MELSOFT GX Works2 (Simple Motion module setting tool)	MELSOFT GX Works3

App. 4 Terms

Adaptive filter II

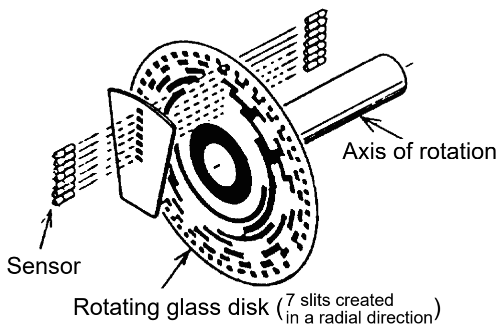
Adaptive filter II (adaptive tuning) is a function in which the servo amplifier detects machine resonance for a certain period of time and sets the filter characteristics automatically to suppress mechanical system vibration. Since the filter characteristics (frequency and depth) are set automatically,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

Analog control <antonym: digital control>

It is a control method which is achieved by a control circuit configured with analog devices such as an operation amplifier.

Absolute position detector <antonym: incremental detector>

It is a detector that enables the angle data within one revolution of the detector to be output to an external device. Models which can take out the angle data of 360 degrees by 8 to 12 bit data are generally used.
The position within one-revolution can be found by using this detector as the servo motor encoder. Thus, it is used to configure an absolute position system combined with a rotation amount counter.
The figure below is the structure of a general absolute position detector. The detector of this example outputs a 7-bit absolute position signal.



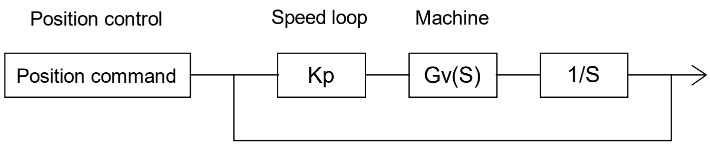
Structure example of an absolute position encoder

Primary delay time constant

It is an exponential time constant, which is the time to reach 63% of the final value. (Refer to the figure in the section "Acceleration time constant".)

Position loop gain

It indicates the responsiveness to commands in a position control. Below is the block diagram of a position control with its speed control system being reduced to "Gv (s)".



The position loop gain here is $K_p \cdot Gv(s) = Kp$ (1/sec)
As the speed loop has feedbacks, the gain is approximately 1.
Then, the position loop gain is expressed as the position responsiveness, resulting in $K_p = \omega pc$ (rad/sec).

Inertia (moment of inertia)

Refer to the section of the moment of inertia.

Impact drop

It indicates the fluctuation width of output in relation to the input command in feedback control. The temporal responsiveness characteristics are expressed using the temporary amount of the fluctuation and the duration when the load is changed stepwise.

It is valid especially when an integral action is included.

Responsiveness

The servo systems have position, speed, and current loops. The responsiveness is the trackability to each command, and generally means the speed responsiveness.

Auto tuning (real-time auto tuning)

The performance (especially, responsiveness and stability) of a machine driven by a servo motor varies depending on the characteristics (moment of inertia and rigidity) of the machine. Therefore, adjustment operations are required to bring out the full performance of the machine, and the operations are called tuning.

The auto tuning is the function which automatically performs the said tuning. This function automatically adjusts the speed loop gain and position loop gain which are usually to be set by the servo amplifier.

The real-time auto tuning is the function which automatically performs tuning by constantly following the change of the machine characteristics even during an operation.

All-digital control (digital control)

It is a method that is controlled by a circuit configured with a micro computer and its peripheral LSI and logic IC.

Regenerative brake

When driving a load with a motor, the electricity is usually supplied from the amplifier to the motor. This state is called power running. In contrast, when decreasing the speed of the load, specifically when decelerating the motor or driving a descending load, the rotation energy of the motor and load flows into the servo amplifier. This state is called regeneration.

The servo amplifier obtains regenerative braking torque by consuming the regenerative energy with the capacitor and resistor. The regenerative braking torque is adjusted automatically in accordance with the deceleration pattern. Regenerative options are used for frequent regeneration.

Rotation irregularity

It is a momentary irregularity at a rotation speed change to a command, and generally increases at a low speed and decreases at a high speed.

Angular frequency (ω)

As the unit of the continuous sine wave, the number of cycles per second is expressed in Hz (herz), and the angular frequency is expressed in angles (radian). The value is converted into 2π frad/sec when the frequency is fHz.

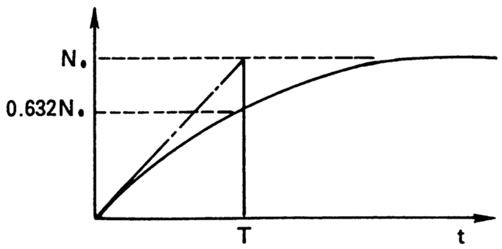
Acceleration time

It is the period of time taken from the current rotation speed to reach the subsequent rotation speed when changing the motor speed.

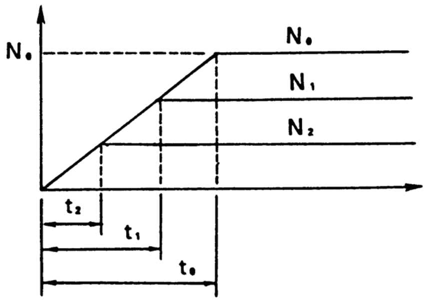
Acceleration/deceleration time constants

It is the period of time taken from 0 [r/min] (0 [mm/s]) to reach the rated speed for the commands or limits, and vice versa.

* It is the period of time taken for the actual speed to reach 63.5% of the target speed for the acceleration pattern in a primary delay function.



Primary delay time constant



Acceleration pattern that has a time constant with the primary delay time constant

Acceleration time and acceleration time constant

t_0: Acceleration time to the reference speed = acceleration time constant

t_1: Acceleration time to the rotation speed N_1

t_2: Acceleration time to the rotation speed N_2

Acceleration

It is the rotation speed change expressed by the ratio relative to the acceleration time, and is the slope against the rotation speed change time. Generally, the term "acceleration" is used for the linear movement in the unit of [m/s^2].

Moment of inertia (inertia)

It is an amount of a rotation weight of a rotating object. It is equivalent to a mass in a linear movement.

Defining equation $J = m \cdot r^2$

Therefore, J: Moment of inertia [kg•cm^2]

m: Mass [kg]

r: Rotation radius [cm]

Note that GD^2, which is conventionally used to express the amount of the moment of inertia, substitutes "r" (radius) in the above expression with "2r" (diameter). The relation can be expressed as $GD^2 = m \cdot (2r)^2 = 4J$.

Gain search

This function can automatically search for gains that achieve the best settling characteristics. (Enabled only in the position control mode)

It finds the gain that has the shortest settling time and small overshoot while changing the gain automatically.

It is effective when a high-level adjustment is required.

In addition, the preparation before executing the gain search can be performed simply by following the gain search setting wizard.

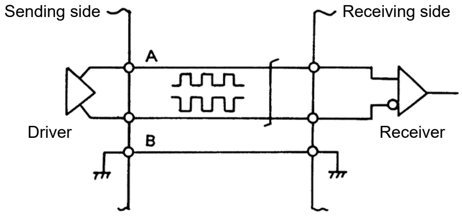
Capacitor regeneration

It is the method which performs regenerative operation by charging regenerative energy to the capacitor of the main circuit.

Since this method does not generate heat, the energy can be used repeatedly as long as the regenerative energy is smaller than the energy charged in the capacitor. Note that only small amount of energy can be charged in the capacitor and thus it is applicable to small-capacity models.

Differential transmission method

It is the method which transmits a signal simultaneously paired with another signal that has the opposite polarity. As the receiving-side device can judge the signal logic as a set, this method has a good noise tolerance, and thus is used for transmitting signals at a high speed such as input/output of pulse trains. In general, devices on the transmission side are called drivers and ones on the receiving side receivers, and dedicated ICs are used in this method.



Frequency response (characteristics)

It expresses the speed responsiveness quantitatively. It indicates up to what frequency the actual motor responds to when a speed command is converted into a form of a sine wave as a minute speed command of approximately 10r/min. It is expressed as ωc [rad/sec] or fc (Hz). This frequency responsiveness can be increased by increasing the speed loop gain, but increasing the gain too much raises the likelihood of vibration and instability depending on the rigidity of the mechanical system or other factors.

