MITSUBISHI ELECTRIC
Changes for the Better

for a greener tomorrow

FATEC

AC Servo School Text
AC Servo Maintenance 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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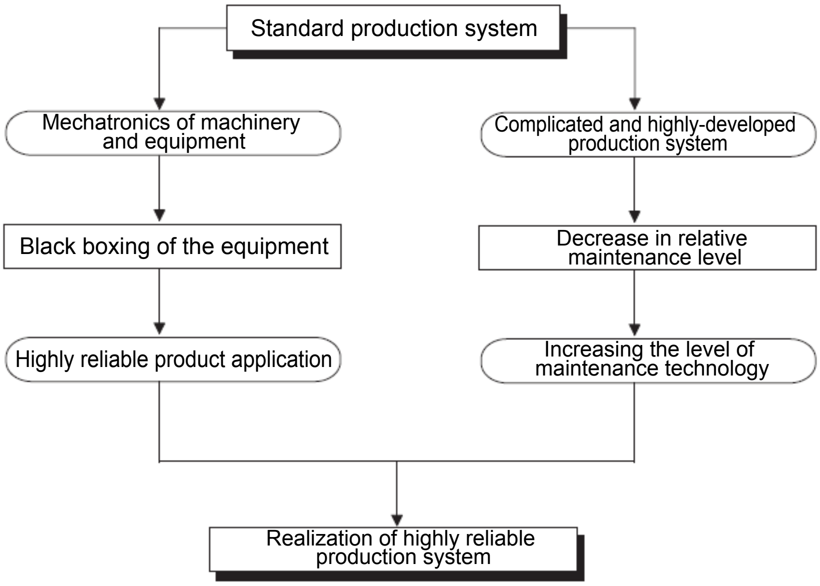
Memo

1. Importance of Production Maintenance

If the production system stops due to a malfunction or power failure, a loss proportional to the stop time occurs.
Therefore, it is necessary to design the equipment system so as to prevent [Stopping due to malfunction] or [Stopping due to power failure].
Even if the production system stops, the important issue is how the system will be quickly restored.
Therefore, organization with maintenance staff is established in each factory to improve the operation rate of the production system.

1.1 Importance of Maintenance

The latest production systems are advancing in terms of machinery mechatronics and system complexity, as well as the black-boxing of remarkably sophisticated equipment. As such, the relative maintenance level is decreasing and it is becoming difficult to improve the availability of the system. Therefore, "highly reliable products" and an "increased level of maintenance technology" are strongly required.



1.2 Maintenance System

In order to achieve a highly reliable production system, it is important to have an established maintenance system in place.
The following shows an outline of a maintenance system.

- **Production maintenance**
  - **Maintenance countermeasure design**: When developing new machinery, give due consideration to maintenance countermeasures at the designing stage.
  - **Preventive maintenance**: Preventive maintenance of the machinery is carried out if the machinery is prone to financial losses or serious disasters due to failures or accidents, and if it is beneficial to carry out preventive maintenance of such machinery. Also perform maintenance actions for predictable failures and accidents before such incidents occur.
    - **Daily maintenance and inspection**: Perform daily inspection to detect any dangerous conditions that may cause breakdown of the production system due to failure or any detrimental decrease in performance.
    - **Periodic maintenance and inspection**: Perform regular inspection to detect any dangerous conditions that may cause breakdown of the production system due to failure or any detrimental decrease in performance.
    - **Condition-based maintenance**: Monitor the status to detect any dangerous conditions that may cause breakdown of the production system due to failure or any detrimental decrease in performance.
  - **Corrective maintenance**: Corrective maintenance is carried out when it is easier to repair equipment after it has broken down (such as digital displays, CRTs, all types of lamps) due to accidents.
  - **Maintenance for improvement**: This maintenance is carried out to minimize degradation of installed machinery and to simplify the inspection process.

1.3 Maintenance Plan

In production systems, the recovery time can be long, and improvements in system availability cannot be expected if repairs are considered only after a malfunction occurs.
Therefore, a maintenance plan is developed from when a production system is implemented, and efficient maintenance is conducted.
In order to quickly restore the system after a malfunction occurs, it is necessary to systematically execute the contents of the following table.

Table 1.1 Daily and periodic inspection

Plan item	Description	
Maintenance training	Information about AC Servo	• Fundamental knowledge of principle, function, performance, etc., of AC servo • Characteristics of AC servo • Location of AC servo • Introductory status of AC servo (Usages in own department, etc.) • Description of installed (introduced) machine type (type, function, performance, characteristics, etc., of AC servo used)
	Maintenance scope & maintenance technology	• Knowledge about maintenance of AC servo (Characteristics of AC servo from maintenance perspective, maintenance items of AC servo) • Precautions for maintenance of AC servo (Handling method, key points of maintenance, etc.)
	Training	• Functions related to maintenance of AC servo • Functions related to maintenance of peripheral equipment (Troubleshooting function, etc.) • Practical training for troubleshooting (Operation of peripheral equipment, replacement of hardware)
Maintenance time	Specify the target type, etc., of preventive maintenance and corrective maintenance, and determine the implementation timing.	
Maintenance equipment	Spare parts, components, measuring instruments, measurement equipment, etc., for maintenance	
Maintenance procedure	Prepare the manuals, etc., and clearly define the implementation method and a description.	
Maintenance staff	Determine the staff procurement, positions, assigned areas, etc.	
Maintenance method improvement	Study to improve the maintenance methods, etc.	
Understanding AC servo manufacturer service and support system	After service	• Service base (location, address, person in charge, etc.) • Service area (target, handling area, etc.) • Service time (Start/end time, turnaround time, emergencies, etc.) • Service period (free service period, handling at the time of paid service, etc.) • Spare parts supply period (repair after discontinuing production, supply period, etc.) • Measures against discontinued production (contents of discontinuance declaration, repair period, etc.) • Time required for repair (standard delivery, shortest/longest deliveries)
	Technical support	• Support base (location, address, person in charge, etc.) • Support area (Target equipment type, hardware/software, system) • Support method (telephone, FAX, visit, school, actual machine operation) • Manual (manual effective for maintenance)

1.4 Management of Maintenance Documents

In order to quickly restore after a malfunction occurs, it is necessary to organize and manage the documents described in the following table.

Table 1.2 Maintenance-related documents to manage

Plan item	Document name	Description
System-specific documents	System and control specifications documents	Documents describing the functions and operations of a target system and control (Sequence and timing of operation, operation condition, and operation procedure)
	Electrical wiring diagrams	Schematic diagrams (Power supply circuit, motor circuit, control circuit, operating circuit, display circuit, etc.) Connection diagrams between equipment and panel (cable layout diagram, grounding wire layout diagram)
	Equipment layout diagrams	Layout diagrams for electrical equipment in the panel, terminal block line number layout drawings, connection assignment tables for connector pins (For identifying models and line numbers for each equipment)
	Lists of hardware used	Lists of electrical equipment used in the system (Model names and specifications of all the electrical equipment including the modules constituting the AC servo system, peripheral equipment, electrical components in the cabinet, I/O equipments, software packages, etc.)
	Controlled system installation guides/maintenance and inspection instructions	For handling (operation), maintenance, and inspection of controlled systems
General documents	Catalogs of hardware used	Identifies configuration and manufacturer of equipment models
	Instruction manuals of hardware used	For troubleshooting hardware and software

1.5 Maintenance Record

After recovery following a malfunction, it is necessary to manage the maintenance record as follows for future reference.

Table 1.3 Maintenance record to manage

Record item	Description
Occurrence status of failure, malfunction	Name of device/equipment, phenomenon, environment
System stop time	Time of occurrence, stop time
Impact due to occurrence	Amount of loss, loss time, other impacts
Cause	Method of cause investigation, cause including presumption
Recovery method	Recovery methods such as replacement, repairs
Measures against re-occurrence	Prevention methods against re-occurrence of similar malfunctions, and lessons learned
Failure record	Record of source of failure, countermeasures, etc.
Name of person in charge	

1.6 Malfunction Modes

In general, the malfunction modes in a complicated system can be classified in three levels of initial malfunctions, random malfunctions, and wear-out malfunctions, as shown in Figure 1.1. An initial malfunction is considered a malfunction that is removed during the manufacturing process or through inspection by the manufacturer. A random malfunction is an unexpected malfunction that cannot be anticipated and can occur anytime before the wear-out progresses during the life of the equipment. It is difficult to take technical measures against random malfunctions, and at this point, only measures based on statistical handling can be implemented.

A wear-out malfunction occurs near the end of the usable life as a result of deterioration or abrasion, and increase rapidly over time. The number of years before replacement is indicated by point tb in Figure 1.1, at which point preventive maintenance is achieved by replacing specific parts with new parts.

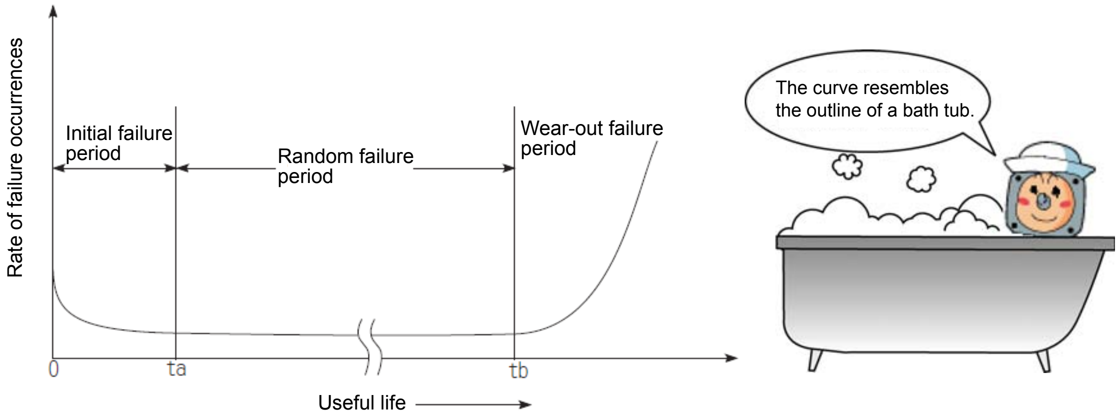
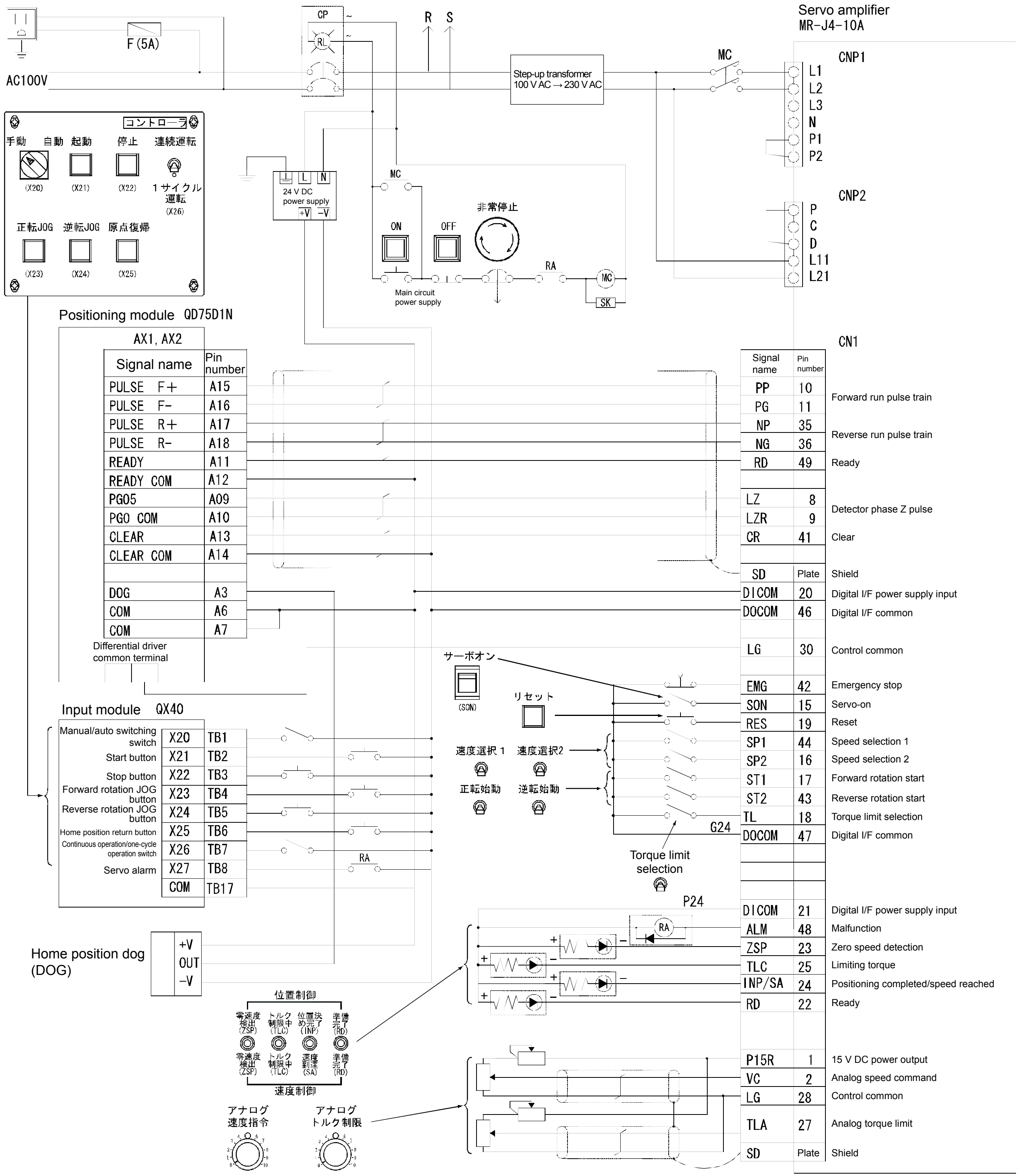
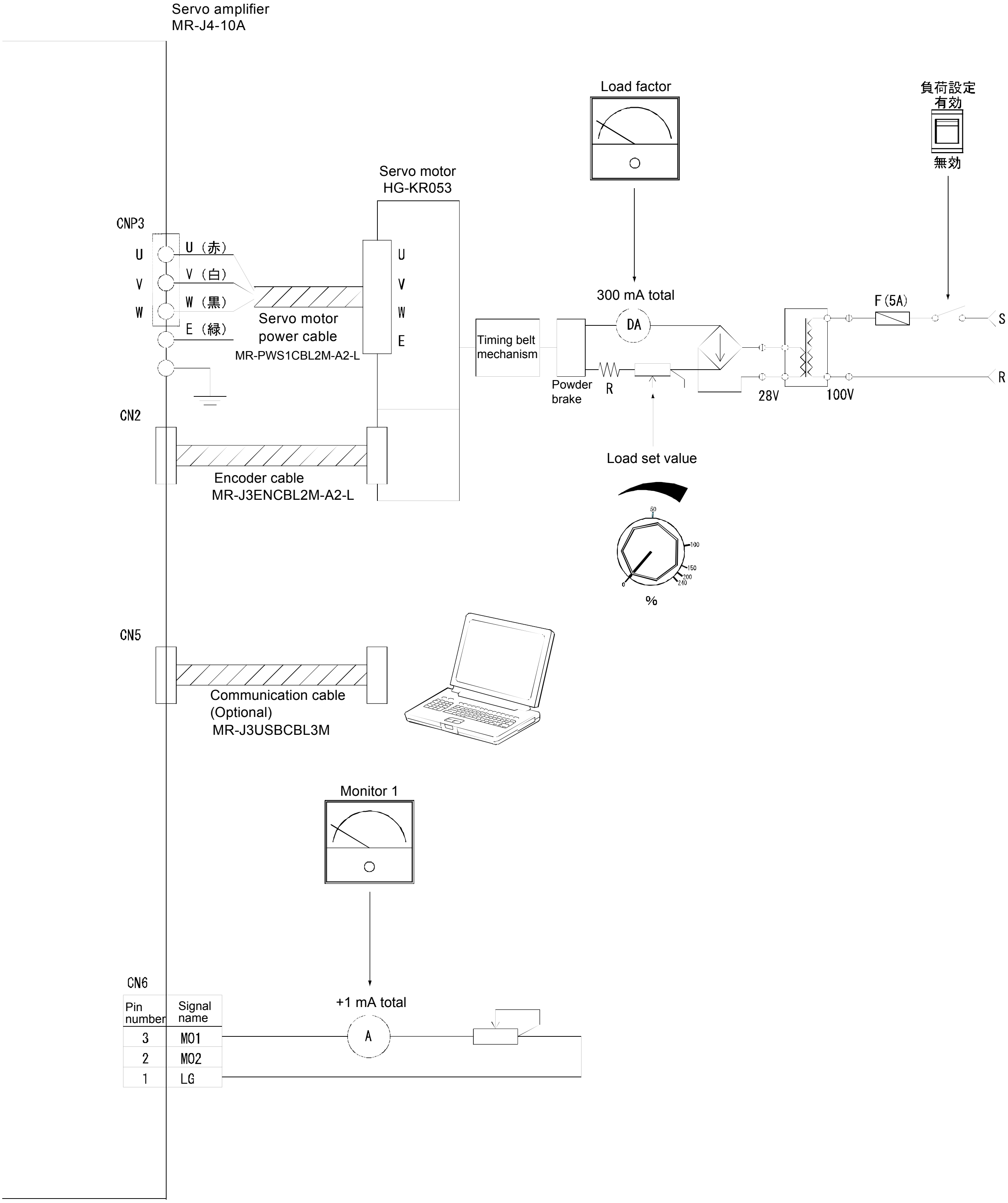


Figure 1.1 Bath tub curve

2.1 Configuration of Training Machine

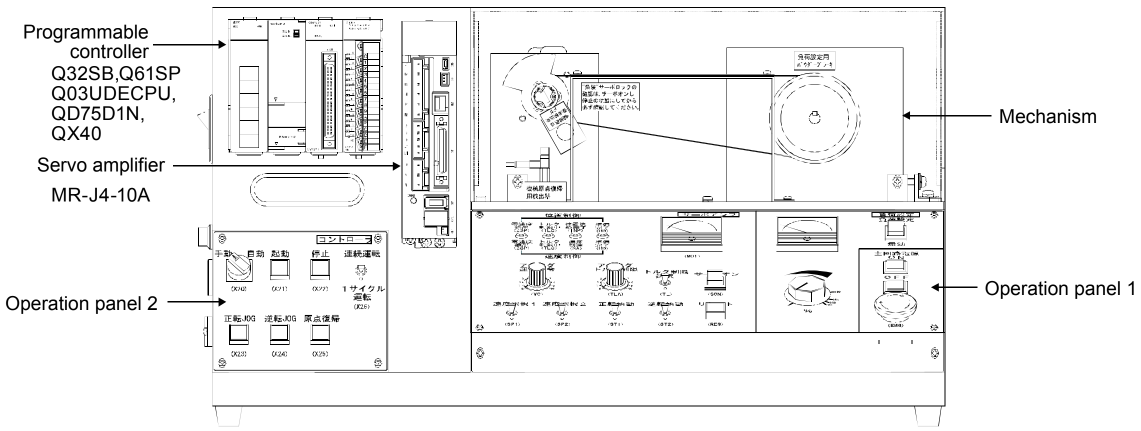


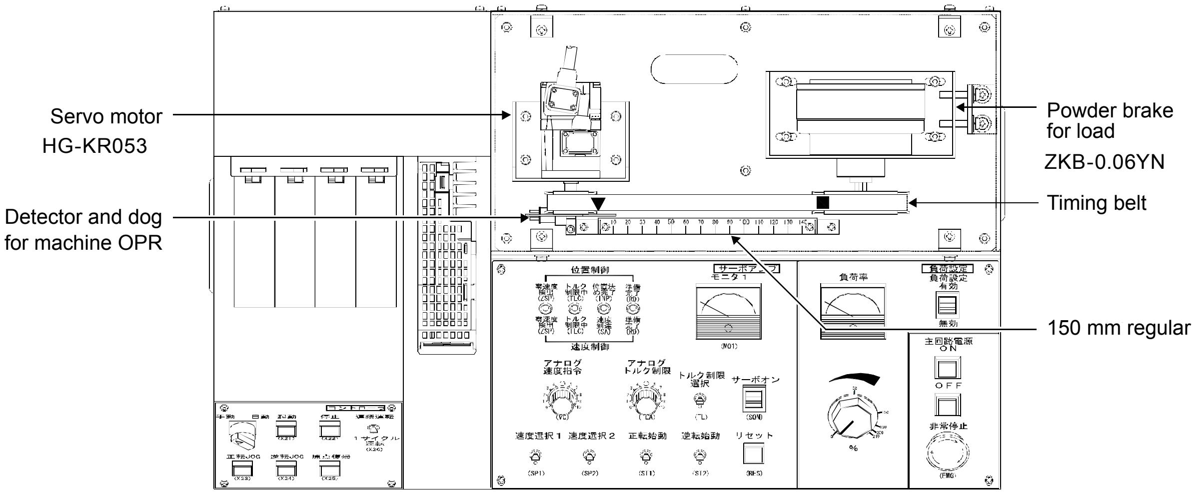


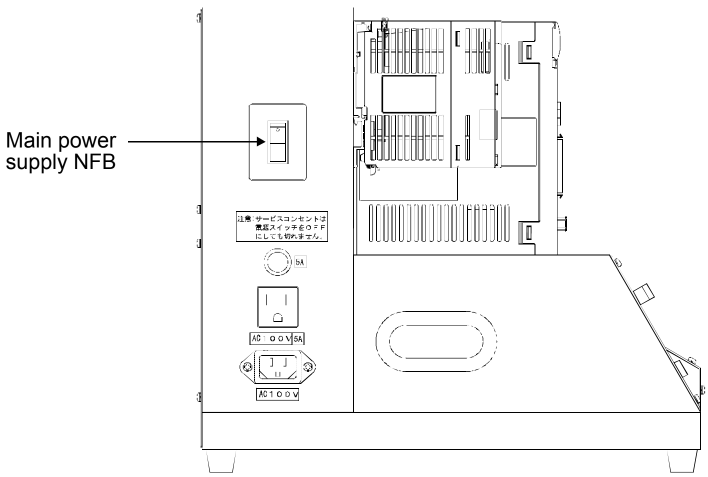
Servo amplifier
MR-J4-10A
Load factor
負荷設定
有効
無効
Servo motor
HG-KR053
CNP3
U
V
W
U（赤）
V（白）
W（黒）
E（緑）
Servo motor
power cable
MR-PWS1CBL2M-A2-L
U
V
W
E
300 mA total
DA
F(5A)
S
R
Timing belt
mechanism
Powder
brake
R
28V
100V
CN2
Load set value
Encoder cable
MR-J3ENCBL2M-A2-L
%
CN5
Communication cable
(Optional)
MR-J3USBCBL3M
Monitor 1
CN6
Pin number
Signal name
3
MO1
2
MO2
1
LG
+1 mA total
A

2.2 External Appearance and Name of Training Machine

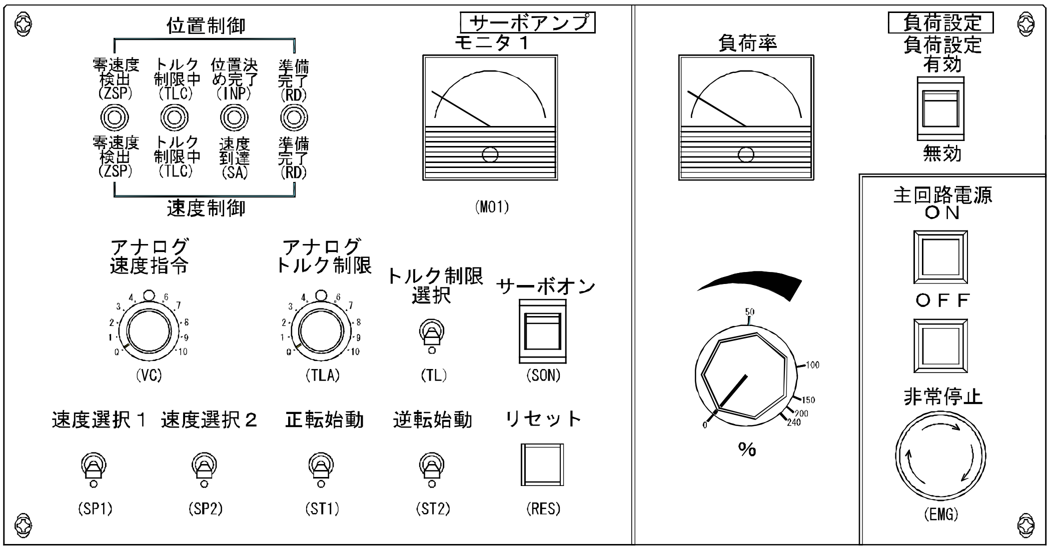
2.2.1 External Appearance/Configuration of Training Machine



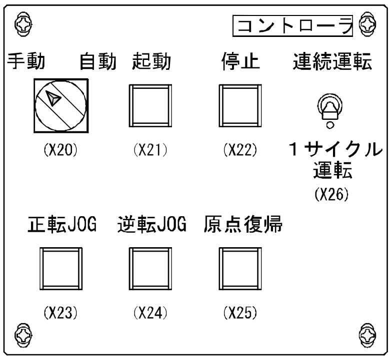




2.2.2 Configuration of Input/Output Operation Panel



Operation panel 1

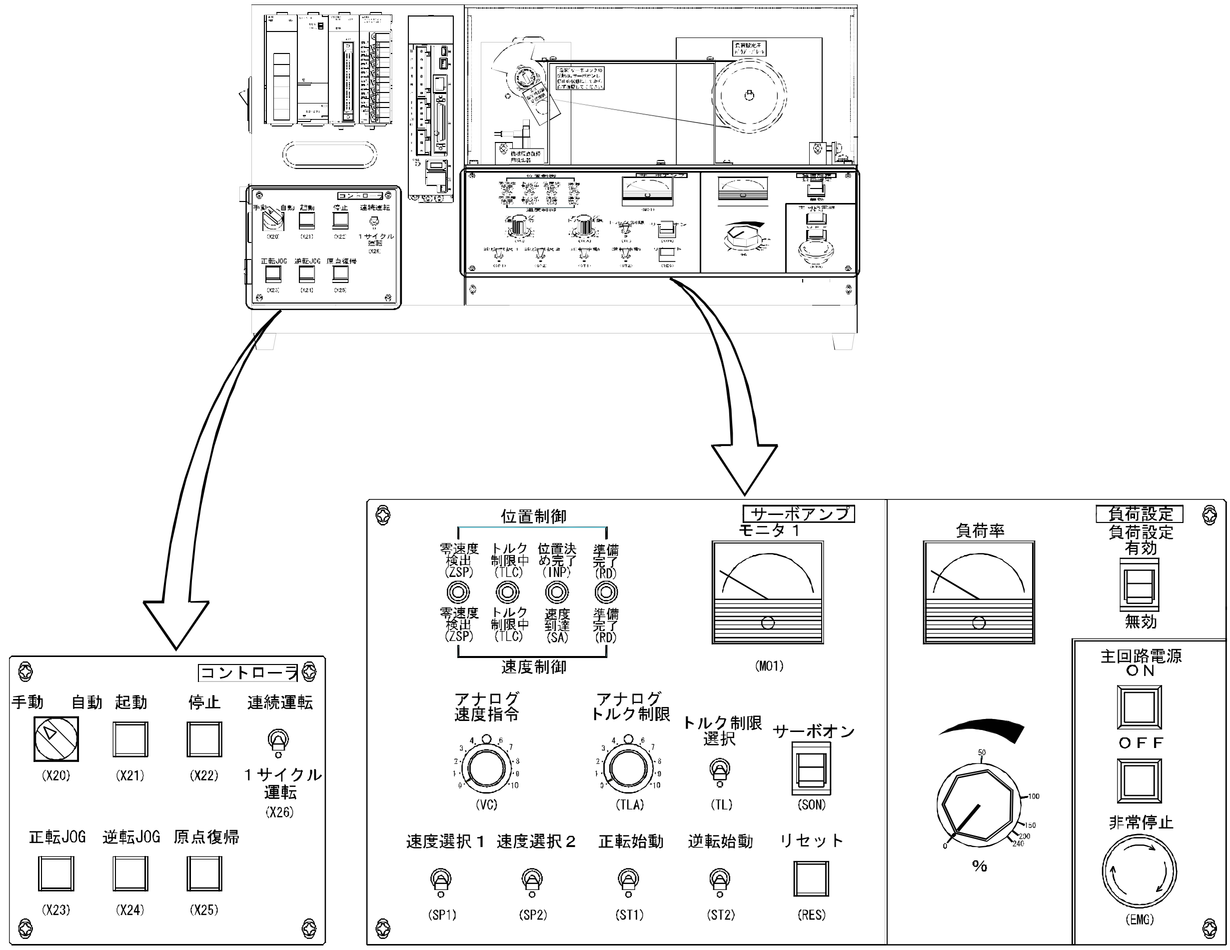


Operation panel 2

2.3 Practical Training of MR-J4 Servo Amplifier

2.3.1 Speed Control

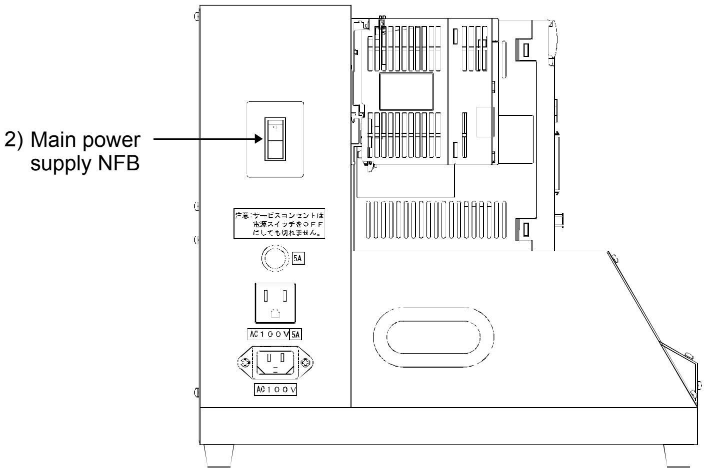
(1) Settings before power-on
Always set all operation switches to OFF.



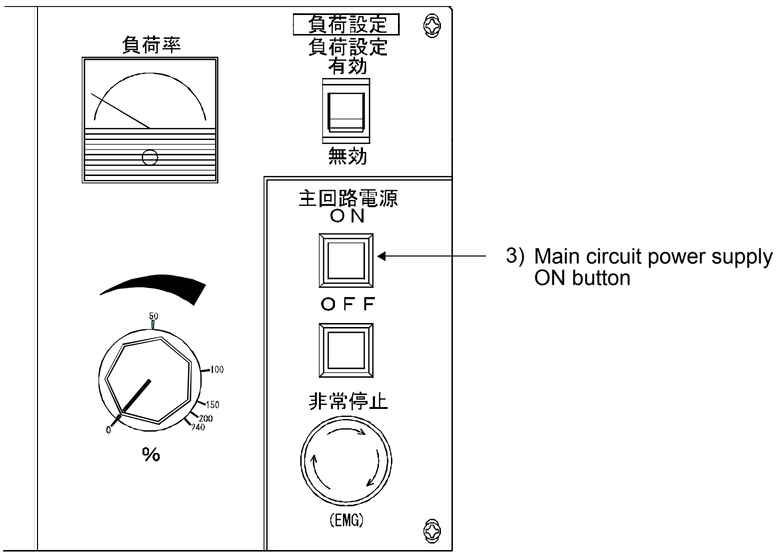
Operation panel 2 Operation panel 1

(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) Set main power supply NFB to ON.



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



(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 7.4.7.

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.	Abbre-viation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Posi-tion	Speed	Torque			Position control	Speed control
PA01	*STY	Operation mode	○	○	○	1000h		1000	1002
PA02	*REG	Regenerative option	○	○	○	0000h		0000	0000
PA03	*ABS	Absolute position detection system	○			0000h		0000	0000
PA04	*AOP1	Function selection A-1	○	○		2000h		2000	2000
PA05	*FBP	Number of command input pulses per revolution	○			10000		10000	10000
PA06	CMX	Electronic gear numerator (command input pulse magnification numerator)	○			1		262144	262144
PA07	CDV	Electronic gear denominator (command input pulse magnification denominator)	○			1		10000	10000
PA08	ATU	Auto tuning mode	○	○		0001h		0001	0001
PA09	RSP	Auto tuning response	○	○		16		16	16
PA10	INP	In-position range	○			100	pulse	100	100
PA11	TLP	Forward rotation torque limit	○	○	○	100.0	%	100.0	100.0
PA12	TLN	Reverse rotation torque limit	○	○	○	100.0	%	100.0	100.0
PA13	*PLSS	Command pulse input form	○			0000h		0000	0000
PA14	*POL	Rotation direction selection	○			0		0	0
PA15	*ENR	Encoder output pulses	○	○	○	4000	pulse/rev	4000	4000
PA16	*ENR2	Encoder output pulse 2	○	○	○	1		0000	0000
PA17		For manufacturer setting						0000	0000
PA18								0000	0000
PA19	*BLK	Parameter writing inhibit	○	○	○	00AAh		00AA	00AA
PA20	*TDS	Tough drive setting	○	○	○	0000h		0000	0000
PA21	*AOP3	Function selection A-3	○	○		0001h		0001	0001
PA22		For manufacturer setting				0000h		0000	0000
PA23	DRAT	Drive recorder arbitrary alarm trigger setting	○	○	○	0000h		0000	0000
PA24	AOP4	Function selection A-4	○	○		0000h		0000	0000
PA25	OTHOV	One-touch tuning - Overshoot permissible level	○	○		0	%	0	0
PA26		For manufacturer setting				0000h		0000	0000
PA27		For manufacturer setting				0000h		0000	0000
PA28		For manufacturer setting				0000h		0000	0000
PA29		For manufacturer setting				0000h		0000	0000
PA30		For manufacturer setting				0000h		0000	0000
PA31		For manufacturer setting				0000h		0000	0000
PA32		For manufacturer setting				0000h		0000	0000

(b) Gain/filter parameters list

No.	Abbre-viation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Posi-tion	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	[kpps]/ [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	○			0.0	Hz	0.0	0.0
PB34	VRF2B	Vibration suppression control 1 - Resonance frequency after gain switching	○			0.0	Hz	0.0	0.0
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

No.	Abbre-viation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Posi-tion	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	○	○	○	0000h		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		0000h	0000h
PB63						0000h		0000h	0000h
PB64						0000h		0000h	0000h

Note: An arbitrary value is set automatically.

(c) Extension setting parameters list

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

No.	Abbre-viation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Posi-tion	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		For manufacturer setting				0		0	0
PC42						0		0	0
PC43	ERZ	Error excessive alarm detection level	○			0	rev	0000	0000
PC44		For manufacturer setting				0000h		0000	0000
PC45						0000h		0000	0000
PC46						0		0000	0000
PC47						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	0.0001 rev	0	0
PC55		For manufacturer setting				0		0	0
PC56						100		100	100
PC57						0000h		0000	0000
PC58						0		0	0
PC59						0000h		0000	0000
PC60	*COPD	Function selection C-D	○	○	○	0000h		0000	0000

(d) List of I/O setting parameters list

No.	Abbre-viation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Posi-tion	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	*DI5L	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

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

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

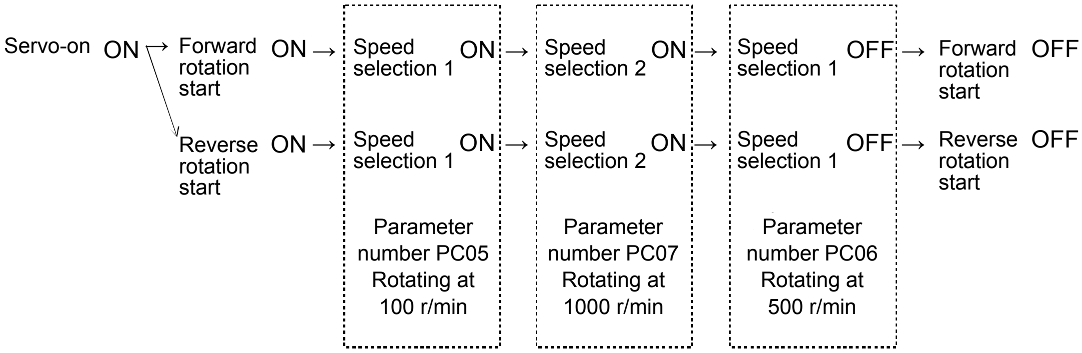
(f) Extension setting 3 parameters ([Pr. PF_ _])

No.	Abbre-viation	Name	Control mode			Initial value	Unit	Setting value of training machine	
			Posi-tion	Speed	Torque			Position control	Speed control
PF09	*FOP5	Function selection F-5	○	○	○	0000h		0000	0000
PF15	DBT	Electronic dynamic brake operating time	○	○	○	2000	[ms]	2000	2000
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	0
PF28						0		0	0
PF29						0000h		0000	0000
PF30						0		0	0
PF31	FRIC	Machine diagnosis function - Friction judgment speed	○	○	○	0	[r/min]	0	0

(4) 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 because of the input offset of the external speed command signal.
In such cases, the motor rotation can be stopped by the method sin Section 2.3.1 (4) (c) 4).

(c) Setting confirmation according to various parameters (For parameter details, refer to section 4.3.7.)

1) Confirmation of acceleration/ deceleration time constant
Confirm the operation by setting the acceleration time constant (parameter number PC01) and the deceleration time constant (parameter number PC02).
Setting example ... Parameter number PC01:0→1000 (1 second)
Parameter number PC02:0→2000 (2 seconds)

2) Confirmation of S-curve acceleration/deceleration time constant
Confirm the operation by setting the acceleration time constant (parameter number PC01), the deceleration time constant (parameter number PC02), and the S-curve acceleration/deceleration time constant (parameter number PC03).
For details, refer to section 7.4.6 (2) (o).

3) Confirmation of torque limit value
Set the internal torque limit (parameter number PA11/PA12).
Setting example: Forward rotation torque limit (parameter number PA11): 100% → 33%
(Torque is limited to 1/3 the maximum torque, with the output torque restricted to no more than the rated torque.)
The analog torque limit potentiometer is enabled when the torque limit selection switch is turned ON.

4) Adjustment of VC Offset
By setting the analog speed command offset (parameter No. PC37), the motor is regulated so as not to rotate when command speed voltage is 0 V.
Setting example: Analog speed command (parameter number PC37): 0 mV → □□ mV
(When forward rotation start is ON, a minus value is set when rotation is in the CCW direction.)

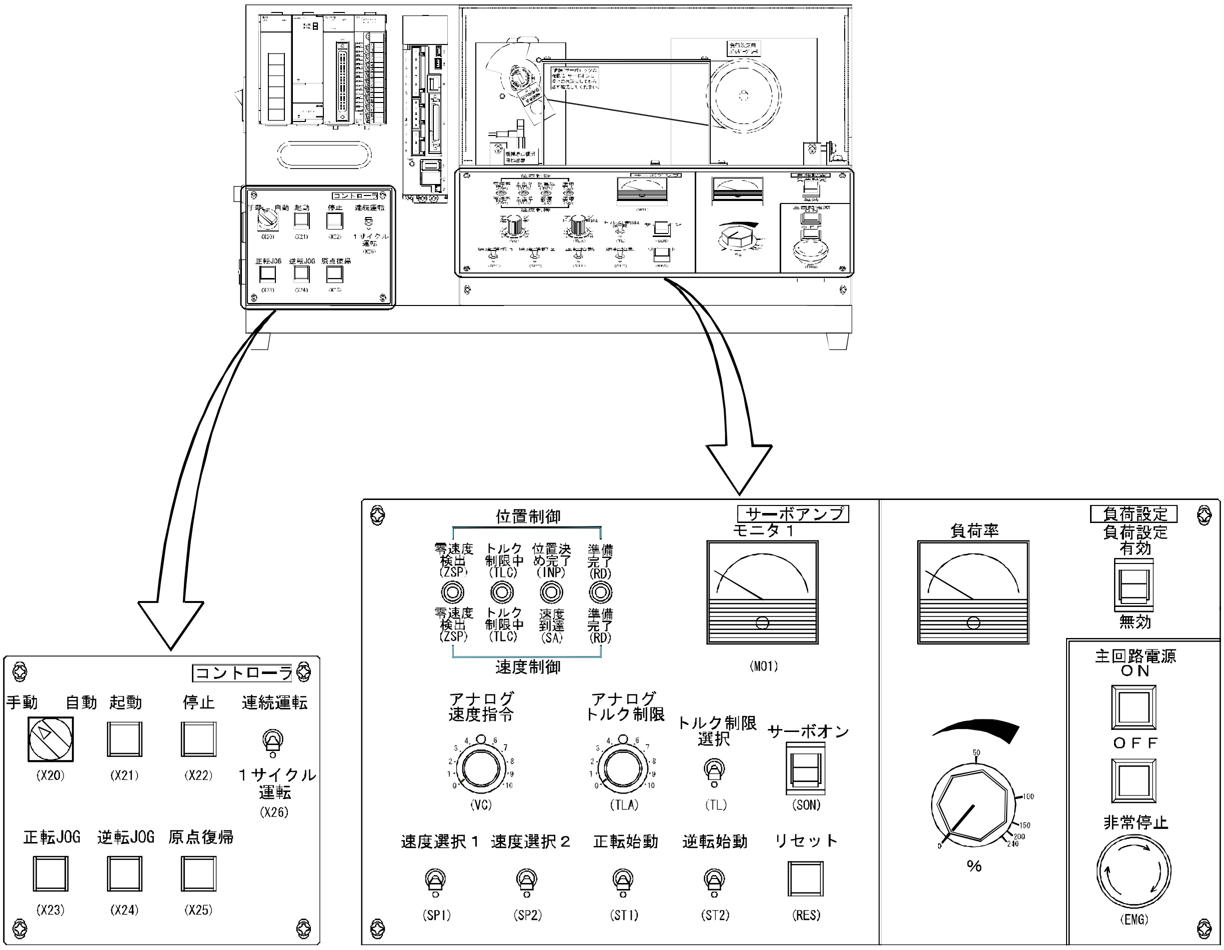
5) Adjustment of analog monitor offset
Set the analog monitor ch 1 offset (parameter number PC39) to correct the monitor output meter.

6) Monitor output setting
The contents of monitor output can be changed by setting the analog monitor 1 output (parameter No. PC14).
Setting example: 0002: Motor speed (+8 V/maximum speed)
0003: Generated torque (+8 V/maximum torque)

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.

2.3.2 Position Control

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



Operation panel 2　　Operation panel 1

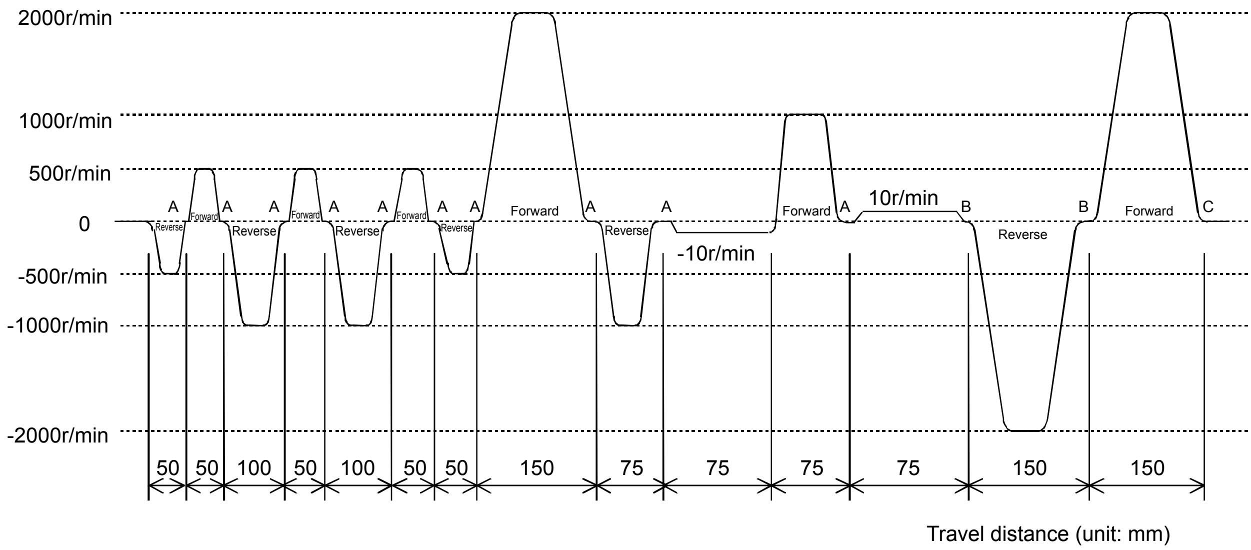
(2) Power-on
Turn on the power by referring to section 2.3.1 (2).

(3) Parameter setting
Before operating the training machine, set the parameters to the training device setting values (position control) in section 2.3.1 (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 selection 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 when button is in ON state)
3) If the reverse movement JOG button is turned ON, the motor will rotate to the reverse movement side (clockwise direction).
(Only when button is in ON state)

(c) Automatic operation
Execute the home position return before automatic operation.
1) Set the manual/auto selection switch to the manual side.
2) When the home position return button is set to ON, the motor returns to the home position. 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.



