

FATEC

AC Servo School Text AC Servo Practice Course (MELSERVO-J4)

● Safety Precautions ●

(Please read the precautions carefully before carrying out practical training.)

Read the relevant manuals and pay careful attention to safety when designing the system. When carrying out practical work, pay sufficient attention to the following points and handle the device properly.

[Practical training precautions]



CAUTION

- Follow the instructions of the instructor.
- Do not remove the training machine module or change the wiring without prior consent. Doing so may cause failure, malfunction, injury, or fire.
- Turn the power supply OFF before removing or installing a module. Removing or installing while the power is ON may cause module failure or electric shock.
- If the training machine emits an abnormal odor or an abnormal sound, press the "Power switch" or "Emergency switch" to stop the device.
- When an error occurs, contact the instructor immediately.



WARNING

- To avoid electric shock, do not touch the terminal while the power is on.
- When opening a safety cover, make sure that the power supply is disconnected or ensure sufficient safety before carrying out the work.

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Memo

1. AC Servo Fundamentals

1.1 What is an AC Servo?

Generally define as "a control system wherein position, direction, and orientation of the object are considered as controlled variables and it is configured in such a way that it conforms to changes in any set values", a servo mechanism detects the present value (position, speed, etc.) if a set value (position, speed, etc.) is input to the servo mechanism by a command part, compares the target value with the set value, and performs control so that the difference is always minimized.

The elements that make up the servo mechanism are called the servo elements, and these consist of a drive amplifier (AC servo amplifier), a drive motor (AC servo motor), and a detector. Figure 1.1 shows a configuration example.

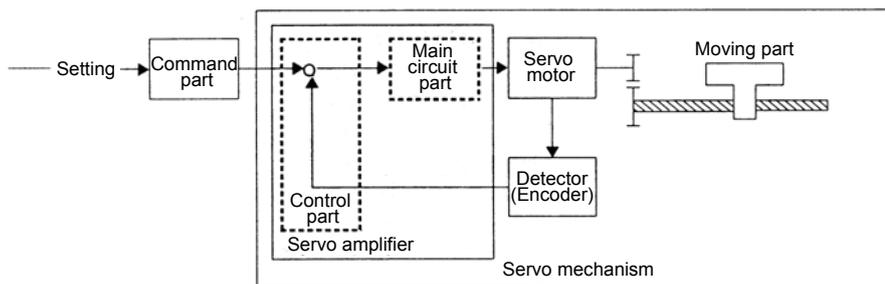


Figure 1.1 Configuration diagram of servo mechanism

1.2 AC Servo Positioning and Performance

Compared to regular motors, a servo motor is specifically designed with consideration for the moment of inertia of the rotor (also called J or GD^2) and the electrical responses in such a way that it can respond to sudden alterations of voltage and current from the servo amplifier. In addition, even the servo amplifier that drives the servomotor is configured so that the speed and position control commands can be precisely and quickly transmitted to the servo motor.

In this way, this section compares the differences between the typical characteristics for using the servomotor (integrated motor combined with a servo amplifier) with those of a motor driven by a general-purpose inverter used a general variable speed device.

- (1) Comparison of features of general-purpose servo and various types of controlling devices

Speed-torque characteristics constitute a general method for indicating motor characteristics.

Figure 1.2 shows a comparison of the characteristics of a servo motor and a general-purpose motor that uses general-purpose inverter.

As shown in this figure, the following three points can be considered features of the servo motor.

- 1) Speed control range is wide
- 2) Torque characteristics are fixed with high-speed operation and low-speed operation
- 3) Maximum torque is high

Note: As the maximum torque is high and the moment of inertia is low, rapid acceleration/deceleration is possible.

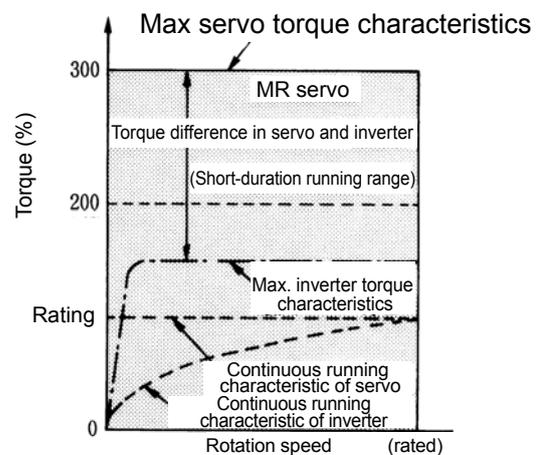


Figure 1.2 Comparison of torque characteristics of servo and inverter

1. AC Servo Fundamentals

Table 1.1 Main performance of servo motor

Item	Specifications	Description
Speed control range	1:1000 to 5000 (1:10)	Use is possible without concern for the rotation stability or the torque dropping until 1/1000 th of the rated speed.
Torque characteristics	No decline in torque during low-speed operation	A fixed output torque can be obtained in an area of the speed control range for both the continuous operation torque and maximum torque. Accordingly, use is safe throughout the entire speed area even with a constant-torque load.
Maximum torque	Approximately 300% (150%)	Approximately 300% of the rated torque can be obtained for instant maximum torque. Accordingly, use is possible for high-frequency positioning because of compatibility with rapid acceleration/deceleration.

Note: The numerical value within () in the specifications column indicates general specifications of a general-purpose inverter.

(2) AC servo applications

The servo motor features are as described in the previous item, but there is also a positioning function for functions that do not exist in other variable speed devices when combined with a servo amplifier.

Although the positioning function details have been mentioned in Chapter 2, this section explains the typical applications of the servo motor, from the positioning function characteristics to the servo and the features described in (1) in the previous section.

1) Machines that require positioning

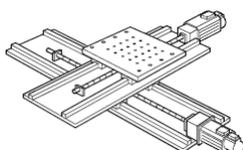
If an AC servo is used combined with a specialized positioning controller, it is possible to perform high-accuracy positioning.

With a general Mitsubishi AC servo, positioning of 4000 to 4194304 divisions is possible in the motor axis, and this can be sufficiently applied for 1 μm positioning in 24 m/minute to 8 m/minute machines.

Application examples: Machine tool devices, wood-working machines, transportation machines, packaging machines, inserters/mounters, individual types of feeders, individual types of cutters, specialized machines

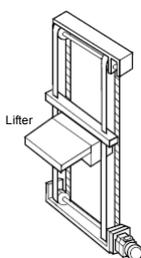
(a) X-Y Table

Connects the respective ball screw loads to the X axis and Y axis, and allows high-speed, high-accuracy positioning by the biaxial AC servo.



(b) Transportation machine (vertical)

Carries out the transportation positioning of the lifter. A servo motor with an electromagnetic brake is used to prevent droppage during a power failure.



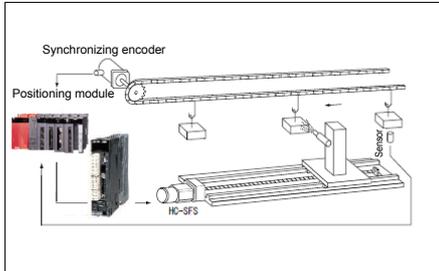
Automated storage/picking system
 Even with automated storage, the AC servo is often used in picking/traveling sections in accordance with the high-speed conversion needs.
 By using an AC servo motor, smooth and accelerated speed can be implemented quickly.
 Automated storage/picking systems connected to the SCM (Supply chain management) deliver significant improvements to the stock management efficiency of commodity distribution from the procurement of raw materials to the delivery of goods.

1. AC Servo Fundamentals

(c) Synchronized feeding (coating line)

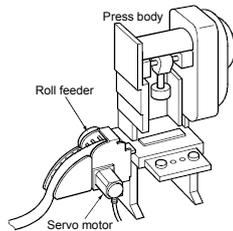
Detects the position of the product by sensors and carries out synchronized feeding according to encoder signals.

Returns to the home position after sending a predetermined distance and waits for arrival of the next product.



(d) Press roll feeder

Drives a feed roll using an AC servo motor and supplies material only for a fixed length. Material is supplied to the press when the press head is elevated, and after positioning is complete, punching is carried out.



2) Machines that require a wide transmission range

Because the AC servo has characteristics that do not exist in other variable speed motors, including highly accurate speed control performance with a speed control range of 1:1000 to 1:5000, speed variation of 0.01% or less, and a fixed output torque, AC servo motors are used for highly accurate variable speed drives that start with varied line controlling.

[Application examples: Various axes of printing machines, paper-making machines, film manufacturing lines, wire drawing machines, coil winding machines, various specialized machine feeding, various transportation machines, winders/rollers, and woodworking machines]

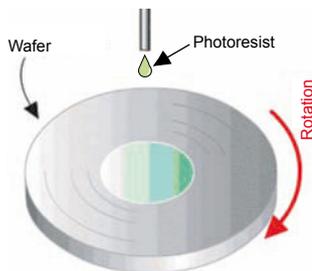
(a) Spin coating

Uses the principles of the following illustration for making semiconductor circuits.

A spin coater applies a photosensitizing agent (photoresist) to a semiconductor wafer.

The principle is drop the resist liquid and spread it out thinly through centrifugal force.

If the rotation speed of the wafer is too fast, the resist will fly off, and conversely, if it is too slow, the resist will not be applied evenly.



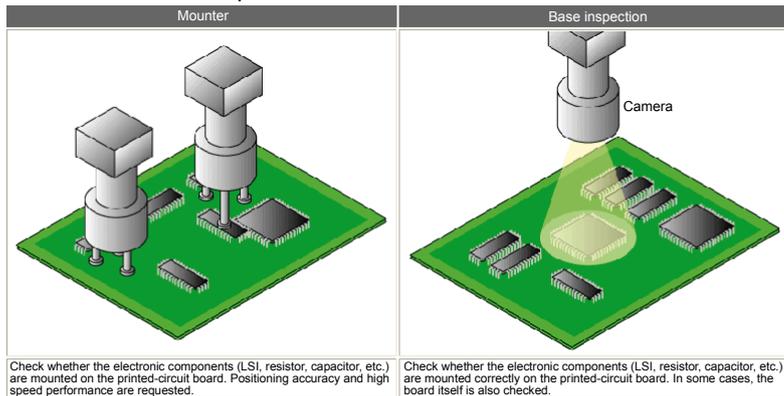
1. AC Servo Fundamentals

3) High-frequency positioning

Although positioning is carried out as described in (1), the AC servo has a maximum torque approximately 300% of the rated torque, and with motor units, it can achieve several 10 ms steep accelerations/decelerations from stopped to the rated speed and can even correspond to high-frequency positioning of 100 times or more in 1 minute. Compared with other positioning methods (clutch brake, DC motor, etc.), using an AC servo offers significant features including no mechanical areas of contact for maintenance-free operation and less effects due to ambient temperatures.

Application examples: Press feeders, bag-making machines, sheet cutting, loaders/unloaders, filling machines, packaging machines, various transportation machines, mounters, bonders

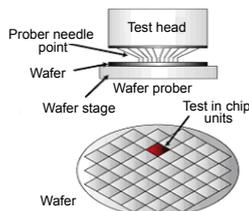
(a) Mounter and base inspection



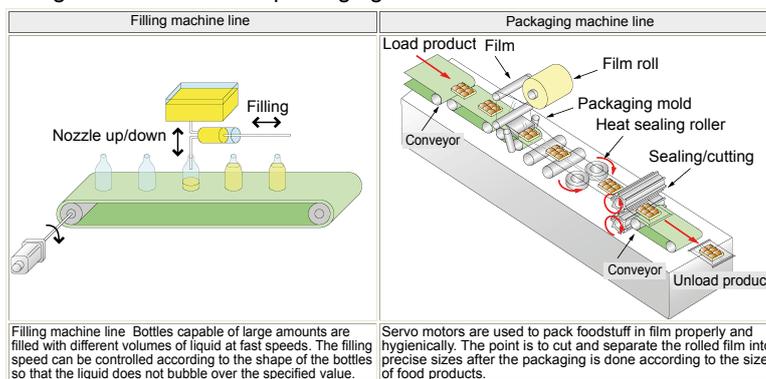
(b) Wafer probers

Because it is possible to have many LSI chips from one wafer, inspection is done before assembly with a wafer prober and tester in chip units.

Accurate positioning is necessary for setting the point in the chip. High speeds are also requested.



(c) Filling machine lines and packaging machine lines

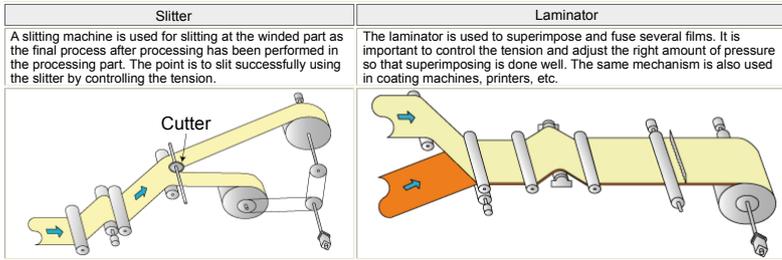


1. AC Servo Fundamentals

4) Torque control

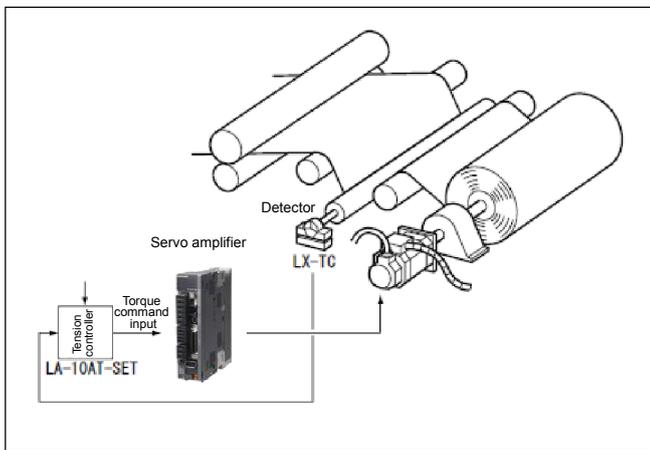
In addition to the speed control and position control functions, there is also a function by which torque control is possible, which allows application even in tension control areas such as various winding/rolling devices.

(a) Slitters and laminators



(b) Winding devices

Carries out winding tension control of sheet material by combining an AC servo and a tension detector/tension controller device.

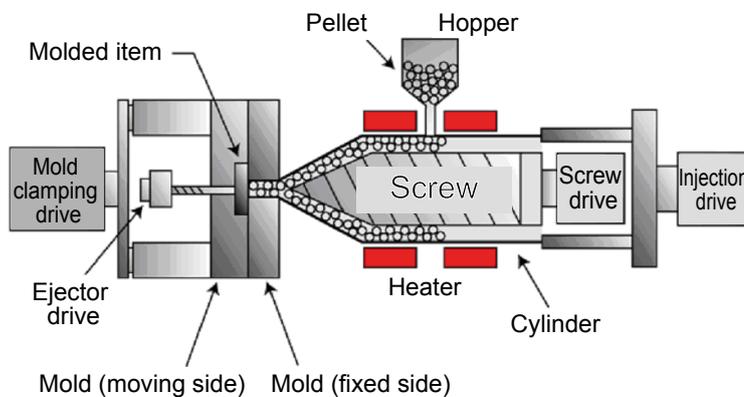


(c) Mold injection machines

Injects plastic raw material pellets of molded articles into the molding part. The pellets are melted by the heater provided in the part consisting of the cylinder and the screw axis.

After that, the mold is opened through a cooling operation and the molded component is extruded by an ejector pin.

Items exceeding 3,000 t also exist in applications with large components and large clamping forces.



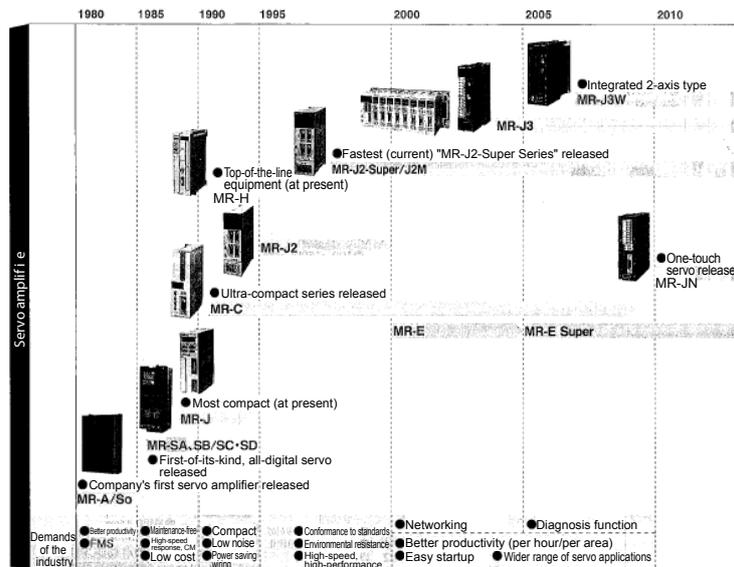
1. AC Servo Fundamentals

1.3 MELSERVO

1.3.1 Road Map of MELSERVO

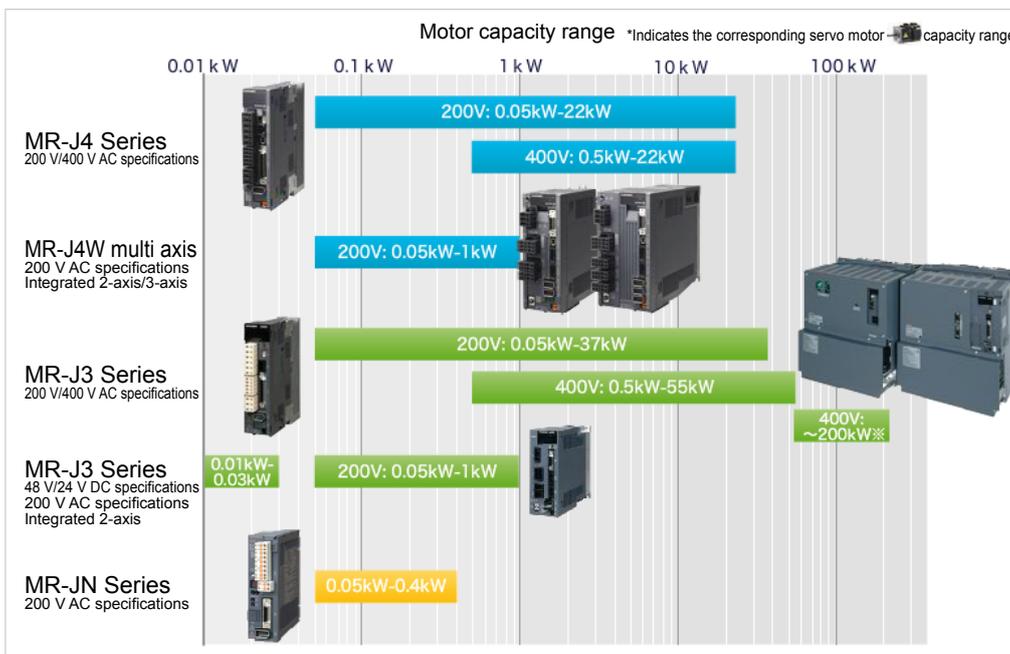
After the release of a general-purpose AC servo in 1982, new products have always incorporated new technology reflecting innovation and items requested by the industry.

Now, the environment surrounding servos is now transitioning into the next generation. The MR-J4 Series is developed in response to requests for even faster speeds, higher accuracy, start-up time reduction, and enhanced diagnostics and maintenance in order to achieve the best performance of a machine. The following table shows the MELSERVO road map.



1.3.2 Product Lineup

The following table shows the MELSERVO Series line up.



1. AC Servo Fundamentals

1.3.3 Comparison Table of General-Purpose Servo Amplifier Specifications

Item \ Model	MR-J4-□ Series	MR-J3-□ Series	MR-JN-□ Series
Appearance			
Features	<ul style="list-style-type: none"> ● Increased performance and functionality over MELSERVO_J3 Series ● High-resolution, industry-leading level servo motor ● MR Configurator2 (SW1DNC-MRC2-E) ● High-speed, SSCNET III/H-compliant optical communication 	<ul style="list-style-type: none"> ● High-performance type ● High-resolution servo motor ● MR Configurator2 (SW1DNC-MRC2-E) ● Low rigidity due to vibration suppression control ● Improved vibration suppression for the machine 	<ul style="list-style-type: none"> ● One-touch servo ● MR Configurator2 (SW1DNC-MRC2-E) ● One-touch tuning/real-time auto tuning, equipped with a tough drive function
Applicable motor capacity	0.05 kW to 22 kW	0.05 kW to 55 kW	0.05 kW to 0.4 kW
Brake/Reducer	Exists	Exists	Exists
Encoder signal	Serial communication	Serial communication	Serial communication
Position resolution	4194304 p/rev	262144 p/rev	131072 p/rev
Detection method	INC/ABS	INC/ABS	INC
Rotation speed (r/min)	Rated speed	3000	3000
	Maximum speed	6000	4500
Maximum torque % (Rated torque % ratio)	350% ^{*1}	350% ^{*2}	300%
Control mode	Position/Speed/Torque	Position/Speed/Torque	Position/Speed/Torque
Frequency response level	2.5 kHz	2.1 kHz	-
Control theory	Sine-wave PWM control/current control	Sine-wave PWM control/current control	Sine-wave PWM control/current control
One-touch tuning	Exists	Does not exist	Exists
Auto tuning	Real-time	Real-time	Real-time
Personal computer I/F	Standard equipment	Standard equipment	Standard equipment
Speed control range	1:5000	1:5000	1:5000
External power supply for I/F	24 V DC required	24 V DC required	24 V DC required
Regenerative brake resistance	Built-in	Built-in	Built-in
Dynamic brake	Built-in	Built-in	Built-in
Display (main body)	5-digit display (alarm 3-digit conversion)	5-digit display	3-digit display
Setting key, etc.	4 setting buttons	4 setting buttons	4 setting buttons
Analog monitor	2 CH	2 CH	Does not exist
Pulse frequency dividing output	Phases A, B, and Z	Phases A, B, and Z	Phases A, B, and Z
Test mode operation	Available	Available	Available
Motor-less operation	Available	Available	Available
EN compatibility	Obtained	Obtained	Obtained
UL/cUL standard compatibility	Obtained	Obtained	Obtained
Supported motors	<ul style="list-style-type: none"> • HG-KR Series • HG-MR Series • HG-SR Series 	<ul style="list-style-type: none"> • HF-KP Series • HF-MP Series • HF-SP Series • HC-RP Series • HC-UP Series 	<ul style="list-style-type: none"> • HC-KN Series

*1: HG-KR Series servo motor only

*2: HF-KP Series servo motor only

1. AC Servo Fundamentals

1.3.4 Servo Motor Model Series and Features

With the AC servo MELSERVO-J4, J3, JN Series, various motors are offered according to machine requirements.

- MELSERVO-J4 Series: ABS, 22-bit (4194304-pulse) encoder
- MELSERVO-J3 Series: ABS, 18-bit (262144-pulse) encoder
- MELSERVO-JN Series: INC, 17-bit (131072-pulse) encoder

Series		Capacity (W)	Encoder resolution pulse/rev	Encoder compatibility	Rated speed	Applicable servo amplifier model	Protection model	Application
Ultra-low inertia, small capacity		HG-MR	50 W to 750 W	4194304	ABS/INC shared	3000 r/min	MR-J4	<ul style="list-style-type: none"> • Inserter, mounter, bonder • Printed circuit board punching machines • In-circuit testers • Label-printing machines • Knitting machines, embroidery machines • Ultra-compact robots • Robot tips etc.
		HF-MP	50 W to 750 W	262144	ABS/INC shared	3000 r/min	MR-J3	
Low inertia, small capacity		HG-KR	50 W to 750 W	4194304	ABS/INC shared	3000 r/min	MR-J4	
HF-KP		50 W to 750 W	262144	ABS/INC shared	3000 r/min	MR-J3		
HF-KN		50 W to 400 W	131072	INC	3000 r/min	MR-JN		
Medium inertia, medium capacity		HG-SR	0.5 kW -7.0 kW	4194304	ABS/INC shared	1500 r/min 3000 r/min	MR-J4	<ul style="list-style-type: none"> • Transportation machines • Specialized machines • Robots, turrets • Loaders, unloaders • Winders, tension devices • X-Y tables • Test machines etc.
		HF-SP	0.5 kW -7.0 kW	262144	ABS/INC shared	1000 r/min 2000 r/min	MR-J3	
Low inertia, medium capacity		HC-LP	0.5 kW -3 kW	262144	ABS/INC shared	2000 r/min	MR-J3	<ul style="list-style-type: none"> • Roll feeders • Loaders, unloaders • High-throughput material handling systems etc.
Flat type		HC-UP	0.75 kW -5 kW	262144	ABS/INC shared	2000 r/min	MR-J3	<ul style="list-style-type: none"> • Robots • Transportation machines • Food-processing machines • Winders, tension devices etc.
Large capacity 400V		HF-JP	0.5 kW -15 kW	262144	ABS/INC shared	1500 r/min to 3000 r/min	MR-J3	<ul style="list-style-type: none"> • Mold injection machines • Semiconductor manufacturing systems • Large transportation machines etc.
		HA-LP□	5 kW -55 kW	262144	ABS/INC shared	1000 r/min to 2000 r/min	MR-J3	
Low inertia, large capacity		HG-JR	11 kW -22 kW	4194304	ABS/INC shared	1500 r/min	MR-J4	<ul style="list-style-type: none"> • Food-packaging machines • Printing machines • Injection molding machine press machines etc.
Low inertia, medium capacity			0.5 kW -9 kW	4194304	ABS/INC shared	3000 r/min	MR-J4	

1. AC Servo Fundamentals

1.4 AC Servo Mechanism

1.4.1 Block Diagram of Servo Amplifier and Operating Principles

The following block diagram shows the basic functions and operating principles of the servo amplifier.

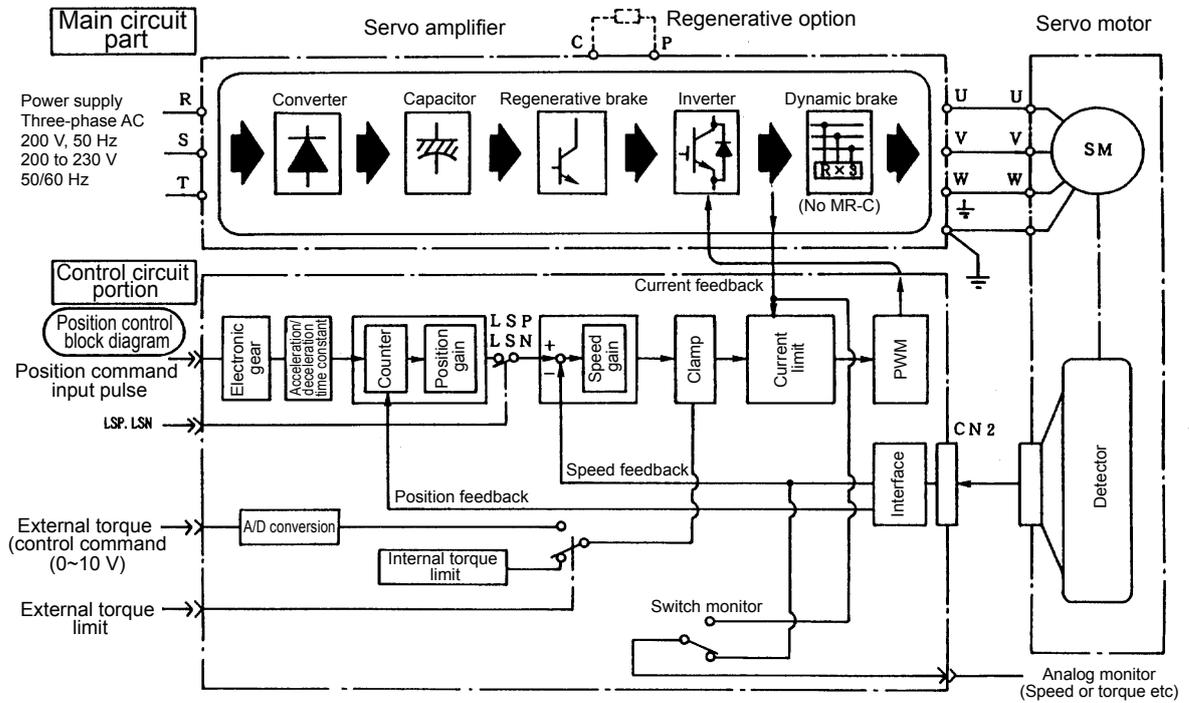


Figure 1.3 AC servo block diagram (pulse train method)

1. AC Servo Fundamentals

(1) Main circuit portion

The basic functions of the main circuit portion include commutating/smoothing AC power (three-phase 200 to 230 V AC, 50/60 Hz) using a converter (diode bridge, capacitor), supplying a three-phase current of any voltage/frequency controlled by a sine-wave PWM from the inverter (IGBT) to the motor, and controlling the speed and torque of the motor.

1) Converter, smoothing capacitor

AC power is commutated using a diode bridge, and a DC power supply with fewer ripples is created using a smoothing capacitor.

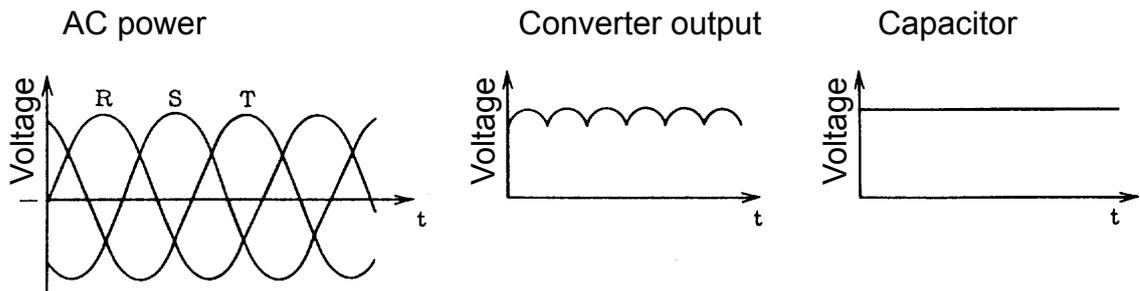


Figure 1.4 External voltage of servo amplifier

2) Inverter

An inverter creates a current of an amplitude that balances with the frequency and load torque corresponding to the rotation speed of the motor from the DC power supply created by the converter and smoothing capacitor, and supplies it to the motor.

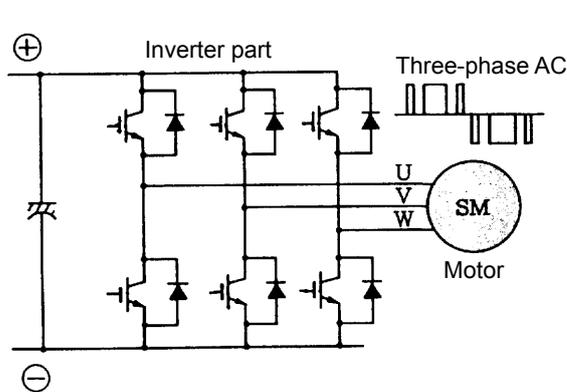


Figure 1.5 Configuration of inverter portion

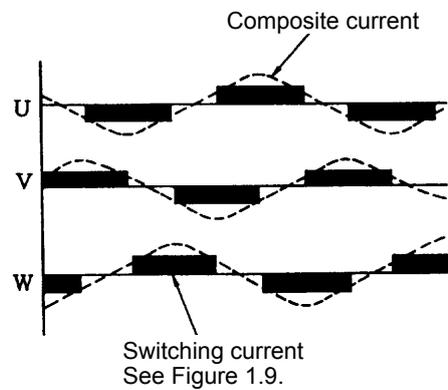


Figure 1.6 Output current of inverter

1. AC Servo Fundamentals

As shown in Figure 1.7, the rotation direction and rotation speed (frequency) of the motor are controlled by the direction of the current and the current-carrying width by switching the transistor in the inverter-portion on/off.

The amplitude of the current is controlled by the energizing width. This method is called PWM control (pulse width control).

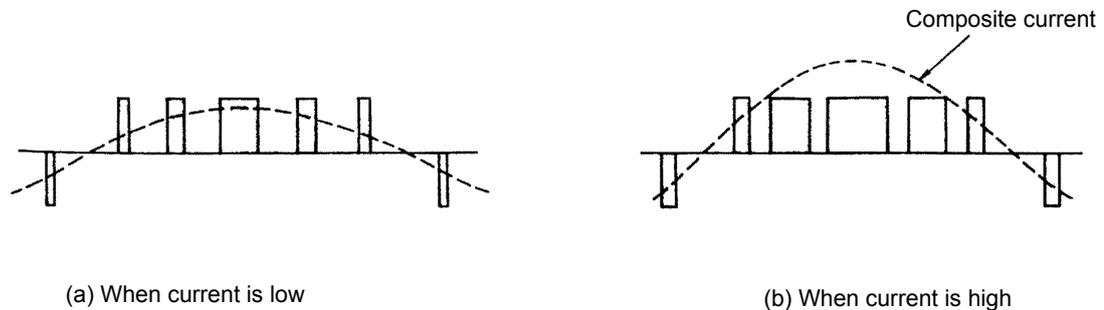


Figure 1.7 Current control according to PWM

3) Regenerative brake

1. Regenerative brake circuit

The regenerative brake is operated when the actual rotation speed of the motor becomes higher than the command speed, such as during deceleration, dropping of the vertical axis, or when braking is applied to the winding axis, and braking force is obtained by absorbing (consuming) the energy through a regenerative resistor built in to the servo amplifier side for the rotation energy contained in the motor and the load.

Such an operating status is called regenerative operation, and a regenerative circuit is provided in normal servo amplifiers. In this case, because the regenerative circuit is operated as a load on the motor, the regenerative braking force differs according to the energy consumption ratio of the circuit, and the amount of regenerative energy is influenced by the operating conditions. When it is necessary to consume a large amount of regenerative energy, it is possible to do so by providing a circuit outside of the servo amplifier.

2. Types of regenerative brake circuit

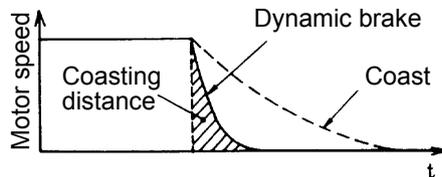
- For small capacity and low regenerative energy, energy is temporarily charged in the aforementioned smoothing capacitor. This is called the capacitor regeneration method and is used for 0.4 kW or lower.
- For medium capacity, the current flows to the resistor and a method where energy is consumed as heat is adopted. This is called the resistance regeneration method, and if the amount of regenerative energy becomes large, the resistor expands, which may result in problems including influence from the generation of ambient heat.
- For large capacity, in order to cover the disadvantages of the abovementioned resistance regeneration method, methods carried out by returning the regenerative energy to the power supply side are also recently being adopted. This is called the power supply regeneration method and is used for 11 kW or more.

4) Dynamic brakes

When stopped (base circuit shut-off) due to the output of the inverter portion when the power turns off or when an alarm occurs, the motor will be free-running and a longer period will be required until stopping, which increases the coasting distance and can result in defects such as collision at the stroke end.

1. AC Servo Fundamentals

Dynamic braking is a function that causes a short-circuit between the terminals of the servo motor through an appropriate resistor when there is a base circuit shut-off, and then heat consumption is performed for rotational energy, which causes an immediate stop. Although dynamic braking is built in to conventional amplifiers, some servo amplifier models like the 11 kW of MR-J3 type or higher have a separately installation. The retaining force at the time of stopping does not exist for dynamic braking, so it is necessary to retain the force by mechanical braking simultaneously with braking for vertical feeding cases.

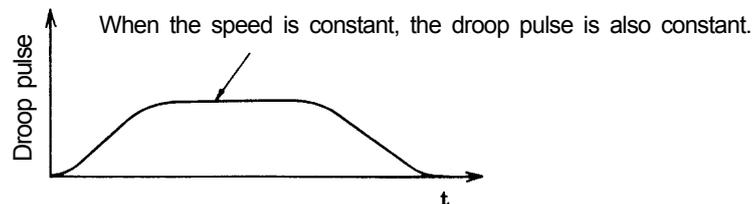
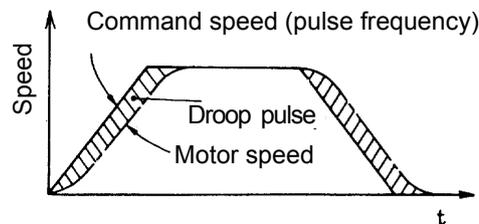
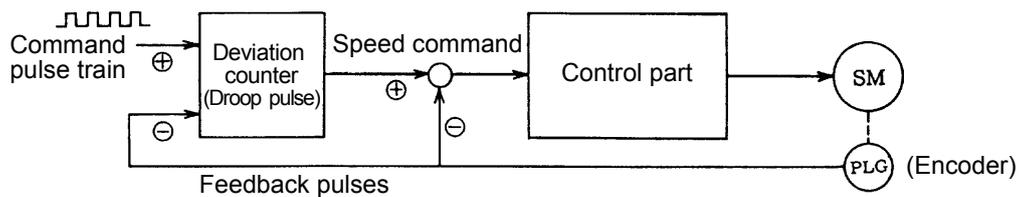


(2) Control circuit portion

Using a micro computer, the control amounts (position, speed, current) from the command values (set values) and current values are subjected to operation processing at high speeds and high accuracy in combination with implementation of high-accuracy, fast-response servo control, and the monitor and module control content is protected. The following section offers a control description summary.

1) Position control

Motor rotation speed/direction control and high accuracy positioning are executed by a pulse train.



Even when a command pulse is input by the position control portion, the motor is operated with a certain degree of delay from the command. As such, a pulse equivalent to the delay is retained in the deviation counter. This is called a droop pulse. This droop pulse is output in the speed control portion as a speed command.

1. AC Servo Fundamentals

2) Speed control

The output of the position control portion deviation counter is proportional to the command speed, and this results in a speed command. The speed command portion outputs the speed command and motor speed deviation as a current command.

When operated in speed control mode, the control signals and analogue voltage (0 to ±10 V) are input from external parts as a speed command.

3) Current control/three-phase generation circuit

The current control portion controls the motor current so that the motor is operated according to the position command or the speed command by controlling the main circuit inverter.

As such, the phase of the three-phase alternate current that conforms to the motor field (decided by the position of the permanent magnet of the rotor) is determined, and a current corresponding to the speed deviation is applied.

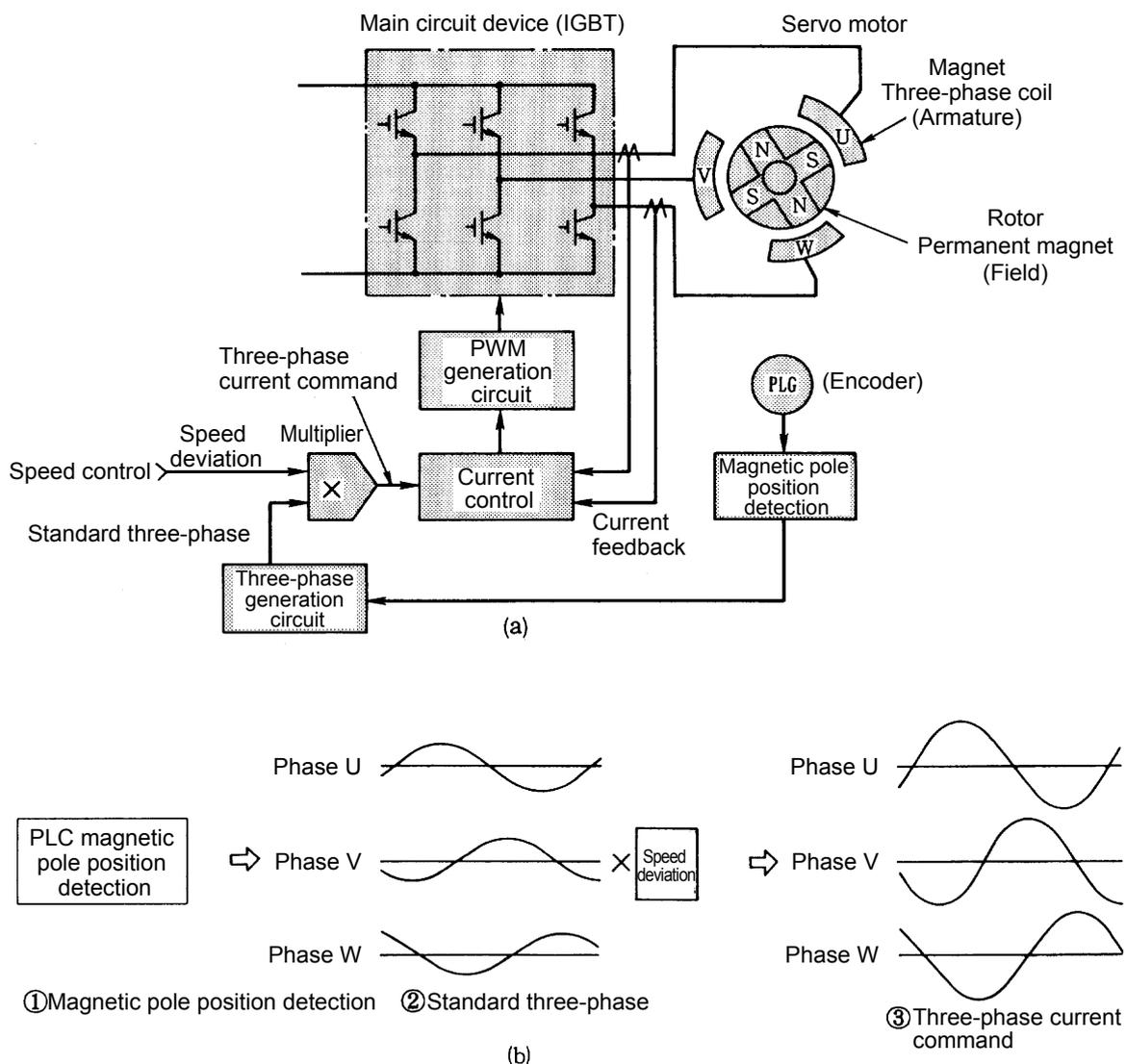


Figure 1.8 Principles of current control

1. AC Servo Fundamentals

With synchronous electric motors, it is necessary for the motor current to match the phase with the field position (magnetic pole position).

This is why the motor detector has the signals that detect the magnetic pole position, and normally there is feedback of that position to the servo amplifier. The servo amplifier creates a reference three-phase current with the three-phase occurrence circuit portion based on those signals. The current control portion sets the speed deviation in the reference three-phase current, creates a three-phase current command, and controls the PWM circuit.

Note: Independent fields do not exist in induction servo motors. Accordingly, magnetic pole position detection is not necessary.

The PWM method is the method that generates the switching pulse several times in one cycle, and changes that pulse width to change the output voltage. The number of switching pulses generated in 1 second is called the carrier frequency. With the PWM method, motor vibrations and undesired motor sounds of frequency components proportional to the carrier frequency will occur.

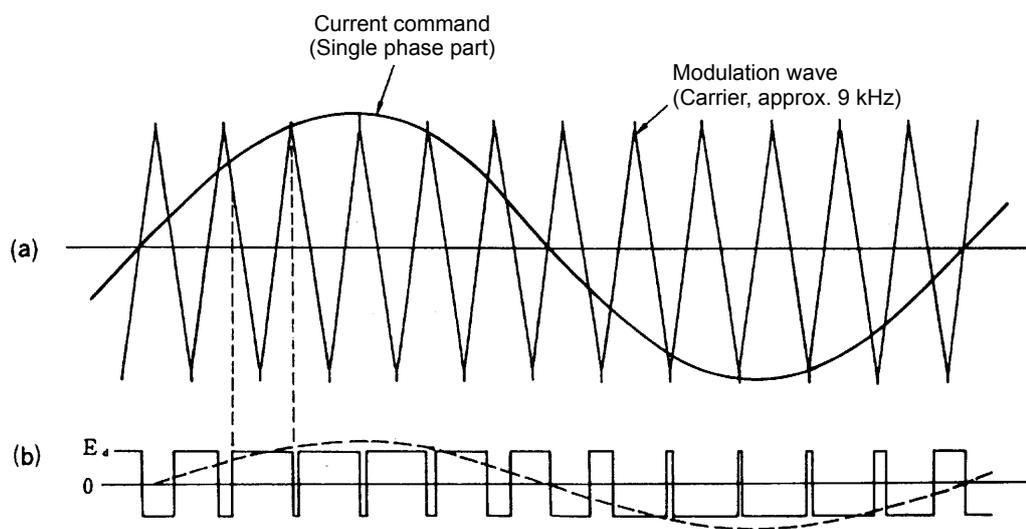


Figure 1.9 Principles of PWM control

1.4.2 Characteristics of AC Servo Motor and Operating Principles

(1) Characteristics

The output torque of the servo motor is proportional to the current that flows in the motor. Because the servo amplifier normally detects the motor speed and controls in such a way that the current flow in response to speed deviations, the servo motor can operate from a low speed to a high speed with a fixed torque.

The figure on the right shows the torque characteristics of a servo motor and servo amplifier combination.

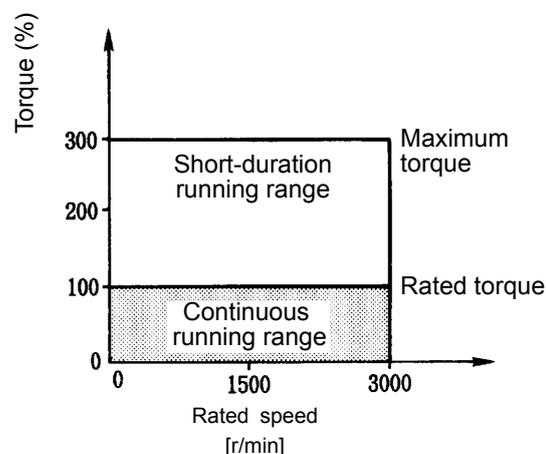
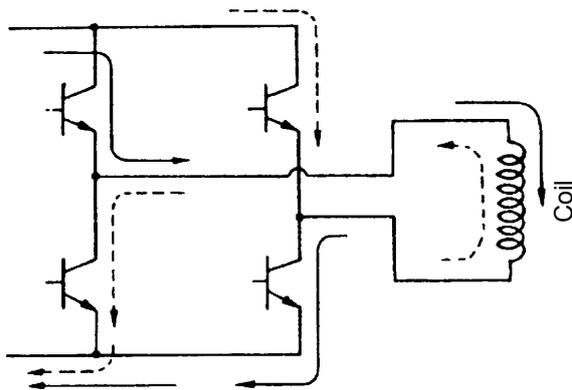


Figure 1.10 Torque characteristics of servo motor

1. AC Servo Fundamentals

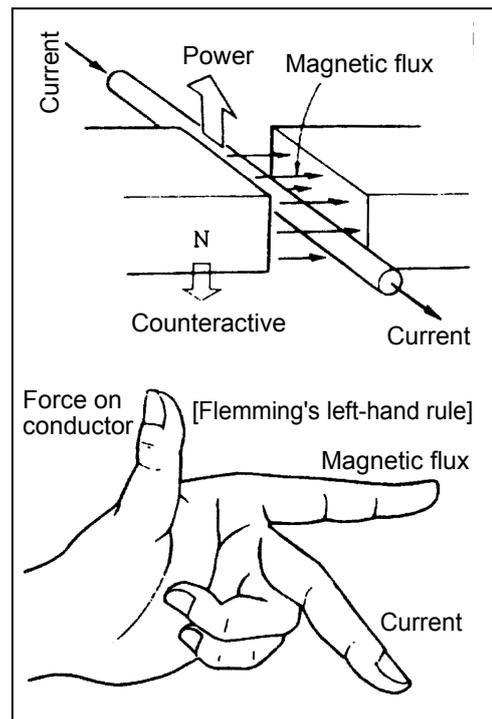
(2) Operating principles

The operating principles of every small and large motor are the same with torque occurring according to Fleming's left-hand rule, which states that if a current flows through a conductor in a magnetic field, a force acts in the conductor. For SM-type (synchronous type) AC servo motors, a permanent magnet is provided in the rotor, a coil through which a current flows is provided in the magnet, and current that corresponds to the rotor operation (rotation speed/direction, output torque) flows through the magnet coil.



Operating principles of SM-type AC servo motors

A current flows through the coil that bisects the magnetic flux from the rotor magnet by turning the amplifier transistor ON/OFF. The applied voltage is subjected to switching by several kHz, and the flowing current is smoothed by reactance of the winding wire and forms a sine-wave. The + - interval of the coil voltage is determined by the magnetic pole position detection signal from the detector directly connected to the motor shaft, and no phenomenon of loss in synchronism such as with a normally synchronous motor does not exist because it is normally controlled in such a way that the magnetic flux and the current bisect.



Principles of motor torque generation

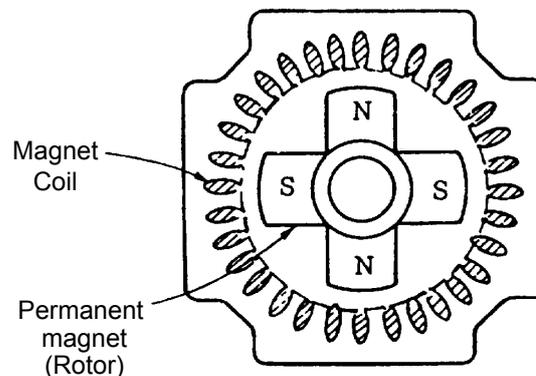


Figure 1.11 Cross-section of SM-type AC servo motor

1. AC Servo Fundamentals

(3) Principles of IM type (induced current electrical motor) motor (vector control inverter)

Even for induced current electric motors, the principles of the occurrence of torque are the same as for synchronous electric motors. However, there is no permanent magnet on the rotor side, as can be seen in the cross-sectional figure shown in the figure on the right, and it is not possible to supply the current I_a and the magnetic flux Φ individually. Accordingly, the current flows through the coil, and torque occurs due to the current that flows in the rotor groove by the electromagnetic induction action and by the magnetic flux created by the motor coil current. In this way, both the torque current and the magnetic flux current flow through the magnet coil, and this relationship is shown in formula (1-1).

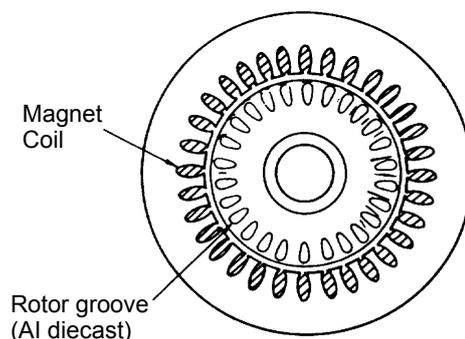


Figure 1.12 Cross-section of IM-type motor

$$I_1 = I_a + I_b \quad (1-1)$$

I_1 : Magnet coil current; I_a : Torque current; I_b : Magnetic flux electric current
 Note: The above formula is a vector summation, not an arithmetic summation.

In other words, it is necessary to control the two currents individually in IM-type motors. This is called vector control. IM-type motors have the same torque characteristics as servo motors using vector control.

(4) Servo motor types and features

An AC servo and a DC servo exist in the servo motor, and the AC servo is further divided into SM types (synchronous electric motors) and IM types (induced current electric motors). Table 1.2 shows the structure and characteristics of each servo motor.

Table 1.2

Type	Structure	Characteristics	
		Pros	Cons
SM-type AC servo motor		<ul style="list-style-type: none"> ● Maintenance-free ● Excellent environmental resistance ● Capable of large torque ● Power generation braking is possible at time of power failure ● Compact, lightweight ● High power rate 	<ul style="list-style-type: none"> ● Servo amplifier is somewhat more complicated than that for a DC motor ● Correspondence of 1:1 motor and servo amplifier necessary ● Risk of magnet demagnetization
IM-type motor		<ul style="list-style-type: none"> ● Maintenance-free ● Excellent environmental resistance ● Capable of high speeds and large torque ● Good efficiency in a large capacity ● Robust structure 	<ul style="list-style-type: none"> ● Servo amplifier is somewhat more complicated than that for a DC motor ● Braking is not possible with a power failure ● Characteristics change according to temperature ● Correspondence of 1:1 motor and servo amplifier necessary
DC-type servo motor		<ul style="list-style-type: none"> ● Configuration of the servo amplifier is simple ● Power generation braking is possible with a power failure ● Low cost with a small capacity ● High power rate 	<ul style="list-style-type: none"> ● Maintenance and periodic inspection around the commutator is necessary ● Generation of brush abrasion powder; difficult to use in clean places ● Cannot be used with high-speed large torque in relation to a commutating brush ● Risk of magnet demagnetization

1. AC Servo Fundamentals

Although the servo motor has been developed from an easily controllable DC servo motor, the complicated control resulting from the development of electronic devices substituted in the micro processor is high-speed, and with the transition to an AC servo motor that is maintenance-free and has good production characteristics with the possibility of being produced at a low cost, applications of 50 W or more are currently substituted with an SM-type AC servo. Furthermore, an IM-type motor has a robust structure and is easily applicable to large-form and high-speed conversions, and a larger capacity also results in improved efficiency. For this reason, this type is mainly used in cases requiring 7.5 kW or more, and with higher accuracy of large-form line control, their use has widened into areas where DC motors were the norm. Recently, however, vector control inverters are being changed to IM-type motors.

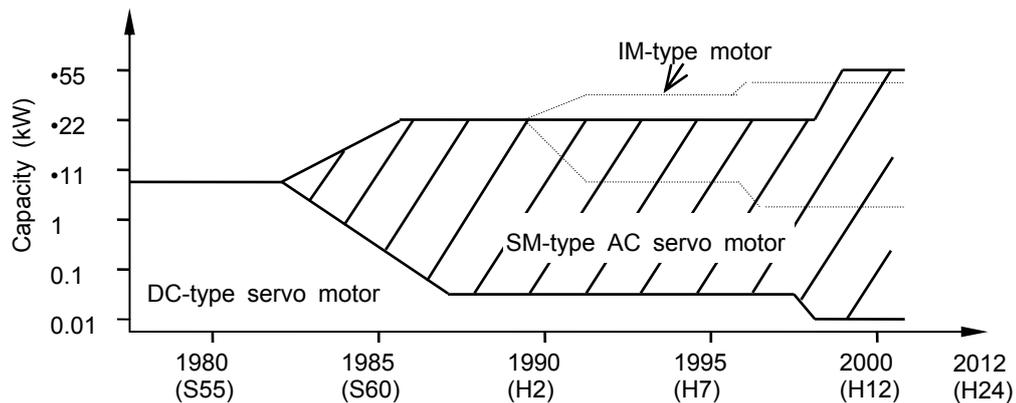


Figure 1.13 Transition of servo motor

1.4.3 Encoder Functions and Operating Principles

As explained above, in servo control, the feedback of the actual value for the command value (motor speed, position) is taken and is controlled so that deviation is reduced.

Accordingly, the detector is an indispensable element of the servo system.

(1) Encoder structure

The following figure shows the structure of the encoder mainly used as the detector.

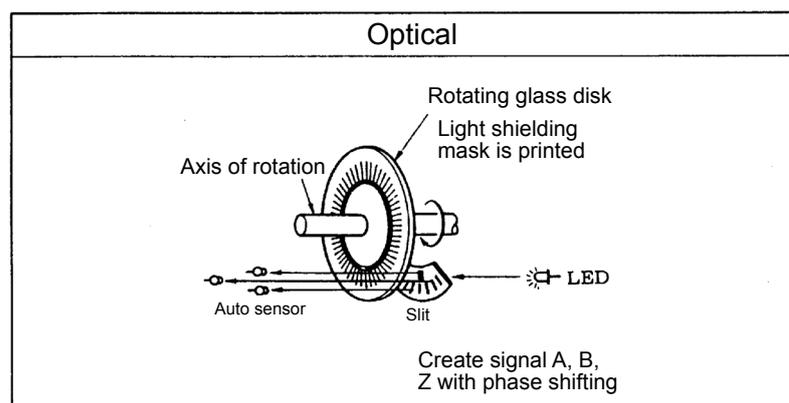


Figure 1.14 Encoder structure

1. AC Servo Fundamentals

(2) Encoder functions and signal types

The functions of the encoder installed in the servo motor are broadly classified into the following three categories.

- 1) Detection of motor position (including rotation direction)
- 2) Detection of motor speed (including rotation direction)
- 3) Detection of motor magnetic pole position (not necessary for IM-type motors, DC servo motors)

For 1) and 2), if the motor rotates, a biphasic pulse that is incrementally output is used.

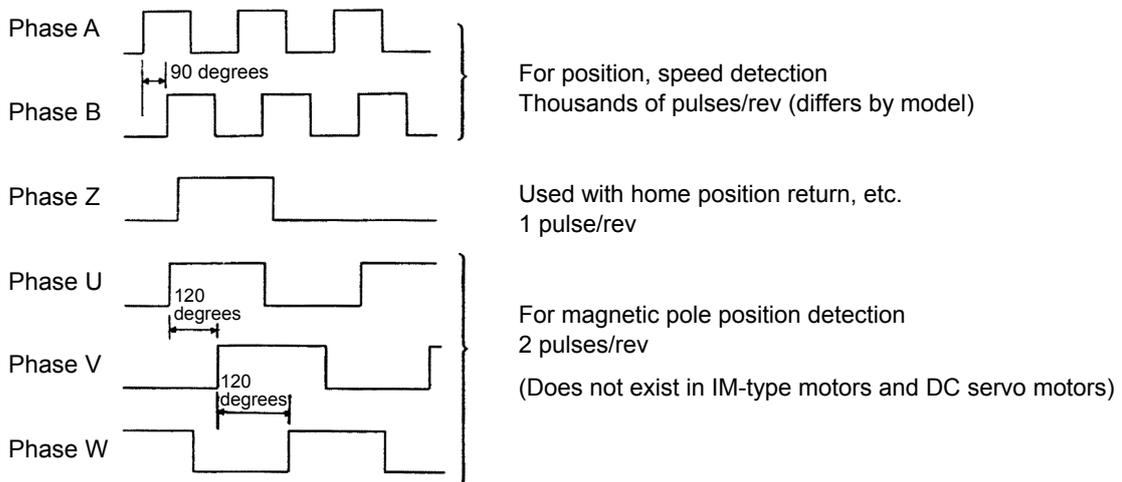
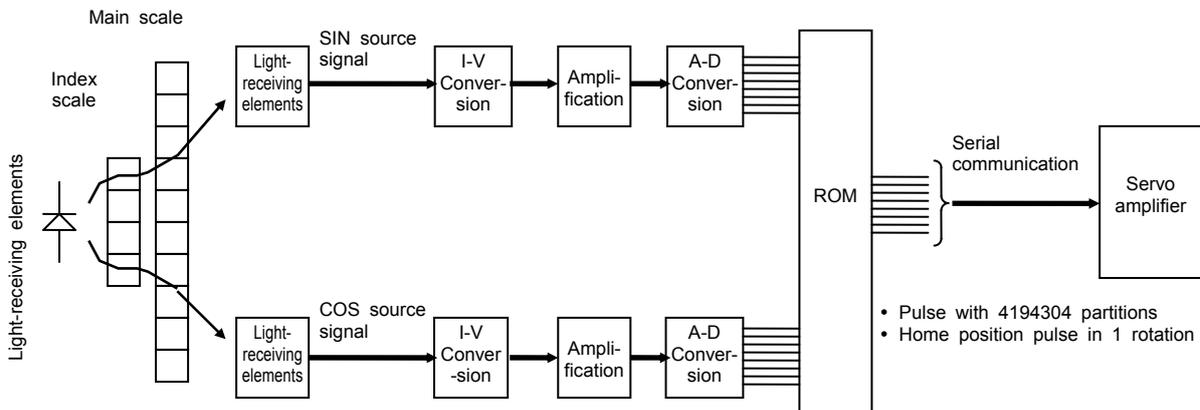


Figure 1.15 Encoder signals

Encoders assembled in recent AC servo motors create a pulse divided in 4194304 partitions according to the SIN source signals and COS source signals, as shown in the following figure, and a home position pulse per motor rotation, and then, using the serial communication method, transfers that data to the servo amplifier using serial communication.



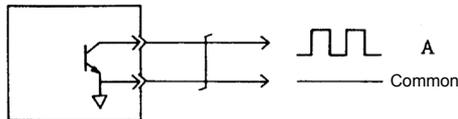
1. AC Servo Fundamentals

(3) Encoder signal interface

Although the encoder signals from the servo motor to the servo amplifier are serialized, the encoder signals emitted from the servo amplifier are converted into pulse form and are output.

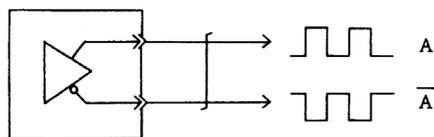
The following are the two types of encoder output signal interfaces. Recently, the differential driver output method, with a steady signal transmission, has become mainstream. Refer to section 3.4 for details.

- Open collector output



At the time of long distance transmission, the wave form can be weakened easily and is vulnerable to noise.

- Differential driver



High-frequency transmission is possible. Also resistant to noise.

Figure 1.16 Interface types

(4) Absolute position encoder

Recently, intending to improve tact time, the absolute position encoder is often attached to the motor and acts as an absolute position detection system for which a home position return after a power failure is not essential. In absolute position detection systems, because it is necessary to determine the rotation position at power-on, absolute position signals such as those shown in the structural figure on the right (7-bit in the figure on the right) are output in addition to the increment signals (A, B) of the previous section (2).

The following figure shows the block diagram of an absolute position detection system.

Note: Besides the abovementioned increment signals (phases A and B) in the absolute position encoder, there is also absolute position detections per motor rotation and the motor rotation amount counter from the home position, and because there is a memory backup, once a position is fixed by the home position return, the servo amplifier and controller can always detect the motor position even when the power supply is turned OFF. Accordingly, even when the home position return is not carried out at power-on from the second time onward, position and speed control can be executed as they are.

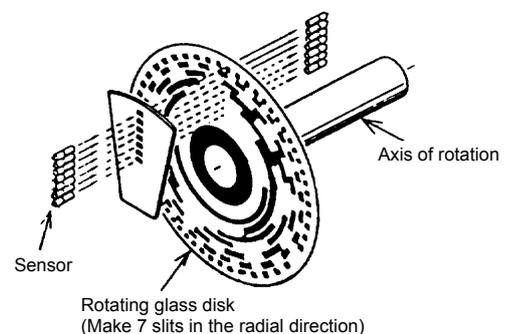


Figure 1.17 Example of absolute position encoder structure

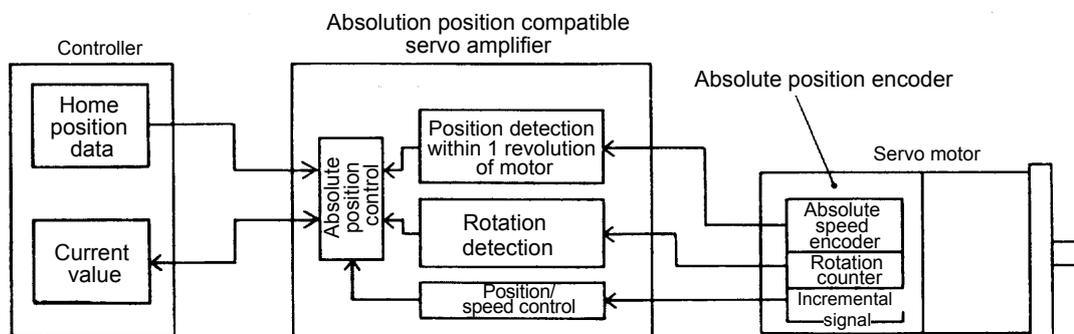


Figure 1.18 Block diagram of absolute position system

1. AC Servo Fundamentals

(5) High-resolution conversion of the encoder

For MELSERVO-J4 Series servo motors, a total capacity ABS, 22-bit (4,194,304) encoder is standard.

By using a high-resolution encoder, improved responding frequency, improved accuracy of speed feedback at low speed, improved position accuracy, and smooth operation for commands can be obtained.

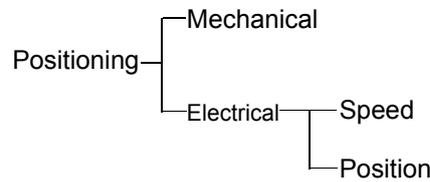
■ Standardization of high-resolution encoder

13 bit (8192), 14 bit (16384) → 17 bit (131072) → 18 bit (262144) → 22 bit (4194304)

2. Positioning Control by AC Servo

2.1 Positioning Method and Stopping Accuracy

2.1.1 Positioning Types



The methods for stopping a moving object with prescribed accuracy at a fixed position consist of a mechanical method and an electrical method. Mechanical methods generally include putting a stopper (inverter stopping control and AC servo torque limiting are up to contact with the stopper) and forcible positioning methods of inserting an object into the cylinder, but there are restrictions on the stopping position. On the other hand, with an electrical method, positioning at many optional positions is easy by employing position sensors. Electrical positioning also has various methods depending on the position detection method and the control method, and these are broadly classified into the speed control methods and position control methods mentioned below.

- (1) Speed control method: There is no signal output device required for positioning in the motor, and a device such as a limit SW exists for backing up on the machine side.
- (2) Positioning control method: There is no device for position detection on the machine side, and highly accurate position control is carried out by the encoder on the servo motor side.

Table 2.1 summarizes this.

2.1.2 Positioning Control and Stopping Accuracy with the Speed Control Method

(1) Limit switch method

When a mobile object operated by the motor stops automatically, the position is normally detected by the limit switch and the motor is stopped by that signal (often resulting in simultaneous braking). Figure 2.1 shows the relation of speed against time of a mobile object. If the horizontal axis is time [sec] and the vertical axis is speed [mm/sec], the area enclosed by the speed pattern constitutes the travel distance [mm].

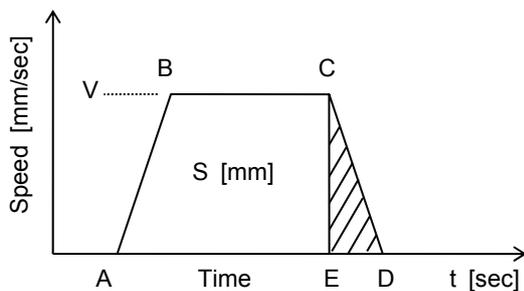


Figure 2.1 Operation (speed) pattern

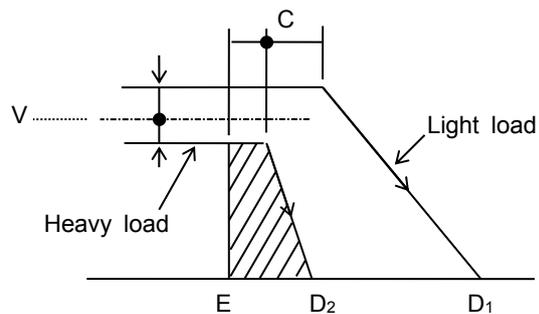


Figure 2.2 Variations in coasting distance

2. Positioning Control by AC Servo

After operation of the limit switch, the coasting distance is equivalent to the area CDE, and the stopping precision becomes the variations in this area CDE. The factors (causes of variations in area CDE) affecting stopping precision are, stop time (ED) changes (load torque fluctuations or brake torque fluctuations), as shown in Figure 2.2, speed fluctuations of moving objects at point C, and variations in the sensor operating position at point C as well as variations in delay time until the start of actual motor deceleration due to sensor operation. These variations in characteristics certainly need to be reduced, but the most effective method would be to reduce the V speed. Thus, when the stopping precision is not satisfactory during stopping from normal speed, a general method is to set a limit switch for low speed switching as shown in Table 2.1 and to stop once the speed is lowered. This method is simple and widely used to increase the precision. However, a drawback is that if the specified time (called creep speed) at low speeds is inadequate, the speed while passing the stop limit switch will be unstable due to load fluctuations, and it will take time for positioning. Also, if the stop positions are increased, a larger number of sensors will be required.

(2) Pulse count method

There is a pulse count method in which the limit switch method is improved. With this method, time can be minimized for short distance movements to obtain deceleration points at several stages by selecting any stop position. The stopping precision itself does not change as with the limit switch method, but the current position of a moving object is always detected. Thus, when the stop position is exceeded, compensation is easily possible.

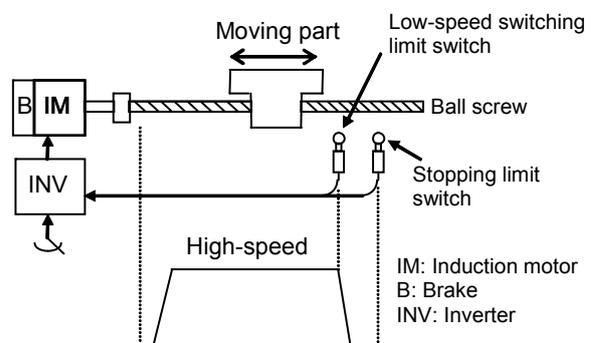
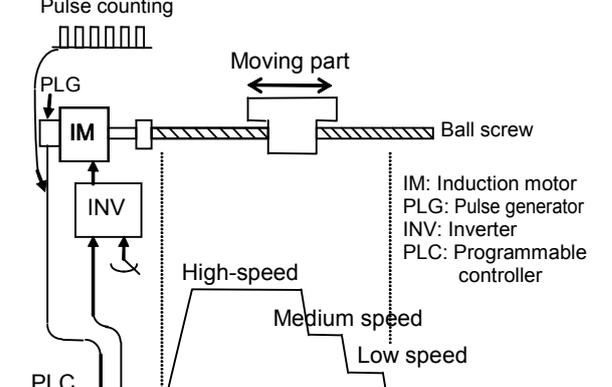
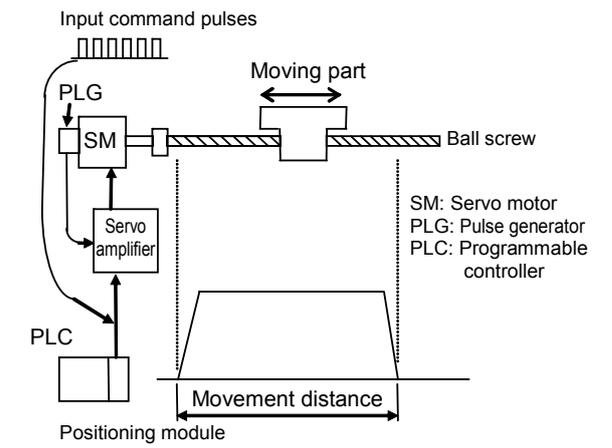
However, the factors that influence stopping precision have similar problems as with the limit switch method. Therefore, a significant improvement to the stopping precision itself cannot be expected.

(3) Pulse command method

In the positioning method used by the servo, the abovementioned drawbacks are removed (improved), and the position of a moving object is always detected similar to in the pulse count method. In this method, setting a low speed creep speed during a stop is not required, the speed is continuously controlled from high speeds to a direct stop target position, and stopping is done with the required precision. This method is called the position control method with respect to the speed control method.

2. Positioning Control by AC Servo

Table 2.1 Positioning method comparison table

Classification	Method	Description	Explanatory overview figure
Speed control method	Limit switch method	<p>In this method, a limit switch is set where a moving object passes by, and the moving object operates the switch, whose signal performs stopping.</p> <p>In general, the speed is lowered by the first of two switches, the motor is turned OFF by the second switch, and the moving object is stopped by the application of brakes.</p> <p>Positioning equipment is not specifically required, and the device can be configured at a low price with simple controls.</p>	
	(Stopping precision reference ± 0.5 to 5.0 mm) (Note)		
Speed control method	Pulse count method	<p>The position detector (pulse encoder, etc.) is set to the motor that drives an object or to the axis of rotation, and the number of pulses output are calculated by a high-speed counter. The pulses are proportional to the movement distance, so when the counter reaches a predetermined value, a stop signal is output and moving objects are stopped.</p> <p>With this method, a limit switch, etc., can be omitted, and position changing is easy. (A high-speed counter module can be used.)</p>	
	(Stopping precision reference ± 0.5 to 5.0 mm) (Note)		
Position control method	Pulse command method	<p>In a driven motor, an AC servo motor that rotates in proportion to the number of pulses input is used.</p> <p>Depending on the number of pulses input with respect to the movement distance to the servo amplifier of the AC servo motor, high-speed positioning proportional to the number of pulses input is possible. (A positioning module can be used.)</p>	

Note: Stopping precision is shown when the low speed is 10 [mm/sec] to 100 [mm/sec].

2.1.3 Position Control Method Types

Positioning control by a servo is a method for sending constant feedback about the position detection. However, there are different types of this detection method, as shown in Table 2.2. (The open loop method is not a servo, but it is shown as a comparison of closed loop.)

Table 2.2 Position control method types

Loop method	Configuration	Characteristics
Open loop		<ul style="list-style-type: none"> • No feedback; not called a servo • Loss in synchronism (operation stops) due to overloading • Small capacity only
Semi-closed loop	Motor shaft detection 	<ul style="list-style-type: none"> • Simple configuration • Quickest response • Stable control system that can be used safely • Reducer backlash compensation is required
	Feed screw terminal detection 	<ul style="list-style-type: none"> • Complicated configuration (a separate position detector is required) • Becomes unstable easily due to reducer or feed screw effects • Reducer backlash compensation not required
Fully closed loop		<ul style="list-style-type: none"> • Requires an expensive position detector • Becomes unstable easily due to gear or feed screw effects, and increased responding is not possible • Reducer backlash compensation not required

The AC servo MELSERVO Series has adopted the semi-closed loop of the motor shaft detection method and focuses on control system stability and user-friendliness. In addition, MELSERVO-J4 models are also compatible with fully closed loops as a standard.

2.2 Fundamentals of Positioning Control by AC Servo

The following section explains positioning control according to the pulse command method.

2.2.1 Position Detection and Number of Pulses per Motor Rotation

As explained in section 2.1.3, the AC servo MELSERVO Series uses a semi-closed loop method to detect the rotating position of a motor, i.e., the position of a machine, with an encoder (detector) directly connected to a motor shaft. (With the MELSERVO-J4, a fully closed loop can also be selected as a standard.)

The pulse signal appropriate for the rotation angle of a motor is generated by the encoder, and positioning control is performed by importing this pulse signal into the servo amplifier. (For more encoder details, refer to section 1.4.3.)

This feedback pulse will be the basis for deciding the movement increment (resolution) of a machine connected to the motor. A higher number of pulses per motor rotation will result in a higher precision in positioning control. HG Series servo motors have 4194304 pulses (represented as 4194304 p/rev). (Refer to section 1.3.4.)

2.2.2 Position Servo Concepts

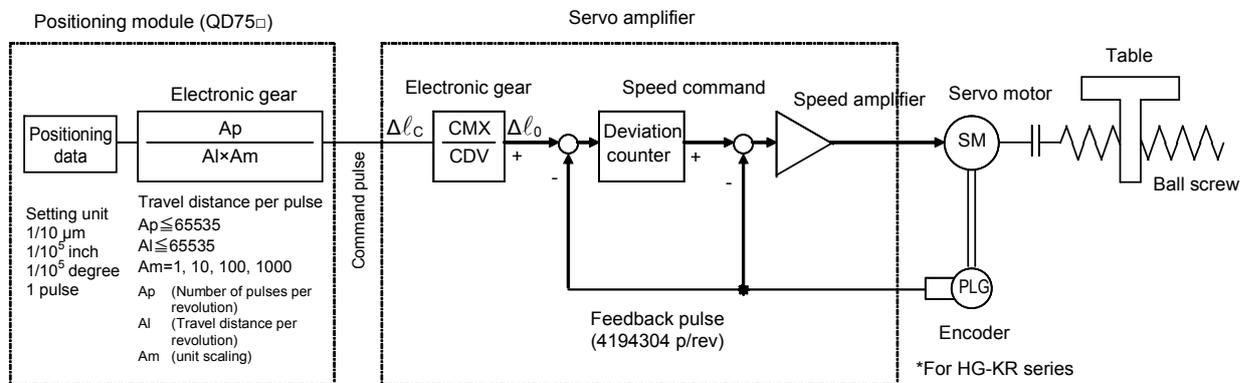


Figure 2.3 Position servo configuration

Positioning by the servo motor means that when command pulses are input by the positioning controller, the servo amplifier stores the feedback pulses appropriate for the command pulses and the motor speed at the deviation counter, and controls the motor so that the difference between the two will be zero.

Therefore, it is possible for a servo motor to perform proper positioning using command pulses.

The basis of positioning control by a servo is the motion of the motor shaft (machine) per command pulse to the servo amplifier, as well as the following.

- 1) The feed length of a machine is proportional to the total number of command pulses.
- 2) The speed of a machine is proportional to the speed of the command pulse train (pulse frequency).
- 3) Positioning is completed within a range of ± 1 final pulse, and the position is maintained by the servo-lock status in the absence of subsequent position commands.

(1) Deviation counter and motor rotation amount

In the deviation counter, command pulses from the positioning controller are added and, at the same time, the counter value starts being reduced when the feedback pulses are returned. If the value of the deviation counter (droop pulses) is large, the speed command becomes large, and the motor starts rotating at a high-speed. When it approaches the target stop position, the command pulses are reduced and the motor speed drops as the deviation counter output decreases. If the value of the deviation counter (droop pulses) becomes zero, the speed command also becomes zero and the motor stops. Therefore, the deviation counter output has a function that automatically controls the number of feedback pulses so that the rotation amount of the motor will be similar to the number of command pulses.

For example, for 1/2 rotation of the HG-KR motor of the MELSERVO-J4 Series with a feedback pulse of 4194304 p/rev 2097152 pulses need to be input by the positioning controller.

(2) Motor speed

The motor speed is proportional to the speed of the command pulse train as the rotation angle of a motor is proportional to the amount of command pulses by deviation counter control.

For example, to operate an HG-KR Series motor at 3000 r/min, inputting command pulses at 3000 rotations \times 4194304 pulses=12582.912 \times 10⁶ pulses in 1 minute, and 12582.912 \times 10⁶/60=209715.2 \times 10³ pulses in 1 second (represented as 209715.2 \times 10³ PPS=209715.2 kpps) by the positioning controller is needed. Normally, input is done using the electronic gear function on the controller side and the servo amplifier side.

(3) Positioning completion and servo-lock

Positioning is completed when the deviation counter (droop pulse) becomes zero, i.e., when the number of command pulses and feedback pulses match. Then, if the servo motor rotates due to any external force, the feedback pulses are input to the deviation counter by the encoder, a speed command is output from the deviation counter, motor rotation is corrected so that the droop pulse normally tends to zero, and motion is normally stopped at the specified position. This is called a servo-lock.

2.3 Positioning Accuracy

2.3.1 Machine Feed Length per Pulse

The per-pulse feed length of a machine is the minimum increment the machine will travel. As shown in Figure 2.4 (1), for mechanical systems without a ball screw and a reducer, the per-pulse feed length of a machine Δl_0 is as shown in formula (2-1). For mechanical systems without a ball screw and those with a reducer, consider the per-motor rotation feed length ΔS of a machine as the basis for calculating the per pulse feed length of a machine. If the per motor rotation feed length in Figure 2.4 is assigned to ΔS in formula (2-1), the feed length per pulse Δl_0 can be obtained.

$$\Delta l_0 = \frac{\Delta S}{P_{f_0}} = \frac{\Delta S}{4194304} \quad [\text{mm/puls}] \quad (2-1)$$

However, P_{f_0} : Number of feedback pulses per motor rotation.

The value of P_{f_0} is the same as the encoder resolution and differs according to the type of motor.

This value is 4000 [pulse/rev] for HC-PQ types, 131072[pulse/rev] for HC-SFS types, 262144 [pulse/rev] for all MELSERVO-J3 Series motors, and 4194304 [pulse/rev] for all MELSERVO-J4 Series motors. (Refer to section 1.3.4.)

2. Positioning Control by AC Servo

Figure 2.4 shows an example of the mechanical system and the calculation formula for ΔS .

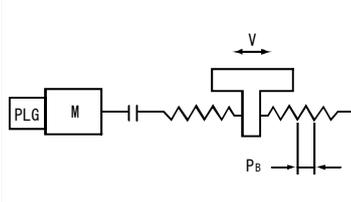
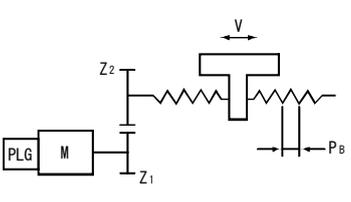
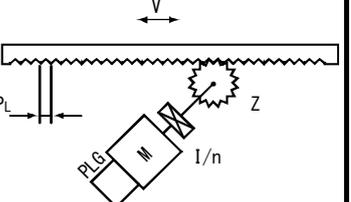
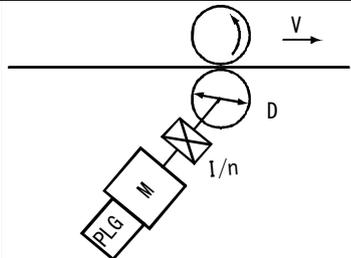
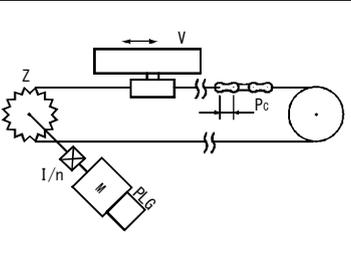
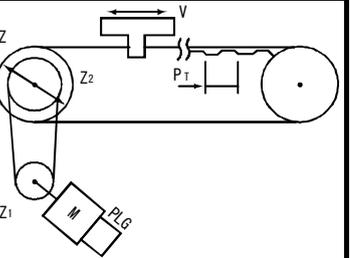
Drive system	(1) Ball screw (direct connection)	(2) Ball screw (gear connection)	(3) Rack and pinion
			
Feed length per motor rotation	$\Delta S = P_B$	$\Delta S = P_B \cdot \frac{Z_1}{Z_2} = P_B \cdot \frac{1}{n}$	$\Delta S = P_L \cdot Z \cdot \frac{1}{n}$ Z: Pinion teeth
Drive system	(4) Roll feed	(5) Chain-driven (direct connection)	(6) Chain, timing belt drive
			
Feed length per motor rotation	$\Delta S = \pi \cdot D \cdot \frac{1}{n}$	$\Delta S = P_c \cdot Z \cdot \frac{1}{n}$ Z: Sprocket teeth	$\Delta S = P_T \cdot Z \cdot \frac{Z_1}{Z_2} = P_T \cdot Z \cdot \frac{1}{n}$ Z: Pulley teeth

Figure 2.4 Feed length per motor rotation (ΔS) of various mechanical systems

2.3.2 Overall Machine Accuracy and Electrical Side Accuracy

Overall machine accuracy $\Delta \epsilon =$ machine side accuracy + electrical side accuracy

Accuracy on the machine side is examined by the machine manufacturer.

Accuracy on the electrical side depends on the feed length per pulse $\Delta \ell_0$ [mm/pulse] for the machine shaft.

If a Mitsubishi MELSERVO Series is used, stopping is ultimately within ± 1 pulse (machine shaft conversion $\pm \Delta \ell_0$) of the output pulses of the electronic gear, and the servo-lock status is initiated. The servo-lock status is maintained unless command pulses are generated. Therefore, electrical side accuracy $\Delta \ell_0$ is set so that no effect on the overall accuracy of machine $\Delta \epsilon$ results. Generally, the settings are configured so as to satisfy the following:

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

<Reference> Overall accuracy of machine $\Delta \epsilon$ and feed length per pulse $\Delta \ell_0$

By considering the overall accuracy of the machine $\Delta \epsilon$, the per-pulse feed length $\Delta \ell_0$ can be obtained.

2.4 Motor Speed for Machine Maximum Speed

As shown in Figure 2.5, when the speed is changed in mechanical systems using gears and driven by a ball screw, the motor speed N [r/min] against the machine speed V [mm/min] becomes as shown in formula (2-3).

$$\text{Motor speed} = \frac{\text{Machine speed}}{\text{Ball screw lead}} \times \frac{1}{\text{Reduction ratio}} \quad (2-3)$$

Therefore, formula (2-3) with a ball screw lead P_B [mm] and a reduction ratio of $1/n$ is as follows:

$$N = \frac{V}{\Delta S} = \frac{V}{P_B} \cdot n \text{ [r/min]} \quad (2-4)$$

If the machine maximum speed V_0 is determined and the motor speed with respect to V_0 is selected to the closest possible value that will not exceed the rated speed N_r [r/min], then high positioning accuracy can be obtained and the motor power can be used effectively.

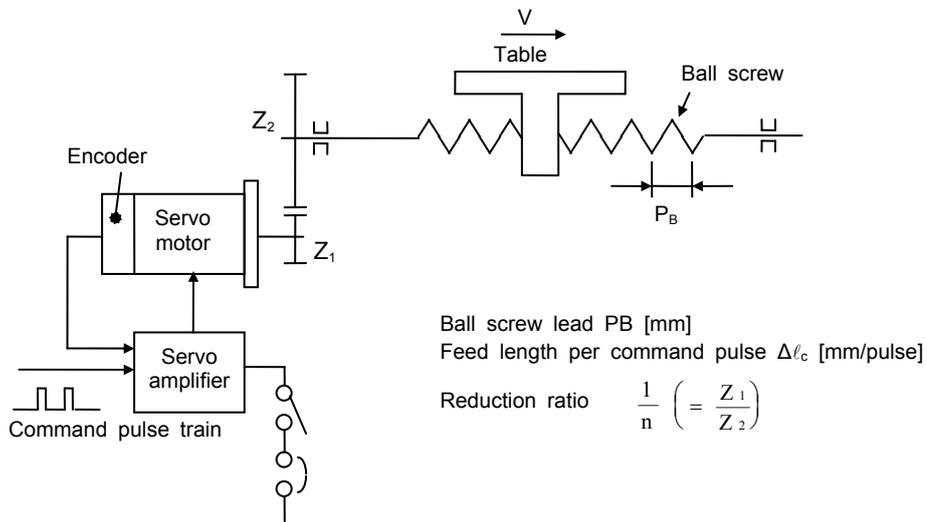


Figure 2.5 Relationship between machine speed and motor speed

2.5 Command Pulse

There is a movement of the number of pulses that are input from the positioning controller and the same number of feedback pulses in the position servo. In addition, the motor is operated at a speed that balances the command and feedback pulses at steady operation. Thus, it is necessary to check whether there is consistency in the relationship between the machine feed length per pulse (section 2.3.1) and the minimum command unit for positioning, as well as whether the pulse frequency at maximum machine speed mutually satisfies the positioning controller and the servo amplifier.

2.5.1 Electronic Gear Functions

Electronic gear function is present at the positioning controller side as well as the servo amplifier side. The electronic gears on the servo amplifier side are explained here.

The AC servo MELSERVO-J4 Series has an electronic gear function, thus flexible positioning is possible without a need to select a detector that matches the mechanical system. The functions are explained below.

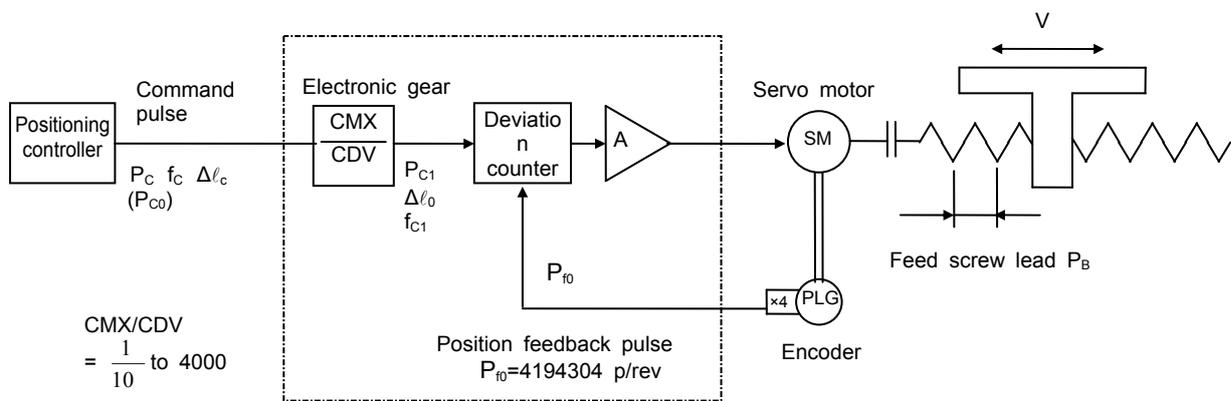


Figure 2.6 Explanation of electronic gear functions

A block diagram of the electronic gear function is shown in Figure 2.6. The following is a summary of the functions and the relational expressions.

The following applies to the figure.

P_C :	Number of command pulses [pulse]	f_C :	Command pulse frequency [pps]
P_{C1} :	Number of deviation counter input pulses [pulse]	f_{C1} :	Deviation counter input command pulse frequency [pps]
P_{f0} :	Number of feedback pulses per motor rotation [pulse/rev]	Δl_0 :	Machine travel distance per feedback pulse [mm/pulse]
P_{C0} :	Number of command pulses per motor rotation [pulse/rev]	Δl_C :	Machine travel distance per command pulse [mm/pulse]
		CMX:	Command pulse multiplication numerator
		CDV:	Command pulse multiplication denominator

2. Positioning Control by AC Servo

<Reference> Electronic gear function

An electronic gear function is present at the positioning controller side as well as the servo amplifier side. Set the electronic gear of the servo amplifier so that the fraction of the encoder is rounded and does not exceed the maximum command pulse frequency. Also, using the electronic gear of positioning controller, configure the detailed settings to match the positioning data units, including for the mechanical system.

(1) Positioning accuracy Δl_0 and set resolution Δl_C can be set separately, and Δl_C can be matched to the non-fractional value from the electronic gear.

(2) The deviation counter input pulse frequency when the motor is operated at the rated speed is fixed (refer to formula (2-11)), but the motor can be operated at a lower command pulse frequency.

(1) Relation between the electronic gear setting and the command pulse

- 1) The pulses for which the command pulses are multiplied by the electronic gear ratio become deviation counter input pulses.

$$P_{C1} = P_C \cdot \frac{CMX}{CDV} \quad (2-5)$$

The following applies:

- P_C : Number of command pulses [pulse]
- P_{C1} : Number of deviation counter input pulses [pulse]
- CMX: Command pulse multiplication numerator
- CDV: Command pulse multiplication denominator

Figure 2.7 shows the relationship between P_C and P_{C1} when the electronic gear ratio $CMX/CDV=8$.

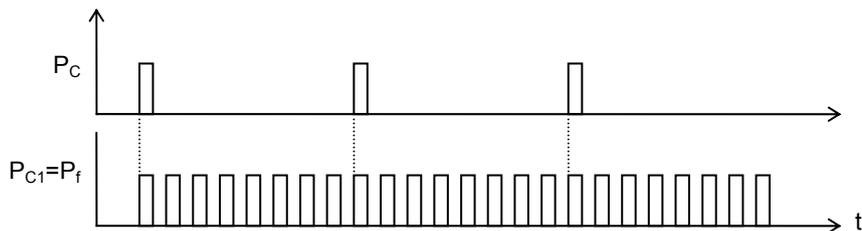


Figure 2.7 Relation of electronic gear setting part I/O when the electronic gear ratio is 8

- 2) The same applies to the pulse frequency.

$$f_{C1} = f_C \cdot \frac{CMX}{CDV} \quad (2-6)$$

The following applies:

- f_C : Command pulse frequency [pps]
- f_{C1} : Deviation counter input pulse frequency [pps]

- 3) The electronic gear is formed outside the position control loop. Therefore, even if the command pulse scaling factor is set to any value, the resolution on the motor shaft becomes as follows.

$$\left(\frac{1}{\text{Encoder resolution}} \times 360^\circ \right)$$

However, positioning accuracy is determined by the machine travel distance per command pulse (mm/pulse).

2. Positioning Control by AC Servo

- 4) If the electronic gear ratio is set to 1 or less, the command pulse input is not output to the deviation counter at 1.
Output is done when the value after the scaling factor becomes 1.

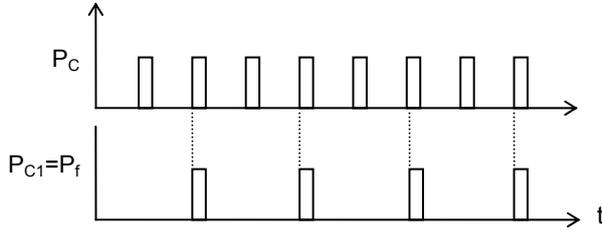


Figure 2.8 Electronic gear at 1/2 gear ratio related to setting part I/O

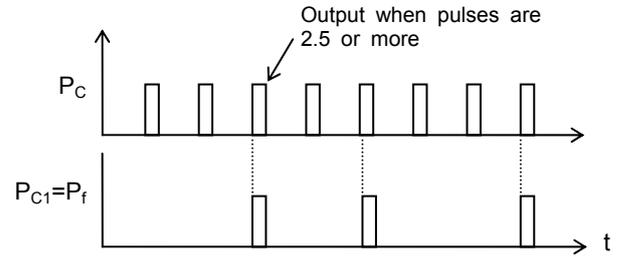


Figure 2.9 Electronic gear at 2/5 gear ratio related to setting part I/O

- 5) With an MR-J4 servo amplifier, the setting range of the electronic gear ratio and the denominator and numerator is as follows.

$$\frac{1}{10} < \frac{\text{CMX}}{\text{CDV}} < 4000 \quad (2-7)$$

CMX: Integer between 1 to 16777215

CDV: Integer between 1 to 16777215

- (2) The relationship between the electronic gear ratio setting and the mechanical system is shown below.