Stroke end

The machine has a range (stroke) where it can move within, and position control is to be performed within this range. If the machine exceeds the range by mistake, the machine needs to be stopped forcibly to protect the machine itself. The stroke end is set by either of the following two methods:

(1) Provide limit switches on the both sides of the machine, then connect them to the stroke end terminal of the positioning command module or servo amplifier. When these limit switches are activated, the servo motor immediately stops.

(2) Set the range defined by the limit switches in the parameter of the positioning command module. The range is called the soft limits, which checks the range at positioning start then generates an error to hold the servo motor.

The moving range of the machine is restricted by both (1) the machine limits and (2) the soft limits as described above, and the machine stops once it overruns a limit. Start the machine towards the opposite direction to pass it over a limit. At an initial operation, the operation of the stroke end limit needs to be checked.

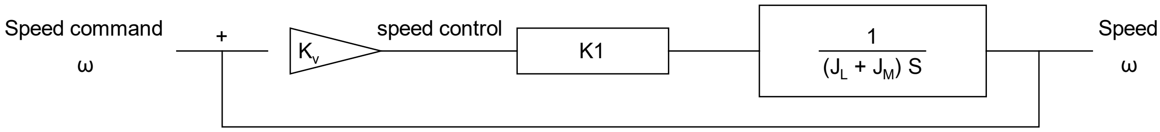
On the other hand, some machines such as rotation tables are disadvantageous if they have stroke ends. In this case, short the stroke end terminals of the positioning command modules or the servo amplifier to operate the machine. In addition, depending on the positioning command module, specific parameters are to be set to "not used" or the current position needs to be changed at appropriate positions.

Speed fluctuation ratio

It expresses the range of fluctuation of the output speed in relation to the input command in speed control. It is a ratio of the fluctuation amount of the rotation speed when the load becomes zero or the rated load value in the reverse direction, generally based on the rotation speed with the rated load.
It was conventionally expressed as an offset in relation to the amplification ratio. However, the other factors often determine the speed fluctuation ratio when an integral action is incorporated. The impact drop characteristics are rather required to be remarked.

Speed loop gain

It indicates the responsiveness to commands in a speed control. The following describes the speed loop gain, assuming the constant determined by the motor to be K1.



The opposite speed loop gain is expressed as follows.

Speed loop gain = $\frac{K_1 \cdot K_v}{J_M + J_L}$

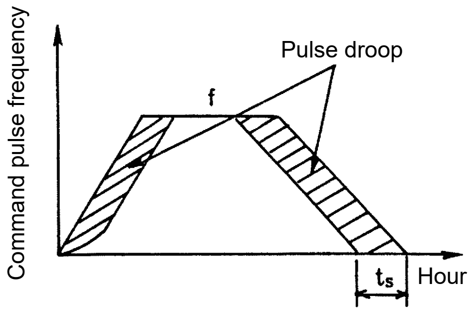
K_V: Speed amplifier gain
J_L: Load inertia
J_M: Motor inertia

Dynamic brake

It is a braking function that is used at a power failure, servo amplifier malfunction, and immediate stop of the machine. Braking torque larger than the electromagnetic brake can be obtained by this function. However, it does not have a holding torque at stop. The MR-J5 servo amplifier has this function. The IM servos, which have induction motors, do not have this function.

Droop pulses

These are the position deviation (number of pulses) accumulated in the servo amplifier at a positioning servo operation. In a low-speed operation, droop pulses are always in proportion to the command pulse frequency. The number of droop pulses becomes within ±1 at positioning completion.



Ground fault

It is a state where either of the cable of the servo amplifier's main power circuit (P and N after rectified by the diode) or the motor power cable (U, V, and W) is short-circuited with the ground.

Resistance regeneration

It is a method which lets the regenerative energy flow in the resistor connected with the servo amplifier bus line to consume the energy as heat, obtaining braking torque.

Stop settling time

Servo motors move with constant deviations against the position command. Therefore, there is a time lag between the stop command completion and the actual servo motor stop.
This time lag is called the stop settling time, and roughly estimated to be 3Tp calculated from the time ts shown in the above figure describing the droop pulses.
(Tp: Position loop time constant)
To consider the operation pattern of the servo motor, this stop settling time needs to be taken into account.

Digital control (antonym: analog control)

It is a control method which is achieved by a control circuit configured with digital devices. Recently, it is becoming more common to use micro computers and micro processors to process the control with their software to handle the increase of the operation amount.
The advantage of the digital control method is that it is stable in performance without an offset and temperature drifts and thus is highly reproducible.

Power supply regeneration

It is a method which returns the regenerative energy to the power supply via the servo amplifier bus line. Although it requires a dedicated module to return the energy to the power supply, it has less heat generation comparing to the resistance regeneration method, allowing the installation dimensions to be smaller especially when a large regenerative energy is generated. Thus, it is used for operations where regeneration is continuous such as on models with a large capacity and vertical axes.

Electronic gear

It changes the ratio of feedback pulses relative to command pulses. Note that the position resolution does not change as it is defined by the encoder. The ratio can be changed by common fractions using parameter settings.
In contrast to the mechanical gear, the motor torque does not increase even when the reduction ratio is increased.

Electromagnetic brake

The electromagnetic brakes attached to servo motors with electromagnetic brakes are non-excitation brakes, which are to be used for mechanisms such as a vertical axis to prevent the workpiece from sliding down at a power failure or servo amplifier malfunction or to protect the mechanisms at a stop.

Torque linearity

It indicates the relation between the torque command and the torque generated by the motor against the command. Especially in the torque control, the motor has a non-sensitive band when the torque is close to zero. In addition, the magnetic force of the magnet used for the motor changes depending on the temperature, affecting the torque linearity as a result. The magnetic force is affected at -0.2/°C for the ferrite magnet and -0.33/°C for the rare-earth magnet.

Backlash compensation

Most of mechanical systems have non-sensitive bands (gaps). This non-sensitive band is called a backlash. If the mechanical system has a backlash, the machine moves by a travel distance without the amount of the backlash regardless of the servo motor rotation. Therefore, an error in an amount of the backlash is generated between the current position of the positioning command module and the actual machine position. However, the errors are not to be accumulated.
The backlash compensation function compensates the said errors as follows.
Setting the backlash amount in the parameter of the positioning command module outputs an extra pulse train signal in an amount equivalent to the backlash only when the rotation direction of the servo motor changes. At this time, the motor rotates without moving the machine. In addition, the positioning command module does not count this pulse train signal as the current position.
Thus the machine position matches with the current position of the positioning command module and the error generated by the backlash is compensated.

(1) The backlash compensation becomes active after homing is executed.
(2) When the backlash settings are changed, homing always needs to be executed.

Power rate

It indicates the acceleration speed of the motor itself when the motor is operated with the output at the rate of its possible output increase on a rated torque motor, and is defined as follows:

$$Q = \frac{T_R^2}{J_M} \times 10 \text{ [kW/s]}$$

T_R: Motor output torque [N•m]
J_M: Motor moment of inertia [kg•cm^2]

Proportional control

The proportional control is also called the "P control". The manipulated variable Y is in proportion to the deviation value ε, thus expressed as Y = εK_p. After positioning completion, if the mechanically-locked motor is forcibly rotated even by one pulse, a large current flows into the motor which then attempts to compensate the position mismatch. To prevent this from happening, setting the control to the proportional control at the same time as the positioning completion can decrease the torque gain, suppressing the current. In addition, the proportional control can suppress the vibration at servo-lock. Note that, although the proportional control introduced here functions to immediately remove the deviation generated by a sudden disturbance, it cannot remove the deviation completely in a continuous disturbance. It is because the control system continues to operate to correct the continuous disturbance, requiring a certain amount of deviation.

Feedback control

It is the control that detects the difference between the command and the actual speed using a closed loop to compensate the command value to reduce this difference.

Feed forward control

It is the control that outputs a speed command before droop pulses increase when a pulse command is input in the position loop control.