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

(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 = 550 mm (round)
2	Number of pulley teeth on the servo motor side	Z 1 = 20
3	Number of pulley teeth on the powder brake side	Z 2 = 40
4	Number of belt teeth	Z 3 = 110
5	Pulley moment of inertia on the servo motor side	J_{P1} = 0.109 kg cm^2
6	Pulley moment of inertia on the powder brake side	J_{P1} = 0.719 kg cm^2
7	Moment of inertia on the powder brake	J_a = 0.61 kg cm^2
8	Moment of inertia of the servo motor itself	J_M = 0.045 kg cm^2
9	Belt travel distance per motor rotation	ΔS = 100 mm
10	Feedback pulse of the motor	P_{f0} = 4194304 P/rev

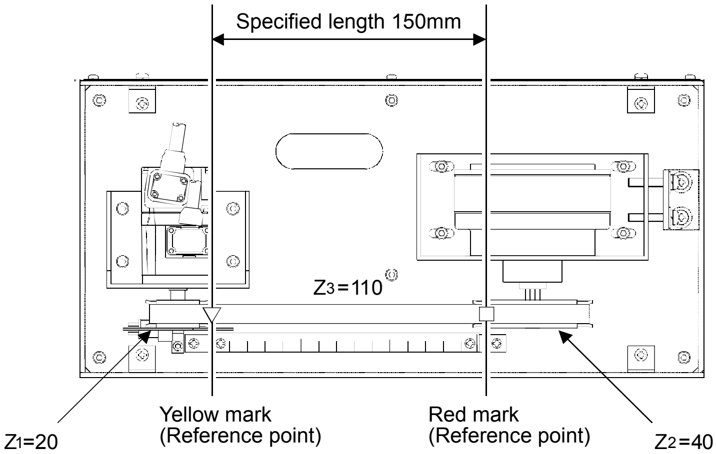
<Clipping data>
Find the load moment of inertia at motor shaft J_L.

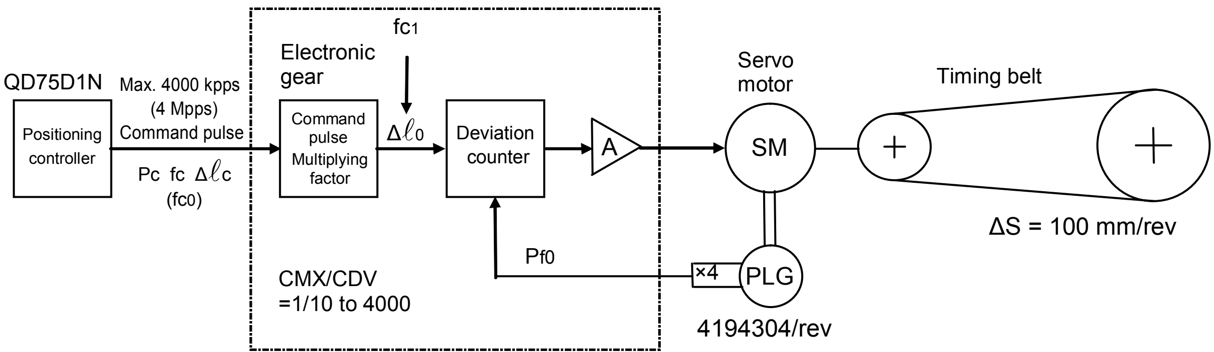
$$J_L = J_{P1} + \frac{J_{P2} + J_a}{(Z_2/Z_1)^2} = 0.109 + \frac{0.719 + 0.61}{2^2} \approx 0.44 \text{ kg cm}^2$$

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

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





(e) Operation confirmation by various parameter settings (For Parameter details, refer to section 7.4.6.)

1) Electronic gear settings and concepts (parameter number PA06, PA07)
Consider the belt travel distance for 1 pulse $\Delta\ell c$=0.001 mm (1 μm) as the unit.

$$\text{Electronic gear ratio}\,\frac{CMX}{CDV}=\frac{\text{Motor feedback pulse Pfo}\times\text{distance traveled by the belt in 1 pulse }\Delta lc}{\text{Belt travel distance }\Delta S\text{ per motor rotation}}$$

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

2) With an electronic gear ratio of 131072/3125, find fc when the motor speed is 3000 r/min.
Consider the belt travel distance for 1 pulse $\Delta\ell c$＝0.001 mm (1μm) as the unit.

$$N=\frac{fc\cdot 60\cdot CMX/CDV}{Pf0}=\frac{fc\cdot 60\cdot 131072/3125}{4194304}=3000\text{r/min}$$

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

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) Consider the travel distance of belt for 1 pulse $\Delta\ell c$＝0.05 mm (50 μm) as the unit.

$$\text{Electronic gear ratio}\,\frac{CMX}{CDV}=\frac{4194304\times 0.05}{100}=\frac{5242880}{2500}=\frac{262144}{125}$$

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

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

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.

$$\frac{CMX}{CDV}=\frac{4194304\cdot 0.01}{100}=\frac{4194304}{10000}$$

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).

2.4 AC Servo Setup Software

This section describes the operation of setup software "MR Configurator2 (SW1DNC-MRC2-E)" for general-purpose AC servos manufactured by Mitsubishi, for smooth setup operation and graph display by using a computer.

Adapted AC servo model name

Individual MR-J4-B, MR-J4-A, MR-J3-B, MR-J3-A, and MR-J3-T series

Operating environment

Software			Capacity selection software MRZJW3-MOTSZ111	MR Configurator2 (setup software) SW1DNC－MRC2－J
Personal computer	OS	Windows® 98, Japanese version	○	×
		Windows® 98 Second Edition Japanese version	○	×
		Windows® Me, Japanese version	○	×
		Windows® 2000 Professional Japanese version	○	○
		Windows® XP Professional, Japanese version	○	○
		Windows® XP Home Edition, Japanese version	○	○
		Windows Vista® Home Basic Japanese version	○	○
		Windows Vista® Home Premium Japanese version	○	○
		Windows Vista® Business Japanese version	○	○
		Windows Vista® Ultimate, Japanese version	○	○
		Windows Vista® Enterprise Japanese version	○	○
		Windows® 7 Starter, Japanese version	○	○
		Windows® 7 Home Premium, Japanese version	○	○
		Windows® 7 Professional, Japanese version	○	○
		Windows® 7 Enterprise, Japanese version	○	○
		Windows® 7 Ultimate, Japanese version	○	○
	Processor		Pentium® 133 MHz or higher: (Windows® 98, Windows® 2000 Professional) Pentium® 150 MHz or higher: (Windows® Me) Pentium® 300MHz or higher: (Windows® XP Professional/Home Edition) 1 GHz or higher, 32 bit (x86): (Windows® Vista® Home Basic/Home Premium/Business/Ultimate/Enterprise, Windows® 7 Starter/Home Premium/ Professional/Enterprise/Ultimate)	Desktop computer: Intel® Celeron® processor 2.8 GHz or higher recommended Notebook computer: Intel® Pentium® M processor 1.7 GHz or higher recommended

○: Supported; ×: Not supported

Software		Capacity selection software MRZJW3-MOTSZ111	MR Configurator2 (setup software) SW1DNC－MRC2－J
Personal computer	Memory	24 MB or more: (Windows® 98) 32 MB or more: (Windows® Me, Windows® 2000 Professional) 128 MB or more: (Windows® XP Professional/Home Edition) 512 MB or more; (Windows® Vista® Home Basic) 1 GB or more: (Windows® Vista® Home Premium/Business/Ultimate/Enterprise, Windows® 7 Starter/Home Premium/ Professional/Enterprise/Ultimate)	512 MB or more (32 bit OS supported) 1 GB or more (64 bit OS supported),
	Hard disk free space	40 MB or more	1GB or more
	Communication interface	-	Using USB port
Display		With a resolution of 800x600 or higher, with High Color (16 bit) display	With a resolution of 1024x768 or higher, with High Color (16 bit) display
Keyboard		Connectable with the above personal computers.	
Mouse		Connectable with the above personal computers.	
Printer		Connectable with the above personal computers.	
Communication cable		Not required	MR-J3USBCBL3M (USB)

Note 1: Celeron and Pentium are registered trademarks of Intel Corporation. Windows and Windows Vista are registered trademarks of Microsoft Corporation in the United States and other countries.

Note 2: Refer to the revision history on the FA site for the capacity selection software and software versions of MR Configurator2 for each servo amplifier and servo motor.

Note 3: This software may not function properly depending on the personal computer used.

Note 4: Capacity selection software is not supported in 64 bit OS.

Note 5: MR Configurator2 is supported only in 64 bit OSWindows® 7.

Characteristics

1) Easy setup and adjustment
   Because the servo assistance function displays a guide for amplifier settings, test operation, servo adjustment, maintenance, and troubleshooting functions from startup to operation, a new user can easily perform the setup.
2) Extensive monitoring and diagnostic functions
   The device is equipped with various monitor functions, alarm functions, diagnostic functions, and a graph display function that displays the status of servomotor triggered by input signals like command pulses, droop pulses, rotation speed, etc.
3) Easy start-up in various test operations
   Various test operations necessary for start-up tasks, including JOG operation, positioning operation, and motor-less operation, can be performed.
4) Higher level of servo adjustment
   Because adjustment and measurement functions required by the servo, including tuning, machine analyzer, etc., are equipped, a higher level of adjustment is possible.

Specifications

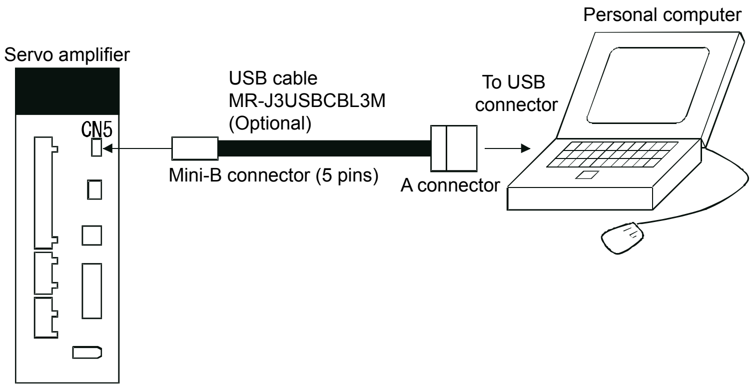
Item	Description
Project	Project creation, reading, storage, and deletion; read-write of other format files; system setup; printing
Parameter	Parameter setting
Positioning data	Point table
Monitor	Batch display, I/O monitor indicator, graph, and ABS data display
Diagnostics	Alarm display, data display in case of alarm, display of reason for no rotation, system configuration display, life diagnostics, fully closed diagnostics, linear diagnostics
Test operation	JOG operation, positioning operation, motor-less operation, D0 forced output, program operation, single-step feed, test operation event information
Adjustment	Tuning, machine analyzer
Others	Servo assistant, parameter setting range updating, machine unit conversion settings, help display, connection to MELFANSweb

2.4.1 Setup Software (SW1DNC-MRC2-J) Startup Operation

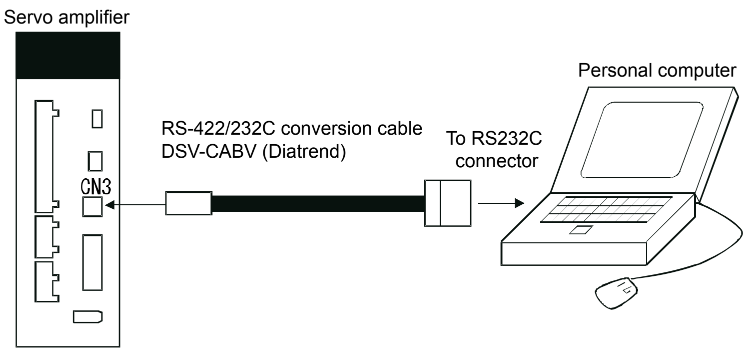
(1) Communication cable connection between personal computer and AC servo amplifier

In addition to the conventional RS-422 interface, the MELSERVO-J4 series provides USB interface as the standard equipment.
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.

1) With USB
Drive and operate a single axis servo amplifier.
Use the optional MR-J3USBCBL3M as the USB cable.



2) With RS-422
Drive and operate a single axis servo amplifier.
Using the following cable is recommended.

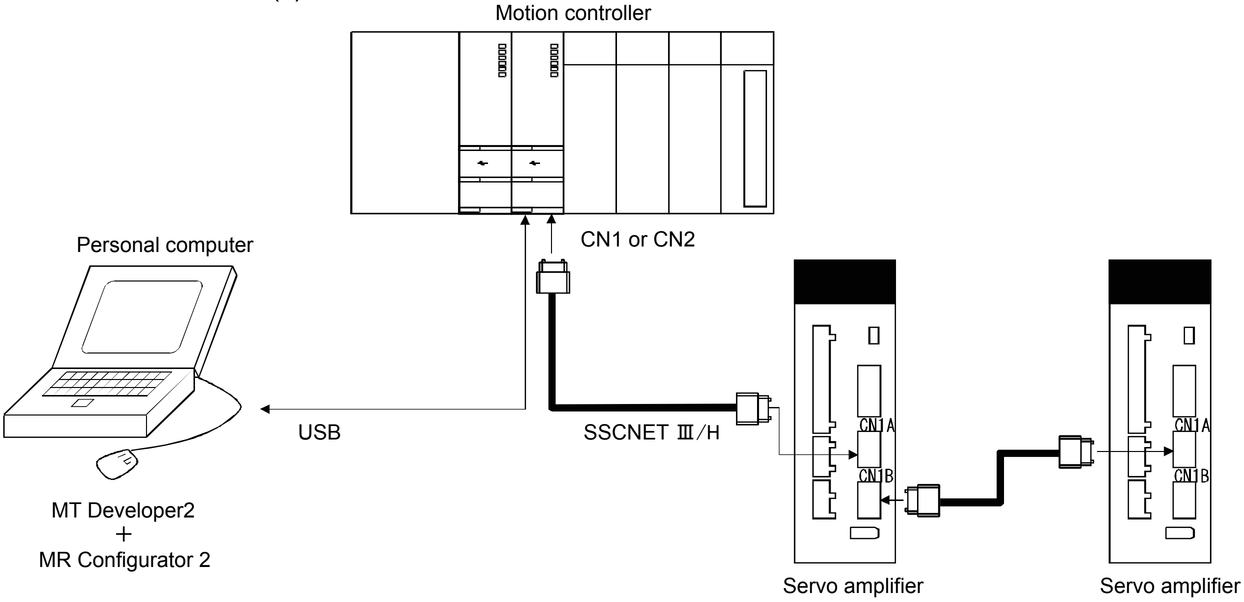


Note: MR Configurator2 is not compatible with an RS-422 cable connection for MR-J4-A.

3) With connection via a motion controller (MR-J4-B)
Multiple servo amplifiers are operated via a motion controller.

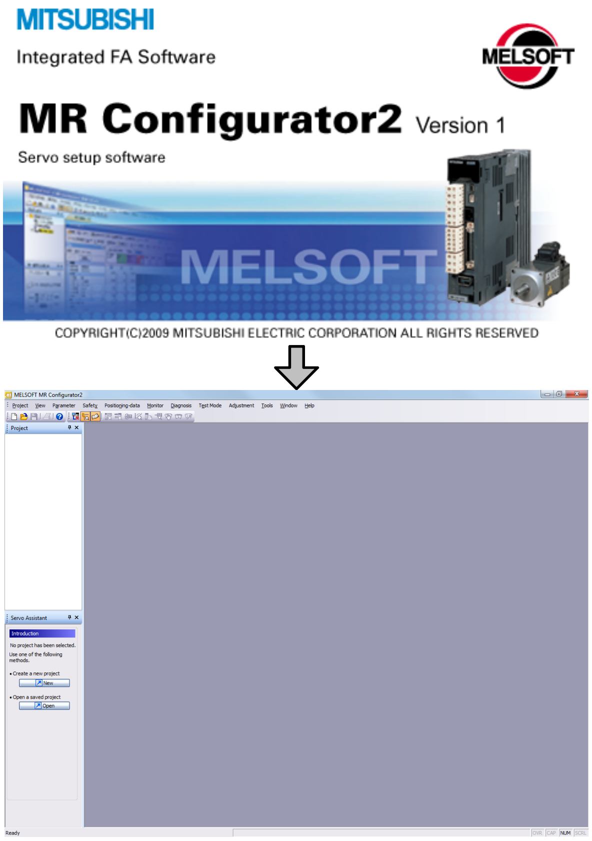
Suitable motion controllers are as follows.
- Q17□DSCPU • Q77MS□ (simple motion)

(a) With a USB connection



(b) With an MT connection setup
When activated from MT Developer2, communication is performed using the communication method and communication path set in the communication settings of MT Developer2.
However, this is not available with SSCNET communication.
When SSCNET communication is selected in the MT Developer2 communication settings, the motion controller USB connection becomes the communication path of MR Configurator2.

(2) Startup of application software



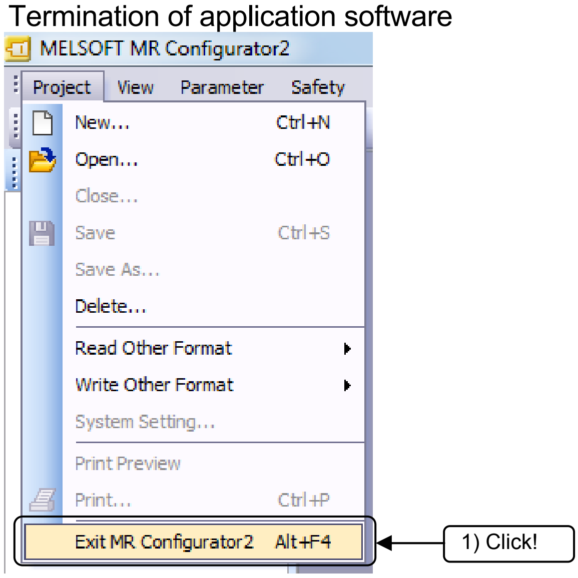
1) Click Windows - [Start] - [All programs] - [MELSOFT application] - [MR Configurator2] - [MR Configurator2].

The startup screen shown on the left will be displayed.

2) Start MR Configurator2

> **POINT**
>
> When operating via the motion controller
> Double click on the "Servo Parameter" icon in the general start-up support software MT Developer2 for the motion controller.

(3) Termination of application software



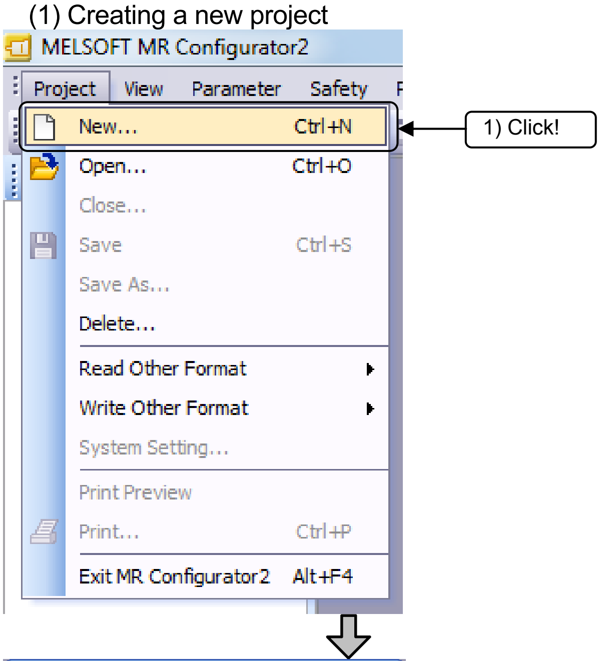
1) In the menu bar, click [Project] → [Exit MR Configurator2].

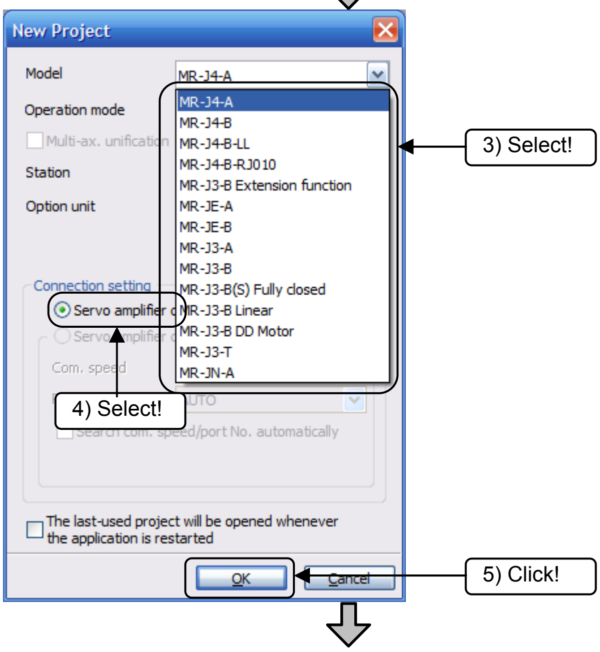
2.4.2 Projects

A project is a compilation of system settings, parameter settings, etc., grouped in a common folder.

Refer to section 2.4.5 (8) for details on commands used through [Project] in the menu bar.

(1) Creating a new project





(To next page)

1) In the menu bar, click [Project] → [Create New].

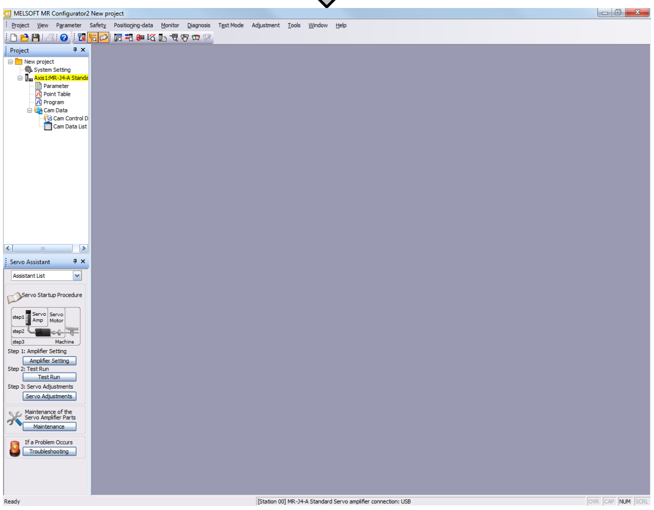
2) The create new dialog box will be displayed.

3) Select the type.

4) Configure the connection settings.

5) Click the OK button.

(From previous page)



5) Open the newly created project.

(2) Open project

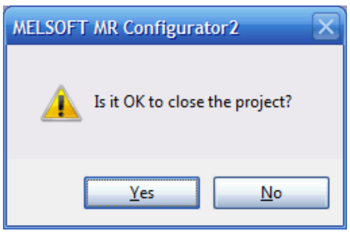
Open an existing MR Configurator2 project.

In the menu bar, click [Project] → [Open] to display the open project dialog box. Then select the project to open and click the Open button.

(3) Close project

Close the currently open MR Configurator2 project.

Clicking [Project] → [Close] in the menu bar will close the currently open project. The following message will be displayed when closing. Click the Yes button.



(4) Save project

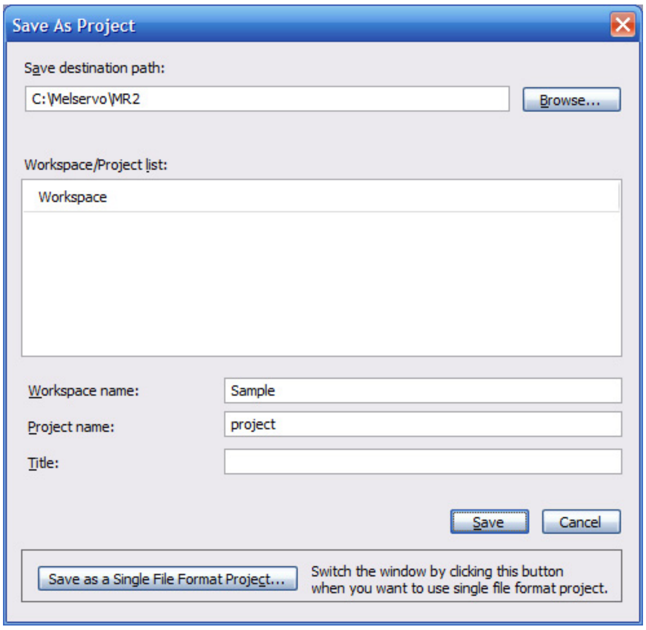
Edit the currently open MR Configurator2 project and save it.

In the menu bar, click [Project] → [Save] to save the project.

POINT
When saving a new project, the Save as dialog box will be displayed. Refer to "(5) Save project as" on the next page.

(5) Save project as

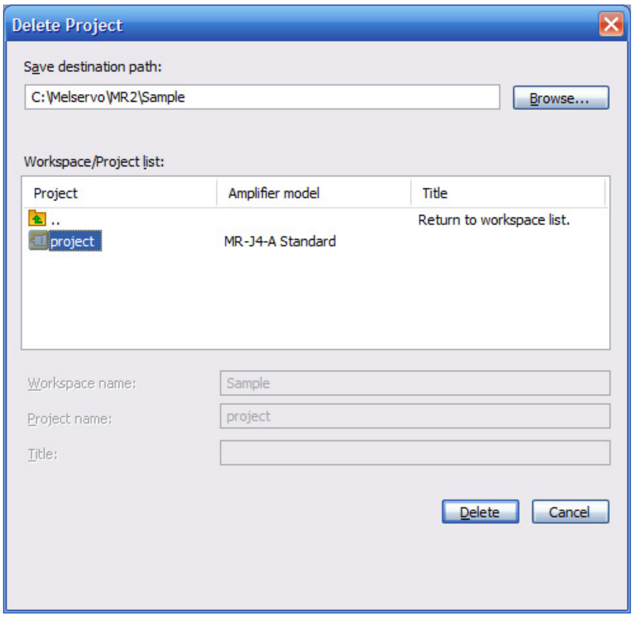
Save the currently open MR Configurator2 project.
In the menu bar, if [Project] → [Save As] is clicked, the following dialog box will be displayed.



Input the save destination path, the workspace name, and the project name, and click the Save button.

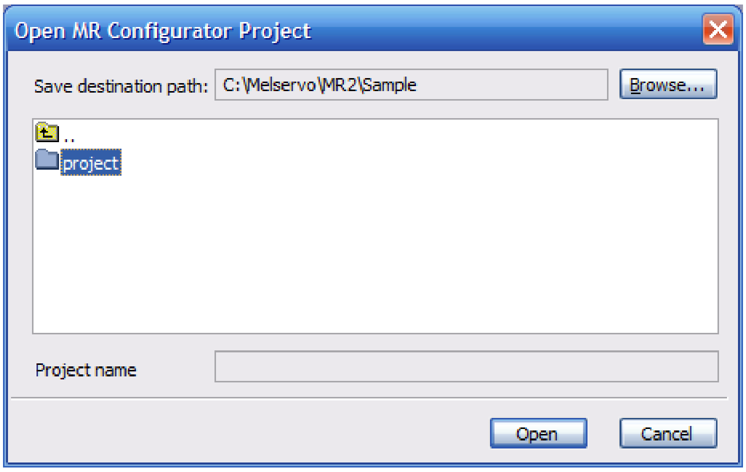
(6) Delete project

Delete the existing MR Configurator2 project.
In the menu bar, if [Project] → [Delete] is clicked, the following dialog box will be displayed.



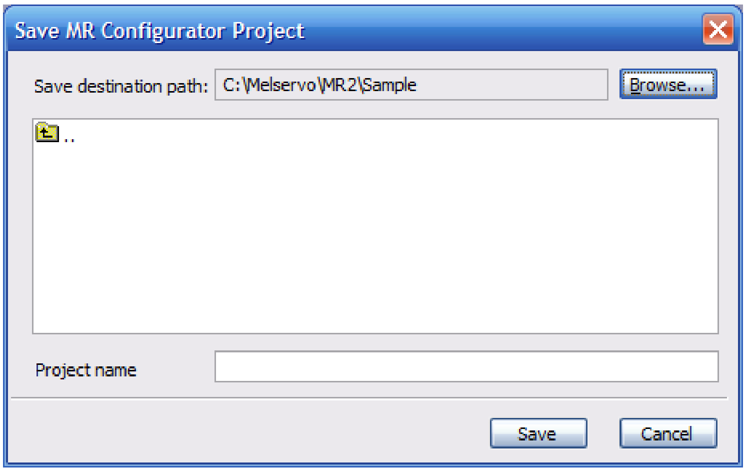
Select the project to be deleted and click the Delete button.

(7) Open an MR Configurator format project
Open an existing MR Configurator project.
In the menu bar, click [Project] → [Read other file type] → [Open MR Configurator type project]. The following dialog box will be displayed.



Select the opened MR Configurator project and click the Open button.

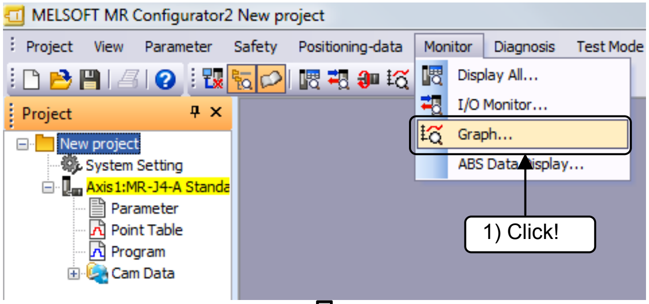
(8) Save the project in the MR Configurator format
Saves the project in the MR Configurator format.
In the menu bar, click [Project] → [Write other file type] → [Save MR Configurator type project]. The following dialog box will be displayed.



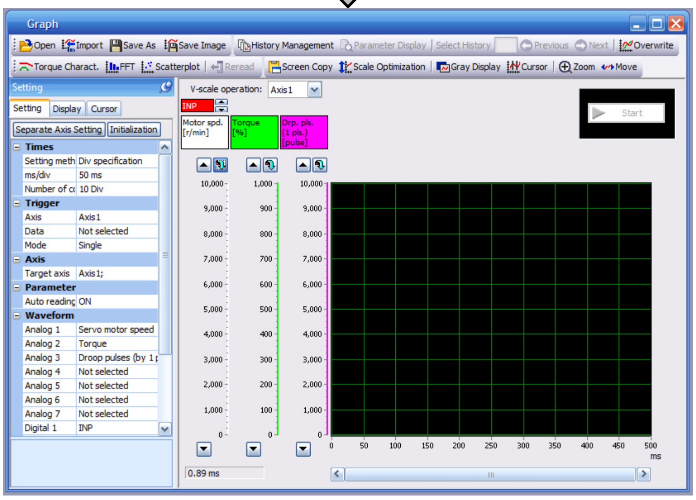
Select the save destination and input project name, and click the Save button.

2.4.3 Graph Display

The selected monitor graph data is displayed in a graph.

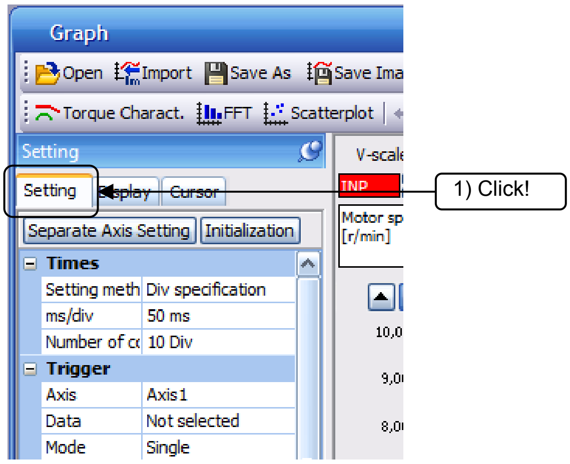


1) In the menu, bar click [Monitor] → [Graph].



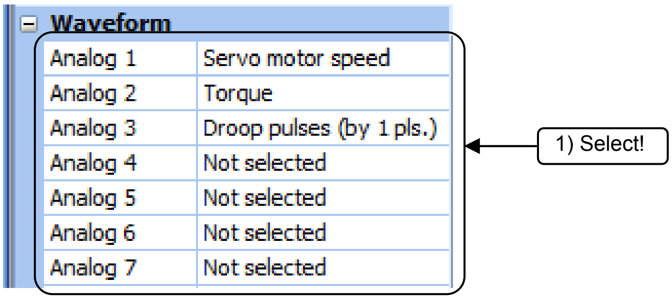
2) The graph display window is displayed.

(1) Waveform setting



1) Click the [Settings] tab of the graph screen.

(a) Analog CH settings



1) Select the analog CH (1 to 7) data from the drop down list in the "Waveform" column.

* Always select analog CH 1 or 2.

(List)

Motor speed	Regenerative load ratio	Command pulse frequency (0.1 r/min
Torque	Position in one rotation	speed unit)
Current command	ABS counter	Speed command (0.1 r/min unit)
Command pulse frequency	Load to motor inertia ratio	Torque command
Command pulse frequency (unit of speed)	Disturbance torque	Speed limit value
Droop pulse (100 pulse unit)	Overload alarm margin	Speed limit value (0.1 r/min unit)
Droop pulse (1 pulse unit)	Error excessive alarm margin	Phase U current F/B
Speed command	Settling time	Phase V current F/B
Bus voltage	Overshoot amount	Encoder inside temperature
Effective load ratio	Motor speed (0.1 r/min unit)	Encoder error counter

(Reference)
By deselecting analog CH3, the measurement time of analog CH1 or CH2 within the same sampling time, can be extended to about 1.5 times.

POINT

When obtaining a graph waveform using the "Test function" from the setup software "MR Configurator2 (SW1DNC-MR-J)" (Reference example)

1. With the "JOG operation" function

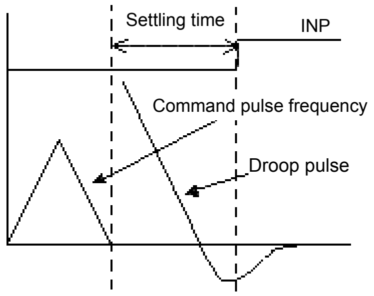
   [Operation selection item]
   CH1: Motor speed
   CH2: Torque
   CH3: Not set

2. With the "Positioning operation" function

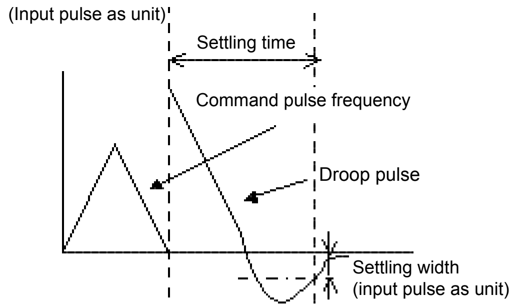
   [Operation selection item]
   CH1: Command pulse frequency
   CH2: Droop pulse +
   CH3: Torque

When analog settling time is selected:
The settling time settings become effective, and the following settings are configured.

- Time from command termination until INP turns on

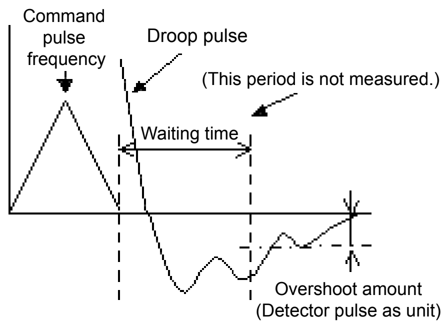


- Time from command termination during which the droop pulse falls within the settling width (The settling width is set with input pulses as the unit.)

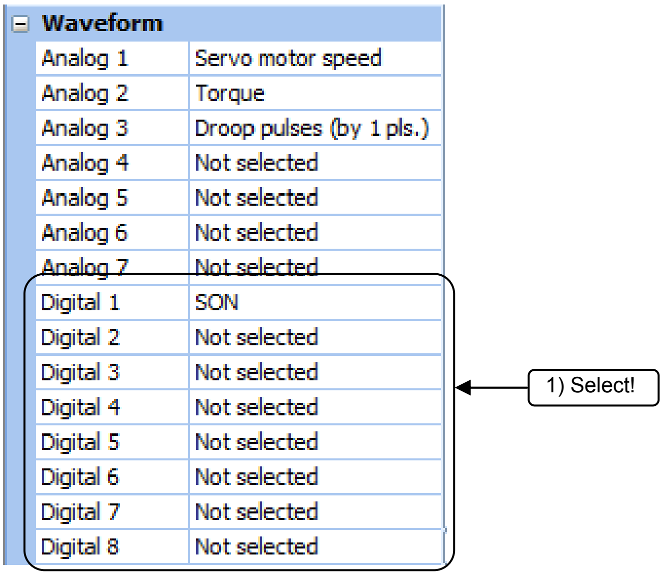


When analog overshoot amount is selected:
The overshoot amount (detector pulse unit) settings become effective and the following settings are configured.

- Maximum value of droop pulse [pulse] measured after waiting time has elapsed following command termination (waiting time specified in ms)



(b) Digital CH setting



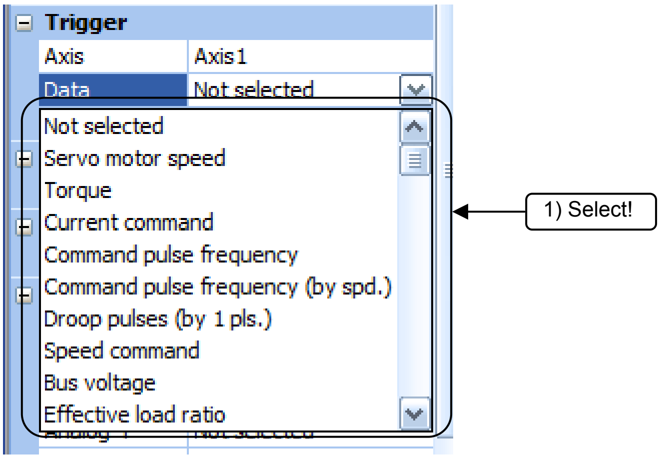
1) Select the digital CH (1 to 8) data from the drop down list in the "Waveform" column.

(List)

SON: Servo on	RS1: Forward rotation selection	MBR: Electromagnetic brake interlock
LSP: Forward rotation stroke end	RS2: Reverse rotation selection	DB: Dynamic brake interlock
LSN: Reverse rotation stroke end	CDP: Gain switching	ALCD0: Alarm code
TL: External torque limit selection	ABSM: ABS transfer mode	ALCD1: Alarm code
TL1: Internal torque limit selection	ABSR: ABS request	ALCD2: Alarm code
PC: Proportional control	D1: (For manufacturer setting)	BWNG: Battery warning
RES: Reset	D2: (For manufacturer setting)	ALM2
CR: Clear	D3: (For manufacturer setting)	STO
SP1: Speed selection 1	D4: (For manufacturer setting)	SMPD
SP2: Speed selection 2	RD: Ready	CDPS: Variable gain selection
SP3: Speed selection 3	SA: Speed reached	CLDS
ST1: Forward rotation start	ZSP: Zero speed detection	ABSV: Absolute position undetermined
ST2: Reverse rotation start	TLC: Limiting torque	IPF
CM1: Electronic gear selection 1	VLC: Limiting speed	SPC
CM2: Electronic gear selection 2	INP: In-position	MTTR: During tough drive
LOP: Control switching	WNG: Warning	ABSB0: ABS transmitted data bit 0
EM2/1: Forced stop 2/1	ALM: Malfunction	ABST1: ABS transmitted data bit 1
RDYC	OP: Encoder phase Z pulse (Open collector)	ABST: ABS transmitted data ready
STAB2: Second acceleration/deceleration selection		

(2) Trigger settings

(a) Selection of triggered data

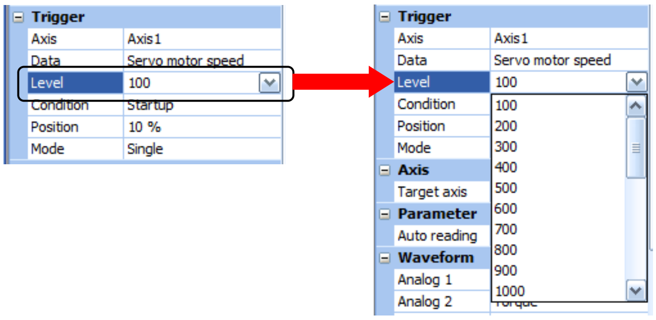


1) Click "Triggered data" in the "Trigger" column, and select trigger specification data from the drop down list.

Selection can be made from analog items and digital items.

(b) Trigger level setting

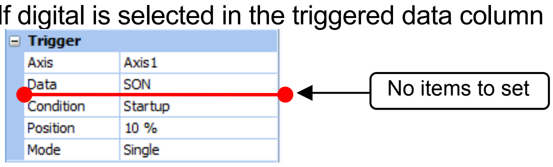
If analog is selected in the triggered data column



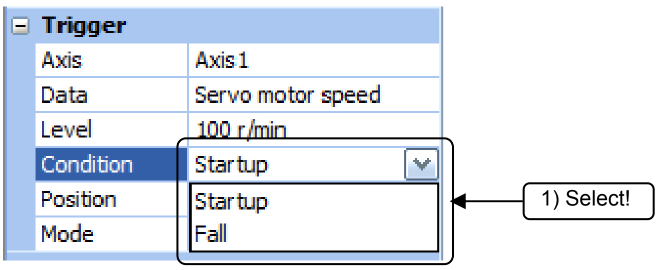
1) Click "Trigger level" in the "Trigger" column to display the drop down list.

If an analog item is selected in the triggered data column, the units and numerical values set in the triggered data column will be displayed in the trigger level column.

If digital is selected in the triggered data column



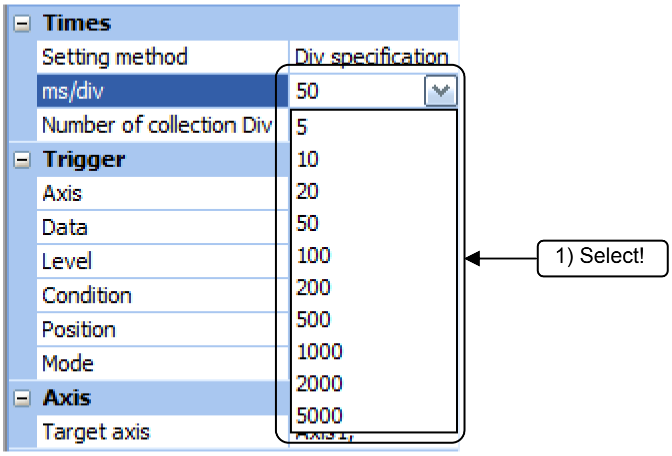
(c) Condition setting



1) Click "Trigger type" in the "Trigger" column and select rise or fall from the drop down list.

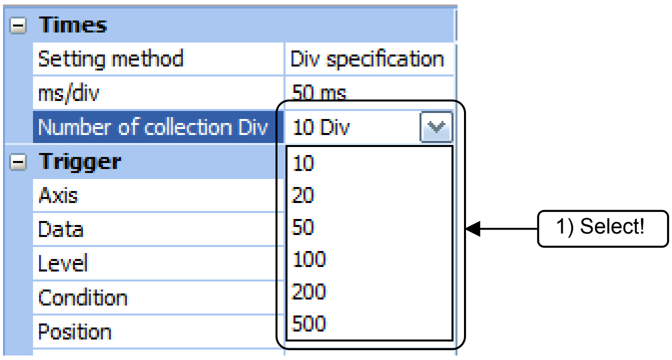
(3) Time setting

(a) Individual Div time setting



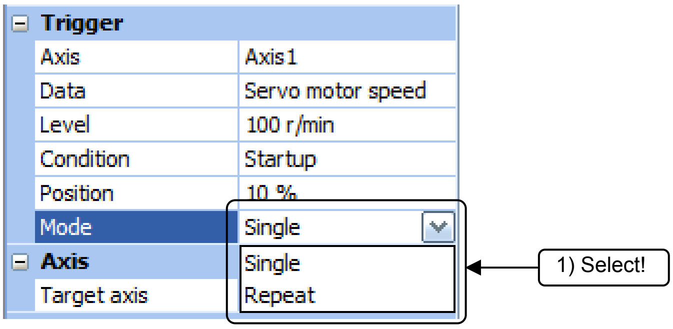
1) Click "Time for each Div" in the "Trigger" column and select the time axis scale from the drop down list.

(b) Collective Div setting



1) Click "Collective Div" in the "Trigger" column and select the number of Div to be processed from the drop down list.

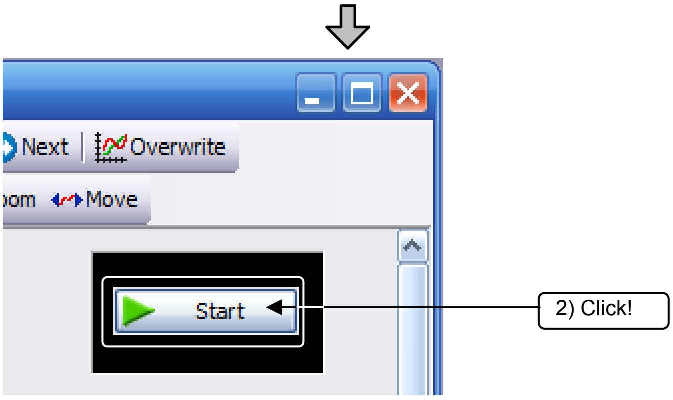
(4) Process start/stop



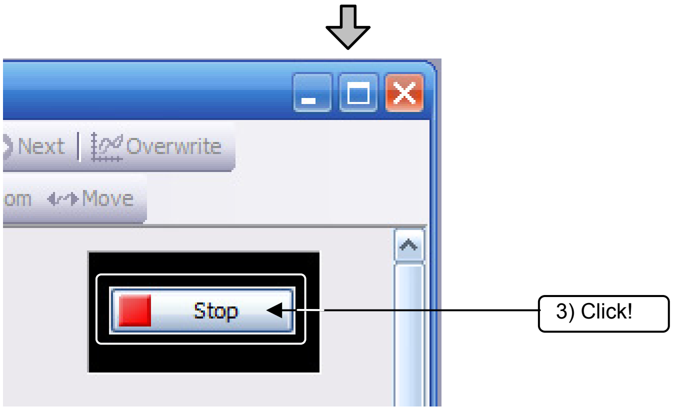
1) Click "Collective mode" in the "Trigger" column and select single or continuous from the drop down list.

Single: Read the process data when the trigger conditions were first satisfied and stop the process.

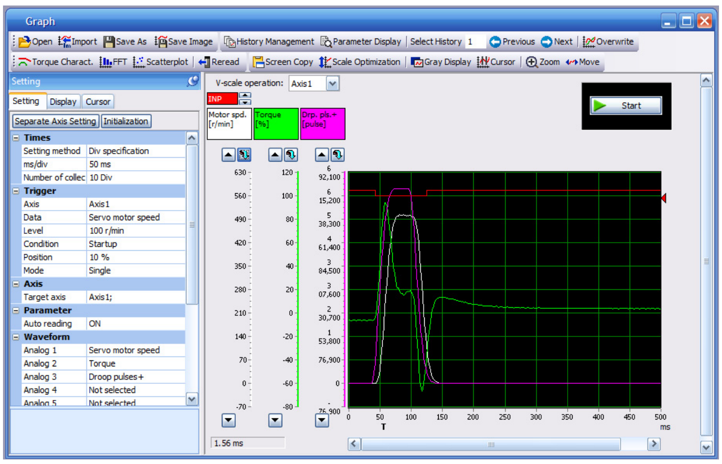
Continuous: Continuously monitor the amplifier and acquire the process data whenever the trigger conditions are satisfied.