- 1) For the rotation angle of the motor shaft, the position feedback pulse for 1 pulse per the following formula becomes the travel unit.

$$\left(\frac{1}{\text{Encoder resolution}} \times 360^\circ \right) \quad * \text{ With an HG-KR motor, the encoder resolution becomes 4194304.}$$

$$\Delta l_0 = \frac{P_B}{P_{f0}} = \frac{P_B}{\text{Encoder resolution}} \quad (2-8)$$

The following applies: P_{f0} : Number of feedback pulses per motor rotation [pulse/rev]

Note: With the reduction ratio, $\Delta l_0 = \frac{P_B}{\text{Encoder resolution}} \cdot \frac{1}{n} = \frac{1}{n} = \text{Reduction ratio}$

- (3) The deviation counter input 1 pulse is equal to the motor rotation of the position feedback 1 pulse. Therefore, by multiplying the command pulse by the electronic gear, the rotation angle of the motor per command pulse can be set to any value of the machine travel distance and then to a non-fractional value (such as 1 μm or 10 μm).

The relationship between the number of pulses per motor rotation P_{C0} on the command side and the number of pulses per motor rotation P_{f0} on the feedback side is similar to formula (2-5).

$$P_{C0} \cdot \frac{\text{CMX}}{\text{CDV}} = P_{f0} \quad (2-5)'$$

If expressed by the travel distance per pulse on the command side in formula (2-8), the following applies:

$$\Delta l_C = \frac{P_B}{P_{C0}} \quad (2-8)'$$

2. Positioning Control by AC Servo

According to the relationship with (2-5), the following applies.

$$\Delta l_c = \frac{P_B}{P_{C0}} = \frac{P_B}{P_{f0}} \cdot \frac{CMX}{CDV} = \Delta l_0 \cdot \frac{CMX}{CDV} \quad (2-9)$$

Also, if the electronic gear ratio is set to the following, the travel distance per command pulse Δl_c can be set to any value, regardless of the mechanical system (P_{f0} , P_B).

$$\frac{CMX}{CDV} = \frac{\Delta l_c}{\Delta l_0} = \Delta l_c \cdot \frac{P_{f0}}{P_B} \quad (2-10)$$

- (4) The motor speed is determined by the pulse train F_{C1} , which is input to the deviation counter after multiplying the command pulse by the electronic gear ratio. Thus, the motor can be rotated at a high speed by making f_{C1} large, even if the number of output pulses from the positioning controller (command pulse frequency) f_c is small.

When the motor is at a constant speed, the input pulse frequency of the deviation counter (f_{C1}) and the feedback pulse frequency f_F are balanced. Therefore, the relationship between the motor speed and the electronic gear is expressed by formula (2-11).

$$f_{C1} = f_c \cdot \frac{CMX}{CDV} = P_{f0} \cdot \frac{N}{60} \quad (2-11)$$

The following applies: f_c : Command pulse frequency [pps]
 f_{C1} : Deviation counter input pulse frequency [pps]
 N : Motor speed [r/min]

Therefore, the electronic gear ratio when operating the motor with the speed N and the command pulse frequency f_c is as follows:

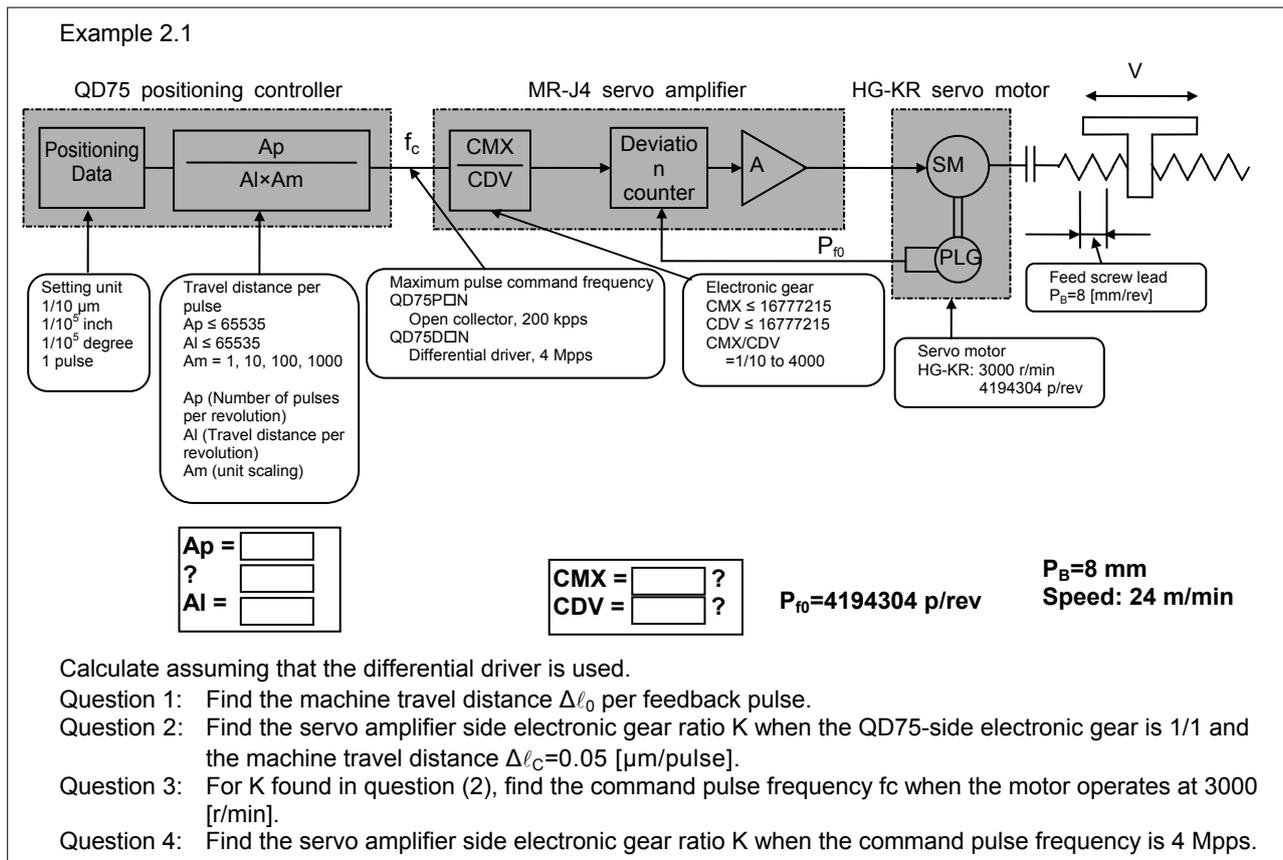
$$\frac{CMX}{CDV} = \frac{f_{C1}}{f_c} = \frac{1}{f_c} \cdot P_{f0} \cdot \frac{N}{60} \quad (2-12)$$

For example, the electronic gear ratio to rotate the servo motor (HG-KR Series) at 3000 r/min with a command pulse frequency of 200 kpps,

$\frac{CMX}{CDV}$, is as follows:

$$\frac{CMX}{CDV} = \frac{1}{200000} \times 4194304 \times \frac{3000}{60} = \frac{131072}{125}$$

2. Positioning Control by AC Servo



Question 1: According to formula (2-8), the following applies:

$$\Delta l_0 = \frac{P_B}{P_{f0}} = \frac{8}{4194304} \approx 0.0019 \times 10^{-3} \text{ [mm/pulse]}$$

* When the positioning is 300 mm, $300 \div 0.0019 \times 10^{-3} = 157894736.842$ pulses and comes out to be a fraction.

Question 2: Calculate the electronic gear ratio to control the servo motor with the travel distance per feedback pulse ($0.0019 \times 10^{-3} \text{ [mm/pulse]}$) by the machine travel distance ($0.05 \times 10^{-3} \text{ [mm/pulse]}$) of the positioning device.

According to formula (2-10),

$$K = \frac{CMX}{CDV} = \Delta l_c \cdot \frac{P_{f0}}{P_B} = 0.05 \times 10^{-3} \times \frac{4194304}{8} = \frac{1}{20000} \times \frac{4194304}{8} = \frac{16384}{625}$$

Δl_c after putting the above-mentioned electronic gear is as follows:

$$\Delta l_c = \frac{P_B}{P_{f0}} \times \frac{CMX}{CDV} = \frac{8}{4194304} \times \frac{16384}{625} = 0.00005 \text{ [mm/pulse]}$$

* When the positioning is 300 mm, $300 \div 0.00005 = 6000000$ pulses, and it is not a fraction.

* By using the electronic gear ratio found above, it is necessary to verify that the maximum command frequency for the QD75 positioning controller does not exceed 4 Mpps.

2. Positioning Control by AC Servo

Question 3: According to formula (2-11), the following applies:

$$f_{C1} = P_{f0} \times \frac{N}{60} = 4194304 \times \frac{3000}{60} = 209715200 \text{ [pps]}$$

According to formula (2-6), the following applies:

$$f_C = \frac{CDV}{CMX} \cdot f_{C1} = \frac{625}{16384} \times 209715200 = 8000000 = 8 \text{ [Mpps]}$$

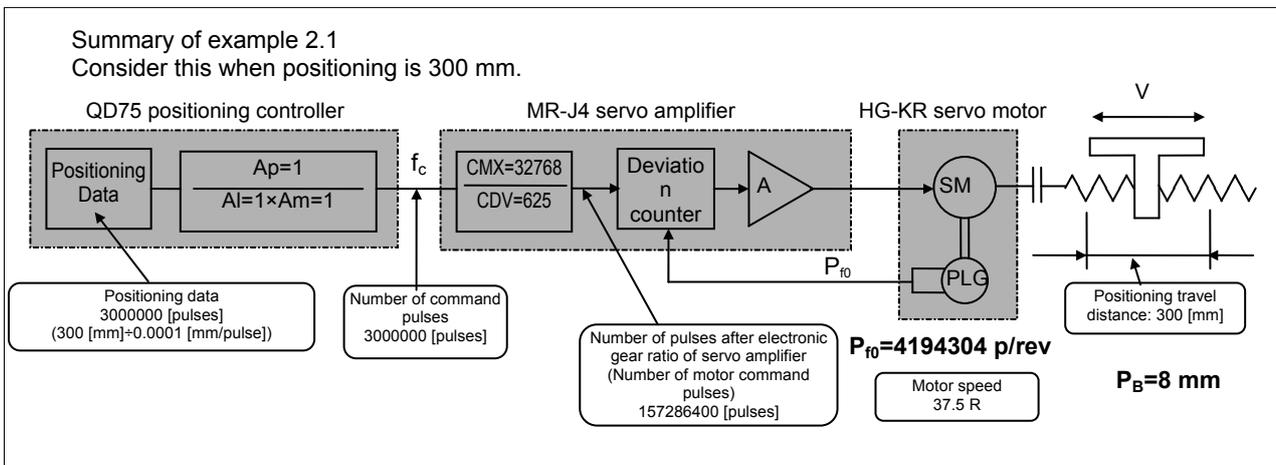
- * The command pulse frequency exceeds 4 Mpps, which is the maximum command pulse frequency for QD75D□N, so control is not possible.
 (→ Find the electronic gear on the servo amplifier side when the maximum command pulse frequency for QD75D□N is 4 Mpps.)

Question 4: According to formula (2-6), the following applies:

$$f_C = \frac{CDV}{CMX} \cdot f_{C1} \Rightarrow \frac{CMX}{CDV} = \frac{f_{C1}}{f_C} = \frac{209715200}{4 \times 10^6} = \frac{32768}{625}$$

Check the positioning accuracy Δl_C after placing the above-mentioned electronic gear.

$$\Delta l_C = \frac{P_B}{P_{f0}} \times \frac{CMX}{CDV} \times \frac{8}{4194304} \times \frac{32768}{625} = 0.0001 \text{ [mm/pulse]}$$



CAUTION

Because the maximum command pulse frequency differs from the used positioning controller, care must be taken when checking the calculation result.

Example

Maximum command pulse frequency for QD75D positioning controller

- QD75D□: 1 Mpps
- QD75D□N: 4 Mpps

2.5.2 Maximum Input Pulse Frequency

The maximum servo amplifier input frequency is determined by the following conditions.

- (1) For the MR-J4 Series, select the value of the electronic gear from formulas (2-11) and (2-12) so that the servo motor can be used up to the rated speed with the maximum input pulse frequency (open collector: 200 kpps; differential driver: 4 Mpps).

In addition, the overall maximum input pulse frequency including the controller is the maximum frequency satisfying the abovementioned servo amplifier as well as controller. (For the maximum output pulse frequency of the positioning controller, refer to Appendix 3.)

Example 2.2

- (1) The maximum input pulse frequency for open collector input of the MR-J4 (3000 r/min) Series is how many kpps?
 (2) Find the range of electronic gear K for the MR-J4 when using the MR-J4 rated speed under the maximum input pulse frequency.
 (3) With open collector input, the maximum input pulse frequency for the overall MR-J4 and QD75 is how many kpps?

- 1) The answer is 200 kpps.
 2) According to (2-11) and (2-12), the range of electronic gear value K is as follows.

$$f_{C1} = P_{f0} \times \frac{3000}{60} = 4194304 \times \frac{3000}{60} = 209715.2 \times 10^3 \text{ pps} \quad 4000 > K \geq \frac{f_{C1}}{f_c} = \frac{209715.2 \times 10^3}{200 \times 10^3} = \frac{1048576}{1000}$$

- 3) The frequency that satisfies both MR-J4 and QD75 is 200 kpps.

Example 2.3

- (1) The maximum input pulse frequency for differential driver input of the MR-J4 (3000 r/min) Series is how many kpps?
 (2) Find the range of electronic gear K for the MR-J4 when using the MR-J4 rated speed under the maximum input pulse frequency.
 (3) With differential driver input, the maximum input pulse frequency for the MR-J4 and QD75 overall is how many kpps?

- 1) The answer is 4 Mpps.
 2) According to (2-11) and (2-12), the range of electronic gear value K is as follows.

$$f_{C1} = P_{f0} \times \frac{3000}{60} = 4194304 \times \frac{3000}{60} = 209715.2 \times 10^3 \text{ pps} \quad 4000 > K \geq \frac{f_{C1}}{f_c} = \frac{209715.2 \times 10^3}{4 \times 10^6} = \frac{524288}{10000}$$

- 3) The frequency that satisfies both MR-J4 and QD75 is 4 Mpps.

2.6 Speed Pattern and Stop Settling Time

2.6.1 Speed Pattern and Droop Pulse Behavior

Droop pulse is the difference between command pulses and feedback pulses in the servo amplifier deviation counter. The behavior is shown in Figure 2.10.

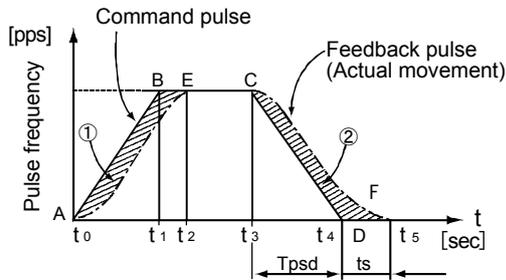


Figure 2.10 Speed pattern and droop pulse

(1) Operation between t_0 and t_2

Regarding the command pulse, the feedback pulse from the encoder is delayed due to the acceleration delay of the servo motor, and droop pulse ϵ is generated.

$$\epsilon = \frac{f_{C1}}{PG1} = \frac{K \cdot f_C}{PG1} \text{ [pulse]} \quad (2-13)$$

PG1: Model loop gain

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

(2) Operation between t_2 and t_3

While maintaining the delay of droop pulse in formula (2-13), operation is performed through synchronization of the command pulse and the servo motor speed.

(3) Operation between t_3 and t_4

Operates to recover the position delay in formula (2-13). Also, for t_4 (as soon as command pulses come to an end), the motor does not reach the command position, but is still ran even if the command pulses come to an end.

(4) Operation between t_4 and t_5

Operates to let out all of the remaining droop pulses. The time between this t_4 and t_5 is called stop settling time t_s .

(5) Motor motion

The actual motion is exponential to the motor speed as well as the droop pulses.

At the end, it is stabilized with all the droop pulses out and enters a servo-lock status.

The result is as follows.

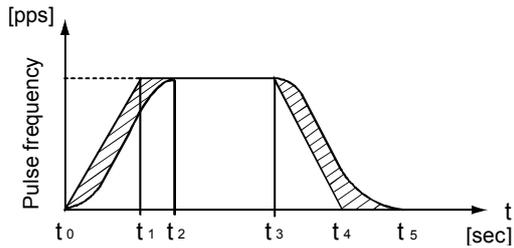
Command quantity of command pulse (area ABCD) = Actual feed length (area AECF)

and

Acceleration time saving (1) (area ABEA) = Deceleration time decrease (2) (area CFDC)

2. Positioning Control by AC Servo

Example 2.4



With $PG1 = 36 \text{ [sec}^{-1}]$ on the left, find droop pulse ε for the following deviation counter input.
 $f_{C1} = K \cdot f_C = 180 \text{ k}, 18 \text{ k}, 0.9 \text{ k}, 72 \text{ [pps]}$
 Also convert the droop pulse into the feed length when $\Delta l_0 = 0.01 \text{ [mm/pulse]}$.
 However, when an MR-J4 motor is used, the following applies:
 (Electronic gear ratio $K=1/16$)

If $\varepsilon = K \cdot f_C / PG1 \text{ [pulse]}$, the following can be assumed.
 When $K \cdot f_C = 180 \text{ kpps (1318 r/min)}$

$$\varepsilon = \frac{180000}{36} = 5000 \text{ [pulses]}, \text{ feed length conversion value } 5000 \times 0.01 = 50 \text{ [mm]}$$

When $K \cdot f_C = 18 \text{ kpps (132 r/min)}$

$$\varepsilon = \frac{180000}{36} = 500 \text{ [pulses]}, \text{ feed length conversion value } 500 \times 0.01 = 5 \text{ [mm]}$$

When $K \cdot f_C = 0.9 \text{ kpps (6.6 r/min)}$

$$\varepsilon = \frac{900}{36} = 25 \text{ [pulses]}, \text{ feed length conversion value } 25 \times 0.01 = 0.25 \text{ [mm]}$$

When $K \cdot f_C = 72 \text{ pps (0.53 r/min)}$

$$\varepsilon = \frac{72}{36} = 2 \text{ [pulses]}, \text{ feed length conversion value } 2 \times 0.01 = 0.02 \text{ [mm]}$$

2.6.2 Stop Settling Time t_s

The stop settling time is the time from the end of command output until positioning is completed. For the part mounters such as the inserter and the mounter, the cycle time is determined by this settling time, thus time minimization is a very important factor.



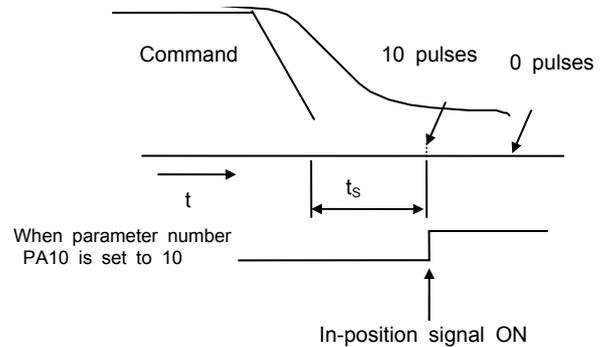
2. Positioning Control by AC Servo

The stop settling time is enabled to obtain the approximate value by model side position loop gain 1 (PG1) for model adaptive control. However, the value of position loop gain 1 is significantly affected by the machine condition and the value of the load moment of inertia. Therefore, it is necessary to consider the compatibility, including the mechanical system, when a feed of high-frequency operation or a high-response stop setting is required.

The stop settling time until the pulses are approximately 10 or less is empirically shown in the following formula.

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

If the droop pulses are within the precision required by the machine, the servo motor is considered stopped even if it is running. Also, a positioning completed signal is output. The stop settling time affects the cycle time during high-frequency positioning.



2.7 Relationship between Machine System and Response Level Setting

2.7.1 Response Level Setting

With standard control methods, it was necessary to adjust the servo position loop gain or the speed loop gain to match the respective machine conditions. Especially with the ratio of load inertia or machine rigidity, this required sufficient knowledge of the relationship between each loop of the servo system, and adjustment was much more time-consuming.

In the MELSERVO-J4 Series, model adaptive control and real-time auto tuning is performed, so the ideal model part as well as the actual loop part are automatically set to the most appropriate gain only by setting the auto tuning response to the value that matches the machine rigidity.

Auto tuning response settings can be configured using the parameters.

Refer to the summary of MR-J4 in the following table.

Table 2.3 MR-J4 parameter number PA09

Setting value	Auto tuning response	Machine target
1 to 13	Slow response	Items with a low machine rigidity. Machines with a belt, chain drive, and a large backlash.
14 to 18	Low-to-medium response	Rigidity level of an average, general-purpose machine. Belt, chain, rack and pinion drive, etc. Default setting value.
19 to 23	Medium response	Slightly higher level of machine rigidity. For response improvement through a ball screw, a timing belt with high rigidity, etc.
24 to 28	Mid-to-high response	Applications with high machine rigidity and when performing positioning very frequently.
29 to 40	Fast response	Applications with a very high machine rigidity and when performing positioning very frequently.

Note: Decrease the setting value if hunting occurs in the machine or if the gear noise is loud.

To improve the performance so as to shorten the stop settling time, increase the setting value.

2.7.2 Real-Time Auto Tuning

If the servo motor is operated by setting the setting value of the auto tuning response to the parameter, the load moment of inertia at that time is auto tuned and the gain for each control loop (position, speed) is set to the most appropriate value with respect to the response setting value already set.

At this time, if the setting value of the auto tuning response is not appropriate, unstable occurs due to the generation of vibration. Because of this, it is necessary to review the setting value of the auto tuning response.

The result of the tuned load moment of inertia can be checked by the load to motor inertia ratio on the status display monitor.

The recommended load to motor inertia ratio has limitations on response, regenerative power, dynamic brake, etc.

Normally, the load to motor inertia ratio for the servo motor is recommended to be 30 times or less, as a guide. (For details, refer to the individual catalog.)

Setting by real-time auto tuning is possible for a majority of machines, but if adjustment to the limit is required, perform gain adjustment manually.

<Reference> Manual gain adjustment method

If the load moment of inertia is excessive, the unbalanced load on the lifts shaft will be enormous, and normal tuning will not be possible. In this case, or when the machine is not compatible with the auto tuning response setting, perform each gain adjustment manually. For details, refer to section 5.3.3.

Memo

3. Positioning Controller

3.1 Division of Servo Function and Positioning Controller

In positioning control by an AC servo, the functions are divided as follows by the servo amplifier and the positioning controller, which generates the command pulse train.

3.1.1 Positioning Controller Side Functions

- (1) Command pulse output corresponding to the feed length of a machine
- (2) Determination of machine speed (command pulse frequency)
- (3) Determination of operation pattern (acceleration/deceleration time constant)
- (4) Storing of the logical machine position

3.1.2 Servo Amplifier Side Functions

- (1) Positioning control over the command position, according to the pulse train from the positioning controller
- (2) Servo-lock function
- (3) Positioning completed signal output function

3.2 Positioning Controller Classification and Configuration

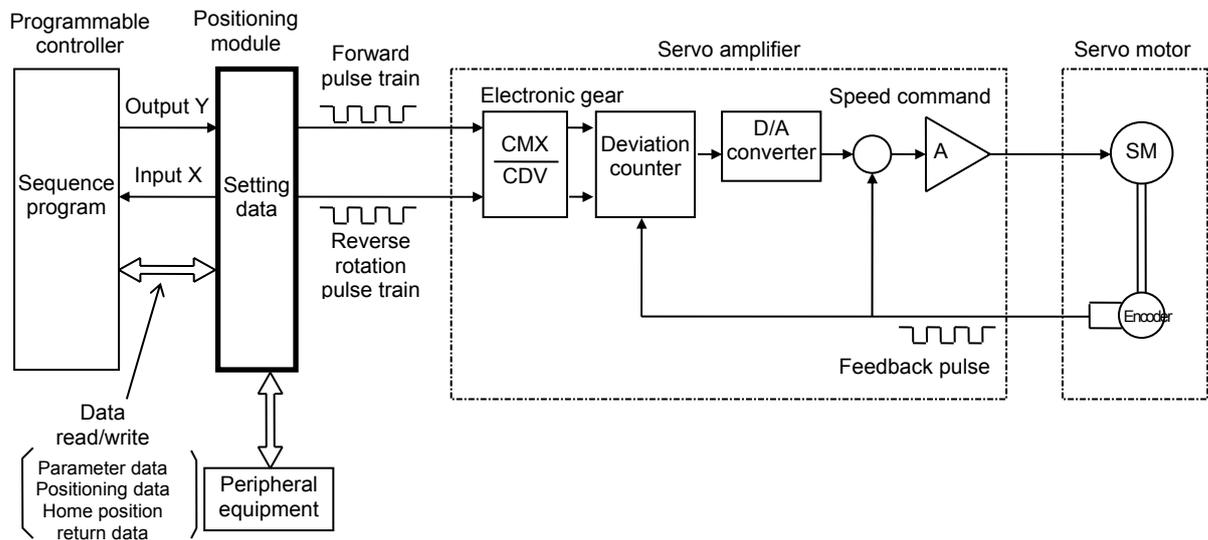


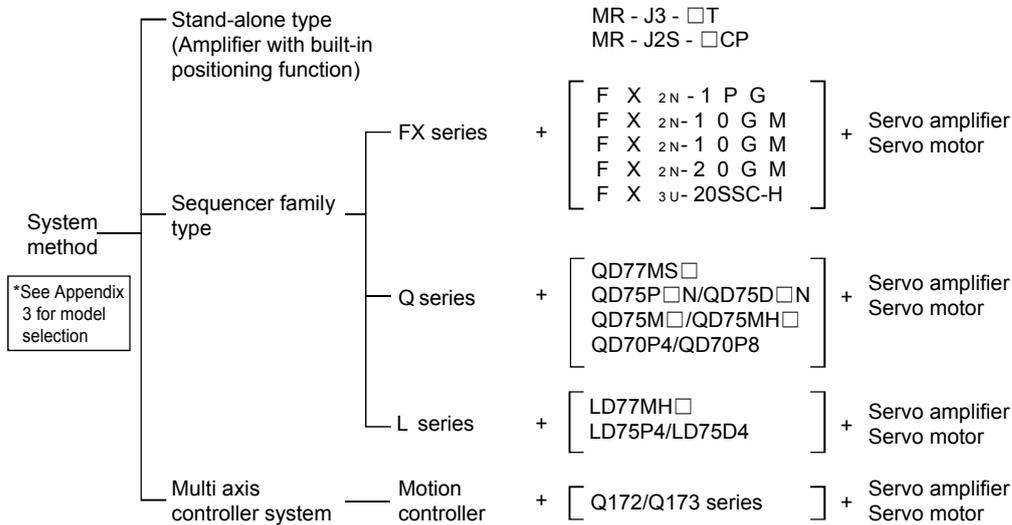
Figure 3.1 Positioning system configuration

- (1) The pulse trains output from the positioning module are added up by the deviation counter. The droop amount of this pulse is converted into D/A, becomes DC analog voltage, and then a speed command.
- (2) The motor rotates according to the speed command. At the same time, a feedback pulse is returned to the deviation counter by the encoder, and the droop pulse is reduced.
- (3) When the pulse train from the positioning module becomes a deceleration command, the droop pulses of the deviation counter disappear and the motor stops.

3. Positioning Controller

The servo motor has a wide range of applications, and a large number of items have been proposed and manufactured for positioning devices for the servo motor during progressing systemization with the host controller. Therefore, the selection of a suitable positioning controller, similar to the selection of a servo motor, is a very important point for servo system efficiency and for pursuing cost performance.

With the above points in mind, the classification and functions of various positioning controllers are explained below.



(1) System method

The servo system method, including positioning controllers and servo amplifier, is as follows.

(2) Number of controlled axes

The number of servo motors or servo amplifiers that can generally be simultaneously controlled by one positioning controller is expressed.

With multiple controlled axes, control is divided into either the simultaneous control method or the independent control method.

- | | |
|---------|---|
| 1 axis | QD75P1(N), QD75D1(N), QD75M1, QD75MH1, FX _{2N} -10GM, MR-J2S□CP, etc. |
| 2 axis | QD75P2(N), QD75D2(N), QD75M2, QD75MH2, QD77MS2, A1SD75M2, FX _{2N} -20GM, FX _{3U} -20SSC-H, etc. |
| 4 axis | QD75P4(N), QD75D4(N), QD75M4, QD75MH4, QD77MS4, QD70P4, LD75P4, LD75D4, LD77MH4 |
| 8 axis | QD70P8, Q172 series |
| 16 axis | Q172(DS), QD77MS16, LD77MH16 |
| 32 axis | Q173 series |

Number of
controlled axes

(3) Simultaneous control and independent control

1) Simultaneous control: This function controls multiple axes simultaneously if a positioning controller has two or more controlled axes.

This means that control of multiple axes is performed by a single program, and the operation mode (auto, manual, home position return, etc.), starting, and stopping are performed simultaneously. Also for such cases, these days many positioning controllers are equipped with interpolation control.

2) Independent control: This function controls each axis independently if a positioning controller has two or more controlled axes.

This means that control of multiple axes is performed by individual programs, and the operation mode (auto, manual, home position return, etc.), starting, and stopping is also performed individually.

3. Positioning Controller

(4) Interpolation control

This function controls multiple axes using interconnectivity, and there is generally linear interpolation and circular interpolation.

- 1) Linear interpolation: Multiple axes are controlled so as to be connected (linked) as closely as possible from the starting point up to the end point (target position). Trajectory becomes linear in this situation, which is why it is called linear interpolation. There is generally linear interpolation of 2 axes and 3 axes.

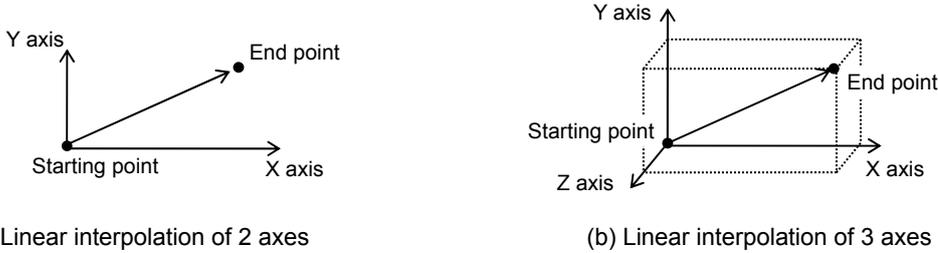


Figure 3.2 Linear interpolation operation

Applicable models	Linear interpolation of 2 axes	FX _{2N} -20GM, QD75P2(N), QD75D2(N), QD75MH2, QD75M2, QD77MS2, FX _{3U} -20SSC-H etc.
	Linear interpolation of 3 axes	QD75P4(N), QD75D4(N), QD75M4, QD75MH4, QD77MS4, QD77MS16, Q172□, Q173□, LD75P4, LD75D4, LD77MH4/MH16 etc. (Linear interpolation of 2 axes is also possible)

- 2) Circular interpolation: Multiple axes are controlled so as to be connected (linked) circularly from the starting point to the end point (target position). There are countless items in the trajectory of a circular arc connecting between the two points, thus the position of two points is specified by the program along with the radius of the circular arc, the center position, the direction etc.

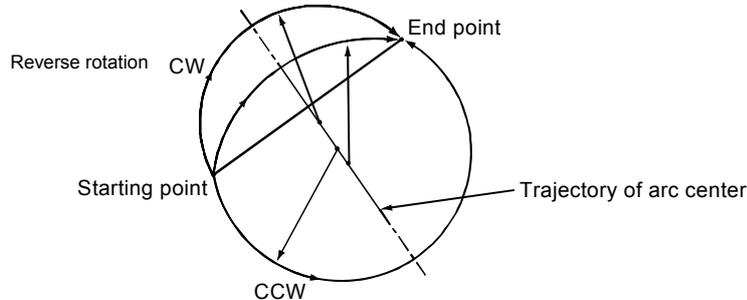


Figure 3.3 Circular interpolation operation

Applicable models	FX _{2N} -20GM, FX _{3U} -20SSC-H, QD75P2(N)/P4(N), QD75D2(N)/D4(N), QD75M2/M4, QD75MH2/MH4, QD77MS2/MH4/MH16, Q172□, Q173□, LD75P4, LD75D4, LD77MH4/MH16 etc.
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3. Positioning Controller

(5) Absolute position detection

In this system, when an absolute position detector is attached to the servo motor, the machine position is backed up by the positioning controller even if the home position return is not executed after power off. In this way, positioning control can be resumed from its position.

To construct an absolute position detection system, a motor with an absolute position detector, a compatible servo amplifier, and a positioning controller are required.

If the following positioning controllers, servo amplifiers, and motors compatible with SSCNET, SSCNETIII and SSCNETIII/H are used, an absolute position detection system can be easily constructed.

SSCNET type	Positioning controller	Servo amplifier	Motor
SSCNET	Q172N Q173N QD75M	MR-J2S-□B series MR-J2M-□B series	HC-KFS HC-MFS HC-SFS HC-LFS HC-RFS HA-LFS HC-UFS
SSCNET III	Q172H Q173H Q172D Q173D Q170M QD75MH QD74MH FX3U-20SSC-H	MR-J3-□B series MR-J3W-B	HF-KP HF-MP HF-SP HF-JP HC-LP HC-RP HC-UP HA-LP
SSCNET III/H	Q172DS Q173DS QD77MS	MR-J4-□B series	HG-KR HG-MR HG-SR

(6) Types of positioning program

Following are the types of positioning programs when compared with the applicable models.

Positioning program	Sequence program	FX2N-1PG, FX2N-10PG, FX3U-20SSC-H, QD75, QD70, D77MS,
	Positioning dedicated instruction	FX2N-10GM, FX2N-20GM
	Motion program (NC language and dedicated language)	Q172□, Q173□
	Contact	MR-J2S-□CP, MR-J3-□T

POINT	<ul style="list-style-type: none"> SSCNET: Abbreviation of Servo System Controller Network Servo network method dedicated for Mitsubishi 	
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3. Positioning Controller

3.3 Setting Data of Positioning Controller

This section explains the setting data of the QD75D□N positioning controller.

3.3.1 Basic Parameters/Detailed Parameters

Item	Setting range				Initial value				
	mm	inch	degree	pulse					
Basic parameter 1	Pr. 1 Unit setting	0	1	2	3	3			
	Pr. 2 Number of pulses per rotation	1 to 65535 pulses				20000			
	Pr. 3 Travel distance per 1 revolution	1 to 65535 × 10 ⁻¹ μm	1 to 65535 × 10 ⁻⁵ inch	1 to 65535 × 10 ⁻⁵ degree	1 to 65535 pulses	20000			
	Pr. 4 Unit scaling	1: 1 time 10: 10 times 100: 100 times 1000: 1000 times				1			
	Pr. 5 Pulse output mode	0: PULSE/SIGN mode; 1: CW/CCW mode; 2: Phase A and B mode (multiplication by 4); 3: Phase A and B mode (multiplication by 1)				1			
	Pr. 6 Rotation direction setting	0: Present value increase by forward pulse output 1: Present value increase by reverse				0			
	Pr. 7 Bias speed at start	0 to 2000000000 × 10 ⁻² mm/min	0 to 2000000000 × 10 ⁻³ inch/min	0 to 2000000000 × 10 ⁻³ degree/min	0 to 4000000 pulses/s	0			
Basic parameter 2	Pr. 8 Speed limit value	1 to 2000000000 × 10 ⁻² mm/min	1 to 2000000000 × 10 ⁻³ inch/min	1 to 2000000000 × 10 ⁻³ degree/min	1 to 4000000 pulses	200000			
	Pr. 9 Acceleration time 0	1 to 8388608 ms				1000			
	Pr. 10 Deceleration time 0					1000			
Detailed parameter 1	Pr. 11 Backlash compensation	0 to 65535 × 10 ⁻¹ μm	0 to 65535 × 10 ⁻⁵ inch	0 to 65535 × 10 ⁻⁵ degree	0 to 65535 pulse	0			
	Pr. 12 Software stroke limit upper limit value	-2147483648 to 2147483647 × 10 ⁻¹ μm	-2147483648 to 2147483647 × 10 ⁻⁵ inch	0 to 35999999 × 10 ⁻⁵ degree	-2147483648 to 2147483647 pulse	2147483647			
	Pr. 13 Software stroke limit lower limit value					-2147483648			
	Pr. 14 Software stroke limit selection	0: Multiply current feed value by software stroke limit 1: Multiply machine feed value by software stroke limit				0			
	Pr. 15 Software stroke limit enable/disable setting	0: JOG operation, inching operation, software stroke limit is enabled at manual pulse generator operation 1: JOG operation, inching operation, software stroke limit is disabled at manual pulse generator operation				0			
	Pr. 16 Command in-position range	1 to 2147483647 × 10 ⁻¹ μm	1 to 2147483647 × 10 ⁻⁵ inch	1 to 2147483647 × 10 ⁻⁵ degree	1 to 2147483647 pulse	100			
	Pr. 17 Torque limit setting value	1% to 500%				300			
	Pr. 18 M-code ON signal output timing	0: WITH mode		1: AFTER mode		0			
	Pr. 19 Speed switchover mode	0: Standard speed switchover mode		1: Acceleration speed switchover mode		0			
	Pr. 20 Interpolation speed specifying	0: Composite speed		1: Reference axis speed		0			
	Pr. 21 Current feed value at speed control	0: Do not replace the current feed value at speed control 1: Replace the current feed value at speed control 2: Clear the current feed value to 0 at speed control				0			
	Pr. 22 Input signal logic selection	b0	Lower limit	b3	Stop signal	b6	Proximity	Each bit value is as follows. 0: Negative logic 1: Positive logic (Set unused bits to 0)	0
		b1	Upper limit	b4	External command	b7, b9 to b15	not used		
		b2	Drive unit ready	b5	Zero-point signal	b8	Manual pulse generator input		
	Pr. 23 Output signal logic selection	b0	Command pulse signal	b2	not used	b4	Deviation counter clear	0	
b1		not used	b3	not used	b5 to b15	not used			
Pr. 24 Manual pulse generator input selection	0: Phase A and B multiplication by 4 1: Phase A and B multiplication by 2 2: Phase A and B multiplication by 1 3: PULSE/SIGN mode				0				
Pr. 150 Speed/position function selection	0: Speed/position switching control of INC mode 2: Speed/position switching control of ABS mode				0				

3. Positioning Controller

Item	Setting range				Initial value	
	mm	inch	degree	pulse		
Detailed parameter 2	Pr. 25	Acceleration time 1				1000
	Pr. 26	Acceleration time 2				1000
	Pr. 27	Acceleration time 3				1000
	Pr. 28	Deceleration time 1				1000
	Pr. 29	Deceleration time 2				1000
	Pr. 30	Deceleration time 3				1000
	Pr. 31	1 to 2000000000 × 10 ² mm/min	1 to 2000000000 × 10 ³ inch/min	1 to 2000000000 × 10 ³ degree/min	1 to 4000000 pulses	20000
	Pr. 32	JOG operation acceleration time selection				0
	Pr. 33	JOG operation deceleration time selection				0
	Pr. 34	Acceleration/deceleration processing selection 0: Automatic trapezoid acceleration/deceleration processing 1: S-curve acceleration/deceleration processing				0
	Pr. 35	S-curve ratio				100
	Pr. 36	Sudden stop deceleration time				1000
	Pr. 37	Stop group 1 sudden stop selection				0
	Pr. 38	Stop group 2 sudden stop selection				0
	Pr. 39	Stop group 3 sudden stop selection				0
Pr. 40	Positioning complete signal output time				300	
Pr. 41	0 to 100000 × 10 ¹ μm	0 to 100000 × 10 ⁵ inch	0 to 100000 × 10 ⁵ degree	0 to 100000 pulse	100	
Pr. 42	External command function selection 0: External positioning start 2: Speed/position/position-speed control switching request 1: External speed change request 3: Skip request				0	

3.3.2 Home Position Return Basic Parameters/Home Position Return Detailed Parameters

Item	Setting range				Initial value	
	mm	inch	degree	pulse		
Home position return basic parameter	Pr. 43	Home position return types 0: Proximity dog method 1: Stopper (1) (By reaching the setting value of the dwell time) 2: Stopper (2) (By zero-point signal when reaching the stopper) 3: Stopper (3) (Method without proximity dog) 4: Count method (1) (Use zero-point signal) 5: Count method (2) (Do not use zero-point signal)				0
	Pr. 44	Home position return direction 0: Positive direction (address increasing direction) 1: Negative direction (address decreasing direction)				0
	Pr. 45	-2147483648 to 2147483647 × 10 ¹ μm	-2147483648 to 2147483647 × 10 ⁵ inch	0 to 35999999 × 10 ⁵ degree	-2147483648 to 2147483647 pulses	0
	Pr. 46	Home position return speed				1
	Pr. 47	Creep speed				1
	Pr. 48	Home position return retry 0: Do not retry home position return with upper/lower limit switch 1: Retry home position return with upper/lower limit switch				0
Home position return detailed parameter	Pr. 49	Home position return dwell time				0
	Pr. 50	0 to 2147483647 × 10 ¹ μm	0 to 2147483647 × 10 ⁵ inch	0 to 2147483647 × 10 ⁵ degree	0 to 2147483647 pulse	0
	Pr. 51	Home position return acceleration time selection				0
	Pr. 52	Home position return deceleration time selection				0
	Pr. 53	-2147483648 to 2147483647 × 10 ¹ μm	-2147483648 to 2147483647 × 10 ⁵ inch	0 to 35999999 × 10 ⁵ degree	-2147483648 to 2147483647 pulse	0
	Pr. 54	Home position return torque limit				300
	Pr. 55	Deviation counter clear signal output time				11
	Pr. 56	Speed specification at home position shift time 0: Home position return speed 1: Creep speed				0
Pr. 57	Dwell time at home position return retry				0	

3. Positioning Controller

3.3.3 Positioning Data

Item	Unit	Setting range				Initial value																																																																																																												
		mm	inch	degree	pulse																																																																																																													
Operation pattern		Exit (00): Positioning exit (Stop) Continuous (01): Continuous positioning control (Start following positioning data numbers) Locus (11): Continuous path control (Run to the end point address of the following positioning data numbers without stopping)				Exit																																																																																																												
Control method		<table border="1"> <thead> <tr> <th>Peripheral equipment display</th> <th>Setup contents</th> <th>Code number</th> </tr> </thead> <tbody> <tr><td>1: ABS linear 1</td><td>Linear control of 1 axis (ABS)</td><td>01H</td></tr> <tr><td>2: INC linear 1</td><td>Linear control of 1 axis (INC)</td><td>02H</td></tr> <tr><td>3: Fixed feed 1</td><td>Fixed feed control of 1 axis</td><td>03H</td></tr> <tr><td>4: Forward rotation, speed 1</td><td>Speed control of 1 axis (forward rotation)</td><td>04H</td></tr> <tr><td>5: Reverse rotation, speed 1</td><td>Speed control of 1 axis (reverse rotation)</td><td>05H</td></tr> <tr><td>6: Forward rotation, speed/position</td><td>Speed/position switching control (reverse run)</td><td>06H</td></tr> <tr><td>7: Reverse rotation, speed/position</td><td>Speed/position switching control (forward run)</td><td>07H</td></tr> <tr><td>8: Forward rotation, position/speed</td><td>Position/speed switching control (forward rotation)</td><td>08H</td></tr> <tr><td>9: Reverse rotation Position/speed</td><td>Position/speed switching control (reverse rotation)</td><td>09H</td></tr> <tr><td>A: ABS linear 2</td><td>Linear interpolation control of 2 axes (ABS)</td><td>0AH</td></tr> <tr><td>B: INC linear 2</td><td>Linear interpolation control of 2 axes (INC)</td><td>0BH</td></tr> <tr><td>C: Fixed feed 2</td><td>Fixed feed control by linear interpolation of 2 axes</td><td>0 CH</td></tr> <tr><td>D: ABS circular interpolation</td><td>Auxiliary point specified circular interpolation control (ABS)</td><td>0DH</td></tr> <tr><td>E: INC circular interpolation</td><td>Auxiliary point specified circular interpolation control (INC)</td><td>0EH</td></tr> <tr><td>F: ABS circular arc right</td><td>Center point specified circular interpolation control (ABS, CW)</td><td>0FH</td></tr> <tr><td>G: ABS circular arc left</td><td>Center point specified circular interpolation control (ABS, CCW)</td><td>10H</td></tr> <tr><td>H: INC circular arc right</td><td>Center 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interpolation control of 4 axes (ABS)</td><td>1AH</td></tr> <tr><td>R: INC linear 4</td><td>Linear interpolation control of 4 axes (INC)</td><td>1BH</td></tr> <tr><td>S: Fixed feed 4</td><td>Fixed feed control by linear interpolation of 4 axes</td><td>1 CH</td></tr> <tr><td>T: Forward rotation, speed 4</td><td>Speed control of 4 axes (forward rotation)</td><td>1DH</td></tr> <tr><td>U: Reverse rotation, speed 4</td><td>Speed control of 4 axes (reverse rotation)</td><td>1EH</td></tr> <tr><td>V: NOP</td><td>NOP instruction</td><td>80H</td></tr> <tr><td>W: Present value change</td><td>present value change</td><td>81H</td></tr> <tr><td>X: JUMP instruction</td><td>JUMP instruction</td><td>82H</td></tr> <tr><td>Y: LOOP</td><td>LOOP to LEND start</td><td>83H</td></tr> <tr><td>Z: LEND</td><td>LOOP to LEND end</td><td>84H</td></tr> </tbody> </table>				Peripheral equipment display	Setup contents	Code number	1: ABS linear 1	Linear control of 1 axis (ABS)	01H	2: INC linear 1	Linear control of 1 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Fixed feed 4	Fixed feed control by linear interpolation of 4 axes	1 CH	T: Forward rotation, speed 4	Speed control of 4 axes (forward rotation)	1DH	U: Reverse rotation, speed 4	Speed control of 4 axes (reverse rotation)	1EH	V: NOP	NOP instruction	80H	W: Present value change	present value change	81H	X: JUMP instruction	JUMP instruction	82H	Y: LOOP	LOOP to LEND start	83H	Z: LEND	LOOP to LEND end	84H	-
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Y: LOOP	LOOP to LEND start	83H																																																																																																																
Z: LEND	LOOP to LEND end	84H																																																																																																																
Acceleration time No.		0 to 3 (Select 0 to 3 for the acceleration time from basic parameter 2 and detailed parameter 2)				0																																																																																																												
Deceleration time No.		0 to 3 (Select 0 to 3 for the deceleration time from basic parameter 2 and detailed parameter 2)				0																																																																																																												

3. Positioning Controller

Item	Unit	Setting range				Initial value
		mm	inch	degree	pulse	
Interpolation target axis		0 to 3 (Set "Interpolation target axis" (partner axis) when performing interpolation operation of 2 axes) 0: Keep axis 1 as interpolation target axis (partner axis) 1: Keep axis 2 as interpolation target axis (partner axis) 2: Keep axis 3 as interpolation target axis (partner axis) 3: Keep axis 4 as interpolation target axis (partner axis)				0
Positioning address / travel distance	Absolute (ABS) present value change	-214748364.8 to 214748364.7 μm	-21474.83648 to 21474.83647 inch	0 to 359.99999 degrees	-2147483648 to 2147483647 pulses	0
	Increment (INC) fixed feed	-214748364.8 to 214748364.7 μm	-21474.83648 to 21474.83647 inch	-21474.83648 to 21474.83647 degrees	-2147483648 to 2147483647 pulses	0
	Speed/position, position/speed switching control	0 to 214748364.7 μm	0 to 21474.83647 inches	0 to 21474.83647 degree (Note)	0 to 2147483647 pulses	0
Circular address (Auxiliary point or center point)		-214748364.8 to 214748364.7 μm	-21474.83648 to 21474.83647 inch	-	-2147483648 to 2147483647 pulses	0
speed command		0.01 to 20000000.00 mm/min	0.001 to 2000000.000 inches/min	0.001 to 2000000.000 degrees/min	1 to 4000000 pulses/s	0
		Same speed as positioning data before -1 (current speed)				
Dwell time	Except JUMP instruction	After 0 to 65535 ms (dwell time) has passed, the positioning completed signal is turned ON.				0
	JUMP instruction	1 to 600 (positioning data No. before jump)				
M code	JUMP instruction, excluding LOOP	0 to 65535 (M code)				0
	JUMP instruction	0 to 10 (condition data No.) 0: Jump without conditions 1 to 10: Jump by satisfying conditions				
	LOOP	0 to 65535 (number of repeats)				

Note: For speed-position switching control in the ABS mode, set an address of 0 to 359.99999.

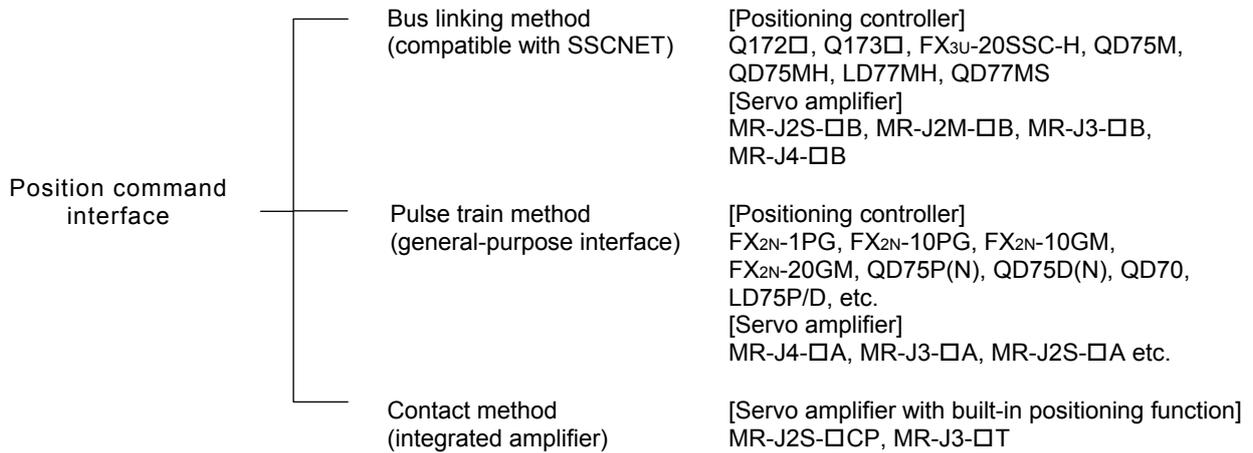
Positioning data setting example

Data No.	Operation pattern	Control method	Acceleration time [ms]	Deceleration time [ms]	Interpolation target axis	Positioning address / travel distance [μm]	Circular address	Command speed [mm/min]	dwell time [ms]	M code
1	0: Exit	1: ABS linear 1	0: 100	0: 100	-	50000.0	0.0	2000.00	0	0
2	0: Exit	1: ABS linear 1	0: 100	0: 100	-	75000.0	0.0	2000.00	0	0
3	0: Exit	1: ABS linear 1	0: 100	0: 100	-	100000.0	0.0	2000.00	0	0
4	0: Exit	1: ABS linear 1	0: 100	0: 100	-	150000.0	0.0	2000.00	0	0
5	0: Exit	1: ABS linear 1	0: 100	0: 100	-	200000.0	0.0	2000.00	0	0
6	0: Exit	1: ABS linear 1	0: 100	0: 100	-	25000.0	0.0	2000.00	0	0
7	0: Exit	0: Not specified	0: 100	0: 100	-	0.0	0.0	0.00	0	0
8	0: Exit	0: Not specified	0: 100	0: 100	-	0.0	0.0	0.00	0	0
9	0: Exit	0: Not specified	0: 100	0: 100	-	0.0	0.0	0.00	0	0
10	0: Exit	0: Not specified	0: 100	0: 100	-	0.0	0.0	0.00	0	0

3.4 Position Command Interface

In the past, a pulse train was generally output as a position command from the positioning controller to the servo amplifier. Recently, however, with the conversion into software and digitization of each module by micro processors (CPUs), a new method to link bus lines with CPUs for positioning controllers and servo amplifiers has also emerged. Thus, it has become possible to construct advanced systems with increased accuracy.

Also, in the pulse train method, there are several types of interfaces. A summary with the applicable models and respective characteristics is shown below.



[Types of pulse train interfaces]

(1) Forward/reverse rotation pulse train method and pulse train/direction identification signal method

To specify the rotation direction of a motor for the pulse train, one method is to input from different terminals according to the rotation direction, and another is a switching method according to the rotation direction identification signal.

Also, there is a 2-phase pulse train method for input of the pulse train directly from the synchronous encoder.

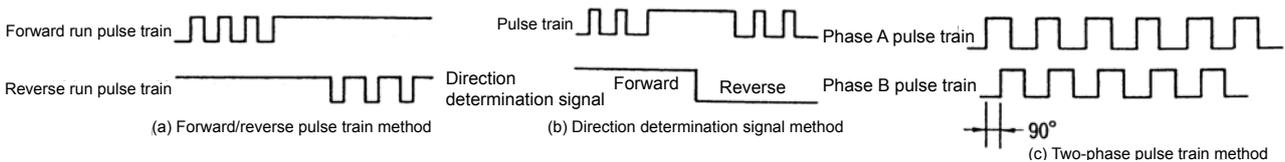


Figure 3.4 Rotation direction command method

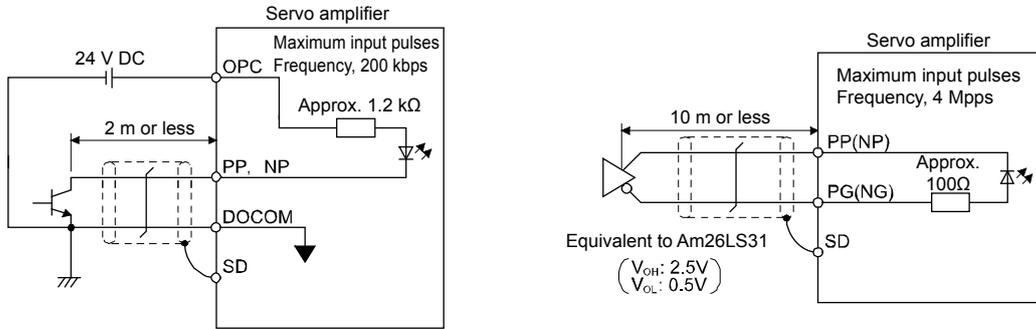
3. Positioning Controller

(2) Open collector output type and differential driver output type

These are the 2 types of interface hardware. A simple open collector output type was the standard, but the differential driver output type is increasingly used these days due to high-speed pulse trains and the improvement of noise resistance.

Mitsubishi's QD75D is a differential driver output type, and the QD75P is an open collector output type.

[Hardware configuration example]



(a) Open collector output type (Max. 200 kpps)

(b) Differential driver output type (Max. 4 Mpps)

Figure 3.5 Example of pulse train hardware

[Pulse train form]



(a) Open-collector type

(b) Differential driver

Figure 3.6 Pulse train form

3.5 Fundamentals of Positioning Control with the Positioning Controller

3.5.1 Travel Direction of Machine and Rotation Direction of Servo Motor

Counterclockwise rotation direction of the servo motor is considered forward rotation when viewed from the load side.

Also, the positive direction of machine travel is generally the direction with increasing coordinates.

When it becomes necessary to change the rotation direction of the servo motor so as to match the travel direction of the machine and the rotation direction of servo motor, change the rotation direction setting using the positioning controller parameters. Normal operation cannot be performed if there is a change in the rotation direction due to a change in the servo motor side phase. Therefore, do not change it.

The method of changing this rotation direction is the same even if the positioning controller model is different.

In addition, check the rotation direction using a function like the JOG operation mode.

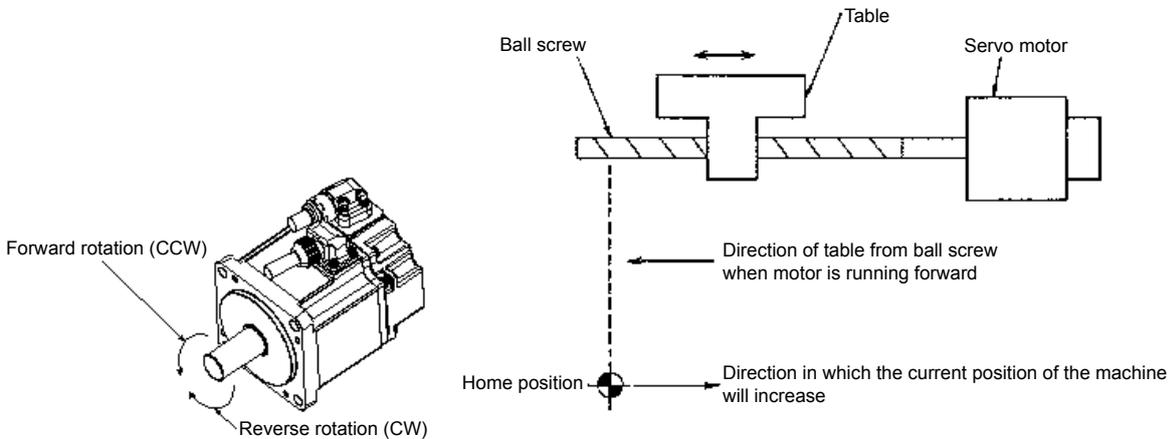


Figure 3.7 Servo motor rotation direction

Figure 3.8 Rotation direction setting example

For the model shown in Figure 3.8, the servo motor moves in the forward rotation in the direction in which the coordinates are decreased for the machine (negative direction). Therefore, in this case, set the rotation direction of the servo motor as reverse rotation in the positioning controller.

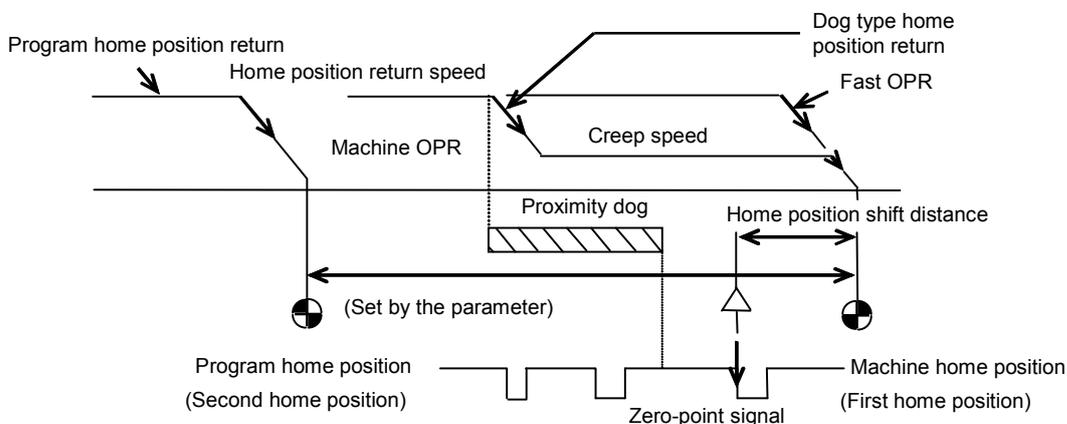
POINT
<ul style="list-style-type: none"> • Forward rotation CCW: Abbreviation of counterclockwise Reverse rotation CW: Abbreviation of clockwise

3.5.2 Types of Home Position Return

1) Types of home position return

	Types of home position return	Types of home position	Operation description
Manual/auto home position	Proximity dog type home position return	Machine home position (First home position)	The creep speed decelerates according to the proximity dog signal OFF→ON, the output pulses are stopped by the zero-point signal from the servo amplifier after the proximity dog ON→OFF, and a clear signal is output. Then, the droop pulses of the deviation counter become zero, and the home position return is completed.
	Fast OPR	Machine home position (First home position)	Returning to the machine home position only using the home position return speed (high-speed) and without using the creep speed is called home position return. Initially, it is necessary to fix the machine home position with the dog type home position return.
Auto home position return	Program home position return	Program home position (Second home position)	Returning to the program home position (standby position) set by the parameters using the home position return speed is called home position return.

Dog type home position return, fast home position return, and program home position return operations



3. Positioning Controller

2) Types of home position return method

The following are the four types of home position return methods.

Home position return method		Example of home position return operation pattern	
Near-point dog signal method home position return	Operation	<p>The creep speed decelerates according to the proximity dog signal OFF→ON, the output pulses are stopped by the zero-point signal from the servo amplifier after the proximity dog ON→OFF, and a clear signal is output. Then, the droop pulses of the deviation counter become zero, and the home position return is completed.</p>	<p>Applicable models: QD75, Motion Series</p>
	Characteristics	<p>Although caution is required when determining the dog length or the mounting position, some good points include good accuracy with repetitive home position returns and no strain on the machine.</p>	
Near-point dog signal method home position return (2)	Operation	<p>When the proximity dog signal is turned ON, the creep speed decelerates along with the start of the counting zero-point signal. When the zero-point signal reaches the set number of times, pulse train signal output is stopped immediately and a clear signal is output to the servo amplifier. The servo motor is then stopped and the home position is set.</p>	<p>Applicable models: FX Series</p>
	Characteristics	<p>Caution is not really required when determining the dog length or the mounting position. However, variations may occur in the counting start timing due to either the accuracy of repetitive operation of the switch for the detecting dog or the home position return speed. This affects the accuracy of repetitive home position returns. Therefore, caution must be taken.</p>	
Count method home position return	Operation	<p>When the proximity dog signal is turned ON, creep speed decelerates due to the home position return speed. It is also possible to start home position return after turning ON the proximity dog signal and continuous home position return. When the first zero-point signal is detected after moving the travel distance specified by the proximity dog signal ON, pulse signal output is stopped immediately and a clear signal is output to the servo amplifier. Then, the servo motor is stopped and the home position is set.</p>	<p>Applicable models: QD75, Motion Series</p>
	Characteristics	<p>Caution is not really required when determining the dog length or the mounting position. However, variations may occur in the counting start timing due to either the accuracy of repetitive operation of the switch for the detecting dog or the home position return speed. This affects the accuracy of repetitive home position returns. Therefore, caution must be taken.</p>	

3. Positioning Controller

		Home position return method	Example of home position return operation pattern
Count method home position return	Count method home position return (2)	<p>Operation</p> <p>When the proximity dog signal is turned ON, creep speed decelerates due to the home position return speed. It is also possible to start home position return after turning ON the proximity dog signal and continuous home position return. After moving the travel distance specified by the proximity dog signal ON, pulse signal output is stopped immediately and a clear signal is output to the servo amplifier. Then, the servo motor is stopped and the home position is set.</p> <p>Characteristics</p> <p>Caution is not really required when determining the dog length or the mounting position. However, variations may occur in the counting start timing due to either the accuracy of repetitive operation of the switch for the detecting dog or the home position return speed. This affects the accuracy of repetitive home position returns. Therefore, caution must be taken.</p> <p>Errors up to 1 ms will occur.</p>	<p>Applicable models: QD75, Motion Series</p>
	Stopper method home position return (1)	<p>Operation</p> <p>When the proximity dog signal is turned ON, the creep speed decelerates due to the home position return speed along with the start of counting the elapsed time. The machine is stopped after striking the stopper, and after the set time (dwell time) has passed, pulse train signal output is stopped and a clear signal is output to the servo amplifier. Then, the servo motor is stopped and the home position is set. Even if the dog signal is turned OFF in progress, home position return is not completed until the set time (dwell time) has passed.</p> <p>Characteristics</p> <p>Caution is required when determining the dog length, creep speed and set time (dwell time). Keep the creep speed sufficiently low in order to reduce the impact when striking the stopper, and the strength of the stopper or machine applying the torque limit must be considered. Set the set time (dwell time) by adding the time to operate overload protection of the servo amplifier to the time until the machine reaches stopper. In addition, distortion occurs as the machine stops after striking the stopper, which affects the accuracy of repetitive home position returns. Therefore, caution must be taken.</p>	<p>Applicable models: QD75 Series</p>
Stopper home position return	Stopper method home position return (2)	<p>Operation</p> <p>When the proximity dog signal is turned ON, the creep speed decelerates and moves further. The machine is stopped after striking the stopper and reaching the torque limit value set by servo amplifier. The pulse output from the controller is then stopped by the zero-point signal due to the signal (limiting torque) confirming the stop status, and then the home position return is completed.</p> <p>Characteristics</p> <p>Caution must be taken similar to home position return by the stopper method (1). Even if the dog signal is turned OFF in progress, home position return is not completed unless the abovementioned torque limit signal is input. Torque limit can be applied in 2 ways: by configuring the settings in the QD75 and by giving analog commands directly to the servo amplifier.</p>	<p>Applicable models: QD75 Series</p>

3. Positioning Controller

Home position return method		Example of home position return operation pattern
Stopper home position return	Stopper method home position return (3)	<p>(Machine home position)</p>
	<p>Operation</p> <p>Movement is done by the creep speed from the start of the home position return, and the machine is stopped by striking the stopper. Pulse output from the controller is stopped by a zero-point signal (signal confirming stop status), a clear signal is output to the servo amplifier, and then the home position return is completed.</p> <p>Characteristics</p> <p>Caution must be taken similar to home position return by the stopper method (2). A proximity dog signal is not required. The deceleration distance to the creep speed can be used even without enough being provided.</p>	
Applicable models: QD75, Motion Series		
Data set method home position return	<p>Operation</p> <p>This home position return method can be executed for absolute position detection systems. Move the machine to any position using JOG operation, and set that position as the home position by executing a home position return. (Motor does not operate)</p> <p>Characteristics</p> <p>After power-on, it is necessary to pass the zero-point before executing a home position return. In the current value display upon power supply OFF and ON, a max. of approximately 1% errors occur due to motor rotation. The home position reply data used for home position returns are nothing but the selection of the home position return method and the setting of the home position address.</p>	<p>(Machine home position)</p>
	Applicable models: QD75 (SSCNET-compatible), Motion Series	

Memo

4. Functions and Operations of MELSERVO-J4

This section describes the MR-J4 servo amplifier (pulse train method).

4.1 Function List

This section describes the MR-J4 function list.

Function	Description
Position control mode	Used as a position control servo.
Speed control mode	Used as a speed control servo.
Torque control mode	Used as a torque control servo.
Position/speed control change mode	Using an input device, control can be switched between position control and speed control.
Speed/torque control change mode	Using an input device, control can be switched between speed control and torque control.
Torque/position control change mode	Using an input device, control can be switched between torque control and position control.
High-resolution encoder	High-resolution encoder of 4194304 pulses/rev is used as the encoder of the rotary servo motor compatible with the MELSERVO-J4 series.
Absolute position detection system	Merely setting a home position once makes home position return unnecessary at every power-on.
Gain switching function	You can switch gains during rotation and during stop, and can use an input device to switch gains during operation.
Advanced vibration suppression control II	This function suppresses vibration at the arm end or residual vibration.
Adaptive filter II	Servo amplifier detects mechanical resonance and sets filter characteristics automatically to suppress mechanical vibration.
Low-pass filter	Suppresses high-frequency resonance which occurs as servo system response is increased.
Machine analyzer function	Analyzes the frequency characteristic of the mechanical system by simply connecting an MR Configurator2 installed personal computer and servo amplifier. MR Configurator2 is necessary for this function.
Robust filter	This function provides better disturbance response in case low response level that load to motor inertia ratio is high for such as roll send axis.
Slight vibration suppression control	Suppresses vibration of ± 1 pulse produced at a servo motor stop.
Electronic gear	Input pulses can be multiplied by 1/10 to 4000.
S-pattern acceleration/ deceleration time constant	Speed can be increased and decreased smoothly.
Auto tuning	Automatically adjusts the gain to optimum value if load applied to the servo motor shaft varies.
Brake unit	Used when the regenerative option cannot provide enough regenerative power. Can be used for the 5 kW or more servo amplifier.
Power regeneration converter	Used when the regenerative option cannot provide enough regenerative power. Can be used for the 5 kW or more servo amplifier.
Regenerative option	Used when the built-in regenerative resistor of the servo amplifier does not have sufficient regenerative capability for the large regenerative power generated.
Alarm history clear	Alarm history is cleared.
Input signal selection (device settings)	ST1 (Forward rotation start), ST2 (Reverse rotation start), and SON (Servo-on) and other input device can be assigned to any pins.
Output signal selection (device settings)	The output devices including MBR (Electromagnetic brake interlock) can be assigned to certain pins of the CN1 connector.
Output signal (DO) forced output	Output signal can be forced on/off independently of the servo status. Use this function for checking output signal wiring, etc.
Restart after instantaneous power failure	If the input power supply voltage had reduced to cause an alarm but has returned to normal, the servo motor can be restarted by merely switching on the start signal. (available in the future)
Command pulse selection	Command pulse train form can be selected from among three different types.
Torque limit	Servo motor torque can be limited to any value.
Speed limit	Servo motor speed can be limited to any value.
Status display	Servo status is shown on the 5-digit, 7-segment LED display.
External I/O signals display	On/off statuses of external I/O signals are shown on the display.
Automatic VC offset	Voltage is automatically offset to stop the servo motor if it does not come to a stop when VC (Analog speed command) or VLA (Analog speed limit) is 0 V.
Alarm code output	If an alarm has occurred, the corresponding alarm number is outputted in 3-bit code.
Test operation mode	Jog operation, positioning operation, motor-less operation, DO forced output, and program operation MR Configurator2 is required to perform positioning operation or program operation.
Analog monitor output	Servo status is output in terms of voltage in real time.
MR Configurator2	Using a personal computer, you can perform the parameter setting, test operation, monitoring, and others.

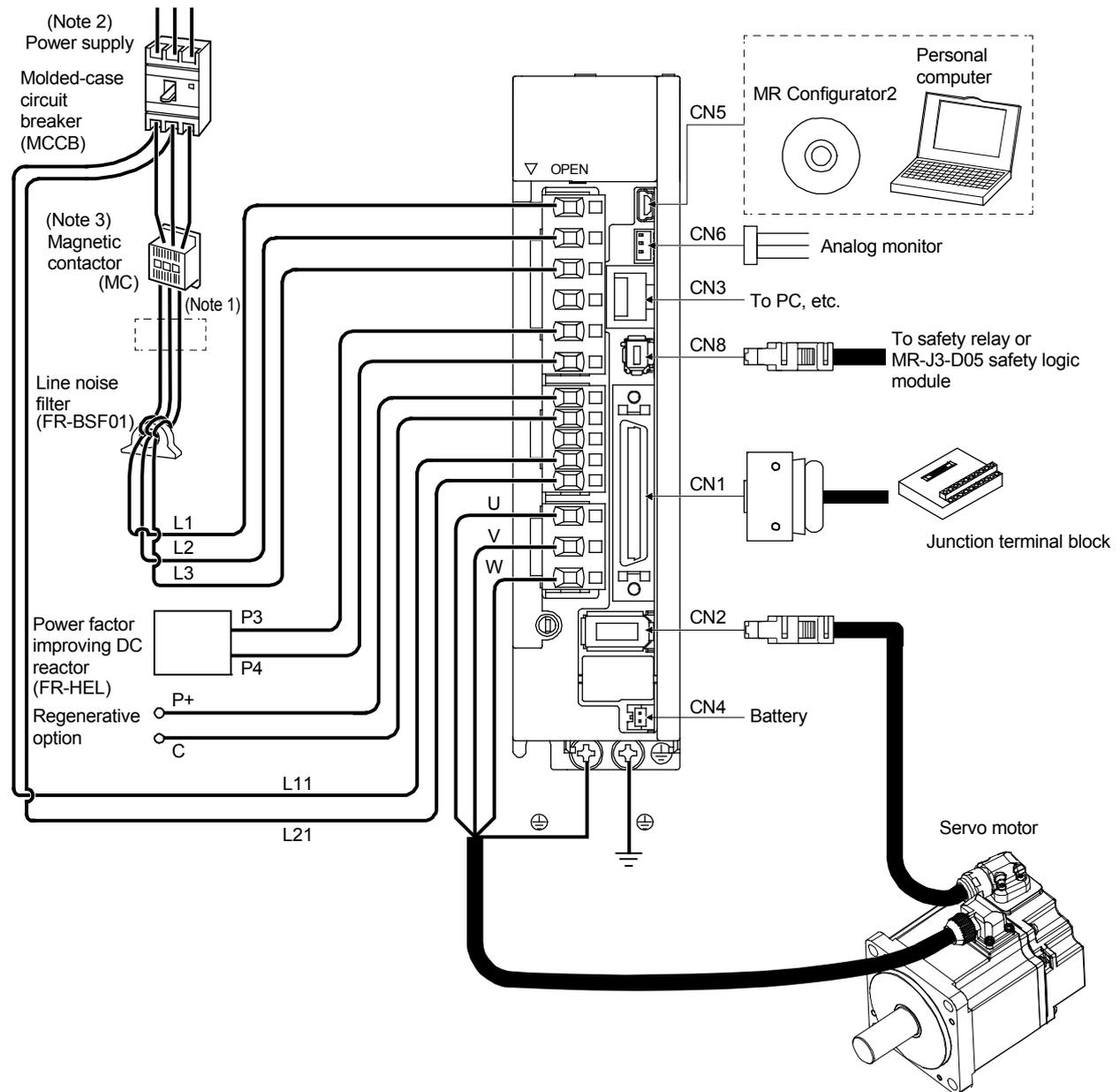
4. Functions and Operations of MELSERVO-J4

Function	Description
One-touch tuning	Gain adjustment is performed just by one click on a certain button on MR Configurator2 or operation section.
Tough drive function	This function makes the equipment continue operating even under the condition that an alarm occurs. The tough drive function includes two types: the vibration tough drive and the instantaneous power failure tough drive.
Drive recorder function	This function continuously monitors the servo status and records the status transition before and after an alarm for a fixed period of time. You can check the recorded data on the drive recorder window on MR Configurator2 by clicking the "Graph" button. However, the drive recorder will not operate on the following conditions. 1. You are using the graph function of MR Configurator2. 2. You are using the machine analyzer function. 3. [Pr. PF21] is set to "-1".
STO function	This function is a functional safety that complies with IEC/EN 61800-5-2. You can create a safety system for the equipment easily.
Servo amplifier life diagnosis function	You can check the cumulative energization time and the number of on/off times of the inrush relay. This function gives an indication of the replacement time for parts of the servo amplifier including a capacitor and a relay before they malfunction. MR Configurator2 is necessary for this function.
Power monitoring function	This function calculates the power running energy and the regenerative power from the data in the servo amplifier such as speed and current. Power consumption and others are displayed on MR Configurator2.
Machine diagnosis function	From the data in the servo amplifier, this function estimates the friction and vibrational component of the drive system in the equipment and recognizes an error in the machine parts, including a ball screw and bearing. MR Configurator2 is necessary for this function.

4.2 Configuration with Peripheral Equipment

In the MR-J4 series servo amplifier, all operations such as connections with external devices, monitoring/diagnostics, and parameter settings can be performed from the front side of the amplifier as shown in the figure below. As such, these operations can be easily performed even when mounted in a board.

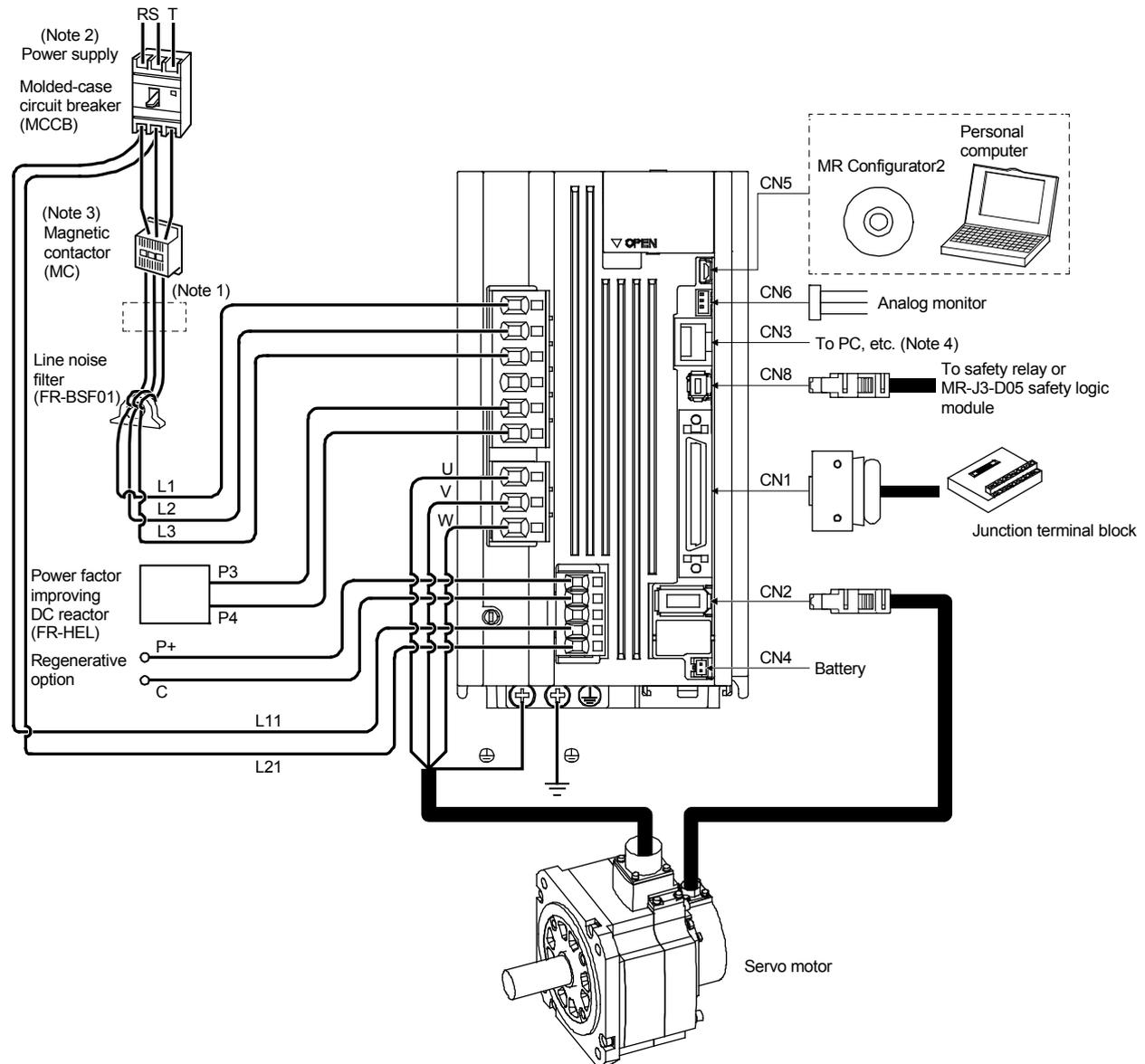
(1) MR-J4-200A or lower



- Note 1: The power factor improving AC reactor can also be used. In this case, the power factor improving DC reactor cannot be used. Short P3 and P4 when not using the power factor improving DC reactor.
2. Single-phase 200 V AC to 240 V AC corresponds to MR-J4-70A or lower. With single-phase 200 V AC to 240 V AC, connect the power supply to L1 and L3, and leave L2 open.
 3. Bus voltage decreases according to the voltage and operation pattern of the main circuit, and there may be a shift in dynamic brake deceleration during forced stop deceleration. If dynamic brake deceleration is not desired, delay the time to turn off the electromagnetic contactor.

4. Functions and Operations of MELSERVO-J4

(2) MR-J4-350A (example)



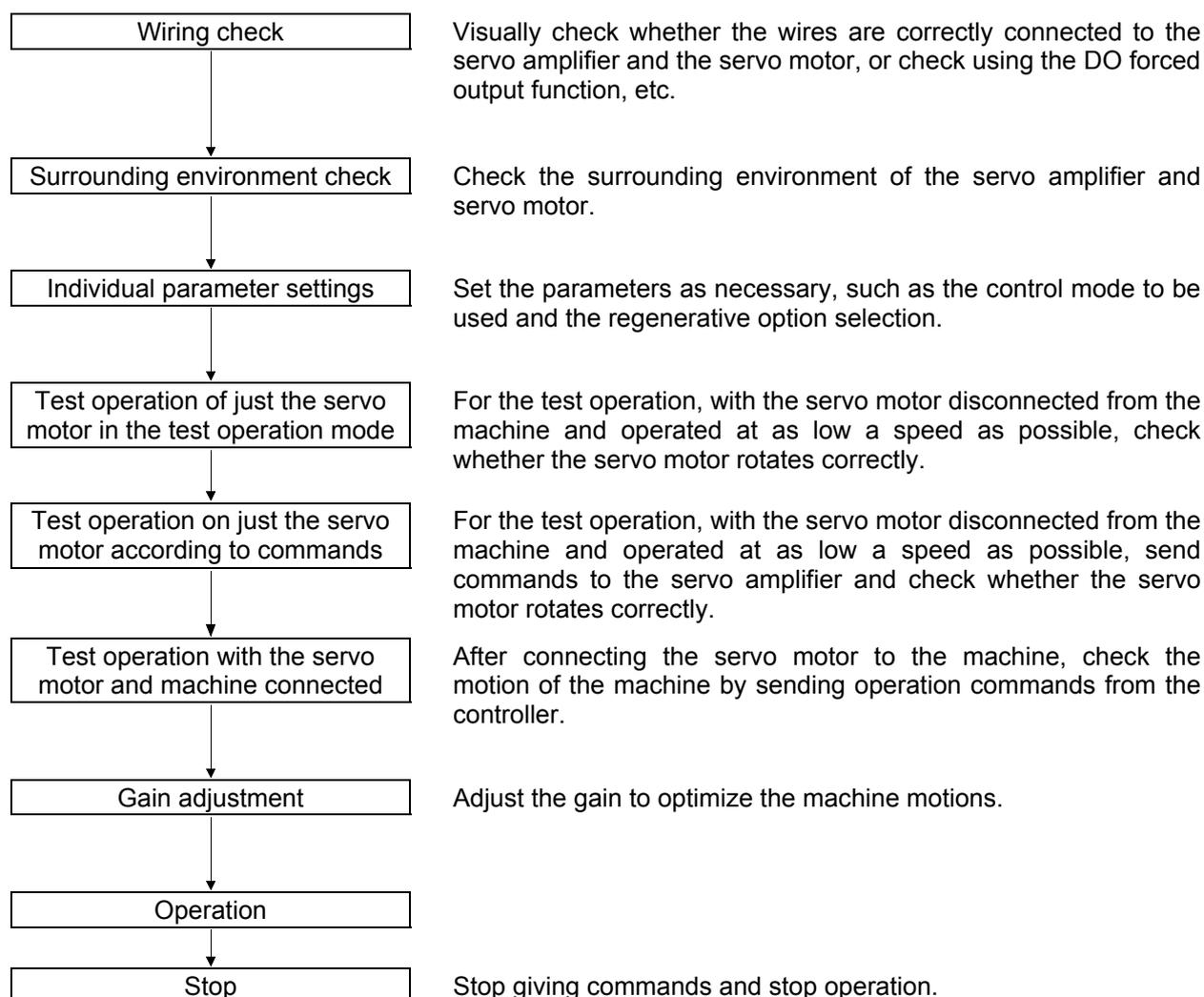
- Note 1: The power factor improving AC reactor can also be used. In this case, the power factor improving DC reactor cannot be used. Short P3 and P4 when not using the power factor improving DC reactor.
- For power supply specifications, refer to the MR-J4-□ servo amplifier instruction manual.
 - Bus voltage decreases according to the voltage and operation pattern of the main circuit, and there may be a shift in dynamic brake deceleration during forced stop deceleration. If dynamic brake deceleration is not desired, delay the time to turn off the electromagnetic contactor.
 - The RS-422 communication function is compatible with Ver.A3 and later.

4.3 Operation after Installation

 WARNING	<ul style="list-style-type: none"> Do not operate the switches with wet hands. Doing so may cause an electric shock.
--	---

 CAUTION	<ul style="list-style-type: none"> Check the parameters before starting operation. Failure to do so may cause some machines to operate unexpectedly. Since the radiator, regenerative resistor, servo motor, or other parts of the servo amplifier may reach high temperatures for some time during energization or after power-off, perform safety practices such as providing covers so that these parts are not touched or do not come into contact with other parts (cables, etc.) by mistake. Failure to do so may cause burn injuries or damage to parts. Never touch the servo motor rotor while operating. Doing so may cause injury.
--	--

4.3.1 Startup Procedure



4.3.2 Installation

 **WARNING**

- Make sure to perform grounding work in order to prevent electric shock.

 **CAUTION**

- Stacking more than the specified number of product packages is not allowed.
- Install with incombustible material. Installing directly or near combustibles may cause a fire.
- Install the servo amplifier and the servo motor in a load-bearing place according to the instruction manual.
- Do not climb on or put heavy loads on the equipment. Doing so may cause injury.
- Use within the range of the specified environment. (Refer to the instruction manual for descriptions on environments.)
- Foreign conductive objects must be prevented from entering the servo amplifier. This includes screws and metal fragments or flammable substances such as oil.
- Do not block the intake and exhaust areas of the servo amplifier. Doing so may cause a malfunction.
- Because the servo amplifier is a precision apparatus, do not drop or subject it to any impact.
- Do not install or operate the servo amplifier if it is damaged or has parts missing.
- Contact Mitsubishi Electric System & Service if the product has been stored for an extended period of time.
- When handling the servo amplifier, be careful of edged parts such as the corners of the servo amplifier.
- The servo amplifier must be installed in a metal cabinet.

POINT

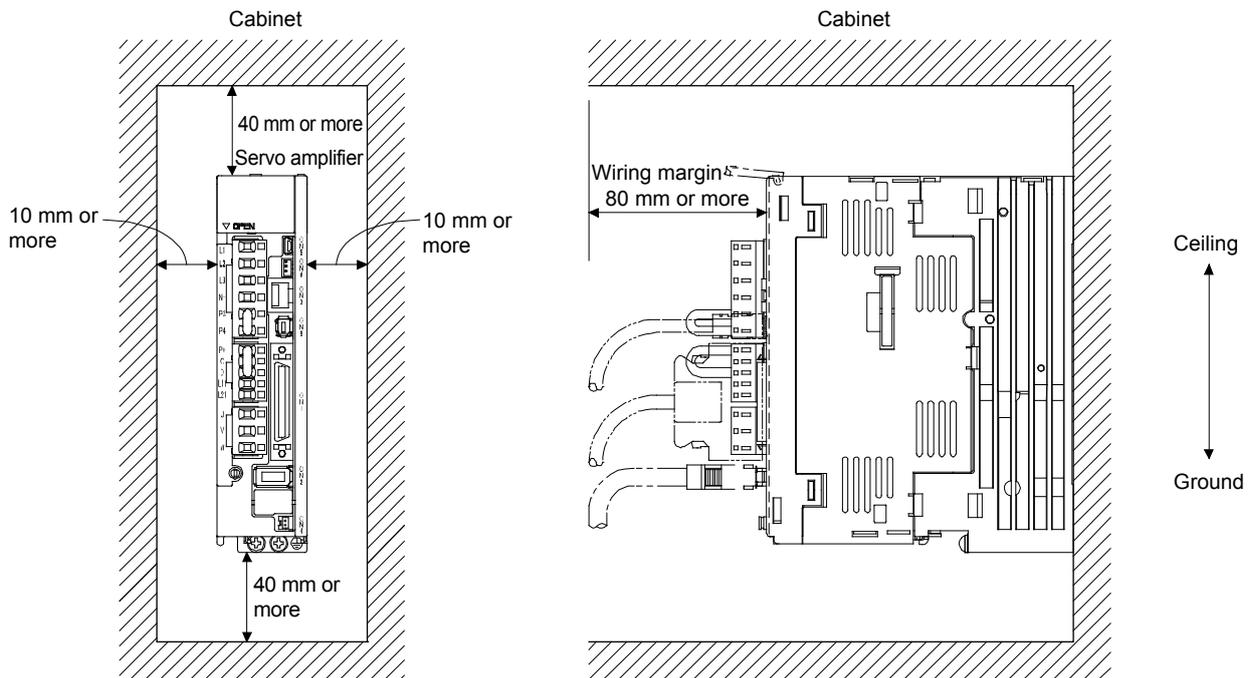
- If the CNP1, CNP2, and CNP3 connectors are unplugged in MR-J4-40A servo amplifiers or lower servo amplifiers, unplug the CN3 and CN8 connectors beforehand.

(1) Mounting direction and distance

 CAUTION

- The mounting direction must be correct. Doing so may cause a malfunction.
- Secure the prescribed distance between the servo amplifier and the inner surface of the cabinet or other devices. Doing so may cause a malfunction.

(a) 7 kW or lower
(1) For single installations

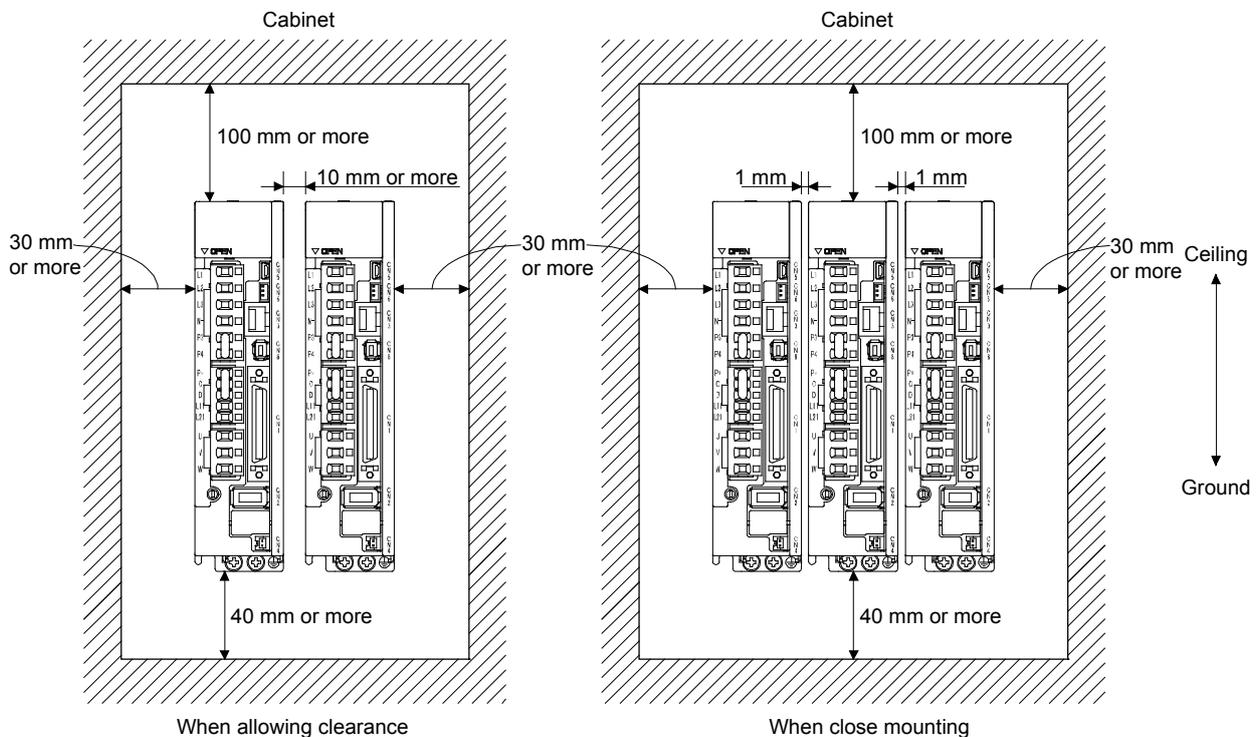


(2) For multiple installations

POINT
<ul style="list-style-type: none"> • Close mounting is possible depending on the servo amplifier. Refer to the instruction manual for advisability regarding close mounting. • Do not place a servo amplifier larger than the depth of the servo amplifier on the left side of the servo amplifier when close mounting because the CNP1, CNP2, and CNP3 connectors will not be detachable.

Significantly increase the distance between the upper surface of the servo amplifier and the inside of the cabinet, and set up a cooling fan to ensure that the internal temperature of the cabinet does not exceed the environment.

When close mounting a servo amplifier, keep a distance of 1 mm from the adjacent servo amplifiers when considering installation allowance. In such cases, maintain an ambient temperature of 0°C to 45°C or use an effective load ratio of 75% or less.



(b) Others

When using equipment that generates heat, such as with regenerative options, set up with sufficient consideration of heat generation so that there is no effect on the servo amplifier. Install the servo amplifier accurately and vertically on a perpendicular wall.

(2) Infiltration of foreign objects

- Ensure that shavings caused by drilling, etc., during cabinet assembly do not enter the servo amplifier.
- Ensure that oil, water, metal powder, etc., from cooling fans set in the ceiling or the inner space of the cabinet does not enter the servo amplifier.
- When setting up the cabinet in places with a lot of corrosive gases and dust, apply air purging (forceful feeding of clean air from outside the cabinet to raise the internal pressure above the external pressure) to ensure that the corrosive gases and dust do not enter the cabinet.

(3) Mounting direction

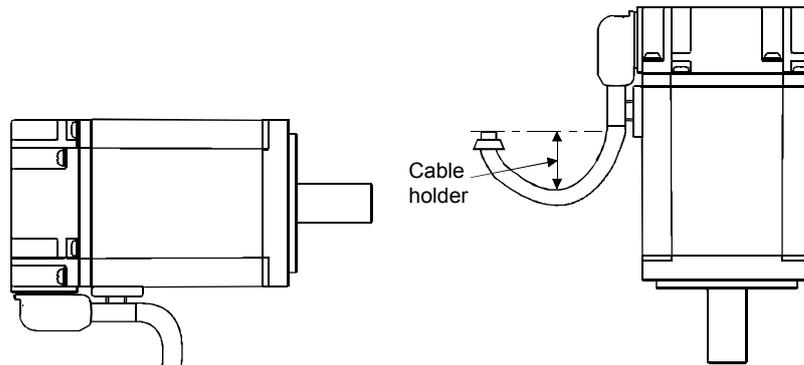
(a) Standard servo motor

The following table shows the mounting direction of a standard servo motor.

Servo motor series	Mounting direction
HG-MR HG-KR HG-SR	Can be installed in all directions

When installing a servo motor horizontally, it is recommended that the connector part face downward.

When installing vertically or diagonally, set up a connection cable and cable holder.



(b) Servo motor with electromagnetic brake

A servo motor with an electromagnetic brake can also be installed in the same direction as a standard servo motor. When installed with the shaft upward, a sliding sound from the brake disk can occasionally be heard, but this is not a malfunction.