Bus voltage

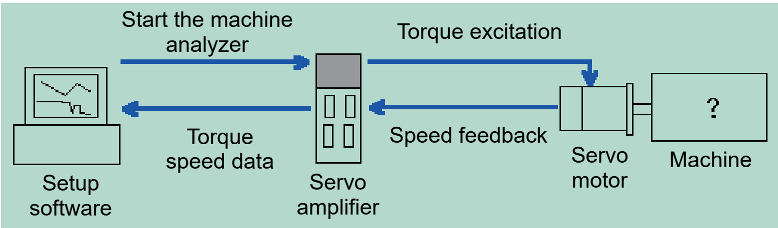
The voltage is once converted into a DC current by being rectified in the power supply converter area, then converted into an AC current again in the inverter area to drive the AC motor. The voltage of the DC current is called the bus voltage.

Machine analyzer

The servo amplifier vibrates the servo motor at a random torque for approximately 0.1 to 2 seconds and measures the rotation speed at this time. Then, MR Configurator2 reads the data of the torque and rotation speed out of the servo amplifier to analyze the data.

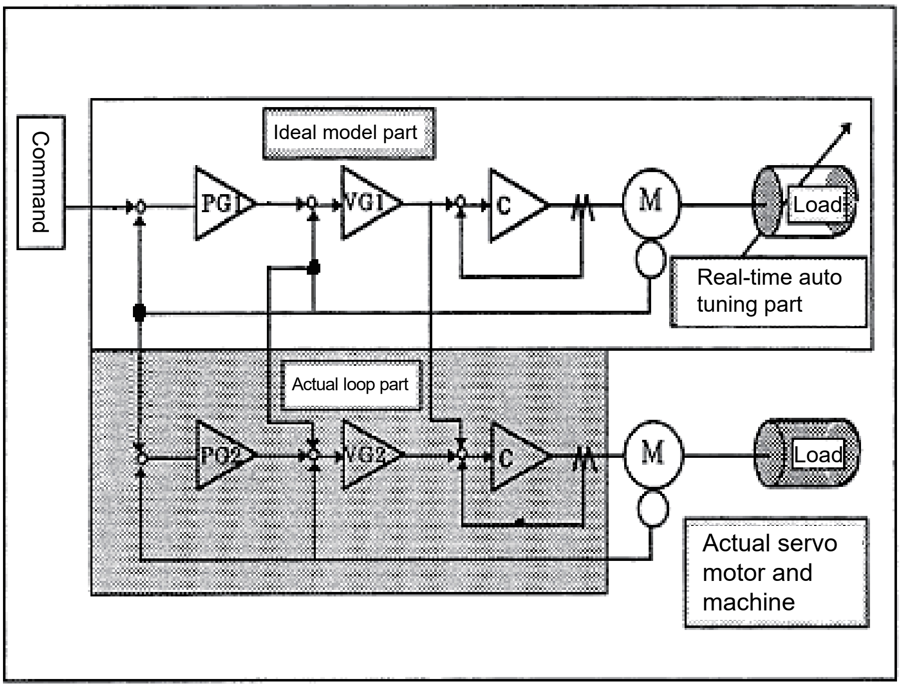
Thus, the response frequency characteristics of the speed against the motor torque of the machine can be measured.

The frequency characteristics indicate the frequency at which the mechanical system has a resonance point, and thus the settings for functions such as the machine vibration suppression filter can be performed easily.



Model adaptive control and real-time auto tuning

The model adaptive control is the control logic originally developed by Mitsubishi Electric based on the modern control theories. It automatically performs settings of the gains of the model and actual loops in accordance with the load inertia obtained by real-time auto tuning. Thus, this control achieves a high response to the command and stable operation of the machine.



[Explanation]

The control logic of the model adaptive control consists of the three sections as shown in the figure above, namely:

(1) Ideal model section
(2) Real-time auto tuning section
(3) Actual loop section (disturbance-suppression section)

The ideal model section adjusts the gain to an optimum value for the inertia estimated by the real-time auto tuning. Each gain maintains acceptable characteristics even in a high-response control because this section is not affected by machine disturbance, looseness, or the similar factors. The position loop gain (PG1) on the model is used to calculate droop pulses and stop settling time.

The real-time auto tuning calculates the load inertia from the current and time at acceleration and deceleration. It is very effective for machines on which inertia varies greatly such as conveyors. In addition, manual settings are available on machines for which the real-time auto tuning cannot be used (in such cases where a vertical axis has a large unbalance, load inertia exceeding the permissible value, or when the droop pulses need to be constant for interpolation operation or similar occasions).

The actual loop section (disturbance-suppression section) is designed based on the conventional PI control. If an error is generated between the model speed configured by the ideal model section and the actual motor speed due to disturbance torque, a torque command is output from the actual loop section side to follow the model speed.

The disturbance can be suppressed more effectively by setting the gain to a higher level, but increasing the gain too much will cause vibration.

This gain value is adjusted to an appropriate level relative to the inertia ratio.

The appropriate values for the model section and actual loop section are set based on the predetermined response setting value for the real-time auto tuning. Therefore, the response setting value needs to be reviewed in order to increase the response.

The model adaptive control is configured as described above, easily enabling adjustment of machines that are too complicated to adjust with the conventional methods, ultra-high frequent application, and other improvements.

RISC

RISC, which stands for "Reduced Instruction Set Computer", is a new type of computer that has a simpler command and command format than the conventional microprocessors (termed CISC as opposed to RISC). Thus, the processing speed can be increased, allowing a huge amount of calculation such as the model adaptive control of a servo in real time.

App. 5 IP Rating of Motors

The IP rating of a motor is expressed by a symbol indicated in appendix table 5.1 as the first digit after IP, followed by another symbol indicated in appendix table 5.2 as the second digit.

Example) IP 6 5

- 5: The second digit (appendix table 5.2)
- 6: The first digit (appendix table 5.1)

Appendix table 5.1 Solid particle protection rating (the first digit)

Type	Digit	Description
Unprotected	0	Unprotected
Diameter ≥ 50mm	1	Protects against solid foreign objects of 50mm or larger, such as the back of a hand.
Diameter ≥ 12.5mm	2	Protects against solid foreign objects of 12mm or larger, such as fingers.
Diameter ≥ 2.5mm	3	Protects against solid foreign objects of 2.5mm or larger, such as the tip of a tool and wires.
Diameter ≥ 1.0mm	4	Protects against solid foreign objects of 1.0mm or larger in diameter, such as wires and flakes.
Dust-proof type	5	Protects against dust. Dust does not enter in sufficient quantity to interfere with the satisfactory operation of the motor.
Dust-resistant type	6	Secure dustproof construction. Completely free from ingress of dust.

Appendix table 5.2 Liquid ingress protection rating (the second digit)

Type	Digit	Description
Unprotected	0	Unprotected
Vertical drop	1	Protects against vertically falling drops of water such as condensation.
Drop (Tilted at 15 degrees)	2	Protects against falling drops of water within the range of an angle up to 15 degrees from the vertical.
Sprinkles	3	Protects against water falling as a spray within the range of an angle up to 60 degrees from the vertical.
Splashes	4	Protects against spraying water from any directions.
Jet	5	Protects against water jets from any directions.
Powerful jet	6	Protects against powerful water jets such as high-sea waves. Water does not enter in sufficient quantity to interfere with the satisfactory operation of the motor.
Temporary submersion	7	Water does not enter in sufficient quantity to interfere with the satisfactory operation of the motor even when the enclosure is immersed in water at a depth of 150mm to 1m.
Continuous submersion	8	Capable of being used in water. The motor can be continuously used underwater.