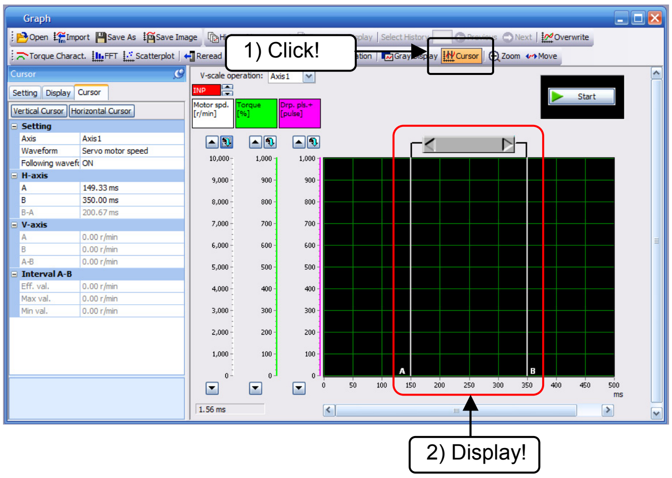
2) When the  button is clicked, the waveform process is started in the currently selected trigger mode.



3) To stop the process, click the  button.



(5) Operating status setting
(a) Cursor



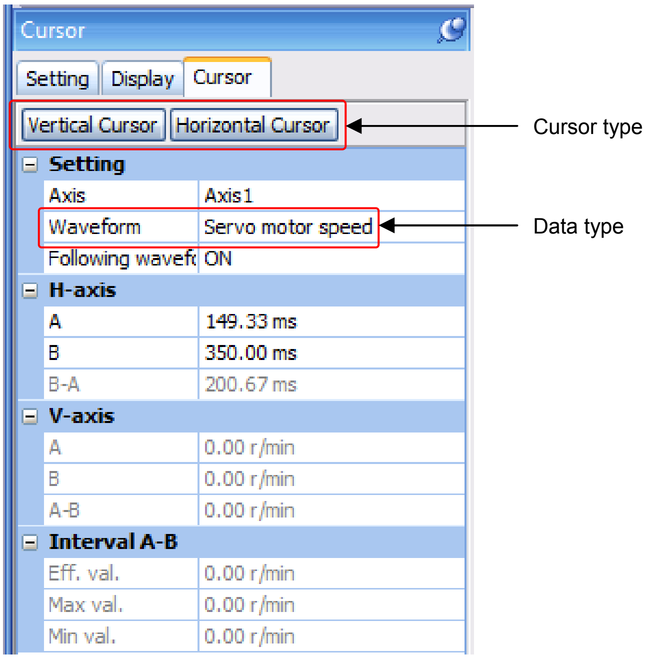
1) Click the Cursor button.

2) The cursor is displayed in the graph display area.

Each cursor can be moved by dragging the mouse.

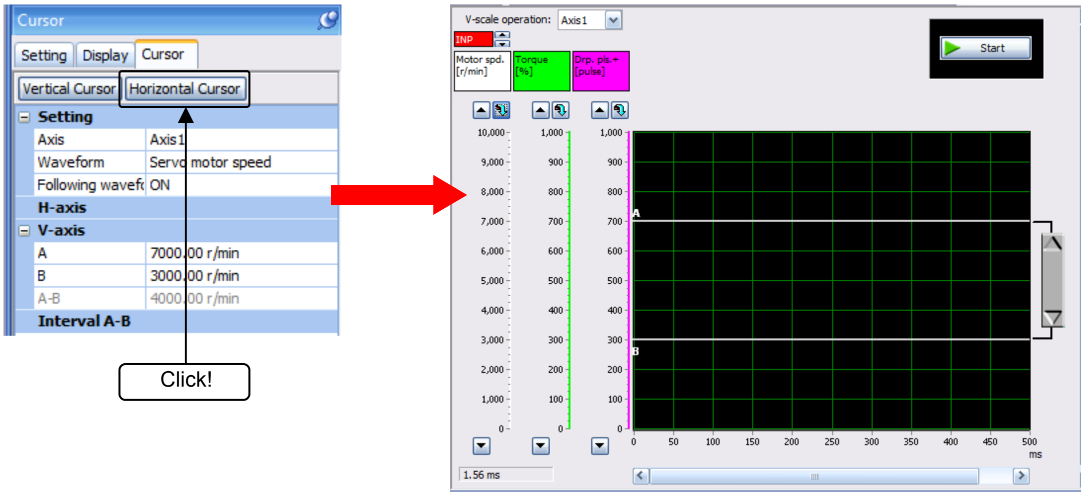
When the cursor is dragged, A and B move simultaneously.
If either A or B is dragged, only one will move.

Also, if a cursor is set to ON, the property screen on the left of the screen will be switched to the following display.



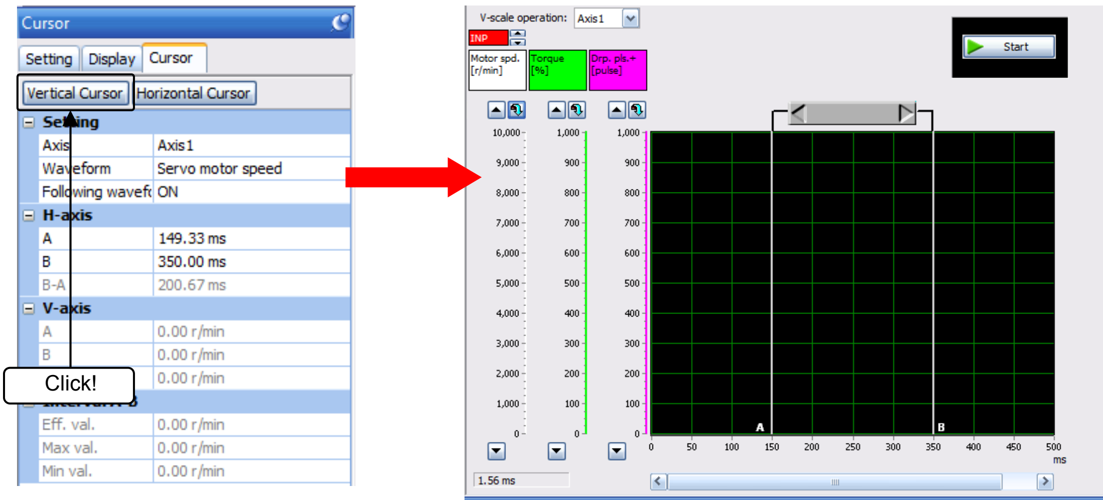
Select the cursor type (vertical axis or horizontal axis) and the data type to be measured.

- With a horizontal axis cursor



If a horizontal axis cursor is selected, the following applies:
- Input and indicate the positions (ms) of cursors A and B.
- The cursor of the graph display area moves according to the input values.
- Also, the value changes in conjunction with the movement of the cursor.
- The time difference is indicated from the input values of cursors A and B.

- With a vertical axis cursor



If a vertical axis cursor is selected, the following applies:
- The data type values for cursors A and B are displayed.
- The time difference is indicated from the values of cursors A and B.

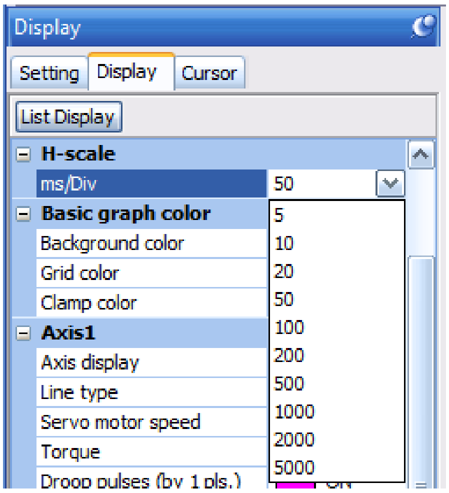
- Any numerical values can be input as the cursor values of A and B, and the A-B display and effective values will be calculated according to the input values.
- If a value exceeding the waveform display limit is specified, the cursor is displayed outside the waveform and that section will be treated as the waveform value on the right edge of the screen.

POINT

Vertical scale optimization

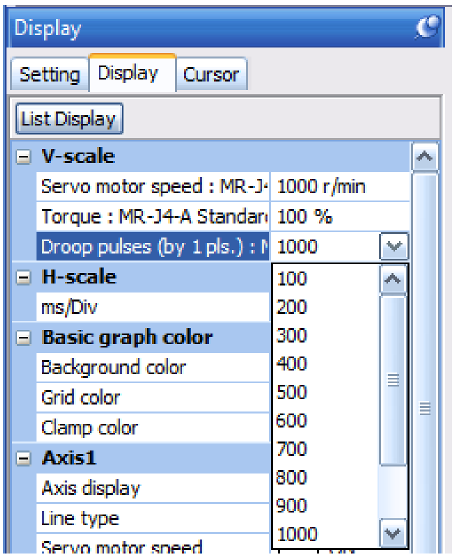
When the [Scale Optimization] button is clicked, the vertical axis scale and 0-point position of each waveform are automatically adjusted so that all of the waveform of the selected history will fit within the screen.

(b) Horizontal axis scale setting of the displayed waveform



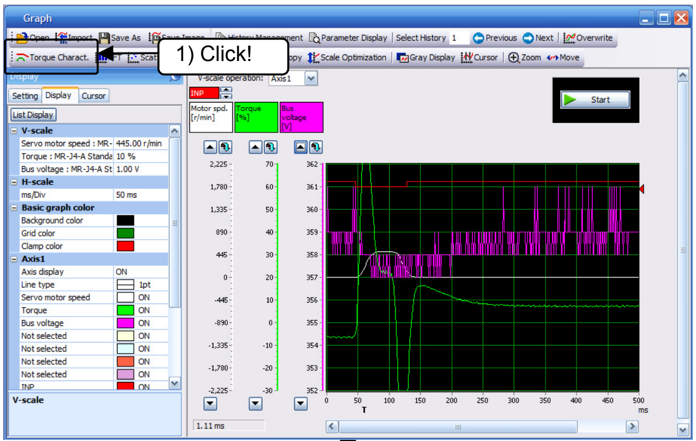
1) Select the "Horizontal axis scale" column of the display tab, and select the horizontal axis division unit from the drop down list or input a value in the input column.

(c) Vertical axis scale setting of the displayed waveform

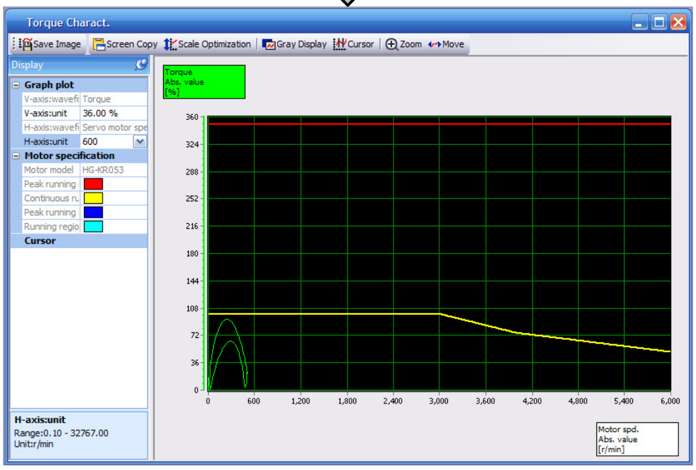


1) Select the "Vertical axis scale" column of the display tab, and select the vertical axis division unit from the drop down list or input a value in the input column.

(d) Torque characteristics

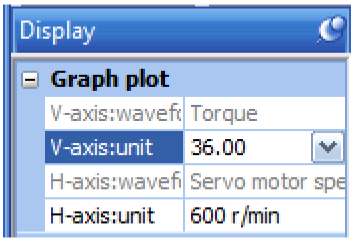


5) Click the Torque Charact. button.



2) The torque characteristics screen is displayed.
The short-duration running range (red) and continuous running range (yellow) of the torque characteristic are displayed simultaneously.
In machines that generate unbalanced torque like an elevated axis, it is recommended that the unbalanced torque be used at 70% of the rated torque or less.

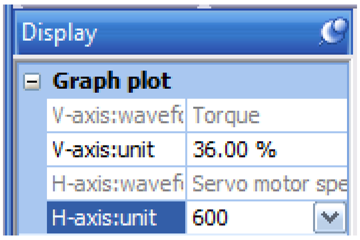
Changing torque absolute values:



Select the Y-axis scale unit of the "Graph plot" column in the property screen, and select the vertical axis division unit from the drop down list or input a value in the input column.

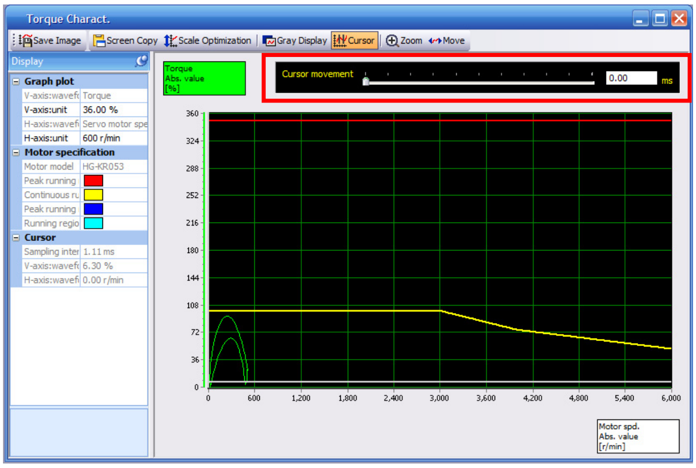
When the Scale Optimization button is clicked, the waveform is automatically converted to a scale value that efficiently fits the waveform.

Changing motor speed absolute values:



Select the X-axis scale unit of the "Graph plot" column in the property screen, and select the horizontal axis division unit from the drop down list or input a value in the input column.

Horizontal scrolling of the displayed waveform:



When the Cursor button is clicked, a cursor travel bar is displayed at the top of the torque characteristic diagram screen.

Input the cursor position (ms) using text input or using the slide bar.

- The cursor of the graph display area moves according to the input value.

Screen copy:

Click the Screen Copy button to copy the graph screen to the clipboard.

It can be pasted in other applications. The graph screen can be easily pasted for creating documents, etc.

Grayout:

Click the Gray Display button to change the graph display to black lines on a white background.

When a screen with a normal black background colored graph is copied to a document and the document is printed, the print will not be clear (the waveform data will not be clearly visible). Use the grayout function in such cases.

(e) Useful graph functions

This section describes the useful functions of the waveform data graph display.

Select history:

Once the setup software is started, collected graph data can be displayed for 20 samplings, including the latest.

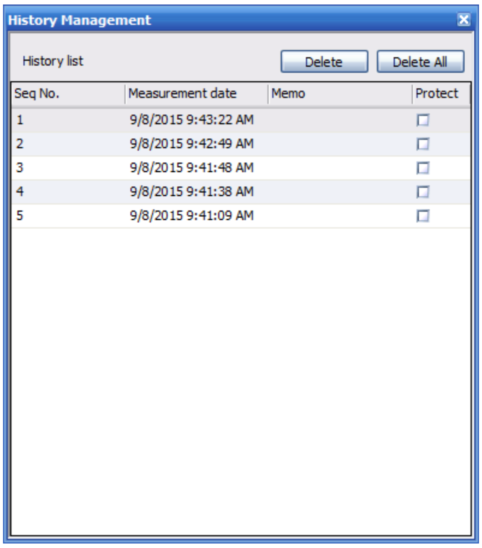
The display can be changed to show the current data or the data of the past 19 samplings by specifying a number or by clicking the Previous or Next button.

Current (1) Past (2 to 20)

If the collection conditions are changed, the history is cleared.

History management:

When the History Management button is clicked, the history management screen of the collected graph is displayed.



The display can be changed by selecting the row of the history number to be displayed.

Overwrite:

Clicking the Overwrite button will enable overwriting. In such cases, only the currently selected history is displayed in color, and the waveform of other histories is grayed out.

Using the graph history selection function, the past waveforms can be changed to a specific color.

Changes in tuning, etc., can be confirmed on the same graph screen.

Re-read:

By clicking the  button, it is possible to read the previous graph condition and data in the servo amplifier. It is possible to read the data by starting the graph (single-trigger mode), disconnecting the personal computer from the servo amplifier, and then connecting it again after the trigger.

Screen copy:

Click the  button to save the [Graph] screen, [FFT display] screen, [Torque characteristics diagram] screen, and [Scatter diagram] screen to the clipboard in bitmap format.
It can be pasted in other applications.
The graph screen can be easily pasted for creating documents, etc.

Grayout:

Click the  button to change the graph display to black lines on a white background.
When a screen with a normal black background colored graph is copied to a document and the document is printed, the print will not be clear (the waveform data will not be clearly visible). Use the grayout function in such cases.

Save as CSV file:

The graph data can be stored not in the usual graph format but as a CSV file. The graph data can be read by applications that support the CSV format.
CSV files cannot be read by the setup software.

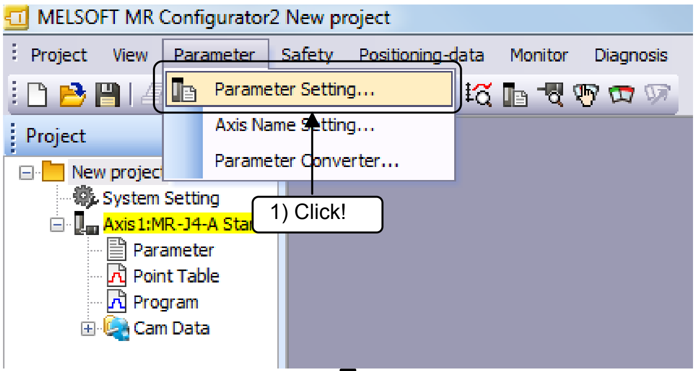
Save as image:

By selecting [File] - [Save image to file], the collected and set screen image is saved as an emf or JPEG file.

2.4.4 Other Functions

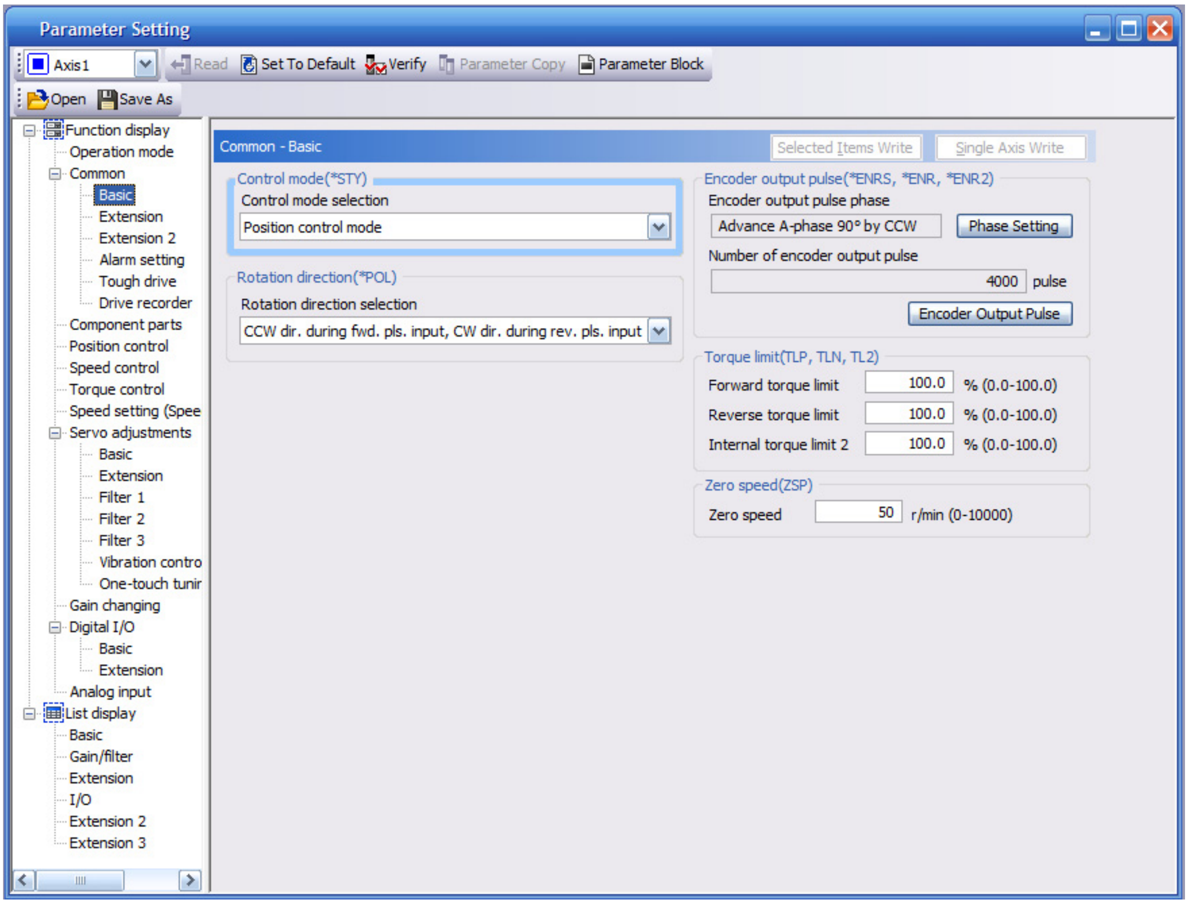
(1) Parameter setting

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) Click [Parameter] → [Parameter setting] from the menu.

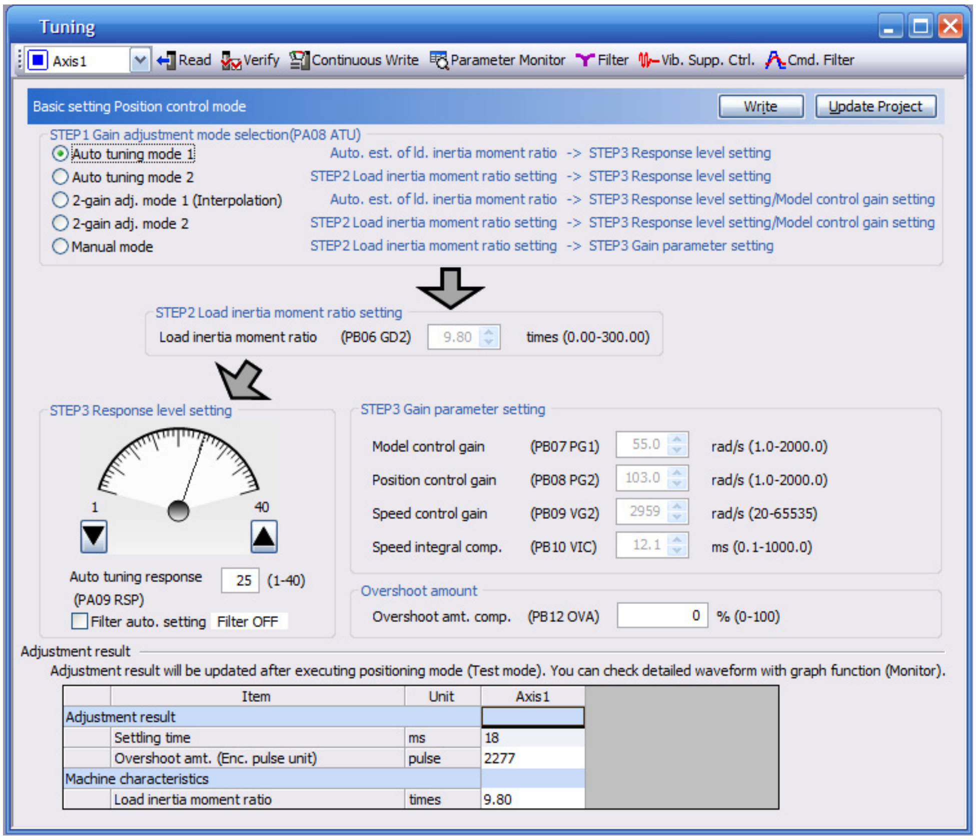
2) The following parameter setting window opens, and parameter reading, writing, or referencing can be done.
Set the training machine parameters.



(2) Tuning

Display method: In the menu bar, click [Adjustment] → [Tuning].

Function: In the tuning dialog box, adjust the gain parameter while viewing the graph to configure the settings so that the desired motion is achieved.

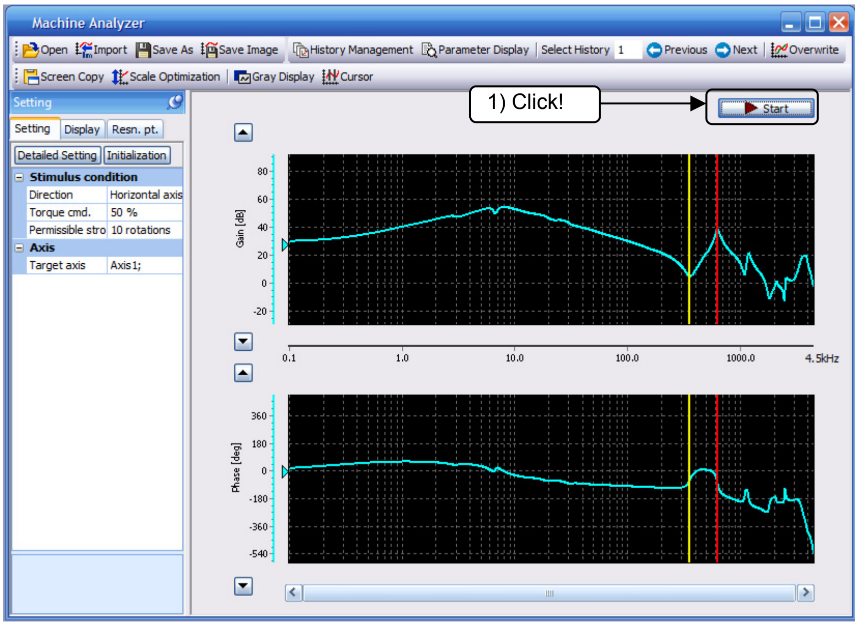


Item		Unit	Axis1
Adjustment result			
	Settling time	ms	18
	Overshoot amt. (Enc. pulse unit)	pulse	2277
Machine characteristics			
	Load inertia moment ratio	times	9.80

(3) Machine analyzer

Display method: In the menu bar, click [Adjustment] → [Machine analyzer].

The machine system and frequency features are displayed using Bode plot.
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.



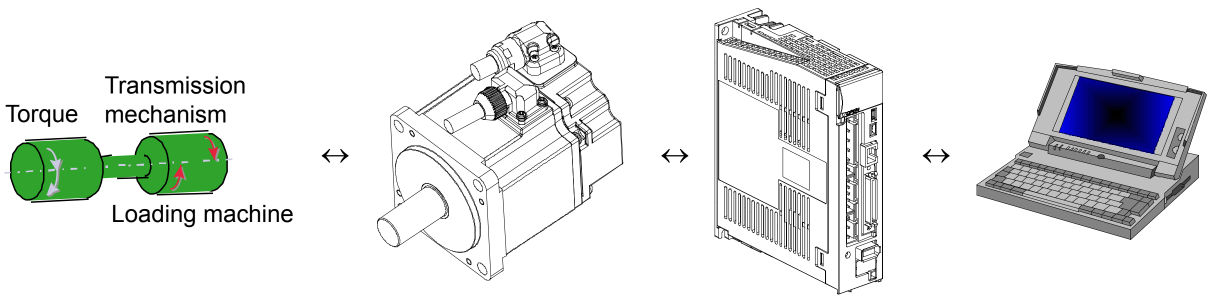
Operating procedure

(1) Set the machine analyzer
↓ Leave default
(2) Run the machine analyzer
↓ Click the Start button.
(3) Observe the waveform data
↓ Resonance point, anti-resonance point check
(4) Filter setting
↓ Not required if not resonating
(5) Save the file
↓ Click the Save As menu.
(6) Finish

* Details can be confirmed using Help.

Yellow line: Anti-resonance point; Red line: Resonance point

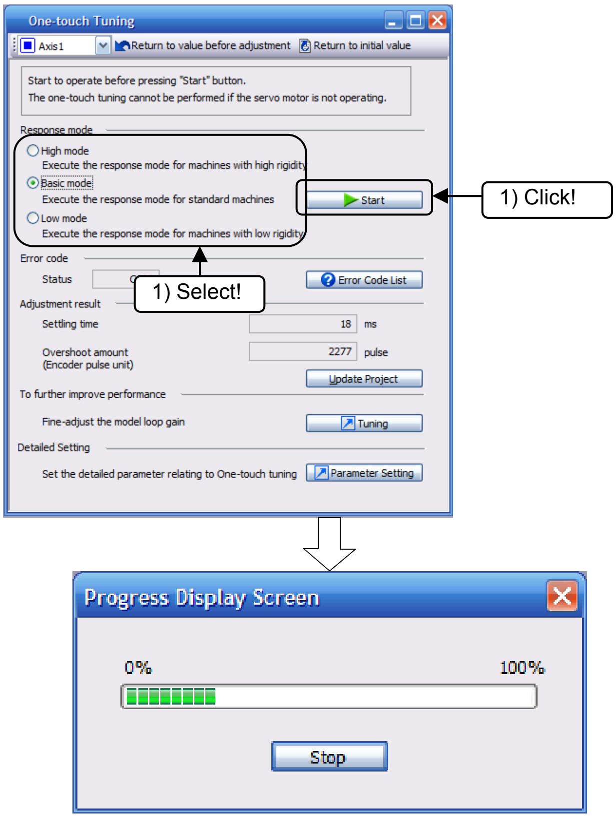
If the resonance frequency of the machine system can be measured, then the frequency of the machine resonance suppression filter (parameter number PB13, parameter number PB15) can be decided based on this result, and the machine vibration when gain increases can be controlled.



(4) One-touch tuning

Display method: In the menu bar, click [Adjustment] → [One-touch tuning].

The gain parameter is adjusted automatically.
The adjusted parameters are automatically written to the servo amplifier when one-touch tuning is completed.



1) Select the [One-touch tuning] response mode and click the  button.

2) The adjustment progress is displayed in the progress display screen as shown on the left during one-touch tuning. One-touch tuning is complete when the progress is 100%.

3) 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".

* Details can be confirmed using Help.

(5) Test operation (positioning operation)

Display method: In the menu bar, click [Test operation] → [Positioning operation].

POINT

- MR Configurator2 is required to perform positioning operation.
- When performing positioning operation, set EMG to ON.

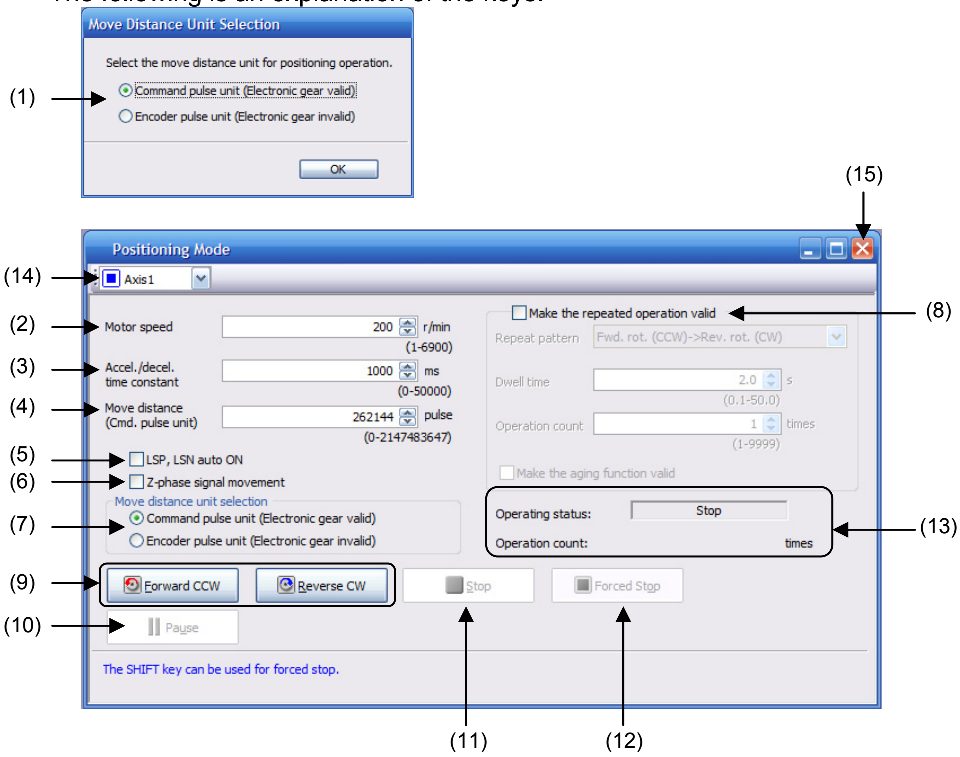
Positioning operation can be executed once when there is no command from an external controller.

(a) Operation/Drive

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	0 to permissible instantaneous speed
Acceleration and deceleration time constant [ms]	1000	0 to 50000
Travel distance [pulse]	4000	0 to 99999999

The following is an explanation of the keys.



(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.
The setting values and setting ranges are shown in the following table.

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 number of times [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 an operation number of times 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.

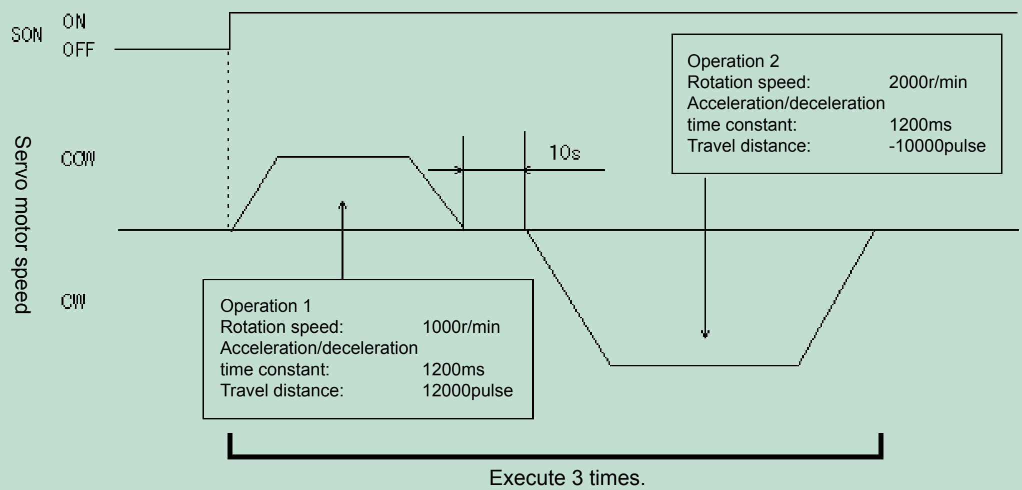
(b) Status display
The status display can be monitored even during positioning operation.

(6) Test operation (program operation)

Display method: In the menu bar, click [Test operation] → [Program operation].

(a) Program example

Press the <Start (G)> button to automatically set the SON to ON and start operation simultaneously.



Program

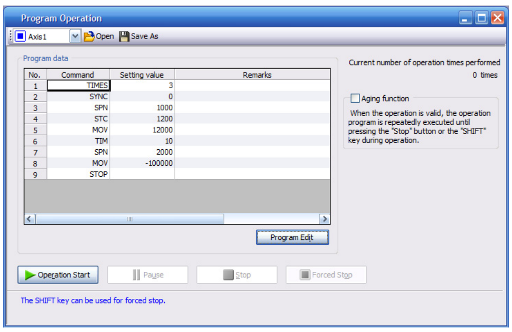
TIMES(3) -------------- Repeat the program 3 times up to STOP.
SYNC(0) --------------- Hold the execution of the program until the input signal setting 0 (SON) turns to ON.
SPN(1000) ------------- Set the command rotation speed to 1000 r/min. (Operation 1)
STC(1200) ------------- Set the acceleration/deceleration time constant to 1200 ms. (Operation 1)
MOV(12000) ------------ Travel 12000 pulses in the CCW direction. (Operation 1)
TIM(10) --------------- Wait 10 seconds for the next operation.
SPN(2000) ------------- Set the command rotation speed to 2000 r/min. (Operation 2)
MOV(-100000) ---------- Travel 100000 pulses in the CW direction. (Operation 2)
STOP

Describe the program in single-byte characters and enter a line break (press the <Enter> key) at the end of the line.

The acceleration/deceleration time 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.



(7) List of MR Configurator2 functions

This section indicates each MR Configurator2 menu and command.

A detailed description of the usage method for each command is given in the help function of the main software.

Initial window

Menu	Command	Main content
Project	New	Creates a new project.
	Open	Calls an existing project.
	Close	Closes an open project.
	Save	Overwrites and saves the open project.
	Save as	Saves the open project with a new name.
	Delete	Deletes the MR Configurator2 format project.
	Read other format file	Calls an MR Configurator format project.
	Write to other format file	Saves the project in the MR Configurator format.
	System settings	Sets the configuration of the hardware to be tuned (adjusted).
	Print preview	Shows a preview of the print result.
	Print	Prints the data, including parameter settings, graphs, data displays during alarm, and machine analyzer data.
	Exit MR Configurator2	Closes MR Configurator2.
Display	System	Open the project and select whether the system toolbars, such as for printing, are displayed.
	Call function	Select whether the toolbar for calling each function is displayed.
	Status bar	Select whether the status bar is displayed.
	Docking window	Select whether the docking window, servo assistant, or docking help functions are displayed.
Parameter	Parameter setting	Servo parameters can be displayed and edited.

~ Next page

Continue from previous page

Menu	Command	Main content
Monitor	Batch display	Displays each servo status items in numerical values.
	Input/output monitor indicator	Displays the status of the I/O signal, analog monitor, etc.
	Graph	Displays the servo status in a graph format.
	ABS data display	Checks the absolute position data in the absolute position detection system.
Diagnostics	Alarm display	Displays the details when an alarm or warning occurs in the current amplifier. Displays the history of past alarms or warnings in a list format.
	Data display in the event of an alarm	Displays the monitor data when an alarm or warning occurs in the current amplifier.
	No rotation reason display	Displays the reason why the servo motor is not running.
	System configuration display	Displays the system configuration information.
	Life diagnostics	Displays the life diagnostics information.
	Fully closed diagnostics	Displays the monitor and parameters related to the fully closed function.
	Linear diagnostics	Displays the monitor and parameters related to the linear function.
Test operation	JOG operation	Executes the JOG operation.
	Positioning operation	Executes the positioning operation.
	Motor-less operation	Executes the motor-less operation.
	DO forced output	Executes the DO forced output.
	Program operation	Executes the program operation.
	Test operation event information	Displays the start/end of operation, and the alarm and warnings during operation in a time series format.

Next page

Continue from previous page

Menu	Command	Main content
Adjustment	Tuning	Sets and adjusts the gain parameters.
	Machine analyzer	Executes the machine analyzer.
	Advanced gain search	Executes the advanced gain search.
Tool	Parameter setting range update	Retrieves the parameter setting range from the connected amplifier and updates the MR Configurator2 data file.
	Machine unit conversion settings	Sets the enable/disable settings for the machine unit conversion display and the unit/pulse/travel distance used in unit conversion.
Window	Cascade	Displays the screens in a cascade format.
	Tile vertically	Displays the screens in a vertical tiled format.
	Tile horizontally	Displays the screens in a horizontal tiled format.
	Arrange icons	Minimizes and arranges the screen icons.
	Close all windows	Closes all the displayed windows.
Help	MR Configurator2 help	Displays the MR Configurator2 help.
	Mitsubishi Electric FA Homepage	Displays the homepage of Mitsubishi Electric FA.
	Version information	Displays the version information.

3. Maintenance Countermeasure Design

It is necessary to consider the maintenance in the design stage in order to achieve a design that is less susceptible to malfunctions or accidents and is easily maintainable.

3.1 Preliminary Actions for Implementing Maintenance Countermeasures

(1) Adopt products with fewer malfunctions

To put it simply, products with high reliability should be used, but the following points should also be considered.

1) Is the manufacturer reliable?
2) Is the manufacturer accredited by various national and international standards?
3) Is the design simple?
4) Does the product have good performance with a low malfunction rate?
5) Is the industry reputation good?

(2) System design with good maintainability

The following points should be considered when designing a system that can be easily maintained.

1) Adopt an AC servo for which the parts and products are easily available.
2) Adopt an AC servo with high maintainability, such as one that has self-diagnosis functions, etc.
3) Adopt an AC servo whose parameters can be easily read, changed, and saved.
4) Design the system so that defects are automatically displayed.
5) Design in a space where maintenance, inspection, and repair work can be carried out easily.
6) Design the system so that the parts replacement, product replacement, wiring change, etc., can be carried out easily.

Memo

4. Preventive Maintenance

Preventive maintenance consists of daily maintenance/inspection and periodic maintenance/inspection.

4.1 Necessity of Preventive Maintenance

A high availability of equipment cannot be ensured if repairs are performed after the occurrence of a production system malfunction.
Because preventing malfunctions and the stopping of equipment are top priorities, if preventive maintenance is reliably performed, prevention of catastrophic malfunctions becomes possible, and recovery from malfunctions will be quick.

4.2 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 shut 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.

4.3 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.

Table 4.1 Daily and periodic inspection

Area of inspection	Check item	Check points	Inspection interval: Daily	Inspection interval: Periodically	Check method	Judgment criteria	Instrument
General	Environment	Check ambient temperature, humidity, dust, etc.	○				Thermometer, hygrometer, recorder
General	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	General devices	Check for unusual vibrations and noise.	○		Auditory and visual check	No fault should be found.	-
General	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.	
Main circuit	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.	
Main circuit	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
Main circuit	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
Main circuit	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

Area of inspection	Check item	Check points	Inspection interval: Daily	Inspection interval: Periodically	Check method	Judgment criteria	Instrument
Control circuit protection circuit	Operation check	(1) Check the output voltage balance of each phase with only the servo unit (no load) operating. (2) Check for faults in the protection/display circuit by performing the sequence protection operation.		○ ○	(1) Measure the voltage between servo amplifier output terminal phase U, V, and W. (2) Simulate shortening of the protection circuit output of the servo amplifier.	(1) Inter-phase voltage balance is within 4 V. (2) There is a faulty operation in the sequence.	Digital multimeter Rectifier-type voltmeter
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.	

Memo

5.1 Troubleshooting

For details regarding troubleshooting, refer to "MELSERVO-J4 Servo Amplifier Instruction Manual (Troubleshooting) SH-030109".
This instruction manual (troubleshooting) shall be distributed during this AC Servo Maintenance course.

5.2 Troubleshooting Using Training Machine

Troubleshooting is carried out using the training machine.
Check the phenomenon by following the procedures and taking the appropriate action.

5.2.1 Motor Does Not Rotate <Torque Limit>

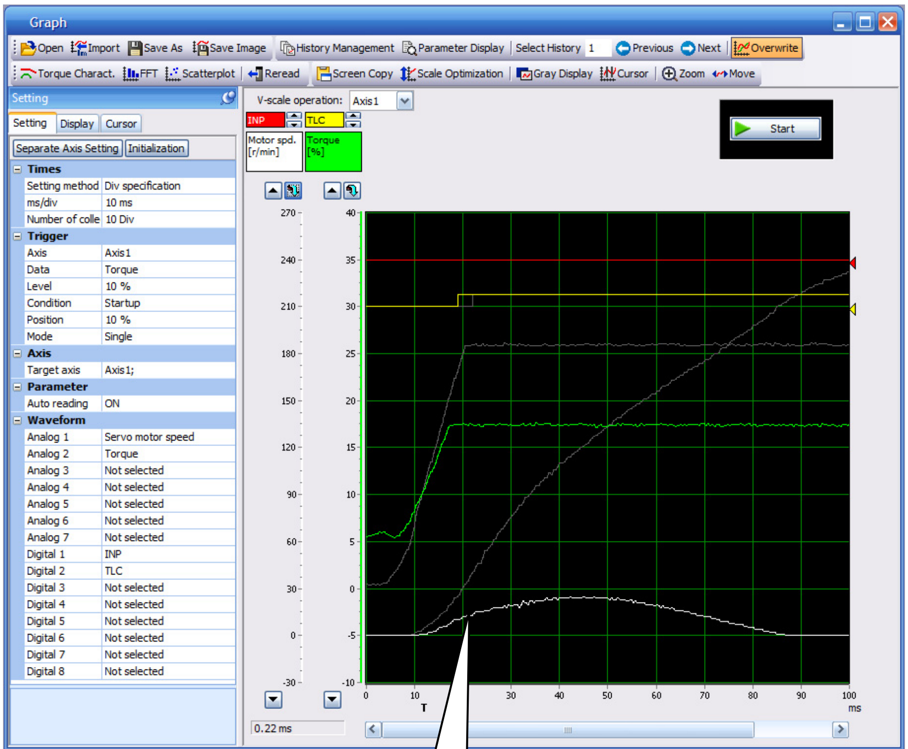
Set speed mode PA01 to 1002 (after setting, enable by turning the training machine NF to ON/OFF) and check whether the belt is rotating correctly in the forward or reverse direction with speed selection 2.

Next, change the initial value of PA11 or PA12 (forward or reverse rotation torque limit) from 100% to 7%.

With forward/reverse rotation, speed selection 2, or analog speed specification (VC), the zero speed detection and limiting torque LED may turn on and off, and the belt may perform awkwardly as noted by the belt moving and stopping.

(1) Action
Raise the speed/torque limit values.

Trigger torque start-up using MR Configurator2, and compare using the graph overlay when the torque limit is reached and when the torque limit is not reached.



Confirm that the torque limit value is not exceeded.

SUPPLEMENT

Set PA11 or PA12 (forward or reverse rotation torque limit) to the initial value (100%), turn the torque limit selection switch of the training machine to ON, and verify that the torque limit is applied even on the analog torque limit potentiometer.