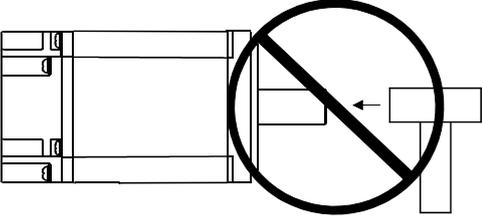
(c) Geared servo motor

The mounting direction of a geared servo motor changes depending on the type of reducer. Make sure to install in the specified direction. For details, refer to the servo motor instruction manual (vol. 3).

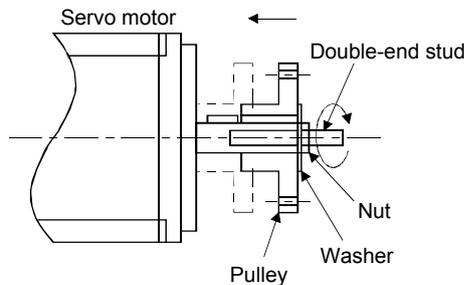
(4) Caution when removing and setting a load

• Absolutely do not strike the shaft end with a hammer, etc., during assembly. Doing so may damage the encoder.

CAUTION



- (a) For servo motors with a key groove, use the screw hole at the end of the shaft to mount the pulley to the shaft. To install, first insert both screw bolts in the screw holes of the shaft, place the washer at the end of coupling, and tighten with a nut.



- (b) For shafts without a key groove, use a friction coupling.
- (c) When extracting the pulley, ensure that there is not excessive load or shock on the shaft and use a pulley remover.
- (d) Set up protective covers, etc., to ensure the safety of rotating parts such as pulleys installed on the shaft.
- (e) When installing a pulley on the shaft, if the shaft end needs to be threaded, place a request with Mitsubishi.
- (f) The direction of the encoder attached to the servo motor cannot be changed.
- (g) When installing the servo motor, tighten sufficiently with a spring washer, etc., so that the bolt does not loosen due to vibration.

(5) Permissible load for the shaft

 **CAUTION**

- Do not use a rigid (solid body) coupling because it will apply an excessive bend load on the shaft and there may be a possibility of bearing deterioration or servo motor axis breakage.

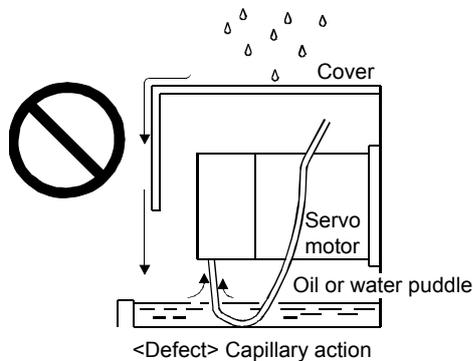
For the permissible load of a shaft specific to the servo motor, refer to the servo motor instruction manual (vol. 3).

- (a) Use a flexible coupling, and ensure that shaft misalignment is less than the permissible radial load of the shaft.
- (b) When using a pulley/sprocket and a timing belt, select ones that can fit in the permissible radial load.
- (c) If the permissible load is exceeded, it may lead to bearing deterioration and shaft damage.
- (d) Loads shown in this section are one-way static loads, and eccentric loads are not included. Eccentric loads should be as small as possible. Otherwise, servo motor damage may occur.

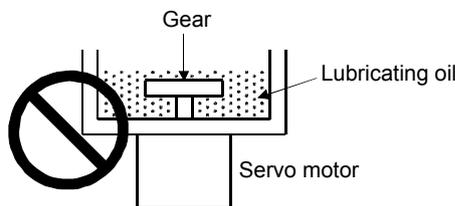
(6) Countermeasures against entry of oil

Ensure that foreign particles such as oil do not mix inside of the servo motor shaft. When installing the servo motor, keep the items in this section in mind.

- (a) Do not use cables soaked in oil.



- (b) For shaft installation, ensure that there is no oil from the load side, gear box, etc.



- (c) With oils such as cutting oil, there may be an influence on seal adhesion, packing, cables, etc., depending on the type of oil.
- (d) Because there may be cases when use cannot be allowed in standard specification servo motors in environments where there is usually oil mist and normal oil, grease, etc., inquire with Mitsubishi.

(7) Cable

Ensure that the cable does not move by fixing the power supply and encoder cable drawn out from the servo motor to the servo motor. Disconnection may occur. Also, do not make alterations to the connector, terminal, etc., at the end of the cable.

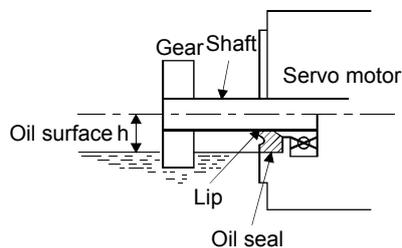
(8) Servo motor with oil seal

For servo motors with an oil seal, oil penetration from outside the oil seal can be prevented. Install appropriately in accordance with this section.

For servo motors with an oil seal, there may be a creaking sound from the oil seal when operating, but this is not a problem with the function.

(a) Pressure/oil level

Install the servo motor horizontally, and ensure that the height (h) of the oil side of the gearbox is always lower than the lip. If the oil side is higher than the oil lip, oil will penetrate inside the servo motor, causing a malfunction.



If pressure on the oil seal is strong, friction will increase and cause the life to decrease. Therefore, set up a suction hole in the gearbox so that the internal pressure of the gearbox does not increase, and ensure that the internal pressure is constant.

(b) Temperature

The life of the oil seal decreases if the lip temperature is high. The allowable temperature for the material used for the lip is 100°C, and because the lip will be subject to a temperature rise of 10°C to 15°C at maximum rotation, ensure that no high temperature oil is splashed on the lip.

(9) Encoder cable stress

(a) Sufficiently examine the clamping method of the cable and ensure that bending stress and cable empty weight stress is not applied to the cable connection part.

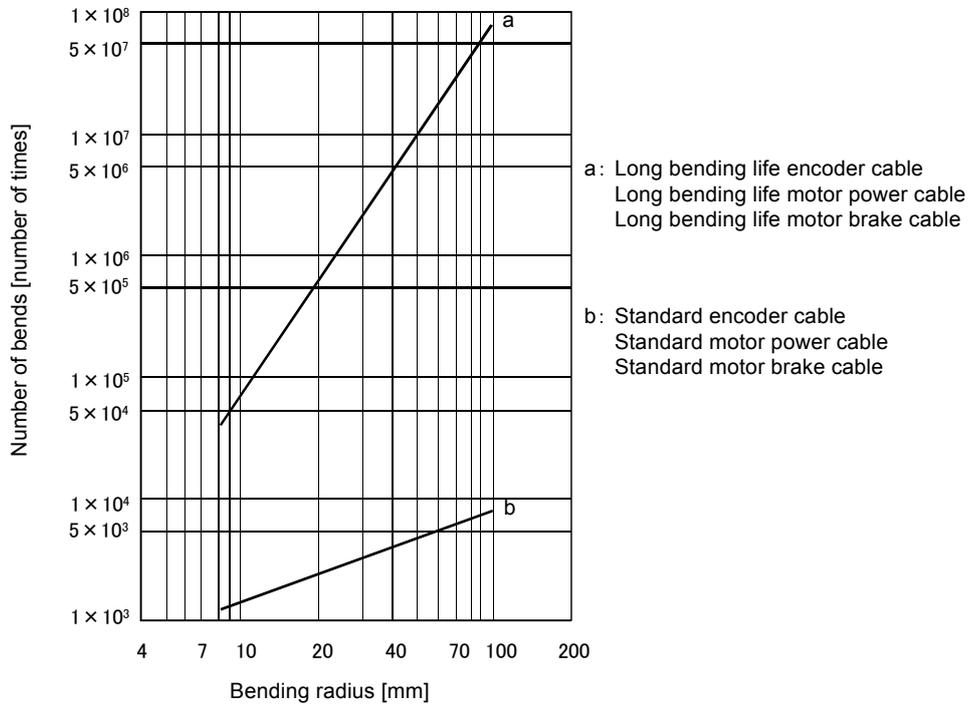
(b) When using in applications where the servo motor itself moves, fix the cable (detector, power supply, brake) by gradually slackening from the connector so that there is no stress on the servo motor connector. Use the optional encoder cable within the bending life range. With cables for the power supply and brake wiring, use within the bending life range of the power supply used.

(c) Ensure that the cable casing is not cut by sharp chips, that it does not rub against the mechanical radian, and that there is no chance of people or cars stepping on the cable.

(d) When the servo motor is installed in a machine that moves, ensure that the bend radius is as large as possible. Refer to the next page for the bending life.

(10) Cable bending life

The bending life of the cable is displayed. This graph is a calculated value. Because it is not a guaranteed value, in reality a little allowance should be provided.



4.3.3 Wiring System and Sequence

(1) Power-on procedure

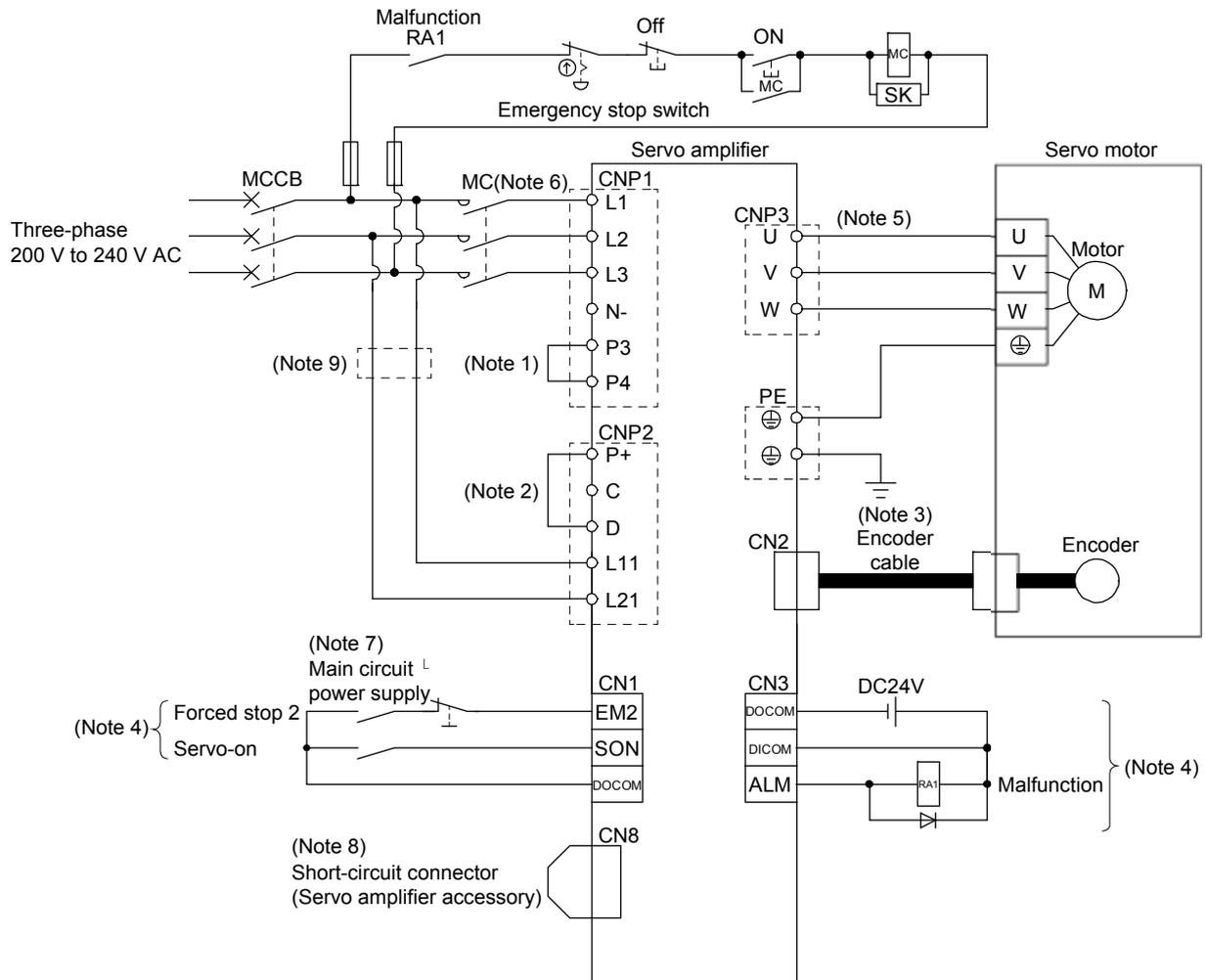
- 1) With the power supply wiring, make sure to use a magnetic contactor in the main circuit power supply (three-phase: L1/L2/L3; one-phase: L1/L3) as shown in section 4.2. Configure so that the magnetic contactor is turned off at the same time as an alarm is generated in the external sequence.
- 2) Turn on the control circuit power supply (L11/L21) at the same time or before turning on the main circuit power supply. If the main circuit power supply is not turned on, a warning is displayed on the display. However, the warning disappears and operation returns to normal when the main circuit power supply is turned on.
- 3) The servo amplifier can receive SON (servo-on) signals 2.5 s to 3.5 s after the main circuit power supply is turned on. Therefore, if SON (servo-on) is turned on at the same time as the main circuit power supply, the base circuit will be turned on after 2.5 s to 3.5 s. After approximately 5 ms, RD (Ready) is turned on and operation becomes available. (Refer to (3) in this section.)
- 4) When RES (reset) is turned on, the base circuit shuts off, and the servo motor shaft goes into a free state.

4. Functions and Operations of MELSERVO-J4

(2) Connection example

Wire the power supply and main circuit so that when an alarm occurrence is detected and the power supply is shut off, SON (servo-on) also turns off at the same time.

Always connect a magnetic contactor between the power supply and the main circuit power supply (L1/L2/L3) of the servo amplifier in order to configure a power supply shut-off on the power supply side of the servo amplifier.



- Note 1. Make sure to connect between P3 and P4. (Wiring is complete when shipped)
For harmonics countermeasures, refer to section 7.3.3 of this manual.
2. Make sure to connect between P+ and D. (Wiring is complete when shipped)
3. Use of the optional cable is recommended for the encoder cable.
For cable selection, refer to the servo motor instruction manual (vol. 3).
4. This is with a sink I/O interface.
5. For servo motor power cable connection, refer to the servo motor instruction manual (vol. 3).
6. Use an electromagnetic contactor with an operation delay time (interval between the current being applied to the coil and closure of the contacts) of 80 ms or less. Bus voltage decreases according to the voltage and operation pattern of the main circuit, and there may be a shift in dynamic brake deceleration during forced stop deceleration. If dynamic brake deceleration is not desired, delay the time to turn off the electromagnetic contactor.
7. In order to prevent unexpected restarting of the servo amplifier, configure the circuit so that EM2 is also turned off when the main circuit power supply is turned off.
8. When not using the STO function, mount the short-circuit connector supplied with the servo amplifier.
9. If the wire used for L11 and L21 is thinner than the wire used for L1, L2, and L3, do not use a fuse breaker.
10. To avoid a malfunction, do not connect the U, V, W, and CN2 phase terminals of the servo amplifier to the servo motor of an incorrect axis.

Power supply/main circuit wiring (three-phase 200 V AC to 240 V power supply for MR-J4-10A to MR-J4-350A)

4. Functions and Operations of MELSERVO-J4

(4) Timing chart at alarm generation



CAUTION

- When an alarm occurs, remove the cause, verify that no operation signal is input, secure safety, and resume operation after clearing the alarm.

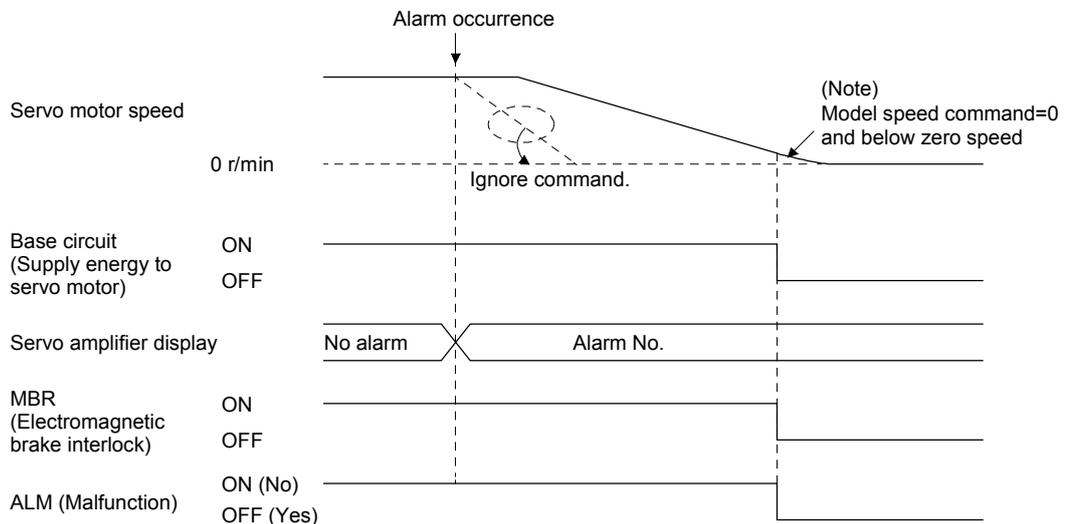
POINT	
	<ul style="list-style-type: none"> In torque control mode, the forced stop deceleration function cannot be used.

When an alarm occurs in the servo amplifier, the base circuit is shut off, and the servo motor stops with dynamic braking. At the same time, shut off the main circuit power supply with an external sequence. Although the alarm can be cleared by turning the control circuit power supply OFF→ON, by pressing the "SET" button on the current alarm screen, or by OFF→ON of Reset (RES), the alarm cannot be truly cleared until the cause of the alarm is removed.

(a) When using the forced stop deceleration function

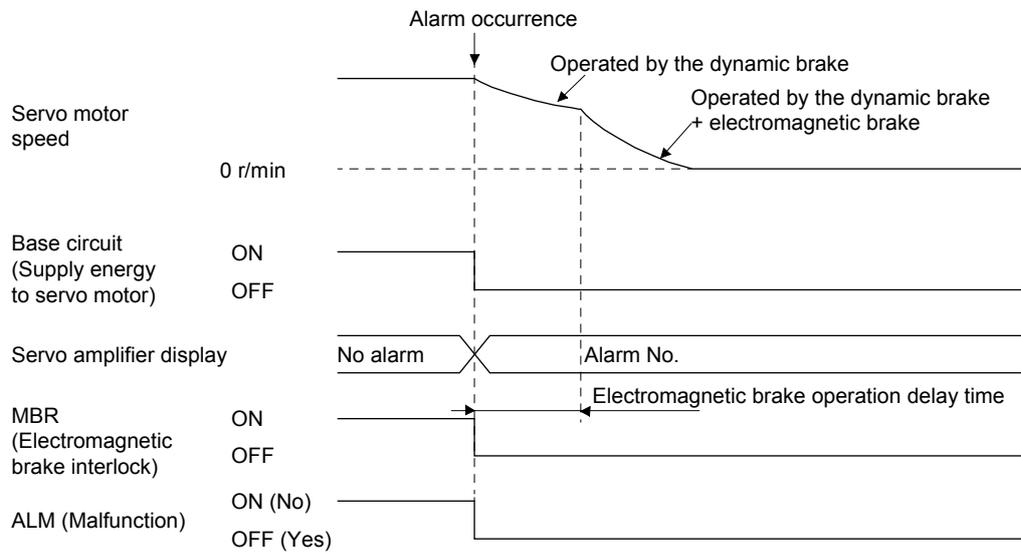
POINT	
	<ul style="list-style-type: none"> This is for when [Pr. PA04] was set to "2 _ _ _" (initial value).

(1) When the forced stop deceleration function is enabled



Note: A model speed command is generated inside the servo amplifier for forced stop deceleration of the servo motor.

(2) When the forced stop deceleration function is not enabled



(b) When not using the forced stop deceleration function

POINT	<ul style="list-style-type: none"> • This applies when [Pr. PA04] is set to "0 _ _ _".
-------	---

The operation status of the servo motor when an alarm occurs is the same as (a)(1) on the previous page.

4. Functions and Operations of MELSERVO-J4

(1) Regenerative error

If regenerative error (AL. 30) occurs and operation is performed by repeatedly clearing the alarm by turning the control circuit power supply OFF→ON, accidents may occur due to heat generation of the external regenerative resistor.

(2) Momentary power failure of the power supply

Undervoltage (AL.10) occurs when the input power supply is in the following states.

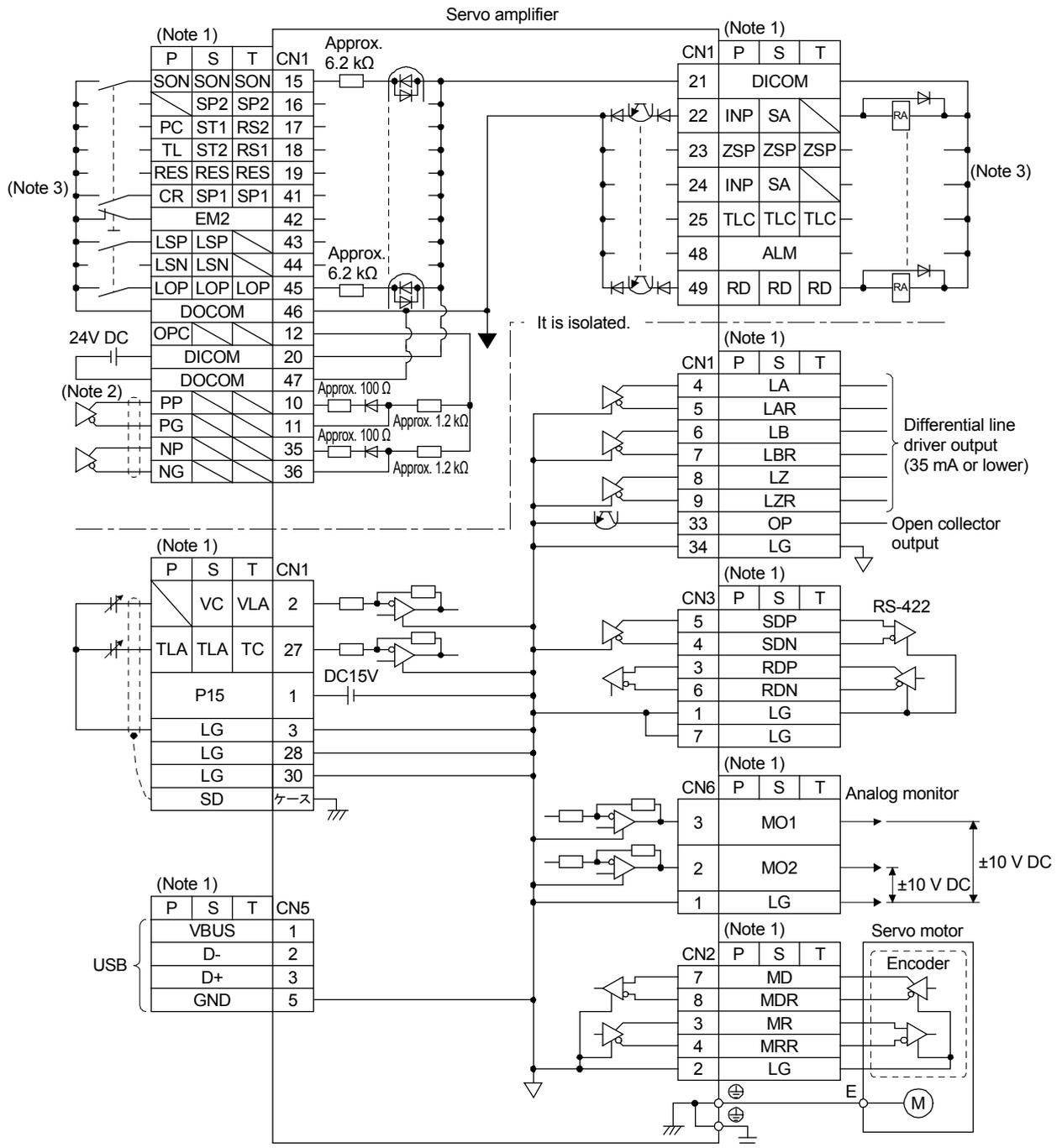
- The power failure of the control circuit power supply continues for 60 ms or more, and the control circuit is not completely OFF.
- The bus voltage drops to 200 V DC or less for MR-J4-□A and 380 V DC or less for MR-J4-□A4.

(3) With position control mode (incremental)

When an alarm occurs, the home position disappears. When operation is restarted after clearing the alarm, execute home position return.

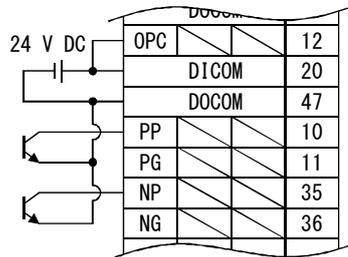
4. Functions and Operations of MELSERVO-J4

(5) Interface internal connection figure

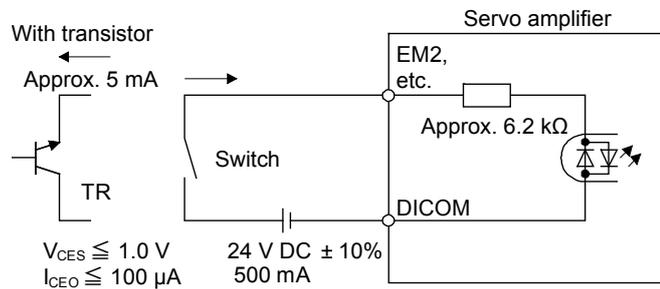


4. Functions and Operations of MELSERVO-J4

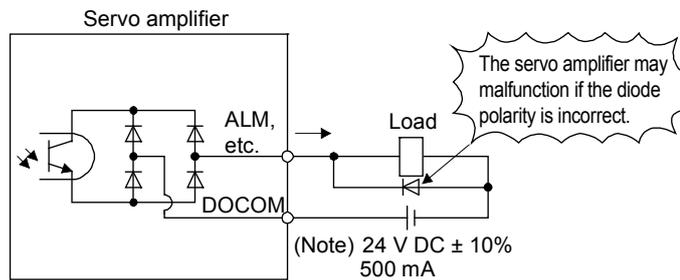
- Note 1. P: Position control mode; S: Speed control mode; T: Torque control mode
 Note 2. This applies to differential line driver pulse train input. For open collector pulse train input, connect as follows.



3. This is with a sink I/O interface. For a source I/O interface, refer to the next figure.



Source input interface



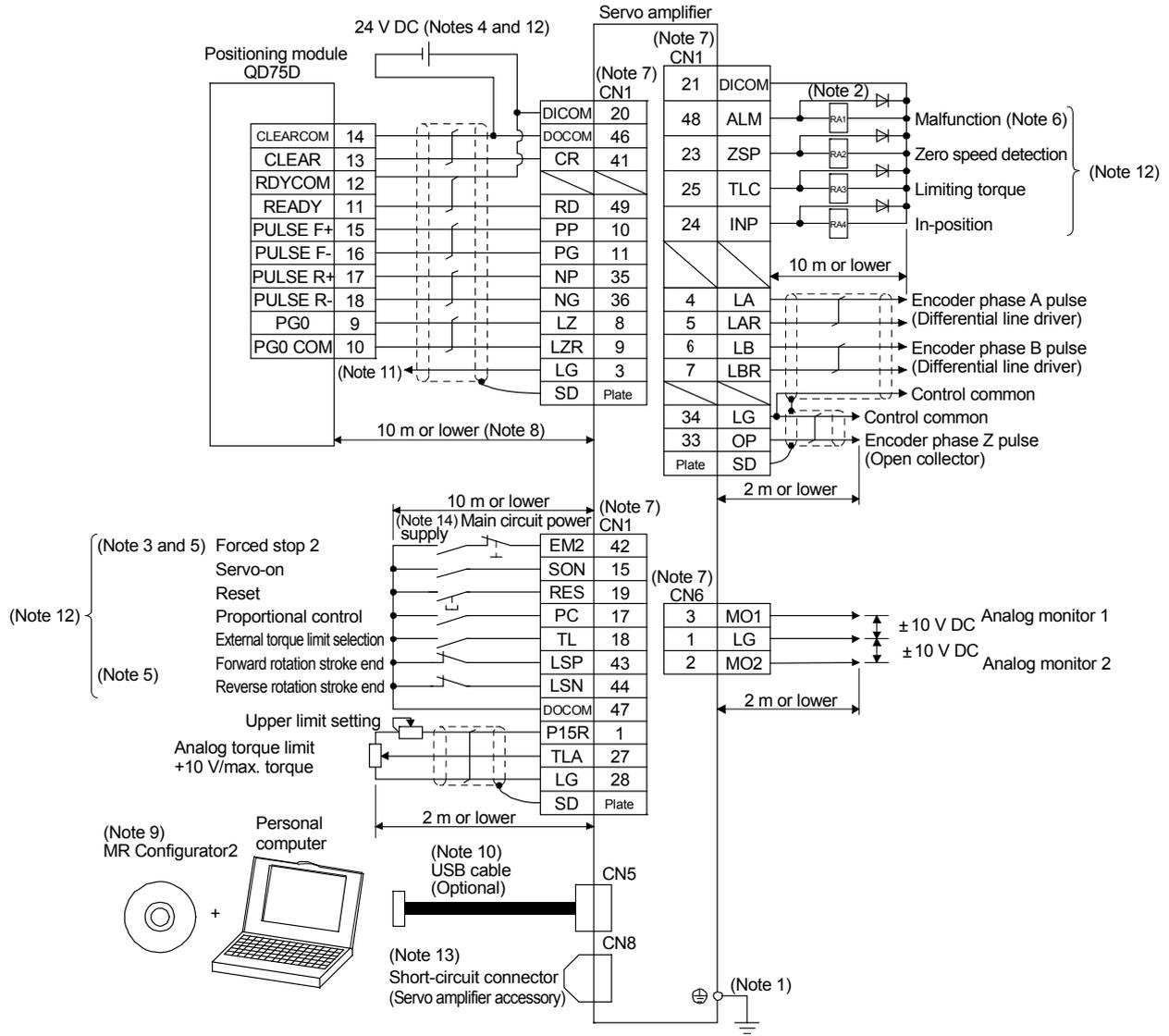
Note: When there is a problem in the relay differential because of a voltage drop (max 2.6 V), input high voltage from outside (max. 26.4 V).

Source output interface

4.3.4 Standard Connection Figure

(1) Position control

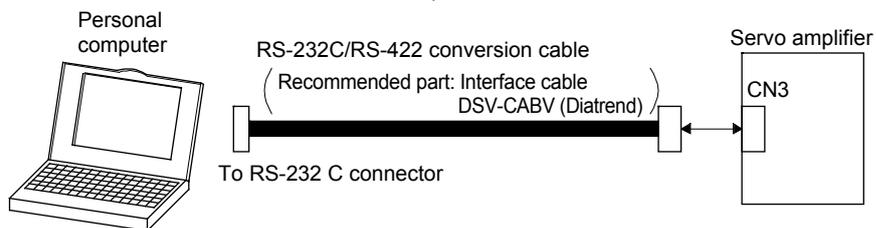
(1) Connection of all I/O signals



Connection I at the time of position control

4. Functions and Operations of MELSERVO-J4

- Note 1. To prevent electric shock, always connect the protective earth (PE) terminal (marked with \oplus) of the servo amplifier to the protective earth (PE) of the cabinet.
- Do not mistake the diode direction. If connected the other way round, the servo amplifier will malfunction and no signal will be output. Also, the protection circuits of EM2 (forced stop 2), etc., may not operate.
 - At the time of operation, make sure to turn on EM2 (forced stop 2). (Normally closed contact)
 - Supply a power supply of 24 V DC \pm 10% 500 mA from outside for the interface. 500 mA is the value when all I/O signals are used. The current capacity can be lowered by reducing the number of I/O points.
 - At the time of operation, make sure to turn on EM2 (forced stop 2), LSP (forward rotation stroke end), and LSN (reverse rotation stroke end). (Normally closed contact)
 - ALM (malfunction) is on when normal and no alarm is generated. When turned off (when an alarm is generated), stop the programmable controller signal with a sequence program.
 - A signal with the same name is connected inside the servo amplifier.
 - Command pulse train input is for differential line driver types. Open-collector types are 2 m or less.
 - Use SW1DNC-MRC2-J.
 - The personal computer can also be connected using RS-422 communication of the CN3 connector. However, the USB communication function (CN5 connector) and the RS-422 communication function (CN3 connector) are exclusive functions. Simultaneous use is not possible.



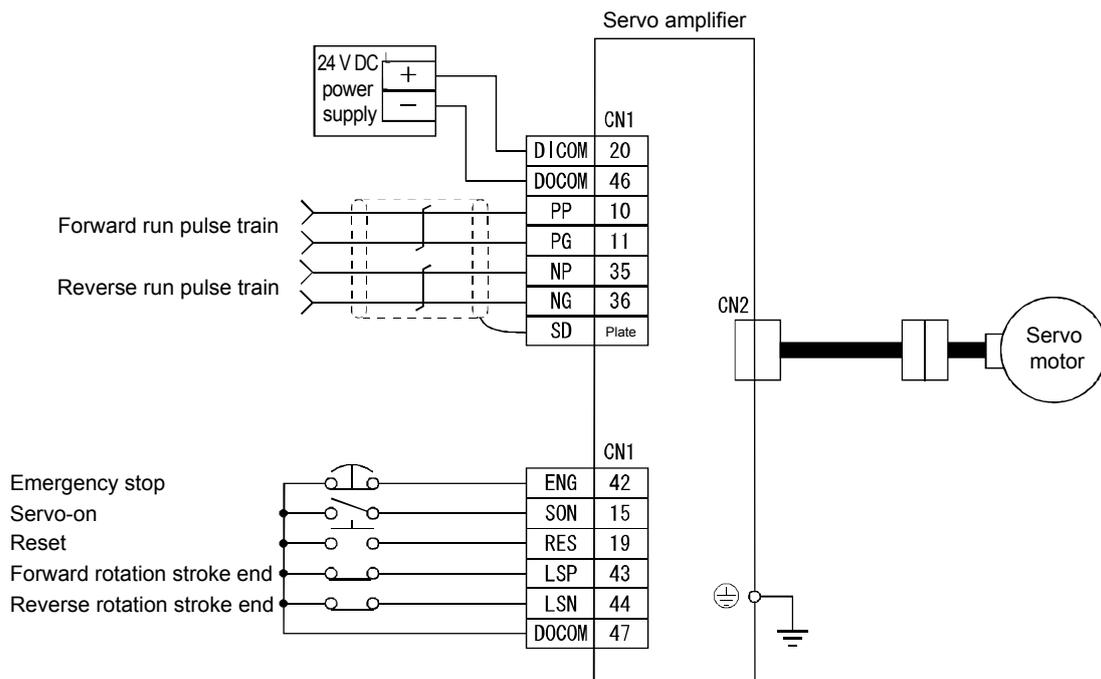
- This connection is not required for QD75D. However, depending on the positioning module used, a connection between the control common and the LG of the servo amplifier is recommended to improve noise tolerance.
- This is with a sink I/O interface.
- When not using the STO function, mount the short-circuit connector supplied with the servo amplifier.
- In order to prevent unexpected restarting of the servo amplifier, configure the circuit so that EM2 is also turned off when the main circuit power supply is turned off.

4. Functions and Operations of MELSERVO-J4

(2) Connection of minimum required I/O signals

Connections below the minimum are required to move the motor. Connection of the output signal is not required.

- 1) Servo-on: Because this signal is used to start the main circuit, it absolutely must be turned on before operation. When turned on, the servo-lock state is initiated.
- 2) Forward/reverse rotation stroke end: Connect to the limit switch on the normal load side. When turned off, movement is not possible in that direction. Movement will be in the reverse direction. If a load side limit switch such as a roll feed does not exist, always short-circuit between the DOCOM.
- 3) Forward/reverse pulse train: When a pulse train is input, the motor moves according to the pulse frequency/count. When not input, the motor stops and there is servo-lock.
- 4) Reset: Used to clear the alarm. Because an alarm can be cleared even when the control circuit power supply is off, this signal is not absolutely necessary. Moreover, when the reset signal is on, servo-lock is cleared and the motor is freed.
- 5) Emergency stop: During operation, make sure to short-circuit the emergency stop signal (EMG) with the DOCOM using the emergency stop switch (normally closed contact).

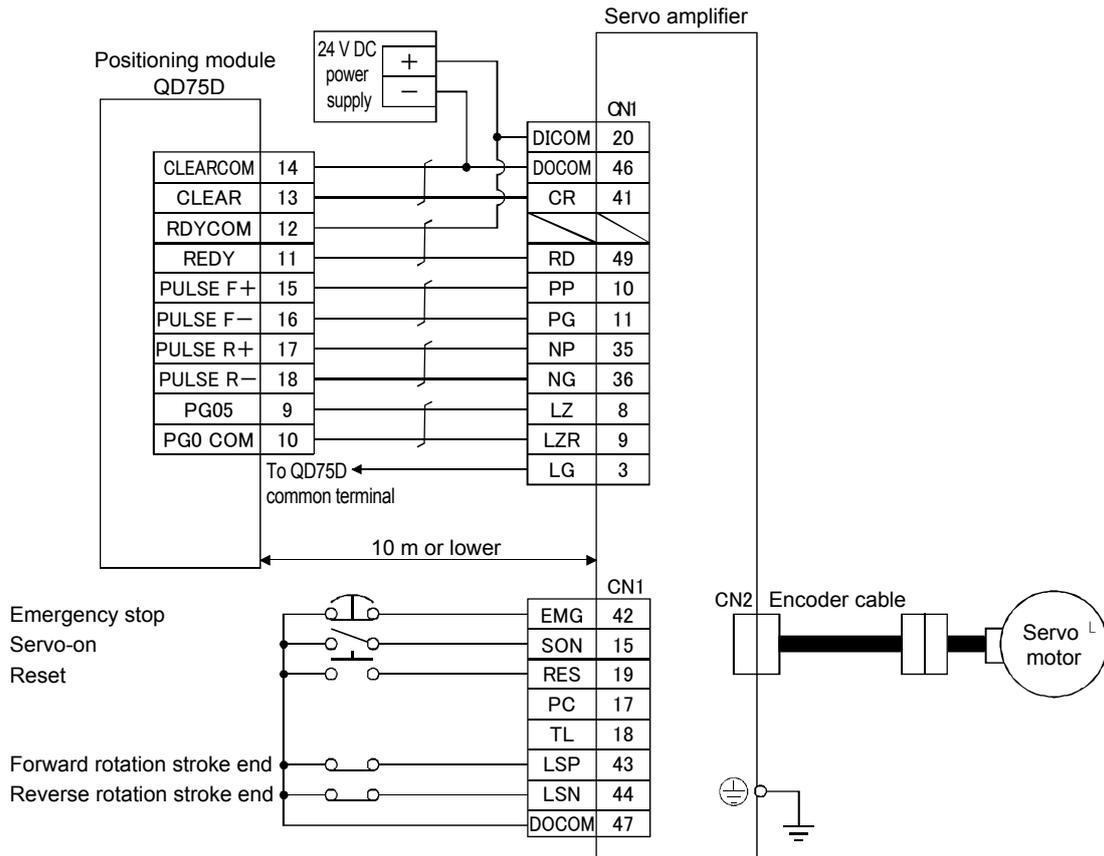


Connection I at the time of position control

4. Functions and Operations of MELSERVO-J4

(3) Connection of minimum required I/O signals when operating with QD75

- 1) Servo-on
- 2) Forward/reverse rotation stroke end
- 3) Forward/reverse pulse train: Connect with the QD75 terminal as shown in the following figure.
- 4) Reset
- 5) Clear: Used to clear the counter when returning to the home position.
- 6) Zero pulse: Used as the home position signal when returning to the home position.
- 7) Ready: The servo-on state is output to the QD75, and it is used as an interlock signal.
- 8) Emergency stop: During operation, make sure to short-circuit the emergency stop signal (EMG) with DOCOM using the emergency stop switch (normally closed contact).



* For details on connections related to Q75, refer to the QD75 manual.

Connection III at the time of position control

4. Functions and Operations of MELSERVO-J4

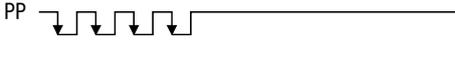
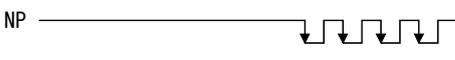
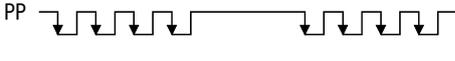
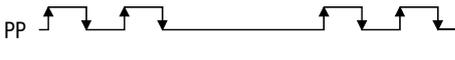
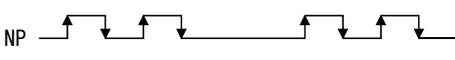
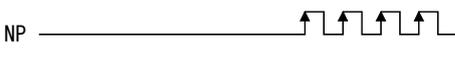
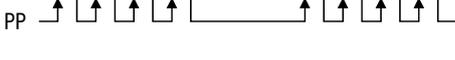
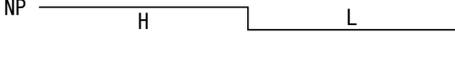
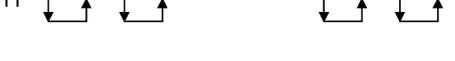
[Supplementary explanation]

(1) Pulse train input types

Generally, the command pulse inputs the forward/reverse rotation pulse train by an open-collector type or a differential system, which is suitable even for FX_{2N}-20GM/10GM/10PG/1PG, QD75P/QD75D, and QD70P.

With MR-J4 Series amplifiers, compatibility with the following pulse trains when switching parameters is also enabled in order to enable compatibility with pulse trains of various other command modules.

1) Types of pulse train forms

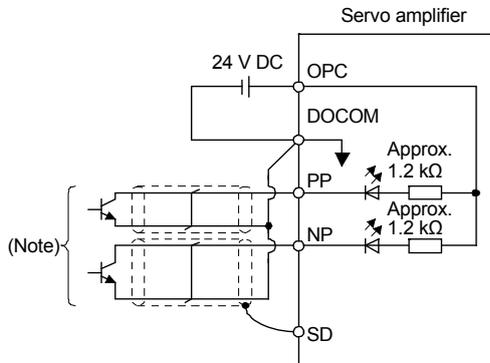
Parameter No. PA13 setting value	Pulse train type	Upon forward rotation command	Upon reverse rotation command	Remarks
0010h	Forward rotation pulse train Reverse rotation pulse train	PP  NP 		QD75P, QD75D, QD70P FX _{2N} -20GM/10GM/10PG/1PG (Setting value at shipping)
0011h	Pulse train + code	PP  NP 		QD75P, QD75D, QD70P, FX _{2N} -20GM/10GM/10PG/1PG
0012h	Phase A pulse train Phase B pulse train	PP  NP 		QD75P, QD75D
0000h	Forward rotation pulse train Reverse rotation pulse train	PP  NP 		QD75P, QD75D, QD70P
0001h	Pulse train + code	PP  NP 		QD75P, QD75D, QD70P
0002h	Phase A pulse train Phase B pulse train	PP  NP 		QD75P, QD75D

Note: An  or  arrow in the table indicates the import timing of the pulse train.

4. Functions and Operations of MELSERVO-J4

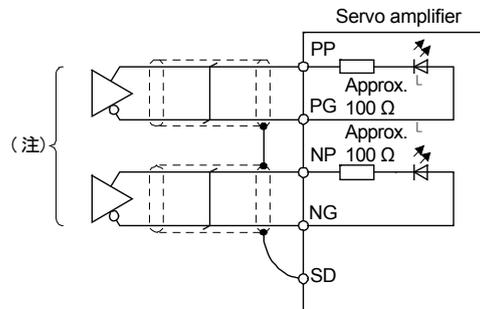
2) Types of hardware

The following configurations can be selected depending on the hardware of command module.



Note: The pulse train input interface uses a photocoupler. Because of this, it is not usually operated as the current decreases when the resistor is connected to the pulse train signal line.

(a) Open-collector type



Note: The pulse train input interface uses a photocoupler. Because of this, it is not usually operated as the current decreases when the resistor is connected to the pulse train signal line.

(b) Differential line driver type

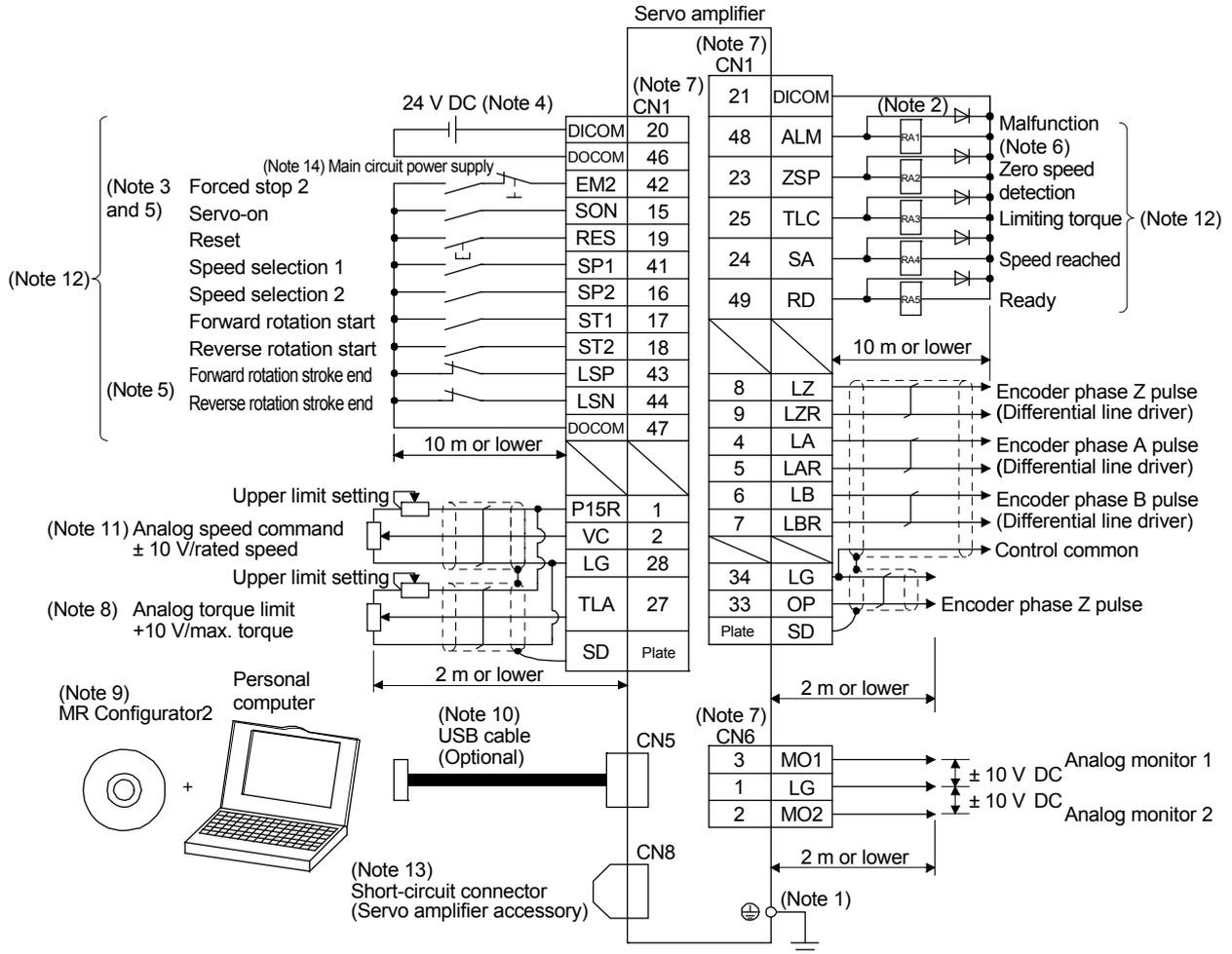
(2) Torque limit

When parameter number PA11 (Forward rotation torque limit) and parameter number PA12 (Reverse rotation torque limit) are set, the maximum torque is always limited during operation.

4. Functions and Operations of MELSERVO-J4

(2) Speed control

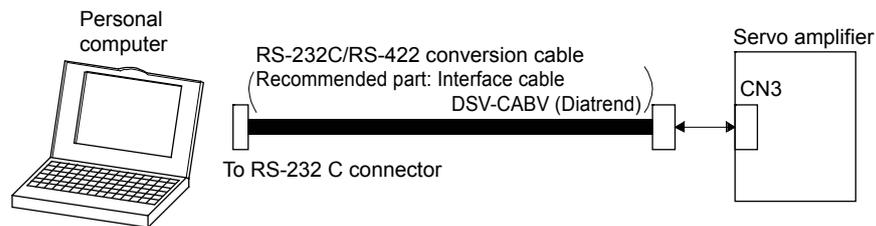
(1) Connection of all I/O signals



Connection I at the time of speed control

4. Functions and Operations of MELSERVO-J4

- Note 1. To prevent electric shock, always connect the protective earth (PE) terminal (marked with \oplus) of the servo amplifier to the protective earth (PE) of the cabinet.
- Do not mistake the diode direction. If connected the other way round, the servo amplifier will malfunction and no signal will be output. Also, the protection circuits of EM2 (forced stop 2), etc., may not operate.
 - At the time of operation, make sure to turn on EM2 (forced stop 2). (Normally closed contact)
 - Supply a power supply of 24 V DC \pm 10% 500 mA from outside for the interface. 500 mA is the value when all I/O signals are used. The current capacity can be lowered by reducing the number of I/O points.
 - At the time of operation, make sure to turn on EM2 (forced stop 2), LSP (forward rotation stroke end), and LSN (reverse rotation stroke end). (Normally closed contact)
 - ALM (malfunction) is on when normal and no alarm is generated.
 - A signal with the same name is connected inside the servo amplifier.
 - If use of TL (external torque limit selection) is enabled in [Pr.PD03] to [Pr.PD22], TLA can be used.
 - Use SW1DNC-MRC2-J.
 - The personal computer can also be connected using RS-422 communication of the CN3 connector. However, the USB communication function (CN5 connector) and the RS-422 communication function (CN3 connector) are exclusive functions. Simultaneous use is not possible.



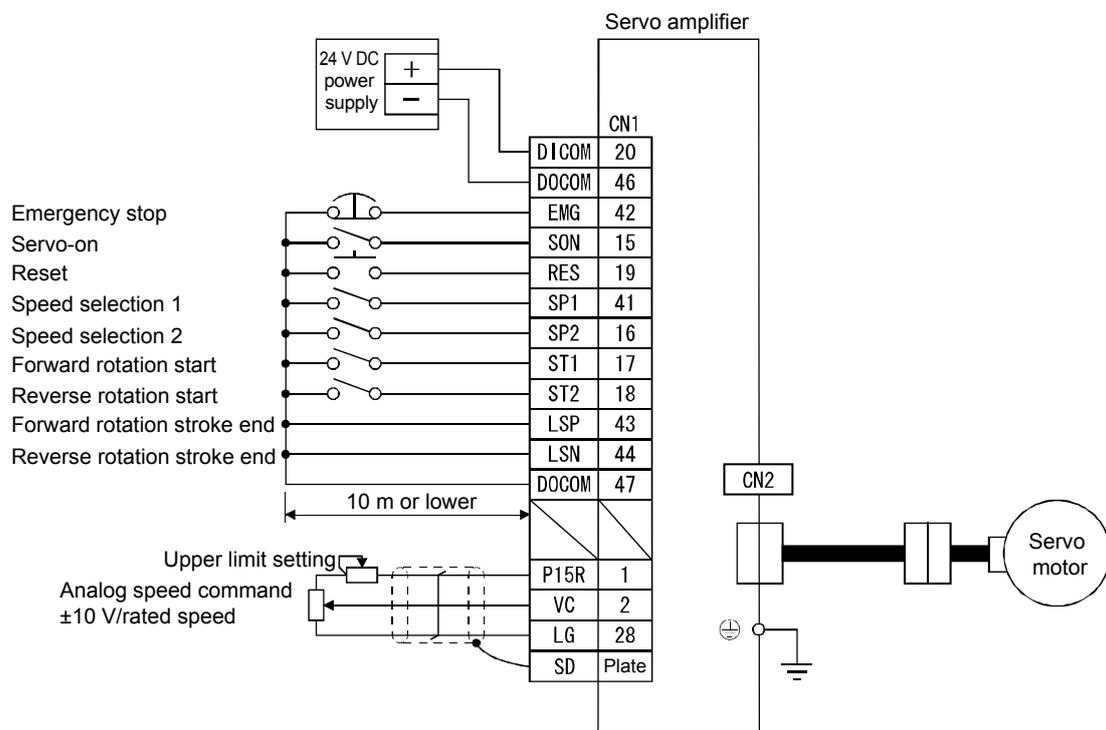
- When a minus voltage is input, use an external power supply.
- This is with a sink I/O interface.
- When not using the STO function, mount the short-circuit connector supplied with the servo amplifier.
- In order to prevent unexpected restarting of the servo amplifier, configure the circuit so that EM2 is also turned off when the main circuit power supply is turned off.

4. Functions and Operations of MELSERVO-J4

(2) Connection of minimum required I/O signals

Connections below the minimum are required to move the motor. Connection of the output signal is not required.

- 1) Servo-on: Because this signal is used to start the main circuit, it absolutely must be turned on before operation.
When turned on, the servo-lock state is initiated.
- 2) Speed selection 1, 2: Select whether the speed command is the parameter setting value or the external analog setting value.
The following figure shows an external analog speed command.
- 3) Forward rotation/reverse rotation start: Used as a start signal.
- 4) Reset: Used to clear the alarm. Because an alarm can be cleared even when the control circuit power supply is off, this signal is not absolutely necessary.
Moreover, when the reset signal is on, servo-lock is cleared and the motor is freed.
- 5) Emergency stop: During operation, make sure to short-circuit the emergency stop signal (EMG) with DOCOM using the emergency stop switch (normally closed contact).



Connection II at the time of speed control

4. Functions and Operations of MELSERVO-J4

[Supplementary explanation] External connection of speed command

(a) Speed selection 1 (SP1)/Speed selection 2 (SP2) and speed command value

The rotation speed settings according to internal speed commands 1 to 3 using speed selection 1 (SP1)/speed selection 2 (SP2) and the rotation speed settings according to analog speed command (VC) are selected as shown in the following table.

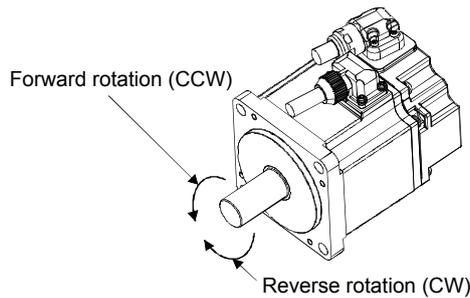
Note: External input signal		Rotation speed command value
SP2	SP1	
0	0	Analog speed command (VC)
0	1	Internal speed command 1 (Parameter number PC05)
1	0	Internal speed command 2 (Parameter number PC06)
1	1	Internal speed command 3 (Parameter number PC07)

Note. 0: OFF
1: ON

(b) Forward rotation start (ST1)/Reverse rotation start (ST2)

Forward rotation start (ST1)/reverse rotation start (ST2) are used to start and stop the motor. When both ST1 and ST2 are OFF or ON, there is deceleration stop and the servo-lock state is entered.

If speed setting is done by an external analog voltage, the relation between the motor rotation direction and the voltage polarity start signal is as shown in the following table.



(Note 1) Input device		(Note 2) Rotation direction			Internal speed command
ST2	ST1	VC (Analog speed command)			
		+ 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)

Note 1. 0: Off
1: On

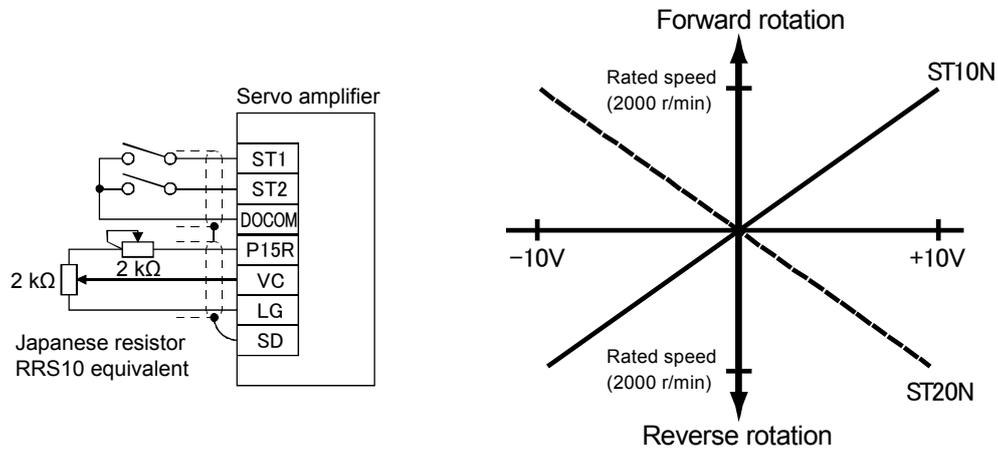
2. When the torque limit is cleared during servo-lock, the servo motor may rotate rapidly depending on the position deviation amount for the command position.

4. Functions and Operations of MELSERVO-J4

(c) External wiring example

The external connection of the speed command is displayed according to the external analog voltage.

(1) When the polarity of the analog voltage is operated in forward/reverse only with \oplus



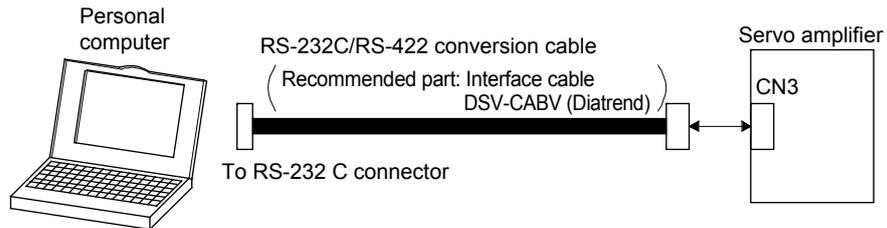
External connection I of speed command

(d) Torque limit

When parameter number PA11 (Forward rotation torque limit) and parameter number PA12 (Reverse rotation torque limit) are set, the maximum torque is always limited during operation.

4. Functions and Operations of MELSERVO-J4

- Note 1. To prevent electric shock, always connect the protective earth (PE) terminal (marked with \oplus) of the servo amplifier to the protective earth (PE) of the cabinet.
- Do not mistake the diode direction. If connected the other way round, the servo amplifier will malfunction and no signal will be output. Also, the protection circuits of EM2 (forced stop 2), etc., may not operate.
 - At the time of operation, make sure to turn on EM2 (forced stop 2). (Normally closed contact)
 - Supply a power supply of 24 V DC \pm 10% 500 mA from outside for the interface. 500 mA is the value when all I/O signals are used. The current capacity can be lowered by reducing the number of I/O points.
 - ALM (malfunction) is on when normal and no alarm is generated.
 - A signal with the same name is connected inside the servo amplifier.
 - Use SW1DNC-MRC2-J.
 - The personal computer can also be connected using RS-422 communication of the CN3 connector. However, the USB communication function (CN5 connector) and the RS-422 communication function (CN3 connector) are exclusive functions. Simultaneous use is not possible.



- When a minus voltage is input, use an external power supply.
- This is with a sink I/O interface.
- When not using the STO function, mount the short-circuit connector supplied with the servo amplifier.
- In order to prevent unexpected restarting of the servo amplifier, configure the circuit so that EM2 is also turned off when the main circuit power supply is turned off.

4. Functions and Operations of MELSERVO-J4

[Supplementary explanation]

(1) External connection of torque control

a. Torque command and generated torque

The relationship between the applied voltage of the analog torque command (TC) and the generated torque of the servo motor is shown in the figure on the left. The output torque command value corresponding to the voltage may have a difference of approximately 5% depending on the product. Moreover, if the voltage is -0.05 to $+0.05$ V, the generated torque may change. A torque generation direction dependant on forward rotation selection (RS1)/reverse rotation selection (RS2) when an analog torque command (TC) is used is shown in Table 4.1.

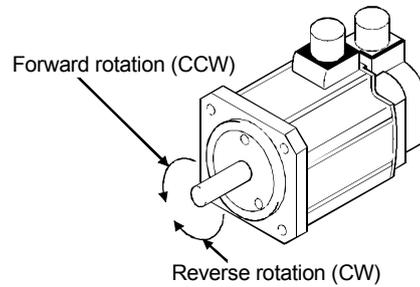
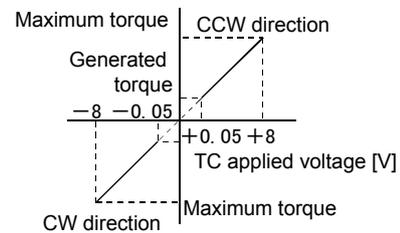


Table 4.1 Torque generation direction

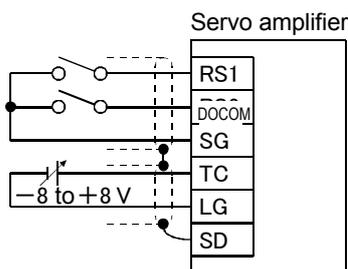
Between RS1 and DOCOM	Between RS2 and DOCOM	Rotation direction		
		+ polarity	0 V	- polarity
Open	Open	No torque	No torque	No torque
Short-circuit	Open	CCW (forward rotation power drive / reverse rotation regenerative driving)		CW (reverse rotation power drive/forward rotation regenerative drive)
		CW (reverse rotation power drive/forward rotation regenerative drive)		CCW (forward rotation power drive/reverse rotation regenerative drive)
Open	Short-circuit	No torque		No torque
Short-circuit	Short-circuit	No torque	No torque	



Torque control level (when RS1: ON)

b. Connection figure

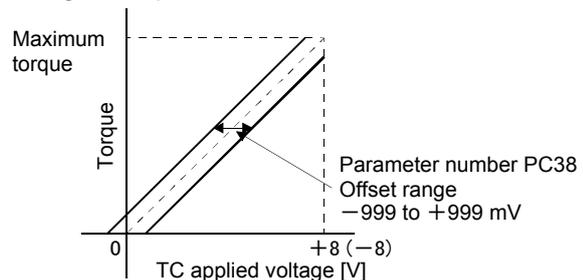
Connect according to the following figure.



Connection example

c. Analog torque command offset

An offset voltage of -999 to 999 mV as shown in the next figure can be added to the TC applied voltage with parameter number PC38.



Analog torque command offset range

(2) Torque limit

When parameter number PA11 (Forward rotation torque limit) and parameter number PA12 (Reverse rotation torque limit) are set, the maximum torque is always limited during operation. The relationship between the generated torque of the servo motor and the limit value is the same as (1) mentioned above. However, an analog torque limit (TLA) cannot be used.

4. Functions and Operations of MELSERVO-J4

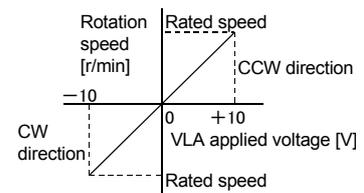
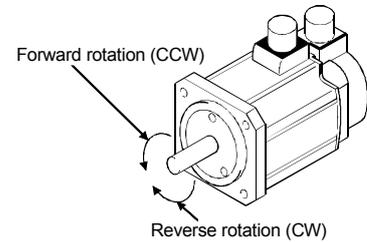
(3) Speed limit

a. Speed limit value and rotation speed

Limits the rotation speed set in parameter number PC05 to PC11 (internal speed limit 1 to 7) or the rotation speed set by the applied voltage of the analog speed limit (VLA). The relationship between the applied voltage of the analog speed limit (VLA) and the servo motor speed is shown in the figure on the left. A limit direction according to forward rotation selection (RS1)/reverse rotation selection (RS2) is shown in Table 4.2.

Table 4.2 RS1/RS2 and speed limit direction

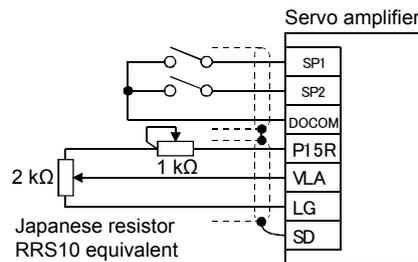
Between RS1 and DOCOM	Between RS2 and DOCOM	Speed limit direction		
		Analog speed limit (VLA)		Internal speed limit
		+ polarity	- polarity	
Short-circuit	Open	CCW	CW	CCW
Open	Short-circuit	CW	CCW	CW



VLA applied voltage and rotation speed (when RS1: ON)

b. Connection figure

Generally, connect according to the following figure.



Connection example 1

Torque limit and torque control

Because the generated torque of the motor is proportional to a current, the generated torque of the motor can be freely controlled by controlling the current of the AC servo motor.

Usually, although an AC servo motor (synchronous type) has a maximum torque of 300% or more, when controlling the position and speed, controlling so that no torque is generated above a certain value is known as a "torque limit".

On the other hand, controlling so that the generated torque of motor is always maintained constantly at a certain value is known as "torque control".

Torque limiting is used to control power during pressing operations, reducer protection, etc., and control is performed so that no more than the required power is applied to a load or machine.

Torque control is used when the power on the material (tension) is kept constant even if the speed changes due to a winding device, etc., and the speed depends on the generated torque and load torque.

4. Functions and Operations of MELSERVO-J4

c. Speed selection 1 (SP1)/speed selection 2 (SP2)/speed selection (SP3) and speed command value

The rotation speed settings according to internal speed commands 1 to 3 using speed selection 1 (SP1)/speed selection 2 (SP2)/speed selection 3(SP3) and the rotation speed settings according to analog speed limit (VLA) are selected as shown in Table 4.3. In the factory settings for MR-J4-A servo amplifiers, speed selection 3 (SP3) is not assigned to an external input signal. Internal speed commands 4 to 7 can be used when speed selection 3 (SP3) is assigned to a connector CN1 pin as external input signals by parameter number PD03 to PD12. However, with this training machine, because assigning speed selection 3 (SP3) and selecting using a switch is not possible, internal speed commands 4 to 7 cannot be used.

If the speed is commanded by internal speed commands 1 to 7, the speed will not change according to the ambient temperature.

Table 4.3 SP1/SP2/SP3 and speed command value

Input signal ^(Note)			Speed command
SP3	SP2	SP1	
0	0	0	Analog speed limit (VLA)
0	0	1	Internal speed limit 1 (Parameter number PC05)
0	1	0	Internal speed limit 2 (Parameter number PC06)
0	1	1	Internal speed limit 3 (Parameter number PC07)
1	0	0	Internal speed limit 4 (Parameter number PC08)
1	0	1	Internal speed limit 5 (Parameter number PC09)
1	1	0	Internal speed limit 6 (Parameter number PC10)
1	1	1	Internal speed limit 7 (Parameter number PC11)

Note. 0: OFF between DOCOMs (open)

1: ON between DOCOMs (short-circuit)

d. During speed limit (VLC)

When the servo motor speed reaches the rotation speed limited by internal speed limit 1 to 7 or the analog speed limit, there is conduction between VLC and DICOM.

4.3.5 Power-On

(1) Confirmation

Confirm the installation and the wiring performed in 4.3.2 and 4.3.3 again thoroughly before power-on.

(a) Installation: Confirm the installation status based on section 4.3.2. Especially check for influences on the amplifier ambient temperature from the heating element in the panel, for contact between the heating element and the cables, and check the waterproof/oil-proof measures of the servo motor.

(b) Wiring: Check the wiring based on section 4.3.3. Because an error in main circuit connections may also lead to module damage, a thorough check is especially required.

Although the main items are listed below, there may be other model-specific problems. For details, refer to the respective installation guides and instruction manuals.

(2) Wiring

Perform the following checks before operation.

(a) Wiring of power supply system

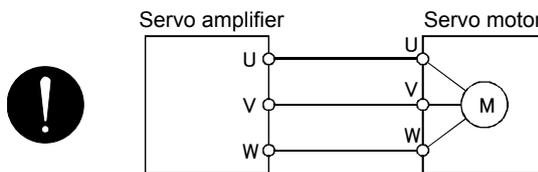
Check the following items before turning on the main circuit or control circuit power supply.

1) Wiring of power supply system

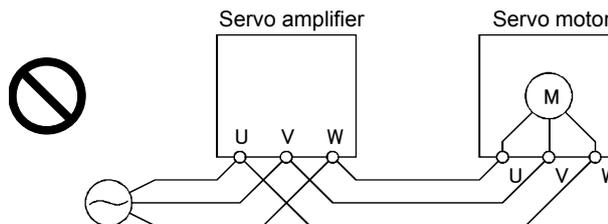
The power supply supplied to the power input terminals (L1, L2, L3, L11, L21) of the servo amplifier should meet the regulated specifications.

2) Servo amplifier/servo motor connection

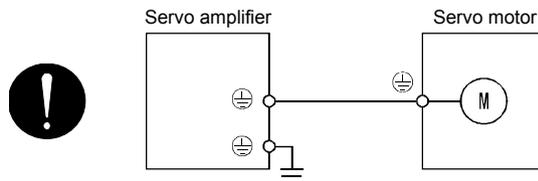
- The phases of the servo motor power terminals (U, V, W) of the servo amplifier and the power input terminals (U, V, W) of the servo motor should match.



- The power supply supplied to the servo amplifier should not be connected to a servo motor power terminal (U, V, W). A connected servo amplifier or servo motor has malfunctioned.

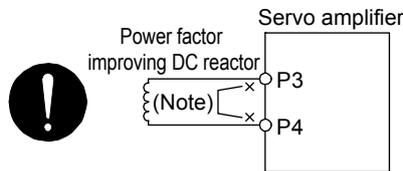


- The ground terminal of the servo motor should be connected to the PE terminal of the servo amplifier.



4. Functions and Operations of MELSERVO-J4

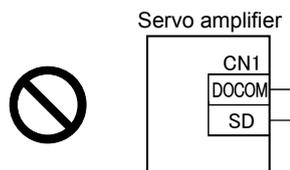
- 3) When optional/peripheral equipment is used
 - 1) When using a 200 V class regenerative option at 5 kW or lower
 - The lead wire between the P+ terminal and the D terminal of the CNP2 connector (3.5 kW or lower) or the TE3 terminal block (5 kW) should be removed.
 - The regenerative option wire should be connected to the P+ terminal and the C terminal.
 - Twisted wire should be used for the wire.
 - 2) When using a 200 V class regenerative option at 7 kW
 - The lead wire of the internal regenerative resistor connected to the P+ terminal and the C terminal should be disconnected.
 - The regenerative option wire should be connected to the P+ terminal and the C terminal.
 - If the wiring length is between 5 m to 10 m, twisted wire should be used for the wire.
 - 3) When using a brake unit or power regenerative converter at 7 kW
 - The lead wire of the internal regenerative resistor connected to the P+ terminal and the C terminal should be disconnected.
 - The wire of the brake unit, power regenerative converter, or the power regenerative common converter should be connected to the P+ terminal and the N- terminal.
 - 4) A power factor improving DC reactor should be connected between P3 and P4.



Note. Make sure to remove the wiring between P3 and P4.

- (b) I/O signal wiring
 - 1) The I/O signals should be connected correctly.

When using DO forced output, the CN1 connector pin can be turned ON/OFF forcefully. A wiring check can be performed using this function. In this case, only turn on the control circuit power supply.
 - 2) Voltage exceeding 24 V DC should not be applied to the CN1 connector pin.
 - 3) The DOCOM and SD of connector CN1 should not be short-circuited.



4. Functions and Operations of MELSERVO-J4

(3) Surrounding environment

(a) Cable routing

- 1) Excessive force should not be applied to the wiring cable.
- 2) The encoder cable should not exceed its bending life.
- 3) Excessive force should not be applied to the connector part of the servo motor.

(b) Environment

There should be no places where the signal wire or power cable is short-circuited by wire offcuts, metal powder, etc.

(4) Start-up of position control mode

Start up according to section 4.3.1. Contents specific to the position control mode are described here.

(a) Power-on

Turn ON the power according to the following procedure. Make sure to follow this procedure at power-on.

- 1) Turn OFF servo-on (SON).
- 2) Check that a command pulse train is not input.
- 3) Turn ON the main circuit power supply and the control circuit power supply.
Data is displayed 2 seconds after "C" (Cumulative feedback pulses) is displayed on the display.



With absolute position detection systems, when power is turned on the first time, the Absolute position erased (AL. 25) alarm occurs, and servo-on is not possible. Clear by shutting off the power supply once and then turning it on again.

Moreover, if the power is switched on and the servo motor is operating at a speed of 3000 r/min or more, position mismatching may occur due to such things as external forces. Power must therefore be switched on when the servo motor is stopped.

(b) Power supply shut-off

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

(5) Stop

In the following statuses, the servo amplifier interrupts and stops the operation of the servo motor. For servo motors with an electromagnetic brake, refer to the servo amplifier instruction manual (vol. 3).

Operation/command	stop status
Turn off SON (servo-on)	The base circuit is shut off and the servo motor enters a free run.
Alarm occurrence	Perform deceleration stop of the servo motor. However, an alarm will occur when stopping by operating dynamic braking.
EM2 (Forced stop 2) off	Perform deceleration stop of the servo motor. [AL. E6 Servo forced stop warning] occurs. In torque control mode, EM2 and EM1 use the same function signal.
STO (STO1, STO2) off	The base circuit shuts off and the servo motor stops by operation of the dynamic brake.
Turn off LSP (forward rotation stroke end) or LSN (reverse rotation stroke end)	There is a servo-lock due to a sudden stop. It is possible to operate in the reverse direction.

4. Functions and Operations of MELSERVO-J4

(6) Start-up of speed control mode

Start up according to section 4.3.1. Contents specific to the speed control mode are described here.

(a) Power-on

Turn ON the power according to the following procedure. Make sure to follow this procedure at power-on.

- 1) Turn OFF servo-on (SON).
- 2) Check that Forward rotation start (ST1)/Reverse rotation start (ST2) are OFF.
- 3) Turn ON the main circuit power supply and the control circuit power supply.
Data is displayed 2 seconds after "r" (Servo motor speed) is displayed on the display.



(b) Power supply shut-off

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

(7) Stop

In the following statuses, the servo amplifier interrupts and stops the operation of the servo motor. For servo motors with an electromagnetic brake, refer to the servo amplifier instruction manual (MR-J4-_A).

Operation/command	stop status
Turn off SON (servo-on)	The base circuit is shut off and the servo motor enters a free run.
Alarm occurrence	Perform deceleration stop of the servo motor. However, an alarm will occur when stopping by operating dynamic braking.
EM2 (Forced stop 2) off	Perform deceleration stop of the servo motor. [AL. E6 Servo forced stop warning] occurs. In torque control mode, EM2 and EM1 use the same function signal.
STO (STO1, STO2) off	The base circuit shuts off and the servo motor stops by operation of the dynamic brake.
Turn off LSP (forward rotation stroke end) or LSN (reverse rotation stroke end)	There is a servo-lock due to a sudden stop. It is possible to operate in the reverse direction.
Turn on/off ST1 (Forward rotation start) and ST2 (Reverse rotation start) simultaneously	The servo motor undergoes a deceleration stop.

POINT

- A sudden stop indicates a deceleration stop when the deceleration time constant is zero.

4. Functions and Operations of MELSERVO-J4

(8) Torque control mode startup

Start up according to section 4.3.1. This section describes content specific to torque control mode.

(a) Power-on

Turn ON the power according to the following procedure. Make sure to follow this procedure at power-on.

- 1) Turn OFF servo-on (SON).
- 2) Check that Forward rotation start (RS1)/Reverse rotation start (RS2) are OFF.
- 3) Turn ON the main circuit power supply and the control circuit power supply.
Data is displayed 2 seconds after "U" (Analog torque command) is displayed on the display.



(b) Power supply shut-off

- 1) Turn OFF Forward rotation start (RS1)/Reverse rotation start (RS2).
- 2) Turn OFF servo-on (SON).
- 3) Shut-off the main circuit power supply and the control circuit power supply.

(9) Stop

In the following statuses, the servo amplifier interrupts and stops the operation of the servo motor. For servo motors with an electromagnetic brake, refer to the servo amplifier instruction manual (MR-J4-_A).

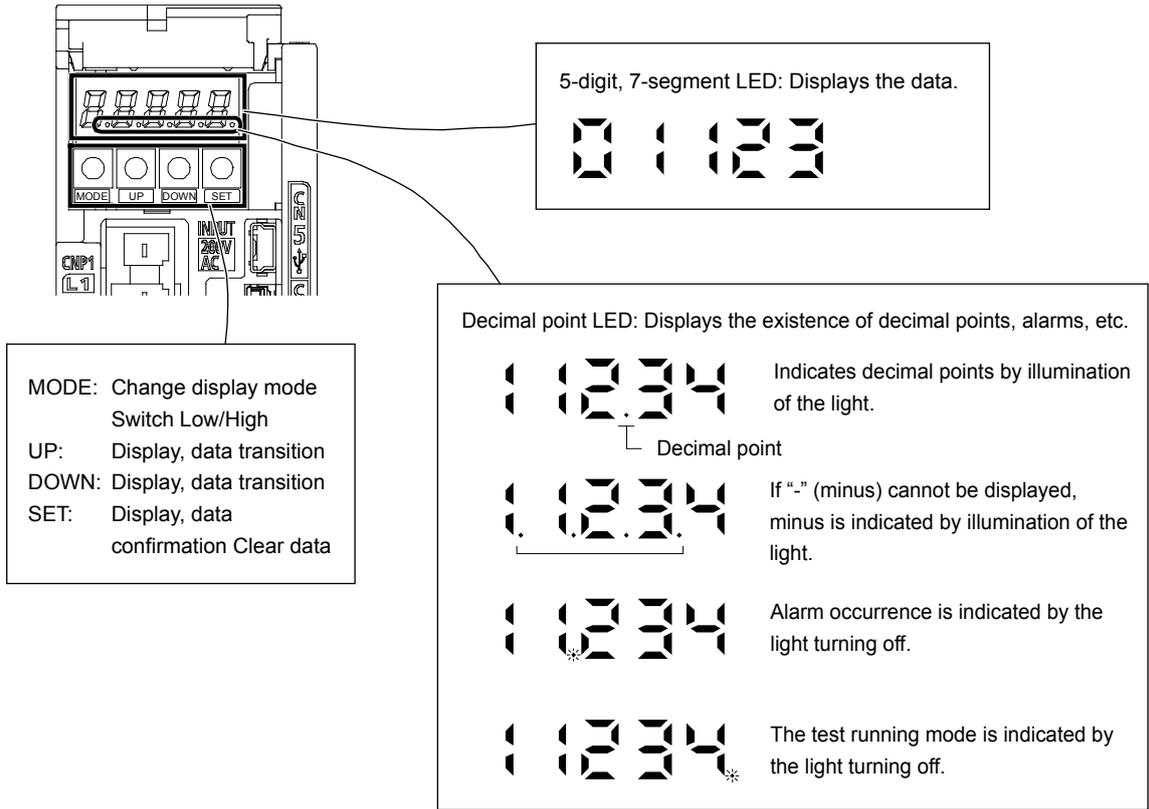
Operation/command	stop status
Turn off SON (servo-on)	The base circuit is shut off and the servo motor enters a free run.
Alarm occurrence	Perform deceleration stop of the servo motor. However, an alarm will occur when stopping by operating dynamic braking.
EM2 (Forced stop 2) off	Perform deceleration stop of the servo motor. [AL. E6 Servo forced stop warning] occurs. In torque control mode, EM2 and EM1 use the same function signal.
STO (STO1, STO2) off	The base circuit shuts off and the servo motor stops by operation of the dynamic brake.
Turn on/off RS1 (forward rotation selection) and RS2 (reverse rotation selection) simultaneously	The servo motor is free-running.

For use with training machine

4.3.6 Display/Diagnosis Function

The MR-J4_A servo amplifier configures such settings as the servo amplifier state, alarm, and parameters depending on the display (5-digit, 7-segment LED) and the component (4 push buttons). This section describes the component and display contents.

(1) Overview



For use with training machine

(2) Display Flow

The following display mode is displayed if the "MODE" button is pressed once. For the individual display mode contents, refer to the details on the following pages.

Enable basic setting parameter [Pr.PA19 Parameter write inhibited] to refer to and operate the gain/filter parameters, the extension setting parameters, and the I/O setting parameters.

Transition of display mode	Initial screen	Function
Status display		Servo status display. Displays at power-on. (Note)
One-touch tuning		One-touch tuning. Select for one-touch tuning.
Diagnostics		Sequence display, external signal display, output signal (DO) forced output, test operation, software version display, VC auto offset, servo motor series ID display, servo motor type ID display, servo motor encoder ID display, drive recorder enable/disable display.
Alarm		Current alarm display, alarm history display, and parameter error No. display.
Basic setting parameters		Display and setting of basic setting parameters.
Gain/filter parameters		Display and setting of gain/filter parameters.
Extension setting parameters		Display and setting of extension setting parameters.
I/O setting parameters		Display and setting of input/output setting parameters.
Extension setting 2 parameters		Display and setting of extension setting parameter 2.
Extension setting 2 parameters		Display and setting of extension setting 3 parameters.

Note: When the axis name is set to the servo amplifier by MR Configurator2, the axis name is displayed first before the servo status is displayed.

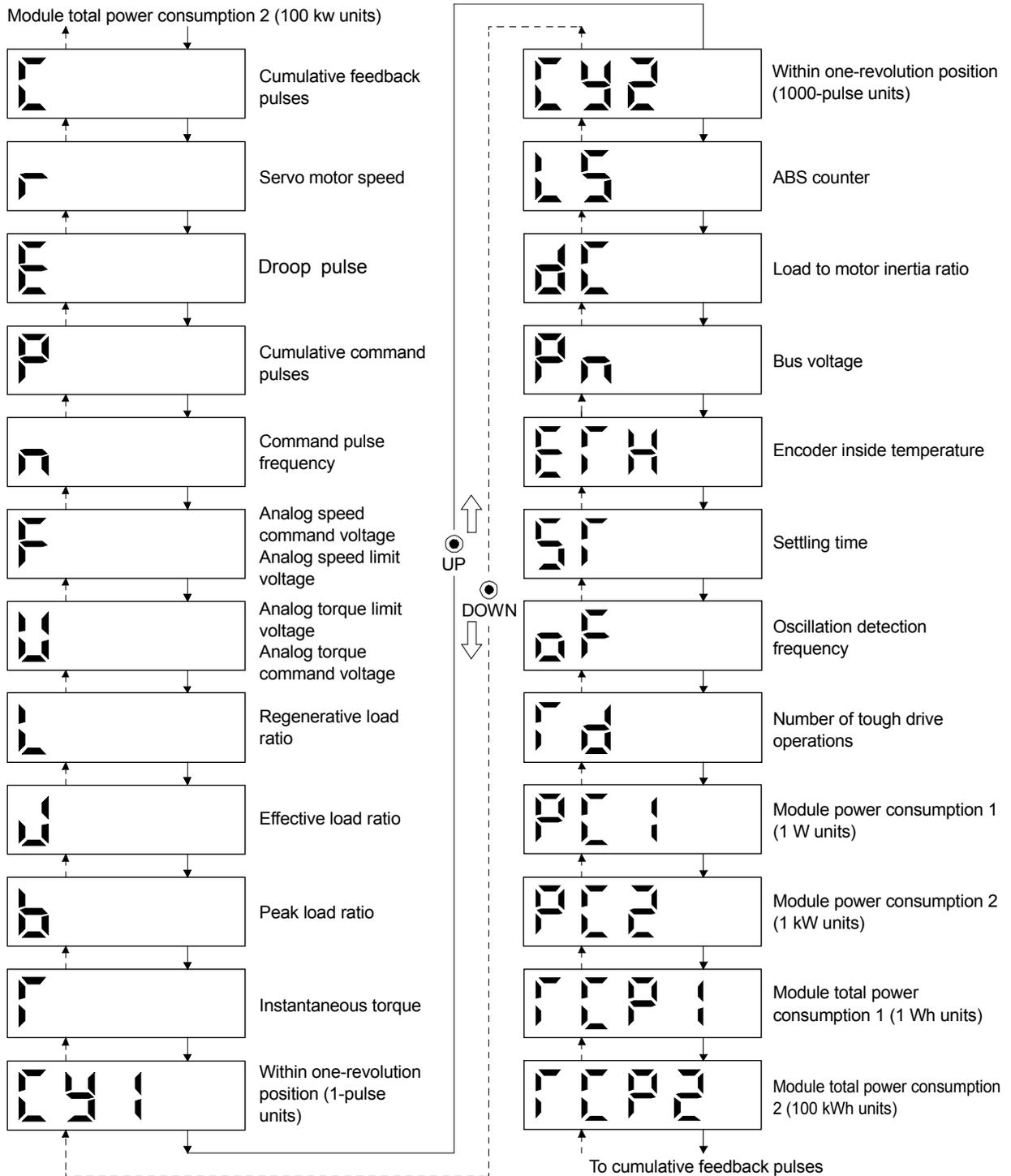
For use with training machine

(3) Status Display

The servo status during operation can be displayed on the 5-digit, 7-segment LED indicator. The contents can be changed arbitrarily with the "UP" or "DOWN" button. When selected, a symbol is displayed and the data is displayed by pressing the "SET" button. However, the data is displayed only at power-on after the status display symbol selected in [Pr. PC36] is displayed for 2 s.

(a) Display transition

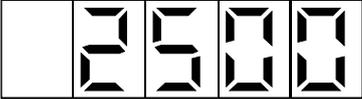
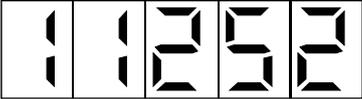
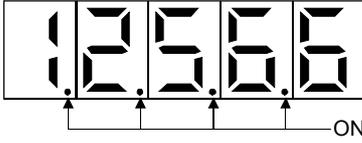
Shift to the status display mode using the "MODE" button, and transition the display as follows by pressing the "UP" or "DOWN" button.



4. Functions and Operations of MELSERVO-J4

For use with training machine

(b) Display example
A display example is shown in the following table.

Item	Status	Display method
		Servo amplifier display
Servo motor speed	Forward rotation at 2500 r/min	
	Reverse rotation at 3000 r/min	 <p>During reverse operation, "-" is displayed.</p>
Load to motor inertia ratio	x 7.00	
ABS counter	11252 rev	
	-12566 rev	 <p>At negative power, the 2, 3, 4, and 5 digit dots illuminate.</p>

4. Functions and Operations of MELSERVO-J4

For use with training machine

(4) Status display list

The servo statuses that can be displayed are shown in the following table.

Table 4.4 (1/2)

Status display	Sym- bol	Unit	Description
Cumulative feedback pulses	C	pulse	Counts and display the return pulse from the servo motor encoder. Although the count continues even after ± 99999 is exceeded, only 5 digits are displayed on the servo amplifier display. Therefore, the last 5 digits of the actual value are displayed. Press the "SET" button to set to 0. With a minus numerical value, the 2nd, 3rd, 4th, and 5th decimal points are illuminated.
Servo motor speed	r	r/min	Displays the servo motor speed. 0.1 r/min units are rounded off and displayed.
Droop pulse	E	pulse	Displays the droop pulse of the deviation counter. With a reverse rotation pulse, the 2nd, 3rd, 4th, and 5th decimal points are illuminated. Although the count continues even after ± 99999 is exceeded, only 5 digits are displayed on the servo amplifier display. Therefore, the last 5 digits of the actual value are displayed. The displayed pulse count is in encoder pulse units.
Cumulative command pulses	P	pulse	Counts and display position command input pulse. Because the value displayed is from before electronic gear (CMX/CDV) multiplication, the display of the cumulative feedback pulses may not match. Although the count continues even after ± 99999 is exceeded, only 5 digits are displayed on the servo amplifier display. Therefore, the last 5 digits of the actual value are displayed. Press the "SET" button to set to 0. At reverse rotation, the 2nd, 3rd, 4th, and 5th decimal points are illuminated.
Command pulse frequency	n	kpps	The frequency of the position command input pulse is displayed. The value before electronic gear (CMX/CDV) multiplication is displayed.
Analog speed command voltage Analog speed limit voltage	F	V	(1) Torque control mode The input voltage of the analog speed limit (VLA) is displayed. (2) Speed control mode The input voltage of the analog speed command (VC) is displayed.
Analog torque command voltage Analog torque limit voltage	U	V	(1) Position control mode/speed control mode The voltage of the analog torque limit (TLA) is displayed. (2) Torque control mode The voltage of the analog torque command (TC) is displayed.
Regenerative load ratio	L	%	The regenerative power ratio with respect to the permissible regenerative power is displayed as %.
Effective load ratio	J	%	The continuous effective load torque is displayed. The rated torque is assumed to be 100%, and the effective value of the previous 15 seconds is displayed.
Peak load ratio	b	%	The maximum value of the generated torque is displayed. The rated torque is assumed to be 100%, and the maximum value of the previous 15 seconds is displayed.
Instantaneous torque	T	%	The instantaneous torque is displayed. The generated torque value, assuming the rated torque as 100%, is displayed in real time.
Within one-revolution position (1 pulse unit)	Cy1	pulse	Within one-revolution position is displayed in increments of encoder pulses. Although the count continues even after ± 99999 is exceeded, only 5 digits are displayed on the servo amplifier display. Therefore, the last 5 digits of the actual value are displayed. Rotating in the CCW direction causes addition.
Within one-revolution position (100 pulse unit)	Cy2	1000 pulse	Within one-revolution position is displayed in increments of 1000 encoder pulses. Rotating in the CCW direction causes addition.
ABS counter	LS	rev	In absolute position detection systems, the travel distance from the home position is displayed in the multi-revolution counter value of the absolute position encoder.
Load to motor inertia ratio	dC	times	The estimated ratio of load moment of inertia converted into an equivalent value on the servo motor shaft with respect to the servo motor moment of inertia is displayed.
Bus voltage	Pn	V	The voltage of the main circuit converter (between P-N) is displayed.
Encoder inside temperature	ETh	°C	The internal temperature detected by encoder is displayed.
Settling time	ST	ms	The settling time is displayed. When 1000 mm/s is exceeded, "1000" is displayed.
Oscillation detection frequency	oF	Hz	The frequency at the time of oscillation detection is displayed.
Number of tough drive operations	Td	times	The number of times that the tough drive function has been operated is displayed.
Module power consumption 1 (1 W unit)	PC1	W	Module power consumption is displayed in 1 W units. The power drive is displayed when positive, and regenerative driving is displayed when negative. Although the count continues even after ± 99999 is exceeded, only 5 digits are displayed on the servo amplifier display. Therefore, the last 5 digits of the actual value are displayed.

4. Functions and Operations of MELSERVO-J4

For use with training machine

Table 4.4 (2/2)

Status display	Sym-bol	Unit	Description
Module power consumption 2 (1 kW unit)	PC2	kW	Module power consumption is displayed in 1 kW units. The power drive is displayed when positive, and regenerative driving is displayed when negative.
Module total power consumption 1 (1 Wh unit)	TPC1	Wh	Module total power consumption is displayed in 1 Wh units. The positive value at the time of power driving is integrated, and a negative value at the time of regenerative driving is integrated. Although the count continues even after ± 99999 is exceeded, only 5 digits are displayed on the servo amplifier display. Therefore, the last 5 digits of the actual value are displayed.
Module total power consumption 2 (100 kWh unit)	TPC2	100 kWh	Module total power consumption is displayed in 100 kWh units. The positive value at the time of power driving is integrated, and a negative value at the time of regenerative driving is integrated.

(5) Change of status display screen

The status display items of the servo amplifier display at power-on can be changed by changing [Pr. PC36]. The display items in the initial status can be changed as follows in the control mode.

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

4. Functions and Operations of MELSERVO-J4

For use with training machine

- (6) Diagnostic display mode
This mode is used to check the status of the external sequence.

Table 4.5 Diagnostic display list table

Name		Display	Description
Sequence			Not ready. When initializing or when an alarm occurs.
			Ready. When initialization is complete and operation is possible by servo-on.
Drive recorder enabled/disabled display			Drive recorder enabled. When an alarm occurs this state, the status when the alarm occurred is recorded by the drive recorder.
			Drive recorder disabled. In the following statuses, the drive recorder will not operate. 1. When the MR Configurator2 graph function is in use. 2. When the machine analyzer function is in use. 3. When [Pr. PF21] is set to "-1".
External I/O signals display		Refer to section 4.3.9.	The ON/OFF statuses of external I/O signals are displayed. For each segment, the upper portion corresponds to the input signal and the lower portion corresponds to the output signal.
Output signal (DO) forced output			The digital output signal can be forced ON/OFF.
Test operation mode	JOG operation		JOG operation can be executed when there is no command from an external controller. For details, refer to section 4.3.13 (2).
	Positioning operation		Positioning operation can be executed once when there is no command from an external controller. MR Configurator2 (setup software) SW1DNC-MRC2-J is required to perform positioning operation.
	Motor-less operation		The status display can be monitored without connecting the servo motor when the output signal is output according to the external input signal as if the servo motor were actually operating. For details, refer to section 4.3.13 (4).
	Machine analyzer operation		The resonance point of the machine system can be measured only by connecting the servo amplifier. MR Configurator2 (setup software) SW1DNC-MRC2-J is required to perform machine analyzer operation.
	For manufacturer adjustment		This is used for manufacturer adjustment.

4. Functions and Operations of MELSERVO-J4

For use with training machine

Name	Display	Description
Software version low		Displays the software version.
Software version high		Displays the software system number.
VC automatic offset		<p>Even if VC (analog speed command) and VLA (analog speed limit) are set to 0 V, when the servo motor rotates slowly by the offset voltage of the internal and external analog circuits of the servo amplifier, the offset voltage is automatically zero-adjusted.</p> <p>To use, enable according to the following procedure. When enabled, the offset voltage where the value of [Pr.PC37] is auto-adjusted is enforced.</p> <p>(1) Press "SET" once. (2) Set 1 as the 1st digit in "UP" and "DOWN". (3) Press "SET".</p> <p>If the VC or VLA input voltage is between -0.4 and +0.4 V, this function cannot be used.</p>
Motor series ID		When the "SET" button is pressed, the motor series ID of the currently connected servo motor is displayed. For a display description, refer to the MELSERVO Servo Motor Instruction Manual (Set 3).
Motor type ID		When the "SET" button is pressed, the motor type ID of the currently connected servo motor is displayed. For a display description, refer to the MELSERVO Servo Motor Instruction Manual (Set 3).
Detector ID		When the "SET" button is pressed, the detector ID of the currently connected servo motor is displayed. For a display description, refer to the MELSERVO Servo Motor Instruction Manual (Set 3).
For manufacturer adjustment		This is used for manufacturer adjustment.
For manufacturer adjustment		This is used for manufacturer adjustment.