App. 6 Setting value of the RD75D2 (demonstration machine)

(1) Parameters (axis 1)

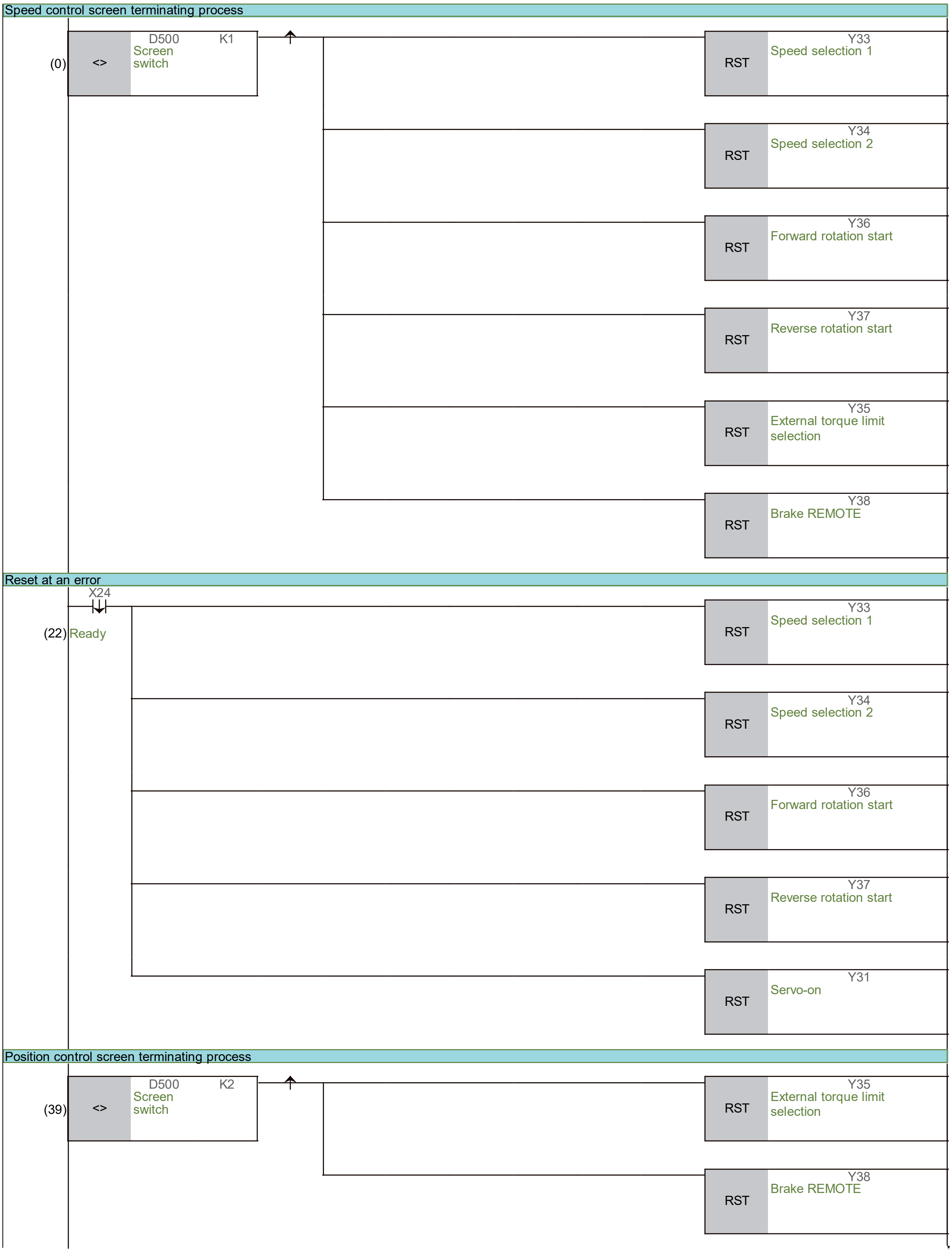
Item		Setting value	Remark
Basic parameter 1	Unit setting	0	mm
	Electronic gear selection	0	16bits
	Number of pulses per revolution (16bits)	1 pulse	
	Travel distance per revolution (16bits)	10.0 μm	
	Number of pulses per revolution (32bits)	20000 pulse	
	Travel distance per revolution (32bits)	2000.0 μm	
	Unit multiplication	1	1 time
	Pulse output mode	1	CW/CCW mode
	Rotation direction settings	0	Increases the current value with forward rotation pulse output
	Offset speed at starting	0.00 mm/min	
Basic parameter 2	Speed limit value	600000.00 mm/min	
	Acceleration time 0	100 ms	
	Deceleration time 0	100 ms	
Detail parameter 1	Backlash compensation amount	0.0 μm	
	Software stroke upper limit value	214748364.7 μm	
	Software stroke lower limit value	-214748364.8 μm	
	Software stroke limit selection	0	Applying software limit to the feed current value
	Software stroke limit enable/ disable setting	1	Disabled
	Command in-position range	10.0 μm	
	Torque limit setting value	300 %	
	M-code ON signal output timing	0	WITH mode
	Speed switching mode	0	Standard speed switching mode
	Interpolation speed specifying method	0	Composite speed
	Feed current value at speed control	0	The feed current value is not updated
	Lower limit signal	1	Positive logic
	Upper limit signal	1	Positive logic
	Drive unit ready signal	0	Negative logic
	Stop signal	0	Negative logic
	External command signal	0	Negative logic
	Zero-point signal	0	Negative logic
	Proximity dog signal	0	Negative logic
	Manual pulse generator input signal	0	Negative logic
	Command pulse signal	0	Negative logic
	Deviation counter clear	0	Negative logic
	Manual pulse generator input selection	0	A-phase/B-phase 4 multiplication
	Speed/position function selection	0	Speed/position switching control (INC mode)

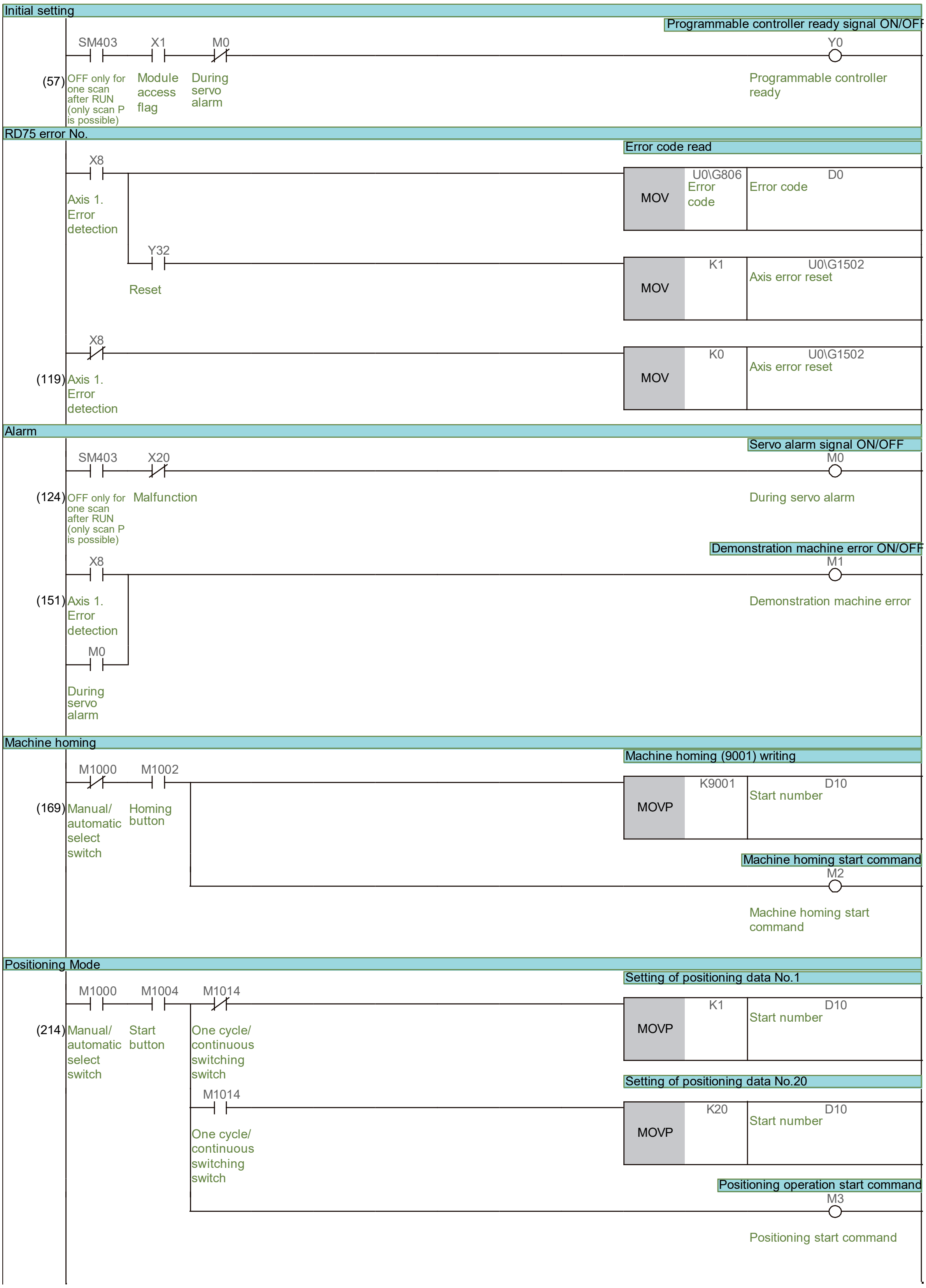
Item		Setting value	Remark
Detail parameter 2	Acceleration time 1	10 ms	
	Acceleration time 2	50 ms	
	Acceleration time 3	1000 ms	
	Deceleration time 1	10 ms	
	Deceleration time 2	50 ms	
	Deceleration time 3	1000 ms	
	JOG speed limit value	600000.00 mm/min	
	JOG operation acceleration time selection	0	Acceleration time 0
	JOG operation deceleration time selection	0	Deceleration time 0
	Acceleration/deceleration process selection	0	Trapezoidal acceleration/deceleration process
	S-pattern ratio	100 %	
	Quick stop deceleration time	1000 ms	
	Stop group 1 quick stop selection	0	Ordinary deceleration stop
	Stop group 2 quick stop selection	0	Ordinary deceleration stop
	Stop group 3 quick stop selection	0	Ordinary deceleration stop
	In-position signal outputting time	300 ms	
	Circular interpolation error permissible range	10.0 μm	
	External command function selection	0	External positioning start
	Start adjusting time	0.00 ms	
Homing Basic parameter	Homing method	0	Proximity dog method
	Homing direction	1	Negative direction (address decreasing direction)
	Home position address	0.0 μm	
	Homing speed	5000.00 mm/min	
	Creep speed	1000.00 mm/min	
	Homing retry	1	Homing retry using the limit switch is performed
Homing Detail parameter	Homing dwell time	0 ms	
	Travel distance settings after proximity dog ON	0.0 μm	
	Homing acceleration time selection	3	Acceleration time 3
	Homing deceleration time selection	3	Deceleration time 3
	Home position shift distance	0.0 μm	
	Homing torque limit value	300%	
	Deviation counter clear signal outputting time	11 ms	
	Speed specification at home position shift	0	Homing speed
	Dwell time at homing retry	0 ms	
	Operation settings at homing incomplete	0	Positioning control is not performed
Basic parameter 3	Operation mode	Q-compatible mode	
	Extension parameter storage settings	CPU	