Also, in the monitor batch display of MR Configurator2, check the level value where the torque limit (TLC ON timing) is applied.

* After completion of training, return the torque limit selection switch to OFF.

POINT

- Torque limit is used in stop-on contact devices such as presses, screw-tighteners, and stroke limiters.

(2) Cause
It is not possible to obtain the torque necessary for acceleration with the torque limit.

5.2.2 E1 and AL. 50 Display <Overload 1 from Overload Warning 1>

Turn the load ON at 3000 r/min in speed mode, turn the load potentiometer to the right, and apply 200% or more of the load.

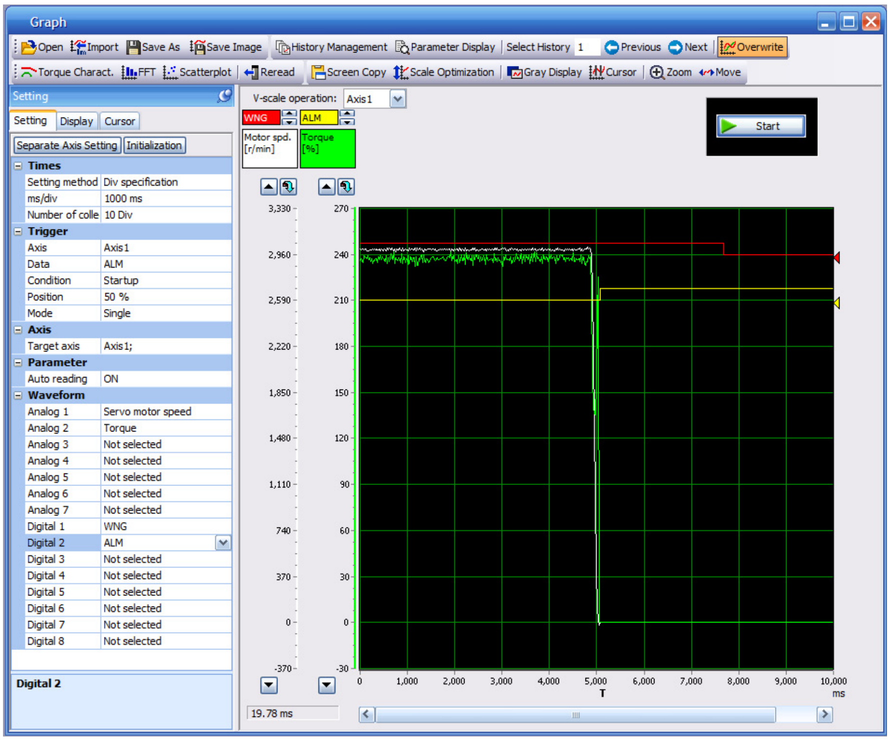
After a while, the servo amplifier display will flash from "E1" to "AL. 50" and the main circuit power supply will turn OFF.

(1) Action

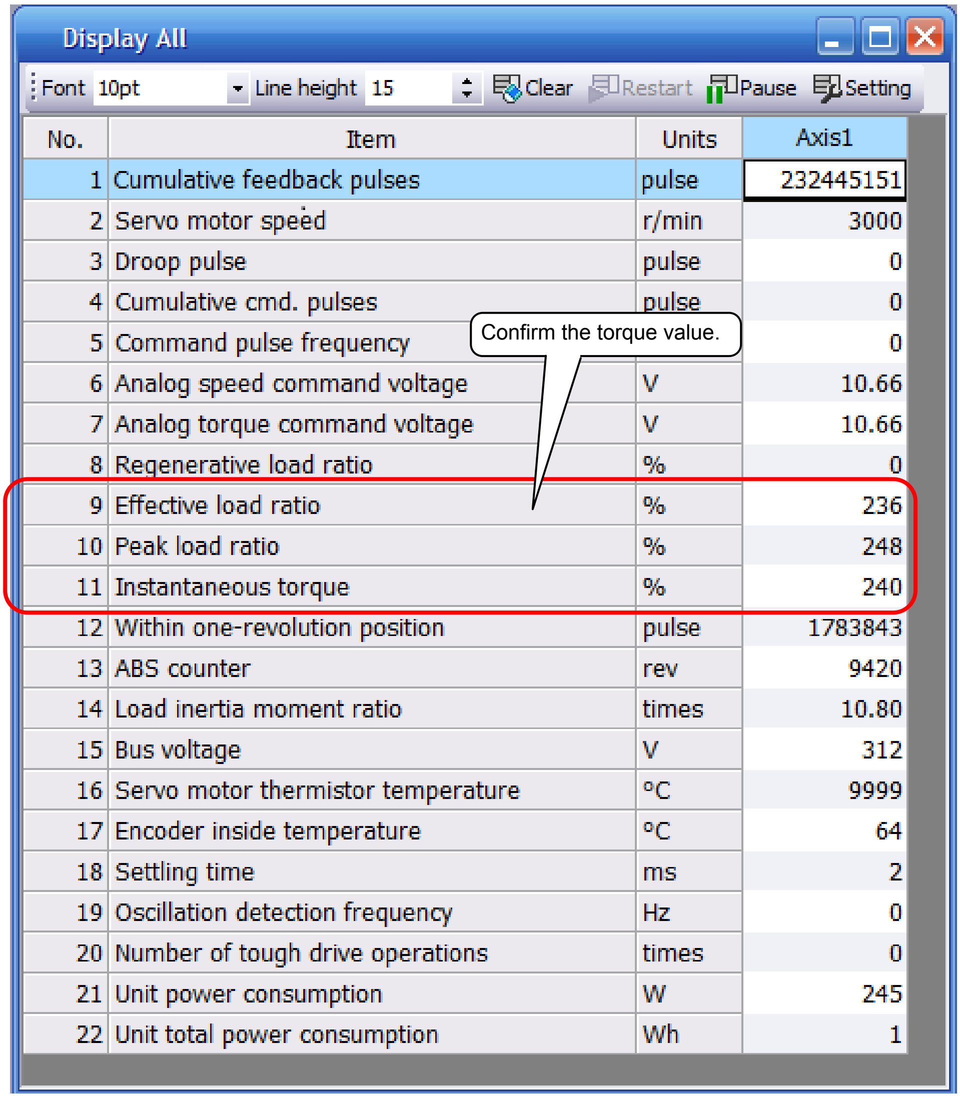
Check along the lines of table "Alarm No: 50" in the MELSERVO-J4 servo amplifier instruction manual (troubleshooting).

Because a state of overload is attained due to mechanical factors, reduce the load potentiometer.

Using MR Configurator2, check the torque value when the WNG signal displaying E1 and the ALM signal displaying AL. 50 are output, and check the torque value by triggering WNG signal start-up.



Check the load factor and the torque value from the MR Configurator2 monitor batch display.



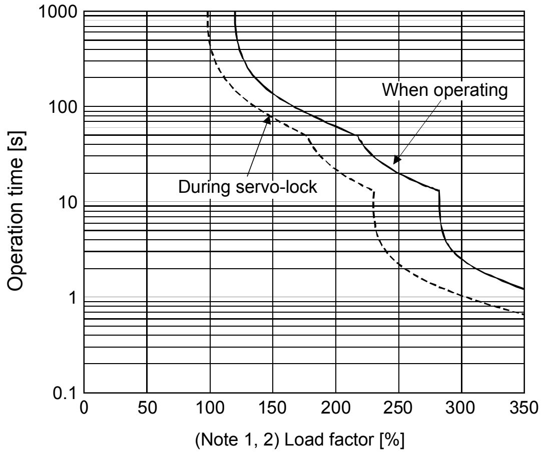
No.	Item	Units	Axis1
1	Cumulative feedback pulses	pulse	232445151
2	Servo motor speed	r/min	3000
3	Droop pulse	pulse	0
4	Cumulative cmd. pulses	pulse	0
5	Command pulse frequency		0
6	Analog speed command voltage	V	10.66
7	Analog torque command voltage	V	10.66
8	Regenerative load ratio	%	0
9	Effective load ratio	%	236
10	Peak load ratio	%	248
11	Instantaneous torque	%	240
12	Within one-revolution position	pulse	1783843
13	ABS counter	rev	9420
14	Load inertia moment ratio	times	10.80
15	Bus voltage	V	312
16	Servo motor thermistor temperature	°C	9999
17	Encoder inside temperature	°C	64
18	Settling time	ms	2
19	Oscillation detection frequency	Hz	0
20	Number of tough drive operations	times	0
21	Unit power consumption	W	245
22	Unit total power consumption	Wh	1

(2) Cause

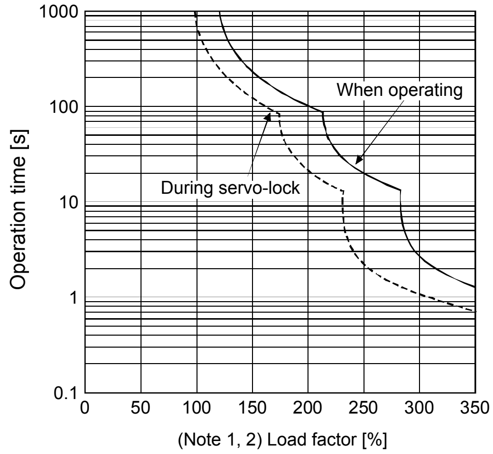
Continuous operation is carried out at a torque exceeding the rated torque.

POINT

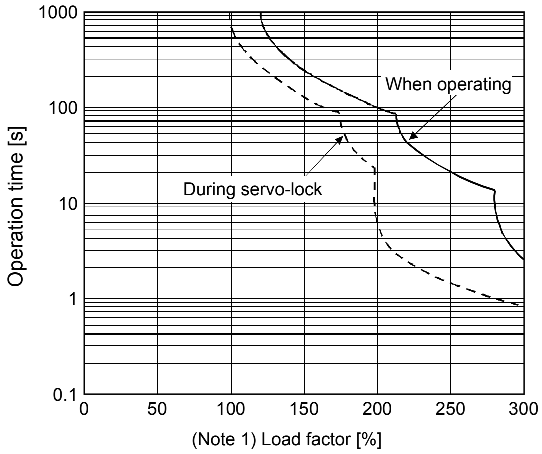
- The overload 1 alarm (AL. 50) display timing is decided from the electronic thermal protection curve (relationship between the operating time and the load factor).
  The servo amplifier is equipped with an electronic thermal for protecting the servo motor, the servo amplifier, and the servo motor power cable from overload.
  [AL. 50 Overload 1] occurs if the overload operation is performed above the electronic thermal protection curve shown in the following figure, and [AL. 51 Overload 2] occurs if the maximum current continues to flow for a few seconds due to mechanical collision, etc. Use in the area on the left side of the solid or broken line in the graph.
  In machines that generate unbalanced torque like an elevated axis, it is recommended that the unbalanced torque be used at 70% of the rated torque or less.
  This servo amplifier has built-in servo motor overload protection functions. (The servo motor overload current (full load current) is established with 120% of the servo amplifier rated current as a reference value.)



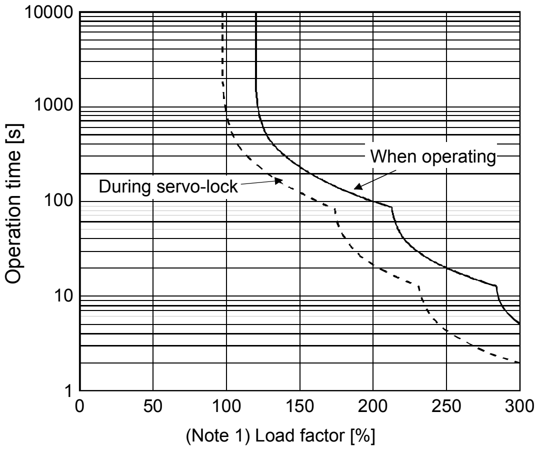
HG-KR053, HG-KR13
HG-MR053, HG-MR13



HG-KR23, HG-KR43, HG-KR73
HG-MR23, HG-MR43, HG-MR73
HG-SR51, HG-SR81, HG-SR52, HG-SR102



HG-SR121, HG-SR201, HG-SR152, HG-SR202,
HG-SR301, HG-SR352



HG-SR421, HG-SR502, HG-SR702

Note 1: When the servo motor is stopped (servo-lock state) or is operating at a low speed of 30 r/min or less, and an operation generating a torque of 100% or more of the rated torque is carried out at an abnormally high frequency, there is a possibility that the servo amplifier may malfunction even though it is within the electronic thermal protection.

2. A load factor of 300% to 350% is for HG-KA servo motors.

Electronic thermal protection characteristics

5.2.3 AL. 51 Display <Overload 2>

Set the [Operate] mode PA01 to 1000 (after setting, enable by turning the training machine NF to OFF/ON), turn the load ON and turn the load potentiometer to the right to apply 200% or more of the load.

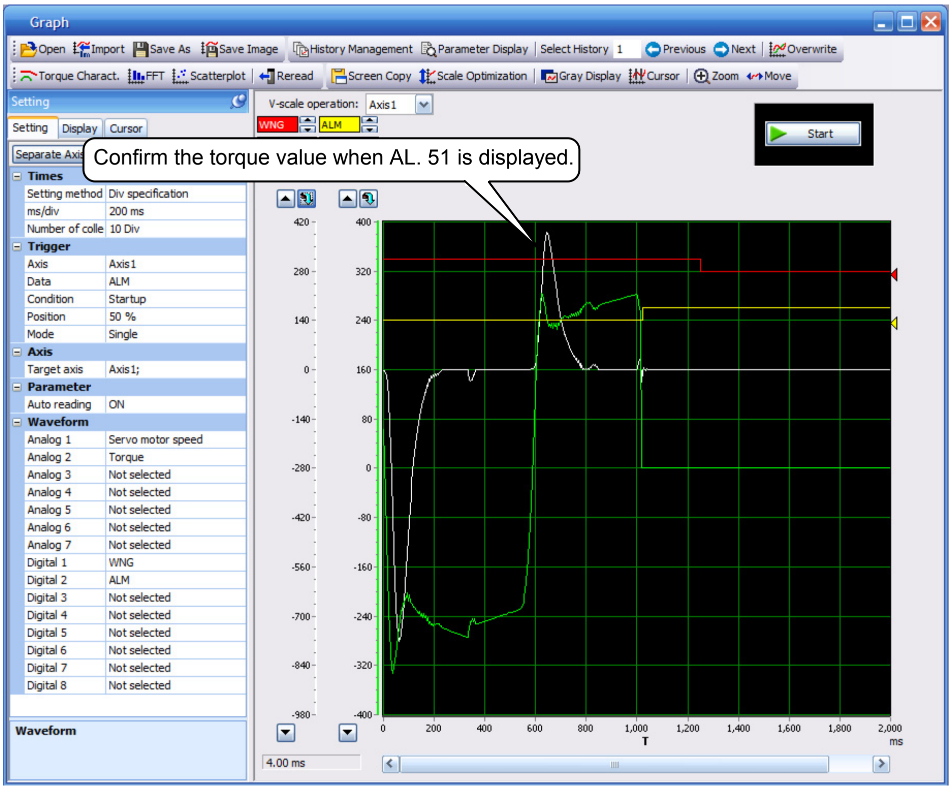
After starting in auto mode and operating several times, the servo amplifier display flashes from "E1" to "AL.51", and the main circuit power supply is turned OFF.

(1) Action

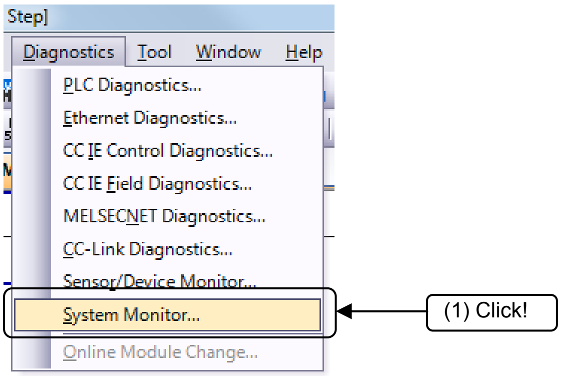
Check along the lines of table "Alarm No: 51" in the MELSERVO-J4 servo amplifier instruction manual (troubleshooting).

Because a state of overload is attained due to mechanical factors, reduce the load potentiometer.

Using MR Configurator2, check the torque value when the ALM signal displaying AL. 51 is output, and check the torque value by triggering ALM signal start-up.

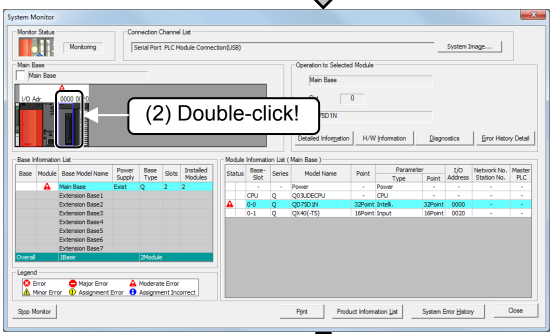


In addition, because AX1 and ERR are flashing on the programmable controller positioning module QD75D1N display, verify that the Ready signal from the drive unit is OFF from the error history of GX Works2 via USB.



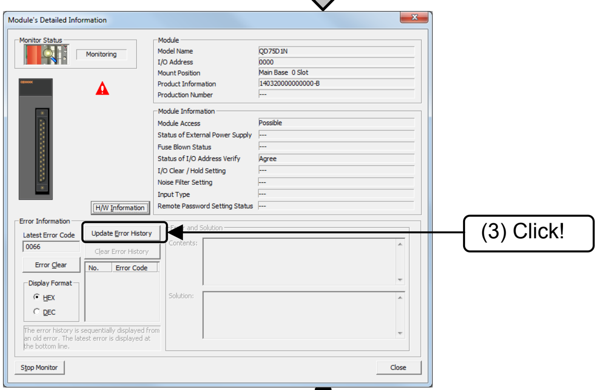
(1) Click [Diagnostics] - [System monitor] on GX Works2.

The system monitor dialog box will be displayed.

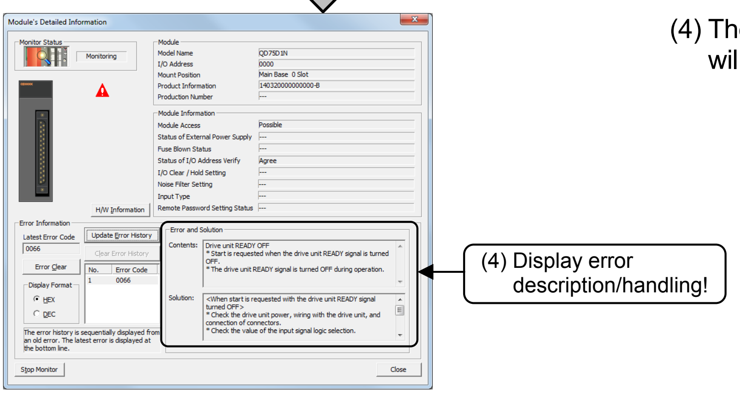


(2) Double click positioning module QD75D1N on the screen.

The module detailed information dialog box will be displayed.



(3) Click [Update error history].



(4) The error contents and corrective actions will be displayed.

(2) Cause
The maximum current continued to flow for a few seconds.

5.2.4 AL. 52 Display <Error Excessive>

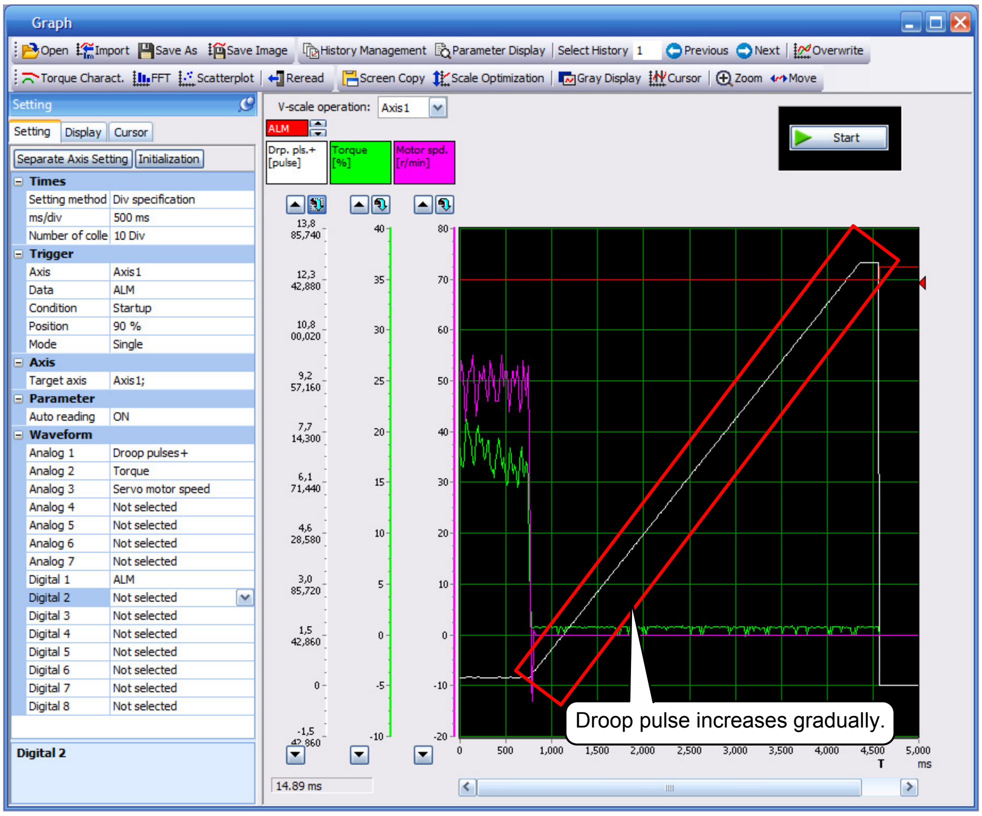
Turn ON the torque limit selection switch in the positioning mode, and check the AL. 52 flashing display by performing manual, forward, or reverse JOG operation when the torque limit is imposed using the analog torque limit potentiometer.

(1) Action

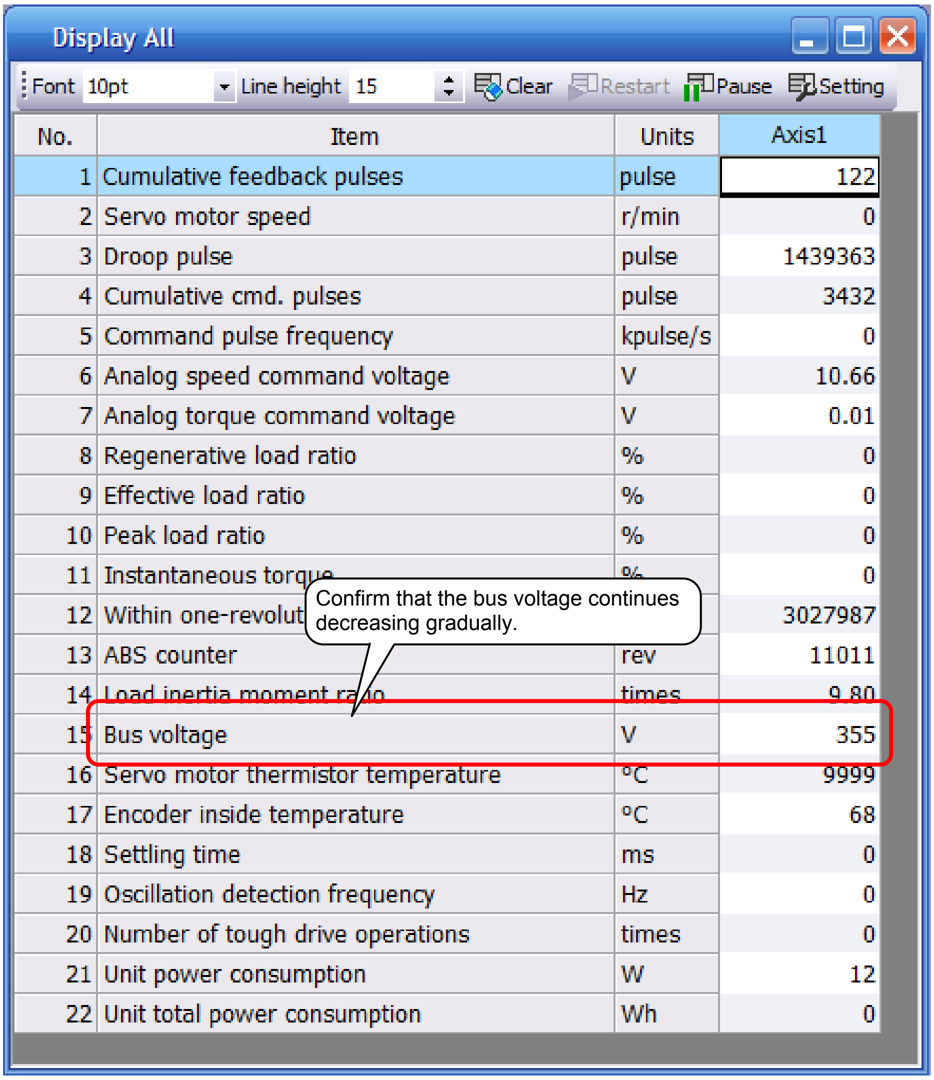
Check along the lines of table "Alarm No: 52" in the MELSERVO-J4 servo amplifier instruction manual (troubleshooting).

Because insufficient torque has resulted at the time of acceleration, loosen the analog torque limit potentiometer to increase the torque limit value.

Using MR Configurator2, check the droop pulse when the ALM signal displaying AL. 52 is output, and check the droop pulse by triggering ALM signal start-up.



Also, on the MR Configurator2 monitor batch display, verify that the droop pulse value gradually increases.



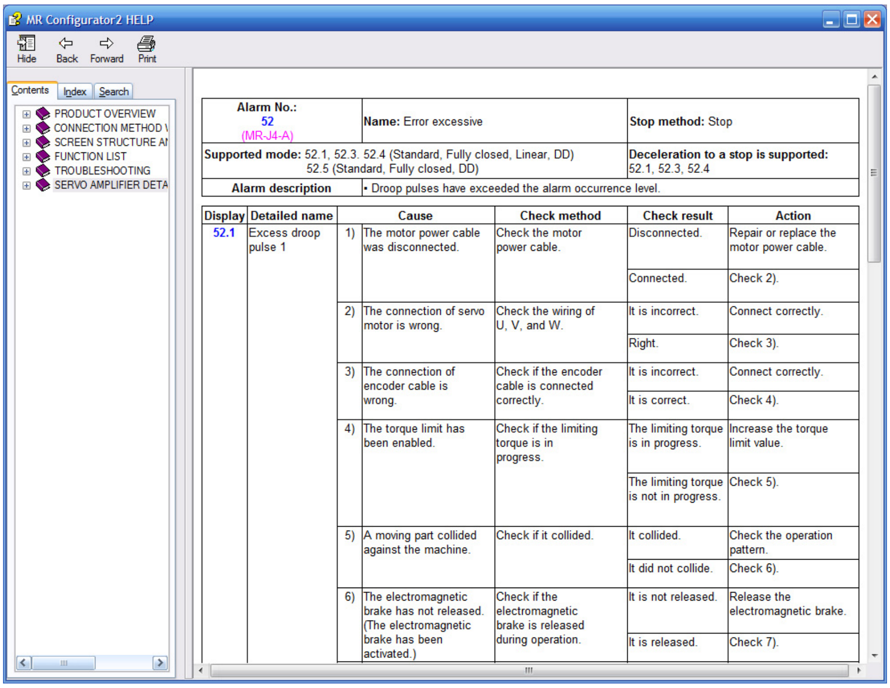
No.	Item	Units	Axis1
1	Cumulative feedback pulses	pulse	122
2	Servo motor speed	r/min	0
3	Droop pulse	pulse	1439363
4	Cumulative cmd. pulses	pulse	3432
5	Command pulse frequency	kpulse/s	0
6	Analog speed command voltage	V	10.66
7	Analog torque command voltage	V	0.01
8	Regenerative load ratio	%	0
9	Effective load ratio	%	0
10	Peak load ratio	%	0
11	Instantaneous torque	%	0
12	Within one-revolut		3027987
13	ABS counter	rev	11011
14	Load inertia moment ratio	times	9.80
15	Bus voltage	V	355
16	Servo motor thermistor temperature	°C	9999
17	Encoder inside temperature	°C	68
18	Settling time	ms	0
19	Oscillation detection frequency	Hz	0
20	Number of tough drive operations	times	0
21	Unit power consumption	W	12
22	Unit total power consumption	Wh	0

(2) Cause

Deviation between the model position and the actual servo motor position exceeds three rotations.

POINT

- Detailed information can be accessed by clicking [Help] - [MR Configurator2 help] in MR Configurator2, selecting [List of Alarms and Warnings] from the table of contents, and then clicking the alarm number.



Alarm No.: 52 (MR-J4-A)	Name: Error excessive	Stop method: Stop
Supported mode: 52.1, 52.3. 52.4 (Standard, Fully closed, Linear, DD) 52.5 (Standard, Fully closed, DD)		Deceleration to a stop is supported: 52.1, 52.3, 52.4
Alarm description	• Droop pulses have exceeded the alarm occurrence level.	

Display	Detailed name	Cause	Check method	Check result	Action
52.1	Excess droop pulse 1	1) The motor power cable was disconnected.	Check the motor power cable.	Disconnected.	Repair or replace the motor power cable.
				Connected.	Check 2).
		2) The connection of servo motor is wrong.	Check the wiring of U, V, and W.	It is incorrect.	Connect correctly.
				Right.	Check 3).
		3) The connection of encoder cable is wrong.	Check if the encoder cable is connected correctly.	It is incorrect.	Connect correctly.
				It is correct.	Check 4).
		4) The torque limit has been enabled.	Check if the limiting torque is in progress.	The limiting torque is in progress.	Increase the torque limit value.
				The limiting torque is not in progress.	Check 5).
		5) A moving part collided against the machine.	Check if it collided.	It collided.	Check the operation pattern.
				It did not collide.	Check 6).
		6) The electromagnetic brake has not released. (The electromagnetic brake has been activated.)	Check if the electromagnetic brake is released during operation.	It is not released.	Release the electromagnetic brake.
				It is released.	Check 7).

* After completion of training, return the torque limit selection switch to OFF.

5.2.5 AL. 10 Display <Undervoltage>

With the main circuit power supply ON and the servo ON, turn the main circuit power supply OFF.
After a while, check whether AL. 10 is displayed.

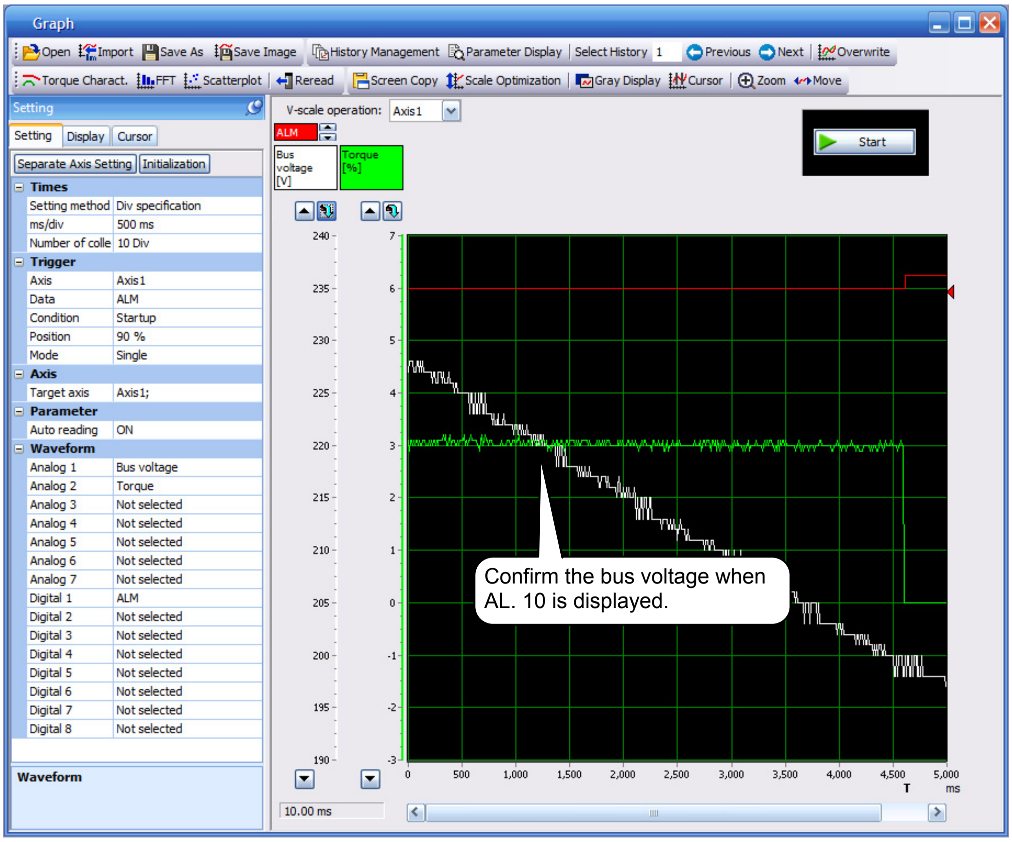
(1) Action

Check along the lines of table "Alarm No: 10" in the MELSERVO-J4 servo amplifier instruction manual (troubleshooting).

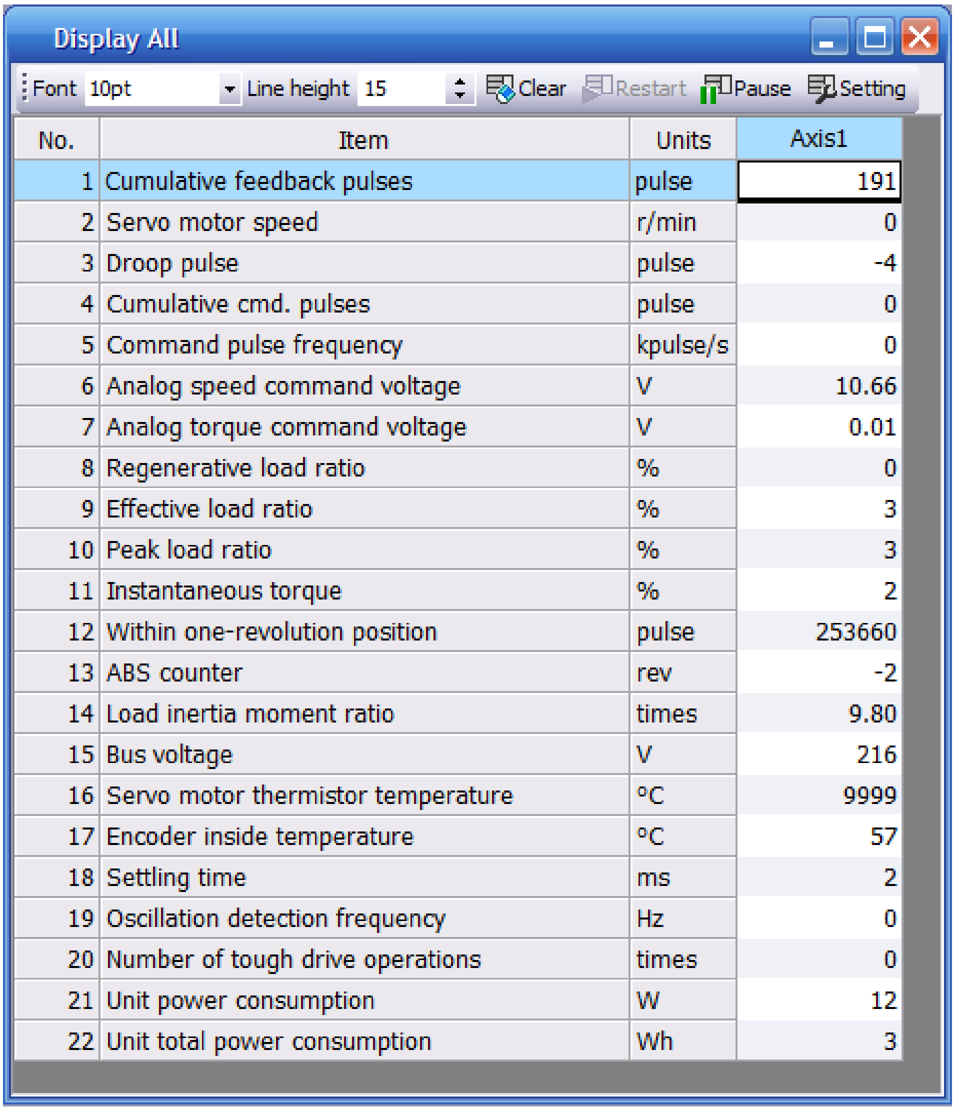
Check the bus voltage in MR Configurator2, and if it is 200 V or less, the main circuit voltage has dropped.

Turn the servo OFF, and after resetting, turn ON the main circuit power supply followed by the servo.
When the main circuit power supply is turned OFF from a status with the main circuit power supply ON and the servo ON, the time and bus voltage will decrease gradually.

Trigger ALM start-up using MR Configurator2, and verify that the bus voltage level when AL. 10 output timing is 200 V.



Also, on the MR Configurator2 monitor batch display, verify that the bus voltage value gradually increases.



No.	Item	Units	Axis1
1	Cumulative feedback pulses	pulse	191
2	Servo motor speed	r/min	0
3	Droop pulse	pulse	-4
4	Cumulative cmd. pulses	pulse	0
5	Command pulse frequency	kpulse/s	0
6	Analog speed command voltage	V	10.66
7	Analog torque command voltage	V	0.01
8	Regenerative load ratio	%	0
9	Effective load ratio	%	3
10	Peak load ratio	%	3
11	Instantaneous torque	%	2
12	Within one-revolution position	pulse	253660
13	ABS counter	rev	-2
14	Load inertia moment ratio	times	9.80
15	Bus voltage	V	216
16	Servo motor thermistor temperature	°C	9999
17	Encoder inside temperature	°C	57
18	Settling time	ms	2
19	Oscillation detection frequency	Hz	0
20	Number of tough drive operations	times	0
21	Unit power consumption	W	12
22	Unit total power consumption	Wh	3

(2) Cause

Power was restored after the bus voltage (between P and N) dropped to 200 V with the servo ON.

POINT

- This time, the main circuit power supply is turned OFF. However even the main circuit is ON, AL. 10 frequently occurs when the power situation is poor, thus countermeasures for stable power supply are desirable.

5.2.6 AL. 52 Display <Output Phase Loss>

After checking that the servo is OFF, display the LED by pressing AL. 52 switch on the back of the training machine. (Because a normally closed contact is used, the phase U between the amplifier and the motor becomes disconnected.)

By turning the servo ON and enabling the load setting (50% or more of the load) and manual, forward, reverse, or JOG operation, check whether AL. 52 is displayed without motor rotation.

(1) Action
Along with the troubleshooting for "Alarm code [52] generated", check for an open phase status from the disconnection of phase U between the servo amplifier and the motor.

* After verifying that the servo is turned OFF after the completion of practical work, press the AL. 52 switch on the back of the training machine to turn off the LED display.

5.2.7 AL. 20 Display <Detector Error>

Press the AL. 20 switch on the back of the training machine, disconnect the encoder cable P5 terminal, and check whether AL. 20 is displayed (only with control power-on).

(1) Action
Along with the troubleshooting for "Alarm code [20] generated", check whether the P5 terminal of encoder connector CN2 is disconnected.

5.2.8 AL. E9 Display <Main Circuit Off Warning>

When the servo is turned ON from a status with training machine NF OFF→ON and the main circuit power supply OFF, check whether AL. E9 is displayed if there is no bus voltage.

(1) Action
Along with the troubleshooting for "Warning core [E9] generated", turn ON the main circuit power supply.

POINT
● Because "E9" is frequently generated due to the servo being turned ON accidentally with the main circuit power supply OFF, a warning is displayed.

Memo

6. Maintenance for Improvement

In order to improve the maintainability of the production system, it is necessary to reduce the deterioration of the equipment and to facilitate the execution of maintenance work.

6.1 Equipment Maintainability Improvement

(1) Improvement for reducing equipment deterioration

1) Review the working environment and apply improvements, such as ventilating or air-conditioning, so that the equipment does not deteriorate abnormally.
2) Apply improvements for preventing abnormal deterioration of equipment by implementing dust-proofing, moisture-proofing, and anti-vibration countermeasures.
3) Replace any equipment presumed to be deteriorating at a faster rate with more durable equipment.

(2) Perform improvements so as to enable easy repairs

1) Improve the equipment structure.
2) Perform improvements so as to secure a repair space.
3) Change to products and parts that can be easily repaired.

(3) Change to products with fewer malfunctions

1) Change to products that have a low malfunction rate and high reliability.

Memo

7. Review of Equipment Environment

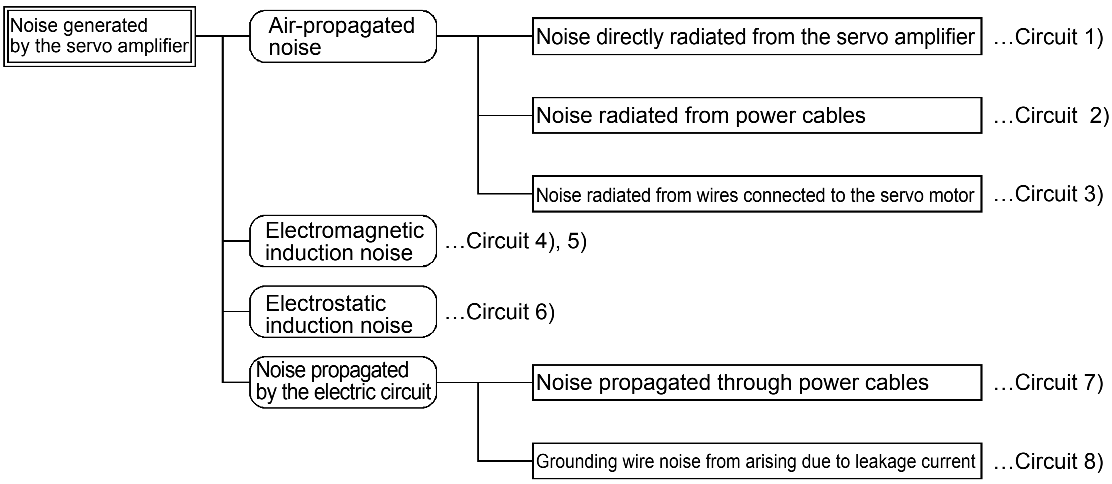
7.1 Noise Reduction Techniques

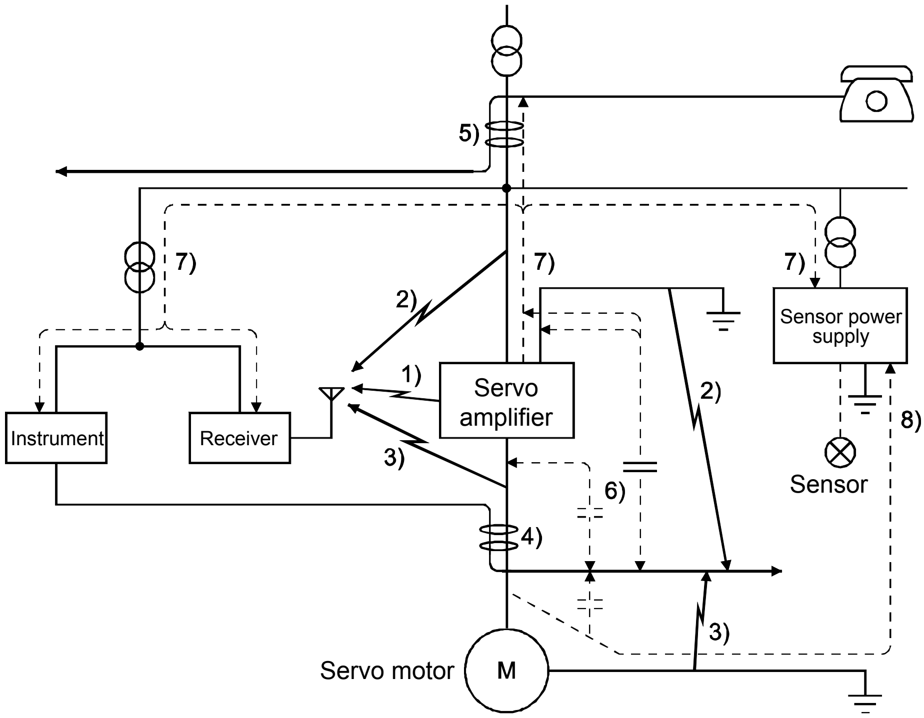
There are two types of noise, noise that penetrates the servo amplifier from the outside and causes a malfunction, and noise that radiates from the servo amplifier and causes the peripheral equipment to malfunction. The following measures must be taken because the servo amplifier is an electronic device that handles weak signals.
Also, the servo amplifier output is subjected to chopping by high carrier frequencies, leading to noise. If this noise generation causes the peripheral equipment to malfunction, implement countermeasures for noise suppression. These countermeasures change slightly depending on the path of noise propagation.

(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.



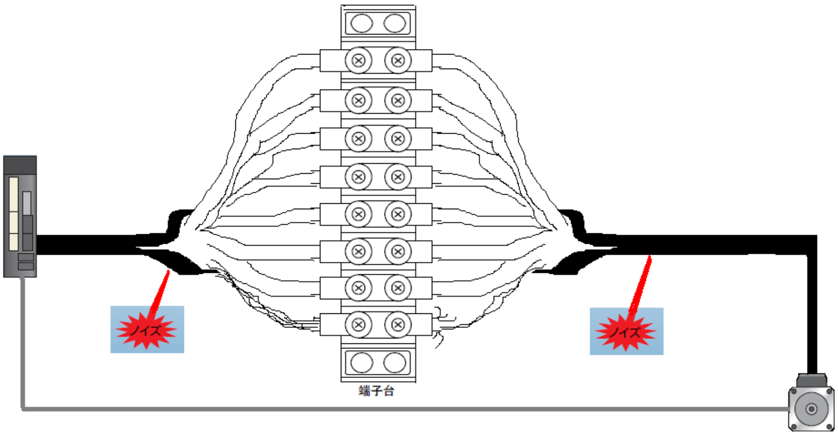


Noise transmission path	Countermeasures
1), 2), 3)	When devices that handle weak signals and that are liable to malfunction due to electromagnetic noises, (e.g., instruments, receivers, and sensors) are contained in the enclosure that contains the servo amplifier, or when their signal cables run near the servo amplifier, the devices may malfunction due to air-propagated electromagnetic noises. Therefore, the following countermeasures must be taken. 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)	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. 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 wire as signal cables and power cables, and insert them into individual metal ducts.
7)	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. 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)	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.