4. Functions and Operations of MELSERVO-J4

For use with training machine

(7) Alarm display mode

The current alarm and previous alarm history and the parameter errors are displayed. The generated alarm number and the parameter number with an error are displayed in the lower two digits of the display. A display example is shown in the following table.

Table 4.6

Name	Display	Description
Current alarm	AL ---	No alarm has occurred.
	AL 331	[AL. 33.1 Main circuit voltage malfunction] occurred. Flashes when an alarm occurs.
Alarm history	A0501	[AL.50.1 Overload thermal error at the time of operation] was not generated the previous time.
	A1331	[AL.33.1 Main circuit voltage malfunction] was not generated for the last 2 times.
	A2101	[AL.10.1 Voltage drop in the control circuit power] was not generated for the last 3 times.
	⋮	⋮
	AA ---	The alarm has not gone off for the last 10 times.
	AA ---	The alarm has not gone off for the last 11 times.
Ab ---	The alarm has not gone off for the last 12 times.	
⋮	⋮	
AF ---	The alarm has not gone off for the last 16 times.	
Parameter error number	E --	[AL. 37 Parameter error] has not occurred.
	E A 12	A fault exists in the data contents of [Pr. PA12 Reverse rotation torque limit].

For use with training machine

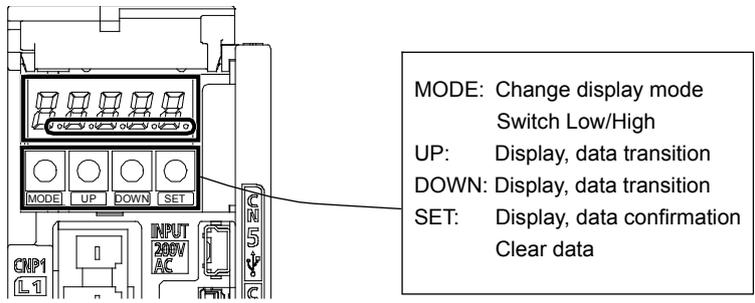
Function when an alarm occurs

- (1) The currently generated alarm is displayed on any mode screen.
- (2) The other screens can be viewed by pressing the component button even when an alarm has occurred. At this time, the decimal point at the 4th digit keeps flashing.
- (3) Clear the alarm by any of the following methods after removing the cause.
 - (a) Turn the power supply off and on.
 - (b) Press the "SET" button on the current alarm screen.
 - (c) Turn RES (reset) on.
- (4) Erase the alarm history with [Pr. PC18].
- (5) Shift to the next history using "UP" or "DOWN".

For use with training machine

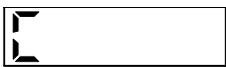
(8) Display operation

Display and parameter settings are configured by the LED indicator and the push button switch (following figure) on the front of the amplifier. The following section explains the operating procedure.



(8-1) Power-on

- (1) Turn the servo-on signal (SON) OFF.
- (2) When the power supply (NFB) is turned on, C (cumulative feedback pulses) is displayed on the display. (In position control mode)



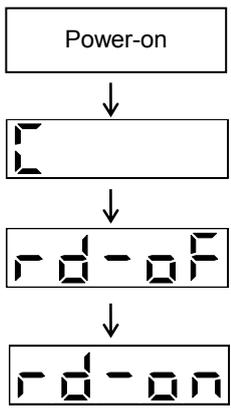
Notice: The initial display at power-on changes according to the control mode.
 In position control mode: C (cumulative feedback pulses)
 In speed control mode: r (motor rotation speed)
 In torque control mode: U (torque command voltage)
 In addition, the initial display at power-on can be changed by parameter number PC 36.

(8-2) SON signal ON

When the Servo-on signal (SON) is ON, operation is possible and the servo motor shaft is locked. (Servo-lock state)

If there is no servo-lock, a servo-on state has not been initiated. Check for an external sequence in the diagnostics display.

Check method



Press MOD 2 times.

Note: One-touch tuning is initiated first.

Turn ON SON.

This display appears with servo-on.

For use with training machine

(8-3) Status display

The initial display of the status display differs depending on the control mode. In position control mode, when <DOWN> is pressed under 'Cumulative feedback pulses' in the initially displayed status, the display contents of the figure in section 4.3.6 (2) shift from top to bottom. Press the <UP> switch to return the display to the top.

When the initial display is to be changed to arbitrary contents, selection can be done with parameter number PC18.

(8-4) Diagnostics display

The display shifts to the diagnostics display mode when the <MODE> button is pressed from the status display mode. The contents to be viewed can be accessed with the <UP> and <DOWN> buttons.

(8-5) Alarm display

To view the alarm contents or the history, the current alarm code is displayed by pressing the <MODE> button again from the diagnostics display mode.

When no current alarm is generated,



is displayed.

By pressing the <UP> button, the previous alarm code is displayed and the history up to 16 previous alarms can be viewed.

Alarm history is stored even after power-off.

Current alarm



(Error excessive)

* The display flashes.

<UP>

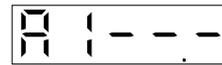
Previous alarm



(Overvoltage)

<UP>

Second previous alarm



(No alarm generated)

(8-6) When an alarm occurs during operation

When operating an alarm during motor operation, the current alarm can be immediately displayed from any display screen.

Alarm generation



(Overspeed)

Note: The other screens can be viewed by pressing the component button even when an alarm has occurred. At this time, the decimal point at the 4th digit keeps flashing.

Example: When the effective load ratio is being viewed during alarm generation
The decimal point at the 4th digit flashes.



4. Functions and Operations of MELSERVO-J4

4.3.7 Parameters

In digital servos, operations such as gain adjustment and offset adjustment of analog I/O signals, which is performed by conventional analog servos, are set by parameters. Moreover, if a mode other than the position/speed/torque control mode is selected, the functions are switched. A parameter list for MR-J4-type servo amplifiers is shown in the following table.

CAUTION

- Never perform extreme adjustments and changes to the parameters, or the operation may become unstable.
- If fixed values are written in the digits of a parameter, do not change these values.
- Do not change parameters for manufacturer settings.

(1) Parameter list (For details on the operation method, refer to section 4.3.8.)

When using this servo as the position control mode, basic parameters at the time of installation can be set mainly by setting basic setting parameters.

To enable a parameter whose abbreviation is preceded by *, turn the power OFF and then ON after setting the parameter.

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

No.	Abbreviation	Name	Initial value	Unit	Control mode		
					Position	Speed	Torque
PA01	*STY	Operation mode	1000h		○	○	○
PA02	*REG	Regenerative option	0000h		○	○	○
PA03	*ABS	Absolute position detection system	0000h		○		
PA04	*AOP1	Function selection A-1	2000h		○	○	
PA05	*FBP	Number of command input pulses per revolution	10000		○		
PA06	CMX	Electronic gear numerator (command input pulse magnification numerator)	1		○		
PA07	CDV	Electronic gear denominator (command input pulse magnification denominator)	1		○		
PA08	ATU	Auto tuning mode	0001h		○	○	
PA09	RSP	Auto tuning response	16		○	○	
PA10	INP	In-position range	100	pulse	○		
PA11	TLP	Forward rotation torque limit	100.0	%	○	○	○
PA12	TLN	Reverse rotation torque limit	100.0	%	○	○	○
PA13	*PLSS	Command pulse input form	0100h		○		
PA14	*POL	Rotation direction selection	0		○		
PA15	*ENR	Encoder output pulses	4000	pulse/rev	○	○	○
PA16	*ENR2	Encoder output pulses 2	1		○	○	○
PA17		For manufacturer setting	0000h				
PA18			0000h				
PA19	*BLK	Parameter writing inhibit	00AAh		○	○	○
PA20	*TDS	Tough drive setting	0000h		○	○	○
PA21	*AOP3	Function Selection A-3	0001h		○	○	
PA22		For manufacturer setting	0000h				
PA23	DRAT	Drive recorder arbitrary alarm trigger setting	0000h		○	○	○
PA24	AOP4	Function Selection A-4	0000h		○	○	
PA25	OTHO V	One-touch tuning - Overshoot permissible level	0	[%]	○	○	
PA26		For manufacturer setting	0000h				
PA27			0000h				
PA28			0000h				
PA29			0000h				
PA30			0000h				
PA31			0000h				
PA32			0000h				

4. Functions and Operations of MELSERVO-J4

(b) Gain/filter setting parameter ([Pr. PB_ _])

No.	Abbreviation	Name	Initial value	Unit	Control mode		
					Position	Speed	Torque
PB01	FILT	Adaptive tuning mode (adaptive filter II)	0000h		○	○	○
PB02	VRFT	Vibration suppression control tuning mode (advanced vibration suppression control II)	0000h		○		
PB03	PST	Position command acceleration/deceleration time constant (position smoothing)	0	ms	○		
PB04	FFC	Feed forward gain	0	%	○		
PB05		For manufacturer setting	500				
PB06	GD2	Load to motor inertia ratio	7.00	times	○	○	
PB07	PG1	Model loop gain	15.0	rad/s	○	○	
PB08	PG2	Position loop gain	37.0	rad/s	○		
PB09	VG2	Speed loop gain	823	rad/s	○	○	
PB10	VIC	Speed integral compensation	33.7	ms	○	○	
PB11	VDC	Speed differential compensation	980		○	○	
PB12	OVA	Overshoot amount compensation	0	[%]	○		
PB13	NH1	Machine resonance suppression filter 1	4500	Hz	○	○	○
PB14	NHQ1	Notch shape selection 1	0000h		○	○	○
PB15	NH2	Machine resonance suppression filter 2	4500	Hz	○	○	○
PB16	NHQ2	Notch shape selection 2	0000h		○	○	○
PB17	NHF	Shaft resonance suppression filter	0000h		○	○	○
PB18	LPF	Low-pass filter setting	3141	rad/s	○	○	
PB19	VRF11	Vibration suppression control 1 - Vibration frequency	100.0	Hz	○		
PB20	VRF12	Vibration suppression control 1 - Resonance frequency	100.0	Hz	○		
PB21	VRF13	Vibration suppression control 1 - Vibration frequency damping	0.00		○		
PB22	VRF14	Vibration suppression control 1 - Resonance frequency damping	0.00		○		
PB23	VFBF	Low-pass filter selection	0000h		○	○	○
PB24	*MVS	Slight vibration suppression control selection	0000h		○		
PB25	*BOP1	Function selection B-1	0000h		○		
PB26	CDP	Gain switching selection	0000h		○	○	
PB27	CDL	Gain switching condition	10	[kpps], [pulse], [r/min]	○	○	
PB28	CDT	Gain switching time constant	1	ms	○	○	
PB29	GD2B	Load to motor inertia ratio after gain switching	7.00	times	○	○	
PB30	PG2B	Position loop gain after gain switching	0.0	rad/s	○		
PB31	VG2B	Speed loop gain after gain switching	0	rad/s	○	○	
PB32	VICB	Speed integral compensation after gain switching	0.0	ms	○	○	
PB33	VRF1B	Vibration suppression control 1 - Vibration frequency after gain switching	0.0	Hz	○		
PB34	VRF2B	Vibration suppression control 1 - Resonance frequency after gain switching	0.0	Hz	○		
PB35	VRF3B	Vibration suppression control 1 - Vibration frequency damping after gain switching	0.00		○		
PB36	VRF4B	Vibration suppression control 1 - Resonance frequency damping after gain switching	0.00		○		
PB37		For manufacturer setting	1600				
PB38			0.00				
PB39			0.00				
PB40			0.00				
PB41			0000h				
PB42			0000h				
PB43			0000h				
PB44			0.00				
PB45	CNHF	Command notch filter	0000h		○		
PB46	NH3	Machine resonance suppression filter 3	4500	Hz	○	○	○
PB47	NHQ3	Notch shape selection 3	0000h		○	○	○
PB48	NH4	Machine resonance suppression filter 4	4500	Hz	○	○	○
PB49	NHQ4	Notch shape selection 4	0000h		○	○	○
PB50	NH5	Machine resonance suppression filter 5	4500	Hz	○	○	○

4. Functions and Operations of MELSERVO-J4

No.	Abbreviation	Name	Initial value	Unit	Control mode		
					Position	Speed	Torque
PB51	NHQ5	Notch shape selection 5	0000h		○	○	○
PB52	VRF21	Vibration suppression control 2 - Vibration frequency	100.0	Hz	○		
PB53	VRF22	Vibration suppression control 2 - Resonance frequency	100.0	Hz	○		
PB54	VRF23	Vibration suppression control 2 - Vibration frequency damping	0.00		○		
PB55	VRF24	Vibration suppression control 2 - Resonance frequency damping	0.00		○		
PB56	VRF21 B	Vibration suppression control 2 - Vibration frequency after gain switching	0.0	Hz	○		
PB57	VRF22 B	Vibration suppression control 2 - Resonance frequency after gain switching	0.0	Hz	○		
PB58	VRF23 B	Vibration suppression control 2 - Vibration frequency damping after gain switching	0.00		○		
PB59	VRF24 B	Vibration suppression control 2 - Resonance frequency damping after gain switching	0.00		○		
PB60	PG1B	Model loop gain after gain switching	0.0	rad/s	○	○	
PB61		For manufacturer setting	0.0				
PB62			0000h				
PB63			0000h				
PB64			0000h				

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

No.	Abbreviation	Name	Initial value	Unit	Control mode		
					Position	Speed	Torque
PC01	STA	Acceleration time constant	0	ms		○	○
PC02	STB	Deceleration time constant	0	ms		○	○
PC03	STC	S-curve acceleration/deceleration time constant	0	ms		○	○
PC04	TQC	Torque command time constant	0	ms			○
PC05	SC1	Internal speed command 1	100	r/min		○	
		Internal speed limit 1					○
PC06	SC2	Internal speed command 2	500	r/min		○	
		Internal speed limit 2					○
PC07	SC3	Internal speed command 3	1000	r/min		○	
		Internal speed limit 3					○
PC08	SC4	Internal speed command 4	200	r/min		○	
		Internal speed limit 4					○
PC09	SC5	Internal speed command 5	300	r/min		○	
		Internal speed limit 5					○
PC10	SC6	Internal speed command 6	500	r/min		○	
		Internal speed limit 6					○
PC11	SC7	Internal speed command 7	800	r/min		○	
		Internal speed limit 7					○
PC12	VCM	Analog speed command maximum speed	0	r/min		○	
		Analog speed limit maximum speed					○
PC13	TLC	Analog torque command maximum output	100.0	%			○
PC14	MOD1	Analog monitor 1 output	0000h		○	○	○
PC15	MOD2	Analog monitor 2 output	0001h		○	○	○
PC16	MBR	Electromagnetic brake sequence output	0	ms	○	○	○
PC17	ZSP	Zero speed	50	r/min	○	○	○
PC18	*BPS	Alarm history clear	0000h		○	○	○
PC19	*ENRS	Encoder output pulses selection	0000h		○	○	○
PC20	*SNO	Station number setting	0	Station	○	○	○
PC21	*SOP	RS-422 communication function selection	0000h		○	○	○
PC22	*COP1	Function selection C-1	0000h		○	○	○
PC23	*COP2	Function selection C-2	0000h		○	○	○
PC24	*COP3	Function selection C-3	0000h		○		
PC25		For manufacturer setting	0000h				
PC26	*COP5	Function selection C-5	0000h		○	○	
PC27	*COP6	Function selection C-6	0000h		○	○	○
PC28		For manufacturer setting	0000h				
PC29			0000h				

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No.	Abbreviation	Name	Initial value	Unit	Control mode		
					Position	Speed	Torque
PC30	STA2	Acceleration time constant 2	0	ms	/	○	○
PC31	STB2	Deceleration time constant 2	0	ms	/	○	○
PC32	CMX2	Command input pulse multiplication numerator 2	1	/	○	/	/
PC33	CMX3	Command input pulse multiplication numerator 3	1	/	○	/	/
PC34	CMX4	Command input pulse multiplication numerator 4	1	/	○	/	/
PC35	TL2	Internal torque limit 2	100.0	%	○	○	○
PC36	*DMD	Status display selection	0000h	/	○	○	○
PC37	VCO	Analog speed command offset	0	mV	/	○	/
		Analog speed limit offset					
PC38	TPO	Analog torque command offset	0	mV	/	/	○
		Analog torque limit offset					
PC39	MO1	Analog monitor 1 offset	0	mV	○	○	○
PC40	MO2	Analog monitor 2 offset	0	mV	○	○	○
PC41	/	For manufacturer setting	0	/	/	/	/
PC42	/		0	/	/	/	/
PC43	ERZ	Error excessive alarm detection level	0	rev	○	/	/
PC44	/	For manufacturer setting	0000h	/	/	/	/
PC45	/		0000h	/	/	/	/
PC46	/		0	/	/	/	/
PC47	/		0	/	/	/	/
PC48	/		0	/	/	/	/
PC49	/		0	/	/	/	/
PC50	/		0000h	/	/	/	/
PC51	RSBR		Forced stop deceleration time constant	100	ms	○	○
PC52	/	For manufacturer setting	0	/	/	/	/
PC53	/		0	/	/	/	/
PC54	RSUP1	Vertical axis freefall prevention compensation amount	0	0.000 1 rev	○	/	/
PC55	/	For manufacturer setting	0	/	/	/	/
PC56	/		100	/	/	/	/
PC57	/		0000h	/	/	/	/
PC58	/		0	/	/	/	/
PC59	/		0000h	/	/	/	/
PC60	*COPD		Function selection C-D	0000h	/	○	○
PC61	/	For manufacturer setting	0000h	/	/	/	/
PC62	/		0000h	/	/	/	/
PC63	/		0000h	/	/	/	/
PC64	/		0000h	/	/	/	/
PC65	/		0000h	/	/	/	/
PC66	/		0000h	/	/	/	/
PC67	/		0000h	/	/	/	/
PC68	/		0000h	/	/	/	/
PC69	/		0000h	/	/	/	/
PC70	/		0000h	/	/	/	/
PC71	2		0000h	/	/	/	/
PC72	/		0000h	/	/	/	/
PC73	/		0000h	/	/	/	/
PC74	/		0000h	/	/	/	/
PC75	/		0000h	/	/	/	/
PC76	/		0000h	/	/	/	/
PC77	/		0000h	/	/	/	/
PC78	/		0000h	/	/	/	/
PC79	/		0000h	/	/	/	/
PC80	/		0000h	/	/	/	/

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

No.	Abbreviation	Name	Initial value	Unit	Control mode		
					Position	Speed	Torque
PD01	*DIA1	Input signal automatic on selection 1	0000h		○	○	○
PD02		For manufacturer setting	0000h				
PD03	*DI1L	Input device selection 1L	0202h		○	○	
PD04	*DI1H	Input device selection 1H	0002h				○
PD05	*DI2L	Input device selection 2L	2100h		○	○	
PD06	*DI2H	Input device selection 2H	0021h				○
PD07	*DI3L	Input device selection 3L	0704h		○	○	
PD08	*DI3H	Input device selection 3H	0007h				○
PD09	*DI4L	Input device selection 4L	0805h		○	○	
PD10	*DI4H	Input device selection 4H	0008h				○
PD11	*DI5L	Input device selection 5L	0303h		○	○	
PD12	*DI5H	Input device selection 5H	0003h				○
PD13	*DI6L	Input device selection 6L	2006h		○	○	
PD14	*DI6H	Input device selection 6H	0020h				○
PD15		For manufacturer setting	0000h				
PD16			0000h				
PD17	*DI8L	Input device selection 8L	0A0Ah		○	○	
PD18	*DI8H	Input device selection 8H	0000h				○
PD19	*DI9L	Input device selection 9L	0B0Bh		○	○	
PD20	*DI9H	Input device selection 9H	0000h				○
PD21	*DI10L	Input device selection 10L	2323h		○	○	
PD22	*DI10H	Input device selection 10H	0023h				○
PD23	*DO1	Output device selection 1	0004h		○	○	○
PD24	*DO2	Output device selection 2	000Ch		○	○	○
PD25	*DO3	Output device selection 3	0004h		○	○	○
PD26	*DO4	Output device selection 4	0007h		○	○	○
PD27		For manufacturer setting	0003h				
PD28	*DO6	Output device selection 6	0002h		○	○	○
PD29	*DIF	Input filter setting	0004h		○	○	○
PD30	*DOP1	Function selection D-1	0000h		○	○	○
PD31		For manufacturer setting	0000h				
PD32	*DOP3	Function selection D-3	0000h		○		
PD33		For manufacturer setting	0000h				
PD34	DOP5	Function selection D-5	0000h		○	○	○
PD35		For manufacturer setting	0000h				
PD36			0000h				
PD37			0000h				
PD38			0				
PD39			0				
PD40			0				
PD41			0000h				
PD42			0000h				
PD43			0000h				
PD44			0000h				
PD45			0000h				
PD46			0000h				
PD47			0000h				
PD48			0000h				

4. Functions and Operations of MELSERVO-J4

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

No.	Abbreviation	Name	Initial value	Unit	Control mode		
					Position	Speed	Torque
PE01		For manufacturer setting	0000h				
PE02			0000h				
PE03			0003h				
PE04			1				
PE05			1				
PE06			400				
PE07			100				
PE08			10				
PE09			0000h				
PE10			0000h				
PE11			0000h				
PE12			0000h				
PE13			0000h				
PE14			0111h				
PE15			20				
PE16			0000h				
PE17			0000h				
PE18			0000h				
PE19			0000h				
PE20			0000h				
PE21			0000h				
PE22			0000h				
PE23			0000h				
PE24			0000h				
PE25			0000h				
PE26			0000h				
PE27			0000h				
PE28			0000h				
PE29			0000h				
PE30			0000h				
PE31			0000h				
PE32			0000h				
PE33			0000h				
PE34			1				
PE35			1				
PE36			0.0				
PE37			0.00				
PE38			0.00				
PE39			20				
PE40			0000h				
PE41	EOP3	Function selection E-3	0000h		○	○	○
PE42		For manufacturer setting	0				
PE43			0.0				
PE44			0000h				
PE45			0000h				
PE46			0000h				
PE47			0000h				
PE48			0000h				
PE49			0000h				
PE50			0000h				
PE51			0000h				
PE52			0000h				
PE53			0000h				
PE54			0000h				

4. Functions and Operations of MELSERVO-J4

No.	Abbreviation	Name	Initial value	Unit	Control mode		
					Position	Speed	Torque
PE55		For manufacturer setting	0000h				
PE56			0000h				
PE57			0000h				
PE58			0000h				
PE59			0000h				
PE60			0000h				
PE61			0.00				
PE62			0.00				
PE63			0.00				
PE64			0.00				

(f) Extension setting 3 parameters ([Pr. PF__])

No.	Abbreviation	Name	Initial value	Unit	Control mode		
					Position	Speed	Torque
PF01		For manufacturer setting	0000h				
PF02			0000h				
PF03			0000h				
PF04			0				
PF05			0				
PF06			0000h				
PF07			1				
PF08			1				
PF09	*FOP5	Function selection F-5	0000h		○	○	○
PF10		For manufacturer setting	0000h				
PF11			0000h				
PF12			10000				
PF13			100				
PF14			100				
PF15	DBT	Electronic dynamic brake operating time	2000	[ms]	○	○	○
PF16		For manufacturer setting	0000h				
PF17			10				
PF18			0000h				
PF19			0000h				
PF20			0000h				
PF21	DRT	Drive recorder switching time setting	0	[s]	○	○	○
PF22		For manufacturer setting	200				
PF23			OSCL1				
PF24	*OSCL 2	Vibration tough drive function selection	0000h		○	○	
PF25	CVAT	Instantaneous power failure tough drive - Detection time	200	[ms]	○	○	○
PF26		For manufacturer setting	0				
PF27			0				
PF28			0				
PF29			0000h				
PF30			0				
PF31	FRIC	Machine diagnosis function - Friction judgment speed	0	[r/min]	○	○	○
PF32		For manufacturer setting	50				
PF33			0000h				
PF34			0000h				
PF35			0000h				
PF36			0000h				
PF37			0000h				
PF38			0000h				
PF39			0000h				
PF40			0000h				

4. Functions and Operations of MELSERVO-J4

No.	Abbreviation	Name	Initial value	Unit	Control mode		
					Position	Speed	Torque
PF41		For manufacturer setting	0000h				
PF42			0000h				
PF43			0000h				
PF44			0000h				
PF45			0000h				
PF46			0000h				
PF47			0000h				
PF48			0000h				

(2) Parameters that must be set or confirmed before operation

When there is a mistake when setting the parameters explained here, the motor will not work and an alarm will occur. Make sure to check before operation, and if different from the initial value, change the settings.

(a) Parameter writing inhibit

		Parameter		Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name					Position	Speed	Torque
PA19	*BLK	Parameter writing inhibit		00AAh		Refer to the text	○	○	○

POINT

- After setting this parameter, it can be enabled by turning the power supply OFF→ON.

With this servo amplifier, the basic setting parameters, gain/filter parameters, and extension setting parameters can be changed in the shipped state. Writing can be prohibited in order to prevent improper changes by setting parameter number PA19.

The following table shows the references and parameters for which writing is enabled by setting parameter number PA19. Operation of parameters marked with □ is possible.

PA19	Setting value operation	PA	PB	PC	PD	PE	PF
Other than the below	Read	○					
	Write	○					
000Ah	Read	Only 19					
	Write	Only 19					
000Bh	Read	○	○	○			
	Write	○	○	○			
000Ch	Read	○	○	○	○		
	Write	○	○	○	○		
00AAh (Initial value)	Read	○	○	○	○	○	○
	Write	○	○	○	○	○	○
100Bh	Read	○					
	Write	Only 19					
100Ch	Read	○	○	○	○		
	Write	Only 19					
10AAh	Read	○	○	○	○	○	○
	Write	Only 19					

4. Functions and Operations of MELSERVO-J4

(b) Operation mode selection

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PA01	*STY	Operation mode	1000h		Refer to the text	○	○	○

POINT
<ul style="list-style-type: none"> After setting this parameter, it can be enabled by turning the power supply OFF→ON.

Select the servo amplifier operation mode.

Parameter number PA01

1	0	0	
---	---	---	--

- Selection of the operation mode
- 0: Position control mode
 - 1: Position control mode and speed control mode
 - 2: Speed control mode
 - 3: Speed control mode and torque control mode
 - 4: Torque control mode
 - 5: Torque control mode and position control mode

(c) Regenerative option selection

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PA02	*REG	Regenerative option	00h		Refer to the text	○	○	○

POINT
<ul style="list-style-type: none"> After setting this parameter, it can be enabled by turning the power supply OFF→ON. An incorrect setting may cause the regenerative option to burn out. When a regenerative option that is not available to use on a servo amplifier is selected, a parameter error (AL. 37) occurs.

This parameter is set when using a regenerative option.

Parameter number PA02

0	0		
---	---	--	--

- Selection of regenerative option
- 00: Do not use regenerative option
 - For a 100 W servo amplifier, do not use the regenerative resistor.
 - For a 0.2 kW to 7 kW servo amplifier, use the built-in regenerative resistor.
 - 01: FR-RC/FR-CV/FR-BU2
 - When using FR-RC, FR-CV, or FR-BU2, select "System 2 (___1) from "Select undervoltage alarm detection system" [Pr. PC27].
 - 02: MR-RB032
 - 03: MR-RB12
 - 04: MR-RB32
 - 05: MR-RB30
 - 06: MR-RB50 (A cooling fan is necessary.)
 - 08: MR-RB31
 - 09: MR-RB51 (A cooling fan is necessary.)
 - 0B: MR-RB3N
 - 0C: MR-RB5N (A cooling fan is necessary.)

4. Functions and Operations of MELSERVO-J4

(d) Use absolute position detection system

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PA03	*ABS	Absolute position detection system	0h		Refer to the text	○		

POINT
<ul style="list-style-type: none"> After setting this parameter, it can be enabled by turning the power supply OFF→ON.

This parameter is set when using the absolute position detection system in the position control mode.

Parameter number PA03

0	0	0	0
---	---	---	---

- └ Select "Absolute position detection system".
 0: Disabled (incremental system)
 1: Enabled: (Absolute position detection system by DIO)

(e) Use electromagnetic brake interlock (MBR)

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PA04	*AOP1	Function selection A-1	2000h		Refer to the text	○	○	

POINT
<ul style="list-style-type: none"> After setting this parameter, it can be enabled by turning the power supply OFF→ON.

This parameter is set when assigning the electromagnetic brake.

Parameter number PA04

0	0	0	0
---	---	---	---

- └ Select "Forced stop deceleration function".
 0: Forced stop deceleration function is disabled (use EM1)
 2: Forced stop deceleration function is enabled (use EM2)
 Refer to the following table for details.

Setting value	EM2/EM1	Deceleration method	
		EM2 or EM1 is off	Alarm occurred
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 _ _ _	EM2	MBR (electromagnetic brake interlock) turns off after the forced stop deceleration.	MBR (electromagnetic brake interlock) turns off after the forced stop deceleration.

(f) Number of command input pulses per servo motor revolution

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PA05	*FBP	Number of command input pulses per revolution	10000		1000 to 1000000	○		

POINT
<ul style="list-style-type: none"> After setting this parameter, it can be enabled by turning the power supply OFF→ON.

The servo motor rotates once with the set command input pulse.
 When "Number of command input pulses per revolution (1 _ _ _)" is selected in "Electronic gear selection" of [Pr. PA21], the set value of this parameter is enabled.

4. Functions and Operations of MELSERVO-J4

(g) Electronic gear

No.	Abbreviation	Parameter Name	Initial value	Unit	Setting range	Control mode		
						Position	Speed	Torque
PA06	CMX	Electronic gear numerator (command pulse multiplication numerator)	1		1 to 16777215	○		
PA07	CDV	Electronic gear denominator (command pulse multiplication denominator)	1		1 to 16777215	○		

CAUTION

- When there are setting errors, unexpected high-speed rotations may occur, leading to damage.

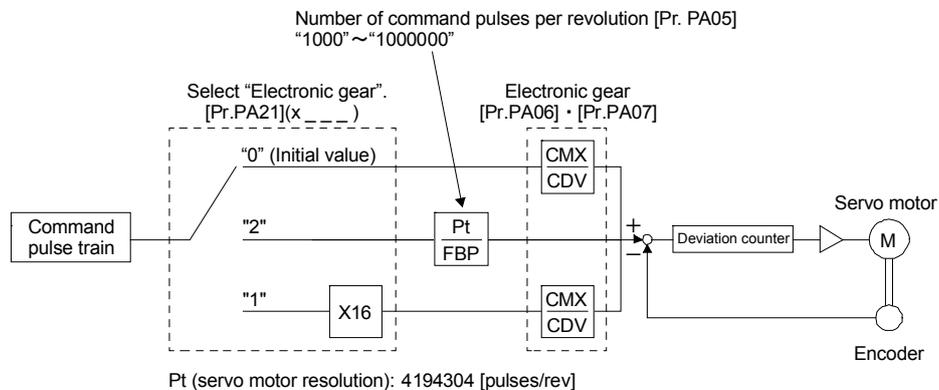
POINT

- The standard setting range of the electronic gear is $\frac{1}{10} < \frac{CMX}{CDV} < 4000$. When a value outside the range is set, there is noise during acceleration/deceleration, and operation may not be possible at the set speed and the acceleration/deceleration time constant.
- The electronic gear settings must be performed in the servo-off status in order to prevent runaway due to incorrect settings.

To enable the parameter, select "Electronic gear (0 __ __)" or "J3A electronic gear setting value compatibility mode (2 __ __)" in "Electronic gear selection" for [Pr. PA21].

(1) Electronic gear concepts

The machine can also be moved at arbitrary magnification with respect to the input pulse.



$$\frac{CMX}{CDV} = \frac{\text{Parameter No.PA06}}{\text{Parameter No.PA07}}$$

The calculation method of the electronic gear is explained in the following setting example.

POINT

- The following parameter symbols are required when calculating the electronic gear each time.
 - Pb: Ball screw lead [mm]
 - n: Reduction ratio
 - Pt: Servo motor resolution [pulse/rev]
 - Δl_0 : Travel distance per command pulse [mm/pulse]
 - ΔS : Travel distance per servo motor revolution [mm/rev]
 - $\Delta \theta^\circ$: Angle per pulse [$^\circ$ /pulse]
 - $\Delta \theta$: Angle per revolution [$^\circ$ /rev]

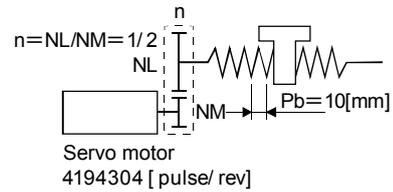
- When moving in increments of 10 μm per pulse

Machine specifications

Ball screw lead: Pb=10 [mm]

Reduction ratio: n=1/2

Servo motor resolution: Pt=4194304
[pulse/rev]



$$\frac{CMX}{CDV} = \frac{\Delta \ell / \Delta S}{\Delta S} = \frac{P_t}{n \cdot P_b} = \frac{10 \times 10^{-3}}{1/2 \cdot 10} \cdot \frac{4194304}{1000} = \frac{8388608}{125} = 1048576$$

Therefore, set CMX=1048576 and CDV=125.

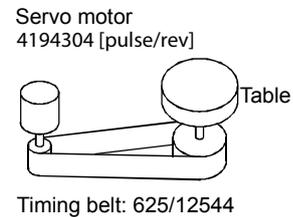
- Conveyor setting example
When rotating in increments of 0.01° per pulse

Machine specifications

Table: 360°/rev

Reduction ratio: n=625/12544

Servo motor resolution: Pt=4194304
[pulse/rev]



$$\frac{CMX}{CDV} = \Delta \theta^\circ \cdot \frac{P_t}{\Delta \theta} = 0.01 \cdot \frac{4194304}{625/12544 \cdot 360} = \frac{1644167168}{703125} \quad (5.1)$$

In this state, because CMX is not within the setting range, a reduction of the fraction is required. If CMX is reduced until within the setting range, the first place below the decimal point is rounded off.

$$\frac{CMX}{CDV} = \frac{1644167168}{703125} = \frac{13153337.3}{5625} \doteq \frac{13153337}{5625}$$

Therefore, set CMX=13153337 and CDV=5625.

POINT
<ul style="list-style-type: none"> When rotating infinitely in one direction with the index table, etc., the rounded off errors accumulate and the index position is shifted. For instance, even if 36000 pulse is input as the command in the previous example, in the table it becomes as follows, and positioning is not possible at the same position in the table. $36000 / \frac{13153337}{5625} / \frac{1}{4194304} / \frac{625}{12544} / 360^\circ = 359.99989^\circ$

(2) Precautions when reducing

The calculated value before reduction and the calculated value after reduction must be as close as possible.

With the examples in (1)(b) of this section, errors will decrease if reduced so that CDV has no fractions. If a fraction is calculated in expression (5.1) before reduction, the following applies.

$$\frac{\text{CMX}}{\text{CDV}} = \frac{1644167168}{703125} = 2338.371083 \quad (5.2)$$

When reduced so that CMX is not a fraction, the following applies.

$$\frac{\text{CMX}}{\text{CDV}} = \frac{1644167168}{703125} = \frac{14681664}{6277.9} \doteq \frac{14681664}{6278} = 2338.589359 \quad (5.3)$$

When reduced so that CDV is not a fraction, the following applies.

$$\frac{\text{CMX}}{\text{CDV}} = \frac{1644167168}{703125} = \frac{13153337.3}{5625} \doteq \frac{13153337}{5625} = 2338.371022 \quad (5.4)$$

Therefore, it is understood that the result of expression (5.4) is a value close to the calculation result of expression (5.2). Thus, the setting values of (1)(b) in this section are CMX=13153337 and CDV=5625.

4. Functions and Operations of MELSERVO-J4

(h) Auto tuning

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PA08	ATU	Auto tuning mode	0001h		Refer to the text	○	○	
PA09	RSP	Auto tuning response	16		1 to 40	○	○	

Implement gain adjustment using auto tuning.

(1) Auto tuning mode (Parameter number PA08)

Select the gain adjustment mode.

Parameter number PA08

0	0	0	
---	---	---	--

Gain adjustment mode setting

Set value	Gain adjustment mode	Automatically adjusted parameters:
___0	2 gain adjustment mode 1 (Interpolation mode)	[Pr. PB06 Load to motor inertia ratio] [Pr. PB08 Position loop gain] [Pr. PB09 Speed loop gain] [Pr. PB10 Speed integral compensation]
___1	Auto tuning mode 1	[Pr. PB06 Load to motor inertia ratio] [Pr. PB07 Model loop gain] [Pr. PB08 Position loop gain] [Pr. PB09 Speed loop gain] [Pr. PB10 Speed integral compensation]
___2	Auto tuning mode 2	[Pr. PB07 Model loop gain] [Pr. PB08 Position loop gain] [Pr. PB09 Speed loop gain] [Pr. PB10 Speed integral compensation]
___3	Manual mode	
___4	2 gain adjustment mode 2	[Pr. PB08 Position loop gain] [Pr. PB09 Speed loop gain] [Pr. PB10 Speed integral compensation]

4. Functions and Operations of MELSERVO-J4

(2) Auto tuning response (Parameter number PA09)

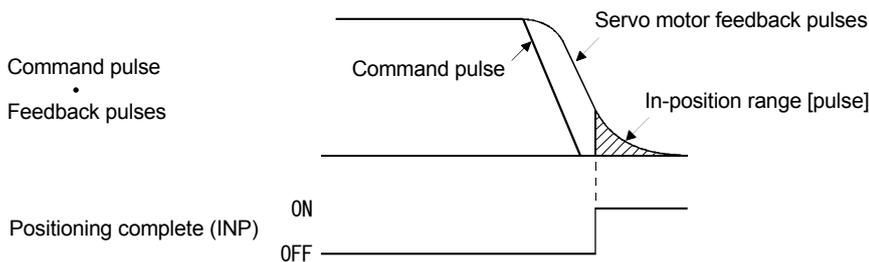
Decrease the setting value when the machine causes hunching and there is excessive gear noise. Decrease the setting value when improving performance, such as reducing the stop setting time.

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

(i) In-position range

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PA10	INP	In-position range	100	pulse	0 to 65535	○	—	—

The range is set in command pulse units before the electronic gear is calculated when positioning not completed (INP) is output. The value can be changed to detector output pulse units by setting parameter number PC24.



(j) Torque limit

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PA11	TLP	Forward rotation torque limit	100.0	%	0 to 100.0	○	○	○
PA12	TLN	Reverse rotation torque limit	100.0	%	0 to 100.0	○	○	○

The torque generated by the servo motor can be limited.

(1) Forward rotation torque limit (Parameter number PA11)

Set the parameter assuming that the maximum torque is 100 [%]. The parameter is set when limiting the torque with CCW power driving and CW regenerative driving of the servo motor. When "0.0" is set, no torque is generated.

When torque is output by analog monitor output, the torque with the higher value between this parameter or parameter number PA12 (reverse rotation torque limit) becomes the maximum output voltage (+8 V).

(2) Reverse rotation torque limit (Parameter number PA12)

Set the parameter assuming that the maximum torque is 100 [%]. The parameter is set when limiting the torque with CW power driving and CCW regenerative driving of the servo motor. When "0.0" is set, no torque is generated.

4. Functions and Operations of MELSERVO-J4

(k) Command pulse input form selection

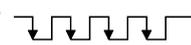
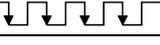
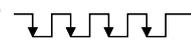
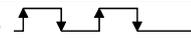
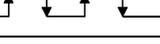
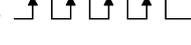
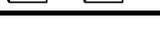
Parameter			Setting digit	Function	Initial value Unit	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PA13	*PLSS	Command pulse input form	___x	Command input pulse train form selection 0 Forward/reverse rotation pulse train 1 Signed pulse train 2 Phase A/phase B pulse train	0h	○		
			--x_	Pulse train logic selection 0 Positive logic 1 Negative logic	0h	○		
			_x__	Command input pulse train filter selection Selecting the proper filter enables noise immunity enhancement. 0 If the command input pulse train is 4 Mpps or less 1 If the command input pulse train is 1 Mpps or less 2 If the command input pulse train is 500 kpps or less 3 If the command input pulse train is 200 kpps or less (compatible from software version A5 onward) "1" corresponds to commands up to 1 Mpps. When a command of 1 Mpps to 4 Mpps is input, set "0".	1h	○		
			x___	For manufacturer setting	0h			

POINT

- After setting this parameter, it can be enabled by turning the power supply OFF→ON.

Select the input form of pulse train input signals. Three forms of command pulse types can be input, and positive logic or negative logic can be selected. An  or  arrow in the table indicates the import timing of the pulse train. Phase A and phase B pulse trains are imported by multiplying by 4.

Command pulse input form selection

Setting value		Pulse train type	At forward rotation (forward direction) command	At reverse rotation (reverse direction) command
0010h	Negative logic	Forward rotation pulse train (Forward direction pulse) Reverse rotation pulse train (Reverse direction pulse)	PP  NP 	
0011h		Pulse train + code	PP  NP 	
0012h		Phase A pulse train Phase B pulse train	PP  NP 	
0000h	Positive logic	Forward rotation pulse train (Forward direction pulse) Reverse rotation pulse train (Reverse direction pulse)	PP  NP 	
0001h		Pulse train + code	PP  NP 	
0002h		Phase A pulse train Phase B pulse train	PP  NP 	

4. Functions and Operations of MELSERVO-J4

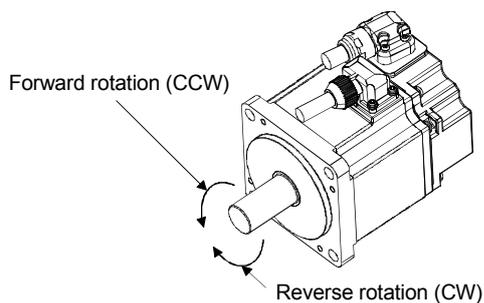
(l) Servo motor rotation direction selection

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PA14	*POL	Rotation direction selection	0		0, 1	○		

POINT
<ul style="list-style-type: none"> After setting this parameter, it can be enabled by turning the power supply OFF→ON.

Select the servo motor rotation direction relative to the input pulse train.

Parameter number PA14 Setting value	Servo motor rotation direction	
	At forward run pulse input (Note)	At reverse run pulse input (Note)
0	CCW	CW
1	CW	CCW



(m) Encoder output pulses

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PA15	*ENR	Encoder output pulses	4000	pulse/rev	1 to 4194304	○	○	○

POINT
<ul style="list-style-type: none"> After setting this parameter, it can be enabled by turning the power supply OFF→ON.

Set for the output pulse count, the dividing ratio, or the electronic gear ratio per rotation of the encoder output pulses output by the servo amplifier. (After multiplication of 4) Set the numerator of the electronic gear when "Phase A/phase B pulse electronic gear setting (_ _ 3 _)" is selected in "Encoder output pulse setting selection" of [Pr. PC19]. The maximum output frequency is 4.6 Mpps. Set to within this range.

(1) For output pulse specification

Set parameter number PC19 to "□□0□" (initial value).

Set the number of pulses per servo motor revolution.

Output pulse = setting value [pulse/rev].

For instance, when "5600" is set in parameter number PA15, the actual output phase A/phase B pulses are as follows.

$$\text{Phase A/phase B output pulse} = \frac{5600}{4} = 1400 \text{ [pulse]}$$

(2) For output dividing ratio setting

Set parameter number PC19 to "□□1□".

The number of pulses per servo motor revolution is divided by the set value.

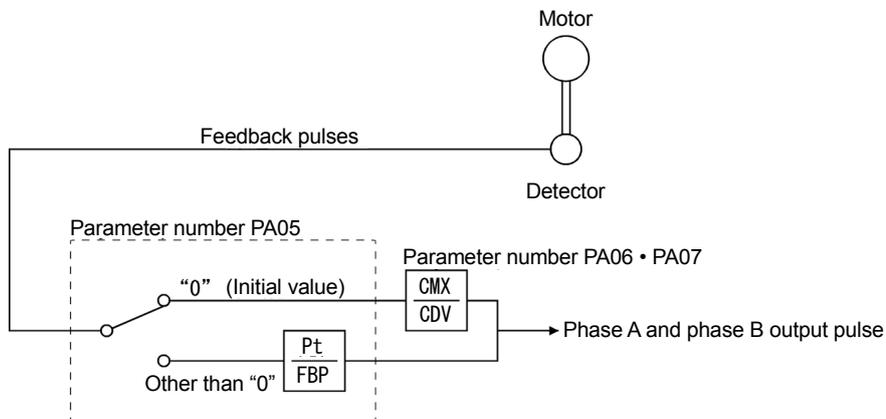
$$\text{Output pulse} = \frac{\text{Resolution per servo motor revolution}}{\text{Set value}} \text{ [pulse/rev]}$$

For instance, when "8" is set in parameter number PA15, the actual output phase A/phase B pulses are as follows.

$$\text{Phase A/phase B output pulse} = \frac{4194304}{8} / \frac{1}{4} = 131072 \text{ [pulse]}$$

(3) When a pulse train the same as the command pulse is output

Set parameter number PC19 to "□□2□". Output the feedback pulse from the servo motor detector through the following process. The feedback pulse can be output with the same pulse unit as the command pulse.



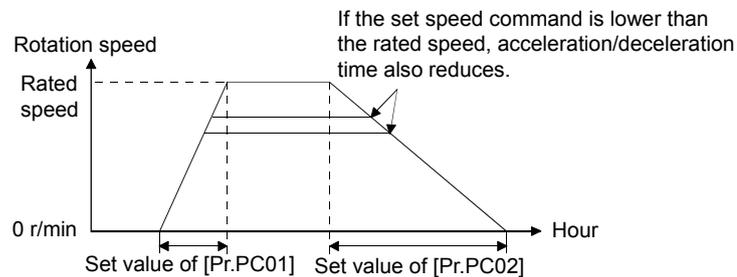
4. Functions and Operations of MELSERVO-J4

(n) Operation pattern in speed control mode

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PC01	STA	Acceleration time constant	0	ms	0 to 50000		○	○
PC02	STB	Deceleration time constant	0	ms	0 to 50000		○	○
PC05	SC1	Internal speed command 1/internal speed limit 1	100	r/min	0 to Instantaneous allowance Rotation speed		○	(Note) ○
PC06	SC2	Internal speed command 2/internal speed limit 2	500	r/min			○	
PC07	SC3	Internal speed command 3/internal speed limit 3	1000	r/min			○	
PC08	SC4	Internal speed command 4/internal speed limit 4	200	r/min			○	
PC09	SC5	Internal speed command 5/internal speed limit 5	300	r/min			○	
PC10	SC6	Internal speed command 6/internal speed limit 6	500	r/min			○	
PC11	SC7	Internal speed command 7/internal speed limit 7	800	r/min			○	

Note: With the torque control mode, these parameters become the internal speed limit.

Set the operation pattern in speed control mode.



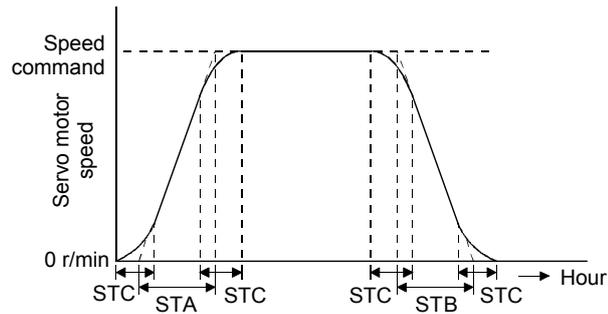
For example, for a servo motor with a rated speed of 3000 r/min, set 3000 (3 s) to increase the speed from 0 to 1000 r/min in 1 s.

4. Functions and Operations of MELSERVO-J4

(o) S-curve acceleration/deceleration time constant

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbreviation	Name				Position	Speed	Torque
PC03	STC	S-curve acceleration/deceleration time constant	0	ms	0 to 1000	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

The starting/stopping of the servo motor is smoothed.
Set the arc part time for S-pattern acceleration/deceleration.



STA: Speed acceleration time constant ([Pr. PC01])

STB: Speed deceleration time constant ([Pr. PC02])

STC: S-curve acceleration/deceleration acceleration time constant ([Pr. PC03])

If a long STA (acceleration time constant) or STB (deceleration time constant) is set, an error may occur in the arc part time for the S-curve acceleration/deceleration time constant setting. The upper limit value of the actual arc part time is limited as follows.

$$\frac{2000000}{STA} \quad \text{at the time of acceleration;} \quad \frac{2000000}{STB} \quad \text{at the time of deceleration}$$

Example: When STA, STB, and STC are set to 20000, 5000, and 200, respectively, the actual arc part time is as follows.

At acceleration: 100 [ms] $\left(\begin{array}{l} \square \text{ Because } \frac{2000000}{20000} = 100 \text{ [ms]} < 200 \text{ [ms]} \\ \square \text{ limited to } 100 \text{ [ms].} \end{array} \right)$

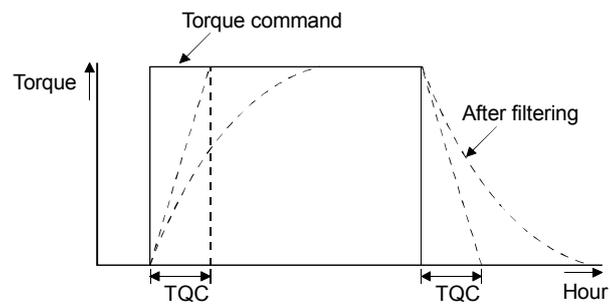
At deceleration: 200 [ms] $\left(\begin{array}{l} \square \text{ Because } \frac{2000000}{5000} = 400 \text{ [ms]} > 200 \text{ [ms]} \\ \square \text{ becomes } 200 \text{ [ms] per the settings.} \end{array} \right)$

4. Functions and Operations of MELSERVO-J4

(p) Torque command time constant

Parameter		Initial value	Unit	Setting range	Control mode		
No.	Abbreviation				Name	Position	Speed
PC04	TQC	Torque command time constant	0	ms	0 to 50000		○

Set the primary delay filter constant for the torque command.



TQC: Torque command time constant

For use with training machine

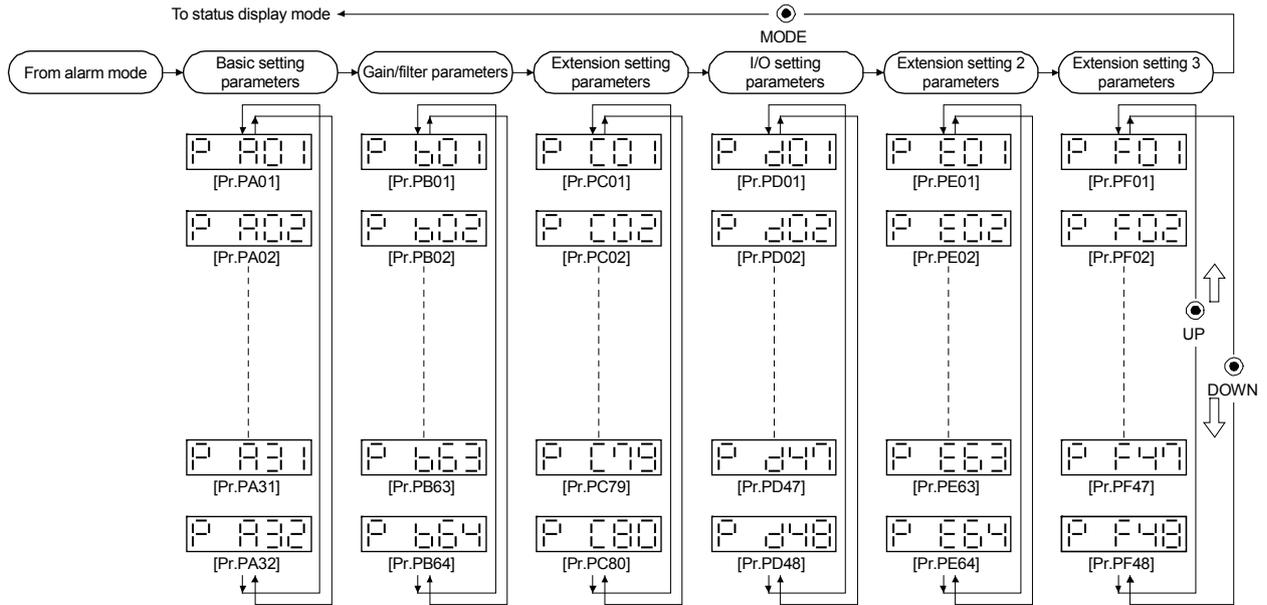
4.3.8 Parameter Setting

After power-on, initialize the parameter value depending on the operation conditions. The parameters are described in section 4.3.7. Set based on the settings specifications.
 In particular, make sure to check the parameters described in section 4.3.7 (2).

[Operating procedure]

Parameter mode transition

Shifting to each parameter mode is done with the "MODE" button, and pressing the "UP" or "DOWN" button will transition the display as follows.



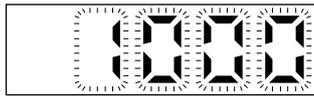
4. Functions and Operations of MELSERVO-J4

[Parameter setting example (setting value is less than 5 digits)]

This example shows the operation method after power-on when the servo has been changed to the speed control mode.



..... Displays the parameter number.
Pressing the "UP" button or "DOWN" button will change the parameter number.



Press the "SET" button twice.

..... The set value of the specified parameter starts flashing.



Press the "UP" button twice.

..... The set value can be changed while it is flashing.

Use the "UP" or "DOWN" button.

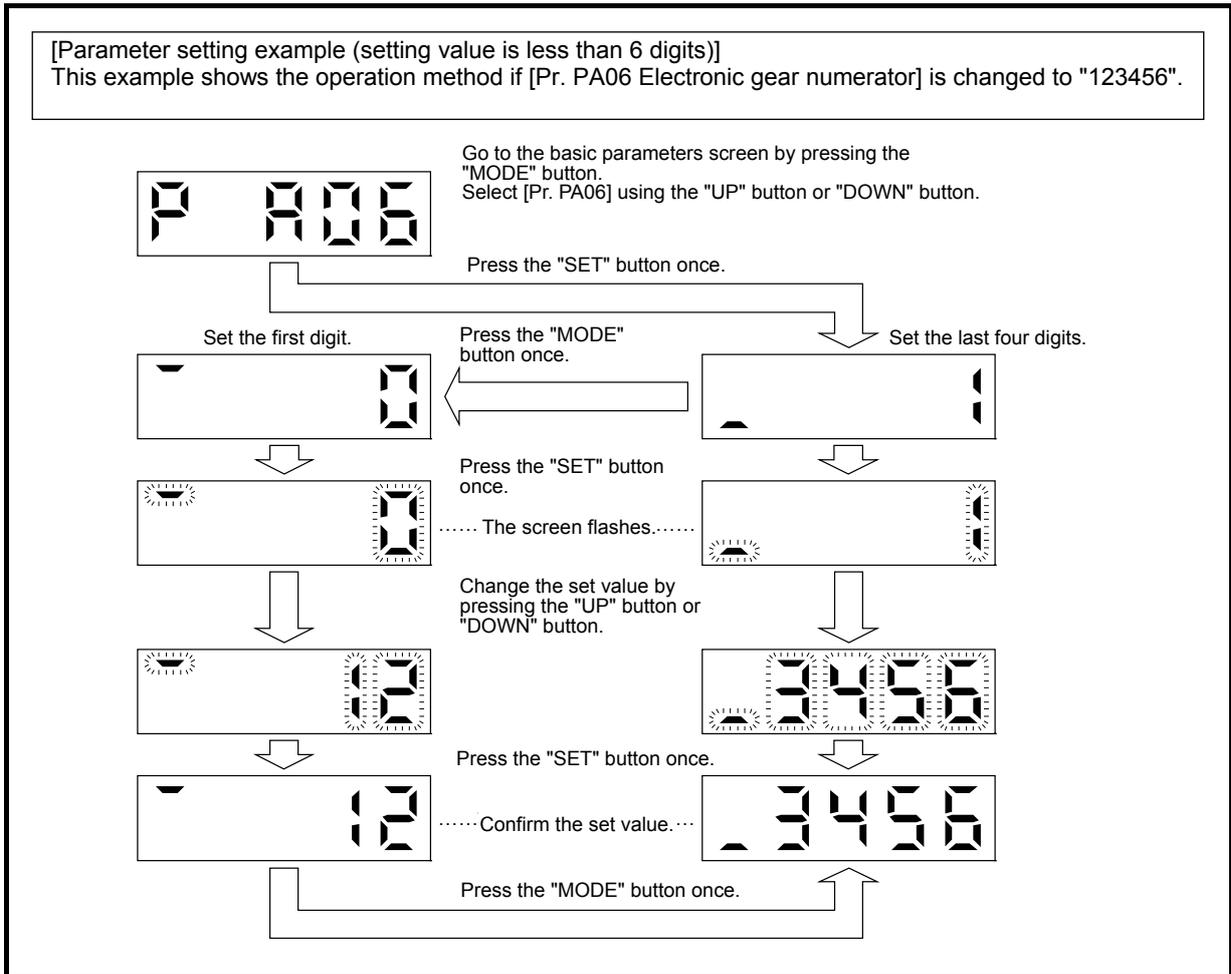
(__2: Speed control mode)

Press the "SET" button to confirm the value.

Press the "UP" or "DOWN" button to move to the next parameter.

Changes to parameter number PA01 are enabled when the power is turned OFF once and then ON again after changing the setting value.

4. Functions and Operations of MELSERVO-J4



For use with training machine

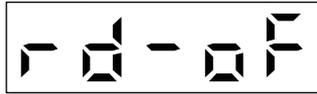
4.3.9 External I/O Signals Check

Before starting operation, verify that the operation panel, surrounding relay, etc., are connected to the I/O signals of the servo amplifier according to the wiring diagram.

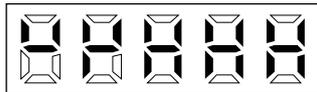
This section explains the ON/OFF diagnostics method of servo amplifier I/O signals that can be checked on the display of a servo amplifier.

(1) Operation

The display screen after power-on is shown. Move to the diagnostics screen using the "MODE" button.

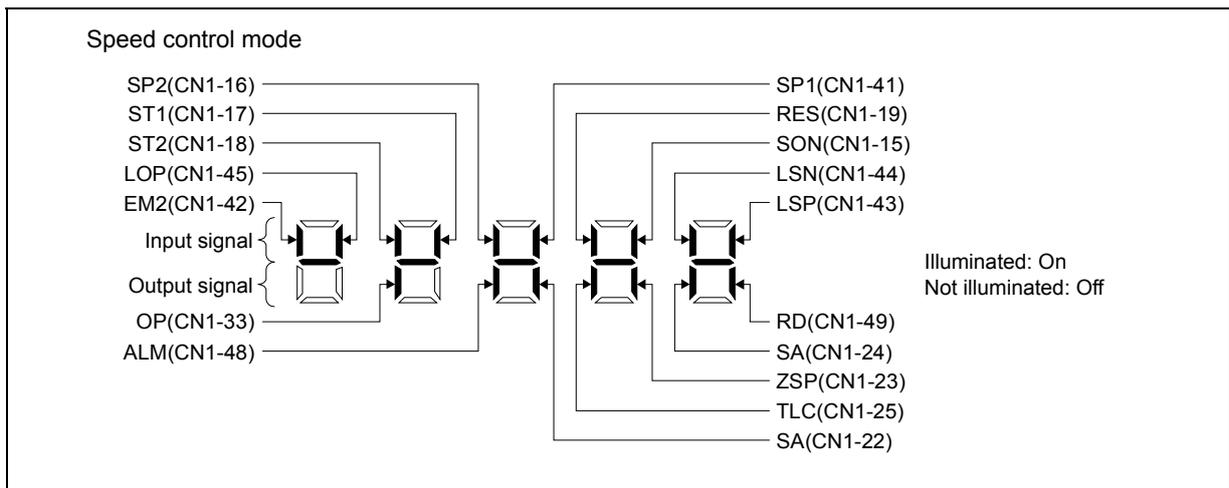
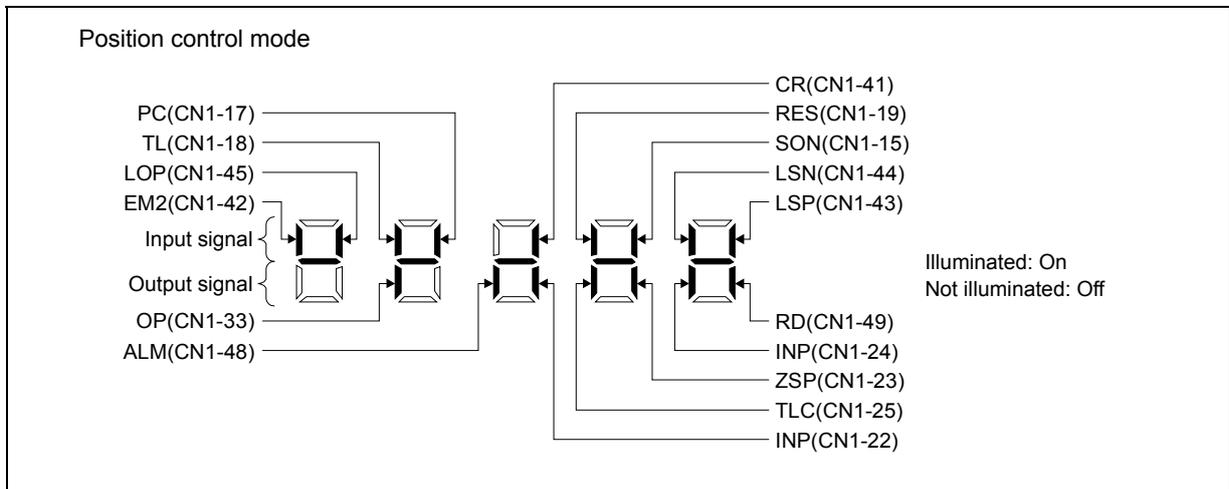


Press the "UP" button twice.

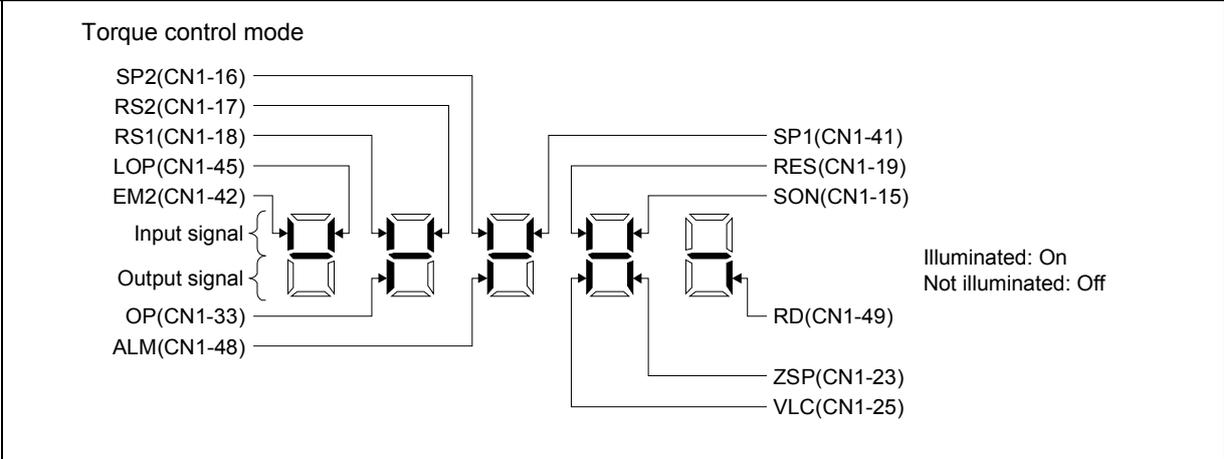


..... External I/O signal display screen

(2) Display description



4. Functions and Operations of MELSERVO-J4



4.3.10 Test Operation of Position Control Mode

Before starting this operation, implement the test operation and confirm that the machine operates normally.
For the power on/off method of the servo amplifier, refer to section 4.3.5 (4).

Test operation of just the servo motor through JOG operation of the test operation mode

Confirm that the servo amplifier and servo motor operate normally.
Check whether the servo motor rotates correctly using the test operation mode at as low a speed as possible with the servo motor disconnected from the machine. For more on the test operation mode, refer to section 4.3.13.

Test operation on just the servo motor according to commands

Confirm that the servo motor rotates correctly at the lowest possible speed using commands from controller.
Check that the servo motor rotates with the following procedure.

- 1) Turn on EM2 (forced stop) and SON (servo-on). When in the servo-on state, RD (ready) is turned on.
- 2) Turn on LSP (forward rotation stroke end) and LSN (reverse rotation stroke end).
- 3) The servo motor rotates when the pulse train is input from the controller. After the first low speed command, confirm the rotation direction of the servo motor, etc. If movement in the intended direction is not carried out, examine the input signal.

Test operation with the servo motor and machine connected

Interlock the servo motor and the machine, and confirm that the machine operates normally using commands from the controller.
Check that the servo motor rotates with the following procedure.

- 1) Turn on EM2 (forced stop) and SON (servo-on). When in the servo-on state, RD (ready) is turned on.
- 2) Turn on LSP (forward rotation stroke end) and LSN (reverse rotation stroke end).
- 3) The servo motor rotates when the pulse train is input from the controller.
After the first low speed command, confirm the operation direction of the machine, etc. If movement in the intended direction is not carried out, examine the input signal. Check the status display to confirm that there are no problems in the servo motor speed, the command pulse frequency, the load factor, etc.
- 4) Next, implement automatic operation confirmation using the controller program.

4.3.11 Test Operation of Speed Control Mode

Before starting this operation, implement the test operation and confirm that the machine operates normally.
For the power on/off method of the servo amplifier, refer to section 4.3.5 (6).

Test operation of just the servo motor through JOG operation of the test operation mode

Confirm that the servo amplifier and servo motor operate normally.

Check whether the servo motor rotates correctly using the test operation mode at as low a speed as possible with the servo motor disconnected from the machine. For more on the test operation mode, refer to section 4.3.13.

Test operation on just the servo motor according to commands

Confirm that the servo motor rotates correctly at the lowest possible speed using commands from controller.

Check that the servo motor rotates with the following procedure.

- 1) Turn on EM2 (forced stop) and SON (servo-on). When in the servo-on state, RD (ready) is turned on.
- 2) Turn on LSP (forward rotation stroke end) and LSN (reverse rotation stroke end).
- 3) The servo motor rotates when VC (analog speed command) is input from the controller and ST1 (forward rotation start) or ST2 (reverse rotation start) are turned on. After the first low speed command, confirm the rotation direction of the servo motor, etc. If movement in the intended direction is not carried out, examine the input signal.

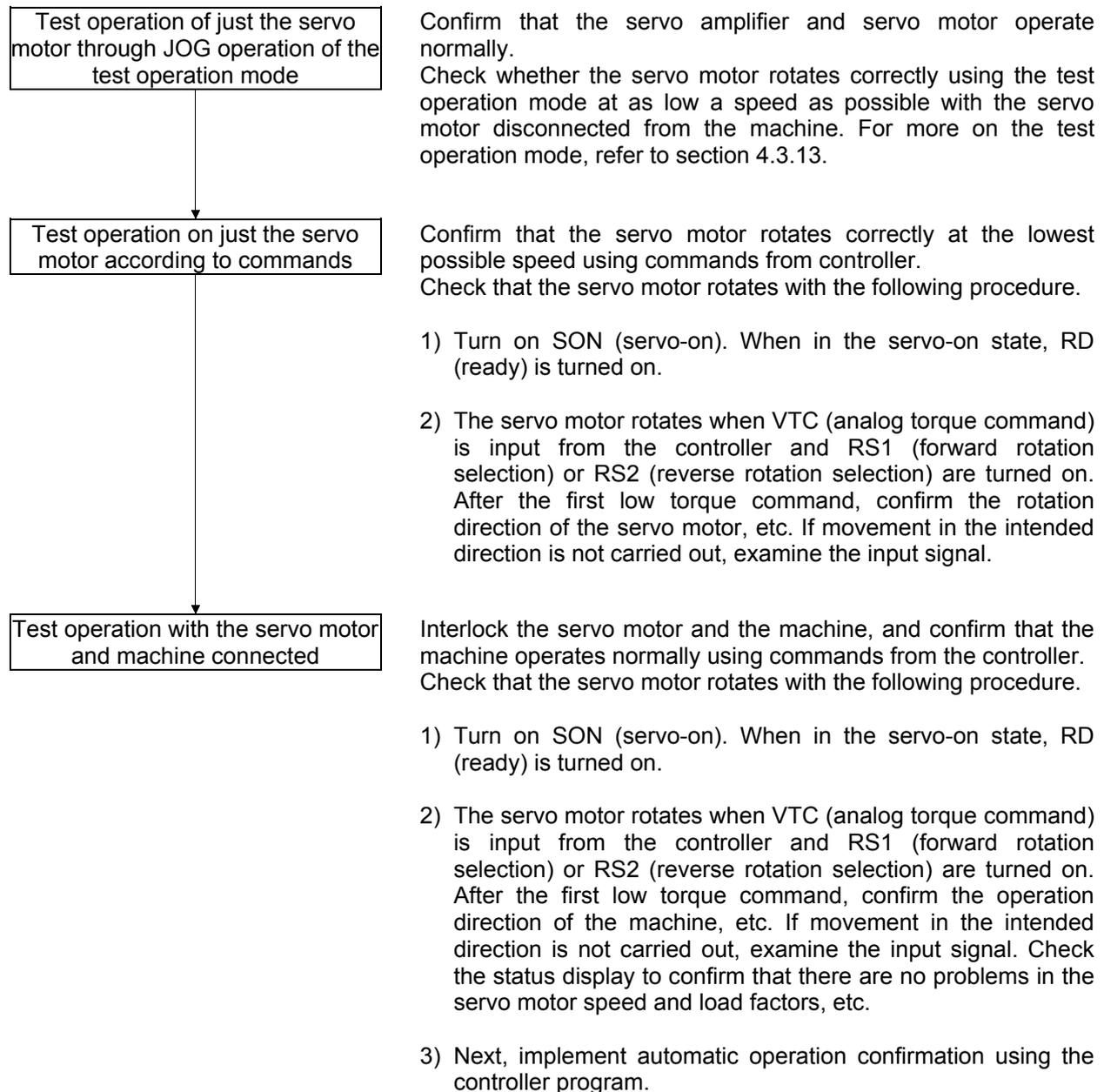
Test operation with the servo motor and machine connected

Interlock the servo motor and the machine, and confirm that the machine operates normally using commands from the controller. Check that the servo motor rotates with the following procedure.

- 1) Turn on EM2 (forced stop) and SON (servo-on). When in the servo-on state, RD (ready) is turned on.
- 2) Turn on LSP (forward rotation stroke end) and LSN (reverse rotation stroke end).
- 3) The servo motor rotates when VC (analog speed command) is input from the controller and ST1 (forward rotation start) or ST2 (reverse rotation start) are turned on. After the first low speed command, confirm the operation direction of the machine, etc. If movement in the intended direction is not carried out, examine the input signal. Check the status display to confirm that there are no problems in the servo motor speed and load factors, etc.
- 4) Next, implement automatic operation confirmation using the controller program.

4.3.12 Test Operation of Torque Control Mode

Before starting this operation, implement the test operation and confirm that the machine operates normally.
For the power on/off method of the servo amplifier, refer to section 4.3.5 (8).



4.3.13 Test Operation Mode



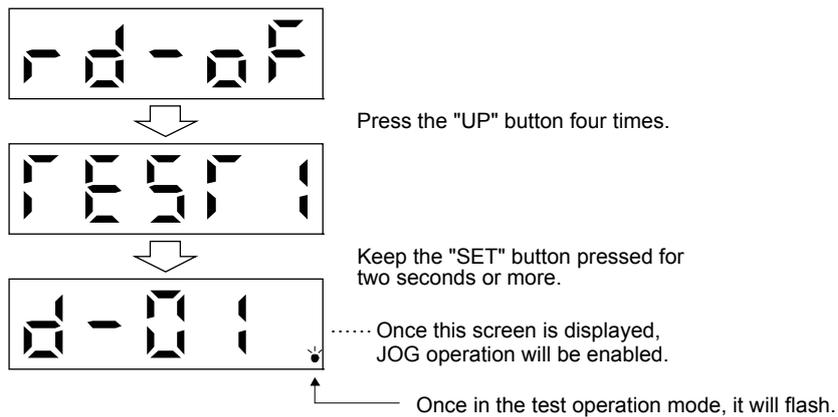
CAUTION

- The test operation mode is for confirming servo operation. Do not use in this operation.
- If an unexpected operating status arises, stop using EM2 (forced stop).

POINT
<ul style="list-style-type: none"> • With the test operation mode, the absolute position detection system by DIO (Set [Pr. PA03] to "_ _ _ 1") cannot be used. • MR Configurator2 is required for positioning operation. • Test operation cannot be executed without turning off SON (servo-on).

(1) Mode switching

The display screen after power-on is displayed. Select JOG operation/motor-less operation using the following procedure. Move to the diagnostics screen using the "MODE" button.



(2) JOG operation

POINT	<ul style="list-style-type: none"> When performing JOG operation, turn on EM2, LSP, and LSN. LSP and LSN can be turned ON automatically by setting [Pr. PD01] to "_ C _ _".
-------	--

JOG operation can be executed when there is no command from a controller.

(a) Operation/Drive

The servo motor rotates while the "UP" or "DOWN" button is pressed. Rotation stops if the button is released. When using MR Configurator2, operation conditions can be changed. The following table shows the initial conditions and setting ranges of the operation.

Item	Initial setting	Setting range
Rotation speed [r/min]	200	0 to permissible instantaneous speed
Acceleration/deceleration time constant [ms]	1000	0 to 50000

The following table offers an explanation of the buttons.

Button	Description
"UP"	Rotates in the CCW direction when pressed. Stops when released.
"DOWN"	Rotates in the CW direction when pressed. Stops when released.

When performing JOG operation using MR Configurator2, deceleration of the servo motor stops when the USB cable is removed during operation.

(b) Status display

The servo status can be confirmed during JOG operation.

The display switches to the status display screen if the "MODE" button is pressed while JOG operation is enabled. Execute JOG operation using the "UP" or "DOWN" button while on this screen. The display switches to the following status display screen each time the "MODE" button is pressed and cycles through before returning to the JOG operation enabled status screen. For details on the status display contents, refer to section 4.5.3. The status display screen can be changed using the "UP" or "DOWN" button while in the test operation mode.

(c) Termination of JOG operation

Terminate JOG operation by shutting off the power supply once or by pressing the "SET" button for 2 s or more after moving to the next screen by pressing the "MODE" button.



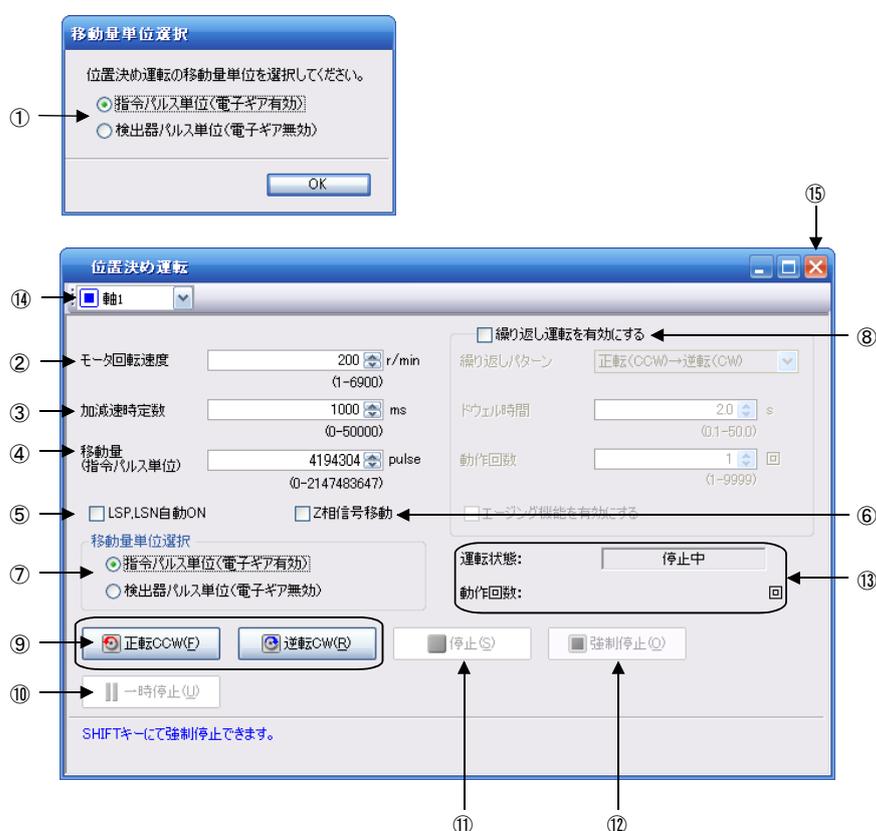
(3) Positioning operation

POINT
<ul style="list-style-type: none"> • MR Configurator2 is required to perform positioning operation. • When performing positioning operation, turn on EM2 (forced stop).

Positioning operation can be executed when there is no command from an external controller.

(a) Operation/Drive

In the MR Configurator2 menu, click on [Test operation]→[Positioning operation].



- (1) Travel distance unit selection
Displayed only when the positioning operation screen is started for the first time. Select the pulse travel distance unit.
- (2) Motor rotation speed [r/min]
Input the servo motor speed in the "Motor rotation speed" input column.
- (3) Acceleration/deceleration time constant [ms]
Input the acceleration/deceleration time constant in the "Acceleration/Deceleration time constant" input column.
- (4) Travel distance [pulse]
Input the travel distance in the "Travel distance" input column.
- (5) Automatic ON of LSP, LSN
Click the check box to enable if the external stroke signal is turned on automatically. When not checked, turn on LSN and LSP from outside.

(6) Phase Z signal movement
 Move until the initial phase Z signal turns on for the travel distance and travel direction.

(7) Travel distance unit selection
 Using the option button, select whether the travel distance set in (4) should be in command pulse units or encoder pulse units.
 When command input pulse units is selected, movement is done by the value that the electronic gear is multiplied to the travel distance set. When encoder output pulse units is selected, the electronic gear is not multiplied.

(8) Enable repeat operation
 To repeat operation, click on the check box. The following table shows the initial setting values and setting ranges of repeat operation.

Item	Initial setting	Setting range
Repeat pattern	Forward rotation (CCW) → Reverse rotation (CW)	Forward rotation (CCW) → Reverse rotation (CW) Forward rotation (CCW) → Forward rotation (CCW) Reverse rotation (CW) → Forward rotation (CCW) Reverse rotation (CW) → Reverse rotation (CW)
Dwell time [s]	2.0	0.1 to 50.0
Operation frequency [times]	1	1 to 9999

For continuous operation with a repeating pattern/dwell time set as in the table above, click on the "Make the aging function valid" check box.

(9) Servo motor start
 The servo motor rotates in the forward direction if the "Forward rotation" button is clicked.
 The servo motor rotates in the reverse run direction if the "reverse rotation" button is clicked.

(10) Servo motor pause
 Rotation of the servo motor pauses if the "Pause" button is clicked during servo motor rotation.
 This button is enabled during servo motor operation.

(11) Servo motor stop
 The servo motor stops if the "Stop" button is clicked during servo motor rotation.

(12) Forced stop
 A sudden stop is initiated if the "Forced stop" button is clicked during servo motor rotation.
 This button is enabled during servo motor operation.

(13) Operating status
 Displays the operation status and operation frequency during repeat operation.

(14) Axis number
 Displays the number of the axis in operation.

(15) Closing the positioning operation window
 The positioning operation mode is cleared and the window closed if the upper-right "X" button is clicked.

(b) Status display
 The status display can be monitored even during positioning operation.

(4) Motor-less operation

The status can be displayed without connecting the servo motor when the output signal is output according to the input device as if the servo motor were actually operating. Use is possible in a sequence check of the upper programmable controllers, etc.

(a) Operation/Drive

Select motor-less operation after turning off SON (servo-on). After that, operate from the outside similar to normal operation.

(b) Start of motor-less operation

After setting [Pr. PC60] to "___ 1", turn off the power supply and turn it on again. After that, operate from the outside similar to normal operation.

(c) Termination of motor-less operation

Turn off the power supply after setting [Pr. PC60] to "___ 0" in order to terminate motor-less operation.

(5) Program operation

Positioning operation that combines multiple operation patterns is possible without using a controller. Use after a forced stop has been cleared. Use is possible regardless of whether the servo is on/off or if a controller is connected.

Operation is performed on the program operation screen of MR Configurator2. For details, refer to the MR Configurator2 instruction manual.

Operation	Screen operation
Start	Click the "Operation start" button.
Stop	Click the "Stop" button.
Forced stop	Click the "Forced stop" button.

(6) Output signal (DO) forced output

Output signals can be turned on/off forcibly regardless of the status of the servo. Use for output signal wiring checks, etc. Operation is done on the DO forced output screen of MR Configurator2.

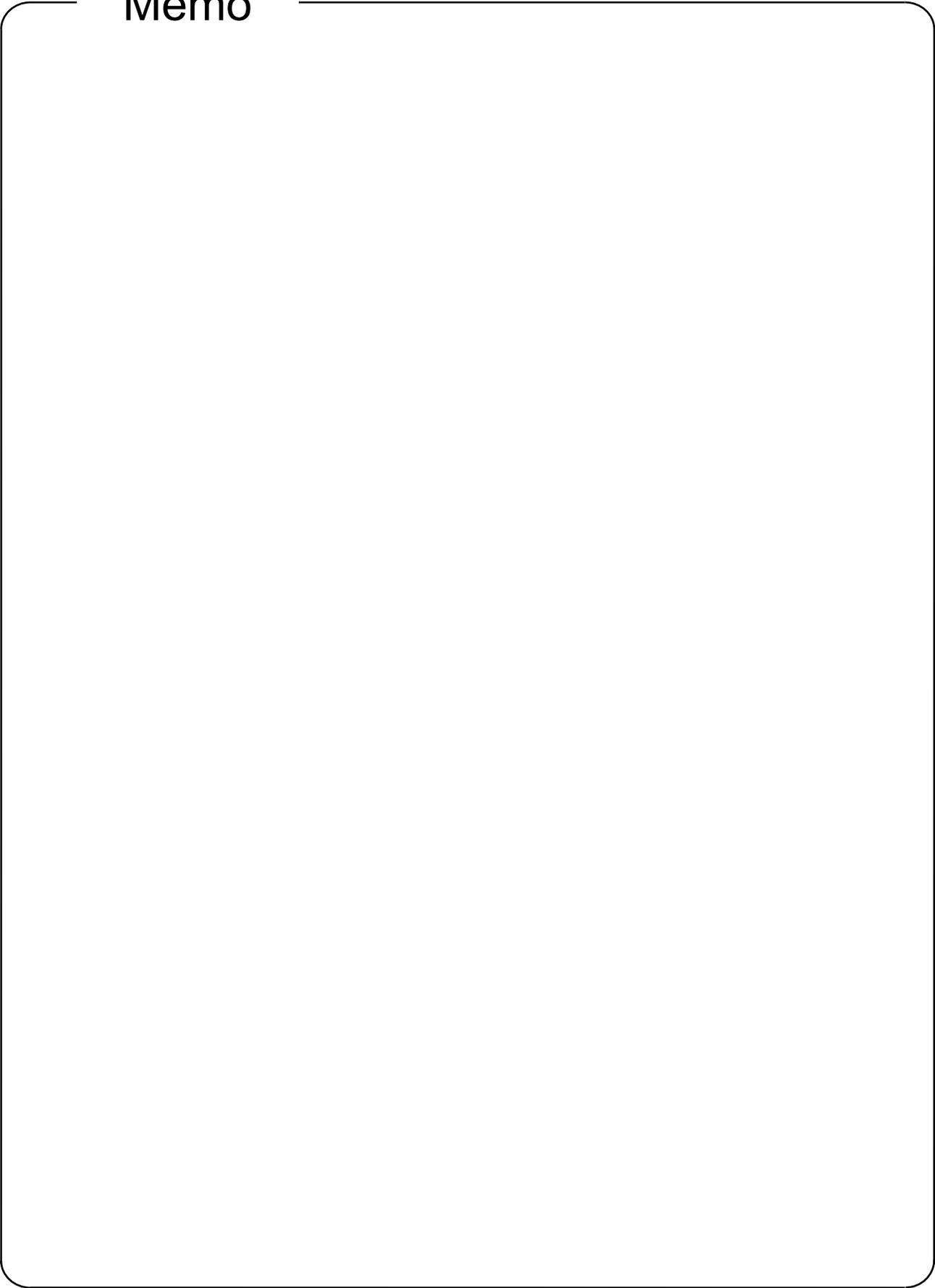
4.3.14 Useful Functions for Start-Up/Diagnostics

The MR-J4 servo amplifier provides useful functions for start-up and diagnostics besides "external I/O signal checking" in section 4.3.9 and "test operation" in section 4.3.13. The main items are listed below.

- (1) One-touch tuning: Gain adjustment of the servo amplifier is possible only by push-button operation or by one click of the MR Configurator2 button.
- (2) Auto tuning: The servo gain can be automatically adjusted per the moment of inertia of load. High, medium, low can be selected depending on the condition of the machine.
- (3) VC automatic offset: The offset of analog input signals such as the speed command can be automatically corrected.
- (4) Display of reason for stop: When the motor stops, its cause is shown on a segment of the display. This is convenient for troubleshooting.
- (5) DO forced output: Forced output of the digital output signal of the amplifier is performed. This is convenient for start-up because the external relays, lamps, etc., can be checked.
- (6) Advanced gain search: This advanced servo adjustment easily allows device performance to be used to the fullest, even without servo expertise.

Note: MR Configurator2 is required when executing advanced gain searches.

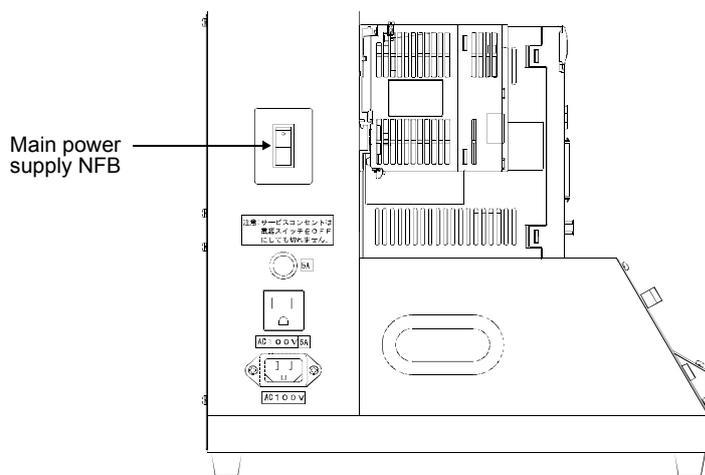
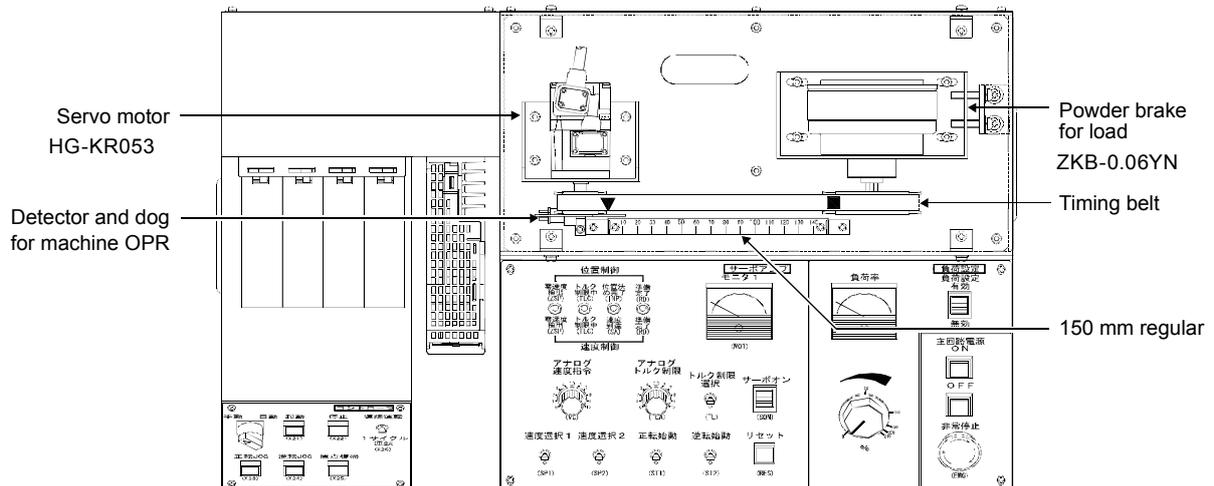
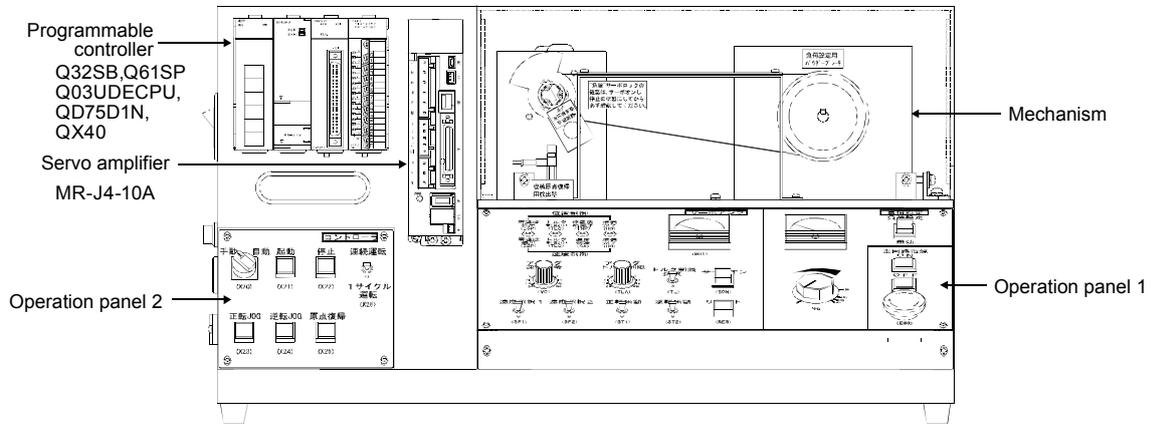
Memo



5. Training Machine Operation

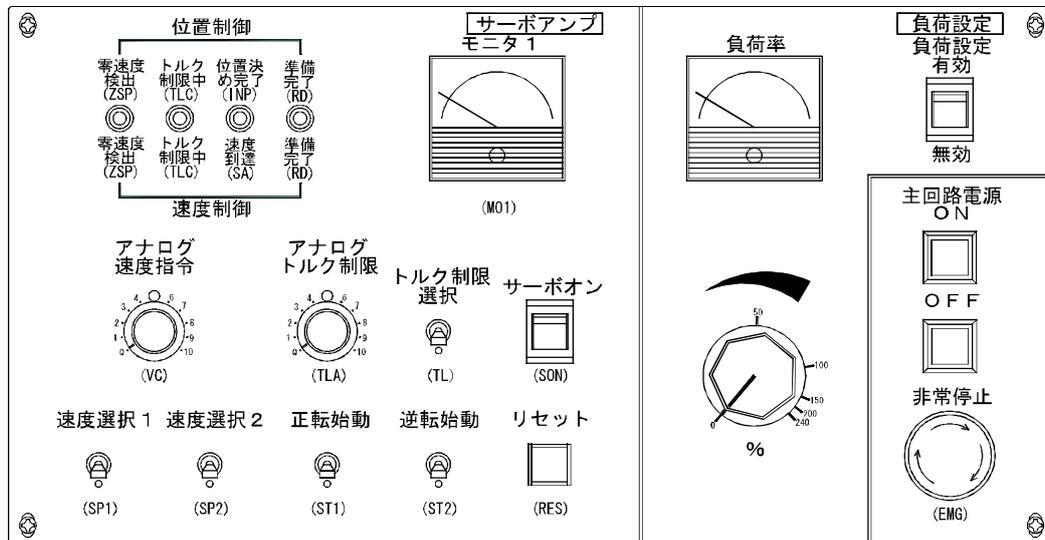
5.1 Overview of AC Servo Training Device

5.1.1 External Appearance/Configuration of Training Machine

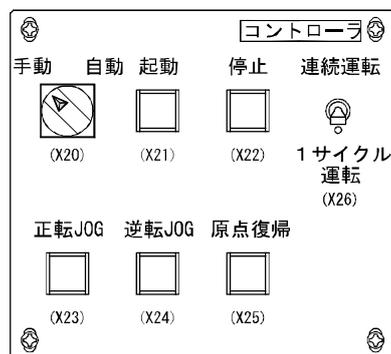


5. Training Machine Operation

5.1.2 Configuration of Input/Output Operation Panel



Operation panel 1

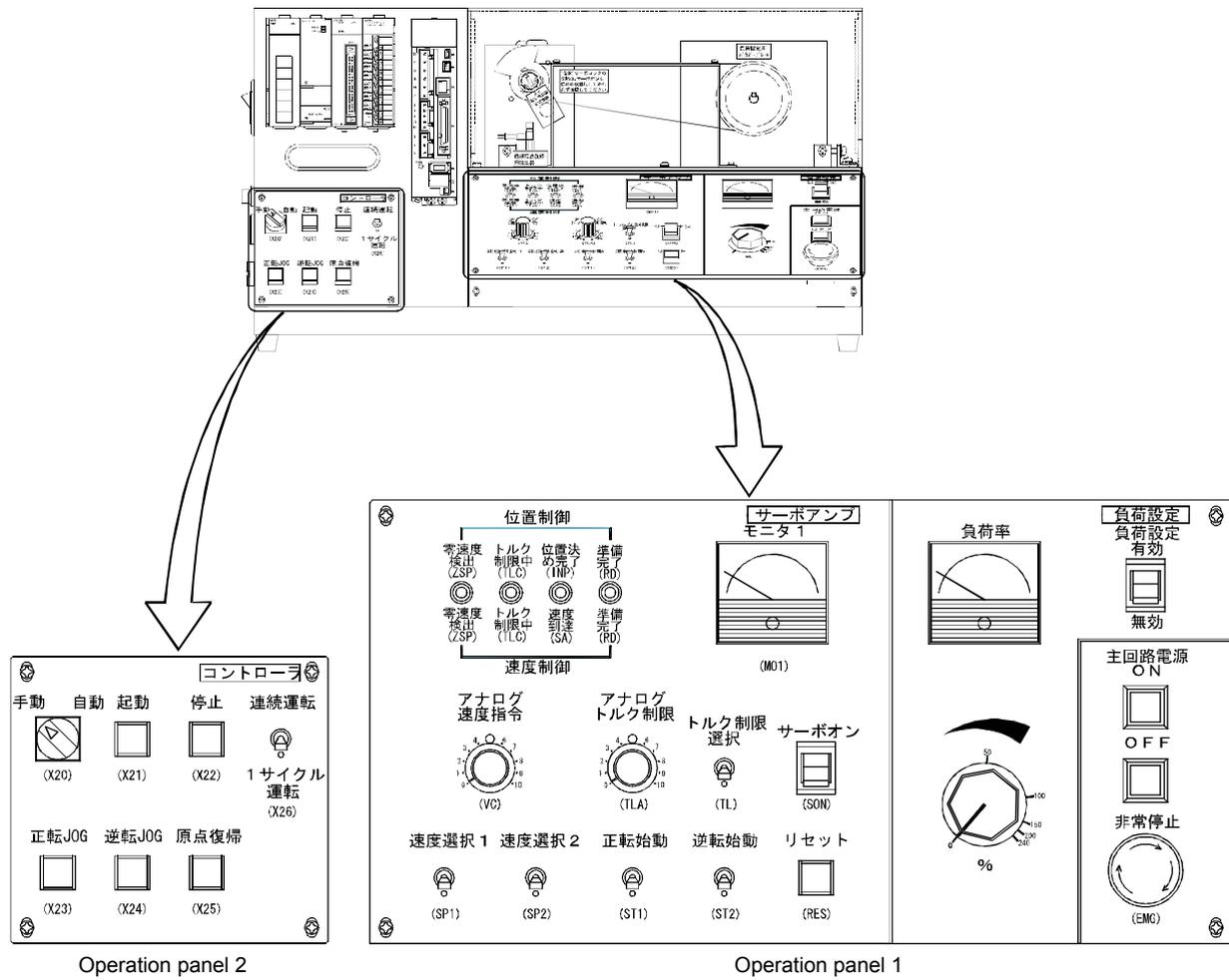


Operation panel 2

5.2 Practical Training of MR-J4 Servo Amplifier

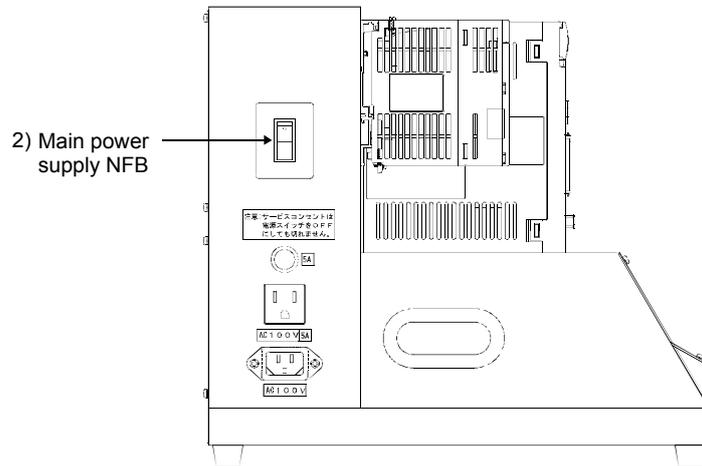
5.2.1 Speed Control

- (1) Settings before power-on
Always set all operation switches to OFF.