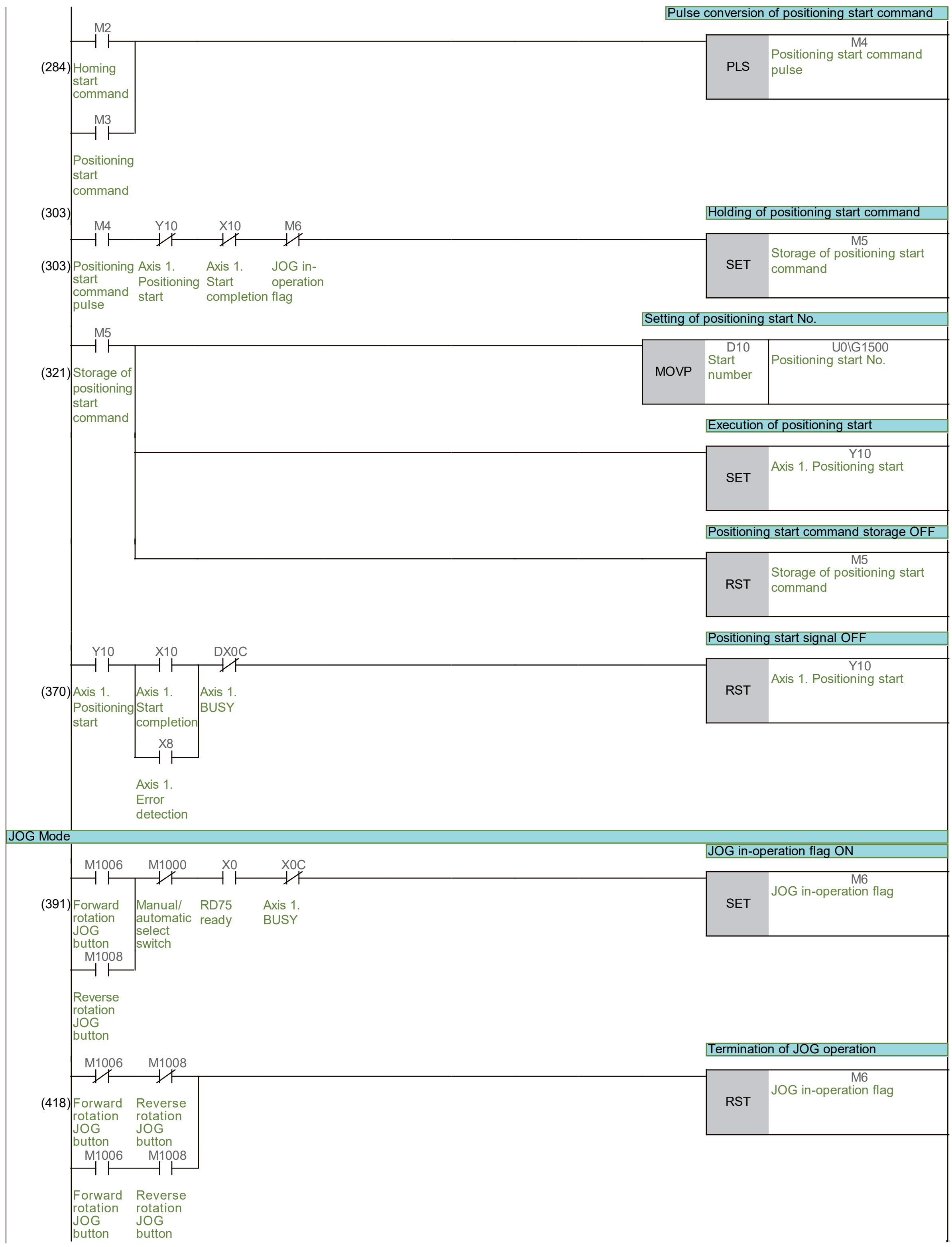
(2) Positioning-data (axis 1)