Fault example (1): Extension of the encoder cable

[Fault description]
For equipment requiring 30 m for the encoder cable, MR-J3ENSCBL20M-H was newly purchased in addition to MR-J3ENSCBL10M-H, which had already been purchased, and a terminal block was used to join the two.
Although there was no problem at first after installation, error excessive AL52 sometimes occurred.

[Cause of fault]
The wiring in the shielded portion of the terminal block at the joint was on the brink of becoming disconnected.



[Countermeasure against fault]
The encoder cable was changed to MR-J3ENSCBL30M-H.

POINT
● When the encoder cable needs to be longer than 50 m, standard cables will not suffice. Because there are differences in the wiring and parameter setting values, consult with the closest dealer.

Fault example (2): Communication error 1

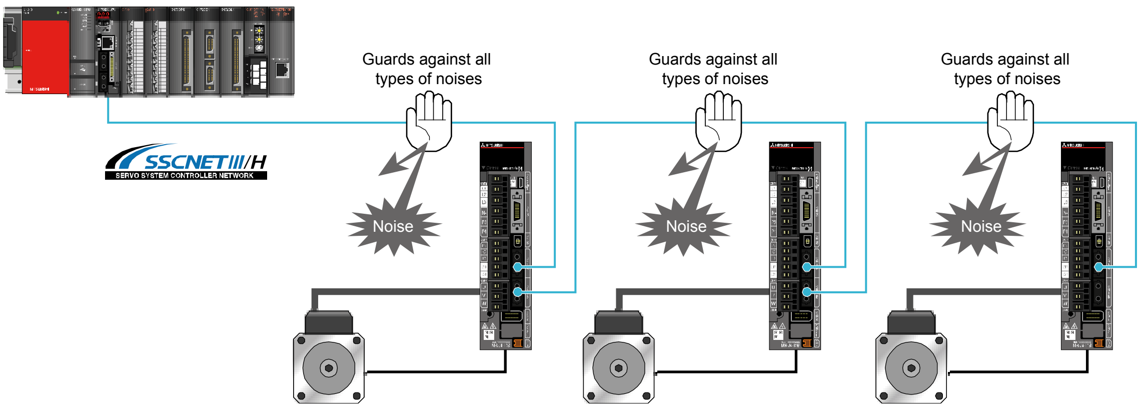
[Fault description]
Devices supplied to the customer were setup parallel to the robot welding line, and position mismatches sometimes occurred.
Implementation of noise reduction techniques were requested, but they could not be implemented due to the cost.

[Cause of fault]
Noise

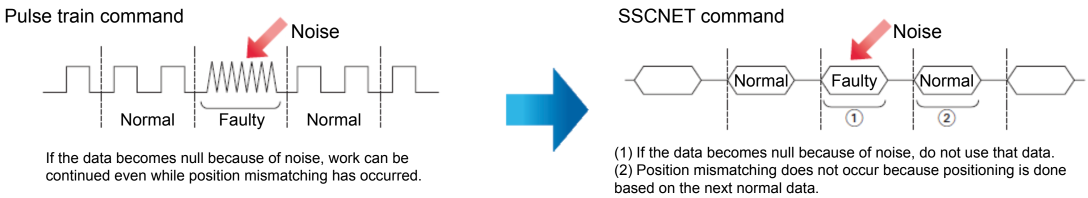
[Countermeasure against fault]
J4A was changed to J4B, and communication cable was changed from metal to optic fiber.

(Reference documents) *Extracted from the catalog

- Improvements in noise immunity: Optic fiber cables are being used in SSCNET III/H. This has significantly improved noise immunity, including against noise that is mixed from the power cable or from external devices.



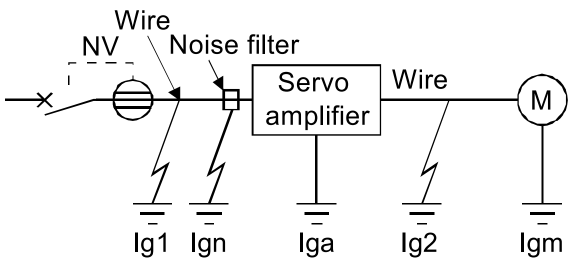
- Improvements in reliability: SSCNET, used for data communication, is highly precise and reliable. Even if there are communication problems, the subsequent normal data is used without using the present data, which results in the errors not becoming cumulative.



7.2 Leakage Current

(1) Selection method for the earth-leakage current breaker
Chopper currents of high frequencies controlled by the PWM flow to the AC servo. Leakage current that contains high frequencies 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 by a distance of at least 30 cm.

Rated sensitivity current ≥ 10 * (Ig1 + Ign + Iga + K * (Ig2 + Igm)) [mA] (7.1)



Earth-leakage current breaker		K
Type	Proprietary product	
Products compatible with harmonics/surges	NV-SP NV-SW NV-CP NV-CW NV-HW	1
General products	BV-C1 NFB NV-L	3

Ig1: Leakage current on the electric path from the earth-leakage current breaker to the servo amplifier input terminal (obtain from Figure 7.1)
Ig2: Leakage current on the electric path from the servo amplifier output terminal to the servo motor (obtain from Figure 7.1)
Ign: Leakage current when a filter is connected on the input side (4.4 mA for one piece for FR-BIF)
Iga: Leakage current of servo amplifier (obtain from Table 7.2)
Igm: Leakage current of servo motor (obtain from Table 7.1)

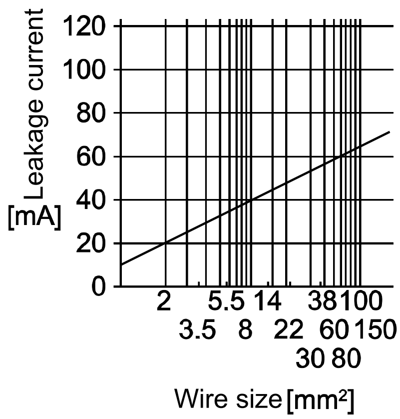


Figure 7.1 Leakage current example per 1 km with CV cables with metal wiring (Ig1, Ig2)

Table 7.1 Leakage current example of servo motor (Igm)

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

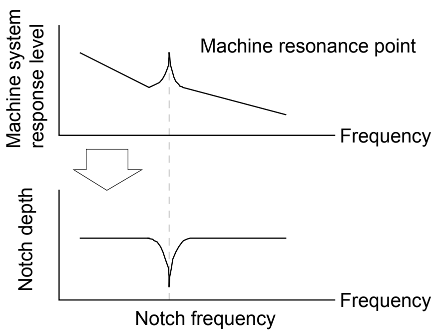
Table 7.2 Leakage current example of servo amplifier (Iga)

Servo amplifier capacity [kW]	Leakage current [mA]
0.1 to 0.6	0.1
0.75 to 3.5	0.15
5, 7	2

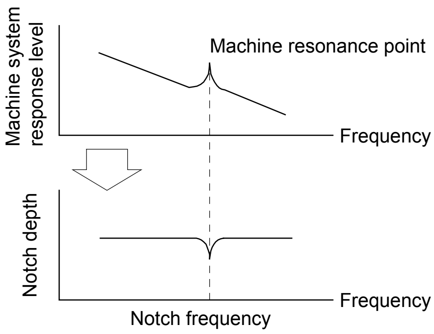
Table 7.3 Earth-leakage current breaker selection example

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

(2) Selection example
The following shows a selection example of the earth-leakage current breaker under the following conditions.



When machine resonance is high and frequency is low



When machine resonance is low and frequency is high

Use an earth-leakage current breaker that is a harmonics/surge-compatible product.
Obtain each item in equation (7.1) from the figure.

$$Ig1 = 20 \cdot \frac{5}{1000} = 0.1 \text{ [mA]}$$

$$Ig2 = 20 \cdot \frac{5}{1000} = 0.1 \text{ [mA]}$$

Ign = 0 (Not used)
Iga = 0.1 [mA]
Igm = 0.1 [mA]
Substitute in equation (7.1).

$$Ig \geq 10 * (0.1 + 0 + 0.1 + 1 * (0.1 + 0.1))$$
$$\geq 4 \text{ [mA]}$$

According to the calculation results, use an earth-leakage current breaker with a rated sensitivity current (Ig) of at least 4.0 [mA].
15 [mA] is used in the NV-SP/SW/CP/CW/HW series.

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 first clarify this.

$$i = i_O + \sum_{n=1}^{\infty} i_n \cdot \sin(2\pi fnt + \psi n) \qquad (7.1)$$

$n = 1, 2, 3$
f = Fundamental frequency

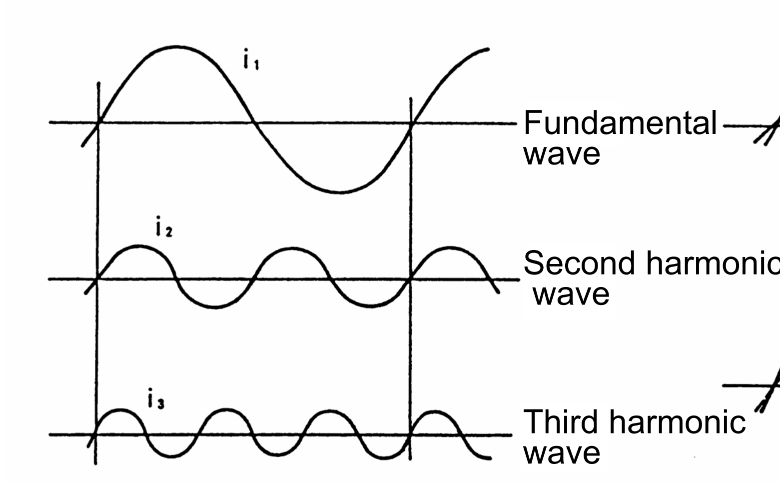


Figure 7.2 Fundamental harmonics and harmonics

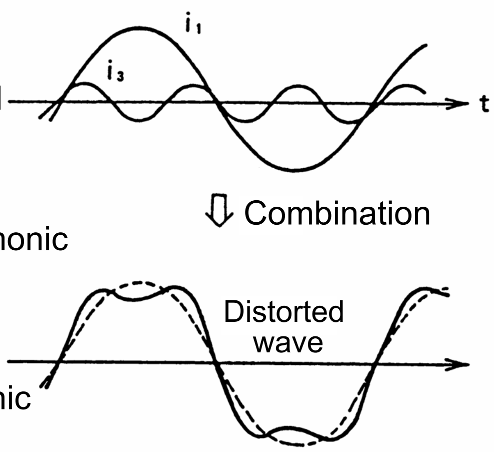


Figure 7.3 Distorted wave

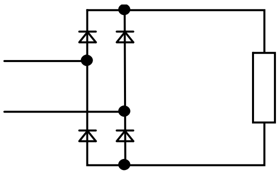
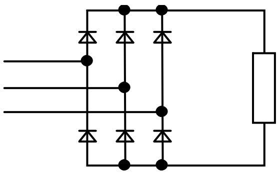
Table 7.3 Difference between harmonics and noise

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

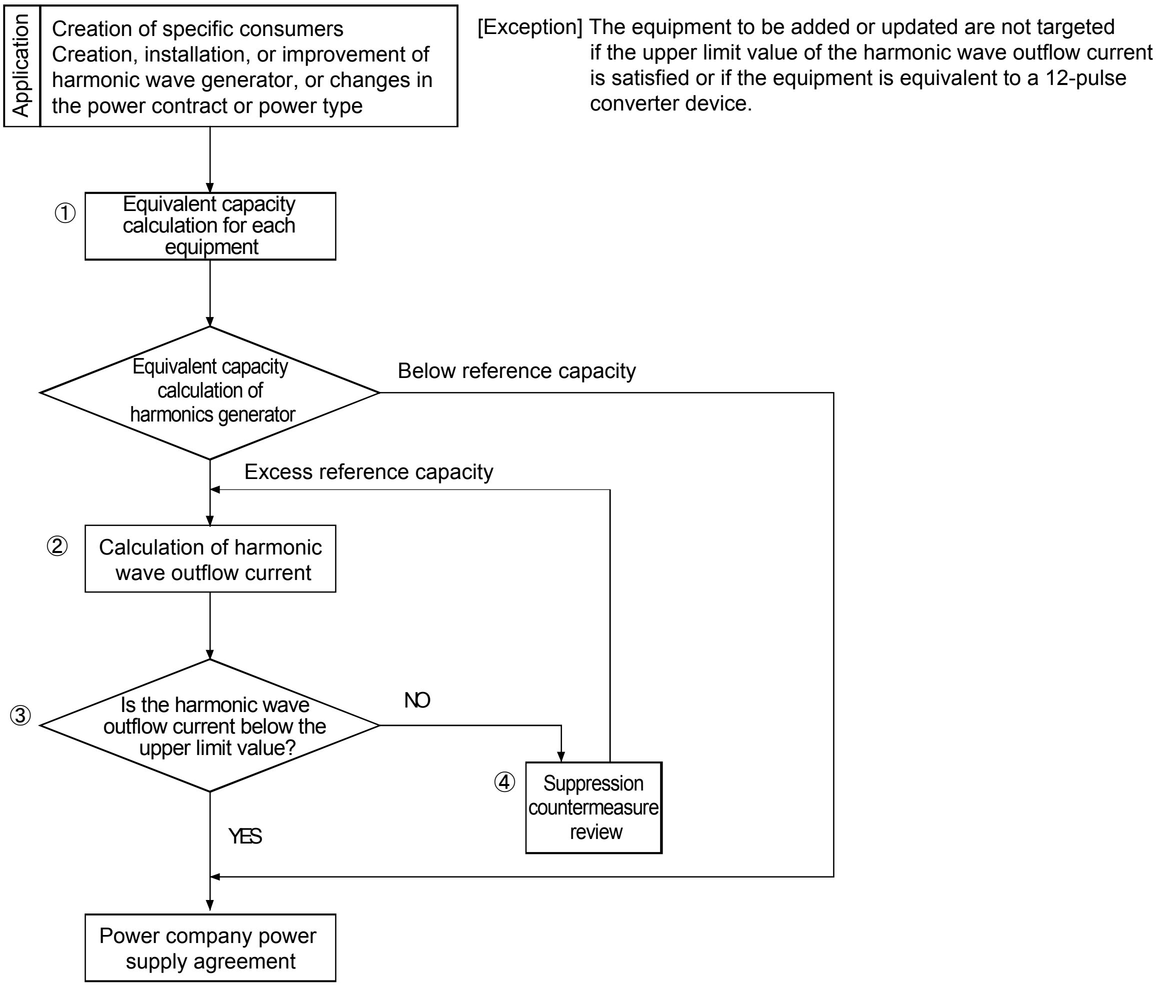
Circuit name	Fundamental circuit figure	High-frequency number	High-frequency content ratio
Single-phase bridge		n = 4K ±1 K = 1, 2, ……	Kn × 1 / n
Three-phase bridge		n = 6K + 1 K = 1, 2, ……	Kn × 1 / n

Kn: Coefficient determined by the control delay angle and the commutation overlap angle

7.3.3 Harmonics Countermeasures

In September 1994, the Japanese government 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.

(1) Power factor improving DC reactor (FR-HEL)
Compared to the power factor improving AC reactor (FR-HEL), a power factor improving DC reactors can decrease loss. In addition, it is effective in reducing input-side harmonics.

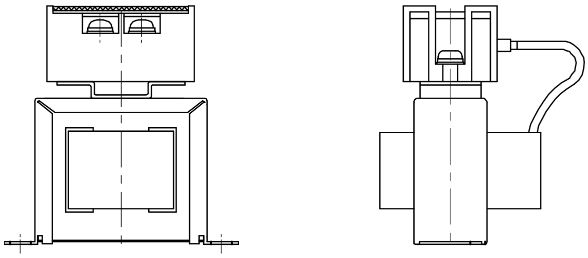


Figure 7.2

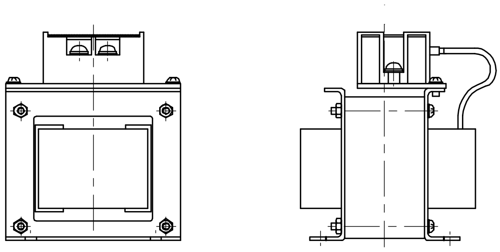
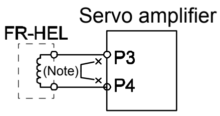


Figure 7.3



(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 [mm2]
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	
MR-J4-350A	FR-HEL-7.5K		3.5 (AWG 12)
MR-J4-500A	FR-HEL-11K		5.5 (AWG 10)
MR-J4-700A	FR-HEL-15K		8 (AWG 8)

(2) Power factor improving AC reactor (FR-HAL)

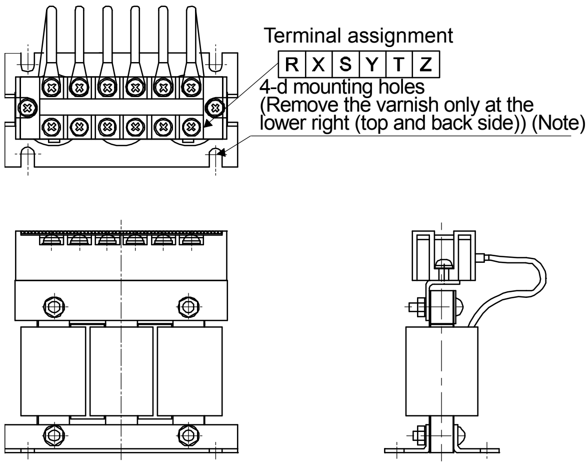


Figure 7.4

(Note) Use when laying the grounding wire.

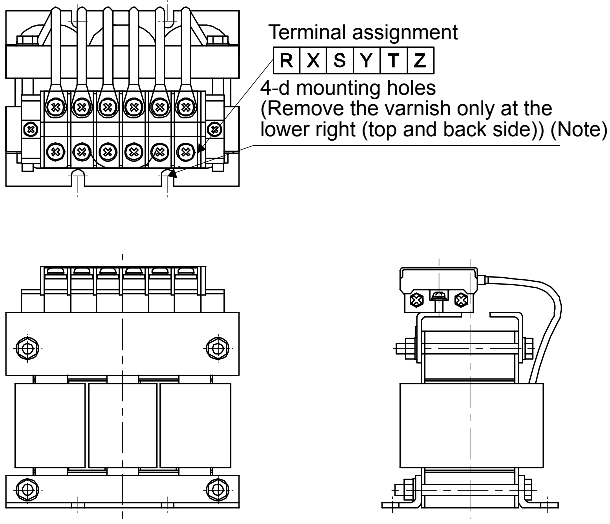
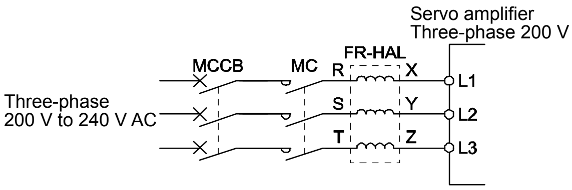
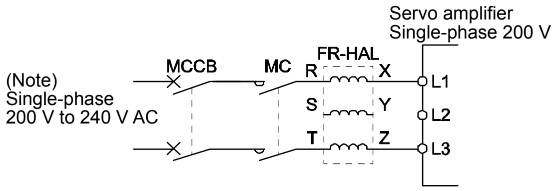


Figure 7.5

(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	

7.4 Operation after Installation

⚠WARNING	● Do not operate the switches with wet hands. Doing so may cause an electric shock.

⚠CAUTION	● 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.

7.4.1 Startup Procedure

Wiring check	Visually check whether the wires are correctly connected to the servo amplifier and the servo motor, or check using the DO forced output function, etc.
↓	
Surrounding environment check	Check the surrounding environment of the servo amplifier and servo motor.
↓	
Individual parameter settings	Set the parameters as necessary, such as the control mode to be used and the regenerative option selection.
↓	
Test operation of just the servo motor in the test operation mode	For the test operation, with the servo motor disconnected from the machine and operated at as low a speed as possible, check whether the servo motor rotates correctly.
↓	
Test operation on just the servo motor according to commands	For the test operation, with the servo motor disconnected from the machine and operated at as low a speed as possible, send commands to the servo amplifier and check whether the servo motor rotates correctly.
↓	
Test operation with the servo motor and machine connected	After connecting the servo motor to the machine, check the motion of the machine by sending operation commands from the controller.
↓	
Gain adjustment	Adjust the gain to optimize the machine motions.
↓	
Operation	
↓	
Stop	Stop giving commands and stop operation.

7.4.2 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 your local sales office 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.

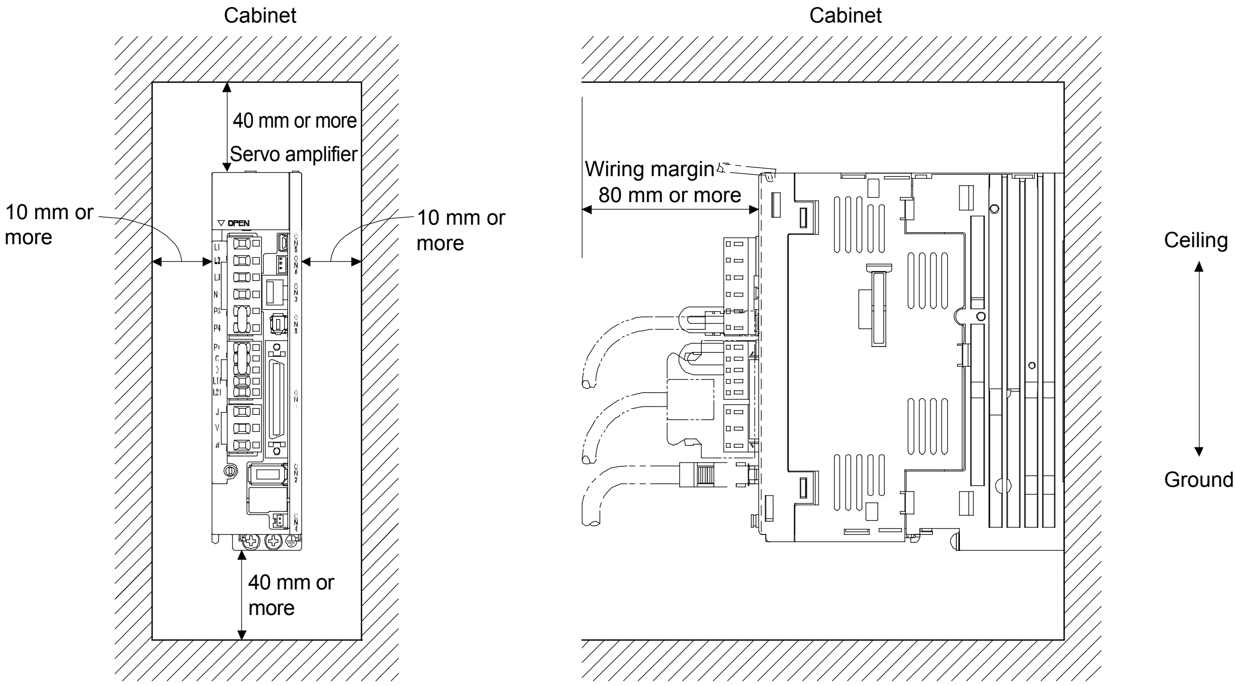
POINT
● If the CNP1, CNP2, and CNP3 connectors are unplugged in MR-J4-40A servo amplifiers or lower servo amplifiers, unplug the CN3 and CN8 connectors beforehand.

(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

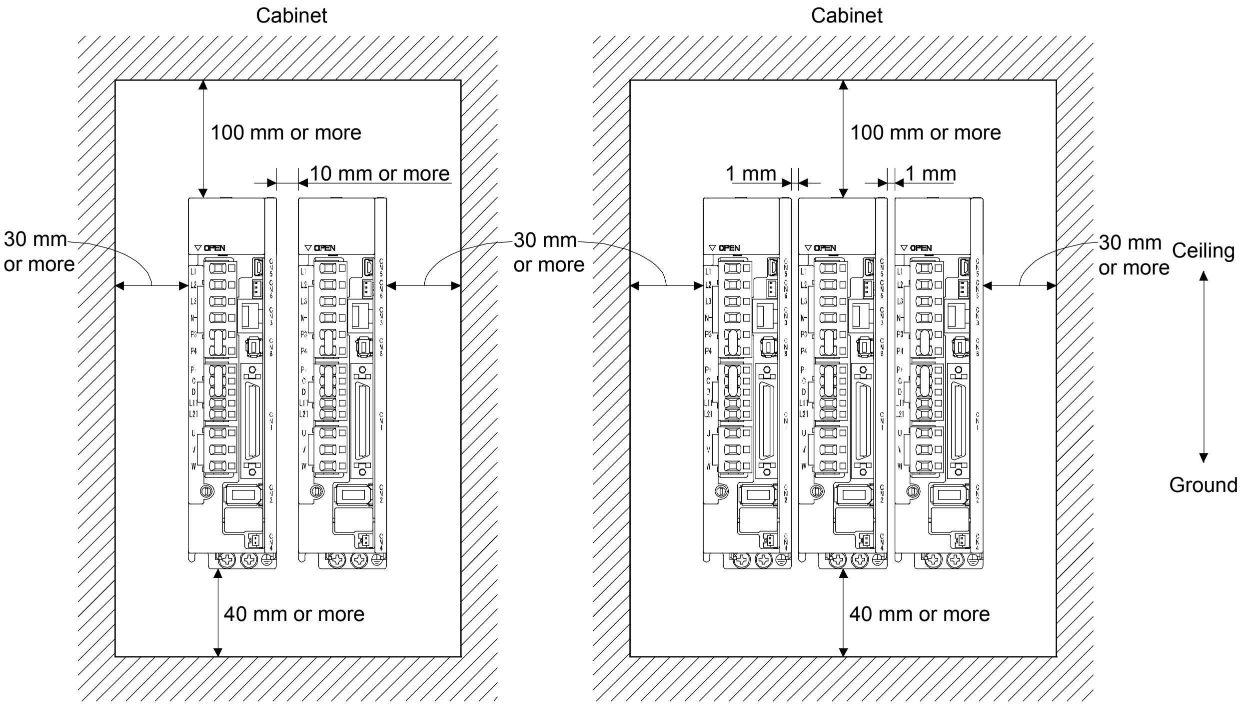
(1) For single installations



(2) For multiple installations

POINT
● 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.



When allowing clearance   When close mounting

(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
(a) Ensure that shavings caused by drilling, etc., during cabinet assembly do not enter the servo amplifier.
(b) 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.
(c) 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.

(c) Others

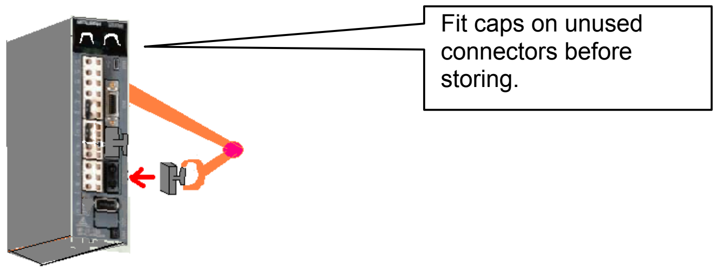
When using equipment that generates heat, such as with regenerative options, set up with sufficient consideration of heat generation so that there is no effect on the servo amplifier.
Install the servo amplifier accurately and vertically on a perpendicular wall.

Fault example: Communication error 2

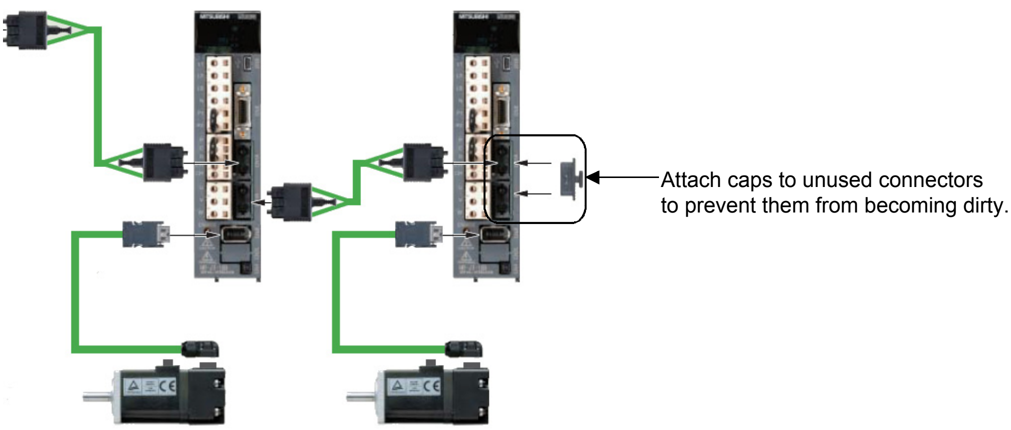
[Fault description]
When a servo amplifier that has been placed flat in a warehouse for some time was used after a long time, there was a communication error.
When replaced with a new one, it worked without any problems.

[Cause of fault]
There was dust stuck to the optical fiber cable connector of the servo amplifier.

[Countermeasure against fault]
Fit caps on unused connectors to store.



(Reference documents) *Extracted from the catalog



(2) Infiltration of foreign objects

(a) Ensure that shavings caused by drilling, etc., during cabinet assembly do not enter the servo amplifier.

(b) 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.

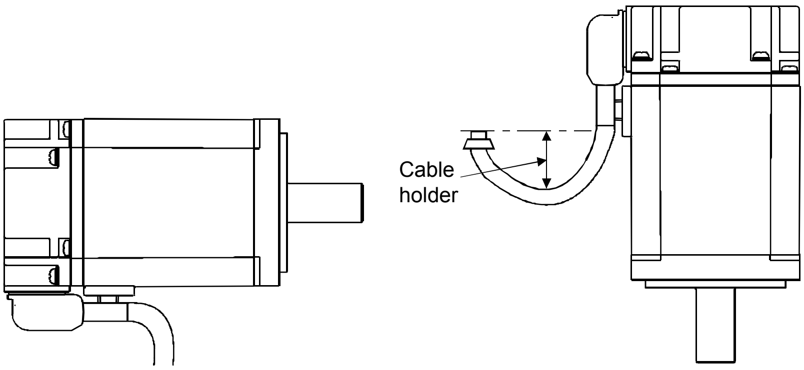
(c) When setting up the cabinet in a place with a lot of corrosive gases and dust, apply air purging (forceful feeding of clean air from outside the cabinet to raise the internal pressure above the external pressure) to ensure that the corrosive gases and dust do not enter the cabinet.

(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

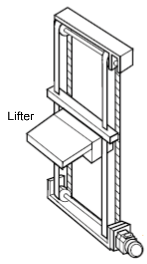
When installing a servo motor horizontally, it is recommended that the connector part face downward.
When installing vertically or diagonally, set up a connection cable and cable holder.



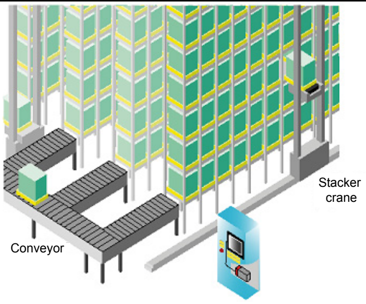
(b) Servo motor with electromagnetic brake
A servo motor with an electromagnetic brake can also be installed in the same direction as a standard servo motor. When installed with the shaft upward, a sliding sound from the brake disk can occasionally be heard, but this is not a malfunction.

Fault example: Electromagnetic brake

<Example of use>
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 servomotor, smooth running at high speeds can be achieved.
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.



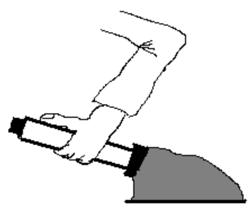
As described earlier, the lifting device uses a servo motor with an electromagnetic brake.

[Fault description]
Because there was a call from the site that there was a strange smell from the motor, the motor was replaced with a spare one as a temporary solution. When the faulty motor was examined, the brake lining was found to have been worn.

[Cause of fault]
From the motor analysis results, there was a possibility that the motor might have been run with the brake locked.

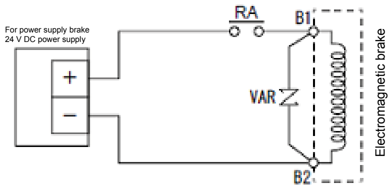
POINT

- The electromagnetic brake is for storage. Do not use for normal braking.
  Even when the electromagnetic brake is accidentally locked as in this case, it is possible for the motor to run because the maximum torque of the motor is larger than the static friction torque.

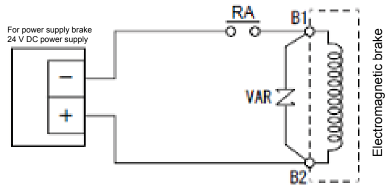
  

  (Similar example)
  The electromagnetic brake works like the hand brake in a vehicle.
  Even when the hand brake has been applied, the vehicle can be forced to move by pressing the accelerator.

Power supply for the electromagnetic brake
Arrange for a dedicated power supply for the electromagnetic brake as described below. The electromagnetic brake terminals (B1/B2) have no polarity.

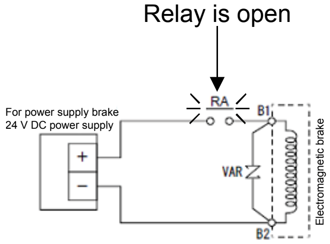


or



Make sure to install a surge absorber between B1 and B2.
Based on the points in the servo motor instruction manual pertaining to the power supply for the electromagnetic brake, the following 5 points were examined, and the main cause was identified as 4).

1) Is 24 V DC being used as the internal power supply output (VDD) for the interface? Table below (Note 4)
2) Is a capacity of 24 V DC sufficient?
3) Has a voltage drop caused the voltage in the electromagnetic brake to fall to 21.6 V or less (24 V DC −10%)?
4) **Has the relay between the 24 V DC and the electromagnetic brake not come ON and is it open? (Is the wiring of the relay disconnected?)**



5) Is the electromagnetic brake power cable disconnected?

Electromagnetic brake characteristics *Extracted from servo motor instruction manual

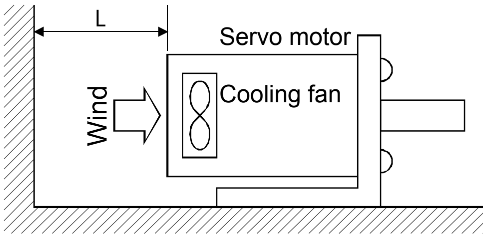
Item	Servo motor	HG-MR and HG-KR series				
		053B	13B	23B	43B	73B
Type (Note 1)		Spring actuated type (spring control) safety brake				
Rated voltage (Note 4)		24 V DC $^{0}_{-10\%}$				
Power consumption	[W] at20°C	6.3	7.9			10
Coil resistance (Note 6)	[Ω]	91.0				57.0
Inductance (Note 6)	[H]	0.15				0.13
Brake static friction torque	[N•m]	0.32				2.4
Release delay time (Note 2)	[s]	0.03	0.03			0.04
Braking delay time (Note 2) [s]	DC off	0.01	0.02			0.02
Permissible braking work	Per braking [J]	5.6	22			64
	Per hour [J]	56	220			640
Brake looseness at servo motor shaft (Note 5)	[degree]	2.5	1.2			0.9
Brake life (Note 3)	Number of times [No. of times]	20000				
	Work per braking [J]	5.6	22			64
Selection example of surge absorbers to be used (Note 7, 8)	For the suppressed voltage 125 V	TND20V-680KB				
	For the suppressed voltage 350 V	TND10V-221KB				

24 V DC $^{0}_{-10\%}$

Note 1. There is no manual release mechanism. Supply 24 V DC and release the electromagnetic brake electrically.
2. This is the value for the initial suction gap at 20°C.
3. The brake gap widens due to the wear and tear of the brake lining due to braking, but it cannot be adjusted.
4. Prepare a dedicated power source for the electromagnetic brake.
5. This value represents the initial value. This value is not guaranteed.
6. This value, being a measured value, is not guaranteed.
7. Select the relay for electromagnetic brake control considering the characteristics of the electromagnetic brake and the surge absorber.
8. Manufactured by Nippon Chemi-Con Corporation

(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).

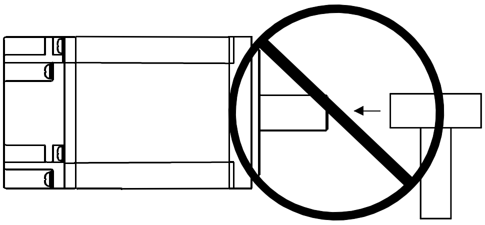
(4) Cooling fan
For a servo motor with a cooling fan, maintain sufficient distance L between the wall and the intake port.



(5) Caution when removing and setting a load

POINT

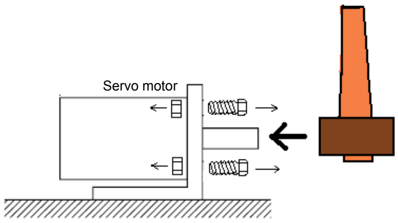
- Absolutely do not strike the shaft end with a hammer, etc., during assembly. Doing so may lead to a malfunction of the detector.



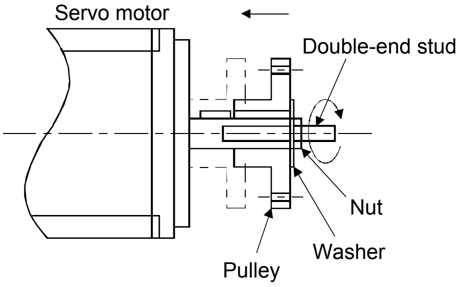
Fault example: Handling of the servomotor

[Fault description]
When assembling the test device, the servo motor was taken from a device that was not in use and installed, but this has caused a detector error from power-on.

[Cause of fault]
Upon examining the faulty motor, a crack was found in the glass disk of the encoder.
The servo motor was removed from a device that was not in use with a wooden hammer.
(It was believed that using the hammer was OK because it was made of wood).



(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 servo motors with a key groove, use the screw hole at the end of the shaft to mount the pulley. Use a friction coupling for shafts without a key groove.

(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.

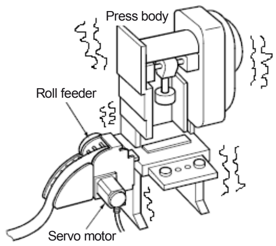
(e) When installing a pulley on the shaft, if the shaft end needs to be threaded, place a request with Mitsubishi.

(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.

Fault example: Vibration

[Fault description]
Even though the press device was made to be a servo type before delivery to the customer, after about 3 months, an encoder error occurred intermittently, and finally the encoder error became permanent.



[Cause of fault]
Upon examining the faulty motor, the glass disk of the encoder was found to have come unfastened.
Because vibration was thought to be the cause, the vibration was measured and found to have been in excess of the permitted value.

(Environment conditions for use of the servo motor) *Extracted from servo motor instruction manual

Environment		Conditions	
Ambient temperature	Operation	0°C to 40°C (non-freezing)	
	Storage	-15°C to 70°C (non-freezing)	
Ambient humidity	Operation	RH 80% or more (non-condensing)	
	Storage	RH 90% or less (non-condensing)	
Ambience		Indoors (away from direct sunlight) Not exposed to corrosive gas, inflammable gas, oil mist, or dust	
Altitude		1000 m or less above sea level	
Vibration*1		HG-MR and HG-KR series	X, Y: 49 m/s^2
		HG-SR51, HG-SR81, HG-SR52,HG-SR102 and HG-SR152	X, Y: 24.5m/s^2
		HG-SR121, HG-SR201, HG-SR202 and HG-SR352	X: 24.5 m/s^2 Y: 49 m/s^2
		HG-SR301, HG-SR421, HG-SR502 and HG-SR702	X: 24.5 m/s^2 Y: 29.4m/s^2

*1: Other than geared servo motors.

[Countermeasure against fault]
The chassis was separated from the press unit so that the vibration was not conducted to the servo motor.
Also, a motor was kept in reserve.

(6) Permissible load for the shaft

POINT
● Do not use a rigid (solid body) coupling because it will apply an excessive bend load on the shaft and may cause the shaft to break.

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.

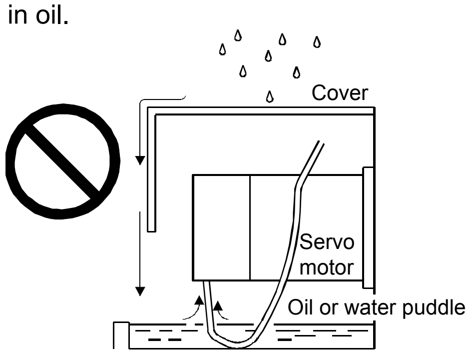
(b) When using a pulley/sprocket and a timing belt, select ones that can fit in the permissible radial load.

(c) If the permissible load is exceeded, it may lead to reduced bearing life and cause 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.

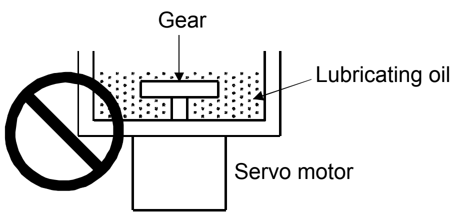
(7) Countermeasures against entry of oil
Ensure that foreign particles such as oil do not mix inside of the servo motor shaft. When installing the servo motor, keep the items in this section in mind.

(a) Do not use cables soaked in oil.



<Defect> Capillary action

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



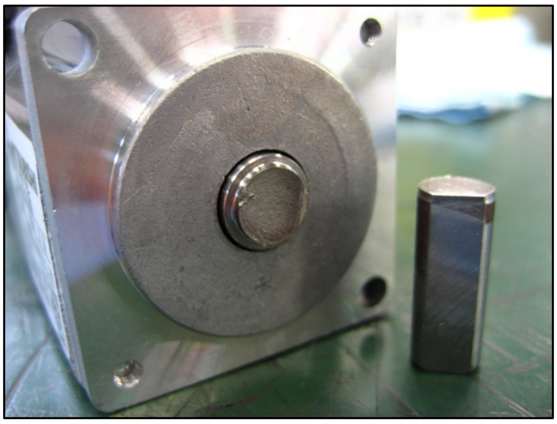
(c) With oils such as cutting oil, there may be an influence on seal adhesion, packing, cables, etc., depending on the type of oil.

(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.

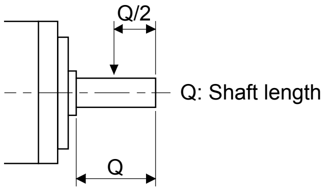
Fault example: Load on the servo motor shaft

[Fault description]
A call was received from a customer stating that the servo motor shaft in a device supplied over 5 years ago had become broken.

[Cause of fault]
A cross-section of the faulty motor revealed a fatigue fracture.
When the radial load was measured, it was found to be in excess of the permissible value.



(Extracted from HG-KR/HG-MR/HG-SR servo motor instruction manual (vol. 3): Permissible load for the shaft)



Servo motor	Reduction ratio	Permissible load (Note)	
		Permissible radial load [N]	Permissible thrust load [N]
HG-KR053(B)G1	1/5	150	200
	1/12	240	320
	1/20	370	450
HG-KR13(B)G1	1/5	150	200
	1/12	240	320
	1/20	370	450
HG-KR23(B)G1	1/5	330	350
	1/12	710	720
	1/20	780	780
HG-KR43(B)G1	1/5	330	350
	1/12	710	720
	1/20	760	760
HG-KR73(B)G1	1/5	430	430
	1/12	620	620
	1/20	970	960

Note: Ensure that the shaft is not subjected to load exceeding this value.
Each value in the table acts as a single entity.

(8) 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.

(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.

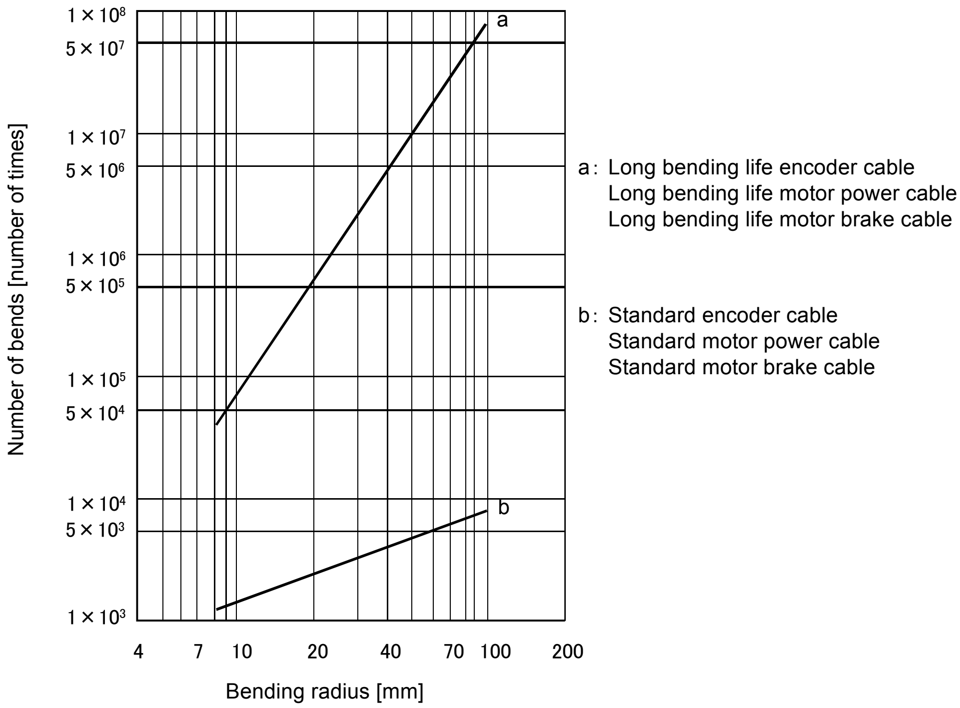
(b) When using in applications where the servo motor itself moves, fix the cable (detector, power supply, brake) by gradually slackening from the connector so that there is no stress on the servo motor connector. Use the optional encoder cable within the bending life range. With cables for the power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

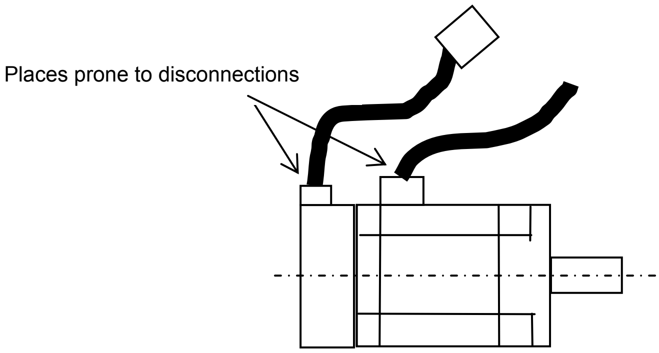


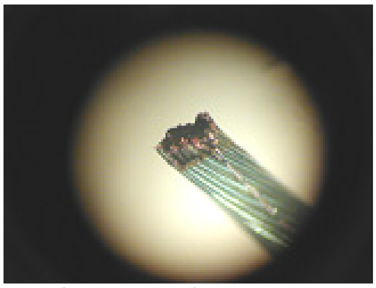
Fault example: Bending of the encoder cable

[Fault description]
There was an encoder communication error in the servo, and this error was corrected by replacing the encoder cable.