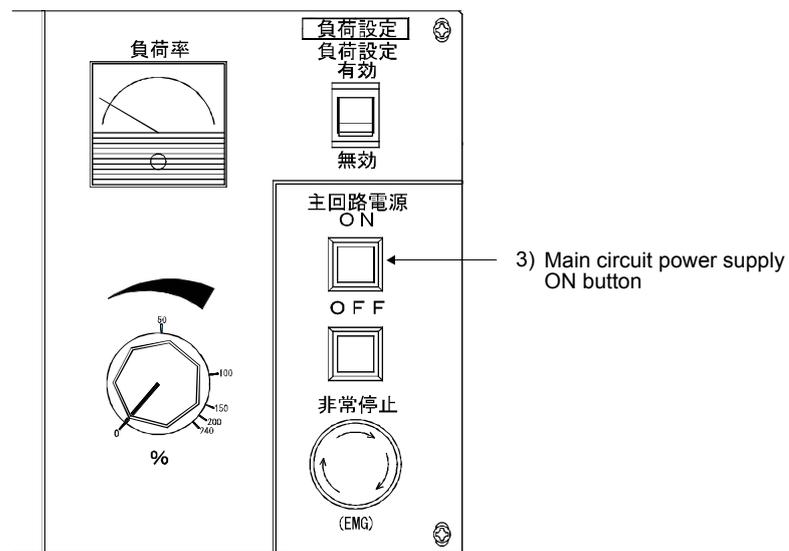


(2) Power-on

- 1) Connect the enclosed 100 V AC cable to match the shape of the outlet (two-pole parallel or two-pole parallel with grounding).
- 2) Put the main power supply NFB to ON.



- 3) Press the main circuit power supply ON button. Power is applied to the main circuit of servo amplifier.



5. Training Machine Operation

(3) Parameter setting

Before operating the training machine, set the parameters to the training device setting values (speed control) per the following table.

For how to set the parameters, refer to section 4.3.8.

POINT

- To enable a parameter whose abbreviation is preceded by *, turn the power OFF and then ON after setting the parameter.

(a) Basic setting parameters list

No.	Abbreviation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Position	Speed	Torque			Position control	Speed control
PA01	*STY	Operation mode	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	1000h		1000	1002
PA02	*REG	Regenerative option	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0000h		0000	0000
PA03	*ABS	Absolute position detection system	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000
PA04	*AOP1	Function selection A-1	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	2000h		2000	2000
PA05	*FBP	Number of command input pulses per revolution	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	10000		10000	10000
PA06	CMX	Electronic gear numerator (command input pulse magnification numerator)	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	1		4194304	4194304
PA07	CDV	Electronic gear denominator (command input pulse magnification denominator)	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	1		10000	10000
PA08	ATU	Auto tuning mode	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	0001h		0001	0001
PA09	RSP	Auto tuning response	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	16		16	16
PA10	INP	In-position range	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	100	pulse	100	100
PA11	TLP	Forward rotation torque limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	100.0	%	100.0	100.0
PA12	TLN	Reverse rotation torque limit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	100.0	%	100.0	100.0
PA13	*PLSS	Command pulse input form	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000
PA14	*POL	Rotation direction selection	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	0		0	0
PA15	*ENR	Encoder output pulses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	4000	pulse/rev	4000	4000
PA16	*ENR2	Encoder output pulses 2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	1		1	1
PA17		For manufacturer setting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000
PA18			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000
PA19	*BLK	Parameter writing inhibit	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	00AAh		00AA	00AA
PA20	*TDS	Tough drive setting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0000h		0000	0000
PA21	*AOP3	Function selection A-3	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	0001h		0001	0001
PA22		For manufacturer setting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000
PA23	DRAT	Drive recorder arbitrary alarm trigger setting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0000h		0000	0000
PA24	AOP4	Function selection A-4	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	0000h		0000	0000
PA25	OTHOV	One-touch tuning overshoot permissible level	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	0	%	0	0
PA26		For manufacturer setting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000
PA27			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000
PA28			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000
PA29			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000
PA30			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000
PA31			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000
PA32			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h		0000	0000

5. Training Machine Operation

(b) Gain/filter parameters list

No.	Abbreviation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Position	Speed	Torque			Position control	Speed control
PB01	FILT	Adaptive tuning mode (Adaptive filter II)	○	○	○	0000h		0000	0000
PB02	VRFT	Vibration suppression control tuning mode (Advanced vibration suppression control II)	○			0000h		0000	0000
PB03	PST	Position command acceleration/deceleration time constant (position smoothing)	○			0	ms	0	0
PB04	FFC	Feed forward gain	○			0	%	0	0
PB05		For manufacturer setting				500		500	500
PB06	GD2	Load to motor inertia ratio	○	○		7.0	times	7.0	7.0
PB07	PG1	Model loop gain	○	○		15.0	rad/s	15.0	15.0
PB08	PG2	Position loop gain	○			37.0	rad/s	37.0	37.0
PB09	VG2	Speed loop gain	○	○		823	rad/s	823	823
PB10	VIC	Speed integral compensation	○	○		33.7	ms	33.7	33.7
PB11	VDC	Speed differential compensation	○	○		980		980	980
PB12	OVA	Overshoot amount compensation	○			0		0	0
PB13	NH1	Machine resonance suppression filter 1	○	○	○	4500	Hz	4500	4500
PB14	NHQ1	Notch shape selection 1	○	○	○	0000h		0000	0000
PB15	NH2	Machine resonance suppression filter 2	○	○	○	4500	Hz	4500	4500
PB16	NHQ2	Notch shape selection 2	○	○	○	0000h		0000	0000
PB17	NHF	Shaft resonance suppression filter	○	○	○	0000h		Note	Note
PB18	LPF	Low-pass filter setting	○	○		3141	rad/s	3141	3141
PB19	VRF11	Vibration suppression control 1 - Vibration frequency	○			100.0	Hz	100.0	100.0
PB20	VRF12	Vibration suppression control 1 - Resonance frequency	○			100.0	Hz	100.0	100.0
PB21	VRF13	Vibration suppression control 1 - Vibration frequency damping	○			0.00		0.00	0.00
PB22	VRF14	Vibration suppression control 1 - Resonance frequency damping	○			0.00		0.00	0.00
PB23	VFBF	Low-pass filter selection	○	○	○	0000h		0000	0000
PB24	*MVS	Slight vibration suppression control selection	○			0000h		0000	0000
PB25	*BOP1	Function selection B-1	○			0000h		0000	0000
PB26	CDP	Gain switching selection	○	○		0000h		0000	0000
PB27	CDL	Gain switching condition	○	○		10	kp/s / (pulse/r min)	10	10
PB28	CDT	Gain switching time constant	○	○		1	ms	1	1
PB29	GD2B	Load to motor inertia ratio after gain switching	○	○		7.00	times	7.00	7.00
PB30	PG2B	Position loop gain after gain switching	○			0.0	rad/s	0.0	0.0
PB31	VG2B	Speed loop gain after gain switching	○	○		0	rad/s	0	0
PB32	VICB	Speed integral compensation after gain switching	○	○		0.0	ms	0.0	0.0
PB33	VRF1B	Vibration suppression control 1 - Vibration frequency after gain switching	○			100.0	Hz	100.0	100.0
PB34	VRF2B	Vibration suppression control 1 - Resonance frequency after gain switching	○			100.0	Hz	100.0	100.0
PB35	VRF3B	Vibration suppression control 1 - Vibration frequency damping after gain switching	○			0.00		0.00	0.00
PB36	VRF4B	Vibration suppression control 1 - Resonance frequency damping after gain switching	○			0.00		0.00	0.00
PB37		For manufacturer setting				1600		1600	1600
PB38						0.00		0.0	0.0
PB39						0.00		0.0	0.0
PB40						0.00		0.0	0.0
PB41						0000h		0000	0000
PB42						0000h		0000	0000
PB43						0000h		0000	0000
PB44						0.00		0000	0000

5. Training Machine Operation

No.	Abbreviation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Position	Speed	Torque			Position control	Speed control
PB45	CNHF	Command notch filter	○	△	△	0000h	△	0000	0000
PB46	NH3	Machine resonance suppression filter 3	○	○	○	4500	Hz	4500	4500
PB47	NHQ3	Notch shape selection 3	○	○	○	0000h	△	0000	0000
PB48	NH4	Machine resonance suppression filter 4	○	○	○	4500	Hz	4500	4500
PB49	NHQ4	Notch shape selection 4	○	○	○	0000h	△	0000	0000
PB50	NH5	Machine resonance suppression filter 5	○	○	○	4500	Hz	4500	4500
PB51	NHQ5	Notch shape selection 5	○	○	○	0000	△	0000	0000
PB52	VRF21	Vibration suppression control 2 - Vibration frequency	○	△	△	100.0	Hz	100.0	100.0
PB53	VRF22	Vibration suppression control 2 - Resonance frequency	○	△	△	100.0	Hz	100.0	100.0
PB54	VRF23	Vibration suppression control 2 - Vibration frequency damping	○	△	△	0.00	△	0.00	0.00
PB55	VRF24	Vibration suppression control 2 - Resonance frequency damping	○	△	△	0.00	△	0.00	0.00
PB56	VRF21B	Vibration suppression control 2 - Vibration frequency after gain switching	○	△	△	0.0	Hz	0.0	0.0
PB57	VRF22B	Vibration suppression control 2 - Resonance frequency after gain switching	○	△	△	0.0	Hz	0.0	0.0
PB58	VRF23B	Vibration suppression control 2 - Vibration frequency damping after gain switching	○	△	△	0.00	△	0.00	0.00
PB59	VRF24B	Vibration suppression control 2 - Resonance frequency damping after gain switching	○	△	△	0.00	△	0.00	0.00
PB60	PG1B	Model loop gain after gain switching	○	○	△	0.0	rad/s	0.0	0.0
PB61	△	For manufacturer setting	△	△	△	0.0	△	0.0	0.0
PB62	△		△	△	△	0000h	△	0000	0000
PB63	△		△	△	△	0000h	△	0000	0000
PB64	△		△	△	△	0000h	△	0000	0000

Note: An arbitrary value is set automatically.

5. Training Machine Operation

(c) Extension setting parameters list

No.	Abbreviation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Position	Speed	Torque			Position control	Speed control
PC01	STA	Acceleration time constant	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	0	ms	0	0
PC02	STB	Deceleration time constant	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	0	ms	0	0
PC03	STC	S-curve acceleration/deceleration time constant	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	0	ms	0	0
PC04	TQC	Torque command time constant	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	0	ms	0	0
PC05	SC1	Internal speed command 1	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	100	r/min	100	100
		Internal speed limit 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>				
PC06	SC2	Internal speed command 2	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	500	r/min	500	500
		Internal speed limit 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>				
PC07	SC3	Internal speed command 3	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	1000	r/min	1000	1000
		Internal speed limit 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>				
PC08	SC4	Internal speed command 4	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	200	r/min	200	200
		Internal speed limit 4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>				
PC09	SC5	Internal speed command 5	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	300	r/min	300	300
		Internal speed limit 5	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>				
PC10	SC6	Internal speed command 6	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	500	r/min	500	500
		Internal speed limit 6	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>				
PC11	SC7	Internal speed command 7	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	800	r/min	800	800
		Internal speed limit 7	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>				
PC12	VCM	Analog speed command maximum speed	<input type="checkbox"/>	<input type="radio"/>	<input type="checkbox"/>	0	r/min	0	0
		Analog speed limit maximum speed	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>				
PC13	TLC	Analog torque command maximum output	<input type="checkbox"/>	<input type="checkbox"/>	<input type="radio"/>	100.0	%	100.0	100.0
PC14	MOD1	Analog monitor 1 output	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0000h	<input type="checkbox"/>	0002	0002
PC15	MOD2	Analog monitor 2 output	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0001h	<input type="checkbox"/>	0001	0001
PC16	MBR	Electromagnetic brake sequence output	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0	ms	0	0
PC17	ZSP	Zero speed	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	50	r/min	50	50
PC18	*BPS	Alarm history clear	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0000h	<input type="checkbox"/>	0000	0000
PC19	*ENRS	Encoder output pulses selection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0000h	<input type="checkbox"/>	0000	0000
PC20	*SNO	Station number setting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0	Station	0	0
PC21	*SOP	RS-422 communication function selection	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0000h	<input type="checkbox"/>	0000	0000
PC22	*COP1	Function selection C-1	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0000h	<input type="checkbox"/>	0000	0000
PC23	*COP2	Function selection C-2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0000h	<input type="checkbox"/>	0000	0000
PC24	*COP3	Function selection C-3	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	0000h	<input type="checkbox"/>	0000	0000
PC25		For manufacturer setting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h	<input type="checkbox"/>	0000	0000
PC26	*COP5	Function selection C-5	<input type="radio"/>	<input type="radio"/>	<input type="checkbox"/>	0000h	<input type="checkbox"/>	0000	0000
PC27	*COP6	Function selection C-6	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h	<input type="checkbox"/>	0000	0000
PC28		For manufacturer setting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h	<input type="checkbox"/>	0000	0000
PC29		For manufacturer setting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	0000h	<input type="checkbox"/>	0000	0000
PC30	STA2	Acceleration time constant 2	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	0	ms	0	0
PC31	STB2	Deceleration time constant 2	<input type="checkbox"/>	<input type="radio"/>	<input type="radio"/>	0	ms	0	0
PC32	CMX2	Command input pulse multiplication numerator 2	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	<input type="checkbox"/>	1	1
PC33	CMX3	Command input pulse multiplication numerator 3	<input type="radio"/>	<input type="checkbox"/>	<input type="checkbox"/>	1	<input type="checkbox"/>	1	1

5. Training Machine Operation

No.	Abbreviation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Position	Speed	Torque			Position control	Speed control
PC34	CMX4	Command input pulse multiplication numerator 4	○	/	/	1	/	1	1
PC35	TL2	Internal torque limit 2	○	○	○	100.0	%	100.0	100.0
PC36	*DMD	Status display selection	○	○	○	0000h	/	0000	0000
PC37	VCO	Analog speed command offset	/	○	/	0	mV	0	0
		Analog speed limit offset	/	/	○	/	/	/	/
PC38	TPO	Analog torque command offset	/	/	○	0	mV	0	0
		Analog torque limit offset	/	○	/	/	/	/	/
PC39	MO1	Analog monitor 1 offset	○	○	○	0	mV	0	0
PC40	MO2	Analog monitor 2 offset	○	○	○	0	mV	0	0
PC41	/	/	/	/	/	0	/	0	0
PC42	/	For manufacturer setting	/	/	/	0	/	0	0
PC43	ERZ	Error excessive alarm detection level	○	/	/	0	rev	0000	0000
PC44	/	/	/	/	/	0000h	/	0000	0000
PC45	/	/	/	/	/	0000h	/	0000	0000
PC46	/	/	/	/	/	0	/	0000	0000
PC47	/	For manufacturer setting	/	/	/	0	/	0000	0000
PC48	/	/	/	/	/	0	/	0000	0000
PC49	/	/	/	/	/	0	/	0000	0000
PC50	/	/	/	/	/	0000h	/	0000	0000
PC51	RSBR	Forced stop deceleration time constant	○	○	/	100	ms	100	100
PC52	/	For manufacturer setting	/	/	/	0	/	0	0
PC53	/	/	/	/	/	0	/	0	0
PC54	RSUP1	Vertical axis freefall prevention compensation amount	○	/	/	0	0.000 1 rev	0	0
PC55	/	/	/	/	/	0	/	0	0
PC56	/	/	/	/	/	100	/	100	100
PC57	/	For manufacturer setting	/	/	/	0000h	/	0000	0000
PC58	/	/	/	/	/	0	/	0	0
PC59	/	/	/	/	/	0000h	/	0000	0000
PC60	*COPD	Function selection C-D	○	○	○	0000h	/	0000	0000
PC61	/	/	/	/	/	0000h	/	0000	0000
PC62	/	/	/	/	/	0000h	/	0000	0000
PC63	/	/	/	/	/	0000h	/	0000	0000
PC64	/	/	/	/	/	0000h	/	0000	0000
PC65	/	/	/	/	/	0000h	/	0000	0000
PC66	/	/	/	/	/	0000h	/	0000	0000
PC67	/	/	/	/	/	0000h	/	0000	0000
PC68	/	/	/	/	/	0000h	/	0000	0000
PC69	/	/	/	/	/	0000h	/	0000	0000
PC70	/	/	/	/	/	0000h	/	0000	0000
PC71	/	For manufacturer setting	/	/	/	0000h	/	0000	0000
PC72	/	/	/	/	/	0000h	/	0000	0000
PC73	/	/	/	/	/	0000h	/	0000	0000
PC74	/	/	/	/	/	0000h	/	0000	0000
PC75	/	/	/	/	/	0000h	/	0000	0000
PC76	/	/	/	/	/	0000h	/	0000	0000
PC77	/	/	/	/	/	0000h	/	0000	0000
PC78	/	/	/	/	/	0000h	/	0000	0000
PC79	/	/	/	/	/	0000h	/	0000	0000
PC80	/	/	/	/	/	0000h	/	0000	0000

5. Training Machine Operation

(d) I/O setting parameters list

No.	Abbreviation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Position	Speed	Torque			Position control	Speed control
PD01	*DIA1	Input signal automatic on selection 1	○	○	○	0000h		0C00	0C00
PD02		For manufacturer setting				0000h		0000	0000
PD03	*DI1L	Input device selection 1L	○	○		0202h		0202	0202
PD04	*DI1H	Input device selection 1H			○	0002h		0002	0002
PD05	*DI2L	Input device selection 2L	○	○		2100h		2100	2100
PD06	*DI2H	Input device selection 2H			○	0021h		0021	0021
PD07	*DI3L	Input device selection 3L	○	○		0704h		0700	0700
PD08	*DI3H	Input device selection 3H			○	0007h		0007	0007
PD09	*DI4L	Input device selection 4L	○	○		0805h		0505	0505
PD10	*DI4H	Input device selection 4H			○	0008h		0000	0000
PD11	*DI9	Input device selection 5L	○	○		0303h		0303	0303
PD12	*DI5H	Input device selection 5H			○	0003h		0003	0003
PD13	*DI6L	Input device selection 6L	○	○		2006h		0606	0606
PD14	*DI6H	Input device selection 6H			○	0020h		0006	0006
PD15		For manufacturer setting				0000h		0000	0000
PD16						0000h		0000	0000
PD17	*DI8L	Input device selection 8L	○	○		0A0Ah		0800	0800
PD18	*DI8H	Input device selection 8H			○	0000h		0008	0008
PD19	*DI9L	Input device selection 9L	○	○		0B0Bh		2000	2000
PD20	*DI9H	Input device selection 9H			○	0000h		0020	0020
PD21	*DI10L	Input device selection 10L	○	○		2323h		2323	2323
PD22	*DI10H	Input device selection 10H			○	0023h		0023	0023
PD23	*DO1	Output device selection 1				0004h		0002	0002
PD24	*DO2	Output device selection 2	○	○	○	000Ch		000C	000C
PD25	*DO3	Output device selection 3	○	○	○	0004h		0004	0004
PD26	*DO4	Output device selection 4	○	○	○	0007h		0007	0007
PD27		For manufacturer setting				0003h		0003	0003
PD28	*DO6	Output device selection 6	○	○	○	0002h		0002	0002
PD29	*DIF	Input filter setting	○	○	○	0004h		0004	0004
PD30	*DOP1	Function selection D-1	○	○	○	0000h		0000	0000
PD31		For manufacturer setting				0000h		0000	0000
PD32	*DOP3	Function selection D-3	○	○	○	0000h		0000	0000
PD33		For manufacturer setting				0000h		0000	0000
PD34	DOP5	Function selection D-5	○	○	○	0000h		0000	0000

5. Training Machine Operation

(e) Extension setting 2 parameters ([Pr. PE__])

No.	Abbreviation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Position	Speed	Torque			Position control	Speed control
PE41	EOP3	Function selection E-3	○	○	○	0000h		0000	0000

(f) Extension setting 3 parameters ([Pr. PF__])

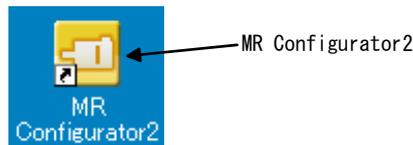
No.	Abbreviation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Position	Speed	Torque			Position control	Speed control
PF21	DRT	Drive recorder switching time setting	○	○	○	0	[s]	0	0
PF22		For manufacturer setting				200		200	200
PF23	OSCL1	Vibration tough drive - Oscillation detection level	○	○		50	[%]	50	50
PF24	*OSCL2	Vibration tough drive function selection	○	○		0000h		0000	0000
PF25	CVAT	Instantaneous power failure tough drive - Detection time	○	○	○	200	[ms]	200	200
PF26		For manufacturer setting				0		0	0
PF27						0		0	
PF28						0		0	
PF29						0000h		0000	
PF30						0		0	
PF31	FRIC	Machine diagnosis function - Friction judgment speed	○	○	○	0	[r/min]	0	0

(4) Parameter setting from MR Configurator2 (setup software)

It is possible to connect a personal computer with MR Configurator2 (setup software) installed and a servo amplifier to carry out simple parameter checks and setting. The method for checking and configuring the settings is shown below.

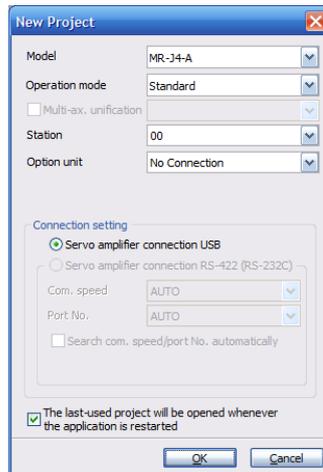


1) Double-click the MR Configurator2 icon.

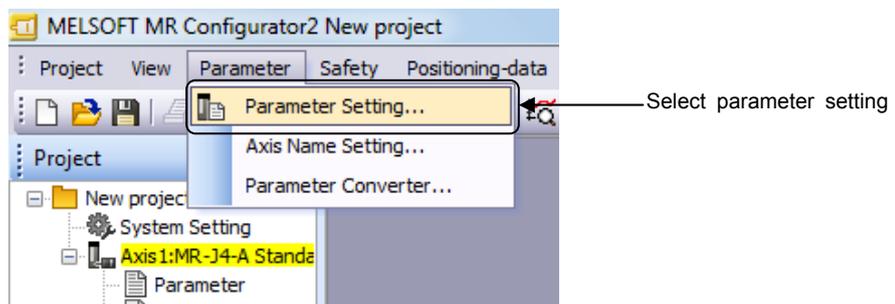


2) Select [Project] → [New] from the menu.

3) Once the new creation dialog box is displayed, select the model, station and connection settings, and click OK button.

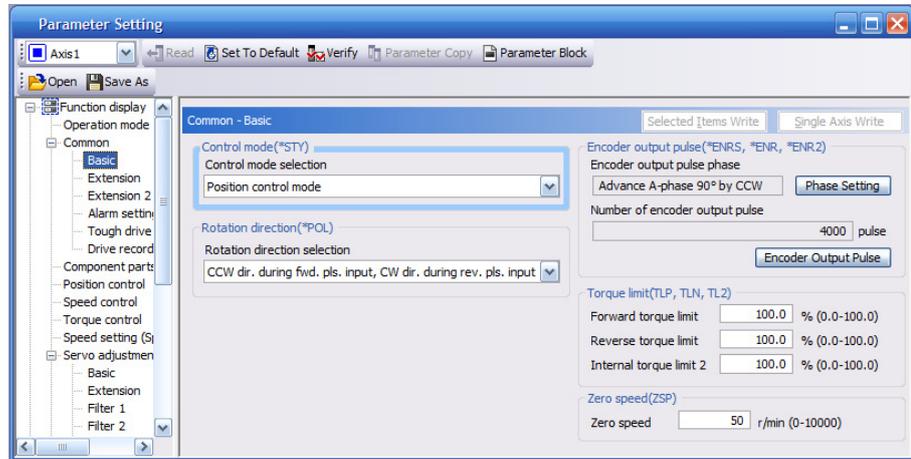


4) Select [Parameter] → [Parameter Setting] from the menu.



5. Training Machine Operation

- 5) The following parameter setting window opens, and parameter reading, writing, or referencing can be done.
Set the training machine parameters.

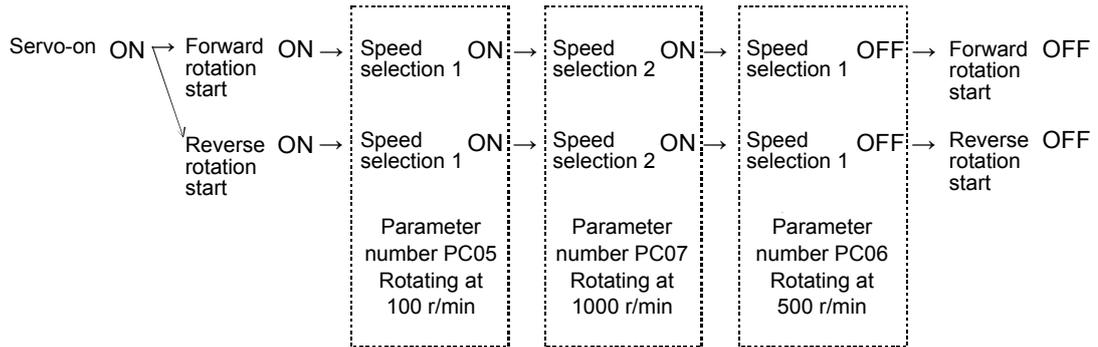


(5) Operation

(a) Internal 3-speed operation

- 1) Operate according to the following procedure and confirm that the forward and reverse speed rotations are as per the internal speed command values 1 to 3 (parameter number PC05 to PC07).

The speed can be confirmed on the display on the front of the servo amplifier (5-digit, 7-segment Human Machine Interface (HMI)) or on the MR Configurator2 monitor on the personal computer.



- 2) Change the internal speed command value from 1 to 3 (parameter number PC05 to PC07) and confirm.

(b) External analog speed command (VC) operation

Operation can be performed through VC input that sets the internal 3 speeds (speed selection 1, speed selection 2) to OFF.

- 1) Set the forward rotation start or reverse rotation start switch to ON and confirm that the speed can be varied by turning the analog speed command potentiometer.

* When the motor rotates with speed command zero, this does not occur at the time of operation by internal speed command due because of the input offset of the external speed command signal. In such cases, the motor rotation can be stopped by the method in Section 5.2.1 (5) (c) 4).

7) Status display setting

The status display shown at power-on is selected by setting the status display selection (parameter number PC36).

Setting example 100: Cumulative feedback pulses
 101: Servo motor speed

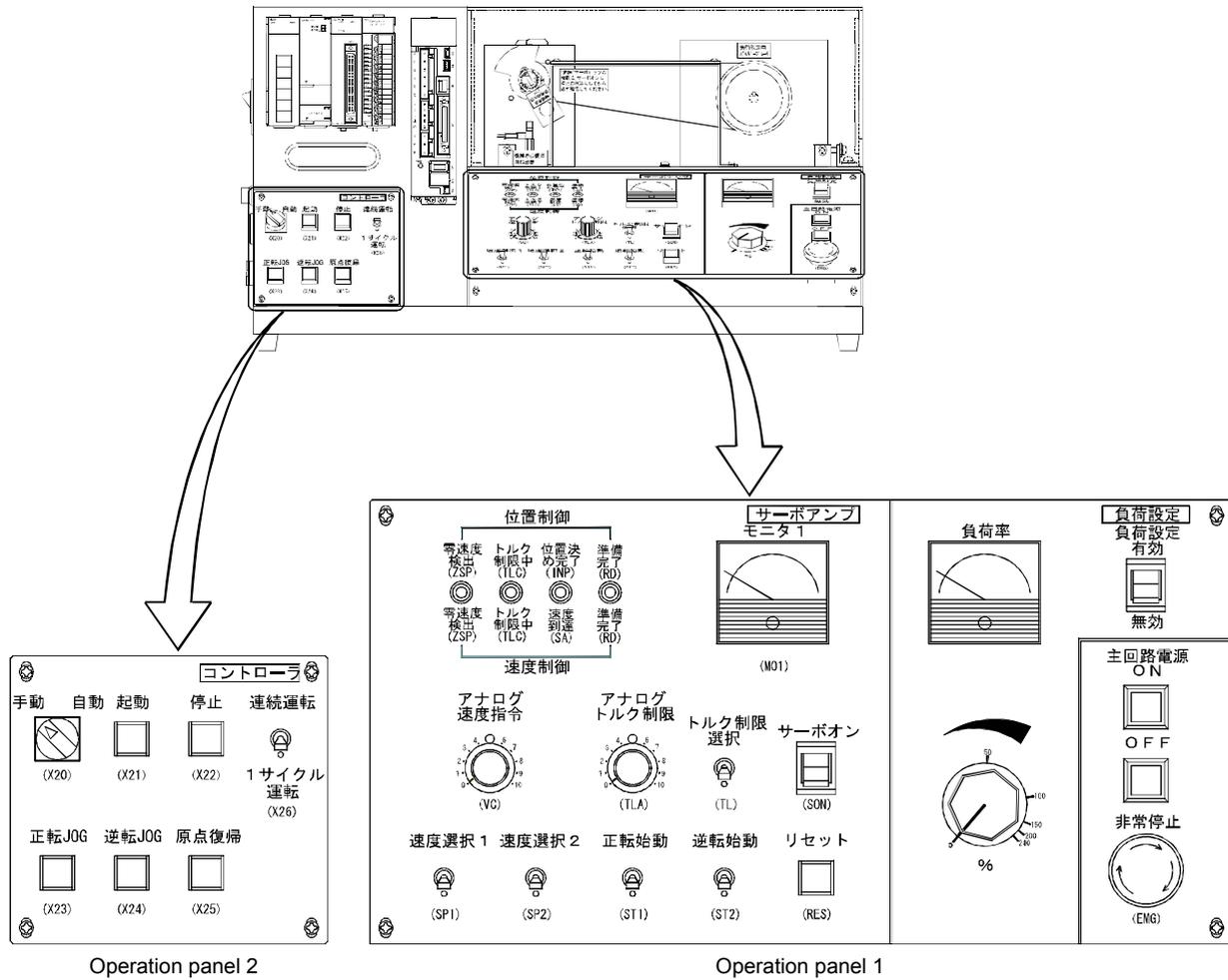
8) Confirmation of various status displays

- 1) Using a load-setting device, confirm the display contents of the peak load ratio, effective load ratio, etc., while the motor is operating.
- 2) Confirm the output of speed command F, rotation speed r, and the speed meter (meter pointer fluctuation) by varying the analog speed command maximum speed (parameter number. PC12) from 0 to 2000 with a 10 V command.

5. Training Machine Operation

5.2.2 Position Control

- (1) Settings before power-on
Always set all operation switches to OFF.



- (2) Power-on
Turn on the power by referring to section 5.2.1 (2).

5. Training Machine Operation

(3) Parameter setting

Before operating the training machine, set the parameters to the training device setting values (position control) in section 5.2.1 (3).

(4) Operation

(a) Servo-on

Turn on the servo by setting the servo-on (SON) to ON.

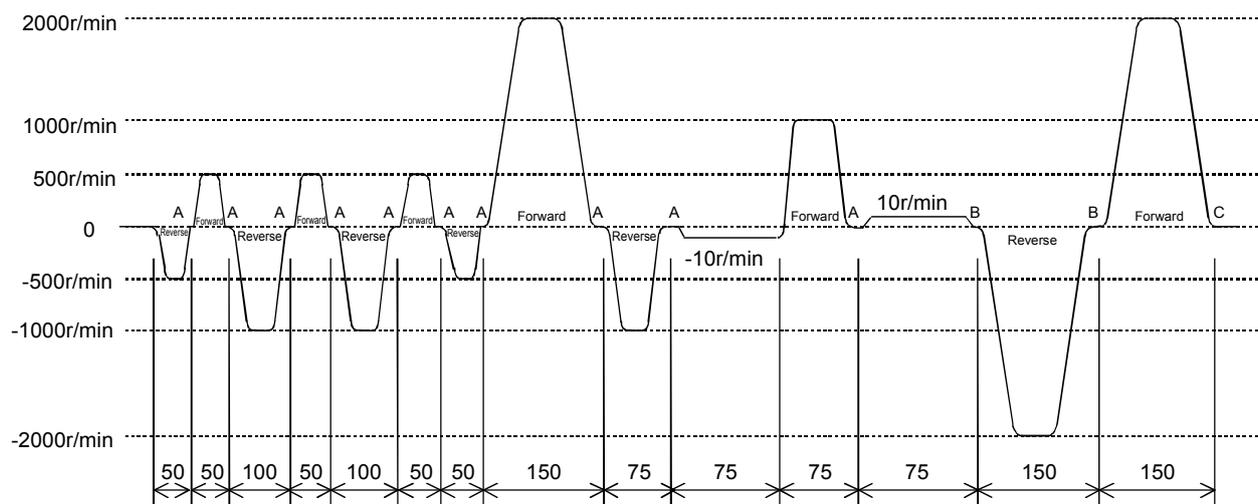
(b) JOG operation

- 1) Set the manual/auto switching switch to the manual side.
- 2) If the forward movement JOG button is turned to ON, the motor will rotate to the forward movement side (counterclockwise direction). (Only while the button is ON)
- 3) If the reverse movement JOG button is turned ON, the motor will rotate to the reverse movement side (clockwise direction). (Only while the button is ON)

(c) Automatic operation

Execute the home position return before automatic operation.

- 1) Set the manual/auto switching switch to the manual side.
- 2) When the home position return button is set to ON, the motor returns to the home position.
For the home position return operation, refer to section 3.5.2.
With automatic operation, turn the switch for manual/automatic switching to the automatic side.
- 3) If the continuous operation/one-cycle operation switch is set to one-cycle operation and the start button is pressed, operation with the pattern shown in the following figure is implemented once.
Press the stop button to stop the operation.
- 4) If the continuous operation/one-cycle operation switch is set to continuous operation and the start button is pressed, operation with the pattern shown in the following figure is implemented repeatedly.
Press the stop button to stop the operation.



Travel distance (unit: mm)

Note: For A, B, and C, dwell time A = 500 ms, B = 1 s, C = 2 s.

5. Training Machine Operation

(d) Timing belt mechanism and home position operation

The specifications of the mechanical part (timing belt mechanism) for this training machine are as follows.

1) Specifications of timing belt mechanism

No.	Item	Specifications
1	Belt length	L = 550mm (one revolution)
2	Number of pulley teeth on the servo motor side	Z1 = 20
3	Number of pulley teeth on the powder brake side	Z2 = 40
4	Number of belt teeth	Z3 = 110
5	Pulley moment of inertia on the servo motor side	JP1 = 0.109 kg cm ²
6	Pulley moment of inertia on the powder brake side	JP2 = 0.719 kg cm ²
7	Moment of inertia on the powder brake	Ja = 0.61 kg cm ²
8	Moment of inertia of the servo motor itself	JM = 0.045 kg cm ²
9	Belt travel distance per motor rotation	ΔS = 100 mm
10	Feedback pulse of the motor	Pf0 = 4194304 p/rev

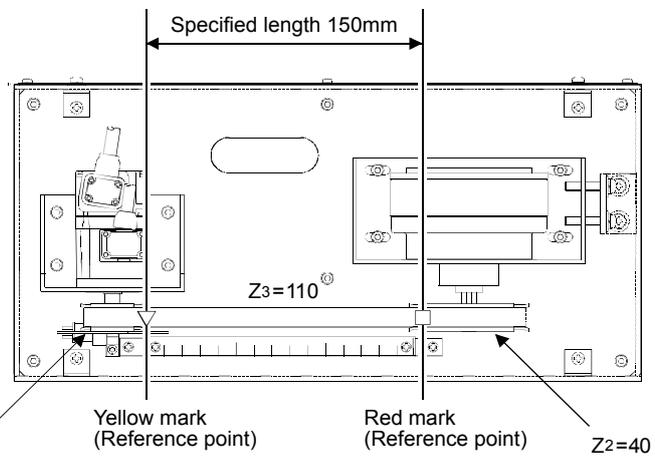
<Clipping data>

Find the load moment of inertia at motor shaft J_L.

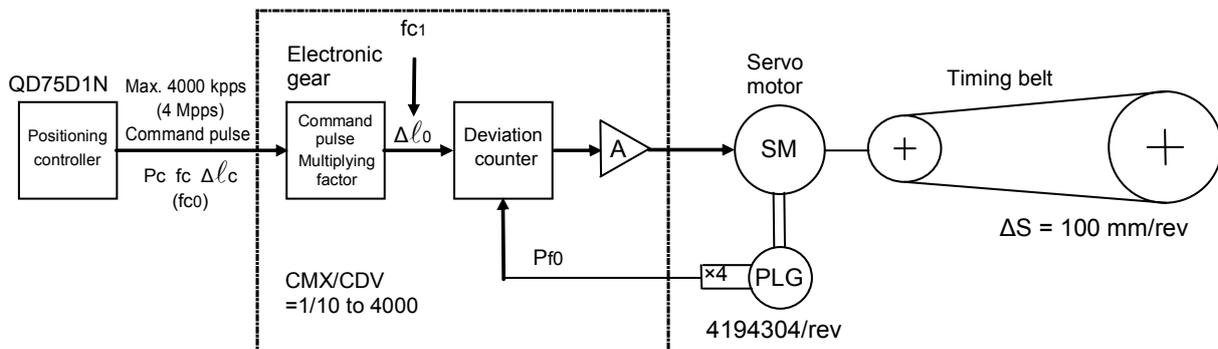
$$J_L = J_{P1} + \frac{J_{P2} + J_a}{(Z_2/Z_1)^2} = 0.109 + \frac{0.719 + 0.61}{2^2} \approx 0.44 \text{ kg cm}^2$$

The ratio of moment of inertia of the motor and load is J_L/J_M = 0.44/0.045 ≈ 9.8 times.

- 2) In the home position operation, when the machine OPR switch ON action is repeated 11 times, the reference point is set as shown in the figure on the right. In other words, the reference points shown in the figure on the right match 1 out of 11 times.



$$n = \frac{L}{\Delta S} = \frac{550}{100} = \frac{11}{2}$$



5. Training Machine Operation

(e) Operation confirmation by various parameter settings (For Parameter details, refer to section 4.3.7.)

- 1) Electronic gear settings and concepts (parameter number PA06, PA07)
Investigate whether a per-pulse belt travel distance $\Delta l_c = 0.001$ mm (1 μ m) unit is possible.

$$\text{Electronic gear ratio} = \frac{C M X}{C D V} = \frac{\text{Motor feedback pulse Pfo} \times \text{distance traveled by the belt in 1 pulse } \Delta l_c}{\text{Belt travel distance } \Delta S \text{ per motor rotation}}$$

$$= \frac{4194304 \cdot 0.001}{100} = \frac{524288}{12500} = \frac{131072}{3125}$$

- 2) With an electronic gear ratio of 131072/3125, find f_c when the motor speed is 3000 r/min.
Investigate whether a per-pulse belt travel distance $\Delta l_c = 0.001$ mm (1 μ m) unit is possible.

$$N = \frac{f_c \cdot 60 \cdot C M X / C D V}{P f 0} = \frac{f_c \cdot 60 \cdot 131072 / 3125}{4194304} = 3000 \text{ r/min}$$

$$f_c = \frac{4194304 \cdot 3000}{60 \cdot 131072 / 3125} = 5000 \text{ kpps} > 4000 \text{ kpps}$$

The maximum command frequency of positioning device QD75D1N is 4000 kpps (4 Mpps). Because the maximum command frequency is exceeded, the settings are disabled.

- 3) Investigate whether a per-pulse belt travel distance $\Delta l_c = 0.05$ mm (50 μ m) unit is possible.

$$\text{Electronic gear ratio} = \frac{C M X}{C D V} = \frac{4194304 \times 0.05}{100} = \frac{5242880}{2500} = \frac{262144}{125}$$

With an electronic gear ratio of 262144/125, find f_c when the motor speed is 3000 r/min.

$$f_c = \frac{4194304 \cdot 3000}{60 \cdot 262144 / 125} = 100 \text{ kpps} < 4000 \text{ kpps}$$

The maximum command frequency of positioning device QD75D1N is 4000 kpps (4 Mpps). There is no problem even at 6000 r/min because 200 kpps < 4000 kpps, which means the maximum command frequency is not exceeded.

* In this training device, the feed length for each pulse is 0.01 mm.

$$\frac{C M X}{C D V} = \frac{4194304 \cdot 0.01}{100} = \frac{4194304}{10000}$$

Command pulse multiplication numerator (Parameter number PA06): 4194304
Set command pulse multiplication denominator (parameter number PA07): 10000.

- 4) Set the in-position range (parameter number PA10).
- 5) Set the position loop gain (parameter number PB07/PB08).

5. Training Machine Operation

5.3 Operation Status Adjustment

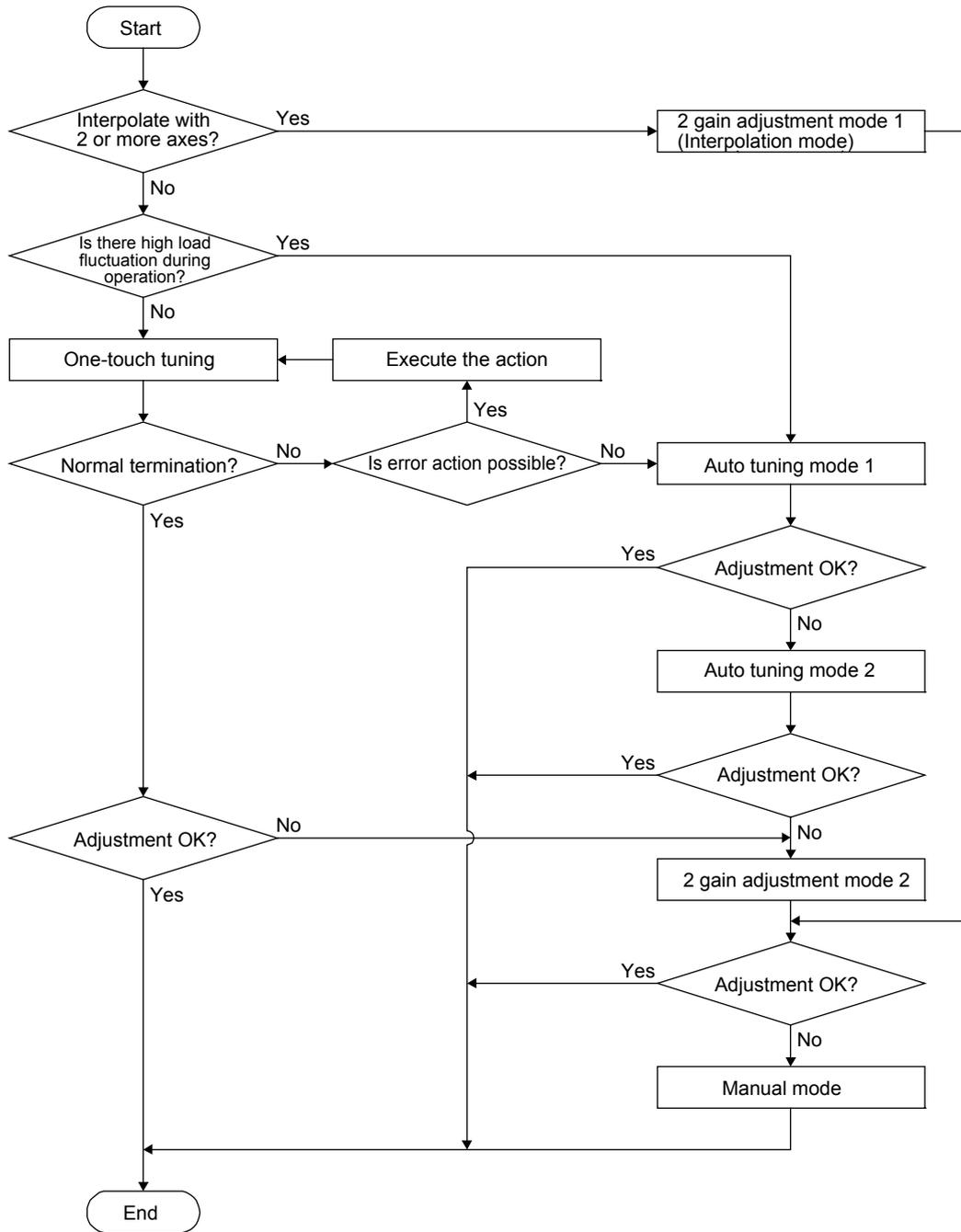
5.3.1 Adjustment of Servo Amplifier Unit

The following table shows the gain adjustment carried out in the servo amplifier units. Implement "Auto tuning mode 1" at the beginning for gain adjustment. When satisfactory adjustment is not obtained, implement "Auto tuning mode 2" followed by "Manual mode".

(1) Gain adjustment mode explanation

Gain adjustment mode	Parameter number PA08 setting	Load to motor inertia ratio estimation	Automatically set parameter	Manually set parameter
Auto tuning mode 1 (Initial value)	0001	Normal estimation	GD2 ([Pr. PB06]) PG1 ([Pr. PB07]) PG2 ([Pr. PB08]) VG2 ([Pr. PB09]) VIC ([Pr. PB10])	RSP ([Pr. PA09])
Auto tuning mode 2	0002	Fix to the value of [Pr. PB06]	PG1 ([Pr. PB07]) PG2 ([Pr. PB08]) VG2 ([Pr. PB09]) VIC ([Pr. PB10])	GD2 ([Pr. PB06]) RSP ([Pr. PA09])
Manual mode	0003			GD2 ([Pr. PB06]) PG1 ([Pr. PB07]) PG2 ([Pr. PB08]) VG2 ([Pr. PB09]) VIC ([Pr. PB10])
2 gain adjustment mode 1 (interpolation mode)	0000	Normal estimation	GD2 ([Pr. PB06]) PG2 ([Pr. PB08]) VG2 ([Pr. PB09]) VIC ([Pr. PB10])	PG1 ([Pr. PB07]) RSP ([Pr. PA09])
2 gain adjustment mode 2	0004	Fix to the value of [Pr. PB06]	PG2 ([Pr. PB08]) VG2 ([Pr. PB09]) VIC ([Pr. PB10])	GD2 ([Pr. PB06]) PG1 ([Pr. PB07]) RSP ([Pr. PA09])

(2) Sequence of adjustment and usage of modes



5. Training Machine Operation

5.3.2 One-Touch Tuning

One-touch tuning can be implemented using MR Configurator2 or with push-button operation. The following parameters are automatically adjusted in one-touch tuning.

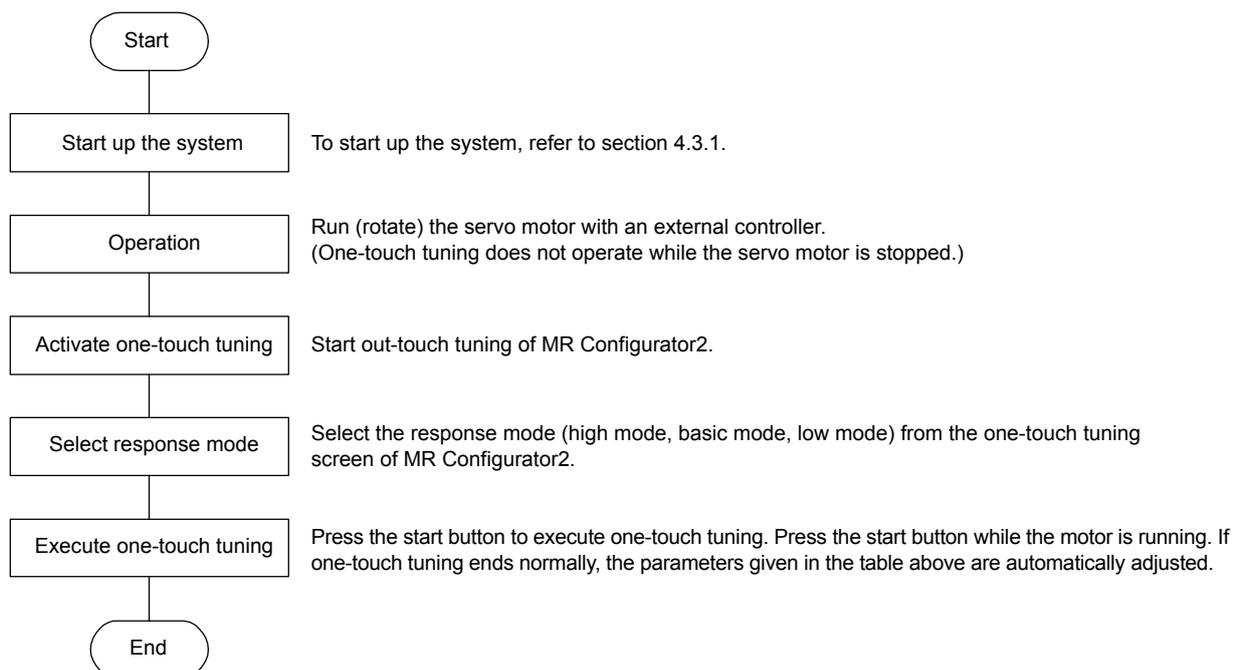
List of parameters automatically adjusted by one-touch tuning

Parameter	Abbreviation	Name
PA08	ATU	Auto tuning mode
PA09	RSP	Auto tuning response
PB01	FILT	Adaptive tuning mode (adaptive filter II)
PB02	VRFT	Vibration suppression control tuning mode (advanced vibration suppression control II)
PB03	PST	Position command acceleration/deceleration time constant (position smoothing)
PB06	GD2	Load to motor inertia ratio
PB07	PG1	Model loop gain
PB08	PG2	Position loop gain
PB09	VG2	Speed loop gain
PB10	VIC	Speed integral compensation
PB12	OVA	Overshoot amount compensation
PB13	NH1	Machine resonance suppression filter 1

Parameter	Abbreviation	Name
PB14	NHQ	1 notch shape selection 1
PB15	NH2	Machine resonance suppression filter 2
PB16	NHQ2	Notch shape selection 2
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
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
PE41	EOP3	Function selection E-3

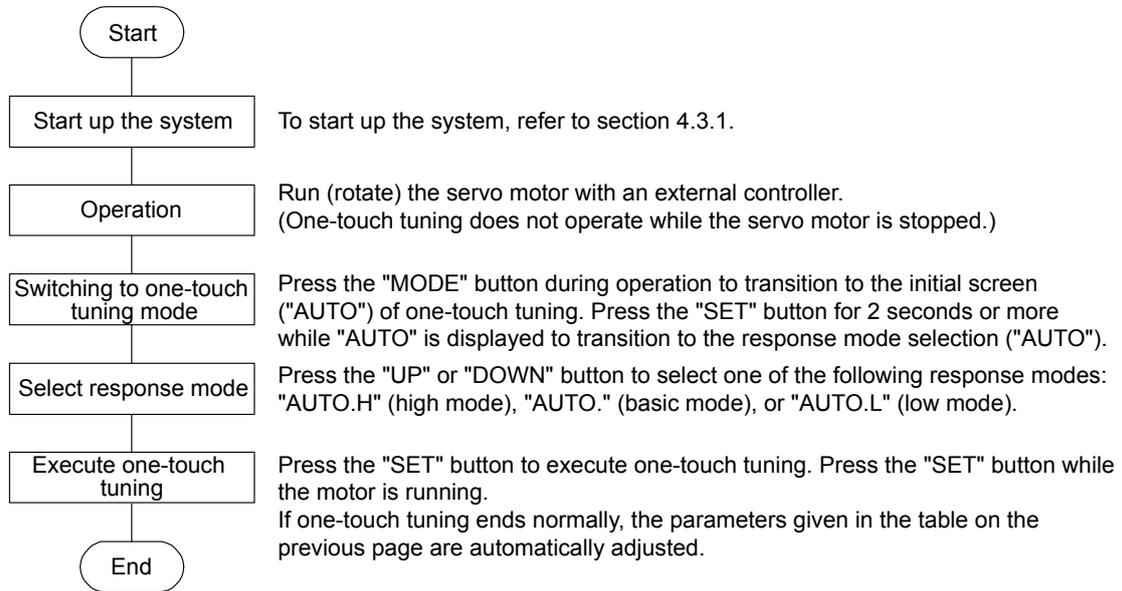
(1) Flow of one-touch tuning

(a) When MR Configurator2 is used
Implement one-touch tuning with the following procedure.



5. Training Machine Operation

(b) When a push button is used
Implement one-touch tuning with the following procedure.

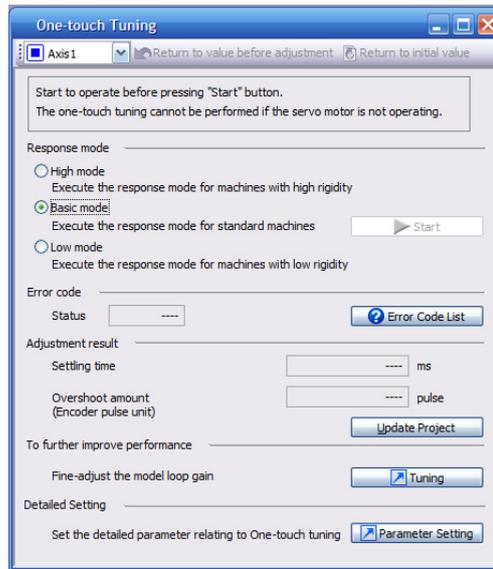


(2) One-touch tuning display transition/operation method

(a) When MR Configurator2 is used

1) Selection of response mode

Select the response mode (3 types) of one-touch tuning from the one-touch tuning screen of MR Configurator2.



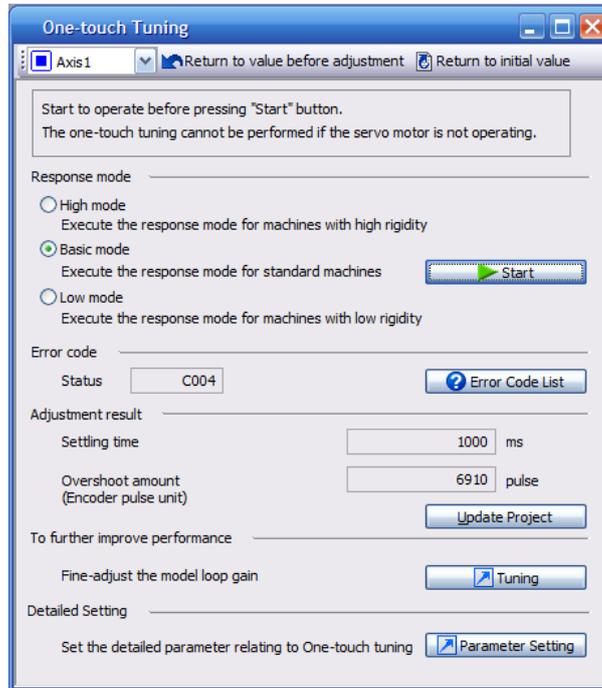
Response mode	Explanation
High mode	Response mode for devices with high machine rigidity.
Basic mode	Response mode for standard machines.
Low mode	Response mode for devices with low machine rigidity.

For the response mode targets, refer to the following table.

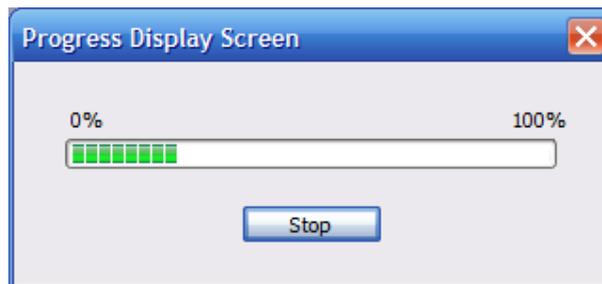
Response mode			Response level	Machine characteristics
Low mode	Basic mode	High mode		Standard value of the corresponding machine
↑ ↓	↑ ↓	↑ ↓	Slow response ↑ ↓ Fast response	

2) Implementation of one-touch tuning

If a response mode is selected in 1) and the start button is pressed while the motor is being driven, one-touch tuning will start. If the start button is pressed when the motor has stopped, "C002" or "C004" is displayed in the error code status. (For error codes, refer to the "List of error codes at the time of one-touch tuning" table under 4) on the next page.)



The adjustment progress is displayed in the progress display screen as follows during one-touch tuning. One-touch tuning is complete when the progress is 100%.



Adjustment parameters are written to the servo amplifier when one-touch tuning is completed. "0000" is displayed in the error code status. After completion of adjustment, the settling time and overshoot amount are displayed in the adjustment result.

3) Stopping of one-touch tuning

If the stop button is pressed during one-touch tuning, one-touch tuning is stopped.

If one-touch tuning is stopped, "C0000" is displayed in the error code status.

5. Training Machine Operation

4) In case of error

When an adjustment error occurs during adjustment, one-touch tuning is terminated. At that time, because the error code is displayed in the error code status, confirm the cause of the adjustment error occurrence.

List of error codes at the time of one-touch tuning

Error code	Name	Description	Action
C000	Cancellation during adjustment	"SET" of the stop button or the push button has been pressed during one-touch tuning.	
C0001	Excessive overshoot	The overshoot is higher than the value set in [Pr. PA10 In-position range].	Increase the in-position setting.
C002	Servo off during adjustment	Implementation of one-touch tuning in the servo-off status in was attempted.	Implement one-touch tuning after the servo is on.
C003	Control mode error	Implementation of one-touch tuning with torque control as the control mode was attempted.	Implement one-touch tuning after changing the control mode from the controller to position control or speed control.
C004	Time-out	1. The one-cycle time during operation has exceeded 30 s.	Lower the one-cycle time during operation to 30 s or less.
		2. The command speed is low.	Change the servo motor rotation speed to 100 r/min or more.
		3. The operation interval of continuous operation is short.	Ensure that the stopping interval during operation is 200 ms.
C005	Load to motor inertia ratio estimation error	1. Estimation of the load to motor inertia ratio at the time of one-touch tuning has failed.	Operate so that the following estimation conditions are fulfilled. <ul style="list-style-type: none"> • The time until reaching 2000 r/min is the deceleration time constant for 5 s or less. • The rotation speed is 150 r/min or more. • The load to motor inertia ratio is $\times 100$ or less. • The acceleration/deceleration torque is 10% or more than the rated torque.
		2. Estimation of the load to motor inertia ratio could not be carried out due to the oscillation effect.	Implement one-touch tuning after setting to an auto tuning mode where load to motor inertia ratio estimation is not carried out as follows. <ul style="list-style-type: none"> • Select "Auto tuning mode 2 (___2)", "Manual mode (___3)", or "2 gain adjustment mode 2 (___4)" in "Gain adjustment mode selection" of "[Pr. PA08]". • Set [Pr. PB06 Load to motor inertia ratio] accurately according to the manual setting.
COOF	Invalid one-touch tuning	"One-touch tuning function selection" of [Pr. PA21] is "Invalid (___0)".	Set the parameter to "Valid (___1)".

5) In case of alarm

When a servo alarm occurs during one-touch tuning, one touch tuning stops.

6) In case of warning

When a warning occurs whereby operation can continue during one-touch tuning, one-touch tuning is continued and executed.

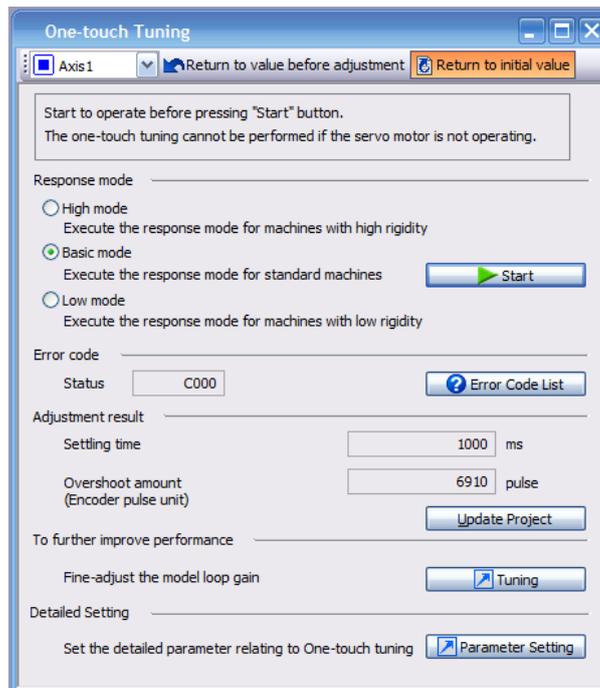
When a warning occurs whereby operation cannot continue during one-touch tuning, one-touch tuning is stopped.

7) Clearing one-touch tuning

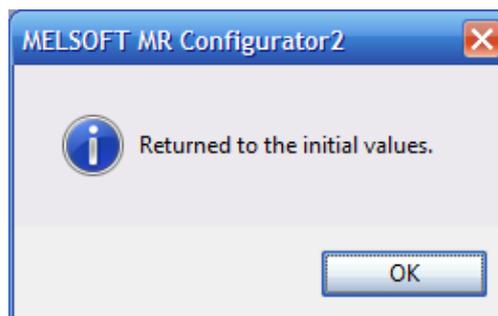
The result of adjustment by one-touch tuning can be cleared.

If "Return to before tuning" on the one-touch tuning screen of MR Configurator2 is pressed, a return to the parameter setting value before pressing start button can be performed.

Also, if "Return to initial value" on the one-touch tuning screen of MR Configurator2 is pressed, the factory default parameters can be rewritten.



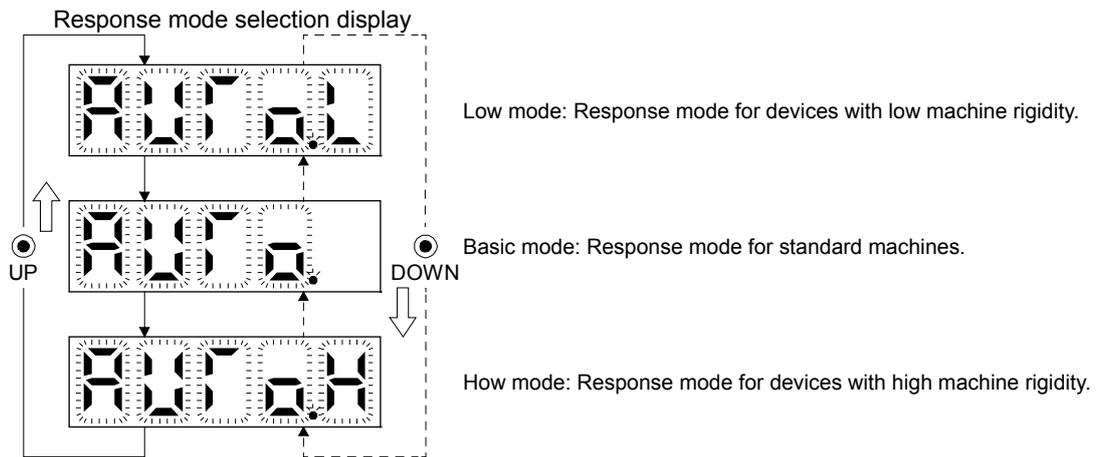
The next screen is displayed when clearing of one-touch tuning is completed. (When returning to the initial value)



(b) When a push button is used

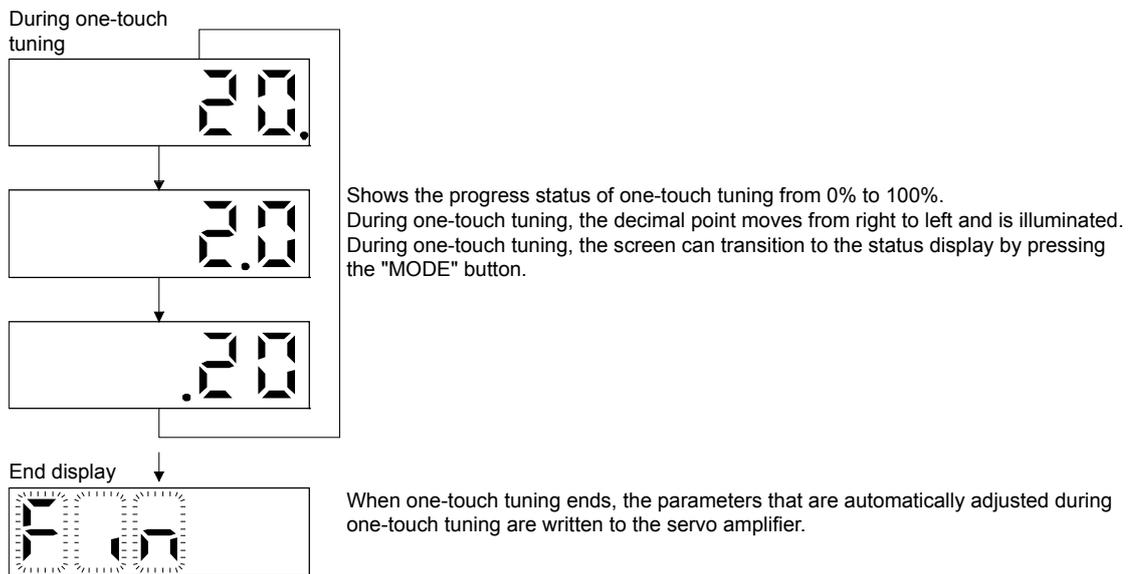
1) Selection of response mode

Select the response mode (three types) of one-touch tuning using the "UP" or "DOWN" button. For the response mode targets, refer to (2) (a) 1) of this section.



2) Implementation of one-touch tuning

If a response mode is selected in 1) and the "SET" button is pressed, one-touch tuning starts.



3) Stopping of one-touch tuning

Stop symbol display



When the screen has transitioned to the one-touch tuning mode, the one-touch tuning mode can be stopped by pressing the "SET" button while any item is displayed.

↕ 2 s interval

Error code



The stop symbol and error code "C 000" (cancellation during tuning) are alternately displayed at 2 s intervals.

↓ The screen transitions to the initial screen when the "SET" button is pressed.

Initial screen



4) In case of error

Stop symbol display



If an error occurs during one-touch tuning, one-touch tuning is terminated and the stop symbol and error codes "C 001" to "C 00F" are displayed alternately at 2 s intervals.

↕ 2 s interval

Error code



To check the cause of the error, refer to the table in section (1) (a) (1).

⋈



↓ The screen transitions to the initial screen when the "SET" button is pressed.

Initial screen



5) In case of alarm

During one-touch tuning



If an alarm occurs during one-touch tuning, one-touch tuning is terminated and the screen transitions to the alarm display.

↓

Alarm display



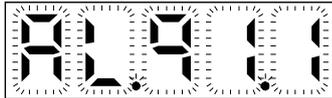
6) In case of warning

During one-touch tuning



If a warning occurs during one-touch tuning, the screen transitions to the alarm display and displays a warning.
If the warning is a kind that allows operation to continue, the one-touch tuning operation will be continued.

↓
Alarm display (warning)

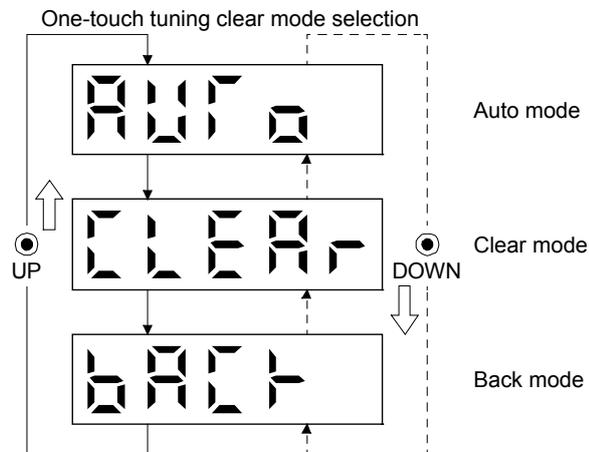


7) Clearing of one-touch tuning

For the parameters that can be cleared, refer to the table in section 5.3.2.

The result of one-touch tuning can be overwritten to the factory default parameters using the clear mode. The one-touch tuning result can be returned to the parameter setting value before adjustment using the back mode.

- 1) Press the "MODE" button and transition to the initial screen "AUTO" of one-touch tuning.
- 2) Select the clear mode or the back mode using the "UP" or "DOWN" button.



↓ One-touch tuning is cleared when the "SET" button is pressed for 2 s or more.

One-touch tuning clear mode display (initial value restoration)



Executes the selected one-touch tuning clear mode. During execution, the one-touch tuning clear mode symbol flashes for 3 s.

↓ The screen transitions to the initial screen when one-touch tuning is completely cleared.

Initial screen



5. Training Machine Operation

(3) Cautions during one-touch tuning

- (a) One-touch tuning is not possible in the torque control mode.
- (b) One-touch tuning is not possible when an alarm occurs or a when a warning whereby operation cannot be continued occurs.
- (c) One-touch tuning can be implemented during test operation mode executions with "O".

One-touch tuning method	Test operation mode				
	Output signal (DO) forced output	JOG operation	Positioning operation	Motor-less operation	Program operation
Using MR Configurator2		○	○		i
Operation by push button					

5.3.3 Auto Tuning

(1) Auto tuning mode

The characteristics (load to motor inertia ratio) of the machine are estimated in real time, and a real-time auto tuning function that automatically sets the appropriate gain corresponding to that value is built-in to the servo amplifier.

Gain adjustment of the servo amplifier can be easily carried out by this function.

(a) Auto tuning mode 1

- The servo amplifier has auto tuning mode 1 set by default.
- The load to motor inertia ratio of the machine is normally estimated by this mode, and the appropriate gain is automatically set.
- The parameters that can be automatically adjusted by auto tuning mode 1 are as shown in the following table.

Parameter number	Abbreviation	Name
PB06	GD2	Load to motor inertia ratio
PB07	PG1	Model loop gain
PB08	PG2	Position loop gain
PB09	VG2	Speed loop gain
PB10	VIC	Speed integral compensation

POINT
<ul style="list-style-type: none"> • If auto tuning mode 1 does not satisfy the following conditions, it may not operate normally. <ul style="list-style-type: none"> • The time until reaching 2000 r/min is the deceleration time constant for 5 s or less. • The rotation speed is 150 r/min or more. • The load to motor inertia ratio is $\times 100$ or less. • The acceleration/deceleration torque is 10% or more than the rated torque. • For machines with operating conditions where a disturbance torque can be rapidly added during acceleration/deceleration or with large gutters at the extremes, auto tuning will not function normally. In such cases, adjust the gain with auto tuning mode 2 or the manual mode.

(b) Auto tuning mode 2

Auto tuning mode 2 is used when normal gain adjustment cannot be carried out in auto tuning mode 1.

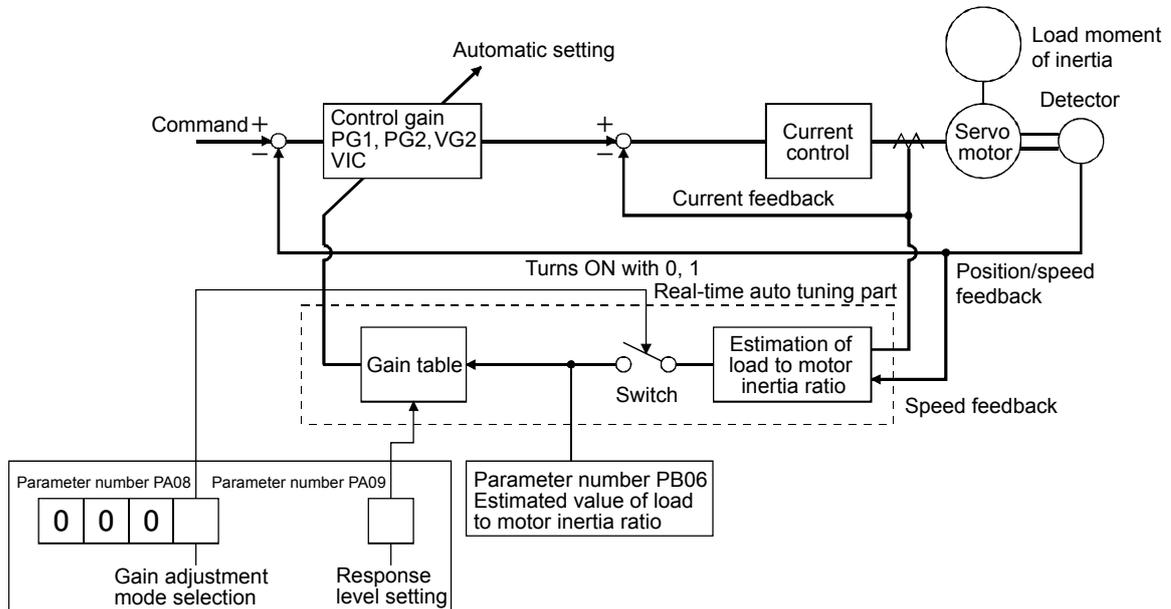
Because estimation of the load to motor inertia ratio is not carried out in this mode, set an accurate value of the load to motor inertia ratio (parameter number PB06).

The parameters that can be automatically adjusted by auto tuning mode 2 are as shown in the following table.

Parameter number	Abbreviation	Name
PB07	PG1	Model loop gain
PB08	PG2	Position loop gain
PB09	VG2	Speed loop gain
PB10	VIC	Speed integral compensation

(2) Auto tuning mode operation

The following shows the block diagram of real-time auto tuning.



If the servo motor is subjected to acceleration/deceleration operation, the moment of inertia ratio estimating portion normally estimates the load to motor inertia ratio from the servo motor current and servo motor speed. The estimated result is written by parameter number PB06 (load to motor inertia ratio). This result can be confirmed by the status display screen of MR Configurator2 (setup software).

When the value of the load to motor inertia ratio is understood beforehand and estimation is unsuccessful, set "Auto tuning mode 2" (parameter number PA08:0002), stop estimation of the load to motor inertia ratio (turn OFF the switch in the above drawing), and set the load to motor inertia ratio (parameter number PB06) manually.

An appropriate control gain is automatically set in the internal gain table from the value of the set load to motor inertia ratio (parameter number PB06) and response (parameter number PA09).

The auto tuning result is stored in the servo amplifier EEP-ROM every 60 minutes from power-on. Auto tuning is carried out for each control gain value stored in EEP-ROM at power-on as an initial value.

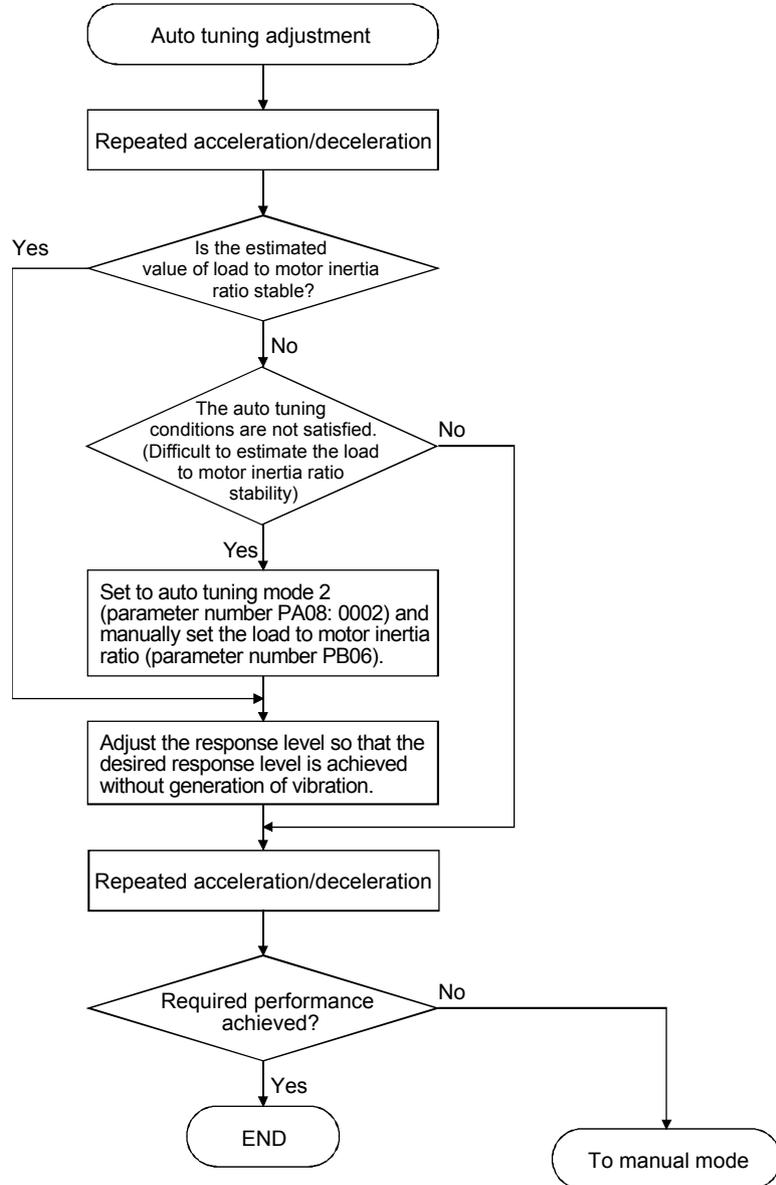
POINT

- Rapid disturbance torques may be experienced during operation, or temporary malfunctioning of estimation of the moment of inertia ratio may occur. In such cases, set auto tuning mode 2 (Parameter number PA08: 0002) and set an accurate load to motor inertia ratio (parameter number PB09).
- If a change from either the auto tuning mode 1 or auto tuning mode 2 setting to the manual mode setting, the currently estimated values for the control gain and load to motor inertia ratio are stored in EEP-ROM.

5. Training Machine Operation

(3) Adjustment procedure using auto tuning

Because auto tuning is enabled by default, only by operation of the servo motor can an appropriate gain that conforms to the machine automatically set. If necessary, adjustment is completed only by changing the response setting value. The following shows the adjustment procedure.

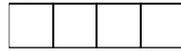


5. Training Machine Operation

(4) Auto tuning mode response setting

Set the response of the entire servo system with [Pr. PA09]. A higher response setting will result in a shorter settling time with better compliance characteristics for the command, but a setting too high will cause vibrations. Therefore, set so that the desired response is obtained in a range where vibrations do not occur. When a high response cannot be set up to the prescribed response because of a machine resonance that exceeds 100 Hz, the machine resonance can be suppressed by selecting filter tuning mode in [Pr. PB01] and machine resonance suppression filter in [Pr. PB13] to [Pr. PB16] and [Pr. PB46] to [Pr. PB51]. A high response setting is also possible by suppressing the machine resonance.

Parameter number PA09



Response level setting

[Pr. PA09]

Set value	Machine characteristics	
	Response level	Target machine resonance frequency [Hz]
1	Slow 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	Medium response	59.6

Set value	Machine characteristics	
	Response level	Target machine resonance frequency [Hz]
21	Medium response	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		Fast response

5. Training Machine Operation

5.3.4 Manual Mode

When satisfactory adjustment is not possible with auto tuning, manual adjustment is carried out for all of the gain.

POINT
<ul style="list-style-type: none"> When machine resonance occurs, suppression of the machine resonance is possible with the filter tuning mode (parameter number PB01) and the machine resonance suppression filter (parameter number PB13 to PB16). (Refer to section 5.4.2.)

(1) With speed control

(a) Parameter

Parameters that are used for gain adjustment are as follows.

Parameter number	Abbreviation	Name
PB06	GD2	Load to motor inertia ratio
PB07	PG1	Model loop gain
PB09	VG2	Speed loop gain
PB10	VIC	Speed integral compensation

(b) Adjustment procedure

Procedure	Operation	Description
1	Rough adjustment is carried out by auto tuning.	
2	Change the settings for auto tuning to manual mode (parameter number PA08:0003).	
3	Set the estimated value in the load to motor inertia ratio. (It is not necessary to change the setting when the value estimated by auto tuning is accurate.)	
4	Set the model loop gain low. Set the speed integral compensation high.	
5	The speed loop gain is high in ranges without vibrations and abnormal noise, and if vibrations occur, it returns slightly.	Set the speed loop gain high.
6	The speed integral compensation is low in ranges where no vibrations are output, and if vibrations occur, it returns slightly.	Set a low time constant for the speed integral compensation.
7	The model loop gain increases, and if overshooting occurs, it returns slightly.	Set the model loop gain high.
8	When the gain cannot be increased due to machine system resonance and the prescribed response cannot be obtained, the response may be increased if procedures 3 to 7 are implemented after suppressing resonance with the adaptive tuning mode and machine resonance suppression filters.	Machine resonance suppression Refer to sections 5.4.1 and 5.4.2.
9	Fine adjustment of each gain is carried out while observing the settling characteristics and the rotation status.	Fine adjustment

5. Training Machine Operation

(c) Adjustment description

1) Speed loop gain (parameter number PB09)

This parameter decides the speed control loop response. If a high value is set, although response will increase, if the setting is too high, the machine will vibrate easily. The response frequency of the actual speed loop is as determined by the following formula.

$$\text{Speed loop response frequency (Hz)} = \frac{\text{Speed loop gain set value}}{(1 + \text{Load to motor inertia ratio}) \times 2\pi}$$

2) Speed integral compensation (VIC: Parameter number PB10)

Speed control loop results in proportional integral control so that there is no steady deviation for commands. Set the integral control time constant for speed integral compensation. A higher setting value results in a worse response. However, when the load to motor inertia ratio is high and vibrating elements exist in the machine system, the machine system may vibrate easily if it is not increased to some extent. The targets are as shown in the following formula.

Speed integral compensation setting value (ms)

$$\geq \frac{2000 \text{ to } 3000}{\text{Speed loop gain set value}/(1 + \text{Load to motor inertia ratio set value})}$$

(3) Model loop gain (PG1: Parameter number PB07)

This parameter decides the position command response. If the model loop gain is high, even though the compliance characteristics for position command improve, if it is too high, overshooting occurs easily at the settling time.

$$\text{Model loop gain target} \leq \frac{\text{Speed loop gain set value}}{(1 + \text{Load to motor inertia ratio})} \times \left(\frac{1}{4} \text{ to } \frac{1}{8} \right)$$

(2) With position control

(a) Parameter

Parameters that are used for gain adjustment are as follows.

Parameter number	Abbreviation	Name
PB06	GD2	Load to motor inertia ratio
PB07	PG1	Model loop gain
PB08	PG2	Position loop gain
PB09	VG2	Speed loop gain
PB10	VIC	Speed integral compensation

5. Training Machine Operation

(b) Adjustment procedure

Procedure	Operation	Description
1	Rough adjustment is carried out by auto tuning.	
2	Change the settings for auto tuning to manual mode (parameter number PA08:0003).	
3	Set the estimated value in the load to motor inertia ratio. (It is not necessary to change the setting when the value estimated by auto tuning is accurate.)	
4	Set the model loop gain and position loop gain low. Set the speed integral compensation high.	
5	The speed loop gain is high in ranges without vibrations and abnormal noise, and if vibrations occur, it returns slightly.	Set the speed loop gain high.
6	The speed integral compensation is low in ranges where no vibrations are output, and if vibrations occur, it returns slightly.	Set a low time constant for the speed integral compensation.
7	The position loop gain is high, and if vibrations occur, it returns slightly.	Set the position loop gain high.
8	The model loop gain increases, and if overshooting occurs, it returns slightly.	Set the model loop gain high.
9	When the gain cannot be increased due to machine system resonance and the prescribed response cannot be obtained, the response may be increased if procedures 3 to 8 are implemented after suppressing resonance with the adaptive tuning mode and machine resonance suppression filters.	Machine resonance suppression Refer to sections 5.4.1 and 5.4.2.
10	Fine adjustment of each gain is carried out while observing the settling characteristics and the rotation status.	Fine adjustment

(c) Adjustment description

1) Speed loop gain (VG2: Parameter number PB09)

This parameter decides the speed control loop response. If a high value is set, although response will increase, if the setting is too high, the machine will vibrate easily. The response frequency of the actual speed loop is as determined by the following formula.

$$\text{Speed loop response frequency (Hz)} = \frac{\text{Speed loop gain set value}}{(1 + \text{Load to motor inertia ratio}) \times 2\pi}$$

2) Speed integral compensation (VIC: Parameter number PB10)

Speed control loop results in proportional integral control so that there is no steady deviation for commands. Set the integral control time constant for speed integral compensation. A higher setting value results in a worse response. However, when the load to motor inertia ratio is high and vibrating elements exist in the machine system, the machine system may vibrate easily if it is not increased to some extent. The targets are as shown in the following formula.

Speed integral compensation setting value (ms)

$$\geq \frac{2000 \text{ to } 3000}{\text{Speed loop gain set value}/(1 + \text{Load to motor inertia ratio set value})}$$

(3) Position loop gain (PG2: Parameter number PB08)

This parameter decides the response regarding position control loop disturbances. If the position loop gain is high, the change regarding disturbances becomes small, but if the setting is too large, the machine system will vibrate easily.

$$\text{Position loop gain target} \leq \frac{\text{Speed loop gain set value}}{(1 + \text{Load to motor inertia ratio})} \times \left(\frac{1}{4} \text{ to } \frac{1}{8} \right)$$

(4) Model loop gain (PG1: Parameter number PB07)

This parameter decides the position command response. If the model loop gain is high, even though the compliance characteristics for position command improve, if it is too high, overshooting occurs easily at the settling time.

$$\text{Model loop gain target} \leq \frac{\text{Speed loop gain set value}}{(1 + \text{Load to motor inertia ratio})} \times \left(\frac{1}{4} \text{ to } \frac{1}{8} \right)$$

5.3.5 Adjustment Using MR Configurator2

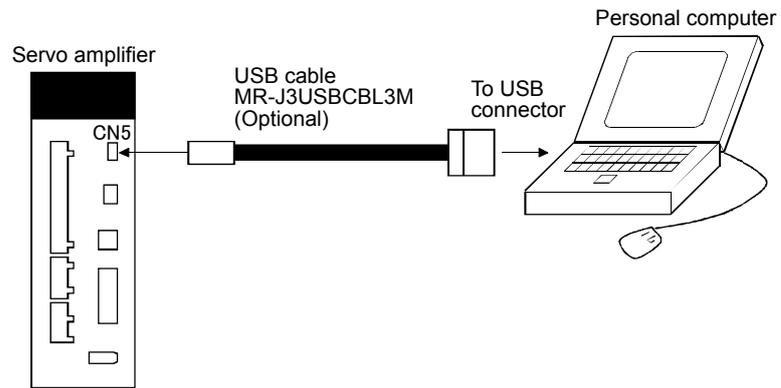
(1) Communication I/F

The MELSERVO-J4 Series is equipped with a USB interface in addition to the standard RS-422 interface.

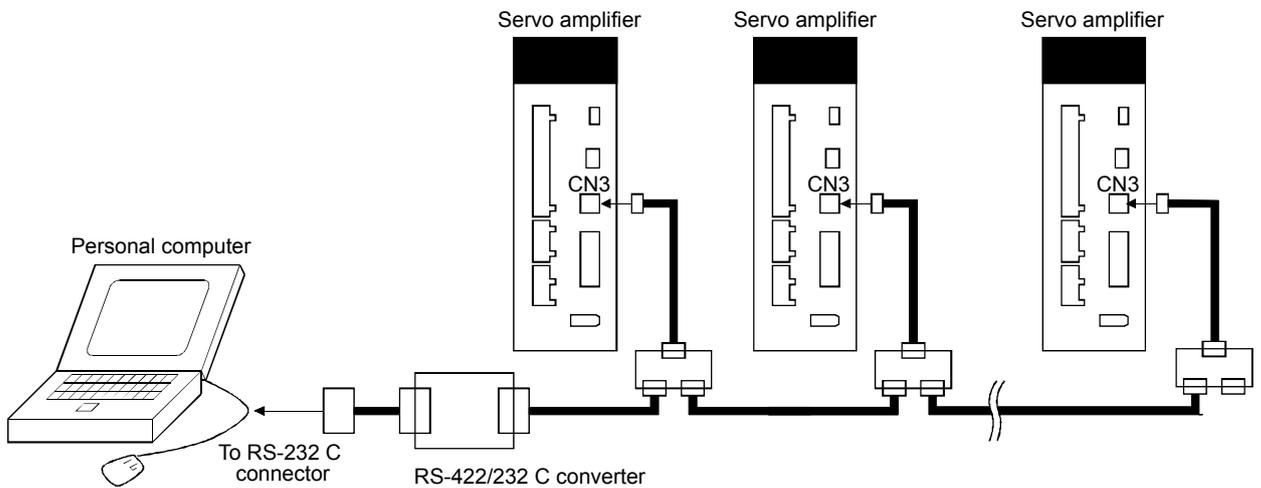
Communicable data includes parameter contents (including various gains), monitor-related information (contents such as current, speed, and pulse drop, which can be displayed on the amplifier LED), I/O signals, and alarm displays.

The protocols and command-related information required for communication are public, so the software for communication can be created by the user.