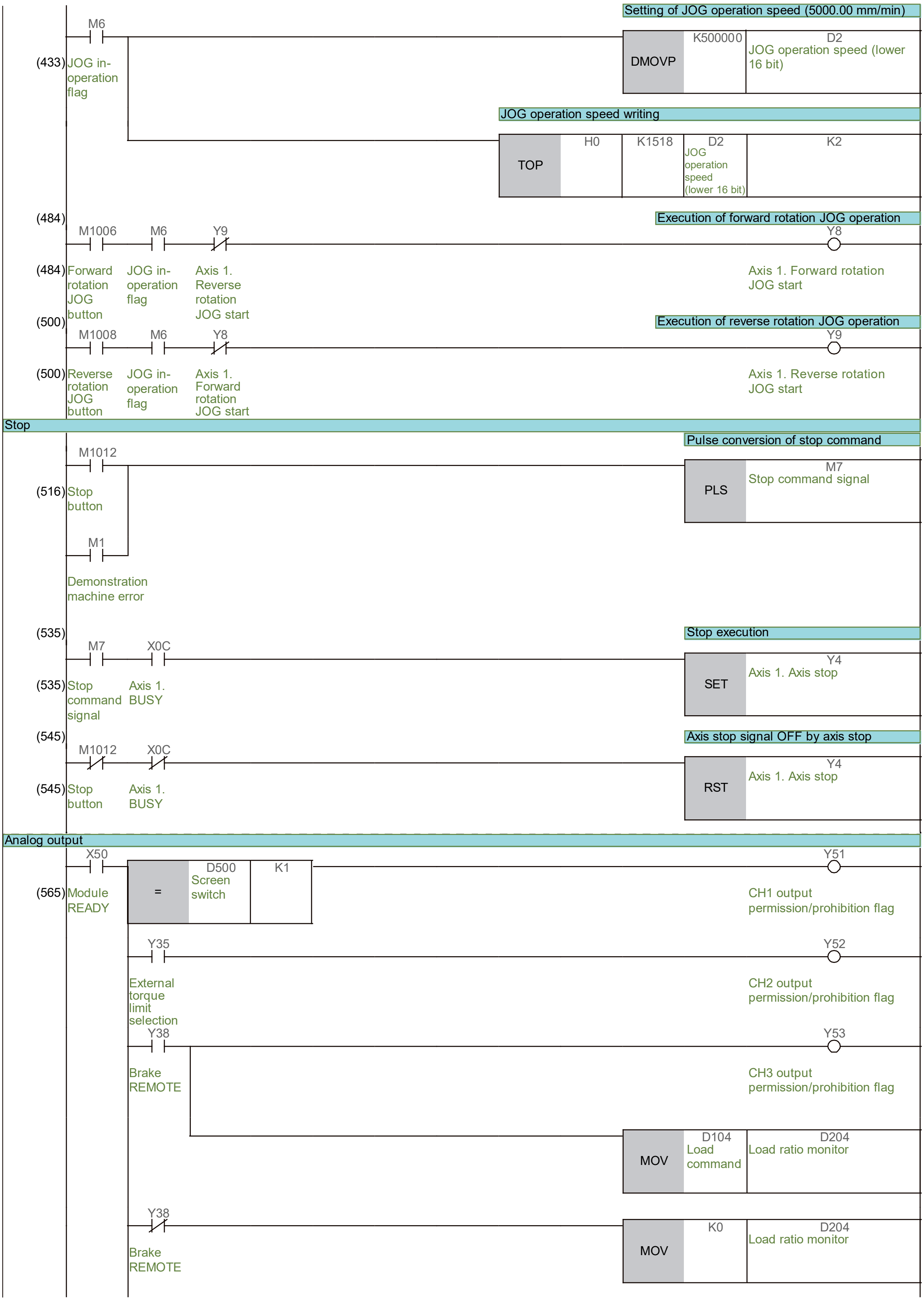
Data No.	Operation pattern	Control method	Acceleration time	Deceleration time	Positioning address	Command speed	Dwell time	M-code
1	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-50000.0	50000.00	500	0
2	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	50000.0	50000.00	500	0
3	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-100000.0	100000.00	500	0
4	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	50000.0	50000.00	500	0
5	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-100000.0	100000.00	500	0
6	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	50000.0	50000.00	500	0
7	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-50000.0	50000.00	500	0
8	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	150000.0	200000.00	500	0
9	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-75000.0	100000.00	500	0
10	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-75000.0	1000.00	1000	0
11	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	75000.0	100000.00	500	0
12	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	75000.0	1000.00	1000	0
13	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-150000.0	200000.00	1000	0
14	0: END	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	150000.0	200000.00	2000	0
15								
16								
17								
18								
19								
20	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	0.0	1000.00	0	0
21	0: END	83: LOOP	0: Acceleration time 0	0: Deceleration time 0	0.0	0.00	0	65535
22	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-50000.0	50000.00	500	0
23	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	50000.0	50000.00	500	0
24	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-100000.0	100000.00	500	0
25	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	50000.0	50000.00	500	0
26	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-100000.0	100000.00	500	0
27	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	50000.0	50000.00	500	0
28	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-50000.0	50000.00	500	0
29	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	150000.0	200000.00	500	0
30	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-75000.0	100000.00	500	0
31	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-75000.0	1000.00	1000	0
32	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	75000.0	100000.00	500	0
33	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	75000.0	1000.00	1000	0
34	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	-150000.0	200000.00	1000	0
35	1: CONT	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	150000.0	200000.00	2000	0
36	0: END	84: LEND	0: Acceleration time 0	0: Deceleration time 0	0.0	0.00	0	0
37	0: END	02: INC Linear 1	0: Acceleration time 0	0: Deceleration time 0	0.0	1000.00	0	0

(3) Sequence program

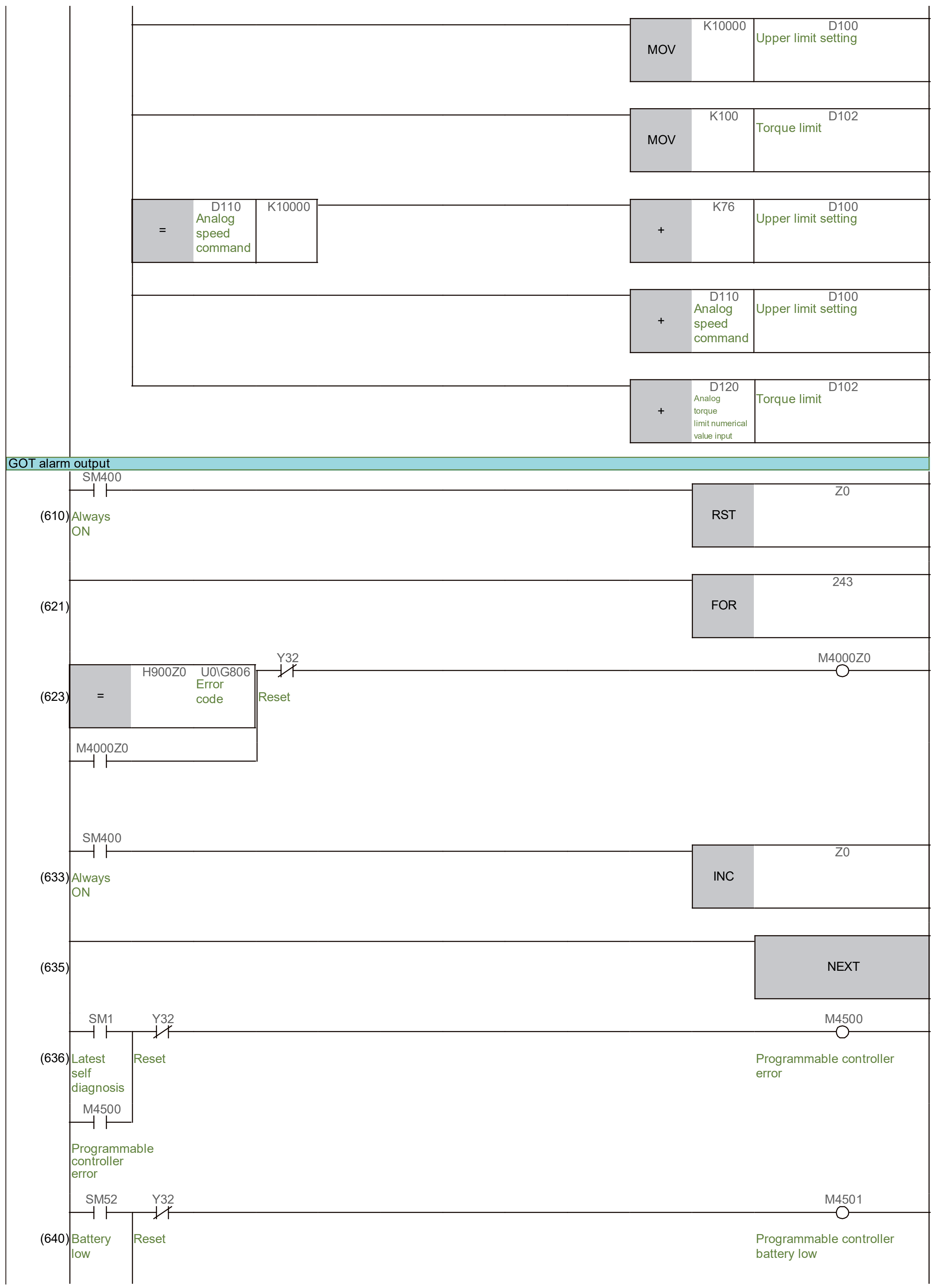



Initial setting
Programmable controller ready signal ON/OFF
SM403
X1
M0
Y0
(57)
OFF only for one scan after RUN (only scan P is possible)
Module access flag
During servo alarm
Programmable controller ready
RD75 error No.
Error code read
X8
MOV
U0\G806
Error code
D0
Error code
Axis 1. Error detection
Y32
MOV
K1
U0\G1502
Axis error reset
Reset
X8
MOV
K0
U0\G1502
Axis error reset
(119)
Axis 1. Error detection
Alarm
Servo alarm signal ON/OFF
SM403
X20
M0
(124)
OFF only for one scan after RUN (only scan P is possible)
Malfunction
During servo alarm
Demonstration machine error ON/OFF
X8
M1
(151)
Axis 1. Error detection
Demonstration machine error
M0
During servo alarm
Machine homing
Machine homing (9001) writing
M1000
M1002
MOVP
K9001
D10
Start number
(169)
Manual/ automatic select switch
Homing button
Machine homing start command
M2
Machine homing start command
Positioning Mode
Setting of positioning data No.1
M1000
M1004
M1014
MOVP
K1
D10
Start number
(214)
Manual/ automatic select switch
Start button
One cycle/ continuous switching switch
Setting of positioning data No.20
M1014
MOVP
K20
D10
Start number
One cycle/ continuous switching switch
Positioning operation start command
M3
Positioning start command