[Cause of fault]
The encoder cable was disconnected.

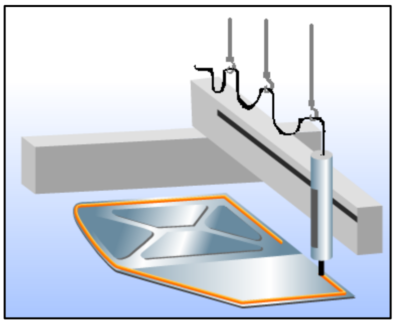
[Countermeasure against fault]
The encoder cable coming from the motor was fixed.




Magnified image of the disconnected portion (15x)

Similar faults

[Fault description]
There was an encoder communication error in the servo used on the main shaft of the device on the sealing, and this error was corrected by replacing the encoder cable at the joints.



The main shaft on the ceiling moves along the processing path, and it is therefore subjected to repeated bending.

[Countermeasure against fault]
Use relay cables with long bending lives at the joints, and also keep spare cables.

7.4.3 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 3.1. Configure so that the magnetic contactor is turned off at the same time as an alarm is generated in the external sequence.

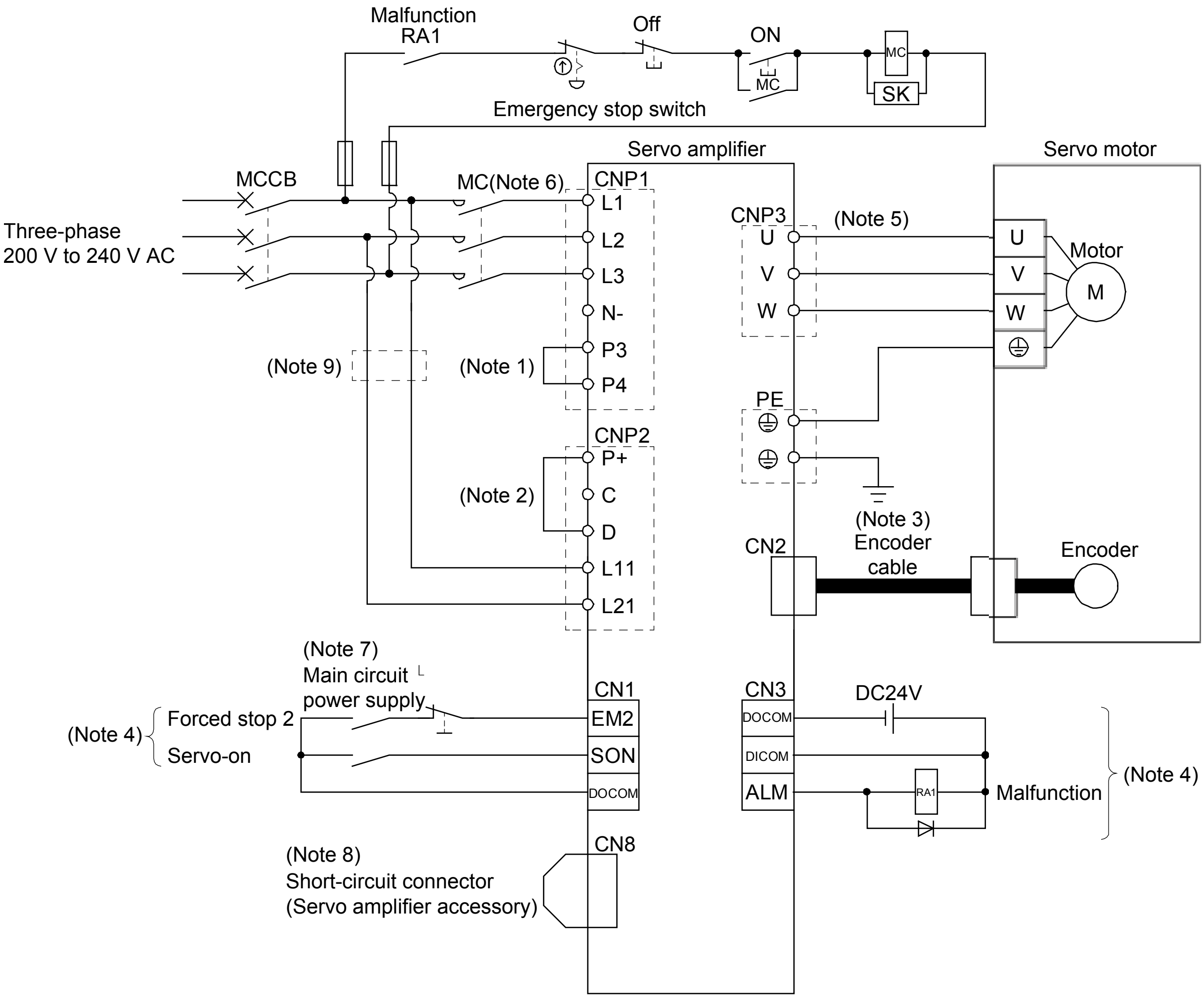
2) Turn on the control circuit power supply (L11/L21) at the same time or before turning on the main circuit power supply. If the main circuit power supply is not turned on, a warning is displayed on the display. However, the warning disappears and operation returns to normal when the main circuit power 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.

(2) Connection example

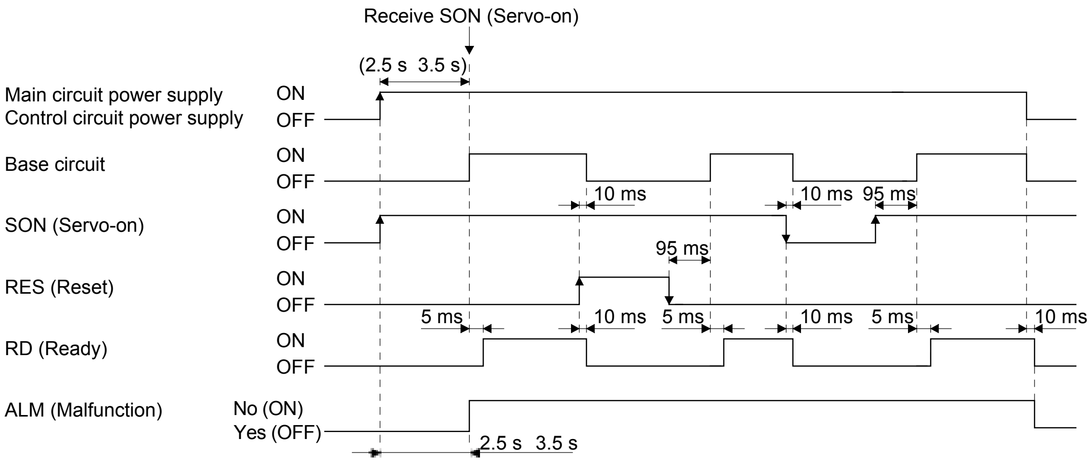
Wire the power supply and main circuit so that when an alarm occurrence is detected and the power supply is shut off, SON (servo-on) also turns off at the same time.
Always connect a magnetic contactor between the power supply and the main circuit power supply (L1/L2/L3) of the servo amplifier in order 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)

(3) Timing chart



Timing chart at power-on

(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

● In torque control mode, the forced stop deceleration function cannot be used.

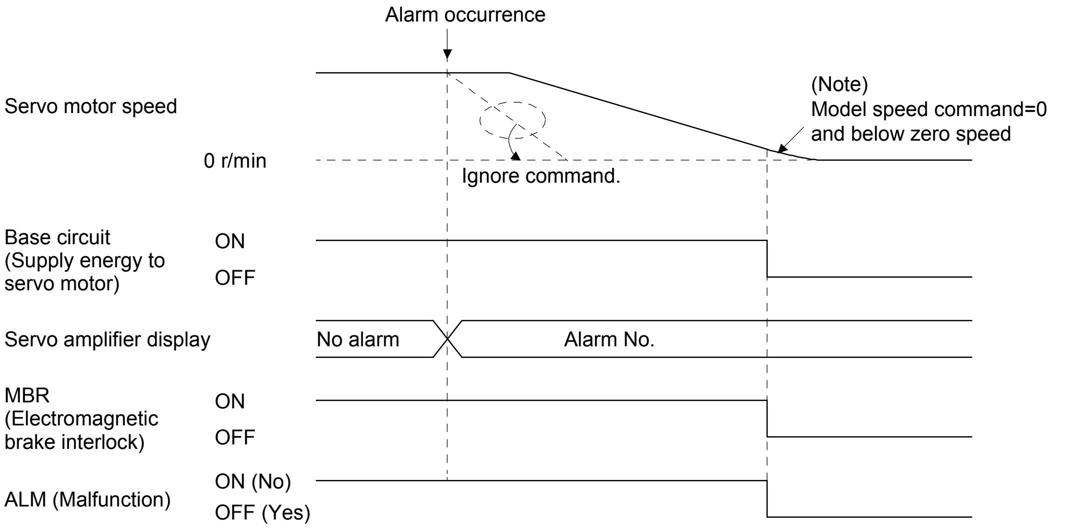
When an alarm occurs in the servo amplifier, the base circuit is shut off, and the servo motor stops with dynamic braking. At the same time, shut off the main circuit power supply with an external sequence. Although the alarm can be cleared by turning the control circuit power supply OFF→ON, by pressing 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

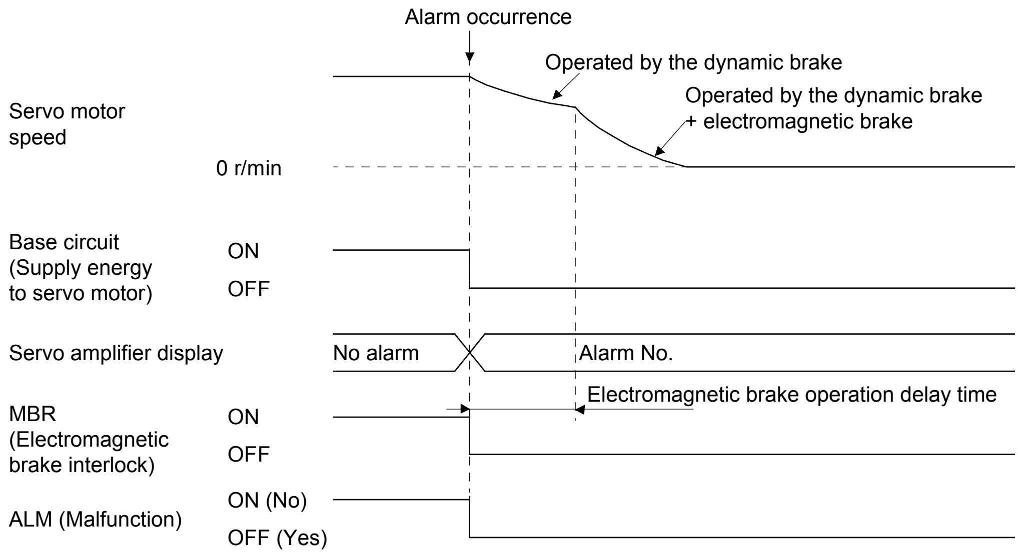
● This is for when [Pr. PA04] was set to "2 _ _ _" (initial value).

(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
● This applies when [Pr. PA04] is set to "0 _ _ _".

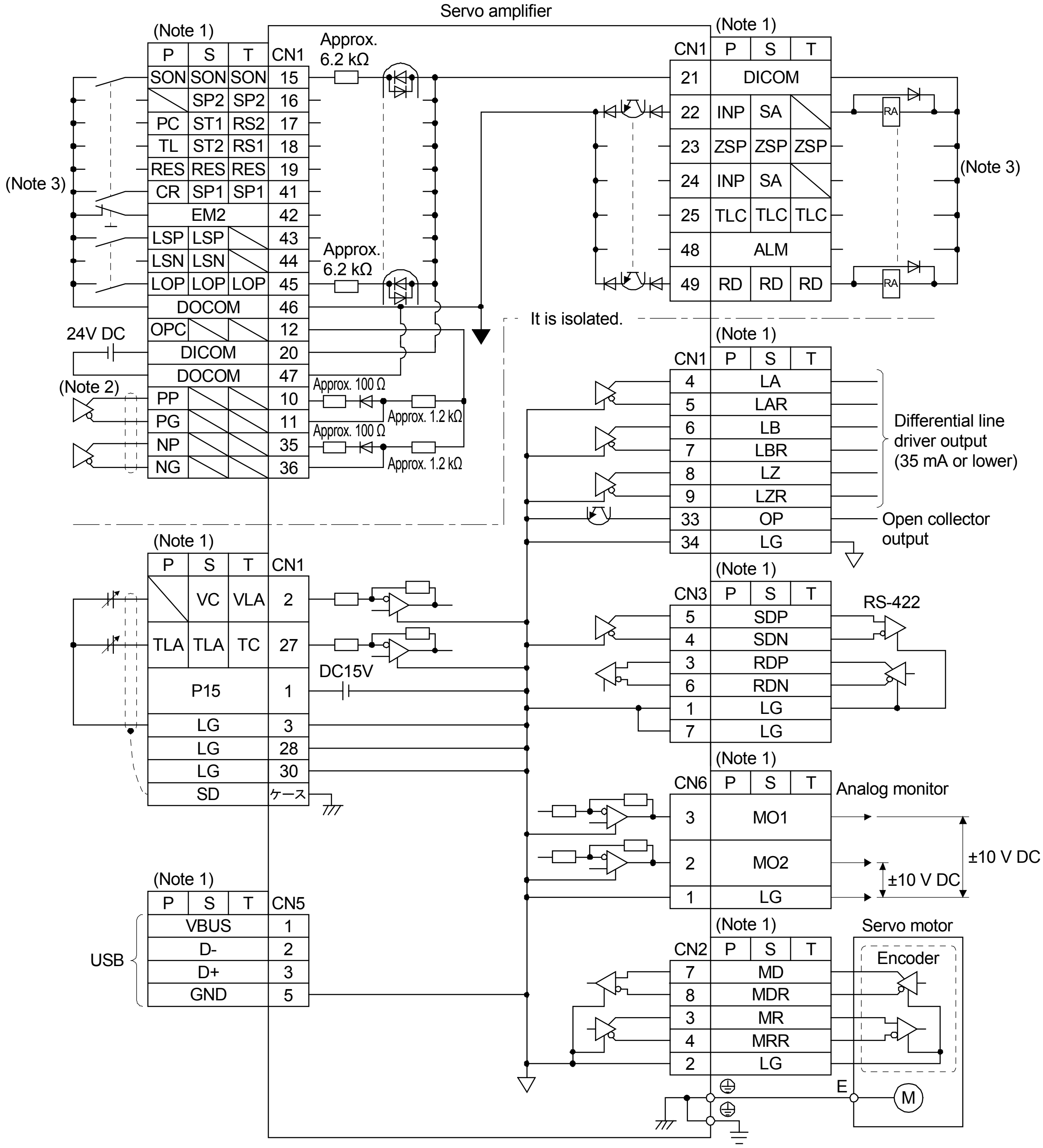
The operation status of the servo motor when an alarm occurs is the same as (a)(1) on the previous page.

(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.

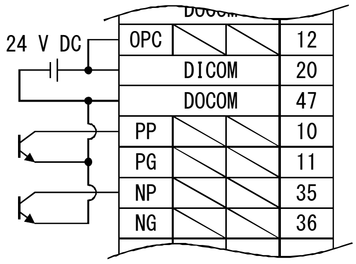
(3) With position control mode (incremental)
When an alarm occurs, the home position disappears. When operation is restarted after clearing the alarm, execute home position return.

(5) Interface internal connection figure

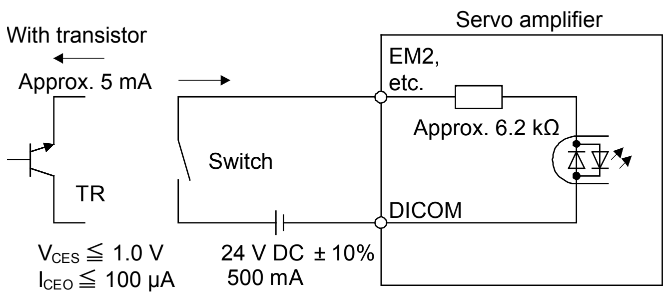


Note 1. P: Position control mode; S: Speed control mode; T: Torque control mode

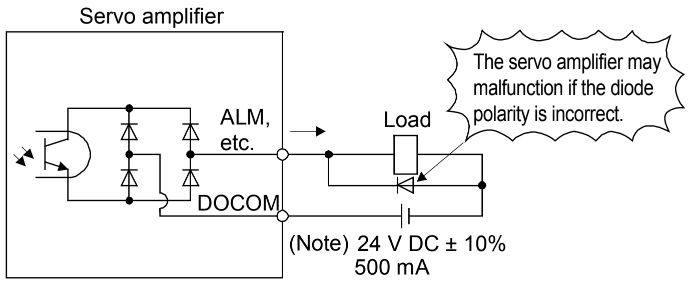
2. This applies to differential line driver pulse train input. For open collector pulse train input, connect as follows.



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



Source input interface



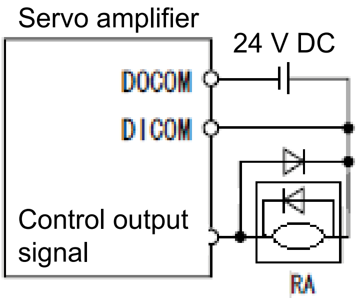
Note: When there is a problem in the relay differential because of a voltage drop (max 2.6 V), input high voltage from outside (max. 26.4 V).

Source output interface

Fault example: No control output

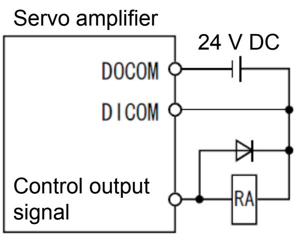
[Fault description]
There is no control output from the ALM, ZSP, TLC, and INP.

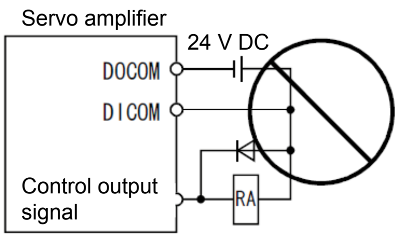
[Cause of fault]
The internal components for servo amplifier control output were burnt out.
Even though the direction of the surge absorbing diode was correct, the relay mounted was a built-in diode type, and the direction was reversed.



⚠CAUTION

- Do not mistake the installation direction of the surge absorbing diode installed in the DC relay for the control output signal.
  A malfunction may occur and the signals may not be able to be output, causing the protection circuits such as the emergency stop (EMG) to be unable to function.

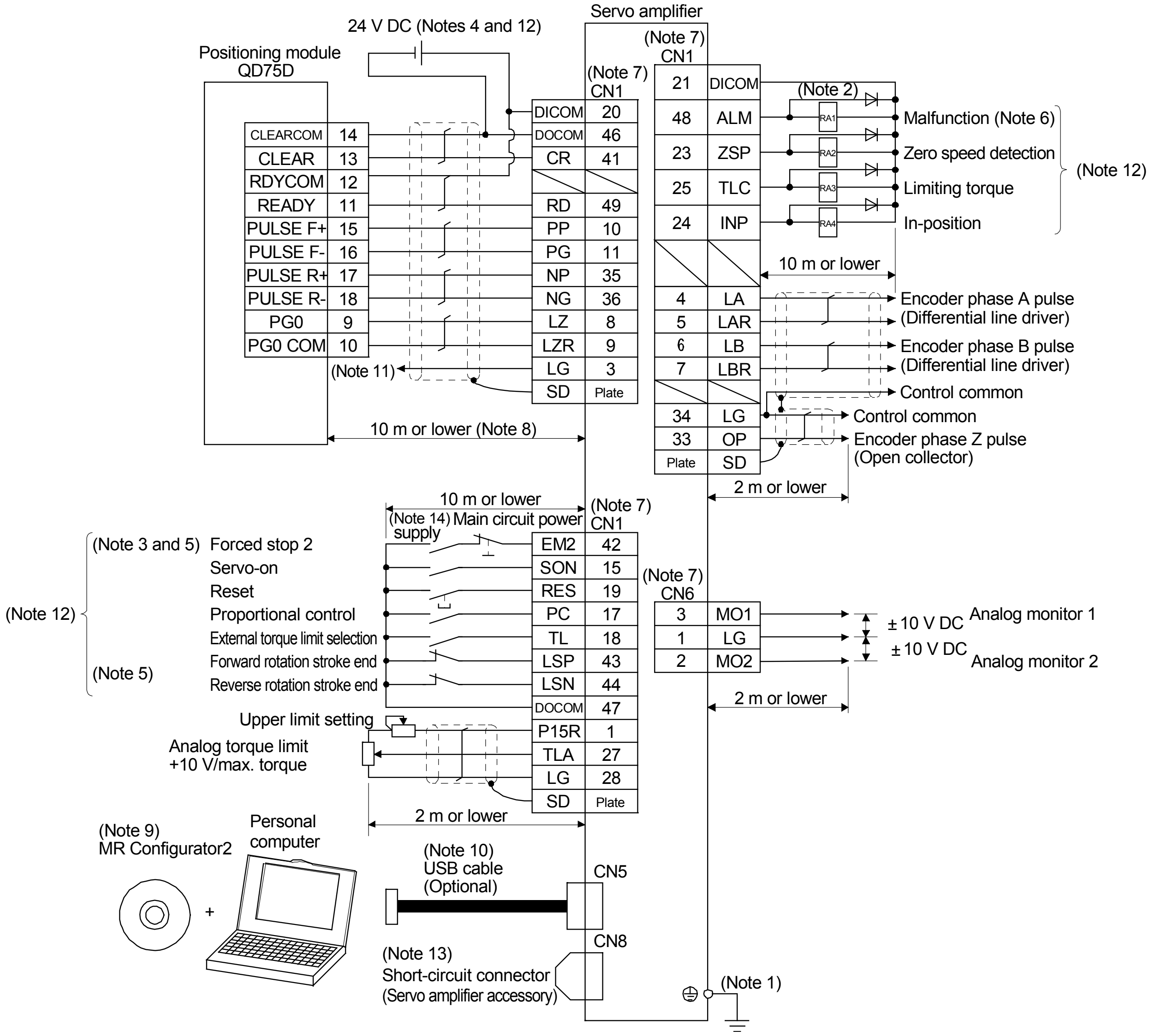




7.4.4 Standard Connection Figure

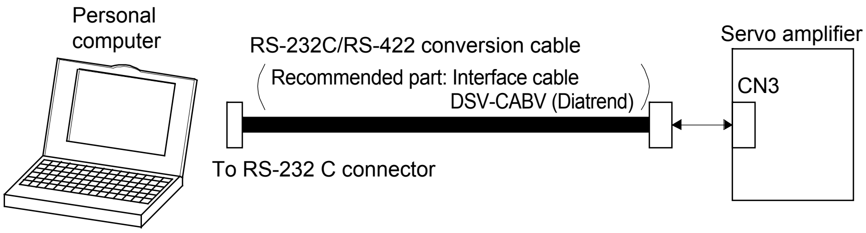
(1) Position control

(1) Connection of all I/O signals



Connection I at the time of position control

Note 1. To prevent electric shock, always connect the protective earth (PE) terminal (marked with ⏚) of the servo amplifier to the protective earth (PE) of the cabinet.
2. 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.
3. At the time of operation, make sure to turn on EM2 (forced stop 2). (Normally closed contact)
4. Supply a power supply of 24 V DC ± 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.
5. 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)
6. 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.
7. A signal with the same name is connected inside the servo amplifier.
8. Command pulse train input is for differential line driver types. Open-collector types are 2 m or less.
9. Use SW1DNC-MRC2-J.
10. 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.



11. 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.
12. This is with a sink I/O interface.
13. When not using the STO function, mount the short-circuit connector supplied with the servo amplifier.
14. 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.

(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.

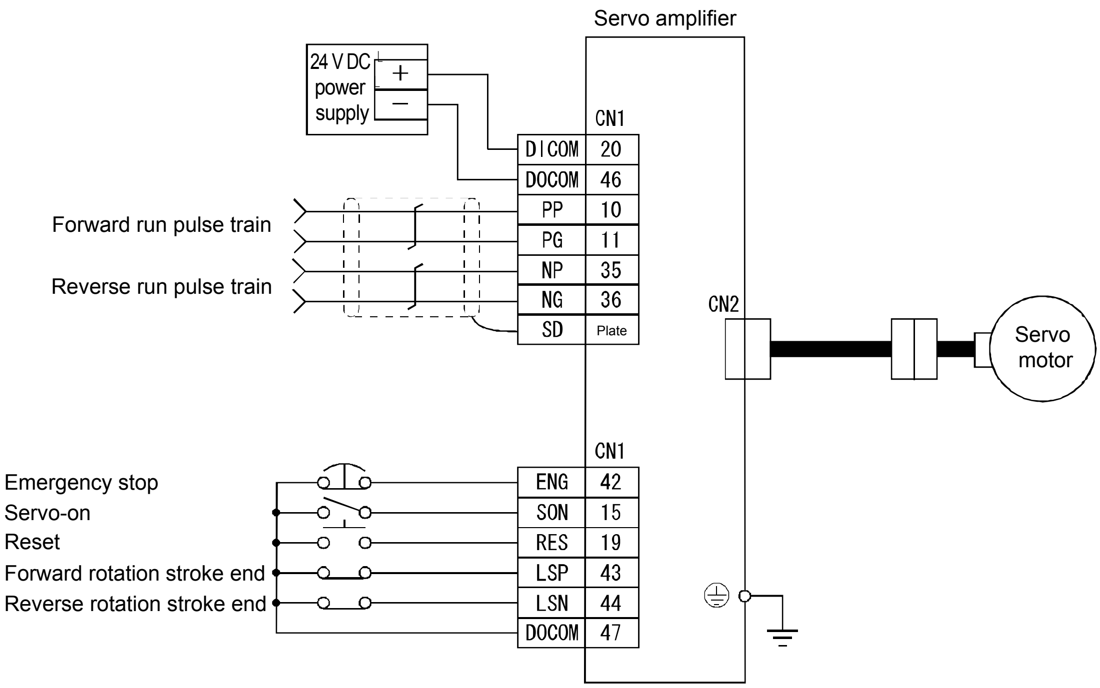
1) Servo-on: Because this signal is used to start the main circuit, it absolutely must be turned on before operation. When turned on, the servo-lock state is initiated.

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.

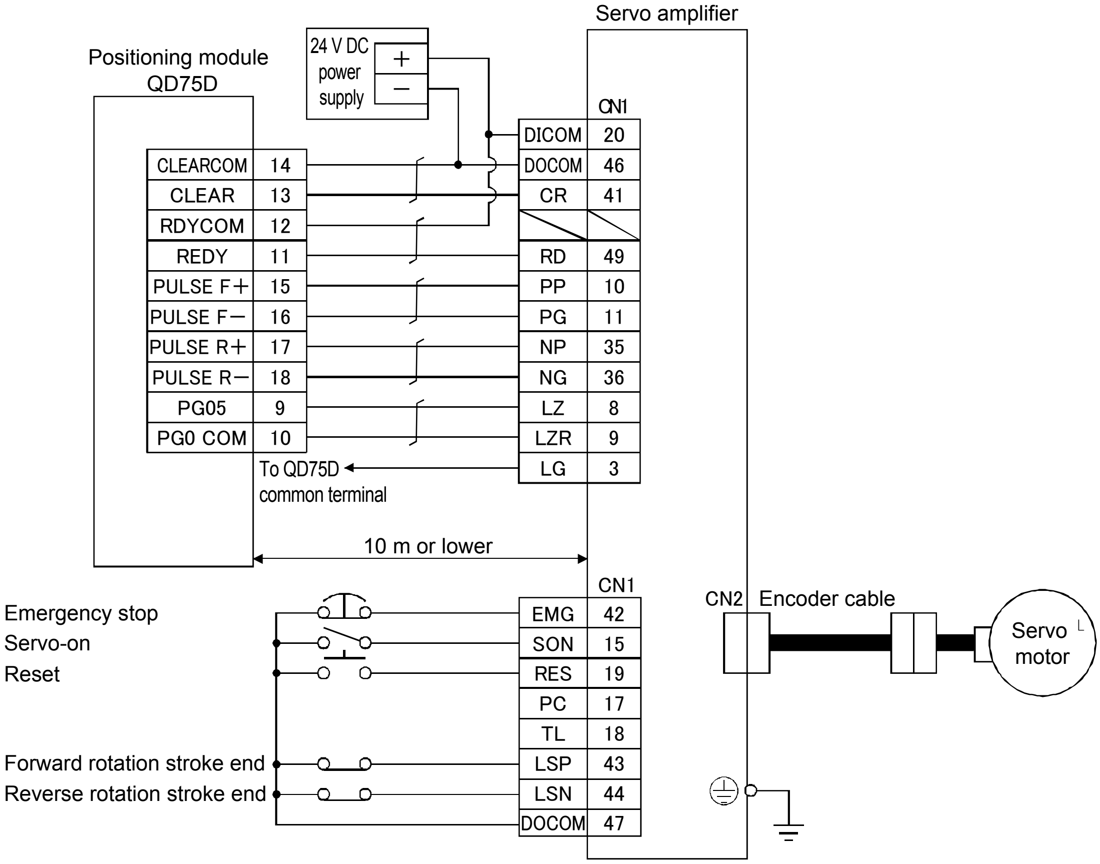
5) Emergency stop: During operation, make sure to short-circuit the emergency stop signal (EMG) with the DOCOM using the emergency stop switch (normally closed contact).



Connection I at the time of position control

(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.

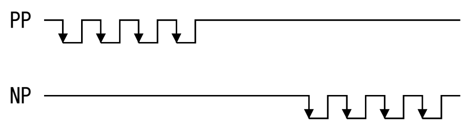
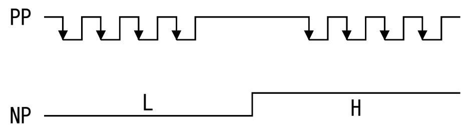
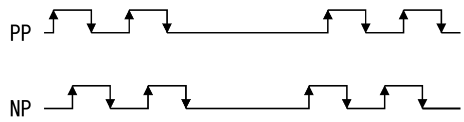
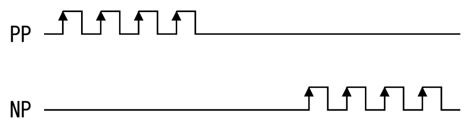
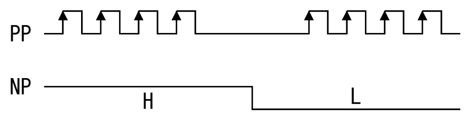
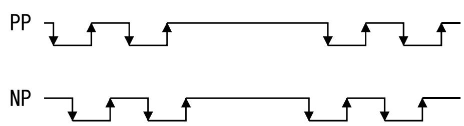
Connection III at the time of position control

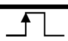
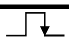
[Supplementary explanation]

(1) Pulse train input types

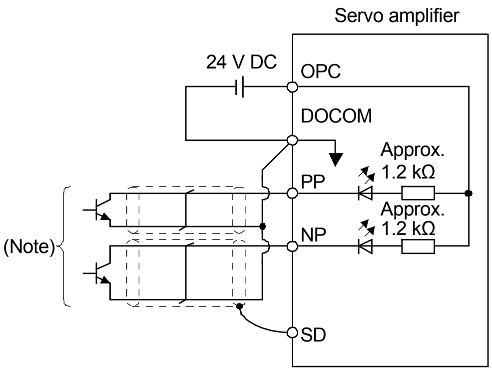
Generally, the command pulse inputs the forward/reverse rotation pulse train by an open-collector type or a differential system, which is suitable even for FX_{2N}-20GM/10GM/10PG/1PG, QD75P/QD75D, and QD70P.
With MR-J4 Series amplifiers, compatibility with the following pulse trains when switching parameters 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	Negative logic	Forward rotation pulse train Reverse rotation pulse train			QD75P, QD75D, QD70P FX_{2N}-20GM/10GM/10PG/1PG (Setting value at shipping)
0011h	Negative logic	Pulse train + code			QD75P, QD75D, QD70P, FX_{2N}-20GM/10GM/10PG/1PG
0012h	Negative logic	Phase A pulse train Phase B pulse train			QD75P, QD75D
0000h	Positive logic	Forward rotation pulse train Reverse rotation pulse train			QD75P, QD75D, QD70P
0001h	Positive logic	Pulse train + code			QD75P, QD75D, QD70P
0002h	Positive logic	Phase A pulse train Phase B pulse train			QD75P, QD75D

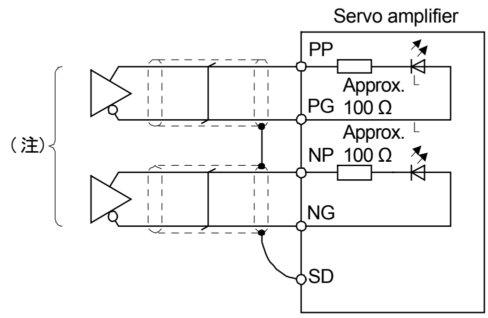
Note: An  or  arrow in the table indicates the import timing of the pulse train.

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



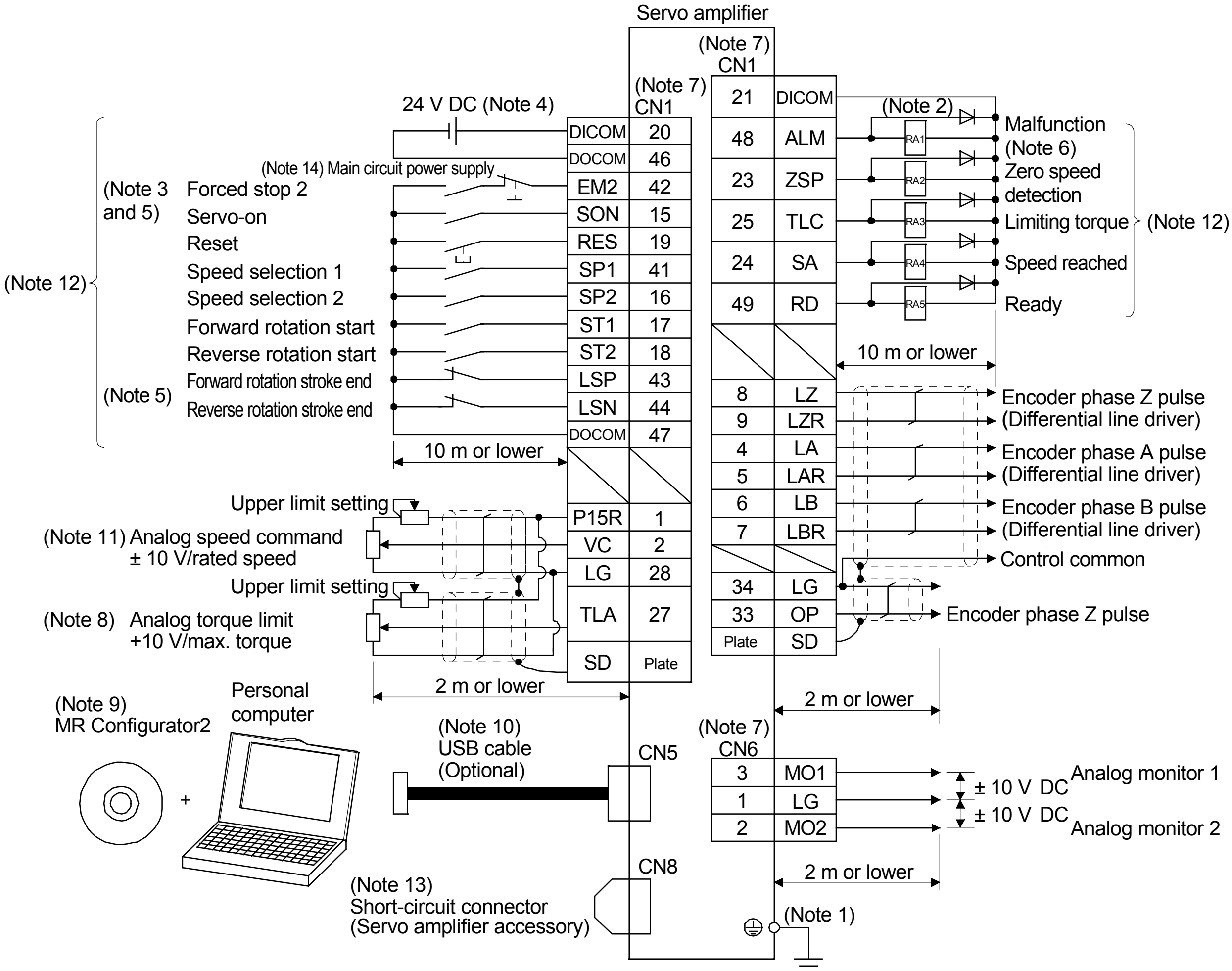
Note: The pulse train input interface uses a photocoupler. Because of this, it is not usually operated as the current decreases when the resistor is connected to the pulse train signal line.

(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.

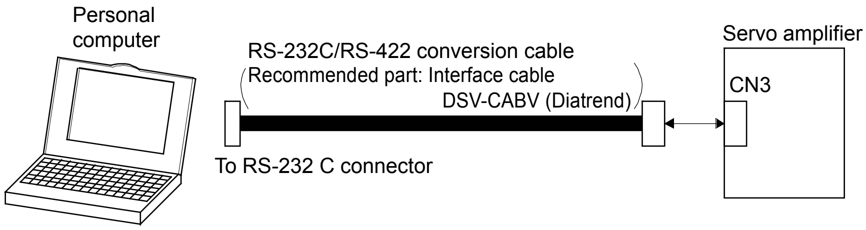
(2) Speed control

(1) Connection of all I/O signals



Connection I at the time of speed control

Note 1. To prevent electric shock, always connect the protective earth (PE) terminal (marked with ⏚) of the servo amplifier to the protective earth (PE) of the cabinet.
2. 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.
3. At the time of operation, make sure to turn on EM2 (forced stop 2). (Normally closed contact)
4. Supply a power supply of 24 V DC ± 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.
5. 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)
6. ALM (malfunction) is on when normal and no alarm is generated.
7. A signal with the same name is connected inside the servo amplifier.
8. If use of TL (external torque limit selection) is enabled in [Pr.PD03] to [Pr.PD22], TLA can be used.
9. Use SW1DNC-MRC2-J.
10. 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.

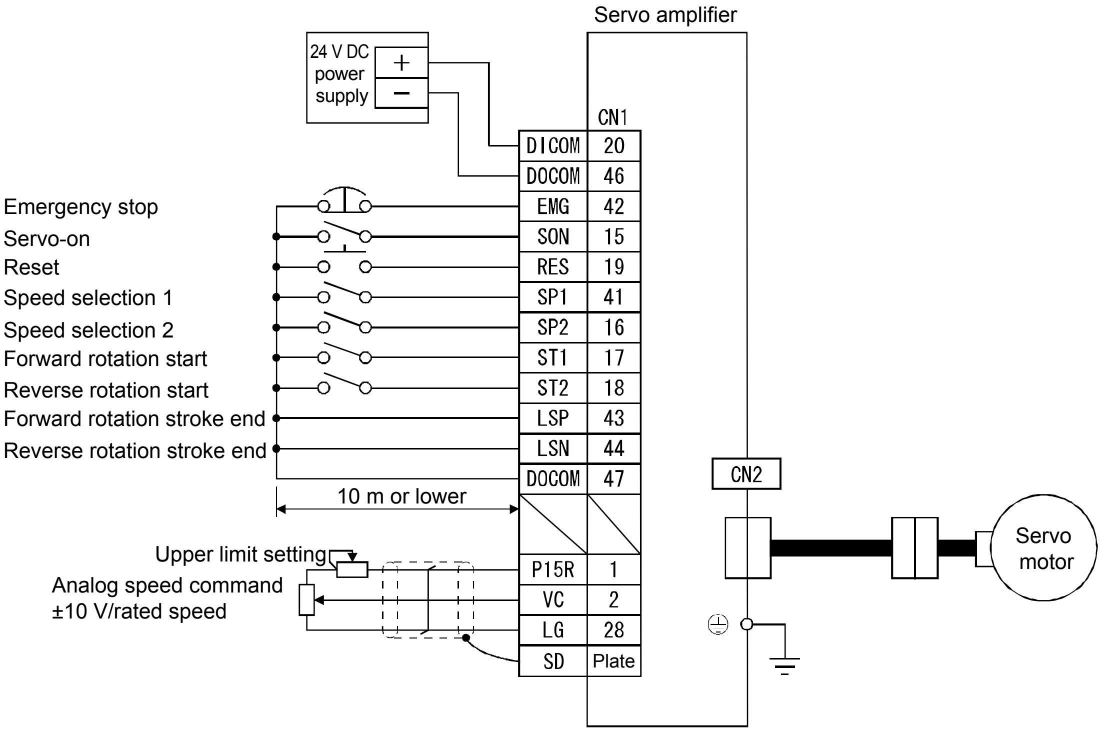


11. When a minus voltage is input, use an external power supply.
12. This is with a sink I/O interface.
13. When not using the STO function, mount the short-circuit connector supplied with the servo amplifier.
14. In order to prevent unexpected restarting of the servo amplifier, configure the circuit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

(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

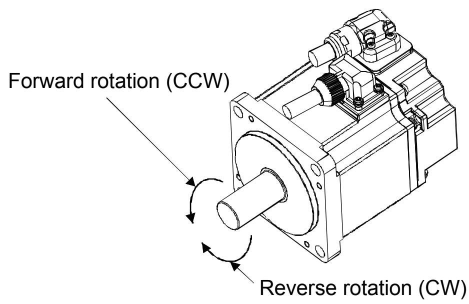
[Supplementary explanation] External connection of speed command

(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.

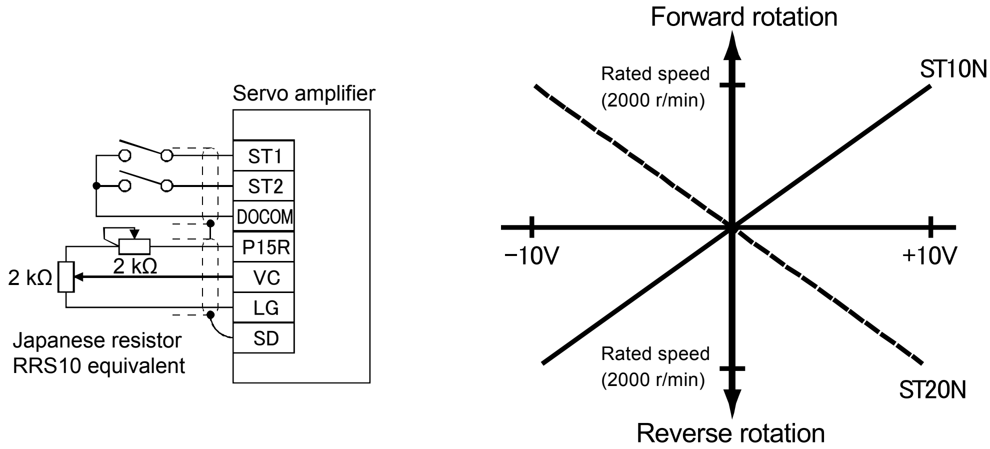


(Note 1) Input device		(Note 2) Rotation direction			
ST2	ST1	VC (Analog speed command)			Internal speed command
		+ polarity	0V	- polarity	
0	0	Stop (servo-lock)	Stop (servo-lock)	Stop (servo-lock)	Stop (servo-lock)
0	1	CCW	Stop (no servo-lock)	CW	CCW
1	0	CW		CCW	CW
1	1	Stop (servo-lock)	Stop (servo-lock)	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.