◆ For USB



◆ For RS-422



5. Training Machine Operation

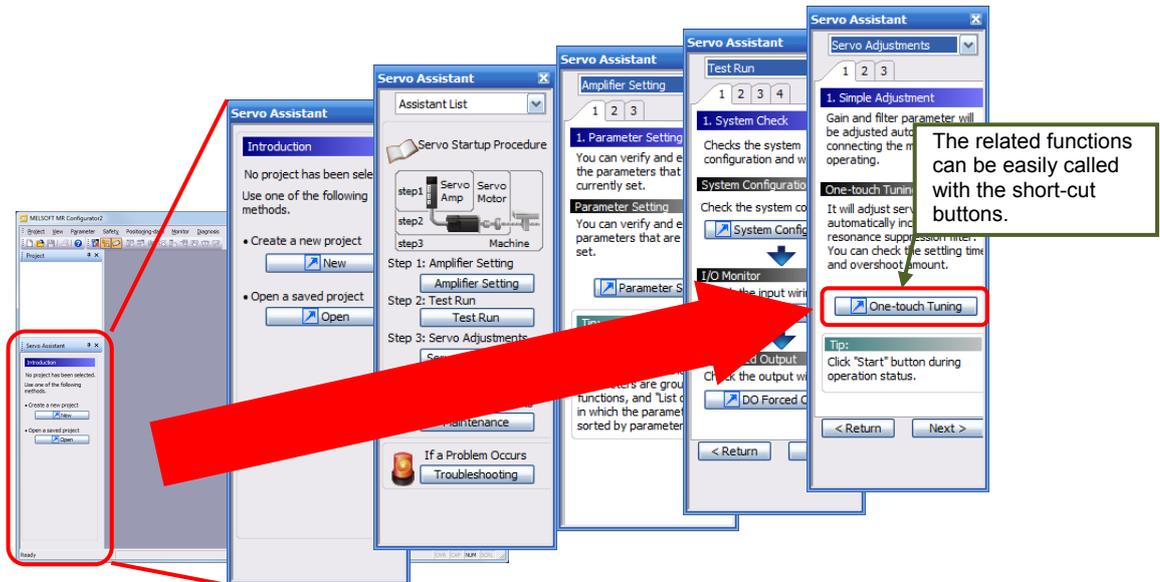
(2) Features of MR Configurator2

MR Configurator2 provides a more useful engineering environment and further improves the setting/start-up adjustment/maintainability efficiency of the servo amplifier.

A portion of the new functions is introduced below.

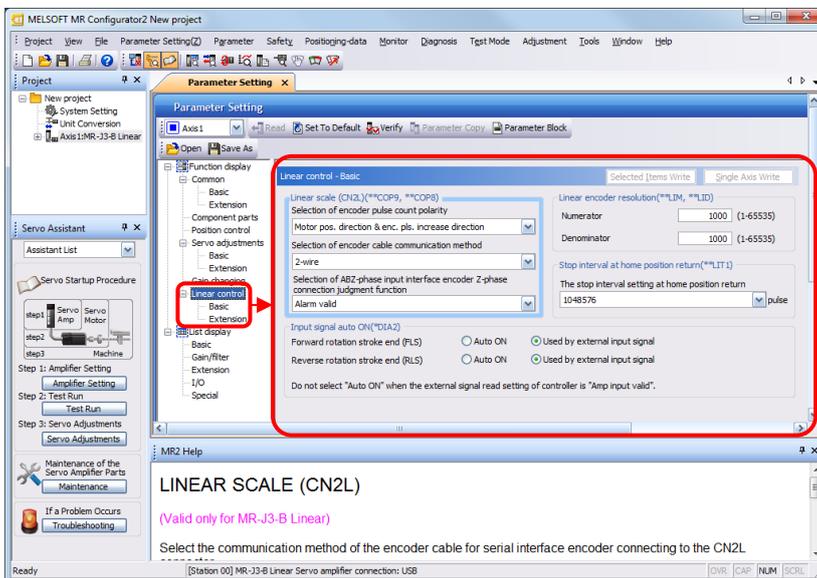
(a) Servo assistant

Complete setup of the servo amplifier just by following the guidance display.



(b) Group parameter settings

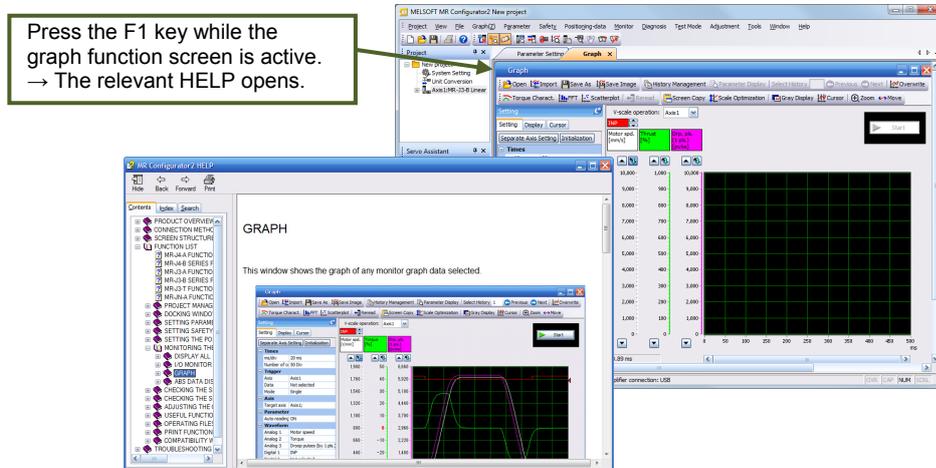
Group parameter settings can be easily configured on the parameter setting screen.



5. Training Machine Operation

(c) Simple help function

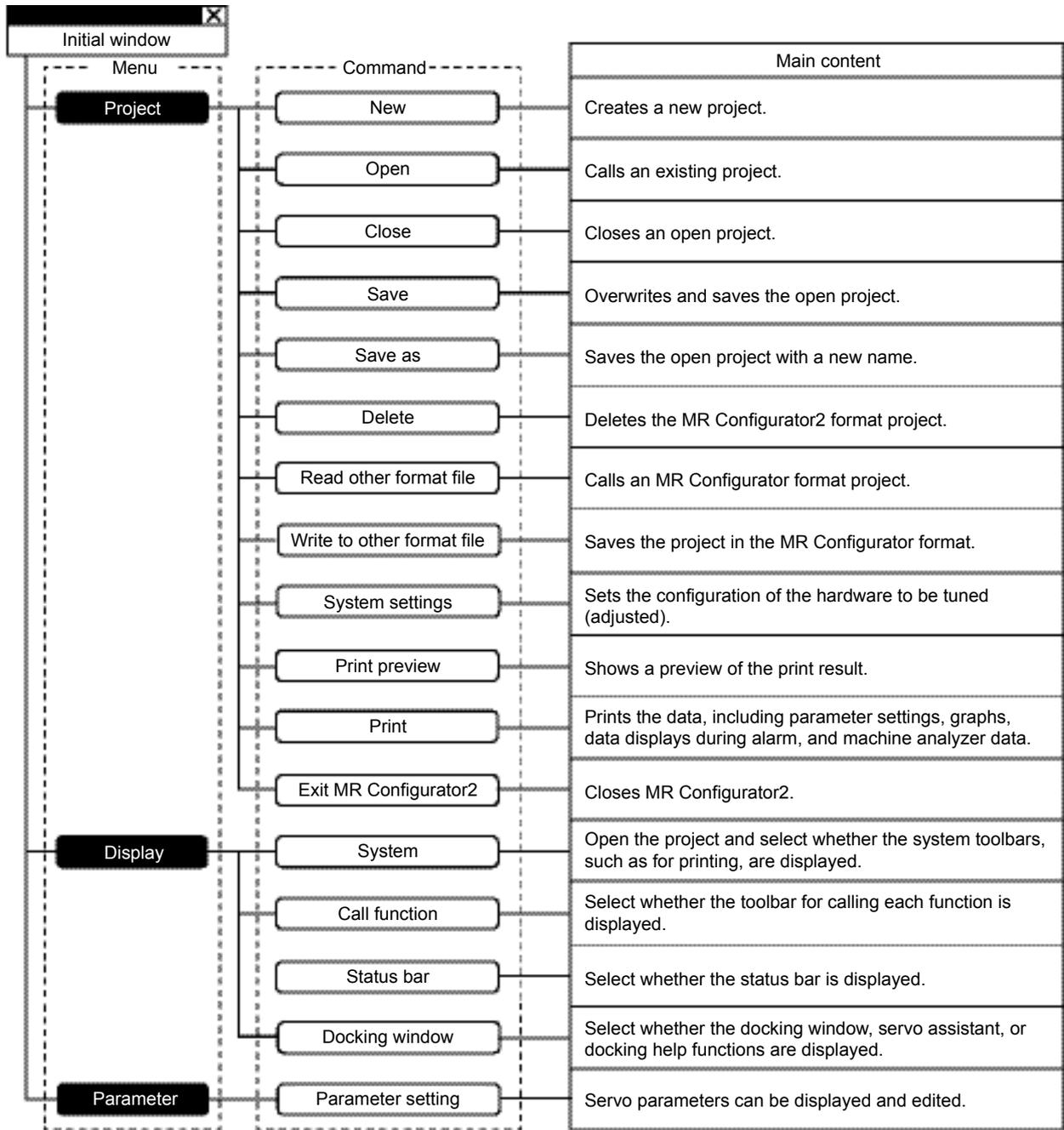
If the operation method is unclear, click the F1 key to open the HELP.



For other new functions and for information on usage of or details on the function UP part, refer to the explanation given in the MR Configurator2 help/function list.

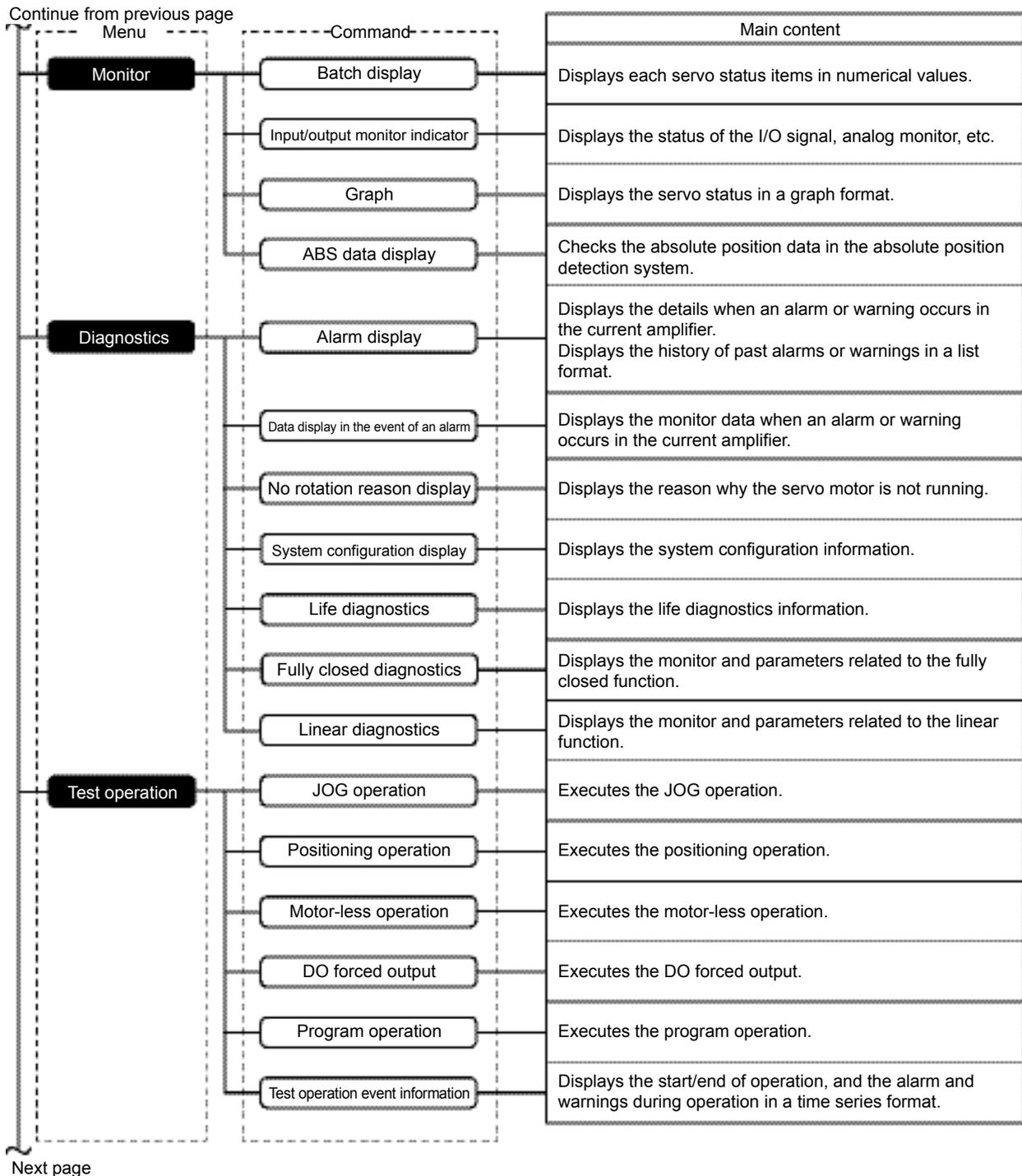
Also, for changes from the standard MR Configurator, refer to "Compatibility with standard product, or Difference from standard product (MR Configurator)" given in the MR Configurator2 help/function list.

(3) Functions of MR Configurator2
 MR Configurator2 has the following functions.

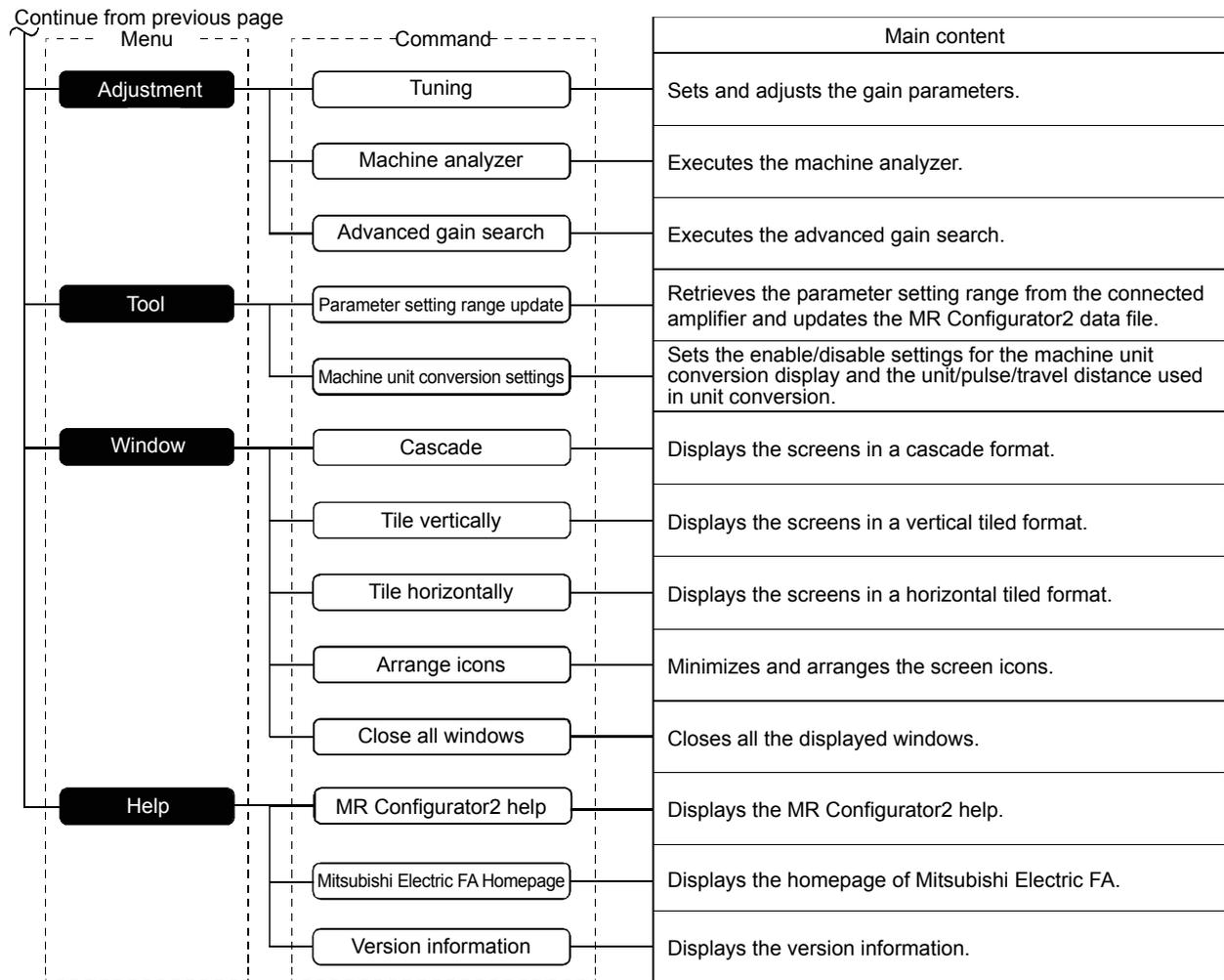


Next page

5. Training Machine Operation



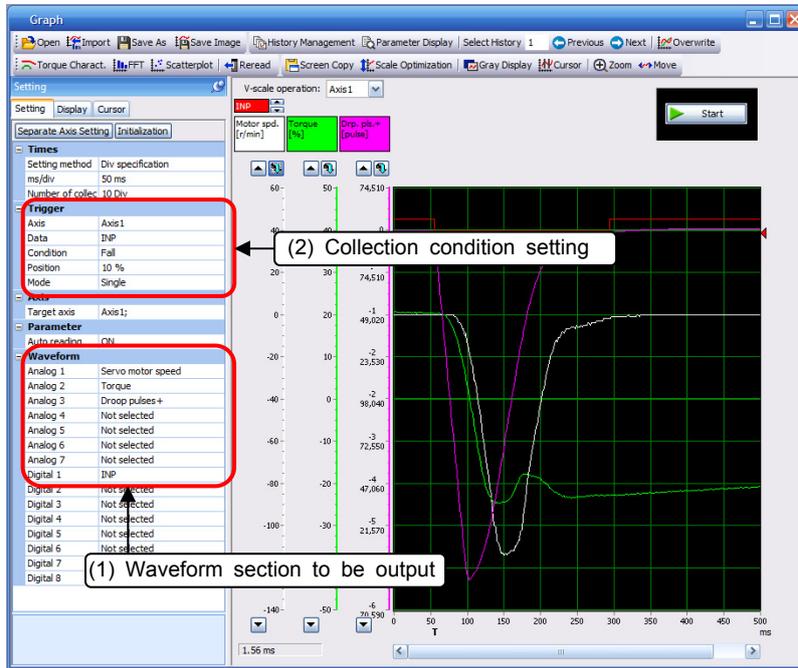
5. Training Machine Operation



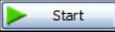
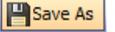
5. Training Machine Operation

(4) Graph ([Monitor] - [Graph] Menu)

In the graph window, optional monitor graph data is displayed as a graph.

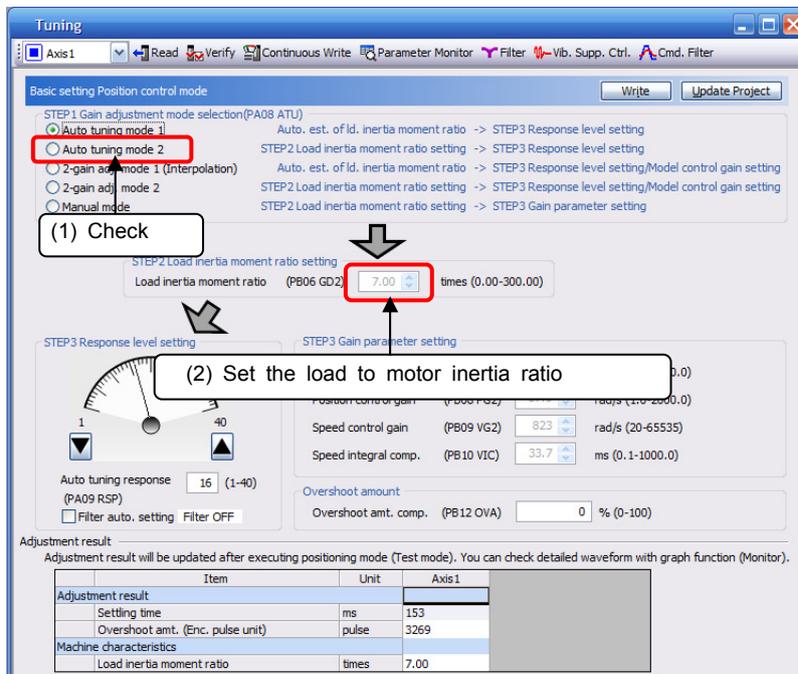


Operating procedure

- (1) Waveform section to be output
 - ↓ Select Motor speed in Analog CH1
 - ↓ Torque in Analog CH2
 - ↓ Pulse drop+ in Analog CH3
 - ↓ INP in Digital
- (2) Collection condition setting
 - ↓ Set INP on the falling edge in the trigger
- (3) Collection of waveform data
 - ↓ 50 ms/Div of horizontal axis sampling
 - ↓ Click the  button.
 - ↓ Training machine automatic operation start (Switch ON the start button on the operation panel.)
- (4) Observe the collected waveform
 - ↓ Adjustment of horizontal axis scale
- (5) Saving the waveform data
 - ↓ Click the  menu.
- (6) Graph completion
 - * Details can be confirmed using Help.

(5) Tuning ([Adjustment]-[Tuning] menu)

In the tuning window, adjust the gain parameter and configure the settings so that operating is possible according to the objective.



Operating procedure

- (1) Select Auto tuning mode
 - ↓ Select Auto tuning mode 2
 - (2) Set the load to motor inertia ratio
 - ↓ Set to 9.8 times *1
- *1: The load inertia moment ratio is the value calculated in (4) (d) of section 5.2.2.

* Details can be confirmed using Help.

5. Training Machine Operation

(6) Machine analyzer ([Adjustment] - [Machine Analyzer] Menu)

The machine system and frequency features are displayed using relational expressions (Bode plot) for the normal, gain, and phase frequency.

Gain indicates the size of the response of the machine system for the torque input, and phase indicates the phase delay of the speed response for the torque input.

If the machine system is rigid and there is no resonance point, gain is linear.

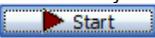
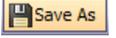
There is generally some resonance point in the machine system, and the frequency or size of the resonance can be measured by the machine analyzer.

The following figure is a measurement example when a resonance of 638 Hz exists in the machine system.

If the speed gain continues to increase, the machine will vibrate easily at that resonance frequency because the gain increases in the resonance point and the response of the machine for the input torque increases.



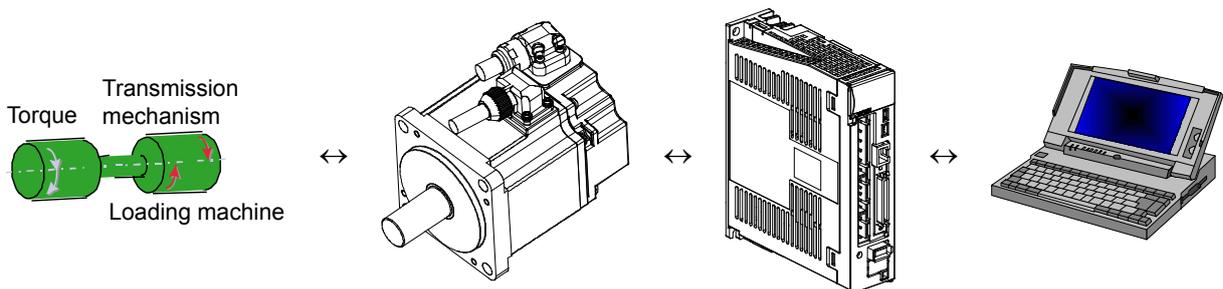
Operating procedure

- (1) Set the machine analyzer
 - ↓ Leave as default
- (2) Run the machine analyzer
 - ↓ Click the  button.
- (3) Observing the waveform data
 - ↓ Resonance point, anti-resonance point check
- (4) Filter setting
 - ↓ Not required if not resonating
- (5) Saving the file
 - ↓ Click the  menu.
- (6) Finish

* Details can be confirmed using Help.

Yellow line: Anti-resonance point; Red line: Resonance point

If the resonance frequency of the machine system can be measured, then the frequency of the machine resonance suppression filter (parameter number PB13, parameter number PB15) can be decided based on this result, and the machine vibration can be controlled when gain increases.



5. Training Machine Operation

- (7) Test operation (positioning operation) ([Test Operation]-[Positioning Operation] menu)
Positioning operation can be executed once when there is no command from an external controller.

(a) Operation/Drive

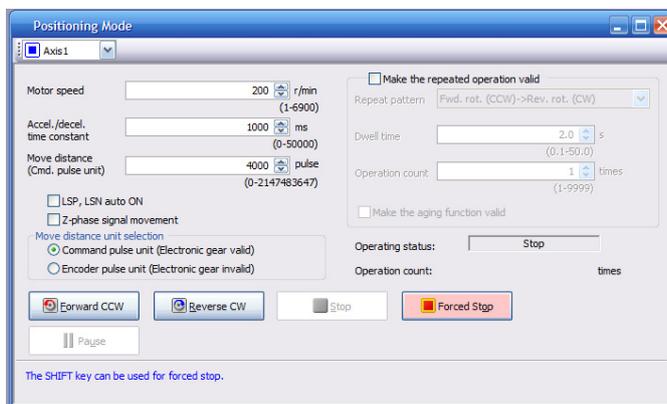
When performing positioning operation, connect EMG-DOCOM.

When the "Forward rotation"/"Reverse rotation" button on the MR Configurator2 is clicked, the servo motor rotates and travels for the set travel distance before stopping. The operation conditions can be changed on MR Configurator2.

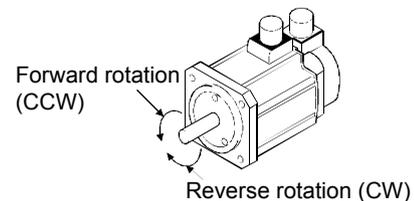
The initial operating values and setting ranges are given in the following table.

Item	Initial setting	Setting range
Motor rotation speed [r/min]	200	1 to 6900
Acceleration and deceleration time constant [ms]	1000	0 to 50000
Travel distance [pulse]	Value obtained from the amplifier	0 to 2147483647

An explanation of the keys is given in the following table.



Button	Description
"Forward rotation"	If this button is clicked, the motor rotates in the CCW direction.
"Reverse rotation"	If this button is clicked, the motor rotates in the CW direction.
"Pause"	If this button is clicked during work, the work is paused. If the "Pause" button is clicked once more, the remaining distance is deleted. To restart the operation, click the same button that initiated the operation.



If the communication cable comes off, the servo motor will stop suddenly.

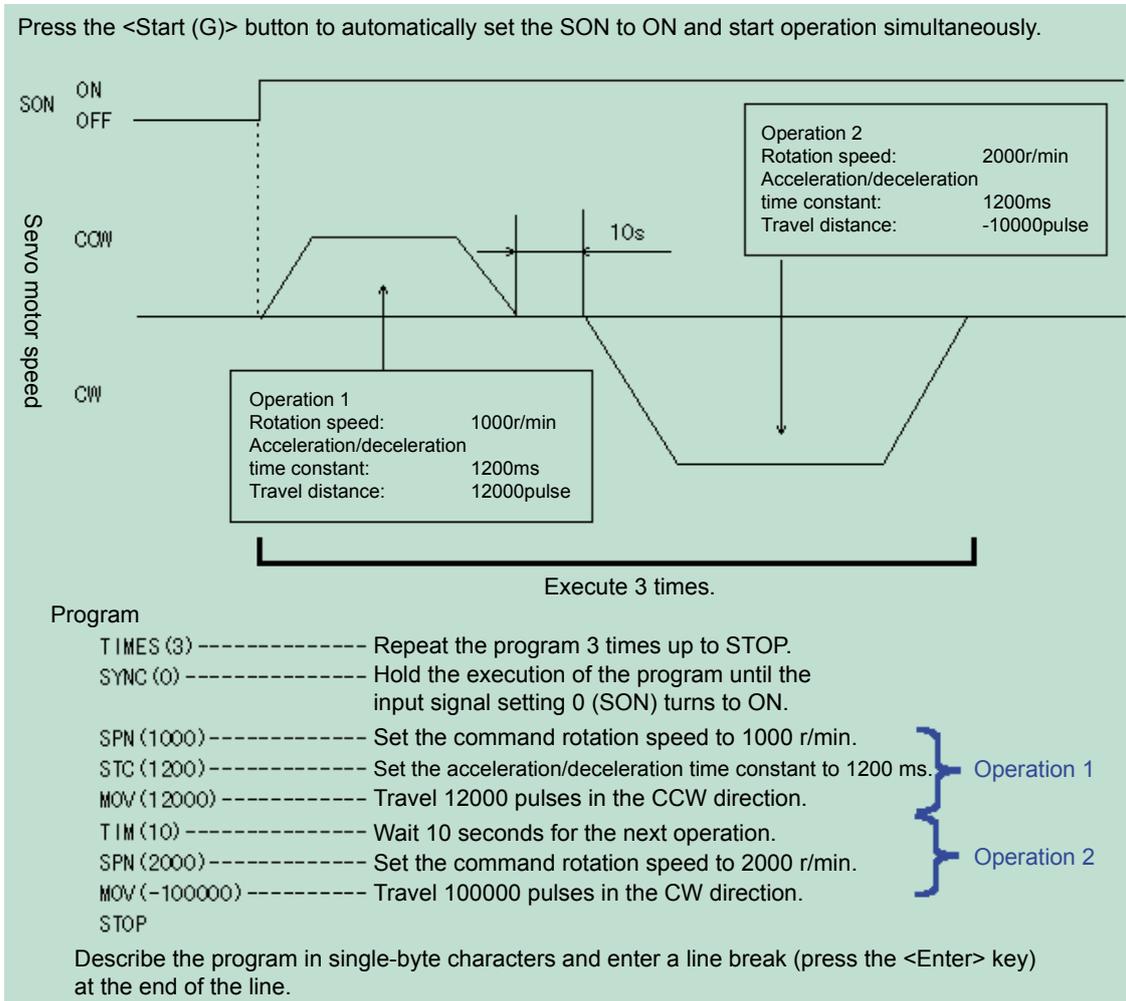
(b) Status display

The status of the servo can be displayed on the monitor even during positioning operation.

POINT
MR Configurator2 is required to perform positioning operation.

5. Training Machine Operation

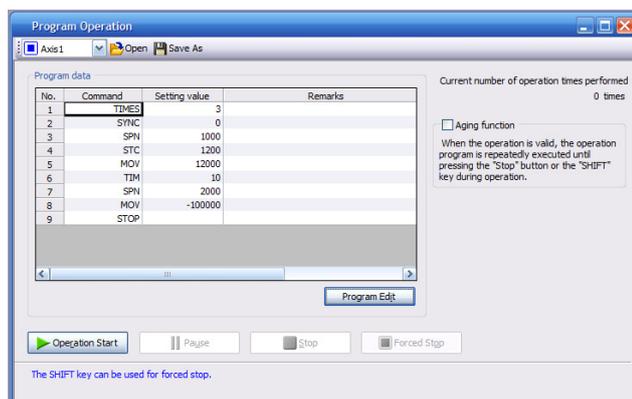
- (8) Test operation (program operation) ([Test Operation]-[Program Operation] menu)
 (a) Program example



The acceleration/deceleration time constant of operation 1 and operation 2 is the same. In this case, there is no need to set the acceleration/deceleration time constant in operation 2. In this way, the operation program only gives the setting value to be changed from the previous operation.

Note: For program operation where the "Program Operation" window and other windows (for example, the "Monitor Batch Display" window) are displayed at the same time, the progress of the program is delayed and the dwell command time becomes longer than the setting value.

Details on the simplified language of the program operation can be checked under Help.



5.4 Special Adjustment Function

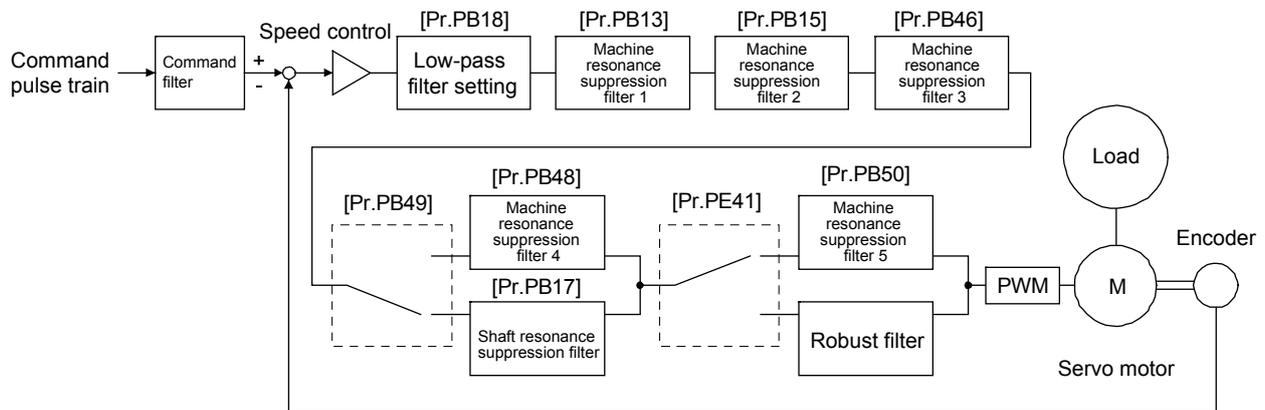
POINT

- Use of the functions displayed in this section is generally unnecessary. Use these functions when the machine status is unsatisfied according to the adjustment methods from section 5.3.

If there is a specific resonance point in the mechanical system and if the servo system response is increased, the mechanical system may resonate (vibration or abnormal noise) at that resonance frequency. The resonance of the machine system can be controlled by using the machine resonance suppression filter and adaptive tuning.

5.4.1 Filter Setting

In the MR-J4 servo amplifier, the filter settings can be configured as shown in the following figure.



5.4.1.1 Machine Resonance Suppression Filter

POINT

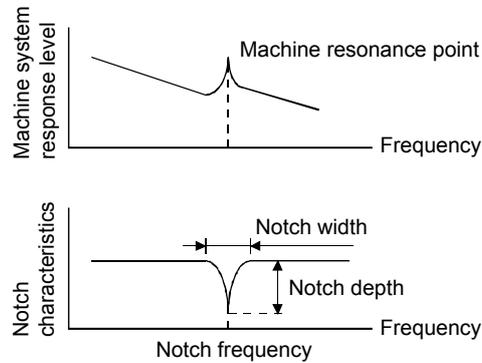
- The machine resonance suppression filter is the delay element for the servo system. Because of this, if a mistaken resonance frequency is set, and if the notch characteristics are deepened, vibrations may increase.
- If the mechanical resonance frequency is unknown, lower the notch frequency. The point where the resonance is smallest is the optimum notch frequency setting.
- A deeper notch depth will have a greater effect in reducing mechanical resonance, but because the phase delay is larger, vibration may increase.
- A wider notch depth will have a greater effect in reducing mechanical resonance, but because the phase delay is larger, vibration may increase.
- The mechanical characteristics can be assessed in advance with a machine analyzer that uses MR Configurator2. This enables the required notch frequency and the notch characteristics to be determined.

If there is a specific resonance point in the machine system, and the response of the servo system continues to increase, the machine system may vibrate (vibration and acoustic noise) at that resonance frequency. The resonance of the machine system can be controlled by using the machine resonance suppression filter and adaptive tuning. The setting range is from 10 Hz to 4500 Hz.

5. Training Machine Operation

(1) Working

The machine resonance suppression filter is the filter function (notch filter) that controls the resonance of the machine system by decreasing a specific frequency gain. The frequency (notch frequency) that decreases the gain and the depth and width that decrease the gain can be set.



At most, the following five machine resonance suppression filters can be set.

Filter	Set parameter	Precautions	Parameters reset by the vibration tough drive function	Parameters automatically set by one-touch tuning
Machine resonance suppression filter 1	PB01/PB13/PB14	Automatic adjustment is possible using "Filter tuning mode selection" of [Pr. PB01].	PB13	PB01/PB13/ PB14
Machine resonance suppression filter 2	PB15/PB16		PB15	PB15/PB16
Machine resonance suppression filter 3	PB46/PB47			PB47
Machine resonance suppression filter 4	PB48/PB49	If this filter is enabled, the shaft resonance suppression filter cannot be used. The shaft resonance suppression filter is enabled in the initial setting.		PB48/PB49
Machine resonance suppression filter 5	PB50/PB51	Even if it is set, this filter is disabled when the robust filter is being used. The robust filter is disabled in the initial setting.		PB51

(2) Parameter

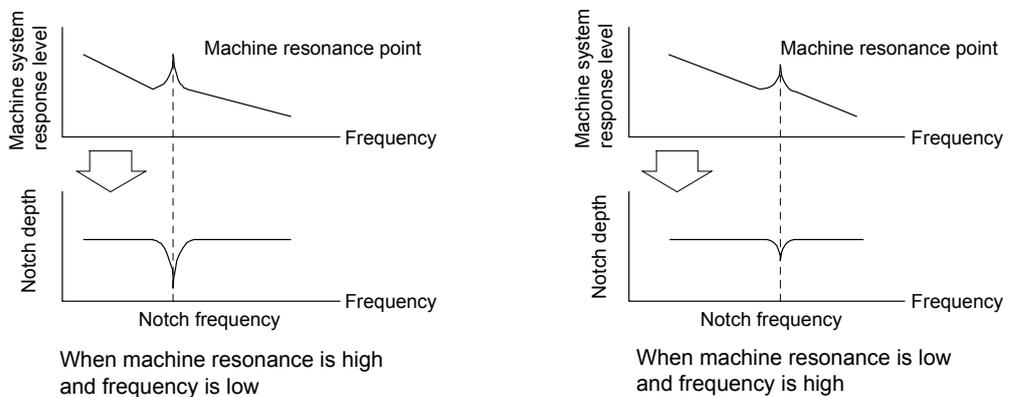
- (a) Machine resonance suppression filter 1 ([Pr. PB13]/[Pr. PB14])
Set the notch frequency, notch depth, and notch width of machine resonance suppression filter 1 ([Pr. PB13]/[Pr. PB14]).
When "Manual setting (_ _ _ 2)" is selected in "Filter tuning mode selection" of [Pr. PB01], the machine resonance suppression filter 1 setting is enabled.
- (b) Machine resonance suppression filter 2 ([Pr. PB15]/[Pr. PB16])
Use is possible by enabling (_ _ _ 1) "Machine resonance suppression filter 2 selection" of [Pr. PB16]. The setting method of machine resonance suppression filter 2 ([Pr. PB15]/[Pr. PB16]) is the same as machine resonance suppression filter 1 ([Pr. PB13]/[Pr. PB14]).
- (c) Machine resonance suppression filter 3 ([Pr. PB46]/[Pr. PB47])
Use is possible by enabling (_ _ _ 1) "Machine resonance suppression filter 3 selection" of [Pr. PB47].
The setting method of machine resonance suppression filter 3 ([Pr. PB46]/[Pr. PB47]) is the same as machine resonance suppression filter 1 ([Pr. PB13]/[Pr. PB14]).
- (d) Machine resonance suppression filter 4 ([Pr. PB48]/[Pr. PB49])
Use is possible by enabling (_ _ _ 1) "Machine resonance suppression filter 4 selection" of [Pr. PB49].
However, when machine resonance suppression filter 4 is enabled, the shaft resonance suppression filter cannot be set.
The setting method of machine resonance suppression filter 4 ([Pr. PB48]/[Pr. PB49]) is the same as machine resonance suppression filter 1 ([Pr. PB13]/[Pr. PB14]).
- (e) Machine resonance suppression filter 5 ([Pr. PB50]/[Pr. PB51])
Use is possible by enabling (_ _ _ 1) "Machine resonance suppression filter 5 selection" of [Pr. PB51].
However, when the robust filter is enabled (Pr. PE41): _ _ _ 1), machine resonance suppression filter 5 cannot be used.
The setting method of machine resonance suppression filter 5 ([Pr. PB50]/[Pr. PB51]) is the same as machine resonance suppression filter 1 ([Pr. PB13]/[Pr. PB14]).

5.4.1.2 Adaptive Filter II

POINT
<ul style="list-style-type: none"> • The machine resonance frequency that is compatible with adaptive filter II (adaptive tuning) is approximately 100 Hz to 2.25 kHz. Manually configure the settings for resonance frequencies outside of this range. • When adaptive tuning is executed, vibration signals are forcibly added, which increases the vibration noise. • If adaptive tuning is executed, the machine resonance is detected for a maximum of 10 seconds and a filter is generated. After the filter is generated, it is automatically transferred to the manual mode. • Adaptive tuning generates the most appropriate filter using the currently set control gain. If vibration is generated when the response level settings are raised, execute adaptive tuning again. • Adaptive tuning generates a filter with the most appropriate notch depth for the set control gain. If an additional filter margin is desired for the machine resonance, deepen the notch depth in the manual mode. • If the machine system has complex resonance characteristics, the result might not be obtained.

(1) Working

The adaptive filter II (adaptive tuning) is a function that detects the machine resonance of the servo amplifier for a fixed period, and automatically sets the filter characteristics to control the vibration of the machine system. Because the filter characteristics (frequency and depth) are set automatically, there is no need to be aware of the resonance frequency of the machine system.



(2) Parameter

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

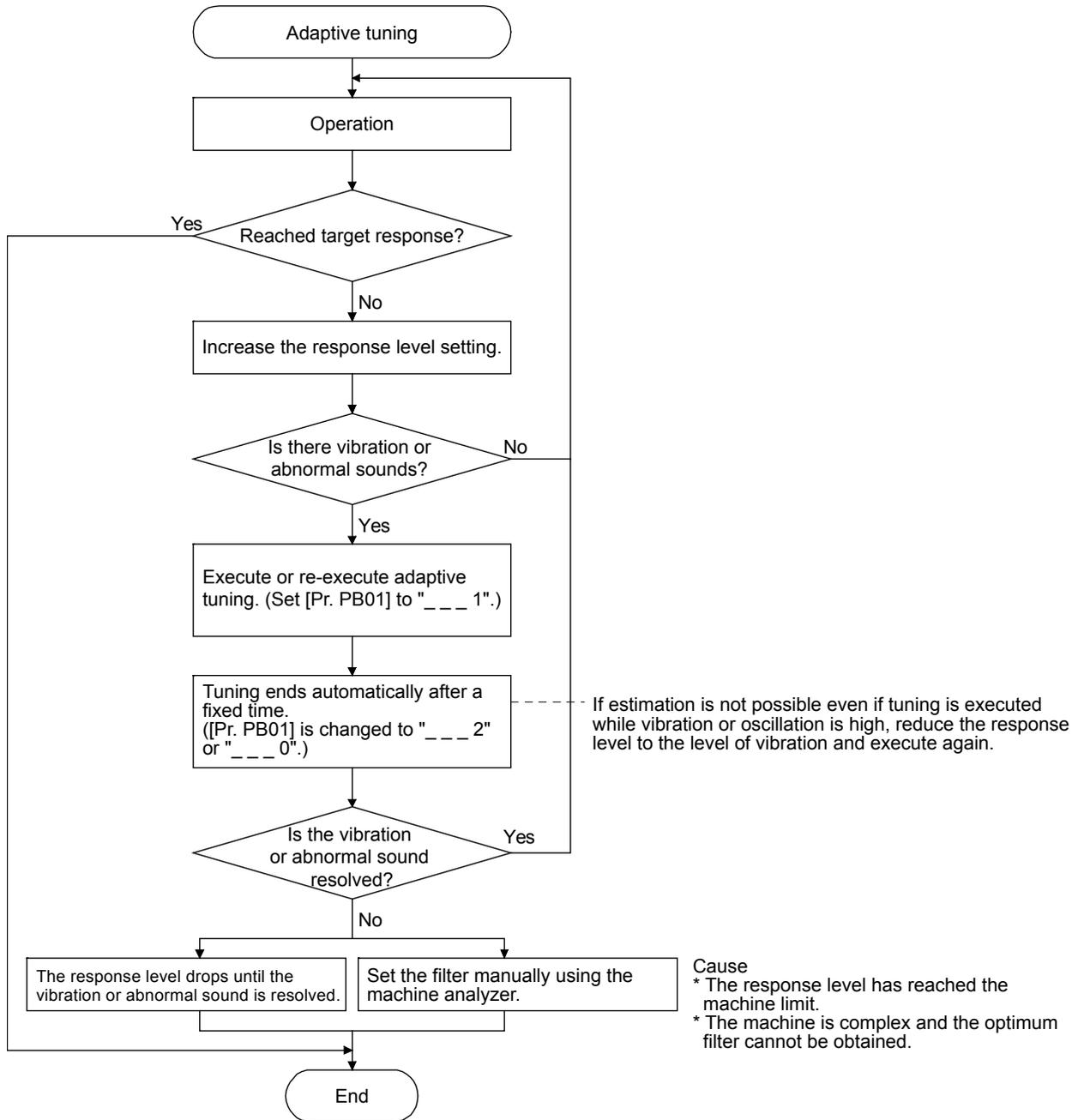
[Pr.PB01]

0	0	0	
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Filter tuning mode selection

Set value	Filter tuning mode selection	Automatically set parameters
0	Disabled	
1	Automatic setting	PB13 • PB14
2	Manual setting	

(3) Adaptive tuning procedure



5.4.1.3 Shaft Resonance Suppression Filter

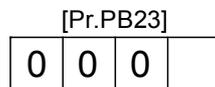
(1) Working

When a load is put on the servo motor shaft, a high-frequency machine vibration may be generated due to resonance caused by shaft torsion while the motor is being driven. The shaft resonance suppression filter is the filter that controls this vibration.

If "Automatic setting" is selected, the filter is set automatically instead of by the motor to be used and the load to motor inertia. When the resonance frequency is high, the response level is raised by disabling the setting.

(2) Parameter

Set the "Shaft resonance suppression filter selection" of [Pr. PB23].



Shaft resonance suppression filter selection
 0: Automatic setting
 1: Manual setting
 2: Disabled

If "Automatic setting" is selected, the settings of [Pr. PB17 Shaft resonance suppression filter] are automatically set.

If "Manual setting" is selected, [Pr. PB17 Shaft resonance suppression filter] can be set manually. The setting values are as follows.

Shaft resonance suppression filter setting frequency selection

Setting value	Frequency [Hz]	Setting value	Frequency [Hz]
__ 0 0	Invalid	__ 1 0	562
__ 0 1	Invalid	__ 1 1	529
__ 0 2	4500	__ 1 2	500
__ 0 3	3000	__ 1 3	473
__ 0 4	2250	__ 1 4	450
__ 0 5	1800	__ 1 5	428
__ 0 6	1500	__ 1 6	409
__ 0 7	1285	__ 1 7	391
__ 0 8	1125	__ 1 8	375
__ 0 9	1000	__ 1 9	360
__ 0 A	900	__ 1 A	346
__ 0 B	818	__ 1 B	333
__ 0 C	750	__ 1 C	321
__ 0 D	692	__ 1 D	310
__ 0 E	642	__ 1 E	300
__ 0 F	600	__ 1 F	290

5.4.1.4 Low-Pass Filter

(1) Working

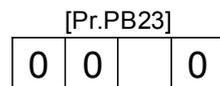
When a ball screw is used and the response level of the servo system is raised, a high-frequency resonance may be generated. To prevent this, the low-pass filter is enabled for the torque command by the initial value. The filter frequency of this low-pass filter is automatically adjusted to the value from the following formula.

$$\text{Filter frequency ([rad/s])} = \frac{VG2}{1+GD2} \times 10$$

If "Manual setting (_ _ 1 _)" is selected in "Low-pass filter selection" of [Pr. PB23], manual settings can be configured in [Pr. PB18].

(2) Parameter

Set "Low-pass filter selection" of [Pr. PB23].



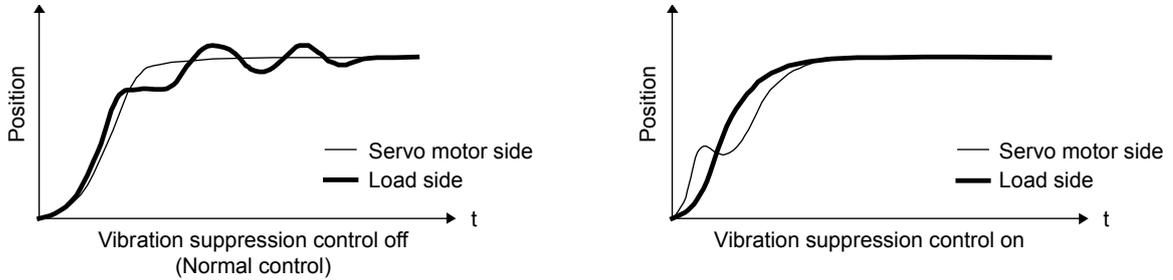
Low-pass filter selection
 0: Automatic setting
 1: Manual setting
 2: Disabled

5.4.1.5 Advanced Vibration Suppression Control II

POINT	
	<ul style="list-style-type: none"> ● The "Gain adjustment mode selection" of "[Pr. PA08]" is enabled with "Auto tuning mode 2 (_ _ _ 2)", "Manual mode (_ _ _ 3)", and "2 gain adjustment mode 2 (_ _ _ 4)". ● The compatible machine resonance frequency in the vibration suppression control tuning mode is from 1.0 Hz to 100.0 Hz. Manually configure the settings for vibration that is out of this range. ● To change the vibration suppression control related parameter, change after stopping the servo motor. Failure to do so may result in the servo motor working unexpectedly. ● For positioning operation during vibration suppression control tuning execution, set the stop time period until the vibration is attenuated and stopped. ● In some cases, vibration suppression control tuning cannot be estimated correctly if the residual vibration of the servo motor is small. ● Vibration suppression control tuning sets the most appropriate parameter using the currently set control gain. Set vibration suppression control tuning again when the response level is raised. ● Set [Pr. PA24] to " _ _ _ 1" when using vibration suppression control 2.

(1) Working

Vibration suppression control is used to further suppress vibrations such as work-side vibrations or base shaking. Determine the positioning by adjusting the work on the servo motor side so that the machine does not shake.



By executing advanced vibration suppression control II ([Pr. PB02 Vibration suppression control 2 tuning mode]), the vibration frequency of the machine system is automatically estimated, and a maximum of two load side vibrations can be suppressed.

Also, transition to the manual setting after performing the positioning operation a fixed number of times in the vibration suppression control tuning mode. With the manual setting, vibration suppression control 1 in [Pr. PB19] to [Pr. PB22] and vibration suppression control 2 in [Pr. PB52] to [Pr. PB55] can be adjusted using manual settings.

(2) Parameter

Set [Pr. PB02 Vibration suppression control tuning mode (advanced vibration suppression control II)].

When one vibration suppression control is used, set to "Vibration suppression control 1 tuning mode selection". When two vibration suppression controls are used, set to "Vibration suppression control 1 tuning mode selection" and "Vibration suppression control 2 tuning mode selection".



Vibration suppression control 1 tuning mode

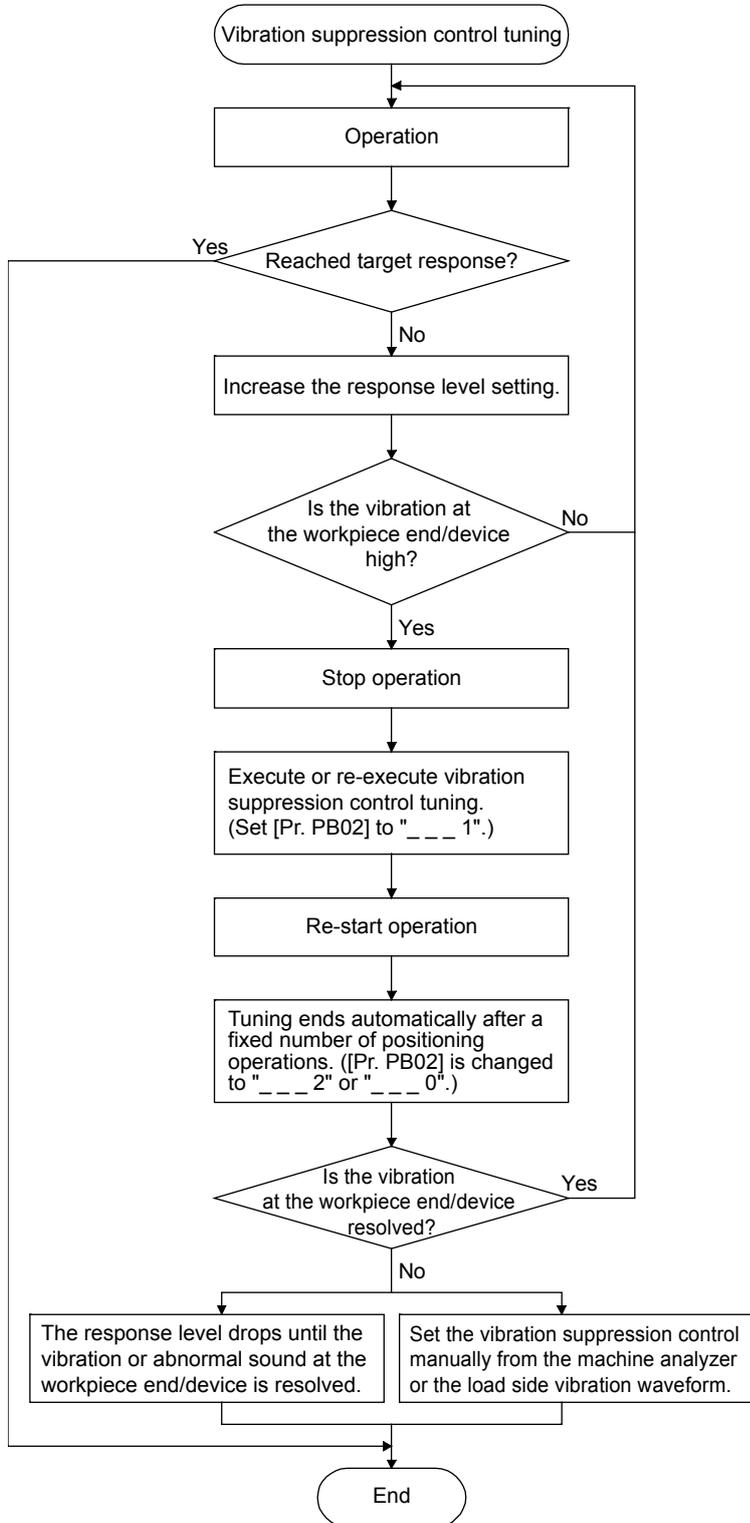
Set value	Vibration suppression control 1 tuning mode selection	Automatically set parameters
__ 0	Disabled	
__ 1	Automatic setting	PB19 • PB20 • PB21 • PB22
__ 2	Manual setting	

Vibration suppression control 2 tuning mode

Set value	Vibration suppression control 2 tuning mode selection	Automatically set parameters
__ 0	Disabled	
__ 1	Automatic setting	PB52 • PB53 • PB54 • PB55
__ 2	Manual setting	

(3) Vibration suppression control tuning procedure

The following figure is for vibration suppression control 1. For vibration suppression control 2, set [Pr. PB02] to "_ _ 1 _" and execute vibration suppression control tuning.



Cause
 * Estimation cannot be done because the vibration on the load side is not transmitted to the servo motor side.
 * The response level has reached the vibration frequency of the model position gain (vibration suppression control limit).

(4) Vibration suppression control manual mode

POINT
<ul style="list-style-type: none"> • If the vibrations of the load side are not transmitted to the servo motor side, there is no effect even if the vibration frequency of the servo motor side is set. • If the anti-resonance frequency and resonance frequency can be checked by the machine analyzer or the external measuring instrument, vibration suppression performance will be best not when the values are the same but when they are set separately. • If the [Pr. PB07 Model loop gain] value and the relation between the resonance frequency and the anti-resonance frequency is as follows, then there is no effect of vibration suppression control. With vibration suppression control 1 $[\text{Pr. PB19}] < \frac{1}{2\pi} (0.9 \times [\text{Pr. PB07}])$ $[\text{Pr. PB20}] < \frac{1}{2\pi} (0.9 \times [\text{Pr. PB07}])$ With vibration suppression control 2 $[\text{Pr. PB52}] < 5.0 + 0.1 \times [\text{Pr. PB07}]$ $[\text{Pr. PB53}] < 5.0 + 0.1 \times [\text{Pr. PB07}]$

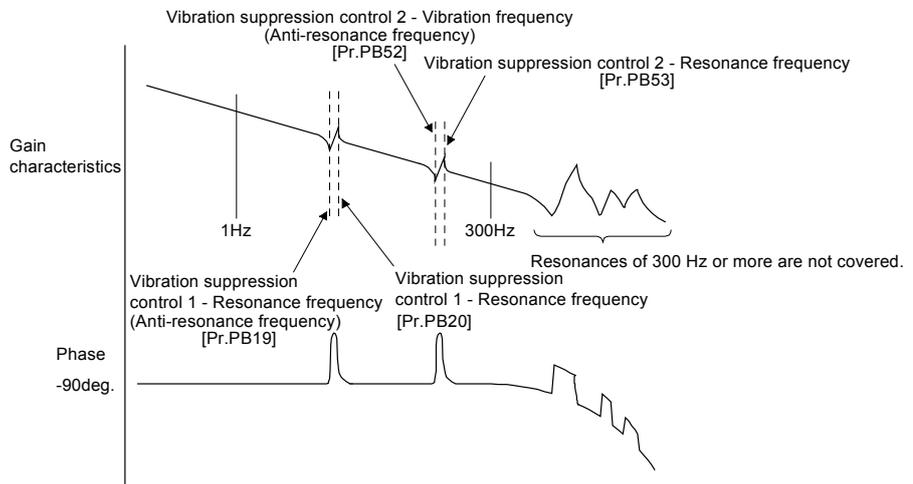
Measure the work-side vibration and the device vibration using the machine analyzer or the external measuring instrument, and then manual adjustment of the vibration suppression control can be done by setting the following parameters.

Setting item	Vibration suppression control 1	Vibration suppression control 2
Vibration frequency for vibration suppression control	[Pr. PB19]	[Pr. PB52]
Resonance frequency for vibration suppression control	[Pr. PB20]	[Pr. PB53]
Vibration suppression control - Vibration frequency damping	[Pr. PB21]	[Pr. PB54]
Vibration suppression control - Resonance frequency damping	[Pr. PB22]	[Pr. PB55]

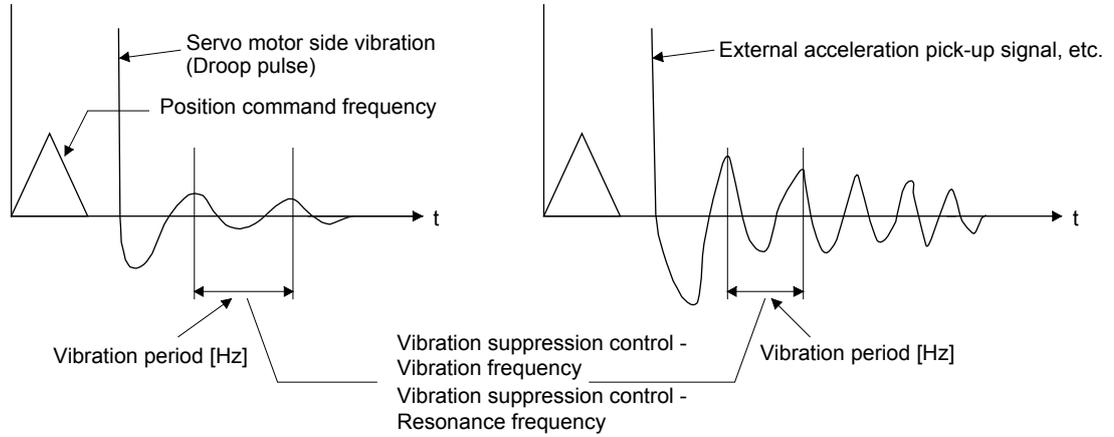
Procedure 1. Select "Manual setting (_ _ _ 2)" in "Vibration suppression control 1 tuning mode selection" of [Pr. PB02], or select "Manual setting (_ _ _ 2)" in "Vibration suppression control 2 tuning mode selection".

Procedure 2. Set vibration frequency for the vibration suppression control and resonance frequency for the vibration suppression control with the following method.

(a) When the vibration peak can be checked using the machine analyzer or the external measuring instrument with MR Configurator2



(b) When vibration can be checked using the monitor signal or the external sensor



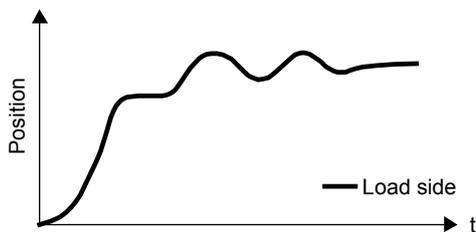
Procedure 3. Finely adjust the vibration suppression control vibration frequency damping setting and the vibration suppression control resonance frequency damping setting.

5.4.1.6 Command Notch Filter

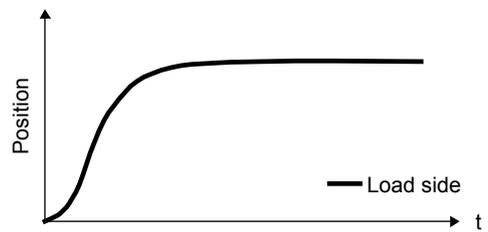
POINT
<ul style="list-style-type: none"> • Three frequency load side vibrations can be suppressed by using advanced vibration suppression control II and the command notch filter. • The frequency of the machine vibration that is compatible with the command notch filter is specified to be from 4.5 Hz to 2250 Hz. Set the frequency near the machine vibration frequency to within this range. • Even if [Pr. PB45 Command notch filter] is changed during positioning operation, the set value will not be reflected. The set value will be reflected after approximately 150 ms after the servo motor stops (after servo-lock).

(1) Working

The command notch filter is a filter function that suppress load side vibrations, such as work-side vibration or base shaking, by decreasing the specified frequency gain included in the position command. The frequency that decreases the gain and the depth that decreases the gain can be set.



Command notch filter disabled



Command notch filter enabled

(2) Parameter

Set [Pr. PB45 Command notch filter] as follows. Set the command notch filter setting frequency to a value near the vibration frequency on the load side.

[Pr.PB45]

0			
---	--	--	--

Notch depth

Command notch filter setting frequency

Set 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

Set value	Frequency [Hz]
00	Disabled
01	2250
02	1125
03	750
04	562
05	450
06	375
07	321
08	281
09	250
0A	225
0B	204
0C	187
0D	173
0E	160
0F	150
10	140
11	132
12	125
13	118
14	112
15	107
16	102
17	97
18	93
19	90
1A	86
1B	83
1C	80
1D	77
1E	75
1F	72

Set value	Frequency [Hz]
20	70
21	66
22	62
23	59
24	56
25	53
26	51
27	48
28	46
29	45
2A	43
2B	41
2C	40
2D	38
2E	37
2F	36
30	35.2
31	33.1
32	31.3
33	29.6
34	28.1
35	26.8
36	25.6
37	24.5
38	23.4
39	22.5
3A	21.6
3B	20.8
3C	20.1
3D	19.4
3E	18.8
3F	18.2

Set value	Frequency [Hz]
40	17.6
41	16.5
42	15.6
43	14.8
44	14.1
45	13.4
46	12.8
47	12.2
48	11.7
49	11.3
4A	10.8
4B	10.4
4C	10.0
4D	9.7
4E	9.4
4F	9.1
50	8.8
51	8.3
52	7.8
53	7.4
54	7.0
55	6.7
56	6.4
57	6.1
58	5.9
59	5.6
5A	5.4
5B	5.2
5C	5.0
5D	4.9
5E	4.7
5F	4.5

5.4.2 Gain Switching Function

With this function, the gain can be switched. Gain can be switched during rotation and when stopped, and also when using the input device during the operation.

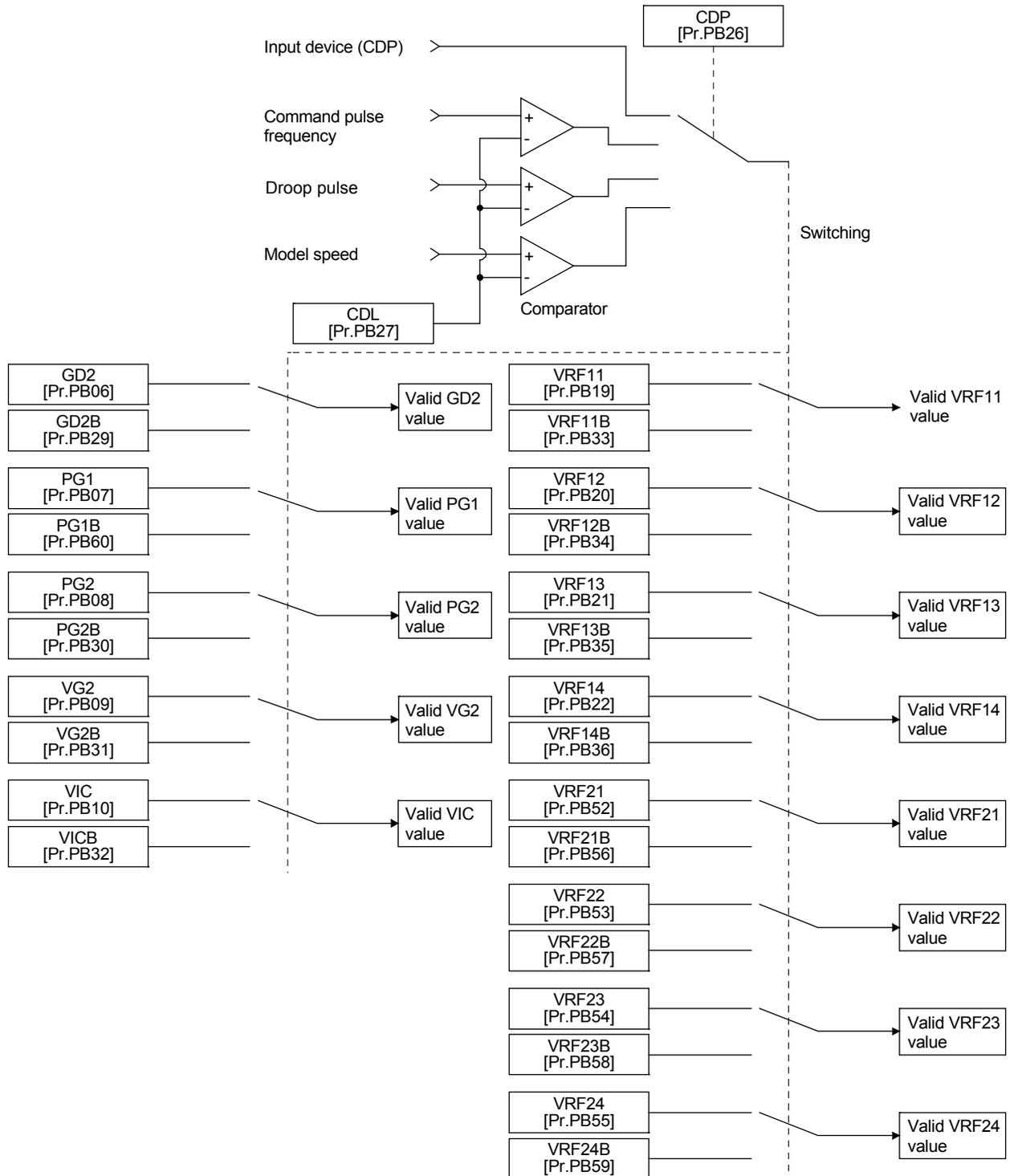
5.4.2.1 Application

This function is used in the following cases.

- (1) Although the gain during servo-lock is to be increased, the gain during rotation is to be decreased so that the driving sound is suppressed.
- (2) When gain is to be decreased during the settling time in order to shorten the stop settling time.
- (3) When gain is to be switched by the input device so that servo system stability is maintained to counteract wide fluctuations of load to motor inertia ratio when stopped (when a heavy transport material is packed on the cart).

5.4.2.2 Function Block Diagram

Each control gain, load to motor inertia ratio, and vibration suppression control can be switched based on the conditions selected from [Pr. PB26 Gain switching function] and [Pr. PB27 Gain switching condition].



5.4.2.3 Parameter

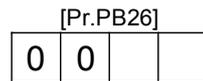
When using the gain switching function, make sure to select "Manual mode (_ _ _ 3)" in "Gain adjustment mode selection" of [Pr. PA08 Auto tuning mode]. The gain switching function cannot be used in the auto tuning mode.

(1) Variable gain operation setting parameter

Parameter number	Abbreviation	Name	Unit	Description
PB26	CDP	Gain switching selection		Select the switching condition.
PB27	CDL	Gain switching condition	[kpps] /[pulse] /[r/min]	Set the value of the switching conditions.
PB28	CDT	Gain switching time constant	[ms]	The filter time constant can be set with regard to the gain changes while switching.

(a) [Pr. PB26 Gain switching function]

Set the gain switching conditions. Select the switching conditions in the first and second digits.



- Gain switching selection
- 0: Disabled
 - 1: Input device (CDP (gain switching))
 - 2: Command frequency
 - 3: Droop pulse
 - 4: Servo motor speed

- Gain switching condition
- 0: Gain enabled after switching above the switching condition
 - 1: Gain enabled after switching under the switching condition

(b) [Pr. PB27 Gain switching condition]

Set the level for switching the gain when "Command frequency", "Droop pulse", or "Servo motor speed" is selected in [Pr. PB26 Gain switching function].

The setting unit is as follows.

Gain switching condition	Unit
Command frequency	[kpps]
Droop pulse	[pulse]
Servo motor speed	[r/min]

(c) [Pr. PB28 Gain switching time constant]

The first-order delay filter can be set for each gain at the time of gain switching. Use to reduce the impact on the machine when the gain difference is not excessive when gain switching.

(2) Changeable gain parameter

Control gain	Before switching			After switching		
	Parameter	Abbreviation	Name	Parameter	Abbreviation	Name
Load to motor inertia ratio	PB06	GD2	Load to motor inertia ratio	PB29	GD2B	Gain switching Load to motor inertia ratio
Model loop gain	PB07	PG1	Model loop gain	PB60	PG1B	Gain switching Model loop gain
Position loop gain	PB08	PG2	Position loop gain	PB30	PG2B	Gain switching Position loop gain
Speed loop gain	PB09	VG2	Speed loop gain	PB31	VG2B	Gain switching Speed loop gain
Speed integral compensation	PB10	VIC	Speed integral compensation	PB32	VICB	Gain switching Speed integral compensation
Vibration suppression control 1 Vibration frequency	PB19	VRF11	Vibration suppression control 1 Vibration frequency	PB33	VRF11B	Vibration suppression control 1 after gain switching Vibration frequency
Vibration suppression control 1 Resonance frequency	PB20	VRF12	Vibration suppression control 1 Resonance frequency	PB34	VRF12B	Vibration suppression control 1 after gain switching Resonance frequency
Vibration suppression control 1 Vibration frequency damping	PB21	VRF13	Vibration suppression control 1 Vibration frequency damping	PB35	VRF13B	Vibration suppression control 1 after gain switching Vibration frequency damping
Vibration suppression control 1 Resonance frequency damping	PB22	VRF14	Vibration suppression control 1 Resonance frequency damping	PB36	VRF14B	Vibration suppression control 1 after gain switching Resonance frequency damping
Vibration suppression control 2 Vibration frequency	PB52	VRF21	Vibration suppression control 2 Vibration frequency	PB56	VRF21B	Vibration suppression control 2 after gain switching Vibration frequency
Vibration suppression control 2 Resonance frequency	PB53	VRF22	Vibration suppression control 2 Resonance frequency	PB57	VRF22B	Vibration suppression control 2 after gain switching Resonance frequency
Vibration suppression control 2 Vibration frequency damping	PB54	VRF23	Vibration suppression control 2 Vibration frequency damping	PB58	VRF23B	Vibration suppression control 2 after gain switching Vibration frequency damping
Vibration suppression control 2 Resonance frequency damping	PB55	VRF24	Vibration suppression control 2 Resonance frequency damping	PB59	VRF24B	Vibration suppression control 2 after gain switching Resonance frequency damping

- (a) [Pr. PB06] to [Pr. PB10]
These parameters are normally the same as manual adjustment. If gain switching is performed, the values of load to motor inertia ratio, position loop gain, speed loop gain, and speed integral compensation can be changed.
- (b) [Pr. PB19] to [Pr. PB22]/[Pr. PB52] to [Pr. PB55]
These parameters are normally the same as manual adjustment. If gain switching is performed when the servo motor is stopped, the vibration frequency, resonance frequency, vibration frequency damping settings, and resonance frequency damping settings can be changed.
- (c) [Pr. PB29 Load to motor inertia ratio after gain switching]
Set the load to motor inertia ratio after switching. When the load to motor inertia ratio is not changed, set it to the same value as the [Pr. PB06 load to motor inertia ratio] value.
- (d) [Pr. PB30 Position loop gain after gain switching]/[Pr. PB31 Speed loop gain after gain switching]/[Pr. PB32 Speed integral compensation after gain switching]
Set the position loop gain, speed loop gain, and speed integral compensation after gain switching.
- (e) Vibration suppression control after gain switching ([Pr. PB33] to [Pr. PB36]/[Pr. PB56]/[Pr. PB59]/[Pr. PB60 Model loop gain after gain switching])
Gain switching vibration suppression control and model loop gain can only be used by turning the input device (CDP) on/off.
The vibration frequency, resonance frequency, vibration frequency damping settings, and resonance frequency damping settings of vibration suppression control 1 and vibration suppression control 2 can be changed.

5. Training Machine Operation

5.4.2.4 Gain Switching Procedure

This section explains by giving an example of the settings.

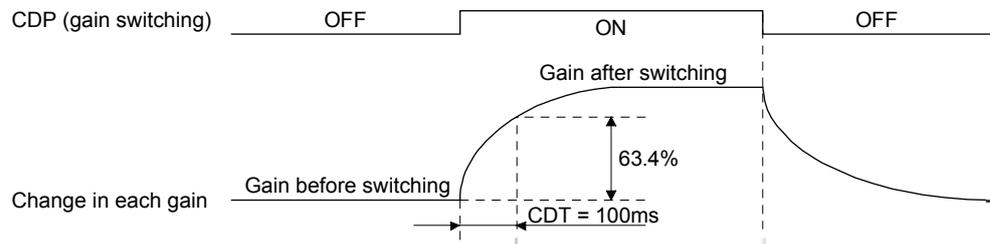
(1) If switching by the input device (CDP) is selected

(a) Settings

Parameter	Abbreviation	Name	Setting value	Unit
PB06	GD2	Load to motor inertia ratio	4.00	[times]
PB07	PG1	Model loop gain	100	[rad/s]
PB08	PG2	Position loop gain	120	[rad/s]
PB09	VG2	Speed loop gain	3000	[rad/s]
PB10	VIC	Speed integral compensation	20	[ms]
PB19	VRF11	Vibration suppression control 1 - Vibration frequency	50	[Hz]
PB20	VRF12	Vibration suppression control 1 - Resonance frequency	50	[Hz]
PB21	VRF13	Vibration suppression control 1 - Vibration frequency damping	0.20	
PB22	VRF14	Vibration suppression control 1 - Resonance frequency damping	0.20	
PB52	VRF21	Vibration suppression control 2 - Vibration frequency	20	[Hz]
PB53	VRF22	Vibration suppression control 2 - Resonance frequency	20	[Hz]
PB54	VRF23	Vibration suppression control 2 - Vibration frequency damping	0.10	
PB55	VRF24	Vibration suppression control 2 - Resonance frequency damping	0.10	
PB29	GD2B	Load to motor inertia ratio after gain switching	10.00	[times]
PB60	PG1B	Model loop gain after gain switching	50	[rad/s]
PB30	PG2B	Position loop gain after gain switching	84	[rad/s]
PB31	VG2B	Speed loop gain after gain switching	4000	[rad/s]
PB32	VICB	Speed integral compensation after gain switching	50	[ms]
PB26	CDP	Gain switching function	0001 (Switch the input device (CDP) on/off.)	
PB28	CDT	Gain switching time constant	100	[ms]
PB33	VRF11B	Vibration suppression control 1 - Vibration frequency after gain switching	60	[Hz]
PB34	VRF12B	Vibration suppression control 1 - Resonance frequency after gain switching	60	[Hz]
PB35	VRF13B	Vibration suppression control 1 - Vibration frequency damping after gain switching	0.15	
PB36	VRF14B	Vibration suppression control 1 - Resonance frequency damping after gain switching	0.15	
PB56	VRF21B	Vibration suppression control 2 - Vibration frequency after gain switching	30	[Hz]
PB57	VRF22B	Vibration suppression control 2 - Resonance frequency after gain switching	30	[Hz]
PB58	VRF23B	Vibration suppression control 2 - Vibration frequency damping after gain switching	0.05	
PB59	VRF24B	Vibration suppression control 2 - Resonance frequency damping after gain switching	0.05	

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(b) Timing chart when switching



Model loop gain	100	→	50	→	100
Load to motor inertia ratio	4.00	→	10.00	→	4.00
Position loop gain	120	→	84	→	120
Speed loop gain	3000	→	4000	→	3000
Speed integral compensation	20	→	50	→	20
Vibration suppression control 1 - Vibration frequency	50	→	60	→	50
Vibration suppression control 1 - Resonance frequency	50	→	60	→	50
Vibration suppression control 1 - Vibration frequency damping	0.20	→	0.15	→	0.20
Vibration suppression control 1 - Resonance frequency damping	0.20	→	0.15	→	0.20
Vibration suppression control 2 - Vibration frequency	20	→	30	→	20
Vibration suppression control 2 - Resonance frequency	20	→	30	→	20
Vibration suppression control 2 - Vibration frequency damping	0.10	→	0.05	→	0.10
Vibration suppression control 2 - Resonance frequency damping	0.10	→	0.05	→	0.10

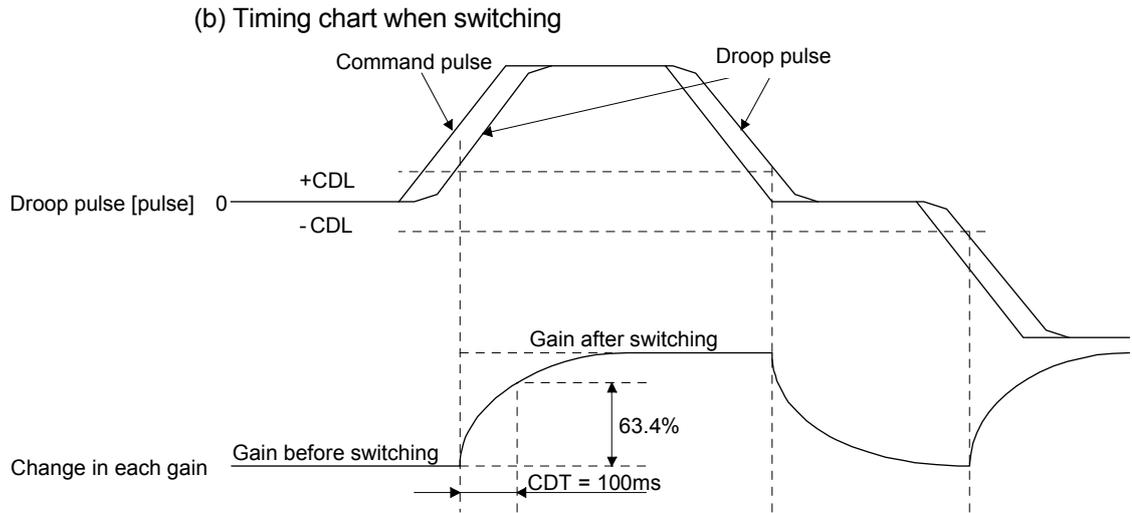
(2) When switching is done using droop pulse

In this case, vibration suppression control after gain switching and model loop gain after gain switching cannot be used.

(a) Settings

Parameter	Abbreviation	Name	Setting value	Unit	
PB06	GD2	Load to motor inertia ratio	4.00	[times]	
PB08	PG2	Position loop gain	120	[rad/s]	
PB09	VG2	Speed loop gain	3000	[rad/s]	
PB10	VIC	Speed integral compensation	20	[ms]	
PB29	GD2B	Load to motor inertia ratio after gain switching	10.00	[times]	
PB30	PG2B	Position loop gain after gain switching	84	[rad/s]	
PB31	VG2B	Speed loop gain after gain switching	4000	[rad/s]	
PB32	VICB	Speed integral compensation after gain switching	50	[ms]	
PB26	CDP	Gain switching function	0003 (Switch using droop pulse.)	/	
PB27	CDL	Gain switching condition	50		[pulse]
PB28	CDT	Gain switching time constant	100		[ms]

5. Training Machine Operation



Load to motor inertia ratio	4.00	→	10.00	→	4.00	→	10.00
Position loop gain	120	→	84	→	120	→	84
Speed loop gain	3000	→	4000	→	3000	→	4000
Speed integral compensation	20	→	50	→	20	→	50

5.4.3 Tough Drive Function

POINT
<ul style="list-style-type: none">• Set whether to enable/disable the tough drive function using [Pr. PA20 Tough drive setting].

Tough drive function is a function that continues operation so that the device does not stop even when there is an alarm.

5.4.3.1 Vibration Tough Drive Function

The vibration tough drive function is a function that instantly resets the filter and prevents vibration when the machine resonance vibration frequency fluctuates and when machine resonance occurs due to changes in the machine over the years.

In order to reset the machine resonance suppression filter with the vibration tough drive function, it is important that [Pr. PB13 Machine resonance suppression filter 1] and [Pr. PB15 Machine resonance suppression filter 2] are set in advance.

Set [Pr. PB13] and [Pr. PB15] using the following method.

(1) Implementation of one-touch tuning (refer to section 5.3.2)

(2) Manual setting (refer to section 5.3.4)

Operate the vibration tough drive function if the retrieved resonance frequency is within $\pm 30\%$ of the range with regard to the set value of [Pr. PB13 Machine resonance suppression filter 1] and [Pr. PB15 Machine resonance suppression filter 2].

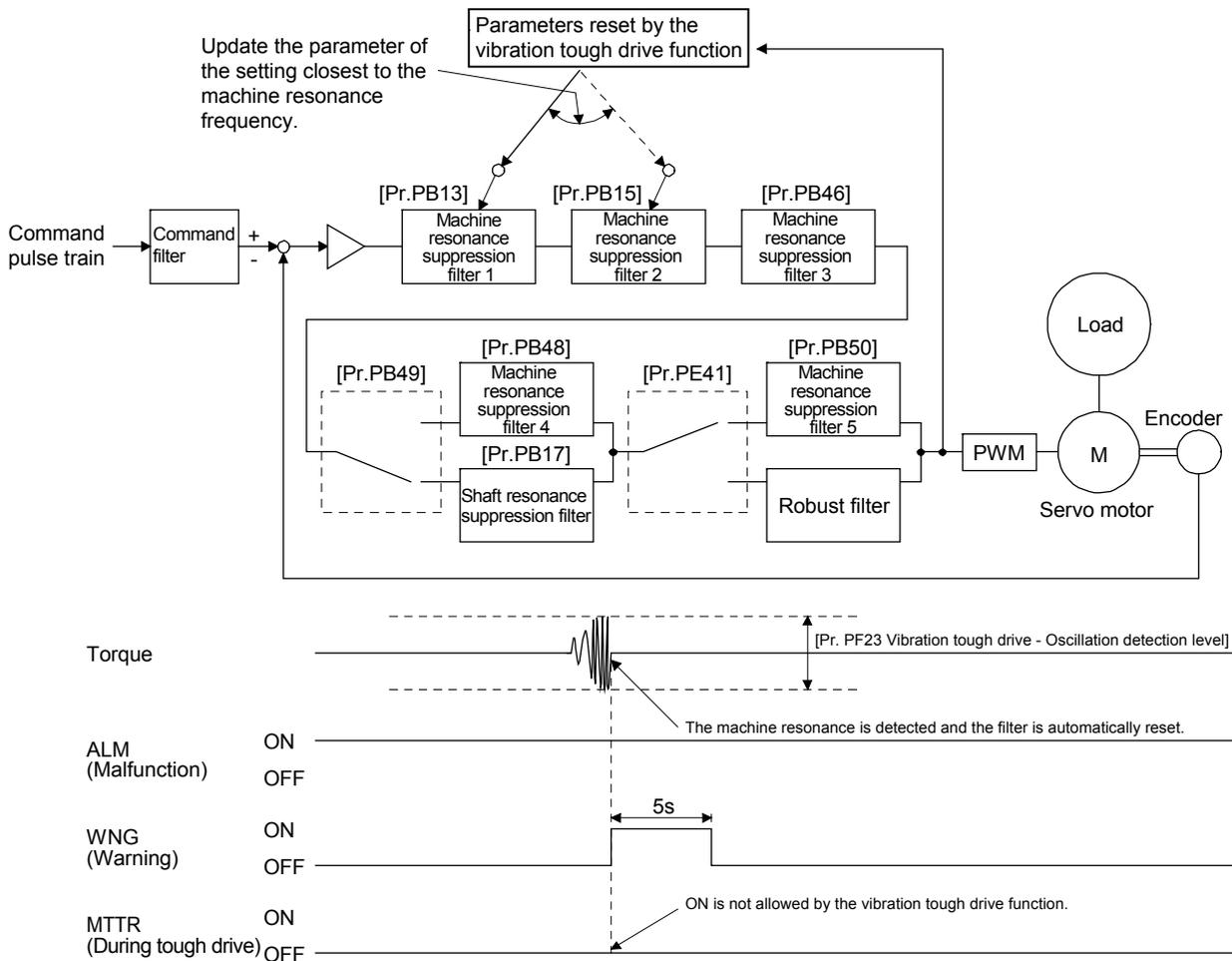
The sensitivity can be set for the detection level of the vibration tough drive function using [Pr. PF23 Vibration tough drive - Oscillation detection level].

POINT
<ul style="list-style-type: none">• The resetting of [Pr. PB13] and [Pr. PB15] is always executed by the vibration tough drive function; however, the number of writes to EEPROM in 1 hour is 1.• [Pr. PB46 Machine resonance suppression filter 3], [Pr. PB48 Machine resonance suppression filter 4], and [Pr. PB50 Machine resonance suppression filter 5] are not reset by the vibration tough drive function.• Vibrations less than 100 Hz cannot be detected by the vibration tough drive function.

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The following figure shows the function block diagram of the vibration tough drive function. Compare the detected machine resonance frequency with [Pr. PB13 Machine resonance suppression filter 1] and [Pr. PB15 Machine resonance suppression filter 2], and reset the machine resonance frequency considering the closest set value.

Filter	Set parameter	Precautions	Parameters to be reset using the vibration tough drive function
Machine resonance suppression filter 1	PB01/PB13/PB14	Automatic adjustment is possible using "Filter tuning mode selection" of [Pr. PB01].	PB13
Machine resonance suppression filter 2	PB15/PB16		PB15
Machine resonance suppression filter 3	PB46/PB47		
Machine resonance suppression filter 4	PB48/PB49	If this filter is enabled, the shaft resonance suppression filter cannot be used. The shaft resonance suppression filter is enabled in the initial setting.	
Machine resonance suppression filter 5	PB50/PB51	Even if it is set, this filter is disabled when the robust filter is being used. The robust filter is disabled in the initial setting.	



5.4.3.2 Instantaneous Power Failure Tough Drive



CAUTION

- During the instantaneous power failure tough drive, the torque can be restricted depending on the set value of [Pr. PF25 Instantaneous power failure tough drive - Detection time] or the load status.
- The momentary power failure tolerance increases due to the instantaneous tough drive function. However, it does not comply with the SEMI-F47 standard.

The instantaneous tough drive function is a function that avoids [AL. 10 Undervoltage] even if instantaneous power failure occurs during operation. When instantaneous power failure tough drive is activated, the momentary power failure tolerance can be increased and, at the same time, the "AL. 10 Undervoltage" alarm level can be changed using the electrical energy charged in the capacitor in the servo amplifier during instantaneous power failure. The [AL. 10.1 Voltage drop in the control circuit power] detection period for the control circuit power supply can be changed in [Pr. PF25 Instantaneous power failure tough drive - Detection time]. Also, the [AL. 10.2 Voltage drop in the main circuit power] detection level for bus voltage is set automatically.

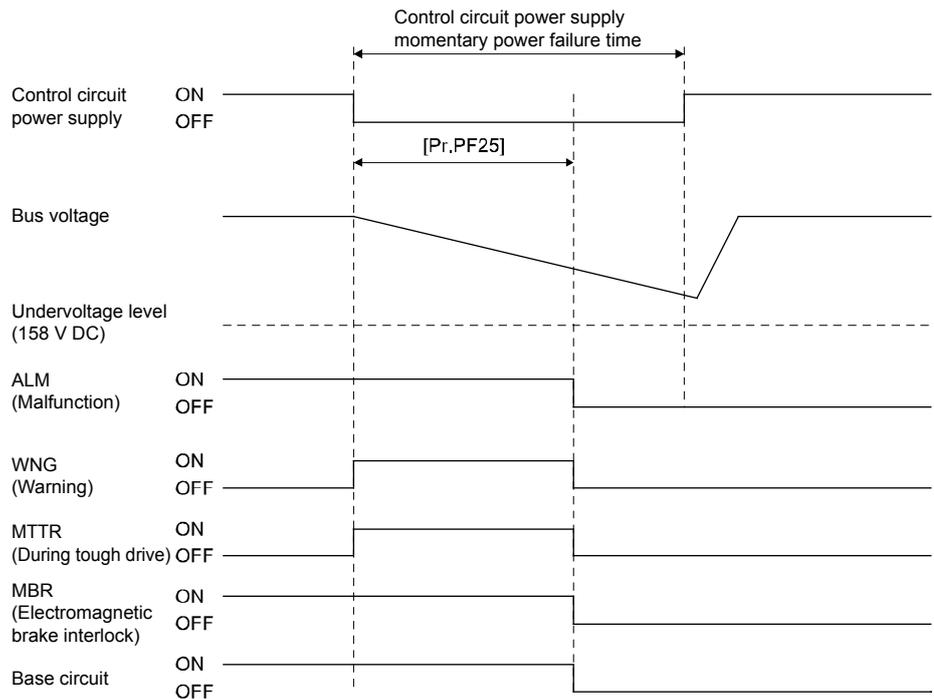
POINT	
•	MBR (Electromagnetic brake interlock) cannot be turned off during instantaneous power failure tough drive.
•	Regardless of the set value of [Pr. PF25 Instantaneous power failure tough drive - Detection time], if the load at the time of momentary power failure is large, there may be an undervoltage alarm ([AL. 10.2]) due to a drop in bus voltage.

(1) When control circuit power supply momentary power failure period > [Pr. PF25 Instantaneous power failure tough drive - Detection time]

When the control circuit power supply momentary power failure period exceeds [Pr. PF25 Instantaneous power failure tough drive - Detection time], an alarm occurs.

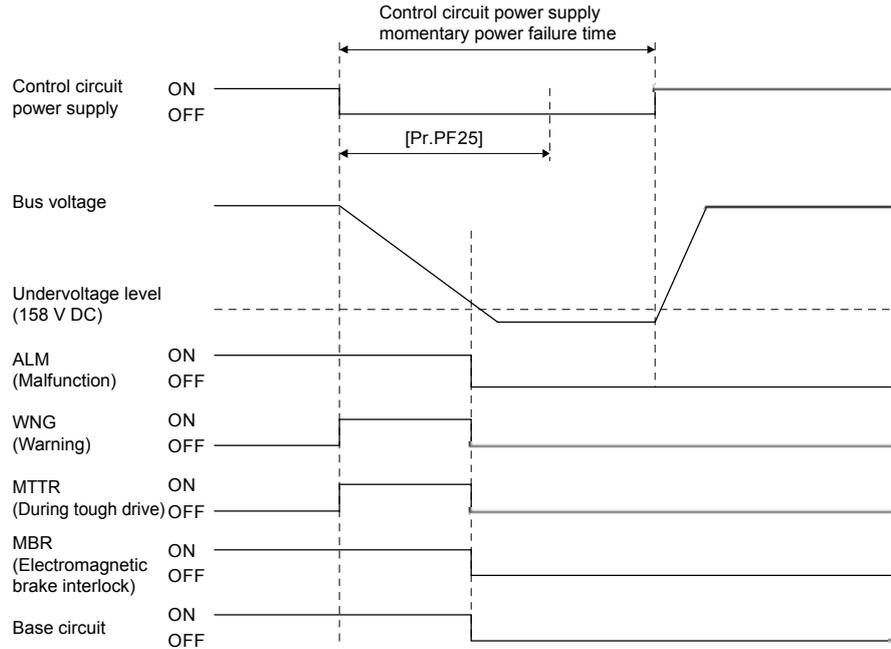
MTTR (during tough drive) is turned on after a momentary power failure is detected.

MBR (electromagnetic brake interlock) is turned off when an alarm occurs.

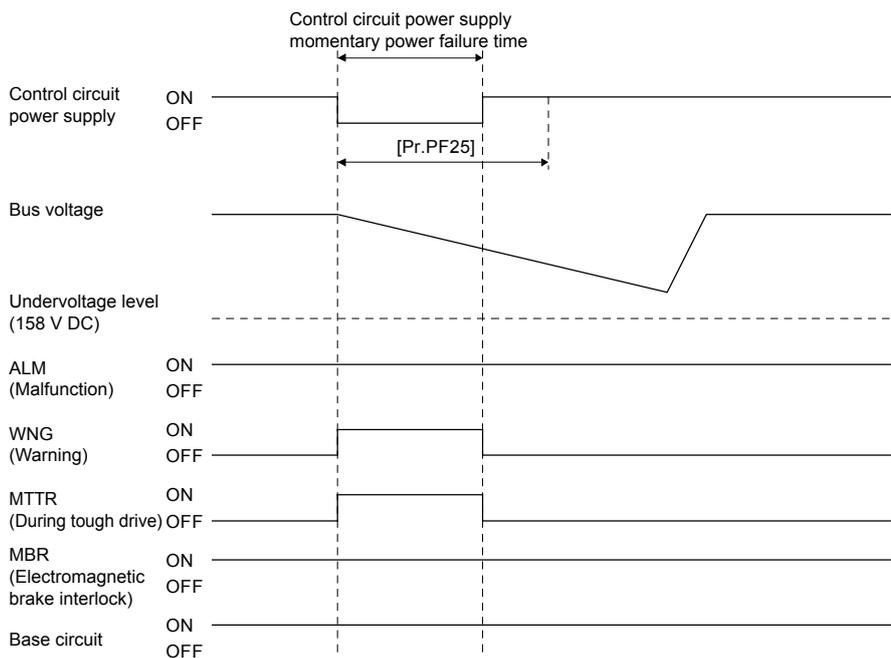


(2) When control circuit power supply momentary power failure period < [Pr. PF25 Instantaneous power failure tough drive - Detection time]
 Depending on the bus voltage drop status, the operation condition will differ.