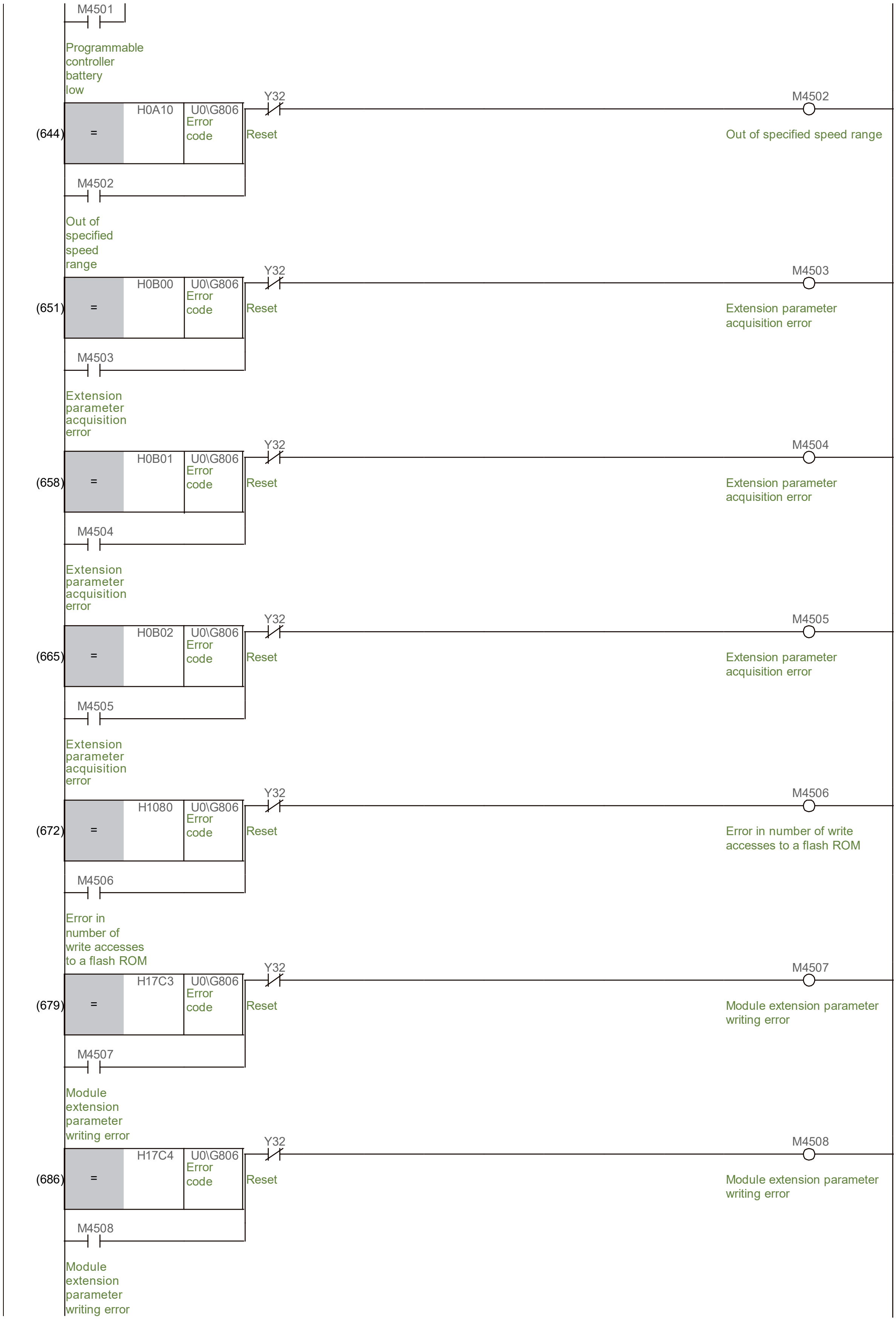

Pulse conversion of positioning start command
M2
(284)
Homing start command
M3
Positioning start command
PLS
M4
Positioning start command pulse
(303)
Holding of positioning start command
M4
Y10
X10
M6
(303)
Positioning start command pulse
Axis 1. Positioning start
Axis 1. Start completion
JOG in-operation flag
SET
M5
Storage of positioning start command
Setting of positioning start No.
M5
(321)
Storage of positioning start command
MOVP
D10
Start number
U0\G1500
Positioning start No.
Execution of positioning start
SET
Y10
Axis 1. Positioning start
Positioning start command storage OFF
RST
M5
Storage of positioning start command
Positioning start signal OFF
Y10
X10
DX0C
(370)
Axis 1. Positioning start
Axis 1. Start completion
Axis 1. BUSY
X8
Axis 1. Error detection
RST
Y10
Axis 1. Positioning start
JOG Mode
JOG in-operation flag ON
M1006
M1000
X0
X0C
(391)
Forward rotation JOG button
Manual/ automatic select switch
RD75 ready
Axis 1. BUSY
M1008
Reverse rotation JOG button
SET
M6
JOG in-operation flag
Termination of JOG operation
M1006
M1008
(418)
Forward rotation JOG button
Reverse rotation JOG button
M1006
M1008
Forward rotation JOG button
Reverse rotation JOG button
RST
M6
JOG in-operation flag