(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 ⊕

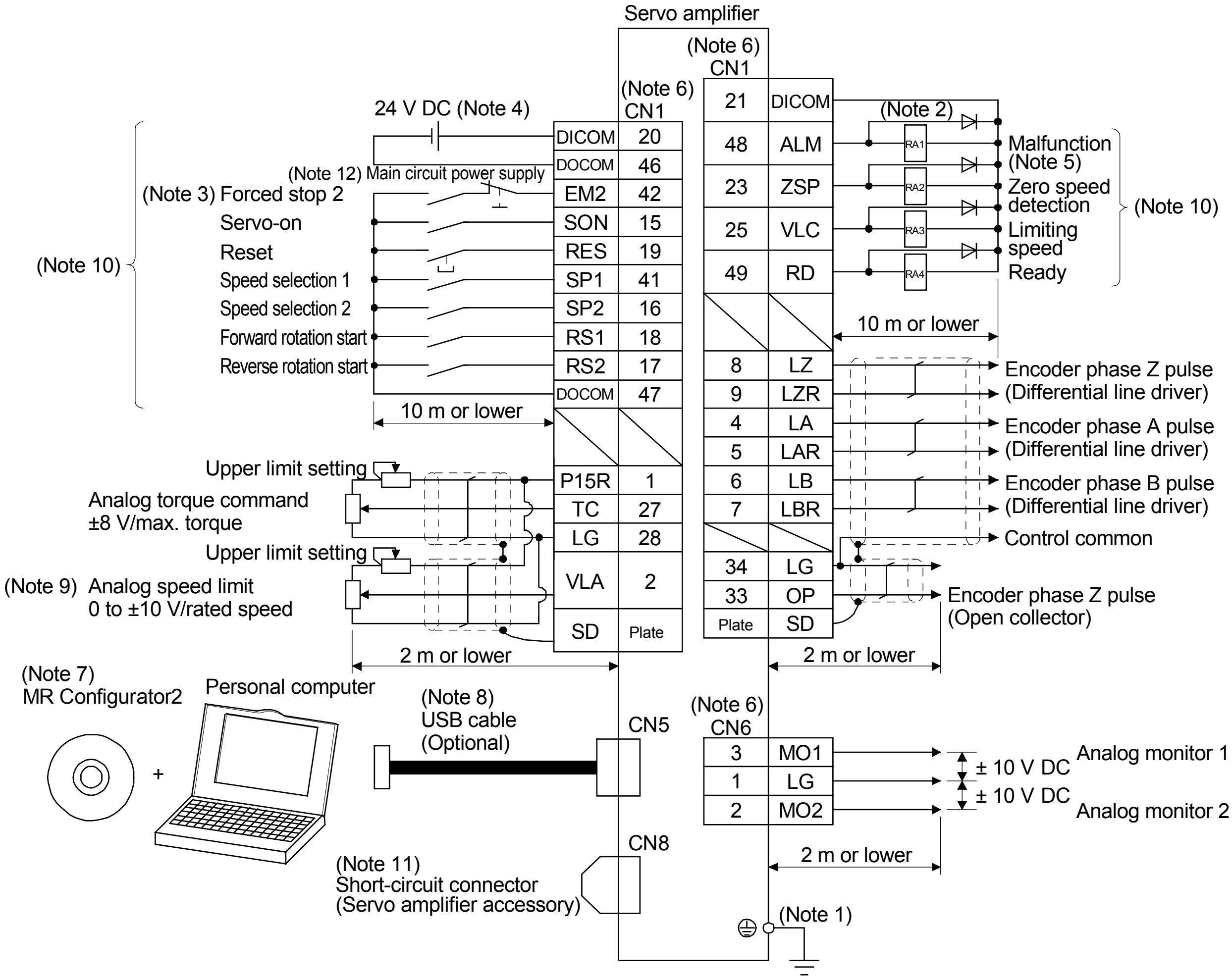


External connection I of speed command

(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.

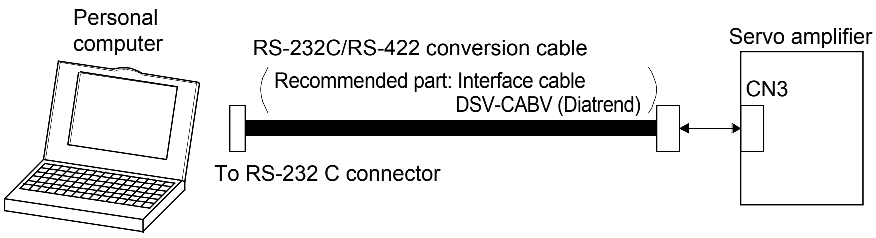
(3) Torque control

(1) Connection of all I/O signals



Torque control connection

Note 1. To prevent electric shock, always connect the protective earth (PE) terminal (marked with ⏚) of the servo amplifier to the protective earth (PE) of the cabinet.
2. 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.
3. At the time of operation, make sure to turn on EM2 (forced stop 2). (Normally closed contact)
4. Supply a power supply of 24 V DC ± 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.
5. ALM (malfunction) is on when normal and no alarm is generated.
6. A signal with the same name is connected inside the servo amplifier.
7. Use SW1DNC-MRC2-J.
8. 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.



9. When a minus voltage is input, use an external power supply.
10. This is with a sink I/O interface.
11. When not using the STO function, mount the short-circuit connector supplied with the servo amplifier.
12. 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.

[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 7.1.

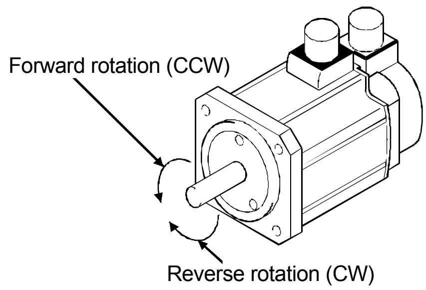
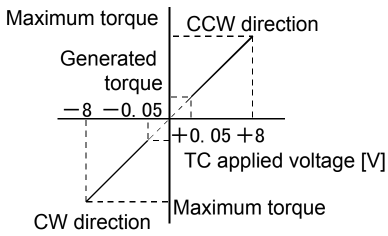


Table 7.1 Torque generation direction

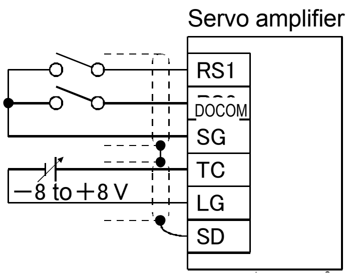
Between RS1 and DOCOM	Between RS2 and DOCOM	Rotation direction		
		+ polarity	0 V	- polarity
Open	Open	No torque	No torque	No torque
Short-circuit	Open	CCW (forward rotation power drive / reverse rotation regenerative driving)		CW (reverse rotation power drive/forward rotation regenerative drive)
Open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



Torque control level (when RS1: ON)

b. Connection figure

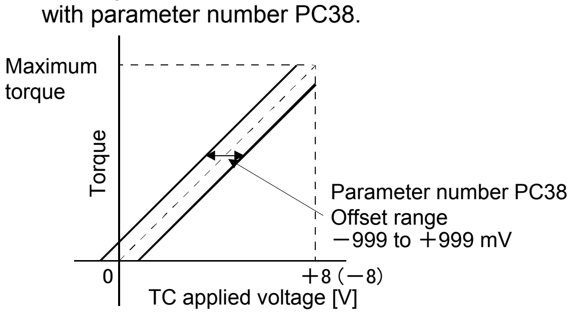
Connect according to the following figure.



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.

(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 7.2.

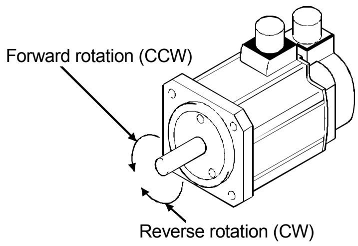
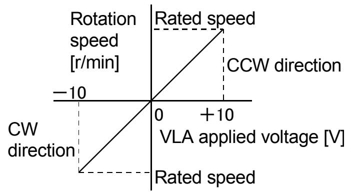


Table 7.2 RS1/RS2 and speed limit direction

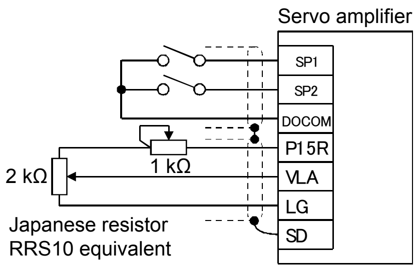
Between RS1 and DOCOM	Between RS2 and DOCOM	Speed limit direction		
		Analog speed limit (VLA)		Internal speed limit
		+ polarity	- polarity	1 to 3
Short-circuit	Open	CCW	CW	CCW
Open	Short-circuit	CW	CCW	CW



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 "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.

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 7.3. 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 7.3 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.

7.4.5 Power-On

(1) Confirmation
Confirm the installation and the wiring performed in 7.4.2 and 7.4.3 again thoroughly before power-on.

(a) Installation: Confirm the installation status based on section 7.4.2. 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.

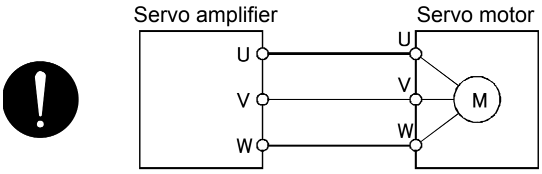
(b) Wiring: Check the wiring based on section 7.4.3. Because an error in main circuit connections may also lead to module damage, a thorough check is especially required.
Although the main items are listed below, there may be other model-specific problems. For details, refer to the respective installation 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.

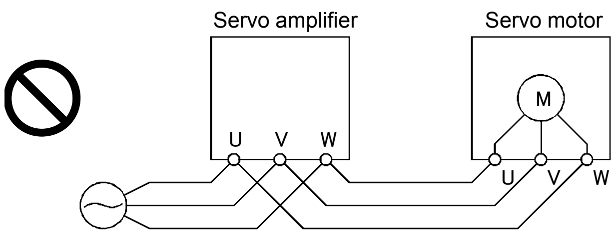
1) Wiring of power supply system
The power supply supplied to the power input terminals (L1, L2, L3, L11, and L21) of the servo amplifier should meet the regulated specifications.

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.

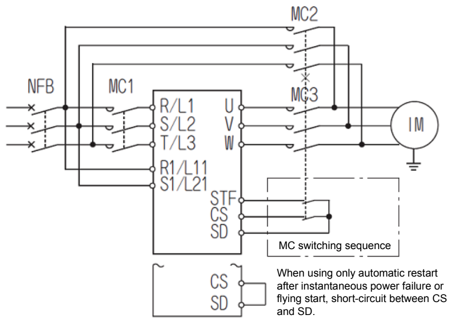


Fault example: Motor connection

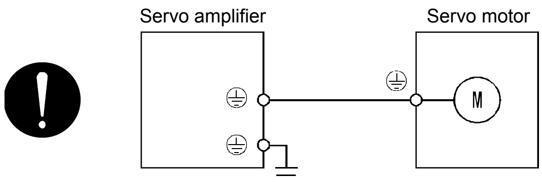
[Fault description]
For the first time, an external company was asked to assemble the device.
In the briefing, it was assured that the external company was experienced in the use of inverters, which is why they were given the job, but there was slight concern about the fact that this was the first time working on a servo.
After a while, we were informed that the motor had overheated and burnt out while starting.

[Cause of fault]
The servo motor was directly connected to AC power.
The following inverter connection diagram was referred to and AC power was directly supplied via the MC.
The motor did not run, and while this was being investigated, the motor rapidly heated up and emitted an abnormal smell.

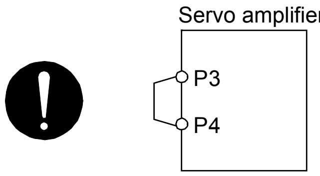
<Inverter connection diagram>



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



• There should be a connection between P3 and P4.



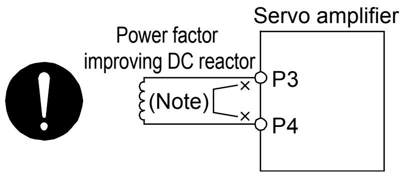
3) When optional/peripheral equipment is used

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.



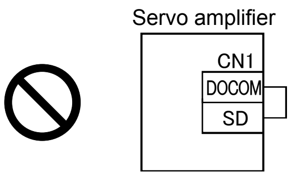
Note. Make sure to remove the wiring between P3 and P4.

(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.



(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.

7.4.6 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 7.4.7.)
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.	Abbre-viation	Name	Initial value	Unit	Control mode		
					Posi-tion	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	OTHOV	One-touch tuning - Overshoot permissible level	0	[%]	○	○	
PA26		For manufacturer setting	0000h				
PA27			0000h				
PA28			0000h				
PA29			0000h				
PA30			0000h				
PA31			0000h				
PA32			0000h				

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

No.	Abbre-viation	Name	Initial value	Unit	Control mode		
					Posi-tion	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	○	○	○

No.	Abbre-viation	Name	Initial value	Unit	Control mode		
					Posi-tion	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	VRF21B	Vibration suppression control 2 - Vibration frequency after gain switching	0.0	Hz	○		
PB57	VRF22B	Vibration suppression control 2 - Resonance frequency after gain switching	0.0	Hz	○		
PB58	VRF23B	Vibration suppression control 2 - Vibration frequency damping after gain switching	0.00		○		
PB59	VRF24B	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.	Abbre-viation	Name	Initial value	Unit	Control mode		
					Posi-tion	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				

No.	Abbre-viation	Name	Initial value	Unit	Control mode		
					Posi-tion	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				

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

No.	Abbre-viation	Name	Initial value	Unit	Control mode		
					Posi-tion	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	*D15L	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				

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

No.	Abbre-viation	Name	Initial value	Unit	Control mode Posi-tion	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				

No.	Abbre-viation	Name	Initial value	Unit	Control mode Posi-tion	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.	Abbre-viation	Name	Initial value	Unit	Control mode Posi-tion	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	Vibration tough drive - Oscillation detection level	50	[%]	○	○	
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				

No.	Abbre-viation	Name	Initial value	Unit	Control mode		
					Posi-tion	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.	Abbre-viation	Name				Posi-tion	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					

(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

- 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

- 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.)

(d) Use absolute position detection system

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbre-viation	Name				Posi-tion	Speed	Torque
PA03	*ABS	Absolute position detection system	0h		Refer to the text	○		

POINT

- 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	

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.	Abbre-viation	Name				Posi-tion	Speed	Torque
PA04	*AOP1	Function selection A-1	2000h		Refer to the text	○	○	

POINT

- 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

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.	Abbre-viation	Name				Posi-tion	Speed	Torque
PA05	*FBP	Number of command input pulses per revolution	10000		1000 to 1000000	○		

POINT

- 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.

(g) Electronic gear

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbre-viation	Name				Posi-tion	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

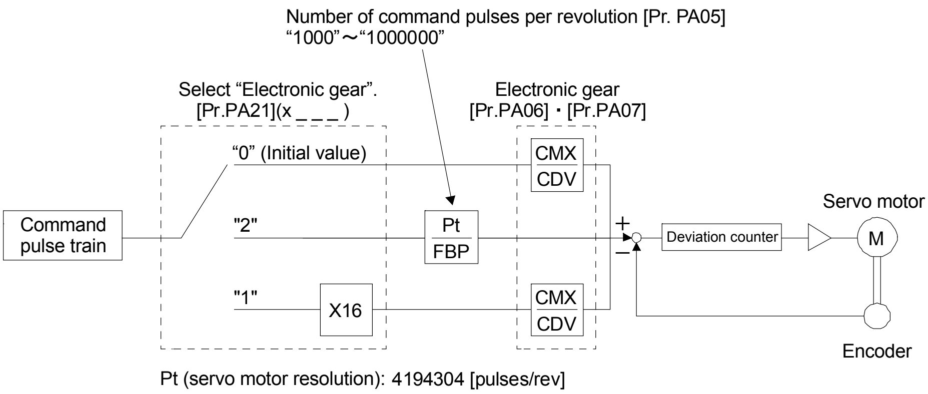
- When there are setting errors, unexpected high-speed rotations may occur, leading to damage.

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.

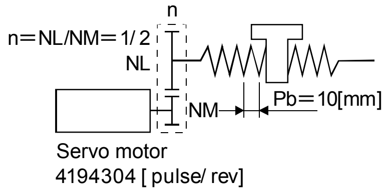
POINT

- The following parameter symbols are required when calculating the electronic gear each time.
Pb: Ball screw lead [mm]
n: Reduction ratio
P_t: Servo motor resolution [pulse/rev]
$\Delta\ell_0$: Travel distance per command pulse [mm/pulse]
ΔS: Travel distance per servo motor revolution [mm/rev]
Δθ°: Angle per pulse [°/pulse]
Δθ: Angle per revolution [°/rev]

- 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: P_t=4194304 [pulse/rev]



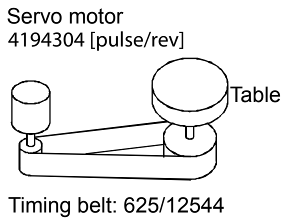
$$\frac{CMX}{CDV} = \Delta\ell_0 / \frac{P_t}{\Delta S} = \Delta\ell_0 / \frac{P_t}{n \cdot Pb} = 10x10^{-3} / \frac{4194304}{1/2 \cdot 10} = \frac{8388608}{1000} = \frac{1048576}{125}$$

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: P_t=4194304 [pulse/rev]



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

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.

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

Therefore, set CMX=13153337 and CDV=5625.

POINT
● 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°=359.99989°

(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.

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

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

$$\frac{CMX}{CDV}=\frac{1644167168}{703125}=\frac{14681664}{6277.9}\fallingdotseq\frac{14681664}{6278}=2338.589359 \qquad (5.3)$$

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

$$\frac{CMX}{CDV}=\frac{1644167168}{703125}=\frac{13153337.3}{5625}\fallingdotseq\frac{13153337}{5625}=2338.371022 \qquad (5.4)$$

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.

(h) Auto tuning

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbre-viation	Name				Posi-tion	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]

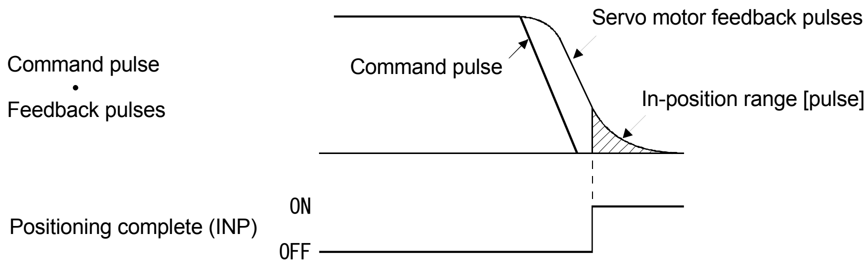
(2) Auto tuning response (Parameter number PA09)
Decrease the setting value when the machine causes hunching and there is excessive gear noise. Decrease the setting value when improving performance, such as reducing the stop setting time.

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.	Abbre-viation	Name				Posi-tion	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.	Abbre-viation	Name				Posi-tion	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.

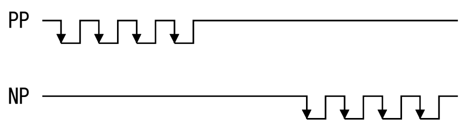
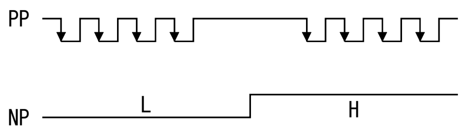
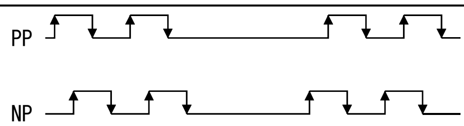
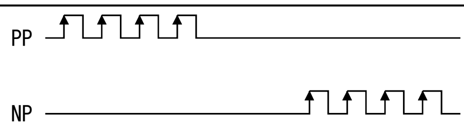
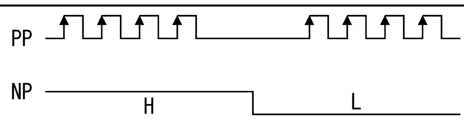
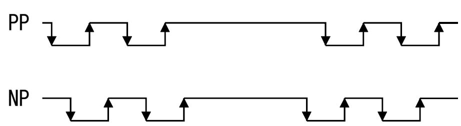
(k) Command pulse input form selection

Parameter No.	Parameter Abbre-viation	Parameter Name	Setting digit	Function	Initial value Unit	Control mode Posi-tion	Control mode Speed	Control mode 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)	
0011h	Negative logic	Pulse train + code	
0012h	Negative logic	Phase A pulse train Phase B pulse train	
0000h	Positive logic	Forward rotation pulse train (Forward direction pulse) Reverse rotation pulse train (Reverse direction pulse)	
0001h	Positive logic	Pulse train + code	
0002h	Positive logic	Phase A pulse train Phase B pulse train	

(l) Servo motor rotation direction selection

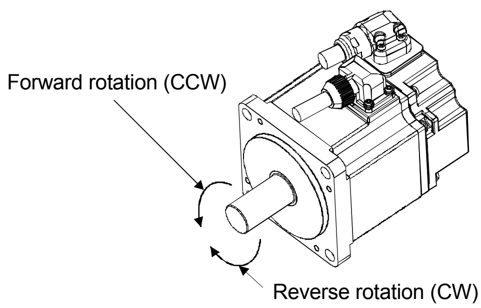
Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbre-viation	Name				Posi-tion	Speed	Torque
PA14	*POL	Rotation direction selection	0		0, 1	○		

POINT

- 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.	Abbre-viation	Name				Posi-tion	Speed	Torque
PA15	*ENR	Encoder output pulses	4000	pulse/rev	1 to 4194304	○	○	○

POINT

- 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.

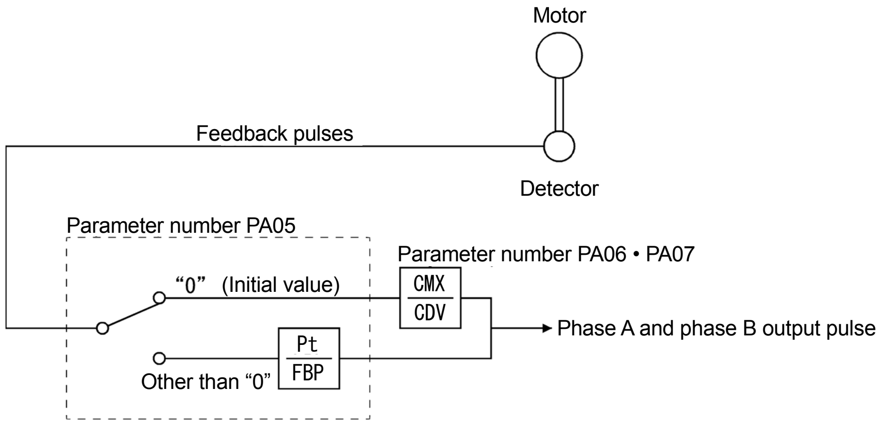
$$\text{Output pulse} = \frac{\text{Resolution per servo motor revolution}}{\text{Set value}} \text{ [pulse/rev]}$$

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.

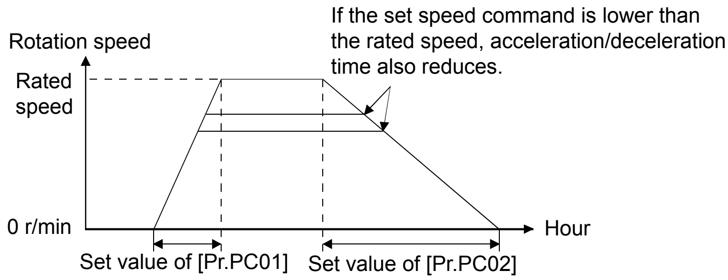


(n) Operation pattern in speed control mode

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbre-viation	Name				Posi-tion	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 Instanta-neous 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.

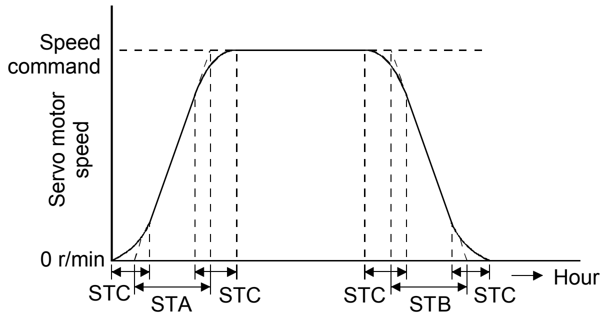


For example, for a servo motor with a rated speed of 3000 r/min, set 3000 (3 s) to increase the speed from 0 to 1000 r/min in 1 s.

(o) S-curve acceleration/deceleration time constant

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbre-viation	Name				Posi-tion	Speed	Torque
PC03	STC	S-curve acceleration/deceleration time constant	0	ms	0 to 1000		○	○

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.

$\frac{2000000}{STA}$ at the time of acceleration; $\frac{2000000}{STB}$ 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.

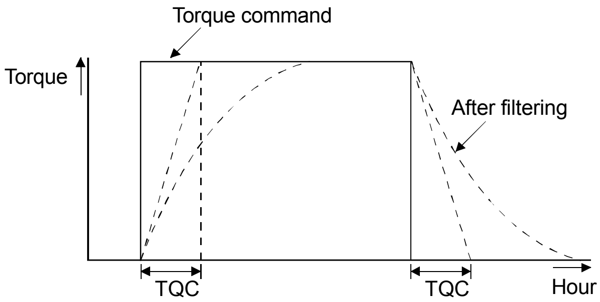
At acceleration: 100 [ms] (Because $\frac{2000000}{20000} = 100$ [ms] < 200 [ms] limited to 100 [ms].)

At deceleration: 200 [ms] (Because $\frac{2000000}{5000} = 400$ [ms] > 200 [ms] becomes 200 [ms] per the settings.)

(p) Torque command time constant

Parameter			Initial value	Unit	Setting range	Control mode		
No.	Abbre-viation	Name				Posi-tion	Speed	Torque
PC04	TQC	Torque command time constant	0	ms	0 to 50000			○

Set the primary delay filter constant for the torque command.



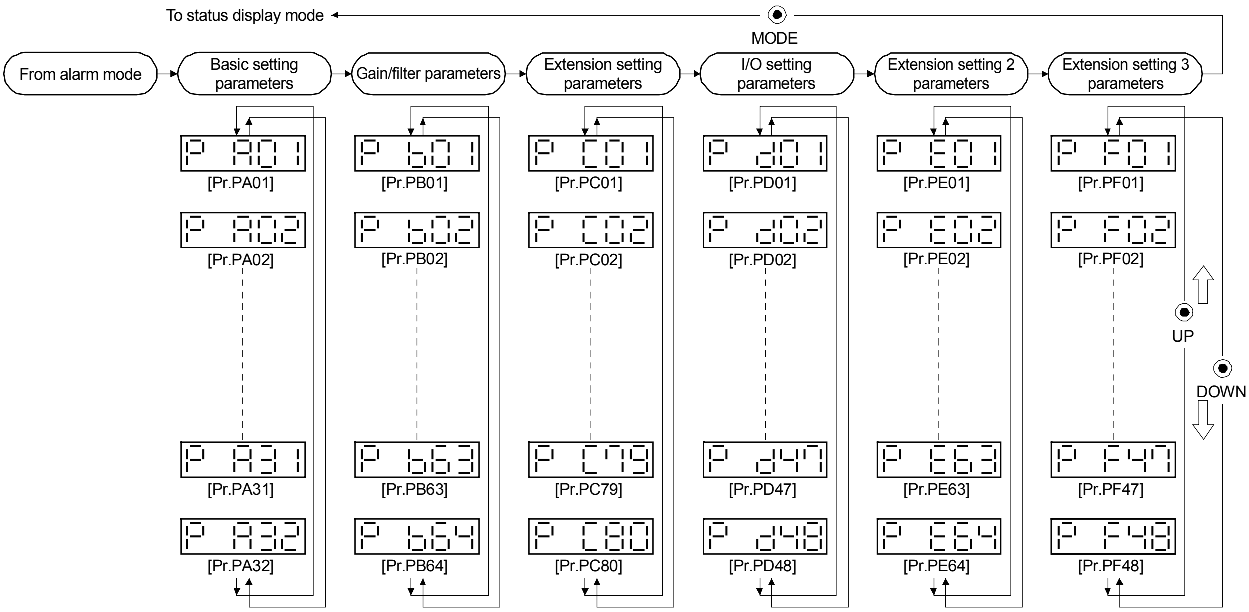
TQC: Torque command time constant

For use with training machine

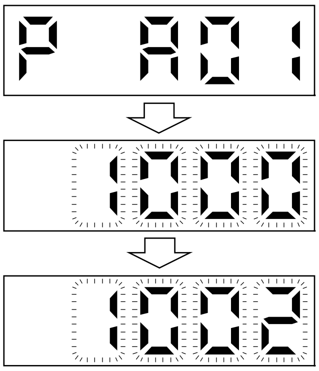
7.4.7 Parameter Setting

After power-on, initialize the parameter value depending on the operation conditions. The parameters are described in section 7.4.6. Set based on the settings specifications.
In particular, make sure to check the parameters described in section 7.4.6 (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.



[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.

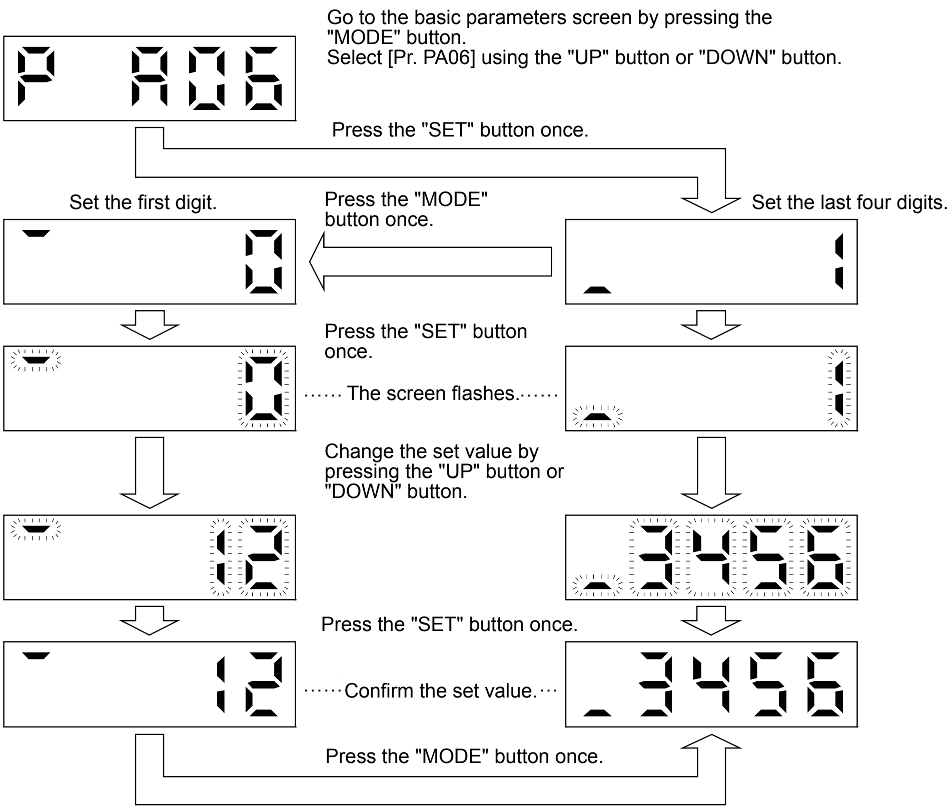
Press the "UP" button twice.

...... 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.

[Parameter setting example (setting value is less than 6 digits)]
This example shows the operation method if [Pr. PA06 Electronic gear numerator] is changed to "123456".

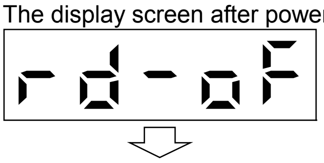


For use with training machine

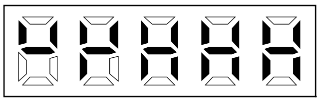
7.4.8 External I/O Signals Check

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



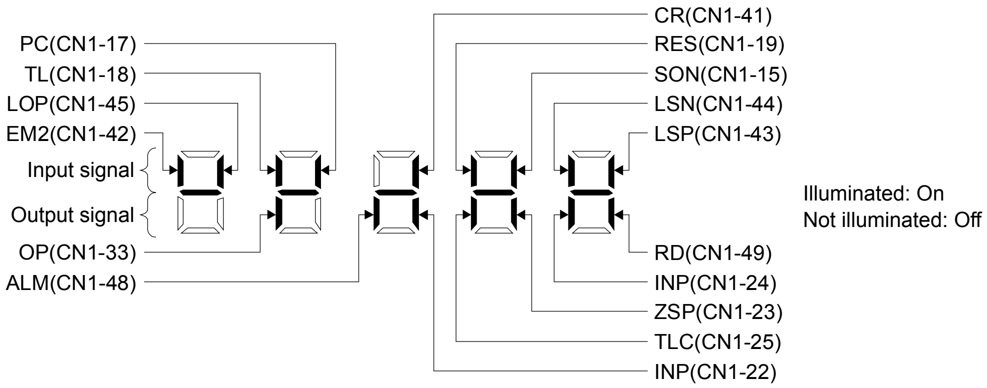
Press the "UP" button twice.



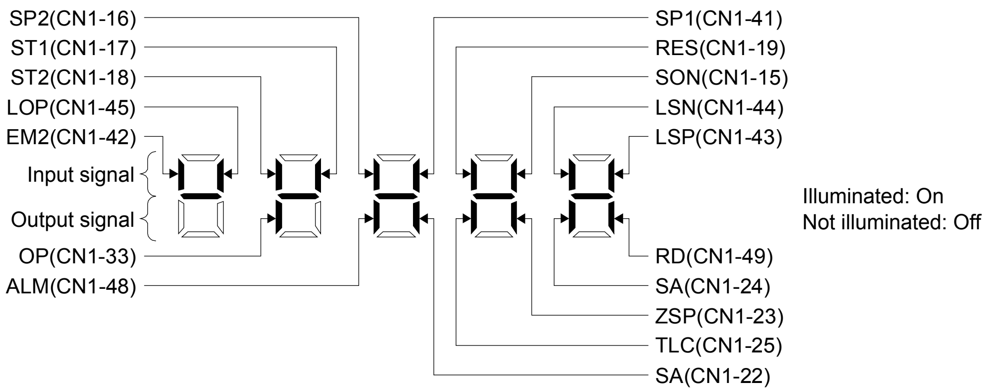
…… External I/O signal display screen

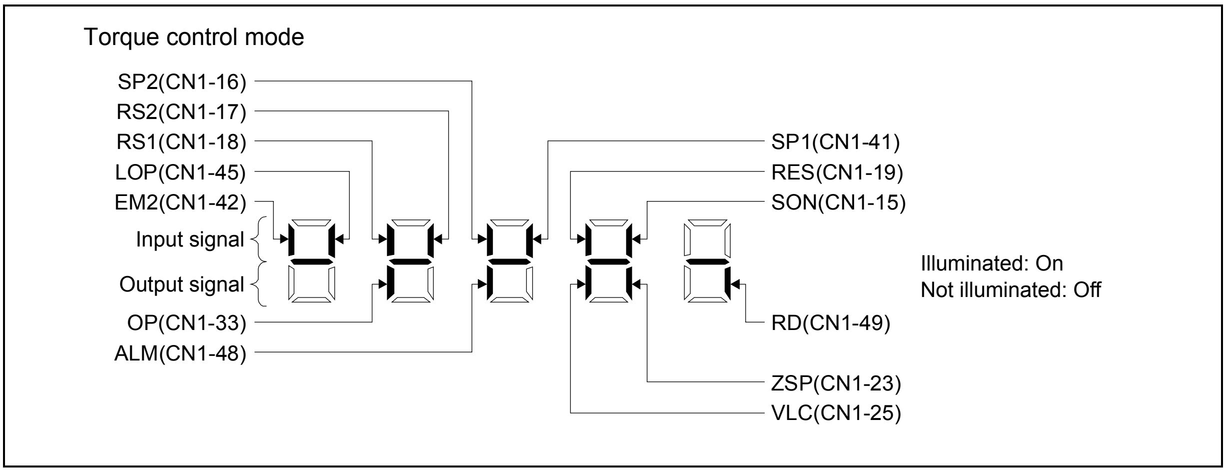
(2) Display description

Position control mode



Speed control mode




Torque control mode
SP2(CN1-16)
RS2(CN1-17)
RS1(CN1-18)
LOP(CN1-45)
EM2(CN1-42)
Input signal
Output signal
OP(CN1-33)
ALM(CN1-48)
SP1(CN1-41)
RES(CN1-19)
SON(CN1-15)
Illuminated: On
Not illuminated: Off
RD(CN1-49)
ZSP(CN1-23)
VLC(CN1-25)

7.4.9 Test Operation of Position Control Mode

Before starting the machine operation, implement the test operation and confirm that the machine operates normally.

Test operation of just the servo motor with 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.

7.4.10 Test Operation of Speed Control Mode

Before starting the machine operation, implement the test operation and confirm that the machine operates normally.

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.

7.4.11 Test Operation of Torque Control Mode

Before starting the machine operation, implement the test operation and confirm that the machine operates normally.

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 SON (servo-on). When in the servo-on state, RD (ready) is turned on. 2) The servo motor rotates when VTC (analog torque command) is input from the controller and RS1 (forward rotation selection) or RS2 (reverse rotation selection) are turned on. After the first low torque 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 SON (servo-on). When in the servo-on state, RD (ready) is turned on. 2) The servo motor rotates when VTC (analog torque command) is input from the controller and RS1 (forward rotation selection) or RS2 (reverse rotation selection) are turned on. After the first low torque 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. 3) Next, implement automatic operation confirmation using the controller program.

7.4.12 Test Operation Mode

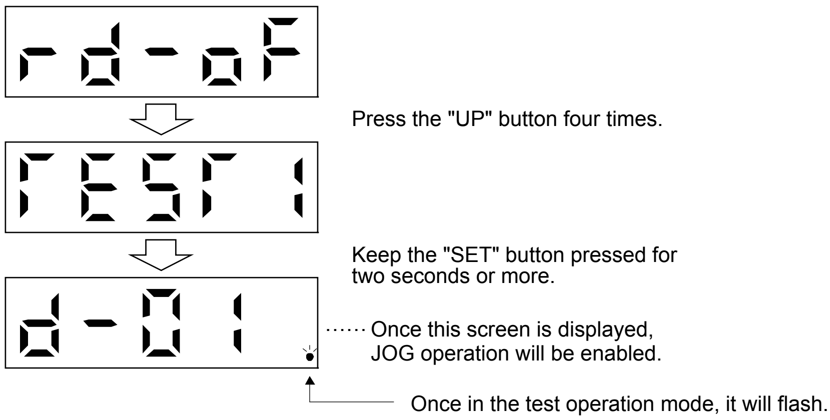
⚠CAUTION

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

POINT

- 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
● 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.

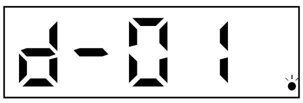
(b) Status display

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. 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) 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 it for a sequence check of 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.

8. Life of AC Servo Parts

8.1 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 supply capacity.

(3) Servo amplifier cooling fan: The cooling fan has a bearing life of 10000 to 35000 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 reducer.) Replacement should be performed every 5000 hours 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.

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 your local sales office. 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		Up to five years from the date of manufacturing	

8.1.1 Battery Replacement Procedure

⚠WARNING	● Before replacing a battery, turn off the main circuit power supply and wait 15 minutes or longer until the charge lamp turns off. Then, check the voltage between P+ and N- with a voltage tester, etc. Otherwise, an electric shock may occur. In addition, when confirming whether the charge lamp is off or not, always check from the front of the servo amplifier.

⚠CAUTION	● The internal circuits of the servo amplifier may be damaged by static electricity. Always take the following precautions. • Ground your body and the work bench. • Do not touch the conductive areas such as the connector pins and electrical parts directly.

POINT

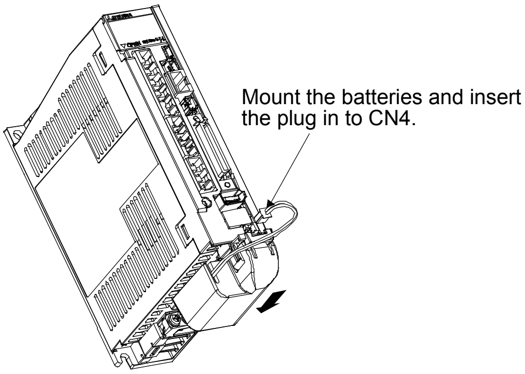
- Replacing a battery with the control circuit power supply turned off will erase the absolute position data.

Replace the battery with only the control circuit power supply turned on. Replacing a battery with the control circuit power supply turned on will not erase the absolute position data.
Refer to section 8.1.2 for the procedure for mounting the battery to the servo amplifier.

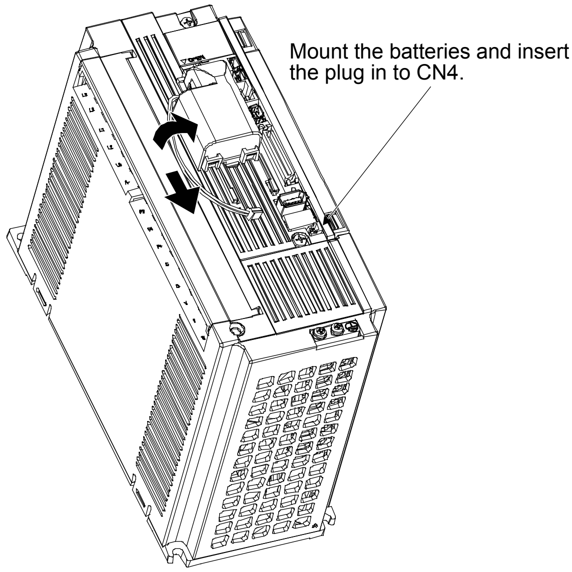
8.1.2 Battery Detachment Procedure

(1) Mounting method

POINT
● For servo amplifiers with a battery holder on the bottom, the structure is such that the grounding wire cannot be laid when the battery is mounted. Always mount the battery after laying the grounding wire of the servo amplifier.



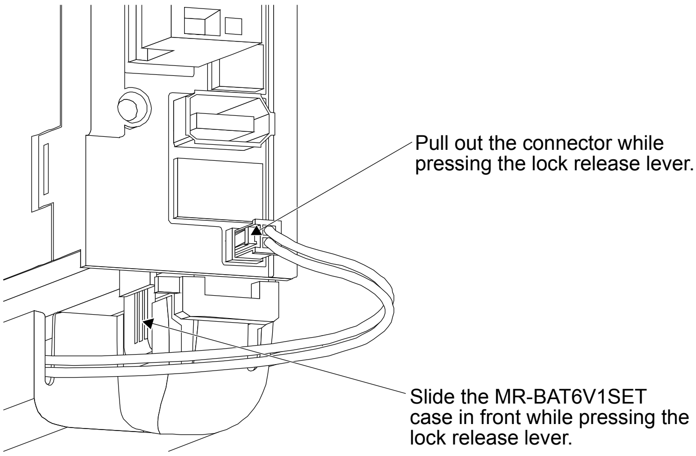
With MR-J4-350A or lower



With MR-J4-500A or higher

(2) Removal method

⚠CAUTION	If the MR-BAT6V1SET connector is pulled out without pressing the lock release lever, the servo amplifier CN4 connector or the MR-BAT6V1SET connector may become damaged.



8.1.3 Method for Battery Replacement by Turning the Control Circuit Power Supply OFF

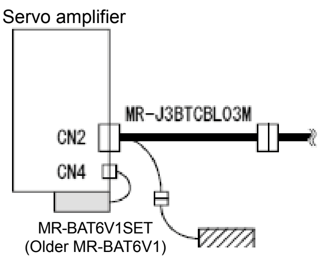
(1) Battery replacement setup
When replacing the battery, a backup battery is needed in addition to the replacement battery. Prepare the batteries shown below.

Name	Application and quantity	Remarks
MR-BAT6V1	1 for replacement	Unused within 2 years from the manufacturing date. Stored at room temperature.
MR-J3BAT	1 for backup	

(2) Replacement procedure

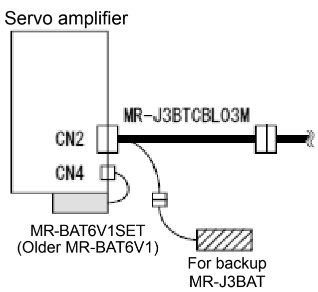
⚠CAUTION

- Do not connect MR-J3BTCBL03M and MR-J3BAT when MR-BAT6V1SET is not mounted whether the controlled power supply is ON or OFF.
- The absolute position is erased when the encoder cable is removed. While replacing the battery, do not remove the encoder cable.
- Use MR-J3BAT only when replacing MR-BAT6V1SET. Use MR-BAT6V1SET as the normal backup.
- Replace the battery when the servo motor is stopped (not rotating due to an external force).

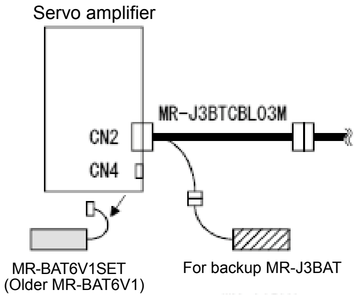


Step 1
Start up the equipment by inserting MR-J3BTCBL03M between the encoder cable and CN2 of MR-J4-A/B.

Step 2
Turn the controlled power supply off.

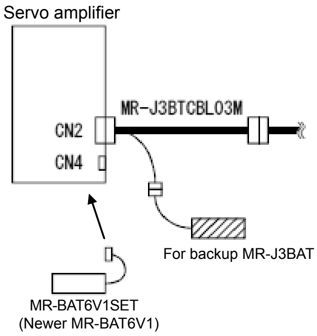


Step 3
Connect backup battery MR-J3BAT to the MR-J3BTCBL03M battery connector.



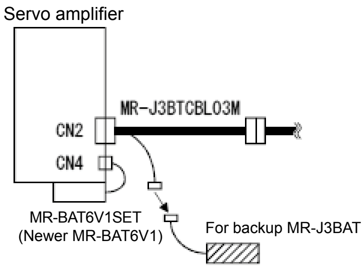
Step 4
Remove from the servo amplifier the MR-BAT6V1SET equipped with the old MR-BAT6V1.

Step 5
Replace the old MR-BAT6V1 built in to the MR-BAT6V1SET with the new MR-BAT6V1. *1



Step 6
Attach the MR-BAT6V1SET equipped with the new MR-BAT6V1 to the servo amplifier. Then, connect the plug of the MR-BAT6V1SET lead wire to the CN4 connector of the servo amplifier.

> CAUTION!
> When MR-J3BAT is connected, if the control power is turned ON without connecting the MR-BAT6V1SET lead wire to CN4, AL. 9F.1 (Battery voltage drop) is detected.