(a) When the bus voltage drops below 158 V DC during the control circuit power supply momentary power failure period
 [AL. 10 Undervoltage] occurs when the bus voltage drops below 158 V DC even if instantaneous power failure tough drive is enabled.

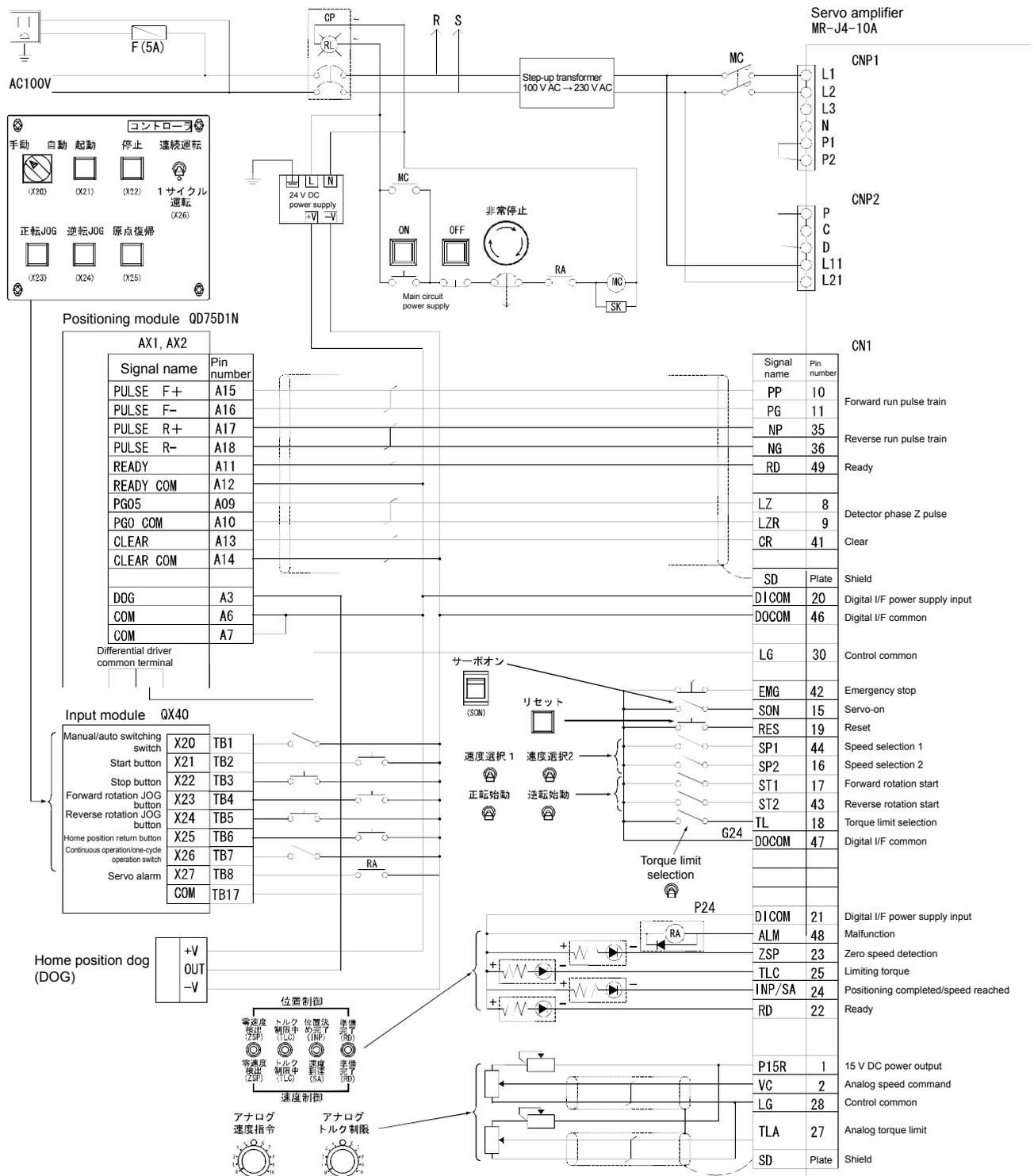


(b) When the bus voltage does not drop below 158 V DC during the control circuit power supply momentary power failure period
 No alarm occurs and operation continues as is.

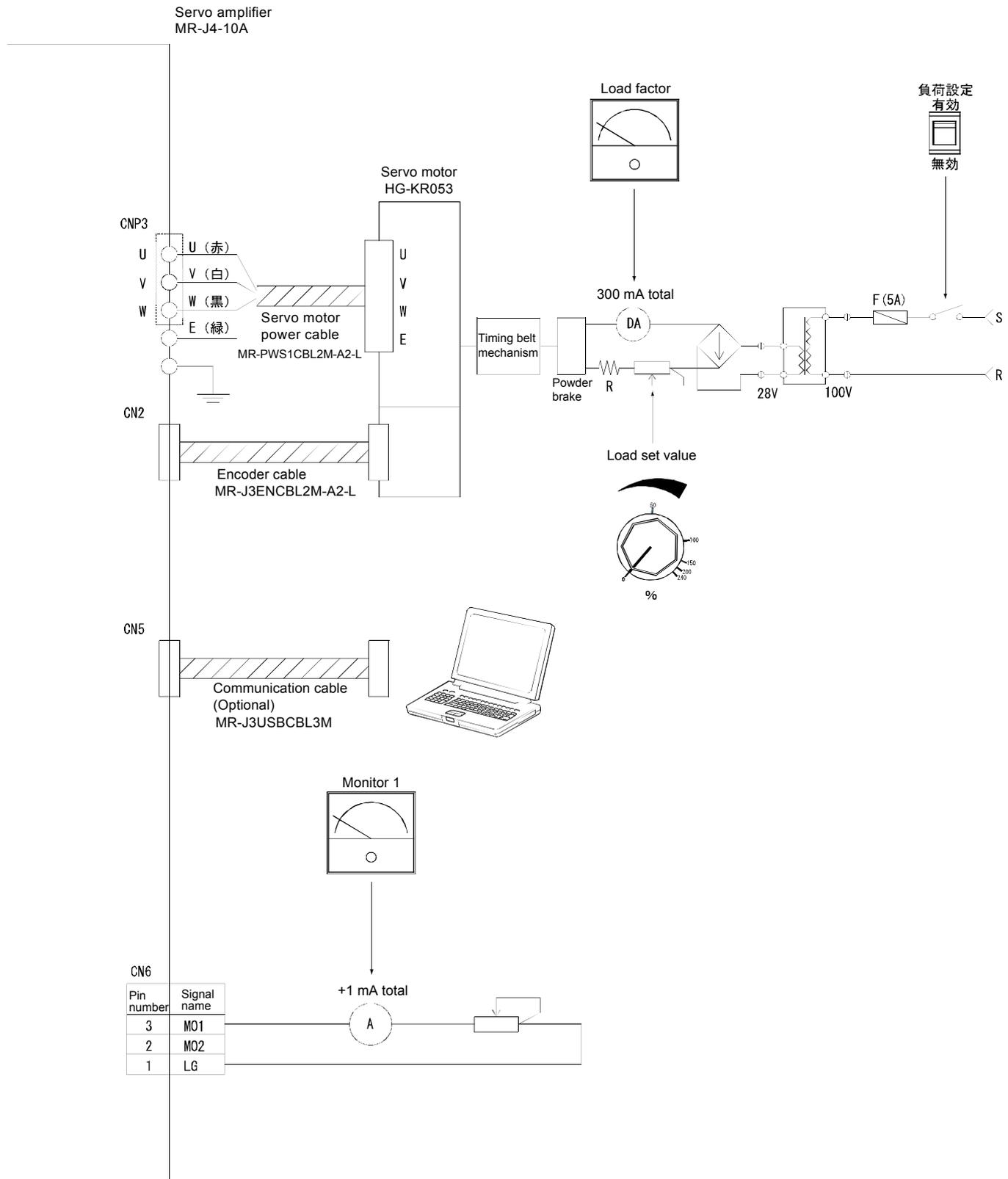


5. Training Machine Operation

5.4.4 Connection of Laboratory Device



5. Training Machine Operation



Memo

A large, empty rectangular box with rounded corners, intended for writing a memo.

6. Selection

6.1 Temporary Selection of Motor Capacity

The aim of the guidelines for selecting the AC servo capacity for the drive axis structure is as follows.

(1) Aim of control loop stability

Load moment of inertia $J_L \leq$ Motor rotor moment of inertia $J_M \times$ Suggested load moment of inertia

(2) Load torque allowance

Load torque $T_L \leq$ Motor rated torque $T_M \times 0.5$ to 0.8

6.1.1 Load Moment of Inertia J_L

This is the moment of inertia of the drive system after the span ring structure and coupling linked with the motor output shaft that form the motor load. The electromagnetic brake and motor reducer is also included.

Also, in the AC servo system, the unit used for the load moment of inertia J_L is $[\text{kg}\cdot\text{cm}^2]$, and the calculation formula of the load moment of inertia is given in Table 6.1.

6.1.2 Load Torque T_L

This is said to be the thrust, frictional force, and the unbalanced torque, which act on the machine moving parts that form the motor load.

Also, the unit used for the load torque T_L is $[\text{N}\cdot\text{m}]$, and the calculation formula of the load torque is given in Table 6.2.

Remarks: Various calculation formula symbols are used as per Appendix 1.

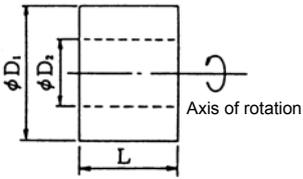
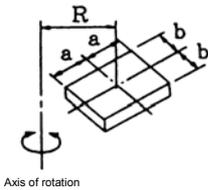
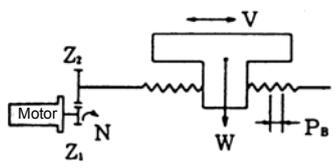
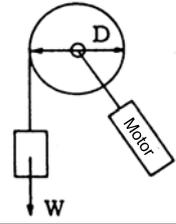
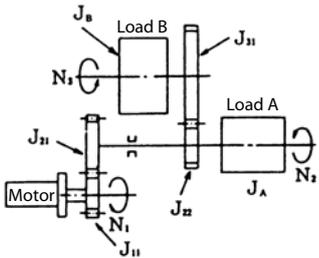
6. Selection

6.1.3 Load Moment of Inertia/Load Torque Calculation Formula

(1) Load moment of inertia calculation formula

The typical calculation formula for the moment of inertia is given in Table 6.1.

Table 6.1 Calculation formula of load moment of inertia

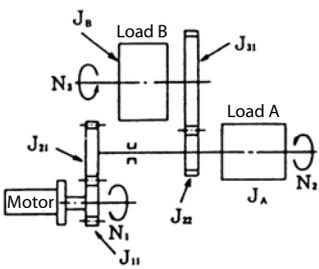
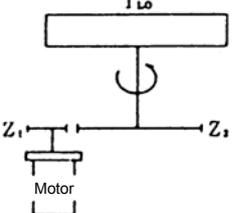
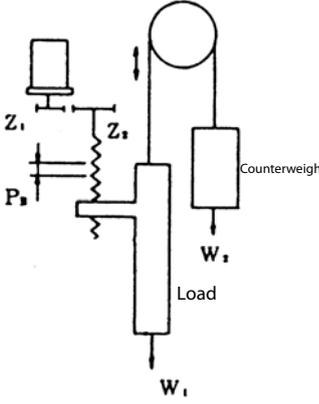
Type	Mechanism	Calculation formula
1. Cylinder		$J_L = \frac{\pi \cdot \rho \cdot L}{32} \cdot (D_1^4 - D_2^4) = \frac{W}{8} (D_1^2 + D_2^2) \dots\dots\dots (6-1)$ <p> J_L: Load moment of inertia [kg·cm²] ρ: Density of cylinder material [kg/cm³] L: Length of cylinder [cm] D_1: Outside diameter of cylinder [cm] D_2: Inside diameter of cylinder [cm] W: Weight of the cylinder [kg] </p> <p>Reference data: Material density – Iron: 7.8/10⁻³[kg/cm³] Aluminum: 2.7/10⁻³ [kg/cm³] Copper: 8.96/10⁻³ [kg/cm³]</p>
2. Rectangular prism		$J_L = W \left(\frac{a^2 + b^2}{3} + R^2 \right) \dots\dots\dots (6-2)$ <p>a, b, R: Left figure [cm]</p>
3. Object that moves linearly		$J_L = W \cdot \left(\frac{V}{600\omega} \right)^2 = W \cdot \left(\frac{1}{2\pi N} \cdot \frac{V}{10} \right)^2 = W \cdot \left(\frac{\Delta S}{20\pi} \right)^2 \dots\dots\dots (6-3)$ <p> J_L: Load moment of inertia at motor shaft [kg/cm²] V: Speed of object moving linearly [mm/min] N: Motor rotation speed [r/min] </p> $\Delta S = P_B \cdot \frac{Z^1}{Z^2} \quad Z^1, Z^2: \text{Number of gear teeth}$
4. Object to be suspended		$J_L = \frac{W}{4} \cdot D^2 + J_p \dots\dots\dots (6-4)$ <p> J_p: Pulley moment of inertia [kg·cm²] D: Pulley diameter [cm] </p>
5. Motor shaft conversion load moment of inertia		$J_L = J_{11} + (J_{21} + J_{22} + J_A) \cdot \left(\frac{N_2}{N_1} \right)^2 + (J_{31} + J_B) \cdot \left(\frac{N_3}{N_1} \right)^2 \dots\dots\dots (6-5)$ <p> J_A, J_B: Load A, Moment of inertia B [kg·cm²] J_{11} to J_{31}: Moment of inertia of gear [kg·cm²] N_1 to N_3: Speed of each shaft [r/min] </p>

6. Selection

(2) Load torque calculation formula

The typical calculation formula for the load torque is given in Table 6.2.

Table 6.2 Load torque calculation formula

Type	Mechanism	Calculation formula
Linear movement		$T_L = \frac{F}{2 \times 10^3 \pi \eta} \cdot \frac{V}{N} = \frac{F \cdot \Delta S}{2 \times 10^3 \pi \eta} \dots \dots \dots (6-6)$ <p>F: Strength of linearly moving machine in axial direction (thrust) [N] η: Efficiency of the drive system</p> <p>For example, when moving the table as in the figure to the left, the force F is obtained as follows:</p> $F = F_c + \mu (W \cdot g + F_G) \dots \dots \dots (6-7)$ <p>F_c: Force applied in the axial direction of the moving part (thrust) [N] F_G: Tightening force of the table guide surface [N] μ: Friction coefficient V: Speed of object moving linearly [mm/min] N: Motor rotation speed [r/min] W: Object mass [kg] g: Gravitational acceleration [9.8 m/s²] ΔS: Feed length of moving object in 1 rotation of the motor [mm]</p>
Rotary movement		$T_L = \frac{Z_1}{Z_2} \cdot \frac{1}{\eta} \cdot T_{L0} + T_F \dots \dots \dots (6-8)$ <p>T_{L0}: Load torque on the load shaft [N·m] T_L: Friction load torque of motor shaft conversion [N·m] T_F: Friction torque of the moving part [N·m]</p>
Vertical movement		<p>When rising $T_L = T_U + T_F \dots \dots \dots (6-9)$ When descending $T_L = -\eta^2 \cdot T_U + T_F \dots \dots \dots (6-10)$</p> <p>$T_U$: Unbalanced torque [N·m] T_F: Friction torque of the moving part [N·m]</p> $T_U = \frac{(W_1 - W_2) \cdot g}{2 \times 10^3 \pi \eta} \cdot \left(\frac{V}{N} \right) = \frac{(W_1 - W_2) \cdot g \cdot \Delta S}{2 \times 10^3 \pi \eta} \dots \dots \dots (6-11)$ $T_F = \frac{\mu \cdot (W_1 + W_2) \cdot g \cdot \Delta S}{2 \times 10^3 \pi \eta} \dots \dots \dots (6-12)$ <p>W_1: Weight of load [kg] W_2: Mass of counterweight [kg] η: Drive system efficiency μ: Friction coefficient (sieve)</p>

6.2 Reduction Ratio

In order to sufficiently exert the servo motor capacity, it is important to efficiently pull the servo motor power and to use the servo system that includes the machine by increasing its stability and response.

For this, the major element is the reduction ratio, which is introduced between the servo motor and the machine.

The conditions for selecting the reduction ratio correctly are explained below.

- (1) To use the maximum motor output (power), select so that the motor is operated at the rated speed when the machine is at its fastest.
 - 1) The servo motor gives the maximum output (rated output) at the rated speed.
 - 2) The load torque at motor shaft and load moment of inertia at motor shaft of the machine decreases when the reduction ratio increases. In other words, when the reduction ratio is selected so as to operate at the rated speed, the observed load from the motor will become lighter.
- (2) In order 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 less than a factor of the recommended load to motor inertia ratio (less than 30 times for HC-MFS motor).

$$\text{Load to motor inertia ratio } m = \frac{\text{Motor shaft conversion load } J_L}{\text{Motor } J_M} < \text{Recommended load to motor inertia ratio}$$

The response can be increased by decreasing the load to motor inertia ratio. Therefore, select so that it is as small ($m < 2$) as possible at the time of high-frequency transmission.

- (3) To ensure positioning accuracy, it is preferred that the feed length for 1 pulse $\Delta \ell_0$ is small. The following is usually a guide for the relationship between machine accuracies $\Delta \varepsilon$ and $\Delta \ell_0$.

$$\Delta \ell_0 < \left(\frac{1}{5} \text{ to } \frac{1}{10} \right) \times \Delta$$

Note: Refer to section 2.5.1 for the relationship between $\Delta \ell_0$ and the reduction ratio.

<Reference>

1. The power during acceleration time is smallest when $m = 1$ is set. In other words, set to the following:

$$1 / n = \sqrt{J_M / J_L} \quad \text{This reduction ratio is generally referred to as the optimum reduction ratio.}$$

2. In case of accelerating using the spur gear or pulley, take care as the load moment of inertia increases conversely due to deceleration if the pulley diameter on the machine side is increased in order to increase the reduction ratio.

6.3 Operation Pattern and Motor Required Torque

The operation pattern is generally divided into acceleration time T_{psa} , constant-speed operation t_c , acceleration time T_{psd} , stop settling time t_s , and stop time t_{st} , and then considered.

The energy required while accelerating the object having moment of inertia (load moment of inertia J_L) is called acceleration torque T_a , and similarly it is called deceleration torque T_d while decelerating.

Also, in the stop settling time after decelerating from the constant-speed operation, the friction load torque T_L is operated similar to that during the constant-speed operation.

6.3.1 Acceleration Torque T_a

The calculation formula for acceleration torque T_a is the expression (6-13):

$$T_a = \frac{(J_L + J_M) \cdot \omega_0}{9.55 \times 10^4 \cdot T_{psa}} \cdot \left(1 - \varepsilon - \frac{T_{psa}}{T_p}\right) \text{ [N}\cdot\text{m]} \dots\dots\dots(6-13)$$

Use the simplified calculation formula (6-14).

$$T_a = \frac{(J_L + J_M) \cdot \omega_0}{9.55 \times 10^4 \cdot T_{psa}} \text{ [N}\cdot\text{m]} \dots\dots\dots(6-14)$$

6.3.2 Deceleration Torque T_d

The calculation formula of deceleration torque T_d is the same as (6-15):

$$T_d = \frac{(J_L + J_M) \cdot \omega_0}{9.55 \times 10^4 \cdot T_{psa}} \cdot \left(1 - \varepsilon - \frac{T_{psa}}{T_p}\right) \text{ [N}\cdot\text{m]} \dots\dots\dots(6-15)$$

Use the simplified calculation formula (6-16).

$$T_d = \frac{(J_L + J_M) \cdot \omega_0}{9.55 \times 10^4 \cdot T_{psa}} \text{ [N}\cdot\text{m]} \dots\dots\dots(6-16)$$

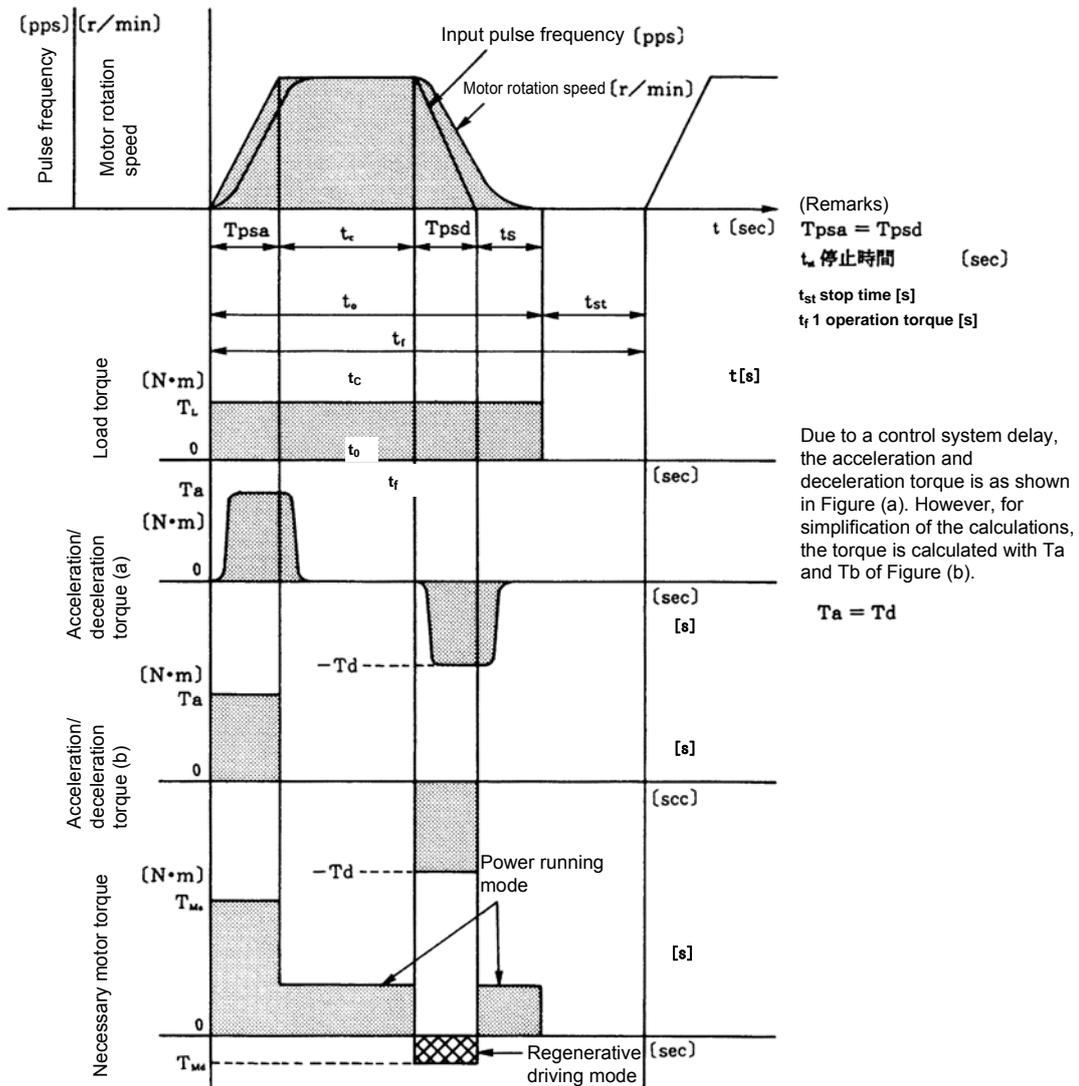
Also, when $T_{psa} = T_{psd}$, the acceleration torque and the deceleration torque have the same value $T_a = -(T_d)$.

6.3.3 Operation Pattern

If the items describe up to here are organized as an operation pattern, the following will apply.

- (1) The motor torque required during a constant speed is the load torque at motor shaft T_L .
- (2) Increasing/decreasing the load torque at motor shaft T_L is positive/negative depending on the conditions.
- (3) The motor torque required during acceleration/deceleration is as follows.
 Motor torque during acceleration $T_{Ma} = \text{Load torque } T_L + \text{Acceleration torque } T_a$
 Motor torque during deceleration $T_{Md} = \text{Load torque } T_L - \text{Deceleration torque } T_d$
- (4) The motor decelerates by supplying energy to the machine at power drive deceleration when $T_{Md} = T_L - T_d > 0$.
- (5) The motor is decelerated by applying brakes to the machine when there is regenerative braking (regenerative mode) when $T_{Md} = T_L - T_d < 0$. The regenerative power flow is from the machine side to the amplifier side.
- (6) If the deceleration pattern and the torque pattern are arranged, the result will look like Figure 6.1.

Figure 6.1 Operation pattern and individual section torque pattern



[s]

6.3.4 Determining Motor Capacity

The availability of the motor is first determined by whether it can cover the necessary motor torque in Figure 6.1. However, in addition to this, it is necessary to examine the rise in motor temperature and the regenerative brake heat capacity for repetitive usage.

A temporary selected motor can be used if it fulfills the following three conditions.

- (1) Motor torque T_{Ma} required during acceleration in Figure 6.1
 $T_{Ma} = T_L + T_a < \text{Motor maximum torque } T_{Mmax}$ (6-17)
- (2) Motor torque T_{Md} required during deceleration in figure 6.1
 $T_{Md} = T_L - T_d < \text{Motor maximum torque } T_{Mmax}$ (6-18)
- (3) Continuous effective load torque T_{rms}
 $T_{rms} \leq \text{Motor rated torque } T_M$ (6-19)

The continuous effective load torque T_{rms} represents the load torque that is equivalent to when there is a continuous temperature rise in a motor that operates in an intermittent cycle. Therefore, if $T_{rms} \leq T_M$, there is no temperature issue.

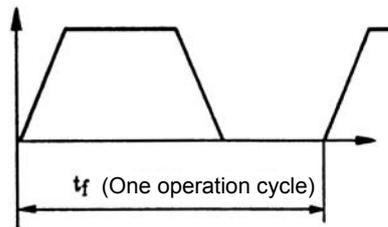
T_{rms} in Figure 6.1 is obtained using the following formula.

$$T_{rms} = \sqrt{\frac{T_{Ma}^2 \cdot T_{psa} + T_L^2 \cdot (t_0 - T_{psa} - T_{psd} - T_s) + T_{Md}^2 \cdot T_{psd}}{t_f}} \text{ [N}\cdot\text{m]} \dots\dots\dots (6-20)$$

If any of the above conditions ((1), (2) or (3)) are not fulfilled, revise the machine side conditions, the operation pattern, and the motor capacity, and reexamine using a similar procedure.

If all of the above conditions ((1), (2) and (3)) are fulfilled, then there is no issue of torque or temperature rise even if the temporarily selected motor is operated using the speed pattern and cycle time according to plan.

However, if negative torque occurs in the torque pattern, the efficiency of the regenerative brake of the servo amplifier also needs to be studied. Refer to the examination of regenerative brake option necessity in section 6.3.5.

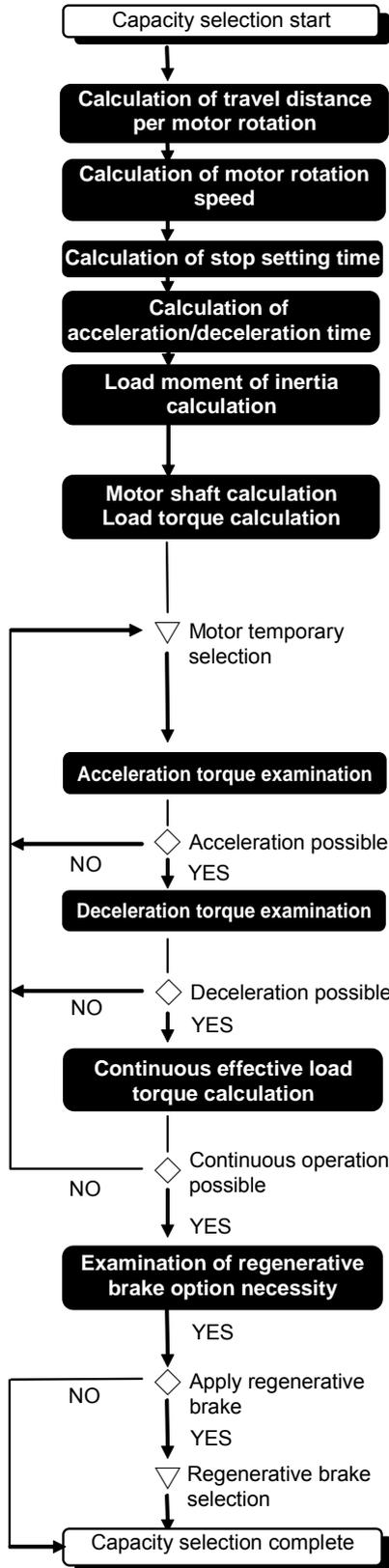


6. Selection

6.3.5 Capacity Selection Flow and Calculation

(1) Ball screw horizontal

(1) Selection flow



Selection guideline	Judgment
Calculate the travel distance per motor rotation $\Delta S = PB \times 1/n \times 1/nm$ [mm/rev]	—
Calculate the motor rotation speed $NO = V0/\Delta S$ [r/min]	—
Calculate the stop settling time $ts = 3 \times 1/Kp$ [s]	—
Calculate the acceleration/deceleration time $Tsa = Tsd = t0-(L/V0 \times 60+ts)$ [s]	—
Calculate the load moment of inertia at motor shaft $JB = \{(\pi \times 0.0078 \times (LB/10))/32\} \times (DB/10)^4$ [kg·cm ²] $JF = (WT+WL) \times (\Delta S / 20\pi)^2$ [kg·cm ²] $JL = JMG+JMB+JF+\{JG+JC+J0+JB \times (1/n)^2\} \times (1/nm)^2$ [kg·cm ²]	—
Calculate the load torque at motor shaft $TL = \{(Fc+ \mu \times (WT+WL) \times g+FG)\} \times \Delta S / (2000 \times \pi \times \eta)$ [N·m]	—
The rated torque of the motor is more than the load torque at motor shaft The moment of inertia is less than the recommended load to motor inertia ratio (catalog value) The Motor rated speed is more than the motor rotation speed at the time of positioning The electrical accuracy is within the request specifications $\Delta L = (\Delta S / Pf) \times 1000$ [μm/pulse]	(0.5 to 0.8)/ $Ttyp > TL$ $m = JL/JM$ < catalog value $NR > NO$ $\Delta L < \text{request specifications}$
Calculate the acceleration torque (motor required torque required during acceleration time) $TMa = \{(JL+JM) \times NO\} / (9.55 \times 10000 \times Tsa) + TL$ [N·m] Check whether the motor maximum torque is greater than the acceleration torque	$Tmax > TMa$
Calculate the deceleration torque (motor required torque required during deceleration time) $TMd = \{(JL+JM) \times NO\} / (9.55 \times 10000 \times Tsa) + TL$ [N·m] Check whether the motor maximum torque is greater than the deceleration torque Peak load ratio is within 300% $Rp = \{(\text{Maximum value } TMa , TMd)\} / Ttyp \times 100$	$Tmax > TMd$ $Rp < 300$
Calculate the continuous effective load torque $tc = t0-Tsa-Tsd-ts$ [s] $Trms = \sqrt{(TMa^2 \times Tsa + TL^2 \times tc + TMd^2 \times Tsd) / tf}$ [N·m] Check whether the fixed torque of motor is greater than the continuous execution load torque Effective load ratio is within 100% $Rrms = (Trms/Ttyp) \times 100$	$Ttyp > Trms$ $Rrms < 100$
Calculate the regenerative power $Ea = 0.1047 \times NO/2 \times TMa \times Tsa$ [J] $Ed = 0.1047 \times NO/2 \times TMd \times Tsd$ [J] $Ef = 0.1047 \times NO \times TL \times tc$ [J] Check whether regenerative power has occurred Absolute value of total negative energy within $Em = Ea, Ed, Ef$ $Pr = \{\eta m \times Em - (Wa \times t) - Ec\} / tf$ [W] Select the permissible regenerative brake option that is more than the regenerative power Regenerative load ratio is within 100% $Ld = (Pr/Ptyp) \times 100$	$Pr > 0$ Regenerative option > Pr $Ld < 100$

6. Selection

(2) Various important symbols related to the load and operation

	Term	Symbol	Unit
Machine-side specifications	Table weight	WT	kg
	Load mass	WL	kg
	Load anti-drag force	Fc	N
	Tightening force of the table guide surface	FG	N
	Speed deceleration ratio	1/n	
	Reducer moment of inertia	JG	kg·cm ²
	Coupling moment of inertia	JC	kg·cm ²
	Other output shaft conversion moments of inertia	JO	kg·cm ²
	Ball screw lead	PB	mm
	Ball screw diameter	DB	mm
	Ball screw length	LB	mm
	Drive system efficiency	η	
	Friction coefficient	μ	
	Fast feed speed	VO	mm/min
	Positioning length	L	mm
Specifications used for searching	Positioning time	tO	s
	1 cycle time	tf	s
	Travel distance per motor rotation	ΔS	mm/rev
	Motor rotation speed	NO	r/min
	Stop settling time	ts	s
	Acceleration time	Tsa	s
	Deceleration time	Tsd	s
	Moment of inertia of ball screw	JB	kg·cm ²
	Moment of inertia of object moving linearly	JF	kg·cm ²
	Load moment of inertia at motor shaft	JL	kg·cm ²
	Load torque at motor shaft	TL	N·m
	Acceleration torque (motor required torque required during acceleration time)	TMa	N·m
	Deceleration torque (motor required torque required during deceleration time)	TMd	N·m
	Continuous effective load torque	Trms	N·m
	Regenerative power	Pr	W
	Energy at time of acceleration	Ea	J
	Energy at time of deceleration	Ed	J
	Energy at time of constant speed	Ef	J
	Absolute value of negative energy total	Em	J
	Maximum regenerative power	Pmax	W
	Interval energy at time of maximum regeneration	E _{max}	J
	Reduction ratio of motor with reducer	1/nm *1	
	Encoder resolution	Pf *1	pulse/rev
	Position loop gain	Kp	1/s
	Moment of inertia of reducer of motor with reducer	JMG *1	kg·cm ²
	Moment of inertia of brake of motor with brake	JMB *1	kg·cm ²
	Motor moment of inertia	JM *1	kg·cm ²
	Recommended load to motor inertia ratio	m *1	
	Motor rated speed	NR *1	r/min
	Gravitational acceleration	g	m/s ²
	Motor maximum torque	Tmax *1	N·m
	Motor rated torque	Ttyp *1	N·m
	Motor inverse efficiency	ηm *1	%
	Amplifier processing	Wa *1	W
	Regenerative operation period	t	s
Capacitor charging energy	Ec *1	J	
Rated power of regeneration unit	Ptyp *1	W	
Regenerative time during maximum regenerative driving	tmax	s	

Note: (1) If there is a code max or min with the symbol (example: Tmax), then it represents a maximum value or a minimum value, respectively.

(2) If 1, 2, 3, n is attached to the symbol (example: I₁, I₂) then it represents an amount when respective conditions differ in the amount represented by the symbol.

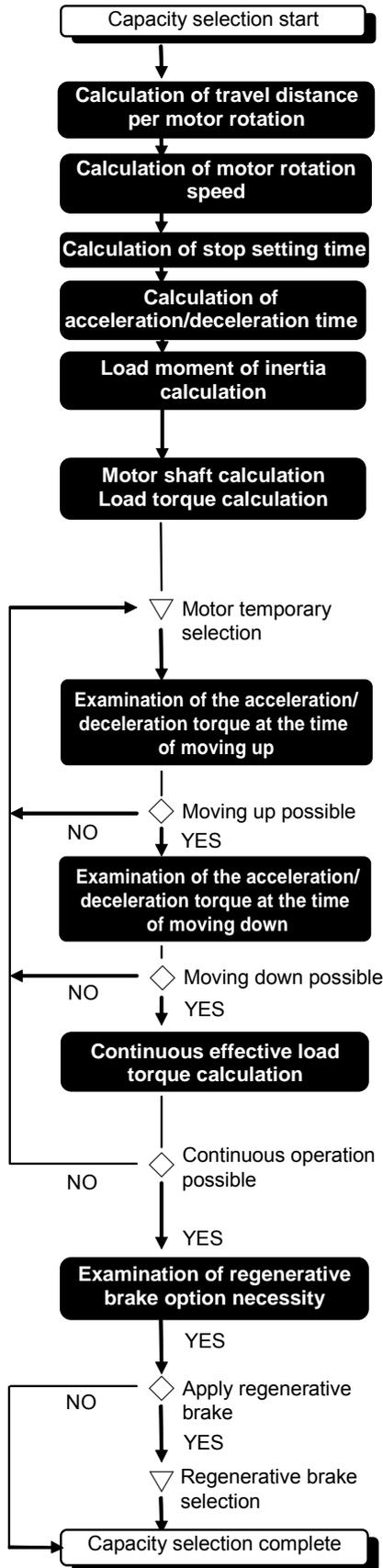
*1. This numerical value is decided based on the combination of the temporarily selected capacity of the servo motor and the servo amplifier.

*2. The minimum required specifications for selecting the capacity is the coupling method in the load, the positioning accuracy, and the shaded portion of the above table.

6. Selection

(2) Ball screw vertical

(1) Selection flow



Selection guideline	Judgment
Calculate the travel distance per motor rotation $\Delta S = PB \times 1/n \times 1/nm$ [mm/rev]	---
Calculate the motor rotation speed $N0 = V0/\Delta S$ [r/min]	---
Calculate the stop settling time $ts = 3 \times 1/Kp$ [s]	---
Calculate the acceleration/deceleration time $Tsa = Tsd = t0-(L/V0 \times 60+ts)$ [s]	---
Calculate the load moment of inertia at motor shaft $JB = \{(\pi \times 0.0078 \times (LB/10)/32) \times (DB/10)^4\}$ [kg·cm ²] $JF = (WT+WL+WC) \times (\Delta S / 20\pi)^2$ [kg·cm ²] $JL = JMG+JMB+JF+\{JG+JC+J0+JB \times (1/n)^2\} \times (1/nm)^2$ [kg·cm ²]	---
Calculate the load torque at motor shaft $TU = \{(Fc+ (WT+WL-WC) \times g) \times \Delta S\} / 2000 \times \pi$ [N·m] $TF = \{\mu \times (WT+WL+WC) \times g+FG\} \times \Delta S\} / 2000 \times \pi$ [N·m] $TLu = (TU+TF) / \eta$ [N·m] $(-TU+TF) > 0: TLd = (-TU+TF) / \eta$ [N·m] $(-TU+TF) < 0: TLd = (-TU+TF) / \eta$ [N·m]	---
The rated torque of the motor is more than the load torque at motor shaft at the time of moving up The rated torque of the motor is more than the load torque at motor shaft at the time of moving down The moment of inertia is less than the recommended load to motor inertia ratio (catalog value) The Motor rated speed is more than the motor rotation speed at the time of positioning The electrical accuracy is within the request specifications $\Delta L=(\Delta S / Pf) \times 1000$ [μm/pulse]	$(0.5 \text{ to } 0.8) \cdot Ttyp > Tlu$ $(0.5 \text{ to } 0.8) \cdot Ttyp > Tld$ $m = JL/JM$ < catalog value $NR > NO$ $\Delta L < \text{request specifications}$
Calculate the acceleration/deceleration torque at the time of moving up Acceleration: $TMau = \{((JL+JM) \times N0)/(9.55 \times 10000 \times Tsa)\}+TLu$ [N·m] Deceleration: $TMdu = -\{((JL+JM) \times N0)/(9.55 \times 10000 \times Tsd)\}+TLu$ [N·m] Check whether the maximum torque of the motor is greater than the acceleration torque when moving up Check whether the maximum torque of the motor is greater than the acceleration torque when moving down	$Tmax > TMau$ $Tmax > TMdu$
Calculate the acceleration/deceleration torque at the time of moving down Acceleration: $TMad = \{((JL+JM) \times N0)/(9.55 \times 10000 \times Tsa)\}+TLd$ [N·m] Deceleration: $TMdd = -\{((JL+JM) \times N0)/(9.55 \times 10000 \times Tsd)\}+TLd$ [N·m] Check whether the maximum torque of the motor is greater than the deceleration torque when moving up Check whether the maximum torque of the motor is greater than the deceleration torque when moving down Peak load ratio is within 300% $Rp = \{(Maximum \text{ value } TMa , TMd)\}/Ttyp \times 100$	$Tmax > TMad$ $Tmax > TMdd$ $Rp < 300$
Calculate the continuous effective load torque $tc = t0-Tsa-Tsd-ts$ [s] $Trms = \sqrt{\frac{(Tmau^2 + Tmad^2) \times Tsa + (TMdu^2 + TMdd^2) \times Tsd + (TLu^2 + TLd^2) \times tc + TU^2 \times (tf - 2 \times t0 + 2 \times ts)}{tf}}$ Check whether the fixed torque of the motor is greater than the continuous execution load torque Effective load ratio is within 100% $Rrms = (Trms^2/Ttyp) \times 100$	$Ttyp > Trms$ $Rrms < 100$
Calculate the regenerative power $Eau = 0.1047 \times NO/2 \times TMau \times Tsa$ [J] $Edu = 0.1047 \times NO/2 \times TMdu \times Tsd$ [J] $Efu = 0.1047 \times NO \times TLu \times tc$ [J] $Ead = 0.1047 \times NO/2 \times TMad \times Tsa$ [J] $Edd = 0.1047 \times NO/2 \times TMdd \times Tsd$ [J] $Efd = 0.1047 \times NO \times TLd \times tc$ [J] Check whether regenerative power has occurred Absolute value of total negative energy within $Em = Eau, Edu, Efu, Ead, Edd, Efd$ $Pr = \{\eta m \times Em-(Wa \times t)-Ec\}/tf$ [W] Select the permissible regenerative brake option that is more than the regenerative power Regenerative load ratio is within 100% $Ld = (Pr/Ptyp) \times 100$	$Pr > 0$ Regenerative option > Pr $Ld < 100$

6. Selection

(2) Various important symbols related to the load and operation

	Term	Symbol	Unit
Machine-side specifications	Table weight	WT	kg
	Load mass	WL	kg
	Counterweight mass	WC	kg
	Load anti-drag force	Fc	N
	Tightening force of the table guide surface	FG	N
	Speed deceleration ratio	1/n	
	Reducer moment of inertia	JG	kg·cm ²
	Coupling moment of inertia	JC	kg·cm ²
	Other output shaft conversion moments of inertia	JO	kg·cm ²
	Ball screw lead	PB	mm
	Ball screw diameter	DB	mm
	Ball screw length	LB	mm
	Drive system efficiency	η	
	Friction coefficient	μ	
	Fast feed speed	VO	mm/min
	Specifications used for searching	Positioning length	L
Positioning time		tO	s
1 cycle time		tf	s
Travel distance per motor rotation		ΔS	mm/rev
Motor rotation speed		NO	r/min
Stop settling time		ts	s
Acceleration time		Tsa	s
Deceleration time		Tsd	s
Moment of inertia of ball screw		JB	kg·cm ²
Moment of inertia of object moving linearly		JF	kg·cm ²
Load moment of inertia at motor shaft		JL	kg·cm ²
Load torque at motor shaft		TL	N·m
Acceleration torque (motor required torque required during acceleration time)		TMa	N·m
Deceleration torque (motor required torque required during deceleration time)		TMd	N·m
Continuous effective load torque		Trms	N·m
Regenerative power		Pr	W
Energy at time of acceleration		Ea	J
Energy at time of deceleration		Ed	J
Energy at time of constant speed		Ef	J
Absolute value of negative energy total		Em	J
Maximum regenerative power		Pmax	W
Interval energy at time of maximum regeneration		Emax	J
Reduction ratio of motor with reducer		1/nm *1	
Encoder resolution		Pf *1	pulse/rev
Position loop gain		Kp	1/s
Moment of inertia of reducer of motor with reducer		JMG *1	kg·cm ²
Moment of inertia of brake of motor with brake		JMB *1	kg·cm ²
Motor moment of inertia		JM *1	kg·cm ²
Recommended load to motor inertia ratio		m *1	
Motor rated speed		NR *1	r/min
Gravitational acceleration		g	m/s ²
Motor maximum torque		Tmax *1	N·m
Motor rated torque	Ttyp *1	N·m	
Motor inverse efficiency	η_m *1	%	
Amplifier processing	Wa *1	W	
Regenerative operation period	t	s	
Capacitor charging energy	Ec *1	J	
Rated power of regeneration unit	Ptyp *1	W	
Regenerative time during maximum regenerative driving	tmax	s	

- Note: (1) If there is a code max. or min. with the symbol (example: Tmax), then it represents a maximum value or a minimum value, respectively.
- (2) If 1, 2, 3, n is attached to the symbol (example: I₁, I₂) then it represents an amount when respective conditions differ in the amount represented by the symbol.
- *1. This numerical value is decided based on the combination of the temporarily selected capacity of the servo motor and the servo amplifier.
- *2. The minimum required specifications for selecting the capacity is the coupling method in the load, the positioning accuracy, and the shaded portion of the above table.

6. Selection

6.3.6 Calculation Example

(1) Ball screw horizontal

System configuration figure		Machine specifications			
		Table weight	WT:	200.00	kg
		Load mass	WL:	50.00	kg
		Load anti-drag force	Fc:	0.01	N
		Tightening force of the table guide surface	FG:	0.01	N
		Reduction ratio (NL/NM)	1/n:	1/1	
		Reducer moment of inertia	JG:	0.20	kg·cm ²
		Coupling moment of inertia	JC:	2.00	kg·cm ²
		Other output shaft conversion moments of inertia	JO:	0.10	kg·cm ²
		Ball screw lead	PB:	10.00	mm
		Ball screw diameter	DB:	20.00	mm
		Ball screw length	LB:	1500.00	mm
		Drive system efficiency	η	0.90	
Friction coefficient	μ	0.10			
Fast feed speed	VO:	20000.00	mm/min		
Positioning length/rotation	L:	400.00	mm		
Positioning time	tO:	1.50	s		
1 cycle time	tf:	2.30	s		

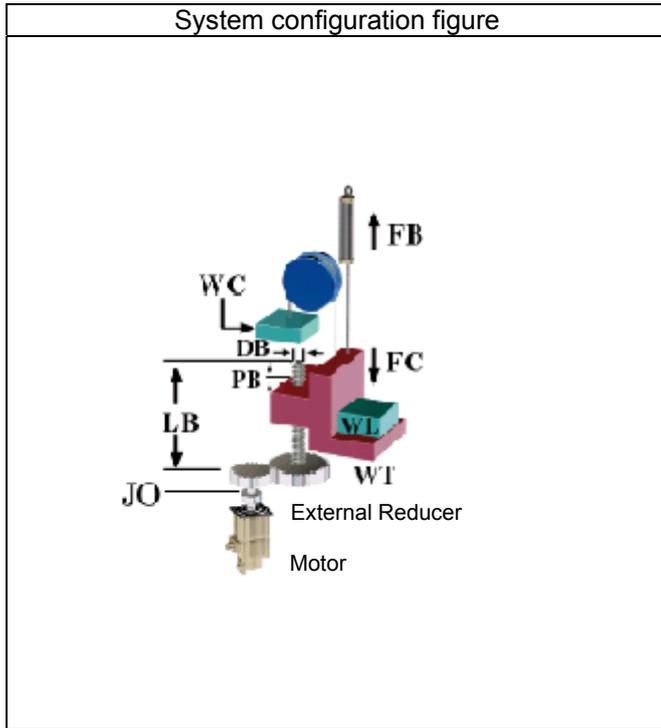
Item	Calculation	Remarks
1. Calculation of various load factors	<p>Calculation of travel distance per motor rotation (for a motor without reducer: $\frac{1}{nm} = 1$)</p> $\Delta s = PB \times \frac{1}{n} \times \frac{1}{nm} = \boxed{10 \times 1 \times 1} = \boxed{10.0} \text{ [mm/rev]}$	
2. Motor rotation speed during maximum machine speed	<p>Motor rotation speed calculation</p> $N0 = \frac{V0}{\Delta S} = \frac{2000}{10.0} = \boxed{2000} \text{ [r/min]}$ <p><Reference>: If the obtained N0 surpasses the motor maximum speed, operation is not possible, and it will therefore be necessary to either reduce the maximum machine speed V0 or increase the feed length ΔS per motor rotation.</p>	
3. Operation pattern	<p>Obtain the acceleration/deceleration time of the servo motor from the positioning time and positioning speed (maximum machine speed) specifications of the machine. Generally, the acceleration and deceleration time are set equally by the linear acceleration/deceleration for the motor. Thus, even in this example, the operation pattern is obtained with these prerequisites. (Position loop gain Kp is set to 70.) Obtain the acceleration/deceleration time in the following manner rather than the previous figure.</p> <p>Stop setting time calculation</p> $ts = 3 \times \frac{1}{Kp} = \frac{3 \times 1}{70} = \boxed{0.043} \text{ [s]}$ <p>Acceleration/deceleration time calculation</p> $Tsa = Tsd = t0 - \left(\frac{L}{V0} \times 60 + ts \right) = \frac{1.5 - (400/20000 \times 60 + 0.043)}{1} = \boxed{0.257} \text{ [s]}$	

6. Selection

Item	Calculation	Remarks
<p>4. Load moment of inertia calculation</p>	<p>The load moment of inertia is a numerical value specified by the machine manufacturer; however, for this drive system, the calculation can be done as shown below. When calculating the load moment of inertia, make sure that the converted value is set to the motor shaft.</p> <p>(1) Ball screw</p> $JB = \frac{1}{32} \times \pi \times 0.0078 \times \frac{LB}{10} \times \left(\frac{DB}{10}\right)^4 = \frac{1}{32} \times 3.1416 \times 0.0078 \times \frac{1500}{10} \times \left(\frac{20}{10}\right)^4 = \boxed{1.838} \text{ [kg}\cdot\text{cm}^2\text{]}$ <p>(2) Object which moves linearly</p> $JF = (WT + WL) \times \left(\frac{\Delta S}{10 \times 2\pi}\right)^2 = (200 + 50) \times \left(\frac{10}{10 \times 2 \times 3.1416}\right)^2 = \boxed{6.333} \text{ [kg}\cdot\text{cm}^2\text{]}$ <p>(3) Load moment of inertia at motor shaft (for a motor without reducer: JMG=0; for a motor without brake: JMB=0)</p> $JL = JMG + JMB + JF + \left\{ JG + JC + JO + JB \times \left(\frac{1}{n}\right)^2 \right\} \times \left(\frac{1}{nm}\right)^2 = \boxed{0+0+6.333+\{0.2+2+0.1+1.838 \times (1)^2\} \times 1^2} = \boxed{10.470} \text{ [kg}\cdot\text{cm}^2\text{]}$ <p><Reference>: The moment of inertia targets all objects that are operating due to rotation of the motor. Therefore, it is necessary to consider all of these.</p>	
<p>5. Load torque calculation</p>	<p>The load torque is a numerical value specified by the machine manufacturer; however, for this drive system, the calculation can be done as shown below. When calculating the load torque, make sure that the converted value is set to the motor shaft. (Gravitational acceleration g = 9.8)</p> <p>Load torque at motor shaft TL</p> $TL = \frac{\left\{ (Fc + \mu \times (WT + WL)) \times g + FG \right\}}{1000} \times \frac{\Delta S}{2\pi} \times \frac{1}{n} = \frac{\{0.01 + 0.1 \times (200 + 50) \times 9.8 + 0.01\}}{1000} \times \frac{10}{2 \times 3.1416} \times \frac{1}{0.9} = \boxed{0.433} \text{ [N}\cdot\text{m]}$	
<p>6. Temporary selection of the motor</p>	<p>If the load torque and load moment of inertia is obtained, an approximate temporary selection of the motor capacity can be done. The guidelines for the temporary selection are as follows:</p> <p>(1) The motor rated torque Ttyp should be more than the load torque. (Normally, there should be a margin of about 50% to 80% of the rated torque Ttyp.)</p> <p>(2) The load moment of inertia JL should be m times less than the moment of inertia JM of the motor itself (the allowable load moment of inertia ratio HG-KR is 30). Temporary selected motor HG-KR Temporary selected servo amplifier MR-J4-A/B</p> $\begin{array}{lcl} \boxed{T_{typ} = 2.4} & > & \boxed{TL = 0.433} \\ \boxed{JM = 0.6} & > & \boxed{JL/30 = 0.349} \end{array}$	
<p>7. Acceleration/ deceleration torque calculation</p>	<p>Finally, after obtaining the load torque, load moment of inertia, and operation pattern of the motor, confirm that the required torque when accelerating and decelerating using the temporarily selected motor in the above points is less than the maximum torque of the temporarily selected motor. If the maximum torque is exceeded, the motor will not be able to follow the acceleration/deceleration time obtained in the previous points and will cause servo faults.</p> <p>Acceleration torque</p> $TMa = \frac{\left\{ (JL + JM) \times N0 \right\}}{9.55 \times 10000 \times Tsa} / \eta + TL = \frac{(10.470 + 0.6) \times 2000}{9.55 \times 10000 \times 0.257} / 0.9 + 0.433 = \boxed{1.436} \text{ [N}\cdot\text{m]} \leq \text{Maximum torque Tmax of motor}$ <p>Deceleration torque</p> $TMa = - \frac{\left\{ (JL + JM) \times N0 \right\}}{9.55 \times 10000 \times Tsa} / \eta + TL = - \frac{(10.470 + 0.6) \times 2000}{9.55 \times 10000 \times 0.257} / 0.9 + 0.433 = \boxed{-0.569} \text{ [N}\cdot\text{m]} < \text{Maximum torque Tmax of motor}$	

6. Selection

(2) Ball screw vertical



Machine specifications			
Table weight	WT:	80.00	kg
Load mass	WL:	50.00	kg
Counterweight mass	WC:	100.00	kg
Load anti-drag force	Fc:	0.01	N
Tightening force of the table guide surface	FG:	0.01	N
Reduction ratio (NL/NM)	1/n:	2-Jan	
Reducer moment of inertia	JG:	0.20	kg-cm ²
Coupling moment of inertia	JC:	2.00	kg-cm ²
Other output shaft conversion moments of inertia	JO:	0.10	kg-cm ²
Ball screw lead	PB:	10.00	mm
Ball screw diameter	DB:	20.00	mm
Ball screw length	LB:	1500.00	mm
Drive system efficiency	η	0.90	
Friction coefficient	μ	0.10	
Fast feed speed	VO:	10000.00	mm/min
Positioning length/rotation	L:	400.00	mm
Positioning time	tO:	2.60	s
1 cycle time	tf:	8.20	s
Balance cylinder retaining force	FB:	0.00	N

Item	Calculation	Remarks
1. Calculation of various load factors	<p>Calculation of travel distance per motor rotation (for a motor without reducer: $\frac{1}{nm} = 1$)</p> $\Delta s = PB \times \frac{1}{n} \times \frac{1}{nm} = \boxed{10 \times 0.5 \times 1} = \boxed{5} \text{ [mm/rev]}$	
2. Motor rotation speed during maximum machine speed	<p>Motor rotation speed calculation</p> $N0 = \frac{V0}{\Delta S} = \frac{10000}{5.0} = \boxed{2000} \text{ [r/min]}$ <p><Reference>: If the obtained N0 surpasses the motor maximum speed, operation is not possible, and it will therefore be necessary to either reduce the maximum machine speed V0 or increase the feed length ΔS per motor rotation.</p>	
3. Operation pattern	<p>Obtain the acceleration/deceleration time of the servo motor from the positioning time and positioning speed (maximum machine speed) specifications of the machine. Generally, the acceleration and deceleration time are set equally by the linear acceleration/deceleration for the motor. Thus, even in this example, the operation pattern is obtained with these prerequisites. (Position loop gain Kp is set to 70.)</p> <p>Obtain the acceleration/deceleration time in the following manner rather than the previous figure.</p> <p>Stop setting time calculation</p> $ts = 3 \times \frac{1}{Kp} = \frac{3 \times 1}{70} = \boxed{0.043} \text{ [s]}$ <p>Acceleration/deceleration time calculation</p> $Tsa = Tsd = t0 - \left(\frac{L}{V0} \times 60 + ts \right) = \boxed{2.6 - (400/10000 \times 60 + 0.043)} = \boxed{0.157} \text{ [S]}$	

6. Selection

Item	Calculation	Remarks									
<p>4. Load moment of inertia calculation</p>	<p>The load moment of inertia is a numerical value specified by the machine manufacturer; however, for this drive system, the calculation can be done as shown below. When calculating the load moment of inertia, make sure that the converted value is set to the motor shaft.</p> <p>(1) Ball screw</p> $JB = \frac{1}{32} \times \pi \times 0.0078 \times \frac{LB}{10} \times \left(\frac{DB}{10}\right)^4 = \frac{1}{32} \times 3.1416 \times 0.0078 \times \frac{1500}{10} \times \left(\frac{20}{10}\right)^4 = \boxed{1.838} \text{ [kg}\cdot\text{cm}^2\text{]}$ <p>(2) Object which moves linearly</p> $JF = (WT + WL + WC) \times \left(\frac{\Delta S}{10 \times 2\pi}\right)^2 = (80 + 50 + 100) \times \left(\frac{5.0}{10 \times 2 \times 3.1416}\right)^2 = \boxed{1.456} \text{ [kg}\cdot\text{cm}^2\text{]}$ <p>(3) Load moment of inertia at motor shaft (for a motor without reducer: JMG=0)</p> $JL = JMG + JMB + JF + \left\{ JG + JC + JO + JB \times \left(\frac{1}{n}\right)^2 \right\} \times \left(\frac{1}{mm}\right)^2 = \boxed{0 + 0.000 + 1.456 + \{ 0.2 + 2 + 0.1 + 1.838 \times (0.5)^2 \} \times 1^2} = \boxed{4.216} \text{ [kg}\cdot\text{cm}^2\text{]}$ <p><Reference>: The moment of inertia targets all objects that are operating due to rotation of the motor. Therefore, it is necessary to consider all of these.</p>										
<p>5. Load torque calculation</p>	<p>The load torque is a numerical value specified by the machine manufacturer; however, for this drive system, the calculation can be done as shown below. When calculating the load torque, make sure that the converted value is set to the motor shaft. (Gravitational acceleration g = 9.8)</p> <p>Unbalanced torque</p> $TU = \frac{\{Fc + (WT + WL - WC) \times g\}}{1000} \times \frac{\Delta S}{2\pi} = \frac{\{0.01 + (80 + 50 - 100) \times 9.8\}}{1000} \times \frac{5}{2 \times 3.1416} = \boxed{0.234} \text{ [N}\cdot\text{m]}$ <p>Friction torque</p> $TF = \frac{\mu \times \{(WT + WL + WC) \times g + FG\}}{1000} \times \frac{\Delta S}{2\pi} = \frac{0.1 \times \{(80 + 50 + 100) \times 9.8 + 0.01\}}{1000} \times \frac{5}{2 \times 3.1416} = \boxed{0.179} \text{ [N}\cdot\text{m]}$ <p>Load torque at motor shaft when rising</p> $TLu = \frac{(TU + TF)}{\eta} = \frac{0.234 + 0.179}{0.9} = \boxed{0.459} \text{ [N}\cdot\text{m]}$ <p>Load torque at motor shaft when descending</p> <ul style="list-style-type: none"> When $(-TU + TF) > 0$ $TLd = \frac{-TU + TF}{\eta} = \boxed{} = \boxed{} \text{ [N}\cdot\text{m]}$ <ul style="list-style-type: none"> When $(-TU + TF) < 0$ $TLd = (-TU + TF) \times \eta = \boxed{(-0.234 + 0.179) \times 0.9} = \boxed{-0.05} \text{ [N}\cdot\text{m]}$										
<p>6. Temporary selection of the motor</p>	<p>If the load torque and load moment of inertia is obtained, an approximate temporary selection of the motor capacity can be done. The guidelines for the temporary selection are as follows:</p> <p>(1) The motor rated torque Ttyp should be more than the load torque. (Normally, there should be a margin of about 50% to 80% of the rated torque Ttyp.)</p> <p>(2) The load moment of inertia JL should be m times less than the moment of inertia JM of the motor itself (the allowable load moment of inertia ratio HG-MR is 30).</p> <p>(3) Select a vertical shaft motor that has brakes for safety.</p> <p>Temporary selected motor HG-MR43B Temporary selected servo amplifier MR-J4-A/B</p> <table style="width: 100%; border: none;"> <tr> <td style="text-align: center;">$\boxed{T_{typ} = 1.3}$</td> <td style="text-align: center;">></td> <td style="text-align: center;">$\boxed{TL = 0.459}$</td> </tr> <tr> <td style="text-align: center;">$\boxed{T_{typ} = 1.3}$</td> <td style="text-align: center;">></td> <td style="text-align: center;">$\boxed{TLd = -0.05}$</td> </tr> <tr> <td style="text-align: center;">$\boxed{JM = 0.142}$</td> <td style="text-align: center;">></td> <td style="text-align: center;">$\boxed{JL/30 = 0.1757}$</td> </tr> </table>	$\boxed{T_{typ} = 1.3}$	>	$\boxed{TL = 0.459}$	$\boxed{T_{typ} = 1.3}$	>	$\boxed{TLd = -0.05}$	$\boxed{JM = 0.142}$	>	$\boxed{JL/30 = 0.1757}$	
$\boxed{T_{typ} = 1.3}$	>	$\boxed{TL = 0.459}$									
$\boxed{T_{typ} = 1.3}$	>	$\boxed{TLd = -0.05}$									
$\boxed{JM = 0.142}$	>	$\boxed{JL/30 = 0.1757}$									

6. Selection

Item	Calculation	Remarks
<p>7. Calculation of acceleration, deceleration torque when moving up</p>	<p>Finally, after obtaining the load torque, load moment of inertia, and operation pattern of the motor, confirm that the required torque when accelerating and decelerating at the time of moving up using the temporarily selected motor in the above points is less than the maximum torque of the temporarily selected motor. If the maximum torque is exceeded, the motor will not be able to follow the acceleration/deceleration time obtained in the previous points and will cause servo faults.</p> <p>Acceleration torque at the time of moving up</p> $TM_{au} = \left\{ \frac{(JL + JM) \times N0}{9.55 \times 10000 \times Tsa} \right\} / \eta + TLu = \left\{ \frac{(4.216 + 0.240) \times 2000}{9.55 \times 10000 \times 0.157} \right\} / 0.9 + 0.459$ $= \boxed{1.104} \text{ [N}\cdot\text{m]} < \text{Maximum torque Tmax of motor} \quad \boxed{1.9}$ <p>Deceleration torque at the time of moving up</p> $TM_{du} = - \left\{ \frac{(JL + JM) \times N0}{9.55 \times 10000 \times Tsd} \right\} / \eta + TLu = - \left\{ \frac{(4.216 + 0.240) \times 2000}{9.55 \times 10000 \times 0.157} \right\} / 0.9 + 0.459$ $= \boxed{-0.186} \text{ [N}\cdot\text{m]} < \text{Maximum torque Tmax of motor} \quad \boxed{1.9}$	
<p>8. Calculation of acceleration, deceleration torque when moving down</p>	<p>Next, confirm that the required torque during acceleration/deceleration at the time of moving down is less than the maximum torque of the temporarily selected motor. If the maximum torque is exceeded, the motor will not be able to follow the acceleration/deceleration time obtained in the previous points and will cause servo faults.</p> <p>Acceleration torque at the time of moving down</p> $TM_{ad} = \left\{ \frac{(JL + JM) \times N0}{9.55 \times 10000 \times Tsa} \right\} / \eta + TLd = \left\{ \frac{(4.216 + 0.240) \times 2000}{9.55 \times 10000 \times 0.157} \right\} / 0.9 + (-0.049)$ $= \boxed{0.596} \text{ [N}\cdot\text{m]} < \text{Maximum torque Tmax of motor} \quad \boxed{1.9}$ <p>Deceleration torque at the time of moving down</p> $TM_{dd} = - \left\{ \frac{(JL + JM) \times N0}{9.55 \times 10000 \times Tsd} \right\} / \eta + TLd = - \left\{ \frac{(4.216 + 0.240) \times 2000}{9.55 \times 10000 \times 0.157} \right\} / 0.9 + (-0.049)$ $= \boxed{-0.694} \text{ [N}\cdot\text{m]} < \text{Maximum torque Tmax of motor} \quad \boxed{1.9}$	
<p>9. Calculation of continuous effective load torque</p>	<p>Obtain the continuous effective load torque from the operation pattern and the required torque obtained in the previous section, and verify that this value does not exceed the rated torque of the temporarily selected motor.</p> <p>Fixed speed time calculation</p> $tc = to - Tsa - Tsd - ts = \boxed{2.6 - 0.157 - 0.157 - 0.043}$ $= \boxed{2.243} \text{ [s]}$ <p>Continuous effective load torque</p> $T_{rms} = \sqrt{\frac{(TM_{au}^2 + TM_{ad}^2) \cdot Tsa + (TM_{du}^2 + TM_{dd}^2) \cdot Tsd + (TLu^2 + TLd^2) \cdot tc + TU^2 \cdot (tf \square 2 \cdot t0 + 2 \cdot ts)}{tf}}$ $= \sqrt{\frac{(1.120^2 + 0.611^2) \times 0.157 + ((-0.201)^2 + (-0.710)^2) \times 0.157 + (0.459^2 + (-0.049)^2) \times 2.243 + 0.243^2 \times (1.5 + 0.043) + 0.243^2 \times (1.5 + 0.043)}{8.2}}$ $= \boxed{0.347} \text{ [N/m]} < \text{Rated torque Ttyp of the motor} \quad \boxed{1.3}$	

6. Selection

Item	Calculation	Remarks
<p>10. Examination of regenerative brake option necessity</p>	<p>Examine whether the regenerative option is required according to the regenerative power and maximum regenerative power.</p> <p>Acceleration energy at the time of moving up</p> $E_{au} = \frac{0.1047}{2} \times N0 \times TMau \times Tsa = \frac{0.1047}{2} \times 2000 \times 1.120 \times 0.157$ $= \boxed{18.405} \text{ [J]}$ <p>Deceleration energy at the time of moving up</p> $E_{du} = \frac{0.1047}{2} \times N0 \times TMdu \times Tsd = \frac{0.1047}{2} \times 2000 \times (-0.201) \times 0.157$ $= \boxed{-3.307} \text{ [J]}$ <p>Fixed speed energy at the time of moving up</p> $E_{fu} = 0.1047 \times N0 \times TLu \times tc = \boxed{0.1047 \times 2000 \times 0.459 \times 2.243} = \boxed{215.585} \text{ [J]}$ <p>Acceleration energy at the time of moving down</p> $E_{ad} = \frac{0.1047}{2} \times N0 \times TMad \times Tsa = \frac{0.1047}{2} \times 2000 \times 0.611 \times 0.157$ $= \boxed{215.585} \text{ [J]}$ <p>Deceleration energy at the time of moving down</p> $E_{dd} = \frac{0.1047}{2} \times N0 \times TMdd \times Tsd = \frac{0.1047}{2} \times 2000 \times (-0.710) \times 0.157$ $= \boxed{10.048} \text{ [J]}$ <p>Fixed speed energy at the time of moving down</p> $E_{fd} = 0.1047 \times N0 \times Tld \times tc = \boxed{0.1047 \times 2000 \times (-0.049) \times 2.243} = \boxed{-23.015} \text{ [J]}$ <p>Absolute value of negative energy total</p> <p>$E_m = (\text{total negative energy in } E_{au}, E_{du}, E_{fu}, E_{ad}, E_{dd}, E_{fd})$</p> $= \boxed{ (-3.307) + (-11.664) } = \boxed{-14.971} \text{ [J]}$ <p>Regenerative power</p> $Pr = \frac{\eta m \times E_m - Wa \times t - Ec}{tf} = \frac{(0.740 \times 37.986 - 9.000)}{8.20}$ $= \boxed{2.330} \text{ [W]} \quad \boxed{<} \text{ Internal regenerative power } \boxed{10} \text{ [W]}$ <p style="text-align: right;"><: Not required; >: Required</p> <p><u>Regenerative brake option not required</u></p> <p>Regenerative brake option required</p> <p>Use the regenerative brake that is greater than the regenerative power. Model name</p>	

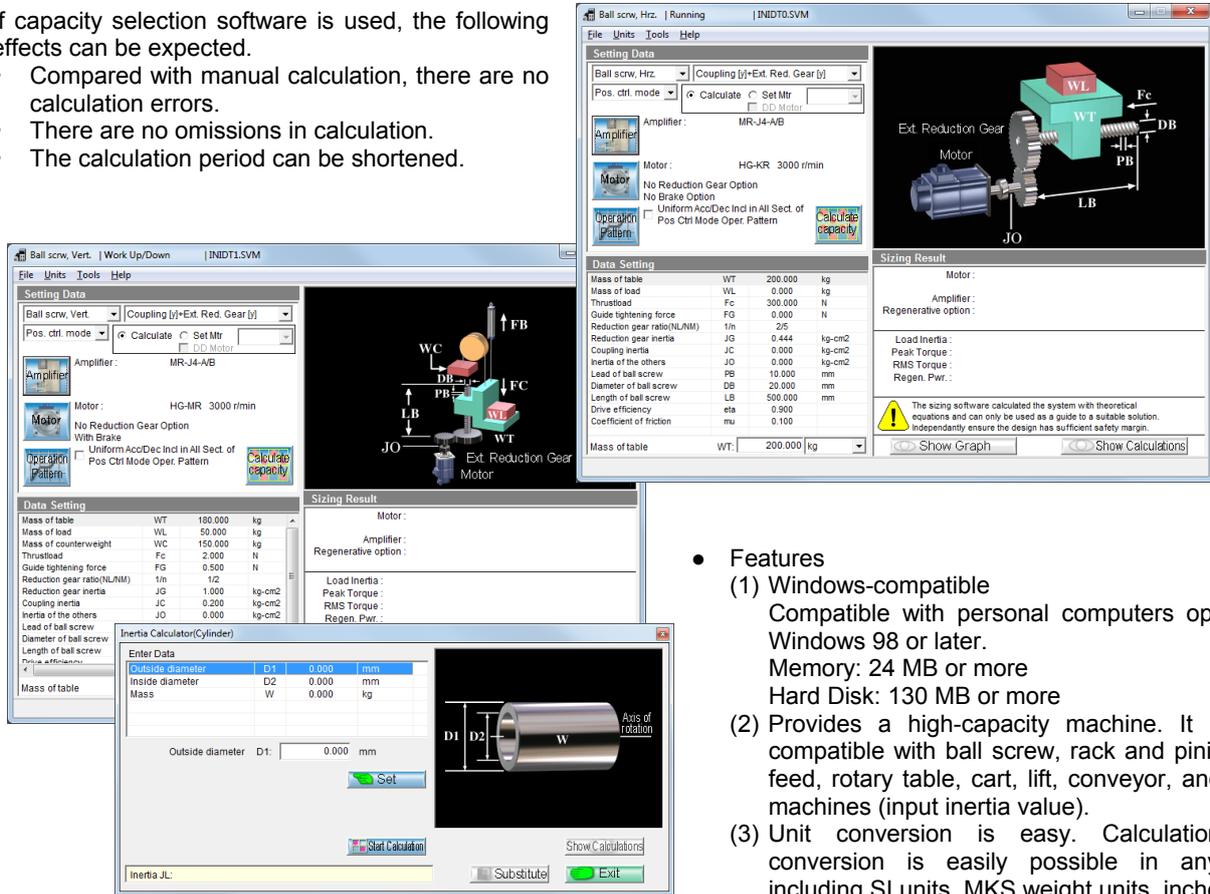
6. Selection

6.4 Capacity Selection Software

By preparing screens corresponding to each machine and by setting the various constants, the most appropriate servo amplifier, servo motor (including brake and reducer), and regenerative option can be selected.

If capacity selection software is used, the following effects can be expected.

- Compared with manual calculation, there are no calculation errors.
- There are no omissions in calculation.
- The calculation period can be shortened.



- Features
 - (1) Windows-compatible
Compatible with personal computers operating Windows 98 or later.
Memory: 24 MB or more
Hard Disk: 130 MB or more
 - (2) Provides a high-capacity machine. It is also compatible with ball screw, rack and pinion, roll feed, rotary table, cart, lift, conveyor, and other machines (input inertia value).
 - (3) Unit conversion is easy. Calculation and conversion is easily possible in any unit, including SI units, MKS weight units, inches, and pounds.

Training Input the specifications given on page 6-12 and 6-15, and confirm the calculation results.

• Specifications

Item	Description
Types of machine components and elements	Ball screw horizontal, Ball screw vertical, rack and pinion, roll feed, rotary table, cart, lift, conveyor, linear servo, and others (input inertia value)
Result output	Item Selected servo amplifier model, selected servo motor model, selected regenerative option model, load moment of inertia, load moment of inertia ratio, peak torque, peak torque ratio, regenerative power, regenerative power ratio
	Print Print the various input elements, operation patterns, calculation processes, feed speeds (or motor rotation speeds) and torque graphs of selection processes, and selection results.
	Data storage Set a file name for the various input elements, operation patterns, and selection results to save
Moment of inertia calculation function	Cylinder, center deviation, transmission, linear movement, hoisting, cone, truncated cone

7. Noise Reduction Techniques, Leakage Current, Harmonics

7.1 Noise Reduction Techniques

There are two types of noise, noise that penetrates the servo amplifier from the outside and causes a malfunction, and noise that radiates from the servo amplifier and causes the peripheral devices to malfunction. The following measures must be taken because the servo amplifier is an electronic device that handles weak signals.

Also, the servo amplifier output is subjected to chopping by high carrier frequencies, leading to noise. If peripheral equipment malfunctions due to this noise generation, take countermeasures for controlling noise. These countermeasures differ slightly depending on the noise transmission path.

7.1.1 Noise Reduction Techniques

(1) General countermeasures

- Do not run the servo amplifier power cables (I/O cables) and signal cables parallel to each other, and use separate wiring.
- Use shielded twisted pair cables for the connecting cables and control signal cables in the encoder, and connect the external conductor of the shielded wire to the SD terminal.
- Ground the servo amplifier and servo motor at one grounding point.

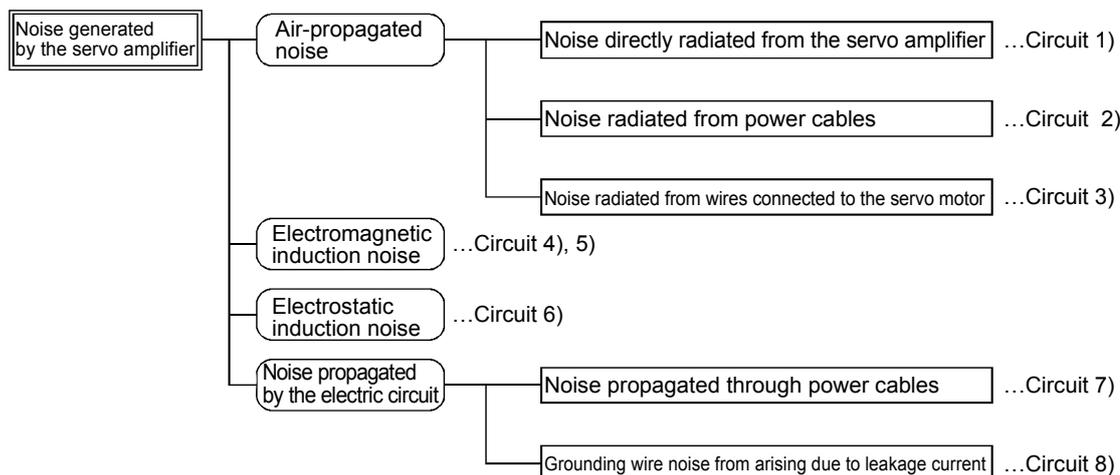
(2) Noise that penetrates from the outside and causes the servo amplifier to malfunction

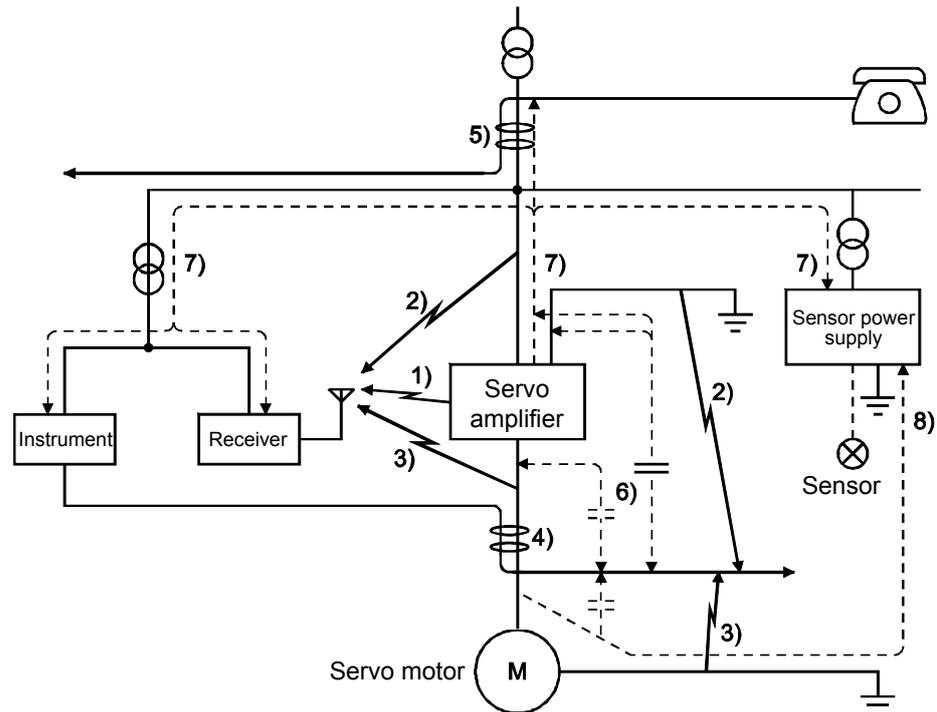
When there is a fear of servo amplifier malfunction due to installation of devices that generate a lot of noise (which use a magnetic contactor, electromagnetic brakes, many relays, etc.) near the servo amplifier, the following countermeasures must be taken.

- Provide a surge killer for devices that generate a lot of electromagnetic noise to suppress the electromagnetic noise.
Install a data line filter to the signal wire.
- Ground the shield of the encoder connecting wires and the signal wire for control using a clamp fitting.
- A surge absorber is built in to the servo amplifier, but it is recommended that a varistor be installed in the power supply input part of the device to protect the servo amplifier and the other equipment from larger external noise or lightning surges.

(3) Noise radiated from the servo amplifier leading to malfunctions of peripheral equipment

Noise generated by the servo amplifier is classified into noise that radiates from the cables connected to the servo amplifier and servo amplifier main circuits (Input/output), noise that is electromagnetically and electrostatically induced to the signal cables of peripheral equipment close to the main circuit power supply, and noise that is transmitted through the power supply cables.





Noise transmission path	Countermeasures
1), 2), 3)	<p>When devices that handle weak signals and that are liable to malfunction due to electromagnetic noises, (e.g., instruments, receivers, and sensors) are contained in the enclosure that contains the servo amplifier, or when their signal cables run near the servo amplifier, the devices may malfunction due to air-propagated electromagnetic noises. Therefore, the following countermeasures must be taken.</p> <ol style="list-style-type: none"> 1. Install the devices that are easily affected as far away from the servo amplifier as possible. 2. Lay the signal wires that are easily affected as far away from the I/O cables of the servo amplifier as possible. 3. Do not run the signal cables and power cables (servo amplifier I/O cables) parallel to each other and do not bundle them together. 4. Install line noise filters to the I/O cables or radio noise filters to the input to control the radiated noise of the line. 5. Use shielded wire as signal cables and power cables, and insert them into individual metal ducts.
4), 5), 6)	<p>When signal cables are run in parallel or are bundled with power cables, electromagnetic induction and electrostatic induction noise may be reproduced in the signal cables and may cause malfunctions. Therefore, the following countermeasures must be taken.</p> <ol style="list-style-type: none"> 1. Install the devices that are easily affected as far away from the servo amplifier as possible. 2. Lay the signal wires that are easily affected as far away from the I/O cables of the servo amplifier as possible. 3. Do not run the signal cables and power cables (servo amplifier I/O cables) parallel to each other and do not bundle them together. 4. Use shielded cables as signal cables and power cables, and insert them into individual metal ducts.
7)	<p>When peripheral equipment and the servo amplifier are connected to the same power supply, the noise generated by the servo amplifier may flow back through the power supply cable and may cause device malfunctions. Therefore, the following countermeasures must be taken.</p> <ol style="list-style-type: none"> 1. Install a radio noise filter (FR-BIF) to the power cable (input cable) of the servo amplifier. 2. Install a line noise filter (FR-BSF01/FR-BLF) to the power cable of the servo amplifier.
8)	<p>If a closed-loop circuit is formed by the grounding wire of the peripheral equipment and the servo amplifier, leakage current may flow, which can cause device malfunctions. In such cases, malfunctions can be prevented if the grounding wire is disconnected.</p>

7.2 Leakage Current

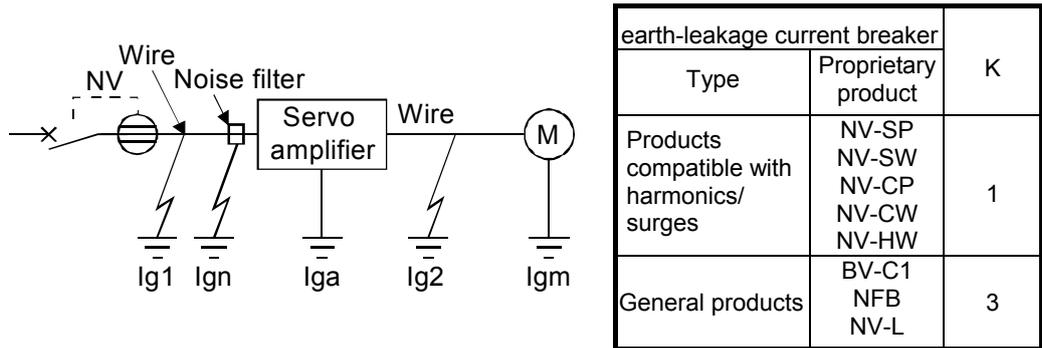
Chopper currents of harmonics controlled by the PWM flow to the AC servo. Leakage current that contains harmonics is greater than leakage current in motors that operate on AC power.

Select the earth-leakage circuit breaker by referring to the following formula, and make sure to ground the servo amplifier, servo motor, etc.

Also, shorten the wiring distance of the I/O cables as much as possible so as to decrease the leakage current, and separate the grounding cables as much as possible (approx. 30 cm).

$$\text{Rated sensitivity current} \geq 10 \times \{I_{g1} + I_{gn} + I_{ga} + K \times (I_{g2} + I_{gm})\} \text{ [mA]}$$

K: Constant that takes harmonics into consideration



- I_{g1}: Leakage current on the electric path from the earth-leakage current breaker to the servo amplifier input terminal (obtain from Figure 7.1)
- I_{g2}: Leakage current on the electric path from the servo amplifier output terminal to the servo motor (obtain from Figure 7.1)
- I_{gn}: Leakage current when a filter is connected on the input side (4.4 mA for one piece for FR-BIF)
- I_{ga}: Leakage current of servo amplifier (obtain from Table 7.2)
- I_{gm}: Leakage current of servo motor (obtain from Table 7.1)

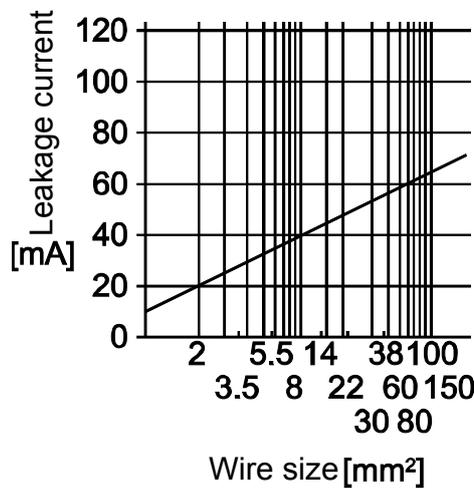


Figure 7.1 Leakage current example per 1 km with CV cables with metal wiring (I_{g1}, I_{g2})

Table 7.1 Leakage current example of servo motor (I_{gm})

Servo motor output [kW]	Leakage current [mA]
0.05 to 1	0.1
2	0.2
3.5	0.3
5	0.5
7	0.7

Table 7.2 Leakage current example of servo amplifier (I_{ga})

Servo amplifier capacity [kW]	Leakage current [mA]
0.1 to 0.6	0.1
0.75 to 3.5	0.15
5, 7	2

Table 7.3 Earth-leakage current breaker selection example

Servo amplifier capacity [kW]	Earth-leakage current breaker rated sensitivity current [mA]
MR-J4-10A to MR-J4-350A	15
MR-J4-500A	30
MR-J4-700A	50

<Note>

EN standard filters have a greater leakage current and therefore may not be usable in Japan.

7.3 Harmonics

7.3.1 Fundamental Harmonic and Harmonics

Harmonics is defined as having multiple integral part frequencies of fundamental waves (generally power supply frequencies) and is referred to as a distorted wave obtained by combining multiple harmonics and a single fundamental wave. (Refer to figure 7.3.)

A distorted wave generally includes the harmonics (kHz - MHz order) of the harmonic area; however, it normally treats 40th to 50th harmonics (up to 3 kHz) as distributed system harmonics. Generally, problems that are different from the problem of the harmonic area with random conditions are exhibited. For example, issues such as radio wave damage due to the personal computer or noise (refer to section 7.1) are local issues that are related to machine hardware and differ from the harmonics that target power networks. It is important to clarify this first.

$$i = i_0 + \sum_{n=1}^{\infty} i_n \cdot \sin(2\pi nft + \psi_n) \dots\dots\dots (7.1)$$

$n = 1, 2, 3, \dots$
 $f = \text{Fundamental frequency}$

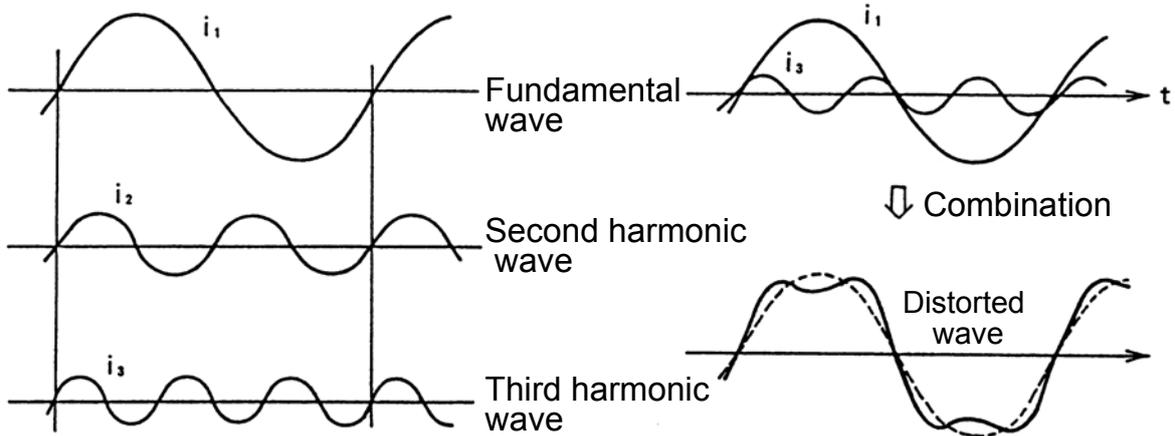


Figure 7.2 Fundamental harmonics and harmonics

Figure 7.3 Distorted wave

Table 7.3 Difference between harmonics and noise

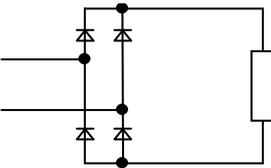
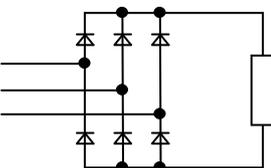
Item	Harmonics	Noise
Frequency	Normally 40th to 50th, 3 kHz or less	Harmonics (numeric, 10 kHz to MHz order)
Environment	Relates to path, power impedance	Relates to space, distance, wiring path
Quantitative understanding	Theoretical calculation possible	Random occurrence, quantitative grasping difficult
Emissions	Nearly proportional to load capacity	Changes with current variation ratio (gets larger as switching speed increases)
Affected equipment tolerance	Specified by standards of each device	Different depending on maker's equipment specifications
Countermeasure examples	Attach the reactor (L)	Expand the distance (ℓ)

7.3.2 Characteristics of Rectification Circuits and Harmonic Occurrence

The occurrence source of harmonics could be rectifiers, alternating power conditioners, etc. Large harmonics occur from the rectifier circuits in the converter part of a general-purpose servo.

As shown in Table 7.4, there are two types of rectifier circuits depending on the main circuit method, and the three-phase bridge method is mostly adopted in general-purpose servos.

Table 7.4 Rectifier circuit methods and harmonics

Circuit name	Fundamental circuit figure	High-frequency number	High-frequency content ratio
Single-phase bridge		$n = 4K \pm 1$ $K = 1, 2, \dots$	$Kn \times 1 / n$
Three-phase bridge		$n = 6K + 1$ $K = 1, 2, \dots$	$Kn \times 1 / n$

Kn: Coefficient determined by the control delay angle and the commutation overlap angle

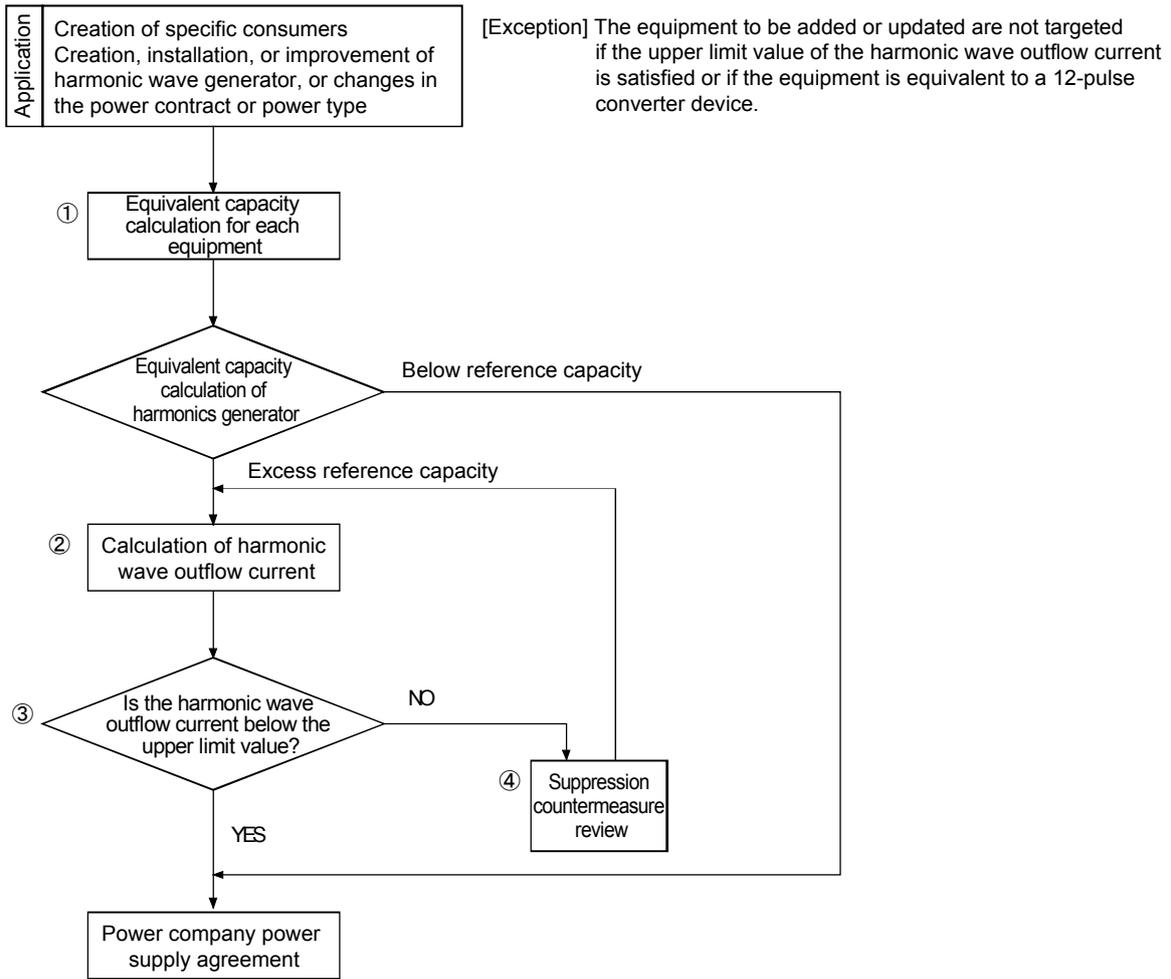
7.3.3 Harmonics Countermeasures

In September 1994, the Ministry of International Trade and Industry established the Harmonic Suppression Guidelines for harmonics suppression countermeasures.

Since January 2004, the guidelines related to power supply harmonics suppression for servo amplifiers were unified with the "Harmonic Suppression Measures Guideline for Consumers Receiving High Voltage or Extra-High Voltage".

As a result, consumers subject to this guideline should calculate the harmonic current based on the guideline for the entire servo amplifier, and measures must be enforced so that the limit level is not exceeded.

Consider the necessity using the following procedure.



Even users who are not subject to the above guidelines should connect power factor improving reactors (FR-BAL or FR-BEL) as usual.

7. Noise Reduction Techniques, Leakage Current, Harmonics

(1) Power factor improving DC reactor (FR-HEL)

Compared to the power factor improving AC reactor (FR-HAL), a power factor improving DC reactors can decrease loss. In addition, it is effective in reducing input-side harmonics.