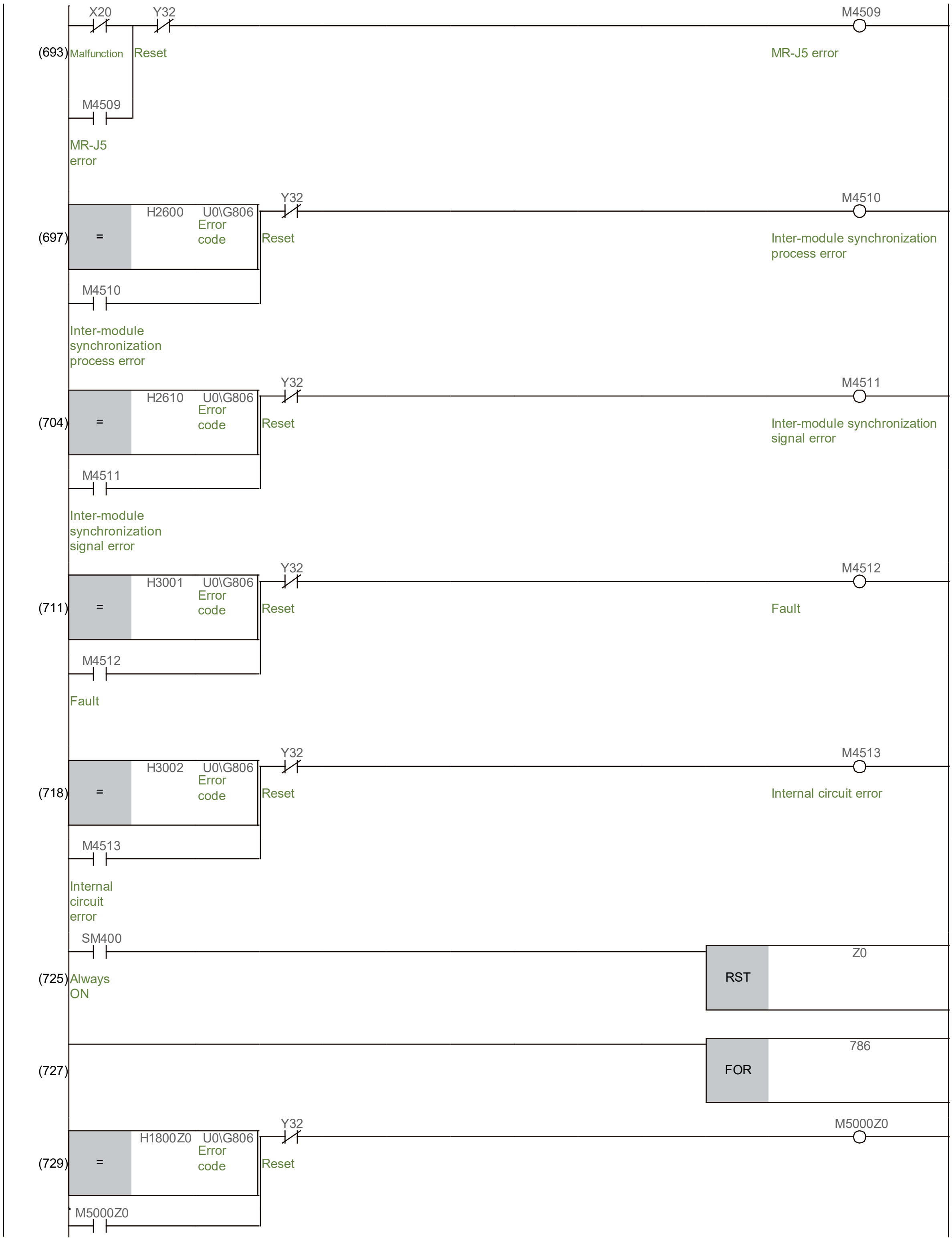


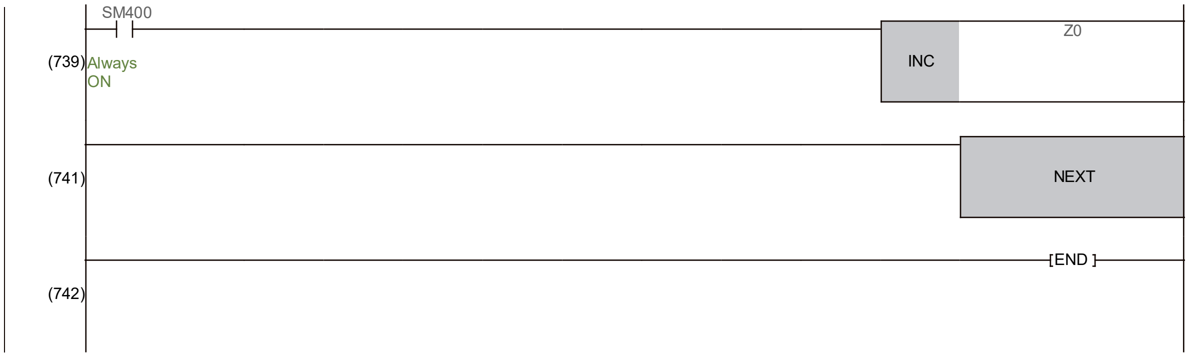
Setting of JOG operation speed (5000.00 mm/min)
M6
(433) JOG in-operation flag
DMOVP
K500000
D2
JOG operation speed (lower 16 bit)
JOG operation speed writing
TOP
H0
K1518
D2
JOG operation speed (lower 16 bit)
K2
(484)
Execution of forward rotation JOG operation
M1006
M6
Y9
Y8
(484) Forward rotation JOG button
JOG in-operation flag
Axis 1. Reverse rotation JOG start
Axis 1. Forward rotation JOG start
(500)
Execution of reverse rotation JOG operation
M1008
M6
Y8
Y9
(500) Reverse rotation JOG button
JOG in-operation flag
Axis 1. Forward rotation JOG start
Axis 1. Reverse rotation JOG start
Stop
Pulse conversion of stop command
M1012
(516) Stop button
PLS
M7
Stop command signal
M1
Demonstration machine error
(535)
Stop execution
M7
X0C
SET
Y4
Axis 1. Axis stop
(535) Stop command signal
Axis 1. BUSY
(545)
Axis stop signal OFF by axis stop
M1012
X0C
RST
Y4
Axis 1. Axis stop
(545) Stop button
Axis 1. BUSY
Analog output
X50
=
D500
Screen switch
K1
Y51
(565) Module READY
CH1 output permission/prohibition flag
Y35
Y52
External torque limit selection
CH2 output permission/prohibition flag
Y38
Y53
Brake REMOTE
CH3 output permission/prohibition flag
MOV
D104
Load command
D204
Load ratio monitor
Y38
Brake REMOTE
MOV
K0
D204
Load ratio monitor



MOV
K10000
D100
Upper limit setting
MOV
K100
D102
Torque limit
=
D110
Analog speed command
K10000
+
K76
D100
Upper limit setting
+
D110
Analog speed command
D100
Upper limit setting
+
D120
Analog torque limit numerical value input
D102
Torque limit
GOT alarm output
SM400
(610)
Always ON
RST
Z0
(621)
FOR
243
(623)
=
H900Z0
U0\G806
Error code
Y32
Reset
M4000Z0
M4000Z0
SM400
(633)
Always ON
INC
Z0
(635)
NEXT
SM1
Y32
(636)
Latest self diagnosis
Reset
M4500
Programmable controller error
M4500
Programmable controller error
SM52
Y32
(640)
Battery low
Reset
M4501
Programmable controller battery low


M4501
Programmable controller battery low
(644)
=
H0A10
U0\G806 Error code
Y32
Reset
M4502
Out of specified speed range
M4502
Out of specified speed range
(651)
=
H0B00
U0\G806 Error code
Y32
Reset
M4503
Extension parameter acquisition error
M4503
Extension parameter acquisition error
(658)
=
H0B01
U0\G806 Error code
Y32
Reset
M4504
Extension parameter acquisition error
M4504
Extension parameter acquisition error
(665)
=
H0B02
U0\G806 Error code
Y32
Reset
M4505
Extension parameter acquisition error
M4505
Extension parameter acquisition error
(672)
=
H1080
U0\G806 Error code
Y32
Reset
M4506
Error in number of write accesses to a flash ROM
M4506
Error in number of write accesses to a flash ROM
(679)
=
H17C3
U0\G806 Error code
Y32
Reset
M4507
Module extension parameter writing error
M4507
Module extension parameter writing error
(686)
=
H17C4
U0\G806 Error code
Y32
Reset
M4508
Module extension parameter writing error
M4508
Module extension parameter writing error


(693)
X20
Y32
M4509
Malfunction
Reset
MR-J5 error
M4509
MR-J5
error
(697)
=
H2600
U0\G806
Error
code
Y32
Reset
M4510
Inter-module synchronization
process error
M4510
Inter-module
synchronization
process error
(704)
=
H2610
U0\G806
Error
code
Y32
Reset
M4511
Inter-module synchronization
signal error
M4511
Inter-module
synchronization
signal error
(711)
=
H3001
U0\G806
Error
code
Y32
Reset
M4512
Fault
M4512
Fault
(718)
=
H3002
U0\G806
Error
code
Y32
Reset
M4513
Internal circuit error
M4513
Internal
circuit
error
(725)
SM400
Always
ON
RST
Z0
(727)
FOR
786
(729)
=
H1800Z0
U0\G806
Error
code
Y32
Reset
M5000Z0
M5000Z0



SM400
(739) Always ON
INC
Z0
(741)
NEXT
(742)
END

App. 7 MR-J5_-_G servo amplifier

The MR-J5_-_G_ operates in the Ethernet open network (communication speed of up to 1Gbps) and compatible with CC-Link IE TSN.
It supports advanced motion control with the minimum command communication cycle of 31.25μs and speed frequency response of 3.5kHz.
One MR-J5W_-_G servo amplifier can drive two or three servo motors. The footprint of one MR-J5W_-_G servo amplifier is considerably smaller than that of two or three MR-J5-_G_ servo amplifiers.
CC-Link IE TSN is a network which performs control in real time through cyclic communication and achieves communication with IT systems at the same time.
Various devices can be incorporated into the system flexibly, and excellent maintenance functions are available, which can optimally build an IoT infrastructure for the entire factory.
It drives servo motors by receiving a command at a constant period in the synchronous communication with a CC-Link IE TSN compatible-controller. (Position/speed/torque)
This network utilizes high-speed and high-accuracy time synchronization by combining with the Motion module and Motion software to achieve accurate synchronous operation between an axis and device.
In addition, it is compatible with the CiA 402 drive profile, supporting the profile mode (position/speed [*1]/torque [*1]) besides the cyclic synchronous mode (position/speed/torque).
When combined with a controller supporting the profile mode, the servo amplifier generates a position command to the target position, reducing the load on the controller.

*1. The MR-J5W2-G/MR-J5W3-G do not support the profile mode (speed/torque).

AC Servo School Text
AC Servo Practice Course (MELSERVO-J5)

MODEL	
MODEL CODE	
SH-030388ENG-A (2109) MEE	

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