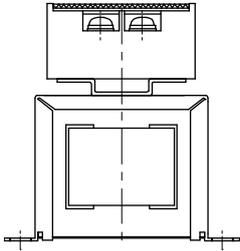


Figure 7.2

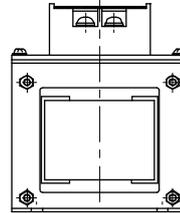
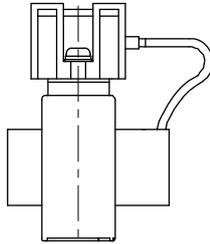
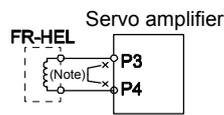
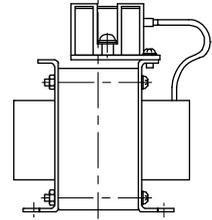


Figure 7.3



(Note) When the power factor improving DC reactor is used, remove the short-circuit bar between P3 and P4.

Servo amplifier	Power factor improving DC reactor	Exterior figure	Application power supply [mm ²]
MR-J4-10A, MR-J4-20A	FR-HEL-0.4K	Figure 7.2	2 (AWG 14)
MR-JR-40A	FR-HEL-0.75K		
MR-J4-60A MR-J4-70A	FR-HEL-1.5K		
MR-J4-100A	FR-HEL-2.2K		
MR-J4-200A	FR-HEL-3.7K	Figure 7.3	3.5 (AWG 12) 5.5 (AWG 10) 8 (AWG 8)
MR-J4-350A	FR-HEL-7.5K		
MR-J4-500A	FR-HEL-11K		
MR-J4-700A	FR-HEL-15K		

(2) Power factor improving AC reactor (FR-HAL)

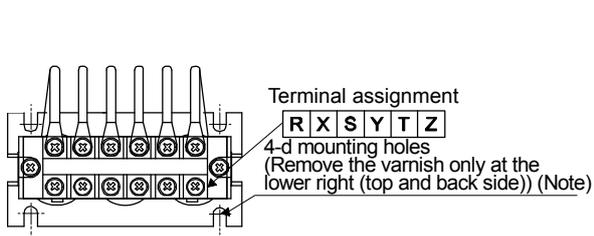


Figure 7.4

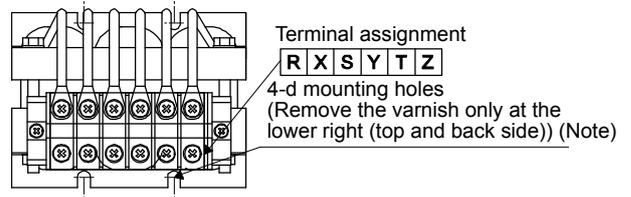
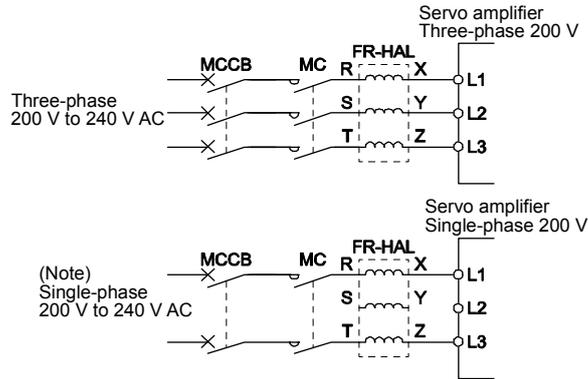


Figure 7.5

(Note) Use when laying the grounding wire.

(Note) Use when laying the grounding wire.



(Note) With a single-phase power supply of 200 V to 240 V AC, connect the power supply to L1 and L3 and do not connect anything to L2.

Servo amplifier	Power factor improving AC reactor	Exterior figure
MR-J4-10A, MR-J4-20A	FR-HAL-0.4K	Figure 7.4
MR-JR-40A	FR-HAL-0.75K	
MR-J4-60A MR-J4-70A	FR-HAL-1.5K	
MR-J4-100A	FR-HAL-2.2K	
MR-J4-200A	FR-HAL-3.7K	
MR-J4-350A	FR-HAL-7.5K	Figure 7.5
MR-J4-500A	FR-HAL-11K	
MR-J4-700A	FR-HAL-15K	

Memo

8. Maintenance and Inspection

The AC servo amplifier is a static unit consisting mainly of semiconductor devices. Daily inspection must be performed to prevent any faults from occurring due to adverse effects of the operating environment (due to such factors as temperature, humidity, dust, dirt, and vibration), changes in parts over time, service life, and other factors.

8.1 Precautions for Maintenance and Inspection

When accessing the AC servo amplifier for inspection, because the smoothing capacitor is in a high-voltage state even after the power supply has been switched OFF, wait until the charge lamp goes off, use a tester to make sure that the voltage across main circuit terminals P and N is 0 V, and then perform the inspection.

8.2 Check Items

(1) Daily inspection

- Basically, check for the following faults during operation.
 - (1) Motor operation fault
 - (2) Improper installation environment
 - (3) Cooling system fault
 - (4) Unusual vibration and noise
 - (5) Abnormal overheating, discoloration
- During operation, check the input voltage of the AC servo with a tester.

(2) Periodic inspection

- Check areas that are inaccessible during operation and that require periodic inspection.
 - (1) Cooling system fault: Clean the air filter, etc., if necessary.
 - (2) Tightening check and retightening: The screws and bolts may become loose due to vibration, temperature changes, etc. Check and tighten if necessary.
 - (3) Check the conductors and insulation material for corrosion and damage.
 - (4) Check the cooling fan, smoothing capacitor, and relays, and replace if necessary.

8. Maintenance and Inspection

Table 8.1 Daily and periodic inspection

Area of inspection	Check item	Check points	Inspection interval		Check method	Judgment criteria	Instrument
			Daily	Periodically			
General	Environment	Check ambient temperature, humidity, dust, etc.	○				Thermometer, hygrometer, recorder
	Storage environment	Check ambient temperature, humidity, dust, etc.	○		Measure using a thermometer or hygrometer	(1) Motor: -10°C to +70°C (Non-freezing) 90% RH or less (Non-condensing) Amplifier: -20°C to +65°C (Non-freezing) 90% RH or less (Non-condensing)	Thermometer, hygrometer, recorder
	General devices	Check for unusual vibrations and noise.	○		Auditory and visual check	No fault should be found.	-
	Power supply voltage	Check for normal main circuit voltage.	○		Servo amplifier board Voltage measurement across the L1, L2, and L3 phases	Refer to the standard specifications.	Tester, digital multimeter
Main circuit	Overall	(1) Check for loosening in the tightened parts. (2) Check for overheating traces on each part. (3) Cleaning		○ ○	(1) Retighten (2) Visual check	(1)(2) No fault should be found.	
	Bus bar/wire	(1) Check the conductors for distortion. (2) Check the wire coating for breakage and deterioration.		○	(1)(2) Visual check	(1)(2) No fault should be found.	
	Terminal block	Check for damage.		○	Visual check	No fault should be found.	
Main circuit	Smoothing capacitor	(1) Check for liquid leakage. (2) Check for protruding and bulging of the safety valve. (3) Measure static capacity.		○ ○	(1)(2) Visual check (3) Measure using capacity-measuring instrument.	(1)(2) No fault should be found. (3) The rated capacity should be 85% or more.	Capacity meter
	Relay	(1) Check for a chattering during operation. (2) Check the timer operating period. (3) Check for contact being made.		○ ○ ○	(1) Auditory check (2) Time from power supply ON to relay suction (3) Visual check	(1) No fault should be found. (2) Operation should take 0.1 to 0.15 seconds. (3) No fault should be found.	Universal counter
	Resistor	(1) Check for cracks in the resistor insulation. (2) Check for disconnection.		○ ○	(1) Visual check Cement resistance and winding resistance (2) Disconnect one side and measure using a tester.	(1) No fault should be found. (2) Errors should be within ±10% of the indicated resistance value.	Tester, digital multimeter

8. Maintenance and Inspection

Area of inspection	Check item	Check points	Inspection interval		Check method	Judgment criteria	Instrument
			Daily	Periodically			
Control circuit protection circuit	Operation check	(1) Check the output voltage balance of each phase with only the servo unit (no load) operating.		○	(1) Measure the voltage between servo amplifier output terminal phase U, V, and W.	(1) Inter-phase voltage balance is within 4 V.	Digital multimeter Rectifier-type voltmeter
		(2) Check for faults in the protection/display circuit by performing the sequence protection operation.		○	(2) Simulate shortening of the protection circuit output of the servo amplifier.	(2) There is a faulty operation in the sequence.	
Cooling system	Cooling fan	(1) Unusual vibration and noise (2) Check for loose screws and bolts.	○	○	(1) Turn by hand when not energized. (2) Retighten	(1) Rotation should be smooth. (2) No fault should be found.	
Display	Display	Check whether the charge lamp and the 7-segment LED display is OFF.	○		Show the amplifier board lamp and indicator.	Check whether it is illuminated.	
Servo motor	Overall	(1) Unusual vibration and noise (2) Check for an unusual odor.	○	○	(1) Auditory, feeling, and visual check (2) Check for abnormal odors due to overheating or damage.	(1)(2) No fault should be found.	
	Detector	Check for unusual vibrations and noise.	○		Auditory and sensory check	No fault should be found.	
	Cooling fan	(1) Unusual vibration and noise (2) Check for adherence of mist or foreign material.	○		(1) Turn by hand when not energized. (2) Visual check	(1) Rotation should be smooth. (2) No fault should be found.	
	Bearing	Check for unusual vibrations and noise.	○		Auditory and sensory check	No fault should be found.	

8. Maintenance and Inspection

8.3 Part Replacement

The following parts exhibit mechanical wear and aging of physical properties that may cause performance degradation or malfunctions in the module. Therefore, periodic inspection and periodic replacement of these parts is required as a part of periodic maintenance.

- (1) Smoothing capacitor: The characteristics of the smoothing capacitor deteriorate due to adverse effects of ripple currents, etc. The life of a capacitor greatly depends on the ambient temperature and usage conditions, but when operated continuously in an air-conditioned environment, it should last 10 years.
- (2) Relay types: Loose connections occur due to contact wear caused by switching currents. A life of 100,000 cumulative switchings (switching life) can be expected, but this greatly depends on the power capacity.
- (3) Servo amplifier cooling fan: The cooling fan has a bearing life of 10000 to 30000 hours. Therefore, with continuous operation, the fan needs to be replaced every two to three years. In addition, when unusual noises or vibrations are noticed during inspection, the cooling fan must be replaced immediately.
- (4) Servo motor bearing: If operated at the rated speed and rated load, replacement should be performed after every 20000 to 30000 hours. However, because the working life greatly depends on the operation conditions, replace immediately if any unusual noise or unusual vibration is noticed during inspection.
- (5) Servo motor oil seal:
(Including the oil seal used in the reducer) Replacement should be performed every 5000 hrs when operated at the rated speed. However, because the working life greatly depends on the operation conditions, replace immediately if an oil leak or other malfunction is detected during inspection.
- (6) Battery: The battery has a life of five years from the date of manufacturing.

Table 8.2 Standard part replacement cycle

Part name		Standard replacement period	Remarks
Servo amplifier	Smoothing capacitor	10 years	The standard replacement period is a reference. Even if the standard replacement period has not passed, the part may need to be replaced if a fault is detected. For part replacement, contact Mitsubishi Electric System & Service. Battery replacement can be performed by the user.
	Relay	-	
	Cooling fan	10000 to 30000 hours (2 to 3 years)	
Servo motor	Bearings	20000 to 30000 hours	
	Encoder	20000 to 30000 hours	
	Oil seal	5000 hours	
Battery		Five years from the date of manufacturing	

8.4 Troubleshooting

POINT
<ul style="list-style-type: none">• For details about alarms and warnings, refer to the MELSERVO-J4 Instruction Manual (Troubleshooting).• Turn on the SON (servo-on) at the same time an alarm occurs and disconnect the power supply.

When a malfunction occurs during operation, an alarm or a warning is displayed. When an alarm or a warning occurs, take the proper action as described in the MELSERVO-J4 Servo Amplifier Instruction Manual (Troubleshooting). If an alarm occurs, the ALM (failure) turns off.

If [Pr. PD34] is set to "___ 1", an alarm code can be output. The alarm code is output with the on/off of bits 0 to 2. There is no alarm code for a warning ([AL.91] to [AL.F3]). The alarm code in the table is output at the time of alarm occurrence. Normally, no alarm code is output.

After removing the cause of the alarm, the alarm can be canceled using any of the methods marked with ○ in the clear column. Warnings are automatically canceled if the occurrence cause is cleared.

To stop alarms and warnings mentioned as SD in the stop method, use the timing brake after forced stop deceleration. To stop alarms and warnings mentioned as DB in the stop method, use the timing brake without performing forced stop deceleration.

8. Maintenance and Inspection

8.4.1 Alarm/Warning List

When a malfunction occurs during operation, an alarm or a warning is displayed. When an alarm or a warning occurs, take the proper action as described in section 1.2 in the separate MELSERVO-J4 Servo Amplifier Instruction Manual (Troubleshooting). If an alarm occurs, the ALM (failure) turns off.

	No.	Name	Detailed display	Detail name
Alarm	10	Undervoltage	10.1	Voltage drop in the control circuit power
			10.2	Voltage drop in the main circuit power
	11	Switch setting error	11.1	Axis number setting error
			11.2	Disabling control axis setting error
	12	Memory error 1 (RAM)	12.1	RAM error 1
			12.2	RAM error 2
			12.3	RAM error 3
			12.4	RAM error 4
			12.5	RAM error 5
	13	Clock error	13.1	Control clock error 1
			13.2	Control clock error 2
	14	Control process error	14.1	Control process error 1
			14.2	Control process error 2
			14.3	Control process error 3
			14.4	Control process error 4
			14.5	Control process error 5
			14.6	Control process error 6
			14.7	Control process error 7
			14.8	Control process error 8
			14.9	Control process error 9
			14.A	Control process error 10
	15	Memory error 2 (EEP-ROM)	15.1	EEP-ROM error at power-on
			15.2	EEP-ROM error during operation
	16	Encoder initial communication error 1	16.1	Encoder initial communication - Receive data error 1
			16.2	Encoder initial communication - Receive data error 2
			16.3	Encoder initial communication - Receive data error 3
			16.5	Encoder initial communication - Transmission data error 1
			16.6	Encoder initial communication - Transmission data error 2
			16.7	Encoder initial communication - Transmission data error 3
			16.A	Encoder initial communication - Process error 1
			16.B	Encoder initial communication - Process error 2
			16.C	Encoder initial communication - Process error 3
			16.D	Encoder initial communication - Process error 4
			16.E	Encoder initial communication - Process error 5
			16.F	Encoder initial communication - Process error 6
	17	Board error	17.1	Board error 1
			17.3	Board error 2
			17.4	Board error 3
			17.5	Board error 4
			17.6	Board error 5
	19	Memory error 3 (FLASH-ROM)	19.1	Flash-ROM error 1
			19.2	Flash-ROM error 2
	1A	Servo motor combination error	1A.1	Servo motor combination error
			1A.2	Servo motor control mode combination error
	1E	Encoder initial communication error 2	1E.1	Encoder malfunction
			1E.2	Load side encoder malfunction
1F	Encoder initial communication error 3	1F.1	Incompatible encoder	
		1F.2	Load side incompatible encoder	

8. Maintenance and Inspection

	No.	Name	Detailed display	Detail name
Alarm	20	Encoder communication error 1	20.1	Encoder normal communication - Receive data error 1
			20.2	Encoder normal communication - Receive data error 2
			20.3	Encoder normal communication - Receive data error 3
			20.5	Encoder normal communication - Transmission data error 1
			20.6	Encoder normal communication - Transmission data error 2
			20.7	Encoder normal communication - Transmission data error 3
			20.9	Encoder normal communication - Receive data error 4
			20.A	Encoder normal communication - Receive data error 5
	21	Encoder communication error 2	21.1	Encoder data error 1
			21.2	Encoder data update error
			21.3	Encoder data waveform error
			21.4	Encoder non-signal error
			21.5	Encoder hardware error 1
			21.6	Encoder hardware error 2
			21.9	Encoder data error 2
	24	Main circuit error	24.1	Ground fault detected at hardware detection circuit
			24.2	Ground fault detected in hardware detection process
	25	Absolute position erased	25.1	Servo motor encoder - Absolute position erased
	27	Initial magnetic pole detection error	27.1	Magnetic pole detection - Abnormal termination
			27.2	Magnetic pole detection - Time-out error
			27.3	Magnetic pole detection - Limit switch error
			27.4	Magnetic pole detection - Estimated error
			27.5	Magnetic pole detection - Position deviation error
			27.6	Magnetic pole detection - Speed deviation error
			27.7	Magnetic pole detection - Current error
	28	Linear encoder error 2	28.1	Linear encoder - Environment error
	2A	Linear encoder error 1	2A.1	Linear encoder error 1-1
			2A.2	Linear encoder error 1-2
			2A.3	Linear encoder error 1-3
			2A.4	Linear encoder error 1-4
			2A.5	Linear encoder error 1-5
			2A.6	Linear encoder error 1-6
			2A.7	Linear encoder error 1-7
			2A.8	Linear encoder error 1-8
	2B	Encoder counter error	2B.1	Encoder counter error 1
			2B.2	Encoder counter error 2
	30	Regenerative error	30.1	Regeneration heat error
			30.2	Regeneration signal error
			30.3	Regeneration feedback signal error
	31	Overspeed	31.1	Abnormal motor speed
	32	Overcurrent	32.1	Overcurrent detected at hardware detection circuit (during operation)
			32.2	Overcurrent detected at software detection circuit (during operation)
			32.3	Overcurrent detected at hardware detection circuit (during a stop)
32.4			Overcurrent detected at software detection circuit (during a stop)	
33	Overvoltage	33.1	Main circuit voltage error	
34	SSCNET receive error 1	34.1	SSCNET receive data error	
		34.2	SSCNET connector connection error	
		34.3	SSCNET communication data error	
		34.4	Hardware error signal detection	
35	Command frequency error	35.1	Command frequency error	
36	SSCNET receive error 2	36.1	Continuous communication data error	
37	Parameter error	37.1	Parameter setting range error	
		37.2	Parameter combination error	
3A	Inrush current suppression circuit error	3A.1	Inrush current suppression circuit error	
3E	Operation mode error	3E.1	Operation mode error	

8. Maintenance and Inspection

	No.	Name	Detailed display	Detail name
Alarm	42	Servo control error (When using linear servo motor or direct drive motor)	42.1	Servo control error by position deviation
			42.2	Servo control error by speed deviation
			42.3	Servo control error by torque/thrust deviation
		Fully closed loop control error (When using fully closed loop control)	42.8	Fully closed loop control error by position deviation
			42.9	Fully closed loop control error by speed deviation
			42.A	Fully closed loop error by position deviation with stop command
	45	Main circuit device overheat	45.1	Main circuit device overheat error
	46	Servo motor overheat	46.1	Servo motor temperature error 1
			46.2	Servo motor temperature error 2
			46.3	Thermistor disconnected
			46.5	Servo motor temperature error 3
			46.6	Servo motor temperature error 4
	47	Cooling fan error	47.1	Cooling fan stop error
			47.2	Cooling fan speed reduction error
	50	Overload 1	50.1	Thermal overload error 1 during operation
			50.2	Thermal overload error 2 during operation
			50.3	Thermal overload error 4 during operation
			50.4	Thermal overload error 1 during a stop
			50.5	Thermal overload error 2 during a stop
			50.6	Thermal overload error 4 during a stop
	51	Overload 2	51.1	Thermal overload error 3 during operation
			51.2	Thermal overload error 3 during a stop
	52	Error excessive	52.1	Excessive droop pulse 1
			52.3	Excessive droop pulse 2
			52.4	Error excessive during 0 torque limit
			52.5	Excessive droop pulse 3
	54	Oscillation detection	54.1	Oscillation detection error
	56	Forced stop error	56.2	Over speed during forced stop
			56.3	Basic estimated distance over during forced stop
	63	STO timing error	63.1	STO1 off
			63.2	STO2 off
	70	Load-side encoder initial communication error 1	70.1	Load-side encoder initial communication - Receive data error 1
			70.2	Load-side encoder initial communication - Receive data error 2
70.3			Load-side encoder initial communication - Receive data error 3	
70.5			Load-side encoder initial communication - Transmission data error 1	
70.6			Load-side encoder initial communication - Transmission data error 2	
70.7			Load-side encoder initial communication - Transmission data error 3	
70.A			Load-side encoder initial communication - Process error 1	
70.B			Load-side encoder initial communication - Process error 2	
70.C			Load-side encoder initial communication - Process error 3	
70.D			Load-side encoder initial communication - Process error 4	
70.E			Load-side encoder initial communication - Process error 5	
70.F			Load-side encoder initial communication - Process error 6	
71	Load-side encoder normal communication error 1	71.1	Load-side encoder communication - Receive data error 1	
		71.2	Load-side encoder communication - Receive data error 2	
		71.3	Load-side encoder communication - Receive data error 3	
		71.5	Load-side encoder communication - Transmission data error 1	
		71.6	Load-side encoder communication - Transmission data error 2	
		71.7	Load-side encoder communication - Transmission data error 3	
		71.9	Load-side encoder communication - Transmission data error 4	
		71.A	Load-side encoder communication - Transmission data error 5	

8. Maintenance and Inspection

	No.	Name	Detailed display	Detail name
Alarm	72	Load-side encoder normal communication error 2	72.1	Load-side encoder data error 1
			72.2	Load-side encoder data update error
			72.3	Load-side encoder data waveform error
			72.4	Load-side encoder non-signal error
			72.5	Load-side encoder hardware error 1
			72.6	Load-side encoder hardware error 2
			72.9	Load-side encoder data error 2
	8A	USB communication time-out error/ Serial communication time-out error	8A.1	USB communication time-out error/ Serial communication time-out error
	8E	USB communication error/ Serial communication error	8E.1	USB communication receive error/Serial communication receive error
			8E.2	USB communication checksum error/Serial communication checksum error
			8E.3	USB communication character error/Serial communication character error
			8E.4	USB communication command error/Serial communication command error
			8E.5	USB communication data number error/Serial communication data number error
	888/ 88888	Watchdog	88._/ 8888._	Watchdog

8. Maintenance and Inspection

	No.	Name	Detailed display	Detail name
Alarm	91	Servo amplifier overheat warning	91.1	Main circuit device overheat warning
	92	Battery cable disconnection warning	92.1	Encoder battery cable disconnection warning
			92.3	Battery degradation
	95	STO warning	95.1	STO1 off detection
			95.2	STO2 off detection
	96	Home position setting warning	96.1	In-position warning at home positioning
			96.2	Command input warning at home positioning
			96.3	Servo off warning at home positioning
	99	Stroke limit warning	99.1	Forward rotation stroke end off
			99.2	Reverse rotation stroke end off
	9F	Battery warning	9F.1	Low battery
			9F.2	Battery degradation warning
	E0	Excessive regeneration warning	E0.1	Excessive regeneration warning
	E1	Overload warning 1	E1.1	Thermal overload warning 1 during operation
			E1.2	Thermal overload warning 2 during operation
			E1.3	Thermal overload warning 3 during operation
			E1.4	Thermal overload warning 4 during operation
			E1.5	Thermal overload warning 1 during a stop
			E1.6	Thermal overload warning 2 during a stop
			E1.7	Thermal overload warning 3 during a stop
			E1.8	Thermal overload warning 4 during a stop
	E2	Servo motor overheat warning	E2.1	Servo motor temperature warning
	E3	Absolute position counter warning	E3.1	Multi-revolution counter travel distance excess warning
			E3.2	Encoder absolute positioning counter warning
			E3.5	Absolute position counter warning
	E4	Parameter warning	E4.1	Parameter setting range error warning
	E5	ABS time-out warning	E5.1	Time-out during ABS data transfer
			E5.2	ABSM off during ABS data transfer
			E5.3	SON off during ABS data transfer
	E6	Servo forced stop warning	E6.1	Forced stop warning
	E7	Controller forced stop warning	E7.1	Controller forced stop warning
	E8	Cooling fan speed reduction warning	E8.1	Decreased cooling fan speed warning
			E8.2	Cooling fan stop
E9	Main circuit off warning	E9.1	Servo-on signal on during main circuit off	
		E9.2	Bus voltage drop during low speed operation	
		E9.3	Ready-on signal on during main circuit off	
EA	ABS servo-on warning	EA.1	ABS servo-on warning	
EB	Other axis error warning	EB.1	Other axis error warning	
EC	Overload warning 2	EC.1	Overload warning 2	
ED	Output watt excess warning	ED.1	Output watt excess warning	
F0	Tough drive warning	F0.1	Instantaneous power failure tough drive warning	
		F0.3	Vibration tough drive warning	
F2	Drive recorder - Miswriting warning	F2.1	Drive recorder - Area writing time-out warning	
		F2.2	Drive recorder - Data miswriting warning	
F3	Oscillation detection warning	F3.1	Oscillation detection warning	

8.4.2 Alarm Corrective Action

 CAUTION	<ul style="list-style-type: none">• When an alarm has occurred, eliminate the cause, ensure safety, and deactivate the alarm before restarting operation. Failure to do so may cause injury.• If [AL.25 Absolute position erased] occurs, make sure to perform home position setting again. Failure to do so may result in the servo motor working unexpectedly.• Turn off the servo at the same time an alarm occurs and disconnect the main circuit power supply.
--	---

POINT
<ul style="list-style-type: none">• When the following alarms occur, cancel the alarm and do not resume operation by repeating. Doing so may cause failure of the servo amplifier and the servo motor. At the same time as the cause of the alarm occurrence is cleared, re-start operation after waiting a cooling time of 30 minutes or more.<ul style="list-style-type: none">• [AL.30 Regenerative error]• [AL.45 Main circuit device overheat]• [AL.46 Servo motor overheat]• [AL.50 Overload 1]• [AL.51 Overload 2]

For details regarding the corrective action for these alarms, refer to section 1.2 of "MELSERVO-J4 Servo Amplifier Instruction Manual (Troubleshooting) SH-030109".

In addition, follow this instruction manual to clear the cause of the alarm.

If MR Configurator2 is used, the cause of the alarm can be referenced.

8. Maintenance and Inspection

8.4.3 Warning Corrective Action



CAUTION

- If [AL.E3 Absolute position counter warning] occurs, make sure to perform home position setting again. Failure to do so may result in the servo motor working unexpectedly.

POINT

- When the following warnings occur, repeatedly turn the power supply of the servo amplifier on/off and do not restart operation. Failure to do so may cause failure of the servo amplifier and the servo motor. When the power supply of the servo amplifier is turned on/off while a warning occurs, restart operation after waiting a cooling time of 30 minutes or more.
 - [AL.91 Servo amplifier overheat warning]
 - [AL.E0 Excessive regeneration warning]
 - [AL.E1 Overload warning 1]
 - [AL.E2 Servo motor overheat warning]
 - [AL.EC Overload warning 2]

For details regarding corrective action for these alarms, refer to section 1.3 of "MELSERVO-J4 Servo Amplifier Instruction Manual (Troubleshooting) SH-030109".

In addition, follow this instruction manual to clear the cause of the warning.

If MR Configurator2 is used, the cause of the warning can be referenced.

Appendix 2. Drive System Types

(1) Types of Motion Direction

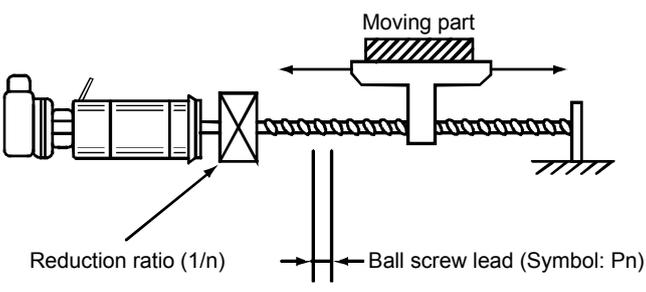
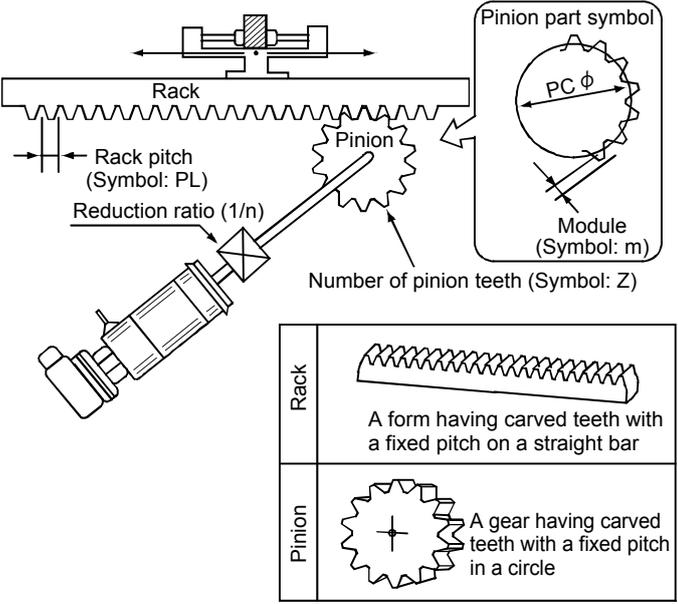
Depending on the servo motor, there are various types of machine drive systems, and all are used for different purposes (request accuracy, feed accuracy, travel distance, machine operation content during work, etc.). The following section shows the types of machine motion direction by classifying these drive system mechanisms while considering the connection with the servo motor. For linear movement, mm is used as the command unit, and for rotary movement, an angle or division number is used. The torque value turns out negative with vertical motion; thus, attention is required when reviewing the capacity.

		Movement direction classification		
		Horizontal direction	Vertical direction (lifting)	
Linear motion			<ul style="list-style-type: none"> • Including the ball screw, this is the most common drive form used in the table feed or transportation machine of various machines using rack and pinion, belt, etc. 	<ul style="list-style-type: none"> • This drive form is used in the lift shaft of transportation machines or in robot vertical axes. As shown in the figure, a counterweight for load balance is often attached, and a motor with an electromagnetic brake is used to preventing dropping at the time of power failure.
	Rotational motion			<ul style="list-style-type: none"> • This drive form is used in the axis of rotation of index tables, etc. The speed of the rotation shaft (axis of rotation of a table) is generally low, and use with a reduced speed by a gear or pulley teeth ratio is common.

Appendix figure 1 Types of motion direction

2) Actual drive system examples

When performing positioning control with a position servo, the basis is the machine feed length per pulse. To calculate, it is necessary to decide the machine travel distance per motor rotation (symbol: ΔS ; unit: mm). This section shows overview figures of various drive systems used for linear motion, as provided in 1), and their basic formulas.

	Drive system type	Features and basic formula
<p>(1) Ball screw</p>		<p>Features and basic formula</p> <ul style="list-style-type: none"> This typical drive system is used when performing highly accurate positioning over a comparatively short travel distance. A smaller ball screw lead (shown in the figure to the left) results in higher precision and lower feed speed. (Provided that the drive servo is same.) <p>Basic formula</p> <p>Feed length per motor rotation $\Delta S \text{ (mm)} = P_B \text{ (mm)} \cdot 1/n$ The following applies for direct coupling connections without a reducer $\Delta S = P_B$</p>
<p>(2) Rack and Pinion</p>		<p>Features and basic formula</p> <ul style="list-style-type: none"> This drive system is used for positioning over a comparatively long distance. In most methods, the pinion side is generally fixed and the rack side moves, but sometimes the rack is fixed and the pinion side, including the motor part, is moved. <p>Basic formula</p> <p>$\Delta S \text{ (mm)} = P_L \text{ (mm)} \cdot Z \cdot 1/n$ or $\Delta S = PC\phi \cdot \pi \cdot 1/n$</p>

Appendix figure 2 Drive system (1)

Drive system type		Features and basic formula
(3) Timing belt		<ul style="list-style-type: none"> • This drive system is used in a wide range from large transportation machines to precision machines. • Unlike V-belts or flat belts, which are frequently used with ordinary motors, feeding takes place by interlocking pulley and belt teeth. This means there are no errors due to slipping. However, the precision drops due to changes such as abrasion over the years, which depends on the material of the belt. Therefore, maintenance needs to be considered. Also, the belt pitch is manufactured in the inch system, and when considering the command pulse and feed length settings, caution must be taken because a fraction will occur with mm conversion. <p>Basic formula</p> $\Delta S \text{ (mm)} = P_r \text{ (mm)} \cdot Z \cdot 1/n$
(4) Chain		<ul style="list-style-type: none"> • This drive system is mainly used in large transportation machines. • It is applicable when feeding over long distances at high speeds. • The chain pitch employs the inch system similar to a timing belt, so care must be taken with regard to the feed length setting. Also, countermeasures must be taken considering the precision is affected by the occurrence of initial elongation. <p>Basic formula</p> $\Delta S \text{ (mm)} = P_c \text{ (mm)} \cdot Z \cdot 1/n$

Appendix figure 2 Drive system (2)

Drive system type		Features and basic formula
(5) Roll feed	<p>Workpiece (material)</p> <p>Feed roll</p> <p>Diameter of feed roll (Symbol: D)</p> <p>Reduction ratio (1/n)</p>	<ul style="list-style-type: none"> In this system, a workpiece is fed (sent) by abrasion power after rotating the roll. It is frequently used in fixed feeding represented by a roll feeder for a press machine, or for feeding film sheets, paper, etc. (drawing control, cutter, etc.). To improve the positioning accuracy, it is necessary to prevent slippage between the roll and material, and process the roll into an exact circle. π is basically an irrational number, thus compensation is required without avoiding the command pulse and feed length conversion fraction. <p>Basic formula</p> $\Delta S \text{ (mm)} = \pi \cdot D \text{ (mm)} \cdot 1/n$
(6) Cart travel	<p>Cart</p> <p>Drive axis (both left and right wheels)</p> <p>Cart drive part</p> <p>Gear deceleration (1/n)</p> <p>Diameter of drive wheel (Symbol: D)</p>	<ul style="list-style-type: none"> In this system, a servo motor is installed in the traveling cart and is used as a drive source. As shown in the figure to the left, it is common for systems to rotate the servo motor by drive wheels. However, sufficient consideration is required to prevent slippage between the wheels and the rail. Rack and pinion is used in systems other than that shown in the figure to the left, and a mechanism to move the pinion part at the fixing rack is also frequently used. <p>Basic formula (for the figure on the left)</p> $\Delta S \text{ (mm)} = \pi \cdot D \text{ (mm)} \cdot 1/n$

Appendix figure 2 Drive system (3)

Appendix 3. Positioning Controller

Controller Positioning module type		Module type	FX2N-1PG	FX2N-10PG	FX2N-10GM	FX2N-20GM	QD75D1 QD75P1	QD75D2 QD75P2	QD75D4 QD75P4	
System configuration	PC-to-PC network	Note: (1) A solid line between a controller and an amplifier shows a bus connection. (2) A dotted line shows a pulse train.	CC-LINK				MELSECNET/H			
	CPU									
	Positioning module									
	Servo amplifier									
Servo motor										
I/F specifications	Positioning module to amplifier	Pulse train				Pulse train				
Command language (language used)		*	Language response + ladder diagram		Data table method + ladder diagram		Data table method + ladder diagram			
Encoder specifications		INC/ABS method	INC/ABS	INC/ABS	INC/ABS		INC/ABS			
Maximum number of controllable axes			1 axis	1 axis	1 axis	2 axes	1 axis	2 axes	4 axes	
Output pulse frequency			10 KPPS	100 KPPS	200 KPPS	200 KPPS	QD75DD□: 1 MPPS (Differential driver) QD75PC□: 200 KPPS (Open collector)			
Interpolation control function			*	*	*	Linear/circular	*	Linear/circular interpolation		
Main control functions			Position/speed	Position/speed	Position/speed	Position/speed	Position/speed/position-speed switching/ speed-position switching/fixed feed			
Positioning model selection points and merits		(1) Number of servo control axes	For small-scale axis control	For small-scale axis control	For control of 1 axis	For control of 2 axes	For control of 1 axis	For control of 2 axes	For control of 4 axes	
		(2) Sequence function (I/O points) (memory capacity)	All positioning data is for ladder diagrams and small-scale I/O systems. For small-scale I/O systems.		3.8 K steps when individually connected to FX2N or FX2NC	7.8 K steps when individually connected to FX2N or FX2NC	Any QCPU can be selected. Position data is acquired with the data table method. (600 points/axis)			
		(3) Servo control function	For easy positioning	For easy positioning	1 axis	Linear and circular interpolation functions for 2 axes are available	1 axis	Linear, circular interpolation control, speed/position control, position/speed control, fixed feed, etc.		
		(4) Cost performance, etc.	Compact, low-price system. Use in combination with CPU.	Compact, low-price system. Use in combination with CPU.	Compact, low-price system. Can also be used individually.	Compact, low-price system. Can also be used individually.	Compact (1 slot occupying 32 points), low cost. Ladder diagram between CPU and module, and pulse train, cable length restrictions between positioning module and servo amplifier. Electronic gears can be used for both QD75 and the servo amplifier. Position data is stored in flash ROM (battery not required).			
Applicable servo amplifier series group		*	MR-J2-Jr MR-J3-A All other pulse train I/F methods can be used.				MR-J2-Jr MR-J3-A All other pulse train I/F methods can be used.			
Peripheral equipment	Programming tools and S/W package for positioning		GX Developer FX-20P FX-10P		E-20TP FX-PCS-VPS/WIN		(Windows version) GX Configurator-QP			

<Special notes>

1. The MR-J3-T type is a CC-Link-compatible servo amplifier. The number of connectable servo amplifiers with 1 master module is 42 max. (when 1 station is occupied), and 32 when 2 stations are occupied.

Appendix

QD75D1N QD75P1N			QD75D2N QD75P2N			QD75D4N QD75P4N			QD70P4		QD70P8	
Pulse train						Pulse train						
Data table method + ladder diagram						Data table method + ladder diagram						
INC/ABS						INC/ABS						
1 axis		2 axes		4 axes		4 axes		8 axes				
QD75D□N: 4 MPPS (Differential driver) QD75P□N: 200 KPPS (Open collector)						200 KPPS						
*		Linear/circular interpolation				*		*				
Position/speed/position-speed switching/ speed-position switching/fixed feed						Position/speed/position-speed switching						
For control of 1 axis		For control of 2 axes		For control of 4 axes		For control of 4 axes		For control of 8 axes				
Any QCPU can be selected. Position data is acquired with the data table method. (600 points/axis)						Any QCPU can be selected. Position data is acquired with the data table method. (10 points/axis)						
1 axis		Linear, circular interpolation control, speed/position control, position/speed control, fixed feed, etc.				Position control, speed/position switching						
Compact (1 slot occupying 32 points), low cost. Ladder diagram between CPU and module, and pulse train, cable length restrictions between positioning module and servo amplifier. Electronic gears can be used for both QD75 and the servo amplifier. Position data is stored in flash ROM (battery not required).						Compact (1 slot occupying 32 points), low cost. Ladder diagram between CPU and module, and pulse train, cable length restrictions between positioning module and servo amplifier. Electronic gears can be used for the servo amplifier only. Position data is stored in flash ROM (battery not required).						
MR-J2-Jr MR-J3-A All other pulse train I/F methods can be used.						MR-J2-Jr MR-J3-A All other pulse train I/F methods can be used.						
(Windows version) GX Configurator-QP						(Windows version) GX Configurator-QT						

- When selecting various systems, it is necessary to select according to (1) Sequence function, (2) Servo function, (3) Number of controlled axes, (4) Cost performance, (5) Programming, and (6) System scale, extensibility, etc.
- There is also a Windows-NT version for the SFC (motion side) method. Incompatible with A171SH.

Appendix

Controller Positioning module type		Module type	QD75M1	QD75M2	QD75M4	QD75MH1	QD75MH2	QD75MH4
System configuration	PC-to-PC network	Note: (1) A solid line between a controller and an amplifier shows a bus connection. (2) A dotted line shows a pulse train.						
	CPU							
	Positioning module							
	Servo amplifier							
	Servo motor							
I/F specifications	Positioning module to amplifier	Pulse train / bus connection	Bus connection					
Command language (language used)	*	Data table method + ladder diagram						
Encoder specifications	INC/ABS method	INC/ABS						
Maximum number of controllable axes		1 axis	2 axes	4 axes	-			
Output pulse frequency		High-speed serial communication method						
Interpolation control function		*	Linear/circular interpolation			-		
Main control functions		Position/speed/position-speed switching/ speed-position switching/ fixed feed				-		
Positioning model selection points and merits	(1) Number of servo control axes	For control of 1 axis	For control of 2 axes	For control of 4 axes	-			
	(2) Sequence function (I/O points) (memory capacity)	Any QCPU can be selected. Position data is acquired with the data table method. (600 points/axis) (A program for communication is also not required when using ABS.)						
	(3) Servo control function	1 axis	Linear, circular interpolation control speed/position control position/speed control, fixed feed, etc.			-		
	(4) Cost performance, etc.	A ladder diagram is required between the CPU and the module, which are compact (1 slot occupies 32 points), low price, and easily wired, and an SSCNET bus and an all axes servo ON signal Y1 is required between the positioning module and the servo amplifier. Electronic gears inside the servo amplifier are not available (none). An electronic gear multiplying factor is required when using a taper. Some servo amplifier parameters can be set from the QD75M(H) side.						
Applicable servo amplifier series group	*	MR-J3-B						
Peripheral equipment	Programming tools and S/W package for positioning	(Windows version) GX Configurator-QP						

<Special notes>

1. The MR-J3-T type is a CC-Link-compatible servo amplifier. The number of connectable servo amplifiers with 1 master module is 42 max. (when 1 station is occupied), and 32 when 2 stations are occupied.

QD77MS2	QD77MS4	QD77MS16
Bus connection		
Data table method + ladder diagram		
INC/ABS		
2 axes	4 axes	16 axes
High-speed serial communication method		
Linear/circular interpolation		
Position/speed/position-speed switching/ speed-position switching/fixed feed		
For control of 2 axes	For control of 4 axes	For control of 16 axes
Any QCPU can be selected. Position data is acquired with the data table method. (600 points/axis) (A program for communication is also not required when using ABS.)		
Linear, circular interpolation control speed/position control position/speed control, fixed feed, etc.		
A ladder diagram is required between the CPU and the module, which are compact (1 slot occupying 32 points) and easily wired, and an SSCNET bus and an all axes servo ON signal Y1 is required between the positioning module and the servo amplifier. Electronic gears inside the servo amplifier are not available (none). An electronic gear multiplying factor is required when using a taper.		
MR-J4-B, MR-J3-B		
(Windows version) GX Works2, MR-Configurator2		

4. When selecting various systems, it is necessary to select according to (1) Sequence function, (2) Servo function, (3) Number of controlled axes, (4) Cost performance, (5) Programming, and (6) System scale, extensibility, etc.
6. By using the actuator I/F module (analog output), driving of a vector INV, another company's vector INV, etc., is possible, as is torque control, etc., of tension control.
7. Fully closed loop control is possible with MR-J3-B-RJ006.
8. When using QD75M□ and QD75MH□, perform everything, including servo amplifier side parameters, from the positioning module side. Accordingly, programming is easy when software is used. Use of software is recommended especially for fixed parameters.

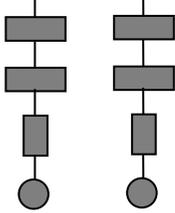
Appendix

Controller Positioning module type		Module type	Q172HCPU	Q173HCPU	Q172DCPU	Q173DCPU	Q172DSCPU	Q173DSCPU	
System configuration	PC-to-PC network	Note: (1) A solid line between a controller and an amplifier shows a bus connection. (2) A dotted line shows a pulse train.	MELSECNET/H				SSCNET III/(H)		
	CPU								
	Positioning module								
	Servo amplifier								
	Servo motor								
I/F specifications	Positioning module to amplifier	Pulse train / bus connection	Bus connection						
Command language (language used)	*		Dedicated language method + ladder diagram (With NC language SV43)				Dedicated language method + ladder diagram		
Encoder specifications	INC/ABS method		INC/ABS						
Maximum number of controllable axes			8 axes	32 axes	8 axes	32 axes	16 axes	32 axes	
Output pulse frequency			High-speed serial communication method						
Interpolation control function			Linear/circular interpolation						
Main control functions			Position/speed/position-speed switching fixed feed/position tracking control/cam						
Positioning model selection points and merits	(1) Number of servo control axes		For control of 8 axes max.	For control of 32 axes max.	For control of 8 axes max.	For control of 32 axes max.	For control of 16 axes max.	For control of 32 axes max.	
	(2) Sequence function (I/O points) (memory capacity)		Any QCPU can be selected. (With a multiple CPU system) When using Q25HCPU: I/O=256 points 34 ns/step						
	(3) Servo control function		Linear interpolation control of 4 axes, circular interpolation control of 2 axes Speed/position, constant speed control, fixed feed Position tracking control						
	(4) Cost performance, etc.		(1) Use of motion language, NC language (SV43) (2) SV13/SV22/SV43/SV54 can be selected (3) SSCNET method between controller and servo amplifier (4) ABS unlimited length positioning is possible				(1) Use of motion language (2) SV13/SV22 can be selected (3) SSCNET method between controller and servo amplifier (4) ABS unlimited length positioning is possible		
Applicable servo amplifier series group	*		MR-J3-B				MR-J4-B		
Peripheral equipment	Programming tools and S/W package for positioning		(Windows version) MT Developer, MT Developer2				(Windows version) MT Developer, MT Developer2		

<Special notes>

1. The MR-J3-T type is a CC-Link-compatible servo amplifier. The number of connectable servo amplifiers with 1 master module is 42 max. (when 1 station is occupied), and 32 when 2 stations are occupied.

Appendix

A171SH CPUN	A172SH CPUN	MR-J2S-□CP	MR-J3-□T
<p>MNET(II), MNET/B (MNET/10)</p> 			
Bus connection		-	
Dedicated language method + ladder diagram (With NC language SV43)		Point table method/contact input	
INC/ABS		INC/ABS	
4 axes	8 axes	1 axis	
High-speed serial communication method		-	
Linear/circular interpolation		*	
Position/speed/position-speed switching fixed feed/position tracking control/cam		Position	
For control of 4 axes max.	For control of 8 axes max.	For control of 1 axis	
A2SH or equivalent I/O=512 points 14 K step 25 μs/step	A2SH-S One phase or equivalent I/O=1024 points 30K step 25 μs/step	All positioning data is acquired with the built-in point table method. For small-scale I/O systems.	
Linear interpolation control of 4 axes, circular interpolation control of 2 axes Speed/position, constant speed control, fixed feed Position tracking control		For easy positioning	
<p>(1) Use of motion language, NC language (SV43) (2) SV13/SV22/SV43/SV54 can be selected (3) SSCNET method between controller and servo amplifier (4) ABS unlimited length positioning is possible</p>		Compact system with low cost. Can be used individually.	
MR-J3-B		MR-J3-□T	
<p>(DOS/V, PC98) (MS-DOS version) For OS: SW*SRX-SV13/SW*NX-SV13 For peripherals: SW*SRX-GSV13/22 : SW*NX-GSV13/22 : SW**-CAMP</p>		General-purpose personal computer body component	

4. When selecting various systems, it is necessary to select according to (1) Sequence function, (2) Servo function, (3) Number of controlled axes, (4) Cost performance, (5) Programming, and (6) System scale, extensibility, etc.
5. There is also a Windows-NT version for the SFC (motion side) method. Incompatible with A171SH.
6. By using the actuator I/F module (analog output), driving of a vector INV, another company's vector INV, etc., is possible, as is torque control, etc., of tension control.
7. Fully closed loop control is possible with MR-J3-B-RJ006.
8. When using QD75M□ and QD75MH□, perform everything, including servo amplifier side parameters, from the positioning module side. Accordingly, programming is easy when software is used. Use of software is recommended especially for fixed parameters.

Appendix 4. Terminology

Adaptive vibration suppression control

If there is a specific resonance point in the mechanical system and if the servo system response is increased, the mechanical system may resonate (vibration or abnormal noise) at that resonance frequency. With the adaptive vibration suppression control function, the servo amplifier detects machine resonance and sets filter properties automatically, and then controls the vibration of the machine system.

Analog control <opposite: digital control>

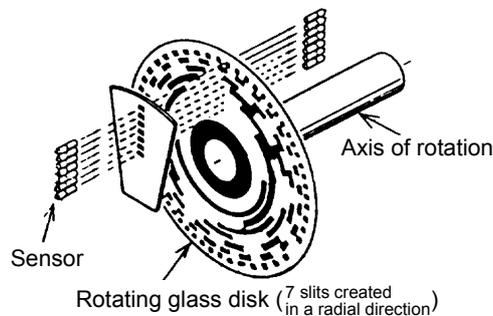
Such control methods are implemented by a control circuit configured using analog elements such as an operational amplifier.

Absolute (absolute position) detector <opposite: increment detector>

With this detector, angle data per detector rotation can be output externally, and those products capable of producing 8- to 12-bit data over 360 degrees are commonly used.

The servo motor detector is used when configuring the absolute position system in combination with the rotation amount counter to understand the position in one motor rotation.

The figure below is a general structure of an absolute position detector. In this case, a 7-bit absolute position signal is output.



Example of absolute position encoder structure

Primary delay time constant

This is the exponential time constant that shows the time until 63% of the final value is reached. (Refer to the diagram in the "Acceleration time constant" section.)

Position loop gain

Here, the response to the commands for position control are indicated. A summary position control block diagram with the speed control system as $Gv(s)$ is shown here.

Here, the position loop gain is as follows.

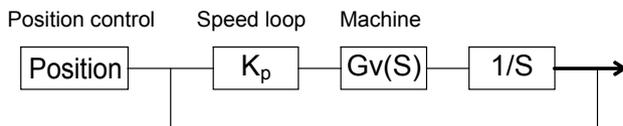
$$\text{Position loop gain} = K_p \cdot Gv(s)$$

$$= K_p (1/\text{sec})$$

The speed loop has feedback, so the gain is approximately 1.

Here, the position loop gain is expressed as a position response level:

$$K_p = \omega_{pc} (\text{rad/sec}).$$



Inertia (moment of inertia)

Refer to the section on moment of inertia.

Impact drop

For the value representing the fluctuating range of output to input commands in feedback control, when the load is changed stepwise, the temporal response characteristics are shown by the magnitude of the temporal variation as well as the duration.

It is enabled especially when integral operations are included.

Response level

The position, speed, and current loop are present in the servo system, but traceability for the respective command is shown and generally indicates the speed response level.

Auto tuning (real-time auto tuning)

The performance of the machine (especially response level and stability) that drives the servo motor is dependent on the mechanical characteristics (moment of inertia, rigidity). Therefore, adjustment operation is required to get the best machine performance, and this operation is called tuning.

Auto tuning means that the above tuning is performed automatically, and it indicates a function that automatically adjusts the speed loop gain and position loop gain, which are generally set by the servo amplifier.

Real-time auto tuning indicates a function by which tuning is performed automatically by tracking the mechanical characteristics in particular even if there is a change during operation.

All-digital control (digital control)

This method allows control by a circuit that is configured by the microcomputer and its peripheral LSI as well as logic IC.

Regenerative brake

Usually, power is supplied from amplifier to the motor when driving a load by the motor. This status is called power running. Similar to the when the motor decelerates or a decreasing load is being driven, the rotation energy of the motor and the load flows to the amplifier when decelerating the load speed. This status is called regeneration.

In a servo amplifier, regenerative energy is consumed by a capacitor and a resistor, and a regenerative brake torque is obtained. The regenerative brake torque is adjusted automatically according to the deceleration pattern, but a regenerative option is used for operations with frequent regenerative driving.

Rotation ripple

The ripple is generally slightly large due to the quick changes/variations in speed with respect to the command, and becomes small at high speeds.

Angular frequency (ω)

The number of cycles per second is expressed with Hz (hertz) as a unit to show a continuous sine wave, but here the angular frequency is expressed using an angle (radian). Frequency fHz is converted into $2\pi f$ rad/sec.

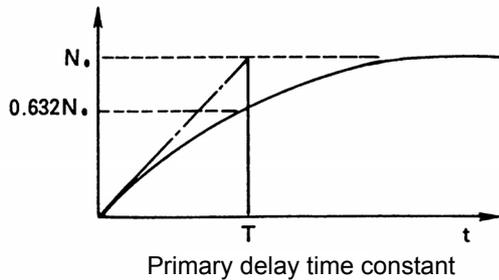
Acceleration time

The acceleration time is the time needed between the current speed and the next speed when changing the motor speed.

Acceleration time constant

The acceleration time constant is the time from the start of acceleration to the completion of acceleration when accelerating from a motor stop status to a specific speed (rated speed, speed limit for parameters, etc.)

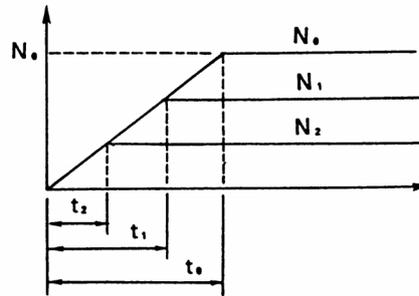
* With acceleration patterns of a primary delay function, the acceleration time constant is the time until the actual speed reaches 63.5% of the target speed.



Primary delay time constant

Acceleration pattern with a time constant of a primary delay

Acceleration time and acceleration time constant



t_0 : Acceleration time until reference speed=Acceleration time constant

t_1 : Acceleration time until speed N_1

t_2 : Acceleration time until speed N_2

Acceleration

Acceleration is the change in speed expressed as a ratio to acceleration time and becomes a slope with respect to the time of the change in speed. Also, acceleration is generally used during linear movement and is expressed by $[m/s^2]$.

Moment of inertia (inertia)

The moment of inertia is the quantity showing the rotation load of a rotating body. It is equivalent to the linear movement mass.

Definitional formula: $J=m \cdot r^2$

Here, J: Moment of inertia $[kg \cdot cm^2]$

m: Mass $[kg]$

r: Radius of rotation $[cm]$

Although GD^2 is conventionally used as the quantity for expressing the moment of inertia, the following shows the relationship with r (radius) from the above formula expressed by $2r$ (diameter):

$$GD^2=m \cdot (2r)^2=4J$$

Gain search

The gain that improves the settling characteristics can be found automatically. (Enabled only in position control mode)

While automatically changing the gain, the gain with the shortest settling time and smallest overshoot is searched for.

This works well when a high level of adjustment is required.

In addition, advance preparation before executing a gain search can be easily done with the gain search setting wizard.

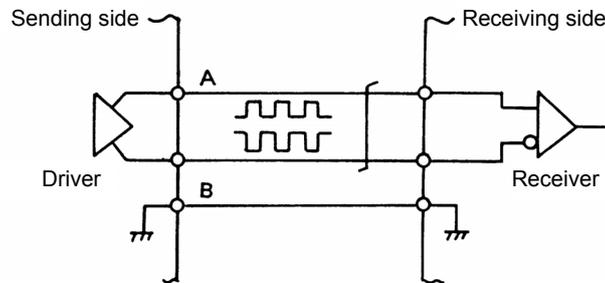
Capacitor regeneration

Capacitor regeneration is a method of performing a regenerative operation by charging the regenerative energy into the main circuit capacitor.

Because no heat is generated, repeated use is possible if the regenerative energy is smaller than the energy charged into the capacitor. However, only a small amount of energy can be charged into the capacitor, so applicability is limited to small-capacity models.

Differential transmission method

When transmitting one signal, this method is a system for transmitting the signal and the polarity reversal signal simultaneously as a pair. The receiving side has excellent noise resistance and is used for transmission of high-speed signals, including pulse train I/O signals, in order to determine the logic of signals as a set. Generally, the sending side is called a driver while the receiving side is called a receiver, and a dedicated IC is used.



Frequency response (characteristics)

This response quantitatively shows the speed response level. Showing until what frequency the motor can actually respond when the speed command is changed into sine wave as a micro speed command with roughly 10 r/min, the response is expressed by ωc [rad/sec] or f_c (Hz). It is best to make the speed loop gain high so as to increase this frequency response level. However, if it becomes too high, vibration or instability will occur more easily due to rigidity of the mechanical system.

Stroke end

The machine has a movable range (stroke), and position control is performed within this range. In addition, the machine needs to be forcibly stopped to protect it when this range is exceeded by mistake. The following two methods are available for setting the stroke end.

- (1) Install limit switches at both ends of the machine, and connect to the stroke end terminal of the positioning controller or the servo amplifier. When these limit switches are operated, the servo motor will be stopped immediately.
- (2) Set the range to the positioning controller parameters. Also called a soft limit, the range is checked when positioning starts, and the servo motor does not operate because of the occurrence of an error.

The operating range of the machine is restricted by the above machine limit (1) as well as the soft limit (2). The machine is stopped if the limit is exceeded and by starting in the opposite direction is thus freed. During the first operation, it is necessary to check the operation of the stroke end limit.

Meanwhile, with the presence of a stroke end similar to a rotary table, the machine may have disadvantages. In this case, use the stroke end terminal of the positioning controller or the servo amplifier by short-circuiting. Also, with the response from the positioning controller, there are some items for which "Not used" is set to the parameters, depending on the model, and for some items the current position must be changed by a proper position.

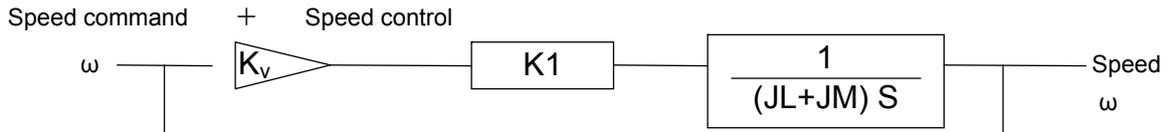
Speed variation

As a value representing the fluctuation range of the output speed for inputting commands in feedback control, the speed variation, generally based on the speed with a rated load, is the ratio of speed variation with no load or with a rated load value in the reverse direction.

Although represented earlier as an offset related to the amplification factor (gain), when integral operation is incorporated, the speed variation is often dependent on the other causes. Therefore, it is necessary to focus rather on impact drop characteristics.

Speed loop gain

The speed loop gain represents the response level for commands in the speed control. If the constant determined by the motor is set to K1, the following applies:



The reverse speed loop gain is as follows:

$$\text{Speed loop gain} = \frac{K1 \cdot Kv}{JM + JL}$$

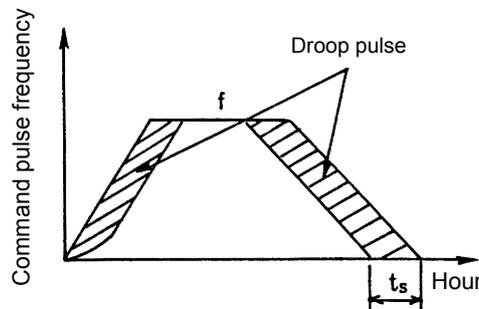
KV: Speed amplifier gain
 JL: Load inertia
 JM: Motor inertia

Dynamic brakes

This brake function is used to stop the machine quickly in case of power failure or a malfunction of the servo amplifier by obtaining a large brake torque from an electromagnetic brake. However, no holding torque during a stop is present. This function is built in to the MR-H servo amplifier. This function is not available in IM servos using an induced current electric motor.

Droop pulse

This position deviation (number of pulses) is retained inside the servo amplifier during position servo operation and is normally proportional to the pulse frequency command at low speeds. When positioning is completed, it is within ±1 pulse.



Ground fault

Ground fault refers to the status in which any of the main power supply circuit lines of the servo amplifier (P or N after diode commutation) and the power cable of a motor (U, V, W) is short-circuited to ground.

Resistance regeneration

This method obtains the braking torque by consuming regenerative energy after passing it through a resistor connected to the bus amplifier.

Stop settling time

The servo motor operates with a fixed deviation for the position command. Therefore, after completion of the commands for a stop, there is a delay until the servo motor stops.

This delay time is called the stop settling time, which is t_s time in the above droop pulse figure, and is expected to be roughly $3T_p$.

(T_p : Position loop time constant)

When reviewing the operation pattern of the servo motor, it is necessary to consider the stop settling time.

Digital control (opposite: analog control)

This control method is implemented by control circuits that are configured with digital elements. Nowadays, in response to the increasing number of mathematical operations, methods that utilize processing with software using a micro-computer and micro-processor are often used.

The advantage of the digital control method is that there are no offsets and temperature drifts, and performance is stable and repeatability is high.

Power regeneration

Power regeneration is a method for returning the regenerative energy to the power supply side through the bus amplifier. A dedicated module is required for return to the power supply side, but compared with the resistance regeneration method, power regeneration has the advantage of less heat generation and reduced installation dimensions as well as a larger amount of regenerative energy. For these reasons, power regeneration is mainly used in continuous regenerative operations such as for large-capacity models and elevated axes.

Electronic gear

The electronic gear changes the ratio of feedback pulses to command pulses. However, position resolution does not change because it is determined by the encoder. The changed ratio can be set to a fraction depending on the parameters.

Unlike with a mechanical gear, the torque of the motor does not increase even if the reduction ratio is increased.

Electromagnetic brake

Electromagnetic brakes equipped in motors with electromagnetic brakes are non-exciting operation-type brakes used either for preventing dropping in case of a power failure or a malfunction of the servo amplifier due to vertical axis drive, or as protection during a stop.

Torque linearity

The torque linearity shows the relationship with the torque generated by the motor in response to the torque command. Especially when using for torque control, there is a dead band near zero torque. Also, the magnetic energy of the magnet used in the motor changes according to the temperature. As a result, the torque linearity is also affected. For ferrite magnets it is $-0.2/^{\circ}\text{C}$, and for rare-earth magnets it is $-0.33/^{\circ}\text{C}$.

Backlash compensation

There is an essentially dead band (clearance) in the mechanical system. This dead band is called the backlash. If backlash is present, that part of the machine will not operate even if the servo motor rotates. Therefore, an error occurs in the part with the backlash in the current position of the positioning controller and the position of the machine. However, this error is not cumulative.

The following backlash compensation function is used to compensate this error.

If the backlash amount is set to the parameters of the positioning controller, an extra pulse train signal equivalent to the part having the backlash is output only when the rotation direction of the servo motor is changed. The motor will rotate at this time, but the machine will not move. In addition, the positioning controller will not count this pulse train signal as the current position.

In this way, the position of the machine and the current position of the positioning controller are matched, and the error due to the backlash will be corrected.

(1) Backlash compensation is effective after executing the home position return.

(2) When backlash settings have changed, a home position return must always be executed.

Power rate

The power rate represents the speed when the motor accelerates itself by increasing the output that can be issued by the motor with a constant-torque motor. This rate is defined as follows.

$$Q = \frac{T_R^2}{J_M} \times 10 \quad [\text{kW/s}]$$

T_R : Motor output torque [N·m]
 J_M : Moment of inertia of motor [kg·cm²]

Proportional control

Proportional control is also called P control. The manipulated value Y is proportional to the deviation value ε; thus it is expressed by $Y = \epsilon K_p$. If a mechanically locked motor becomes stuck even for 1 pulse after positioning completion, a large current passes through the motor and tries to compensate for the position mismatch. To avoid this, if proportional control is performed simultaneously with positioning completion, the torque gain decreases and the current is suppressed. Also, it is possible to suppress vibration during servo-lock using proportional control. In this proportional control, the operation takes place immediately to prevent deviation with an unexpected disturbance. However, it is not possible to completely reduce deviation for continuous disturbances. This is because the control system continues to operate in a corrective manner with a continuous disturbance. Therefore, deviation is required to a certain extent.

Feedback control

Feedback control is considered the control that detects the difference between the command and the actual speed using a closed loop, and then the command value is corrected in order to reduce this difference.

Feed forward control

Feed forward control refers to control that sends a speed command before a droop pulse increase when the pulse command is input during position loop control.

Bus voltage

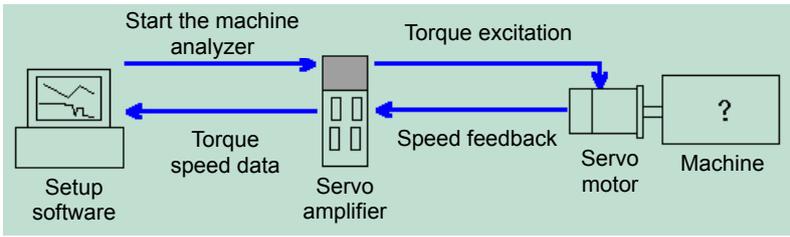
Voltage that is rectified by a power converter, once converted into DC, is again converted into AC by the inverter, and drives the AC motor. The voltage of the DC portion is called bus voltage.

Machine analyzer

The servo amplifier vibrates the servo motor for approximately 0.1 to 2 seconds at a random torque, and the speed is measured at that time. Then, MR Configurator2 analyzes the reading of the torque and speed data from the servo amplifier.

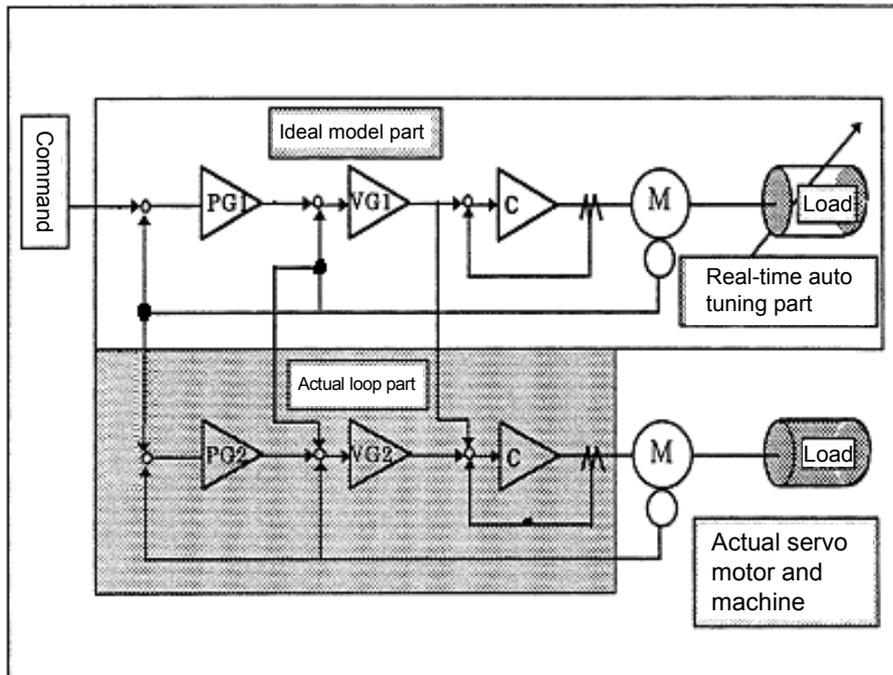
As a result, the response frequency characteristics of the speed for the motor torque of a machine can be measured.

By looking at these characteristics, it is possible to understand at what frequency the mechanical system has a resonance point, which allows setting of the machine vibration suppression filter to be performed easily.



Model adaptive control and real-time auto tuning

Model adaptive control is Mitsubishi's independent control logic developed on the basis of current control theory. With this control, the model loop and actual loop gain are automatically set on the basis of the load inertia obtained by real-time auto tuning, and the settings for machine stability with an increased response to commands can be configured.



Explanation

As shown in the above figure, the model adaptive control within the control logic consists of three parts.

- (1) Ideal model part
- (2) Real-time auto tuning part
- (3) Actual loop part (disturbance suppression part)

The ideal model part adjusts the most appropriate gain for the inertia estimated through real-time auto tuning. Because there is no machine disturbance or backlash, each gain shows good characteristics even with fast responses. Model side position loop gain (PG1) is used in the calculation of droop pulses or the stop settling time. Real-time auto tuning calculates the inertia of load from the current and the time during acceleration/deceleration. This is extremely effective in machines in which the inertia changes greatly, such as transportation machines. Manual setting is also possible in machines where real time auto tuning is not possible (when the unbalance is large in the vertical axis, when the load inertia exceeds the permissible value, when the droop pulse of interpolation operation is to be kept constant).

The actual loop part (disturbance control unit) is designed based on conventional PI control, and when an error occurs in the model speed created in the ideal model part and actual motor speed due to the disturbance torque, a torque command is sent from the actual loop side in order to follow the model speed from the actual loop part.

Although a high gain is set for imparting the disturbance suppression effect, vibrations occur if it is too high.

The value of this gain is also adjusted to the appropriate level with respect to the inertia ratio.

The appropriate gain value of the model part and the actual loop part is set on the basis of the set real time auto tuning response setting value. Therefore, when the response is to be raised, the response setting value must be reviewed.

Because the model adaptive control is configured as mentioned above, easily responding to complex machine adjustments is possible, a feat which was not possible with the conventional method and in extreme frequency applications.

RISC

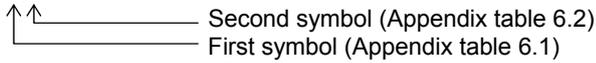
RISC is the abbreviation of "Reduced Instruction Set Computer" and is a new type of computer wherein commands and the command format are simplified compared to conventional micro-processors (called CISC in regard to RISC). Because of this, it is possible to increase the processing speed, which means execution of enormous operation processing, such as model adaptive control of a servo in real time, is possible.

Appendix 5. Protection Model of Motor

(1) Classification according to JIS

For the symbols of the protection model of the electric motor, arrange the symbols in Appendix table 6.1 as the first symbols and those in Appendix table 6.2 as the second symbols after JP.

Example: JP 4 4



Note: Insert W between JP and the first symbol for outdoor use, E for explosion-proof types, and C for protection against other forms of harmful air. Example JPW44: E and C are not 1EC standards.

Appendix table 6.1 Protection models for humans and solid foreign matter (first symbol)

Model	Symbol	Description
Non-protection type	0	A structure in which special protection is not provided against contact with the human body or invasion of solid foreign matter.
Half-protection type	1	A structure in which a large part of a human body, for example, a hand, is prevented from accidentally touching the rotating part or the guidance section inside the machine.
Protection type	2	A structure that prevents invasion of solid foreign matter exceeding a diameter of 50 mm. A structure that prevents fingers from touching the rotating part or the conductive part inside the machine. A structure that prevents invasion of solid foreign matter exceeding a diameter of 12 mm.
Totally enclosed type	4	A structure in which tools or wires with a minimum width and minimum thickness more than 1 mm are prevented from touching the rotating part or the dielectric part inside the machine. A structure that prevents invasion of solid foreign matter exceeding a diameter of 1 mm. However, intakes and exhausts of drainage holes and cooling fans are better if the structure of symbol 2 is used.
Dust-proof type	5	A structure that prevents any matter from touching the rotating part or the dielectric part inside the machine. A structure that prevents the invasion of dust as much as possible and assists normal operation without trouble even if there is any invasion.

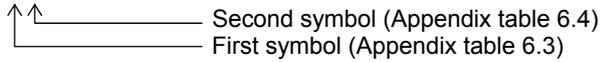
Appendix table 6.2 Protection model for intrusion of water (second symbol)

Model	Symbol	Description
Non-protection type	0	A structure with no special protection against the intrusion of water.
Drip-proof type	2	A structure in which a drop of water dropped in a vertical direction within 15° has no harmful effects.
Rain-proof type	3	A structure in which a drop of water dropped in a vertical direction within 60° has no harmful effects.
Splash-proof type	4	A structure in which a drop of water from any direction has no harmful effects.
Jet-proof type	5	A structure in which a jet flow from any direction has no harmful effects.
Breakwater wave type	6	A structure in which a strong jet flow from any direction has no harmful effects.
Dust-proof type	7	A structure in which being drenched or immersed in water for a specified time has no harmful effects even if there is water intrusion.
Submersible type	8	A structure that operates normally under water.

(2) Classification according to IEC

For protection models of electric motors, arrange the symbols in Appendix table 6.3 as the first symbols and those in Appendix table 6.4 as the second symbol after IP.

Example: IP 6 5



Appendix table 6.3 Degrees of protection for invasion of solid foreign matter (first symbol)

Model	Symbol	Description
Unprotected	0	Unprotected
Diameter \geq 50 mm	1	Protects from invasion of solid foreign matter as small as 50 mm, for example, a hand.
Diameter \geq 12.5 mm	2	Protects from invasion of solid foreign matter as small as 12 mm, for example, a finger.
Diameter \geq 2.5 mm	3	Protects from invasion of solid foreign matter having a diameter of 2.5 mm or more, for example, the tip of a tool or a wire.
Diameter \geq 1.0 mm	4	Protects from invasion of solid foreign matter having a diameter of 1.0 mm or more, for example, a wire or flake.
Dust-proof type	5	Protects from dust. No invasion of dust will disturb normal operation.
Dust-resistant type	6	Safe dustproof structure. Invasion of dust is impossible.

Appendix table 6.4 Degrees of protection for intrusion of water (second symbols)

Model	Symbol	Description
Unprotected	0	Unprotected
Vertical drop	1	Protects from a drop of water dropped vertically, for example, condensation.
Drop (15 degrees deviation)	2	Protects from a drop of water in a range of 15 degrees from vertical.
Sprinkles	3	Protects from spray in a range of 60 degrees from vertical.
Splashes	4	Protects against water droplets from all directions.
Jet	5	Protects against strong jets of water from all directions.
Powerful jet	6	Protects against strong jets of water, such as waves. No intrusion of water will disturb normal operation.
Temporary submersion	7	Even if submerged between 150 mm and 1 m, there is no intrusion of water that will disturb normal operation.
Continuous submersion	8	Underwater usage is possible. Can be used for a long period of time under water.

Appendix 6. QD75D1N Setting Values (Training Machine)

(1) Parameter (Axis 1)

	Item	Setting value	Remarks
Basic parameter 1	Unit setting	0	mm
	Number of pulses per rotation	1 pulse	
	Travel distance per 1 revolution	10.0 μm	
	Unit scaling	1	$\times 1$
	Pulse output mode	1	CW/CCW mode
	Rotation direction setting	0	Current value increment with forward rotation pulse output
	Bias speed at start	0.00 mm/min	
Basic parameter 2	Speed limit value	600000.00 mm/min	
	Acceleration time 0	100 ms	
	Deceleration time 0	100 ms	
Detailed parameter 1	Backlash compensation	0.0 μm	
	Software stroke limit upper limit value	214748364.7 μm	
	Software stroke limit upper lower value	-214748364.8 μm	
	Software stroke limit selection	0	Multiply current feed value by software limit
	Software stroke limit enable/disable setting	1	Disabled
	Command in-position range	100.0 μm	
	Torque limit setting value	300 %	
	M code ON signal output timing	0	WITH mode
	Speed switchover mode	0	Standard speed switchover mode
	Interpolation speed specification method	0	Composite speed
	Current feed value at speed control	0	Does not replace the current feed value
	Lower limit	1	Positive logic
	Upper limit	1	Positive logic
	Drive unit ready	0	Negative logic
	Stop signal	0	Negative logic
	External command	0	Negative logic
	Zero-point signal	0	Negative logic
	Proximity signal	0	Negative logic
	Manual pulse generator input	0	Negative logic
	Command pulse signal	0	Negative logic
Deviation counter clear	0	Negative logic	
Manual pulse generator input selection	0	Phase A and B mode	
Speed/position function selection	0	Speed/position switching control (INC mode)	

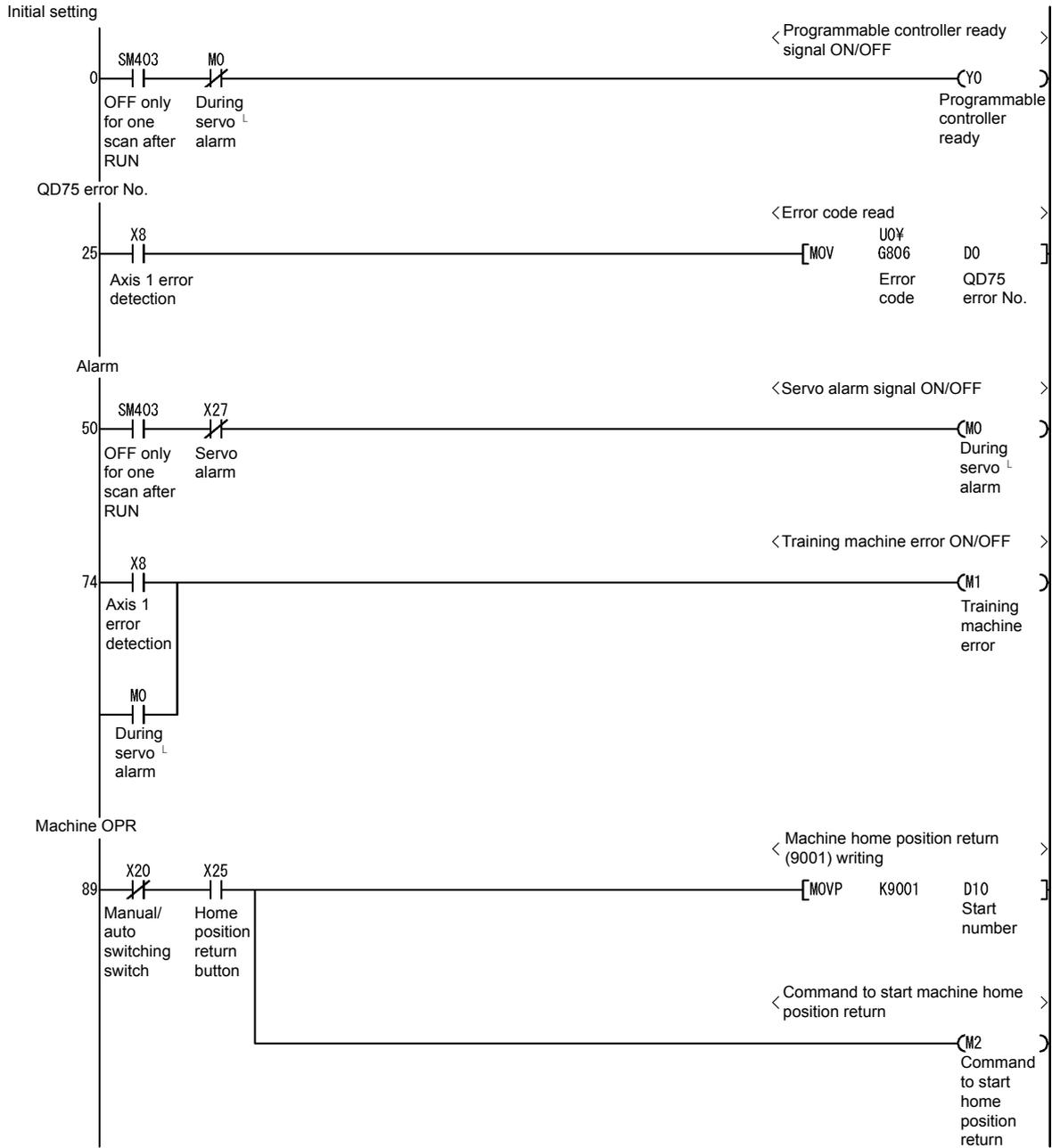
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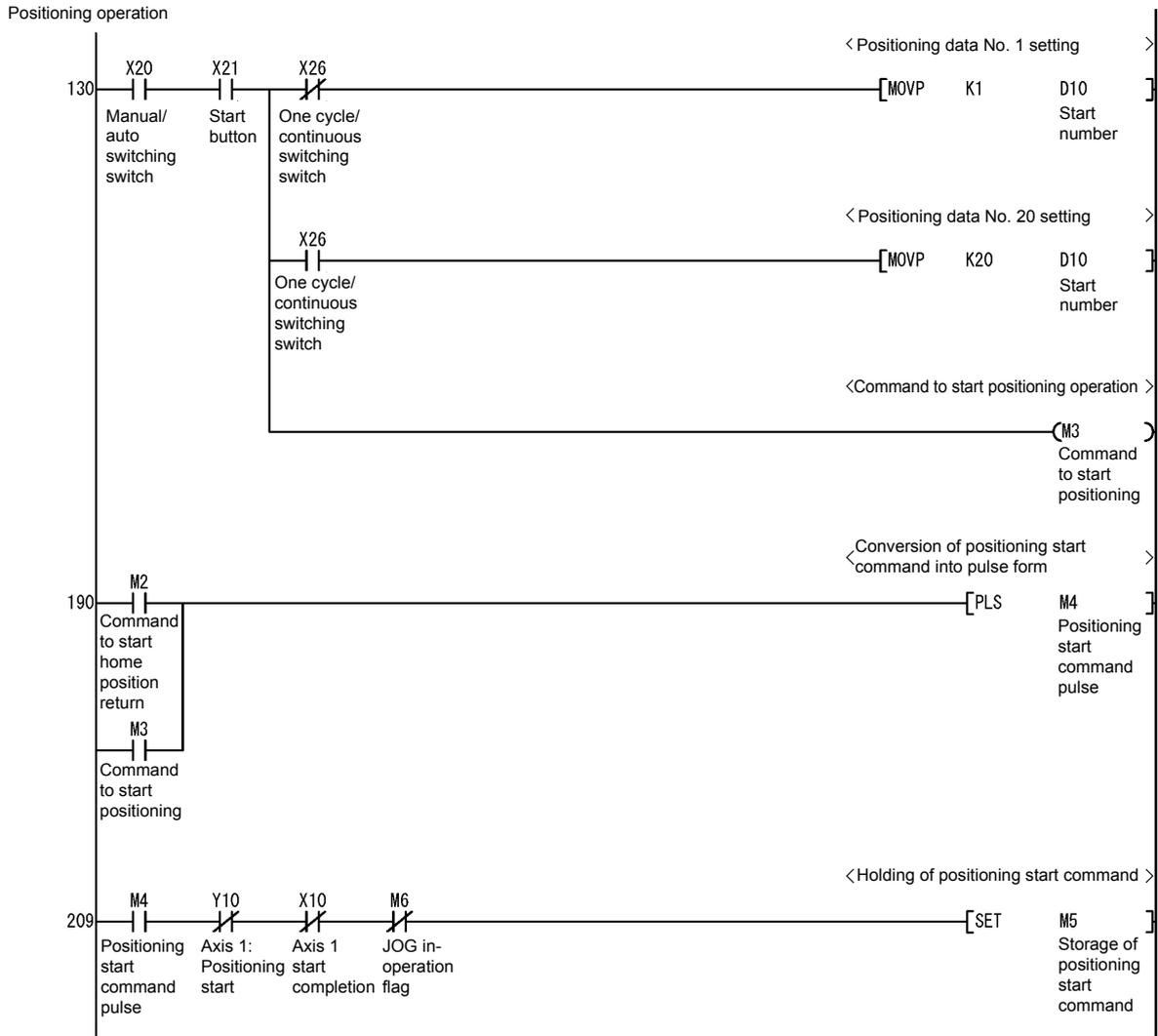
	Item	Setting value	Remarks
Detailed parameter 2	Acceleration time 1	10 ms	
	Acceleration time 2	50 ms	
	Acceleration time 3	1000 ms	
	Deceleration time 1	10 ms	
	Deceleration time 2	50 ms	
	Deceleration time 3	1000 ms	
	JOG speed limit value	600000.00 mm/min	
	JOG operation acceleration time selection	0	100
	JOG operation deceleration time selection	0	100
	Acceleration/deceleration processing selection	0	Trapezoid acceleration/deceleration processing
	S-curve ratio	100 %	
	Sudden stop deceleration time	1000 ms	
	Stop group 1 sudden stop selection	0	Normal deceleration stop
	Stop group 2 sudden stop selection	0	Normal deceleration stop
	Stop group 3 sudden stop selection	0	Normal deceleration stop
	In-position signal output time	300 ms	
	Circular interpolation permissible error range	10.0 μm	
	External command function selection	0	External positioning start
Home position return basic parameter	Home position return method	0	Near-point dog signal method
	Home position return direction	1	Negative direction (address decreasing direction)
	Home position address	0.0 μm	
	Home position return speed	5000.00 mm/min	
	Creep speed	1000.00 mm/min	
	Home position return retry	1	Retry home position return with limit switch
Home position return detailed parameter	Home position return dwell time	0 ms	
	Travel distance after proximity dog signal turned on	0.0 μm	
	Home position return acceleration time selection	3	1000
	Home position return deceleration time selection	3	1000
	Home position shift distance	0.0 μm	
	Home position return torque limit value	300%	
	Deviation counter clear signal output time	11 ms	
	Speed specification at home position shift time	0	Home position return speed
Dwell time at home position return retry	0 ms		

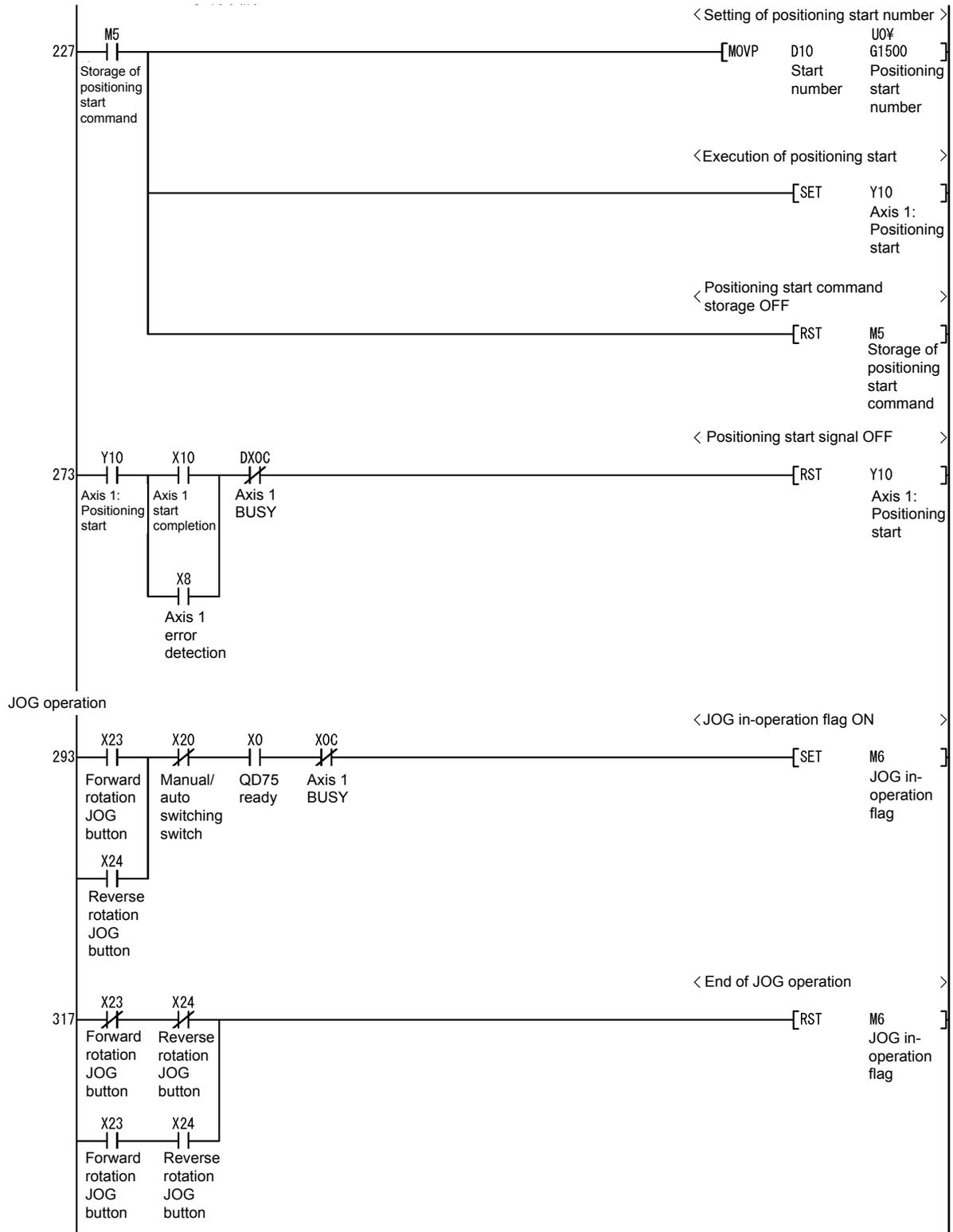
(2) Positioning data (Axis 1)

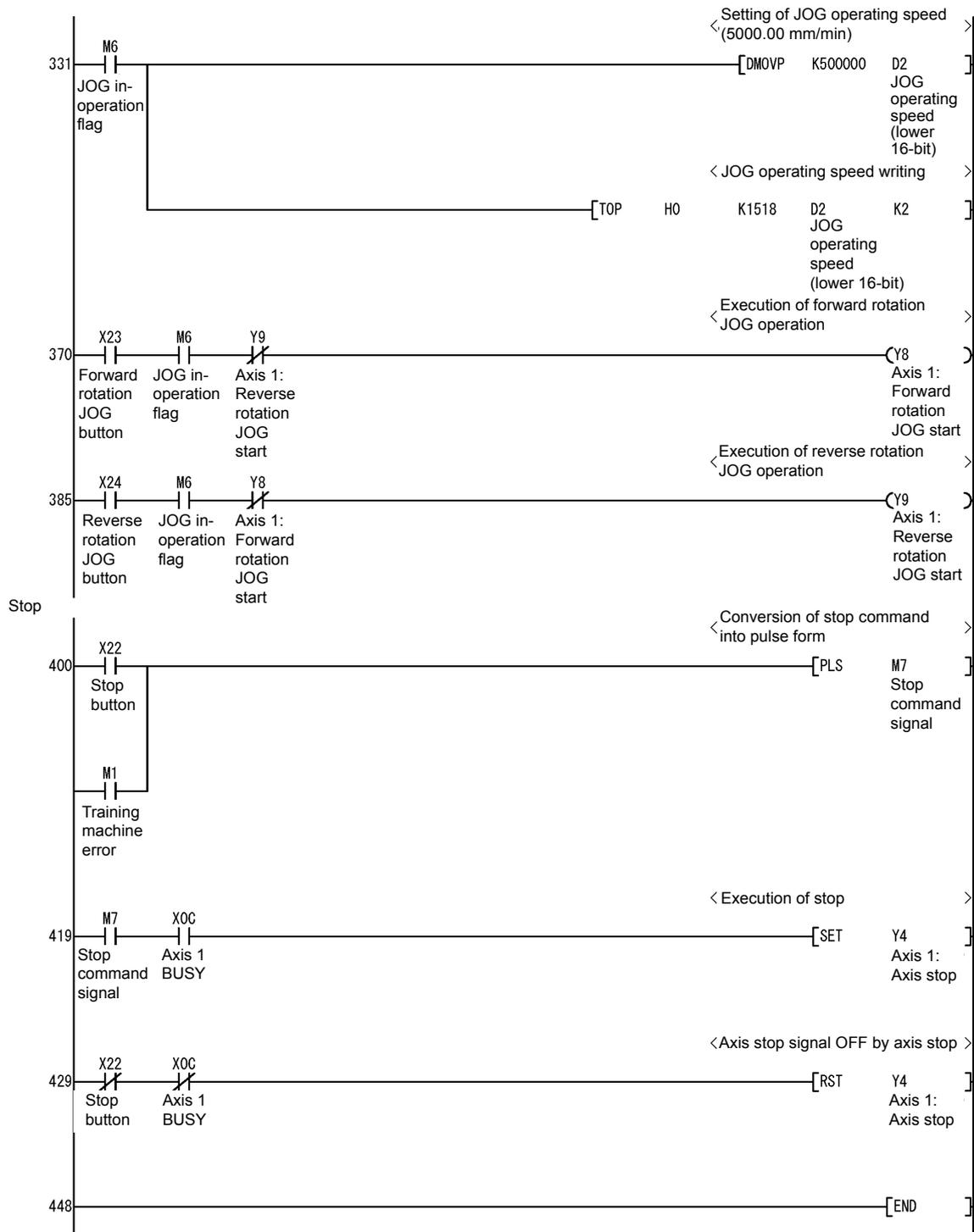
Data No.	Operation pattern	Control method	Acceleration time	Deceleration time	Interpolation target axis	Positioning address	Command speed	Dwell time	M code
1	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-50000.0	50000.00	500	0
2	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	50000.0	50000.00	500	0
3	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-100000.0	100000.00	500	0
4	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	50000.0	50000.00	500	0
5	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-100000.0	100000.00	500	3
6	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	50000.0	50000.00	500	0
7	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-50000.0	50000.00	500	0
8	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	150000.0	200000.00	500	0
9	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-75000.0	100000.00	500	0
10	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-75000.0	1000.00	1000	0
11	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	75000.0	100000.00	500	0
12	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	75000.0	1000.00	1000	0
13	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-150000.0	200000.00	1000	0
14	0: Exit	02: INC linear 1	0: 100 ms	0: 100 ms	-	150000.0	200000.00	2000	0
15									
16									
17									
18									
19									
20	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	0.0	1000.00	0	0
21	0: Exit	83: LOOP	0: 100 ms	0: 100 ms	-	0.0	0.00	0	65535
22	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-50000.0	50000.00	500	0
23	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	50000.0	50000.00	500	0
24	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-100000.0	100000.00	500	0
25	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	50000.0	50000.00	500	0
26	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-100000.0	100000.00	500	3
27	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	50000.0	50000.00	500	0
28	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-50000.0	50000.00	500	0
29	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	150000.0	200000.00	500	0
30	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-75000.0	100000.00	500	0
31	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-75000.0	1000.00	1000	0
32	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	75000.0	100000.00	500	0
33	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	75000.0	1000.00	1000	0
34	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-150000.0	200000.00	1000	0
35	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	150000.0	200000.00	2000	0
36	0: Exit	84: LEND	0: 100 ms	0: 100 ms	-	0.0	0.00	0	0
37	0: Exit	02: INC linear 1	0: 100 ms	0: 100 ms	-	0.0	1000.00	0	0

(3) Sequence program









Memo

AC Servo School Text
AC Servo Practice Course (MELSERVO-J4)

MODEL	
MODEL CODE	
SH-030146ENG-A (1509) MEE	



HEAD OFFICE : TOKYO BUILDING, 2-7-3 MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN
NAGOYA WORKS : 1-14, YADA-MINAMI 5-CHOME, HIGASHI-KU, NAGOYA, JAPAN

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Specifications subject to change without notice.