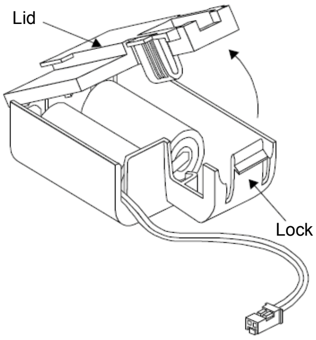


Step 7
Remove the backup MR-J3BAT.

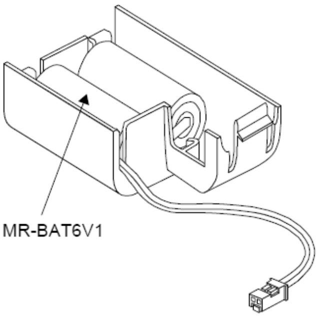
Step 8
Turn the controlled power supply ON to complete the replacement procedure.

*1: Refer to the next page for the method of replacing MR-BAT6V1 in MR-BAT6V1SET.

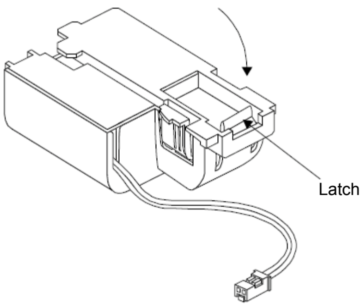
(3) Replacement procedure of battery built in to MR-BAT6V1SET
It is possible to replace the MR-BAT6V1 battery built in to MR-BAT6V1SET.



Step 1
Open the lid by pressing the lock portion.



Step 2
Replace the built-in battery with a new MR-BAT6V1 battery.



Step 3
Close the lid and press down until secured to the latch of the lock portion.

Memo

Appendix 1. Various Symbols

Appendix table 1 List of various symbols

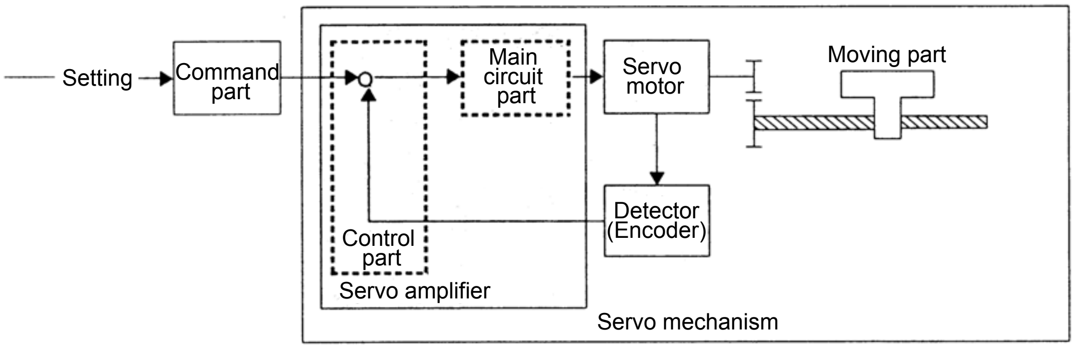
Ta	: Acceleration torque	[N·m]	P_f	: Number of feedback pulses	[pulse/rev]
Td	: Deceleration torque	[N·m]	f_{c1}	: Electronic gear output pulse frequency	[pps]
T_{Ma}	: Motor torque necessary for acceleration	[N·m]	f_c	: Electronic gear input pulse frequency	[pps]
T_{Md}	: Motor torque necessary for deceleration	[N·m]	f_0	: Input pulse frequency during maximum machine speed	[pps]
T_L	: Load torque at motor shaft	[N·m]	Tpsa	: Acceleration time of command pulse frequency	[s]
T_u	: Unbalanced torque	[N·m]	Tpsd	: Deceleration time of command pulse frequency	[s]
T_F	: Load friction torque	[N·m]	K_p	: Position loop gain	[s^{-1}]
T_{LO}	: Load torque on load shaft	[N·m]	T_p	: Position loop time constant (Tp = 1/Kp)	[s]
Trms	: Continuous effective load torque at motor shaft	[N·m]	$\Delta\ell_0$	: Feed length per electronic gear output pulse	[mm/pulse]
T_M	: Motor rated torque	[N·m]	$\Delta\ell_c$	: Feed length per electronic gear input pulse	[mm/pulse]
T_{mmax}	: Motor maximum torque	[N·m]	ℓ	: Feed length per rotation	[mm]
J_L	: Load moment of inertia at motor shaft	[$kg·cm^2$]	P	: Number of command input pulses	[pulse]
J_{LO}	: Load moment of inertia on load shaft	[$kg·cm^2$]	t_f	: 1 operation cycle	[s]
J_M	: Rotor moment of inertia of the motor	[$kg·cm^2$]	t_o	: Positioning time	[s]
Nr	: Motor rated speed	[r/min]	t_{st}	: Stop time	[s]
No	: Motor speed during maximum machine speed	[r/min]	t_c	: Rated operation time	[s]
N	: Motor speed	[r/min]	t_s	: Stop settling time	[s]
Vo	: Maximum machine high speed	[mm/min]	m	: Inertia ratio (m = JL/JM)	
V	: Machine speed	[mm/min]	ε	: Number of droop pulses	[pulse]
P_B	: Ball screw lead	[mm]	Δε	: Positioning accuracy	[mm]
Z_1	: Number of gear teeth on motor shaft side		ΔS	: Feed length per motor rotation	[mm]
Z_2	: Number of gear teeth on load shaft side			Example: For ball screw	
	Reduction ratio $1/n = \frac{Z1}{Z2}$			With direct connection $\Delta S = P_B$	
	Speed is reduced when 1/n < 1 and increased when 1/n > 1			When reduction ratio is 1/n $\Delta S = P_B \cdot 1/n$	

Remarks 1. When the moment of inertia unit is expressed by GD^2, $GD^2 = 4×J$.
2. In the system of units, 1 $kg·m^2$ = 10000 $kg·cm^2$.
3. These various symbols are mainly for the servo amplifier and are described in relation to input and output.
Considered from the positioning controller side
For example, it can be read as follows:
Electronic gear input pulse frequency f_c → Command output pulse frequency
Feed length per electronic gear input pulse $\Delta\ell_c$ → Feed length per command output pulse (command minimum feed unit).

Appendix 2. AC Servo Fundamentals

Appendix 2.1 What is an AC Servo?

Defined by JIS 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 entered 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. Appendix figure 2.1 shows a configuration example.

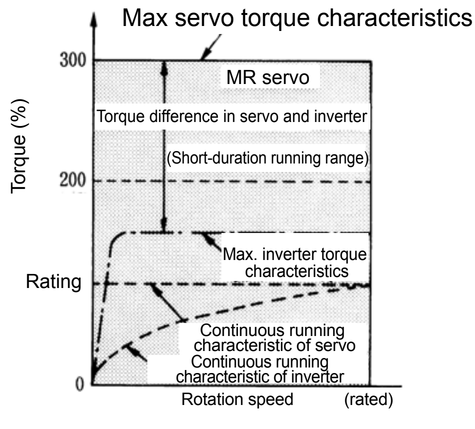


Appendix figure 2.1 Configuration diagram of servo mechanism

Appendix 2.2 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. Attached figure 2.2 shows the comparison of characteristics of a servo motor and a general-purpose motor that uses a 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: Because the maximum torque is high and the moment of inertia is low, rapid acceleration/deceleration is possible.



Appendix figure 2.2 Configuration diagram of servo mechanism

Appendix table 2.1 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 1/1000th 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

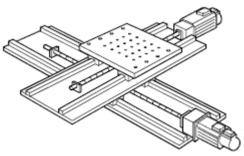
If an AC servo is used combined with a specialized positioning controller, it is possible to perform high-accuracy positioning.

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]

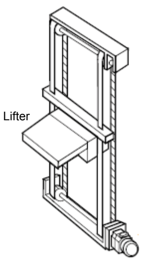
(a) X-Y table

Connects the respective worm gear 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. (Applied even in multi-level parking garages.)

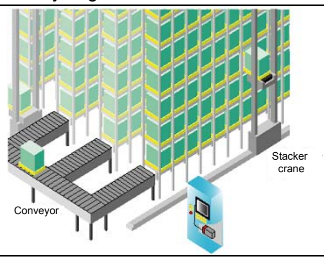


Automated storage/picking system

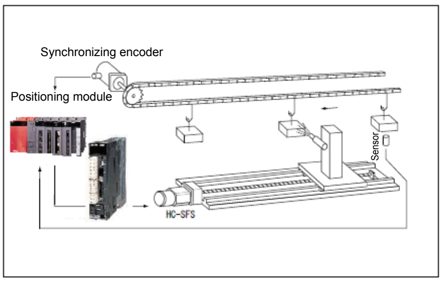
Even with automated storage, the AC servo is often used in picking/traveling sections in accordance with the high-speed conversion needs.

By using an AC servo motor, smooth and accelerated speed can be implemented quickly.

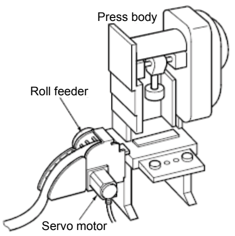
Automated storage/picking systems connected to the SCM (Supply chain management) deliver significant improvements to the stock management efficiency of commodity distribution from the procurement of raw materials to the delivery of goods.



(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.



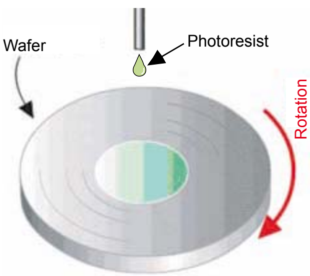
(d) Press roll feeder
Drives a feed roll using an AC servo motor and supplies material only for a fixed length. Material is supplied to the press when the press head is elevated, and after positioning is complete, punching is carried out.



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.

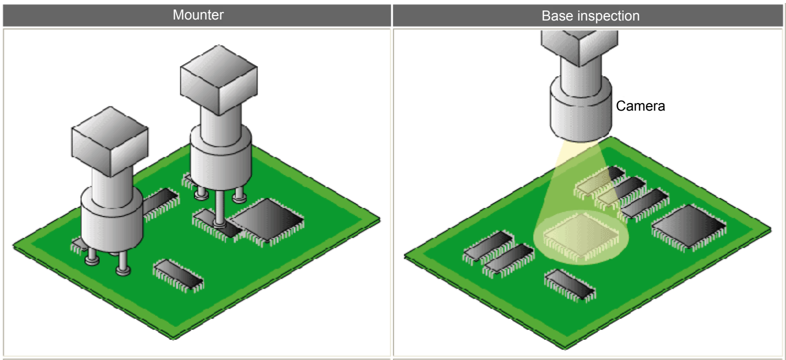


3) High-frequency positioning

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 rotations 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 cutters, loaders/unloaders, filling machines, packaging machines, various transportation machines, mounters, bonders]

(a) Mounter and base inspection



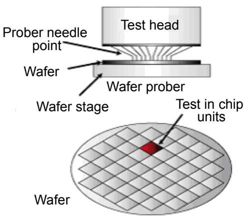
Mounter: Check whether the electronic components (LSI, resistor, capacitor, etc.) are mounted on the printed-circuit board. Positioning accuracy and high speed performance are requested.

Base inspection: Check whether the electronic components (LSI, resistor, capacitor, etc.) are mounted correctly on the printed-circuit board. In some cases, the board itself is also checked.

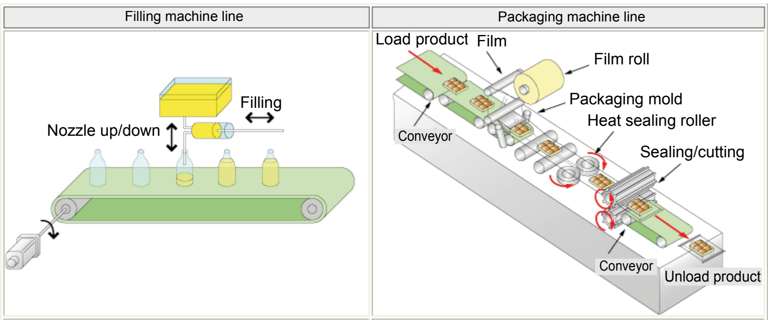
(b) Wafer probers

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



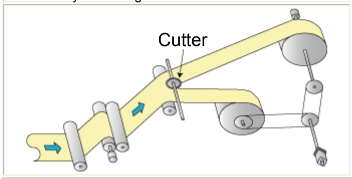
Filling machine line: Filling machine line Bottles capable of large amounts are filled with different volumes of liquid at fast speeds. The filling speed can be controlled according to the shape of the bottles so that the liquid does not bubble over the specified value.

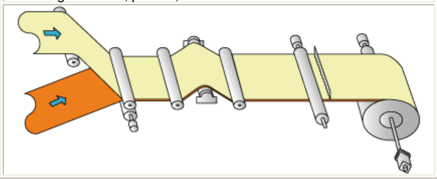
Packaging machine line: Servo motors are used to pack foodstuff in film properly and hygienically. The point is to cut and separate the rolled film into precise sizes after the packaging is done according to the size of food products.

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.

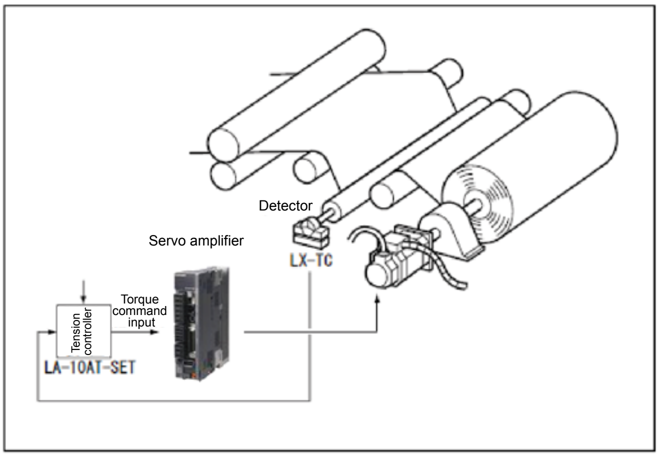
(a) Slitters and laminators

Slitter	Laminator
A slitting machine is used for slitting at the winded part as the final process after processing has been performed in the processing part. The point is to slit successfully using the slitter by controlling the tension.	The laminator is used to superimpose and fuse several films. It is important to control the tension and adjust the right amount of pressure so that superimposing is done well. The same mechanism is also used in coating machines, printers, etc.

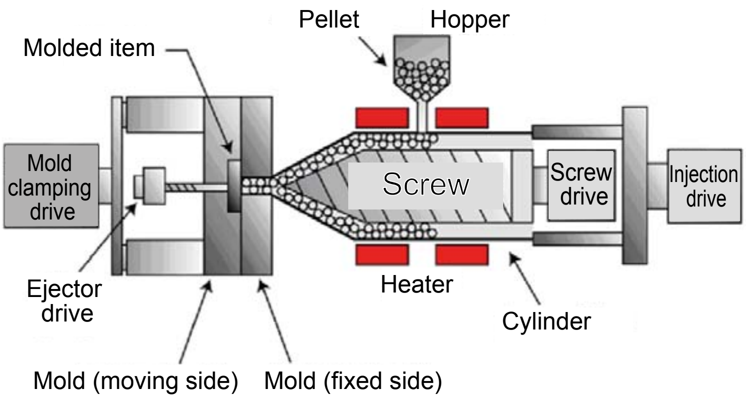




(b) Winding devices
Carries out winding tension control of sheet material by combining an AC servo and a tension detector/tension controller device.



(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.



Appendix 2.3 AC Servo Mechanism

Appendix 2.3.1 Block Diagram of Servo Amplifier and Operating Principles

The basic functions of the main circuit portion include commutating/smoothing AC power (three-phase 200 to 230 AC V, 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.

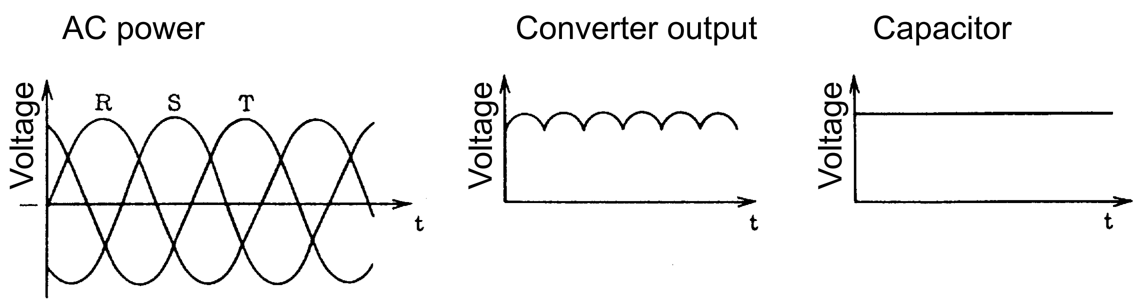
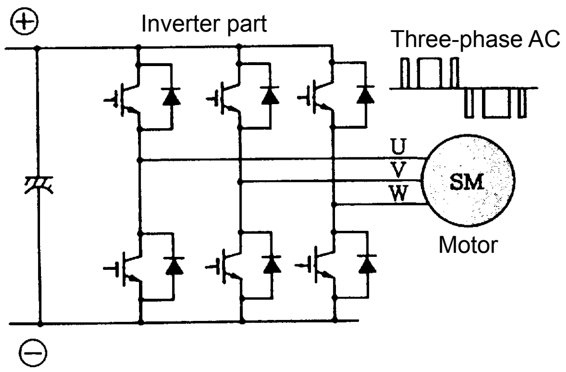
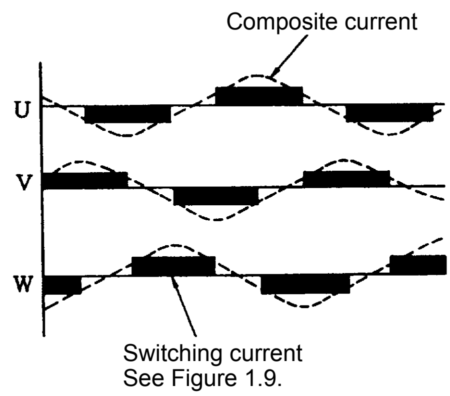


Figure 1.4 External voltage of servo amplifier

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.

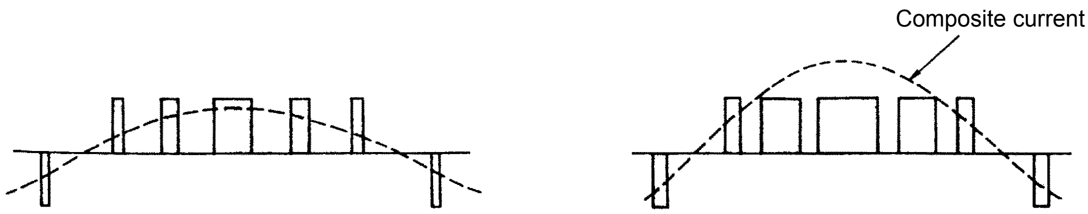


Appendix figure 2.5 Configuration of inverter portion



Appendix figure 2.6 Output current of inverter

As shown in Appendix figure 2.7, 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 on width between energizing widths. This method is called PWM control (pulse width control).



(a) When current is low

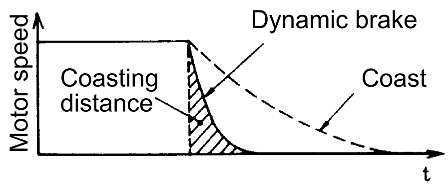
(b) When current is high

Appendix figure 2.7 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 less.
      - 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.

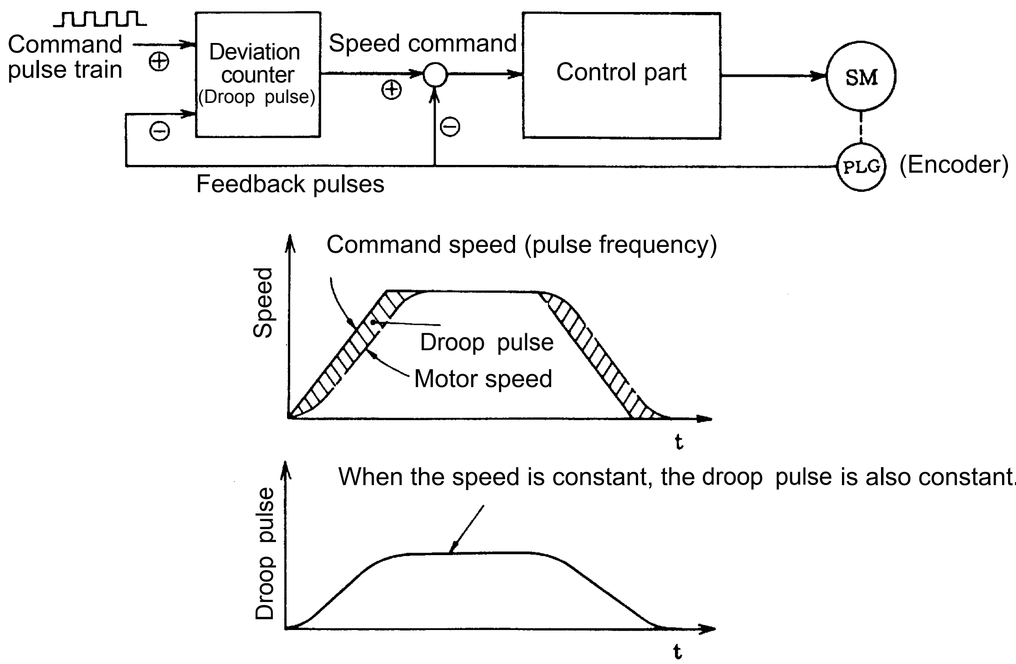
4) Dynamic brakes
   When stopped (base circuit shut-off) due to the output of the inverter portion when the power turns off or when an alarm occurs, the motor will be free-running and a longer period will be required until stopping, which increases the coasting distance and can result in defects such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

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 of MR-J3 type or higher and MR-C type 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.

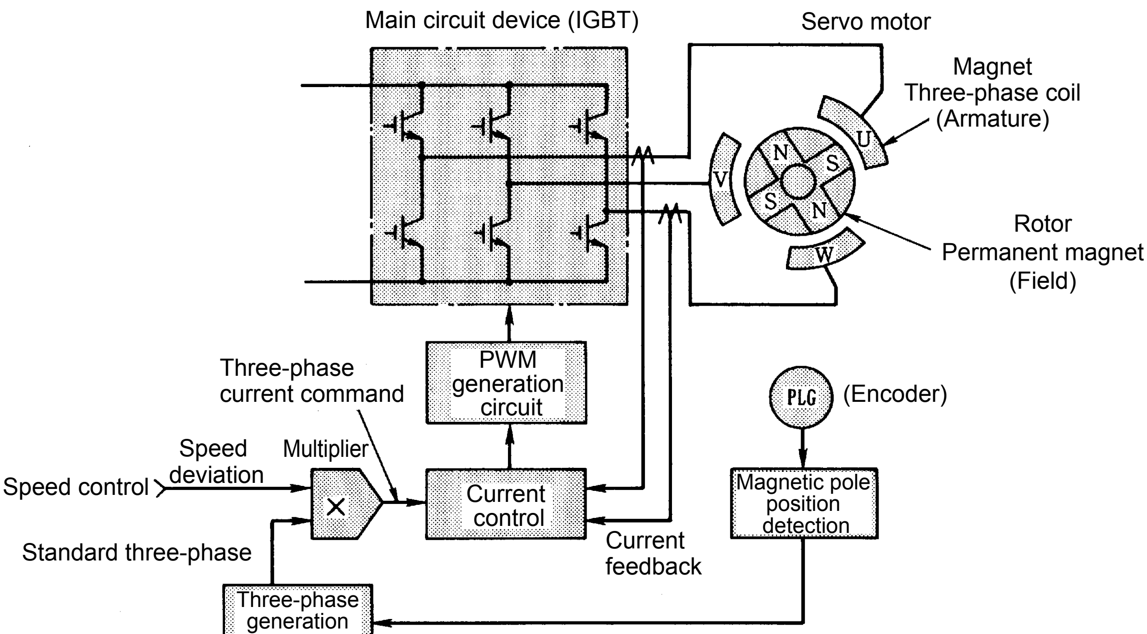
1) Position control
Motor rotation speed/direction control and high accuracy positioning are executed by a pulse train.



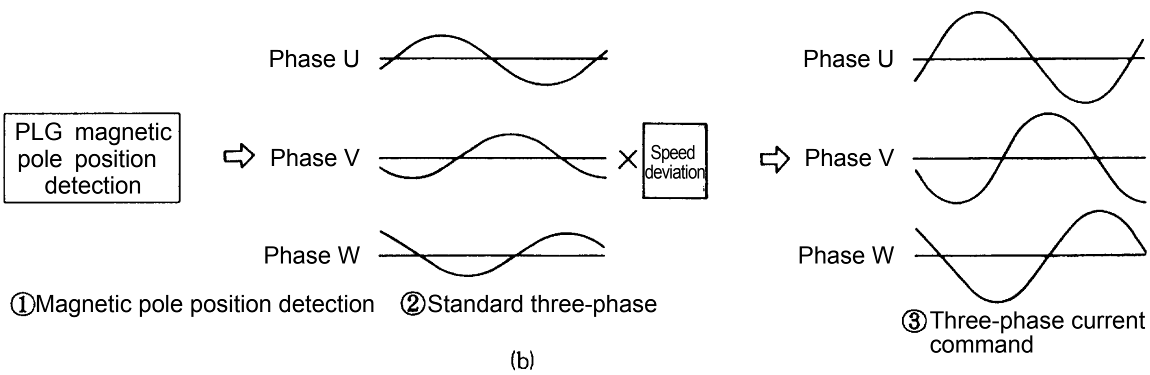
Even when a command pulse is input by the position control portion, the motor is operated with a certain degree of delay from the command. As such, a pulse equivalent to the delay is retained in the deviation counter. This is called a droop pulse. This droop pulse is output in the speed control portion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

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, analog voltage (0 to ±10 V) is 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.



(a)

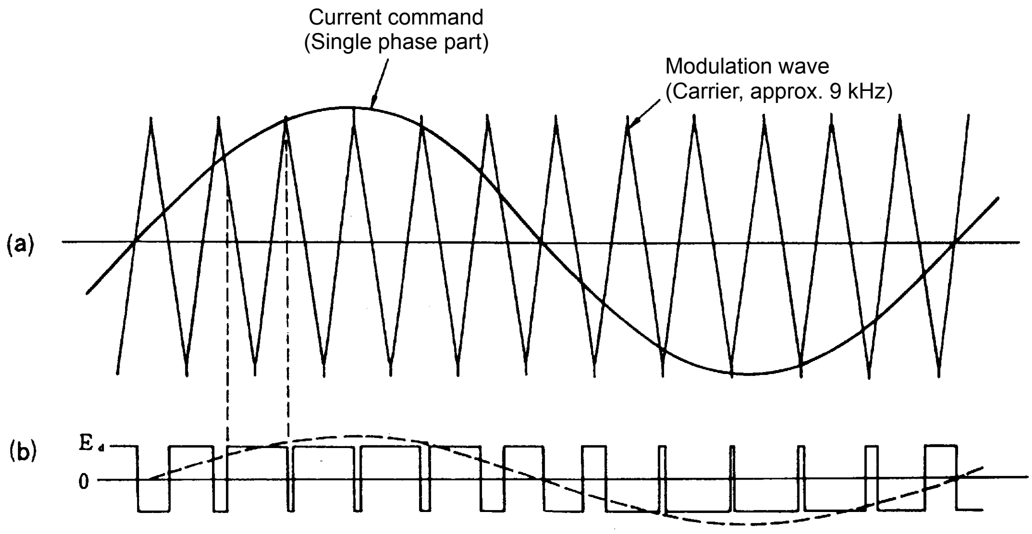


(b)

Appendix figure 2.8 Principles of current control

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.

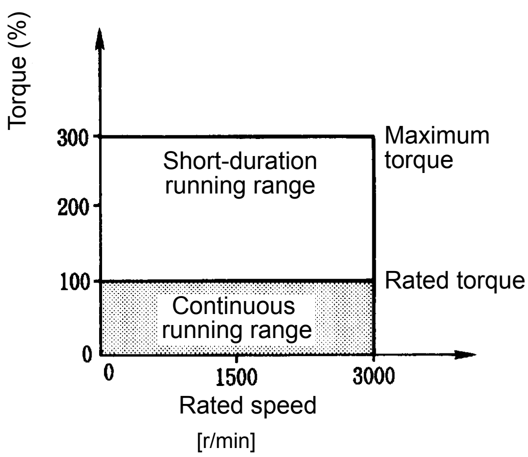
The PWM method is the method that generates the switching pulse several times in one cycle, and changes that pulse width to change the output voltage. The number of switching pulses generated in 1 second is called the carrier frequency. With the PWM method, motor vibrations and undesired motor sounds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



Appendix figure 2.9 Principles of PWM control

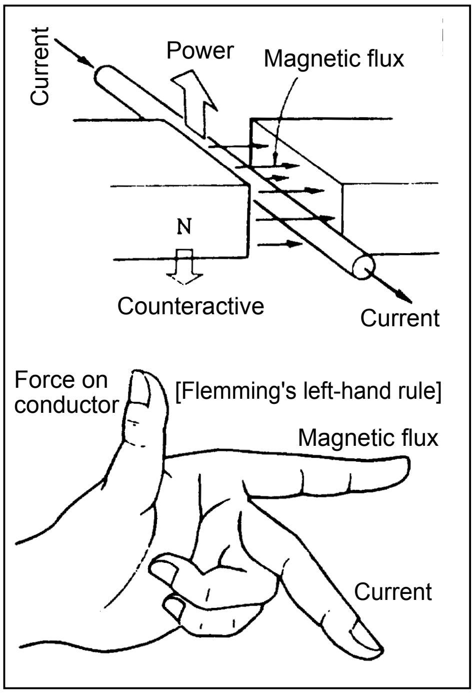
Appendix 2.3.2 Characteristics of AC Servo Motor and Operating Principles

(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.

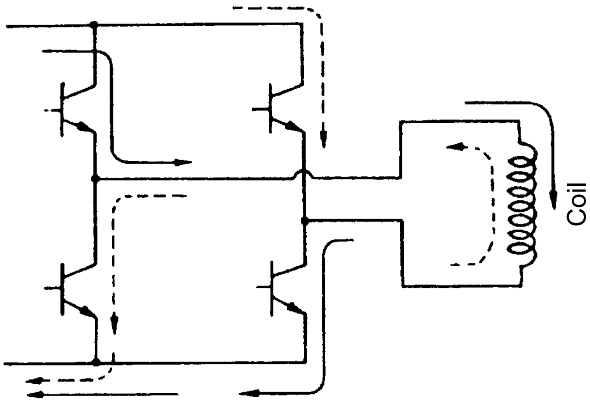


Appendix figure 2.10 Torque characteristics of servo motor

(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.

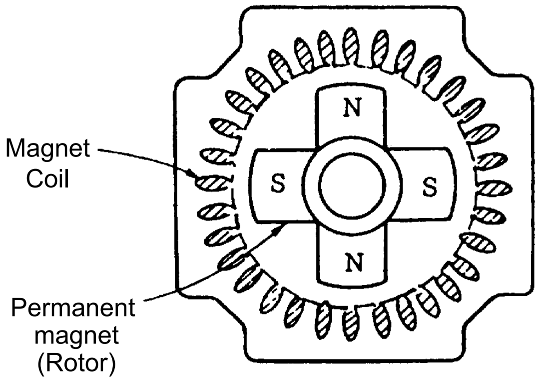


Principles of motor torque generation

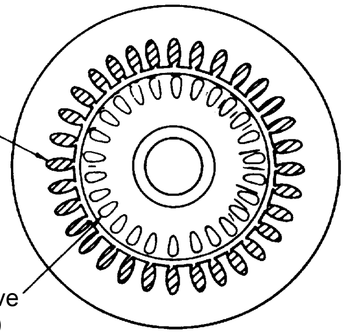


Operating principles of SM-type AC servo motors

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 smoothened 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.



(3) Principles of IM type motor (induced current electrical motor) motor (vector control inverter)
Even for IM type motor, 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 individually supply the current I_a and the magnetic flux Φ of formula (2-1) and (2-2). 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 (2-3).



Appendix figure 2.12 Cross-section of IM-type motor

$I_1 = I_a + I_b$ ……………………………………(2-3)

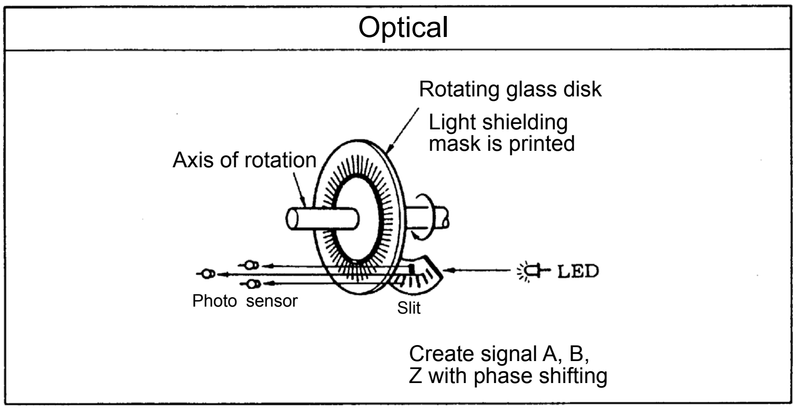
[I_1: Magnet coil current; I_a: Torque current; I_b: Magnetic flux electric current
Note: The above formula is a vector summation, not an arithmetic summation.]

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.

Appendix 2.3.3 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.



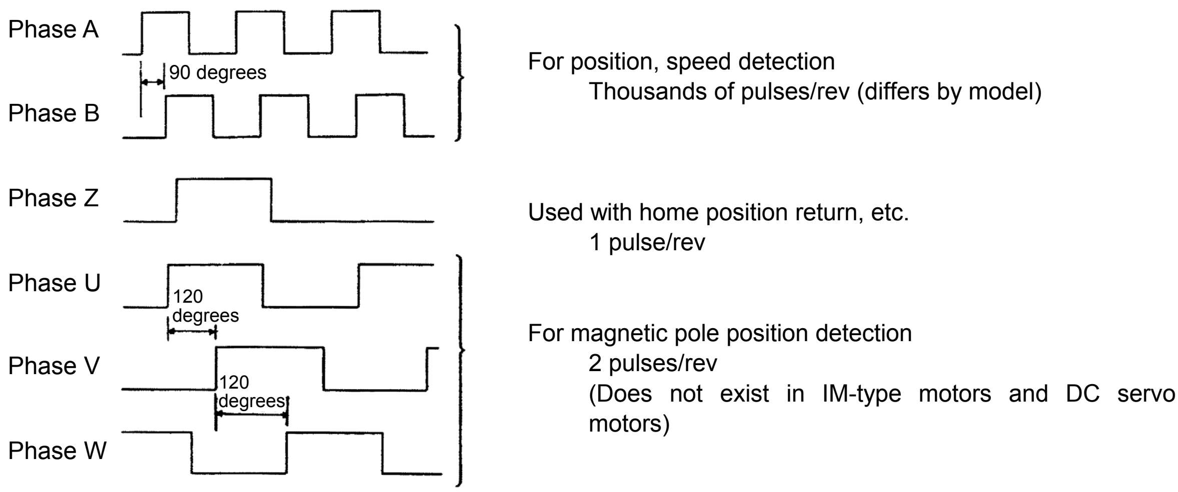
Appendix figure 2.14 Encoder structure

(2) Encoder functions and signal types

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

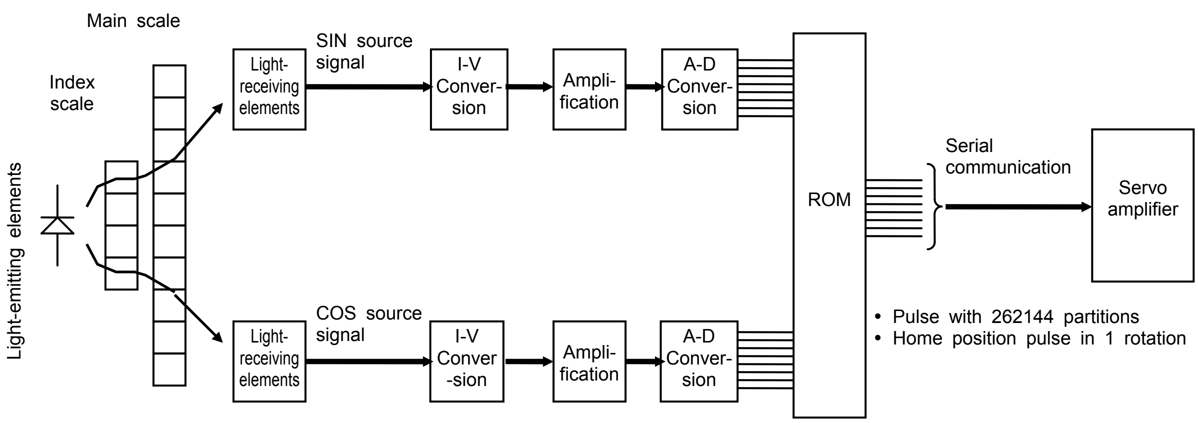
1) Detection of motor position (including rotation direction)
2) Detection of motor speed (including rotation direction)
3) Detection of motor magnetic pole position (not necessary for IM-type motors, DC servo motors)

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



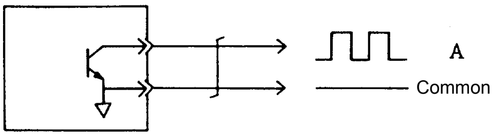
Appendix figure 2.15 Encoder signals

Encoders assembled in recent AC servo motors create a pulse divided in 262144 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.



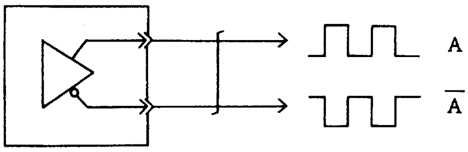
(3) Encoder signal interface
Although the encoder signals from the servo motor to the servo amplifier are serialized, the encoder signals emitted from the servo amplifier are converted into pulse form and are output.
The following are the two types of encoder output signal interfaces. Recently, the differential driver output method, with a steady signal transmission, has become mainstream.

- Open collector output



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

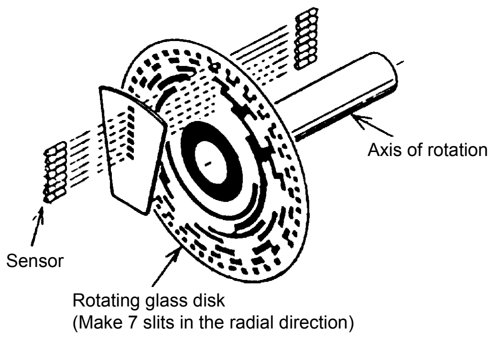
- Differential driver



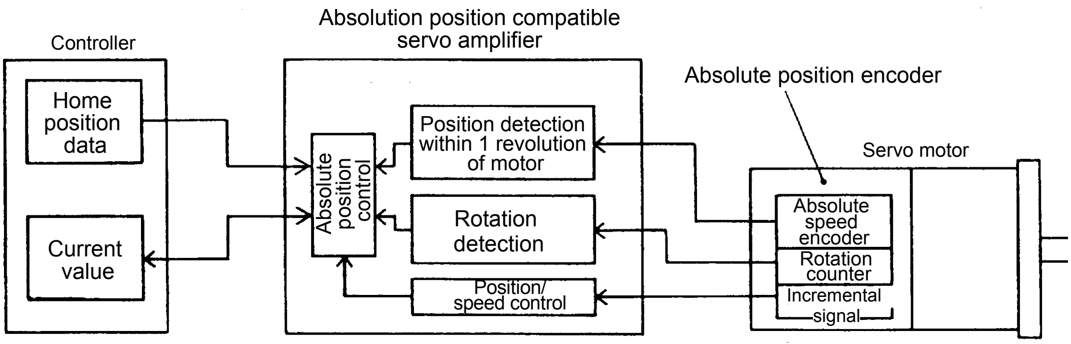
High-frequency transmission is possible.
Also resistant to noise.

(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.



Appendix figure 2.17 Example of absolut e position encoder structure



Appendix figure 2.18 Block diagram of absolute position system

Appendix 3 Positioning Control by AC Servo

Appendix 3.1 Positioning Method and Stopping Accuracy

Appendix 3.1.1 Positioning Types

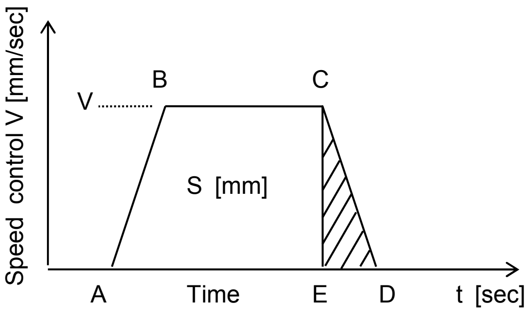
The methods for stopping a mobile object with prescribed accuracy at a fixed position consist of a mechanical method and an electrical method. Mechanical methods generally include putting a stopper (inverter stopping control and AC servo torque limiting are up to contact with the stopper) and forcible 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 detector on the servo motor side.

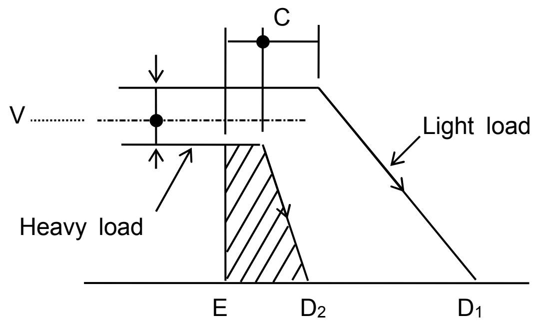
Appendix table 3.1 summarizes this.

Appendix 3.1.2 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 time against speed 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].



Appendix figure 3.1 Operation (speed) pattern



Appendix figure 3.2 Variations in coasting distance

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 3.2, 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. Therefore, 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 Appendix table 3.1 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

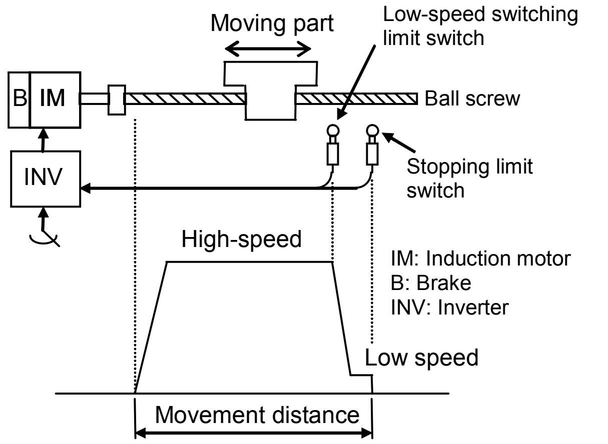
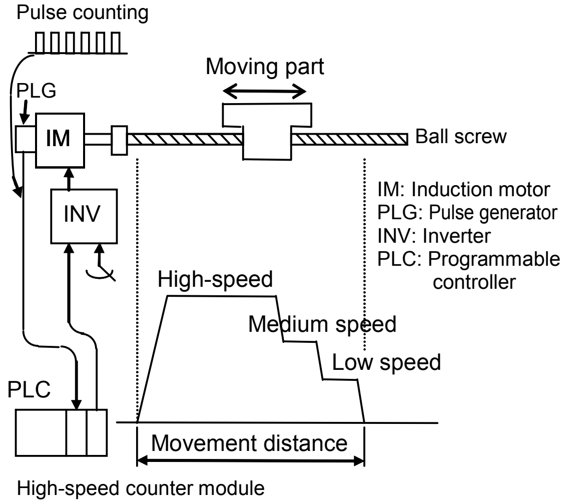
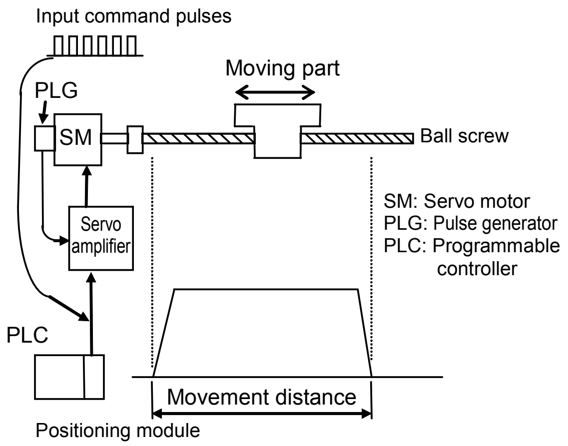
There is a pulse count method in which the limit switch method is improved. With this method, time can be minimized for short distance movements to obtain deceleration points at several stages by selecting any stop position. The stopping precision itself does not change as with the limit switch method, 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.

Appendix table 3.1 Positioning method comparison table

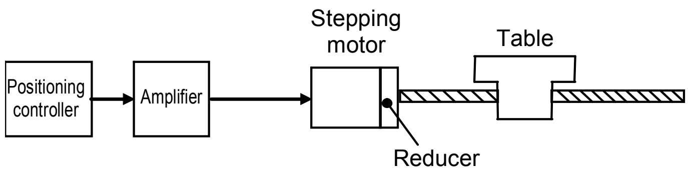
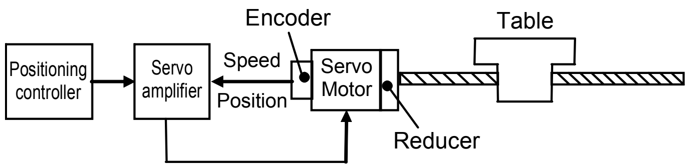
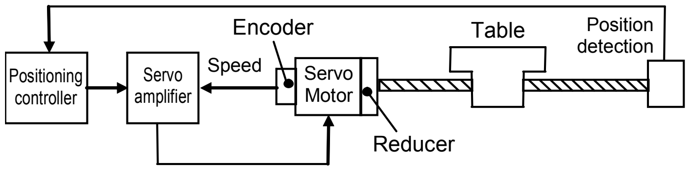
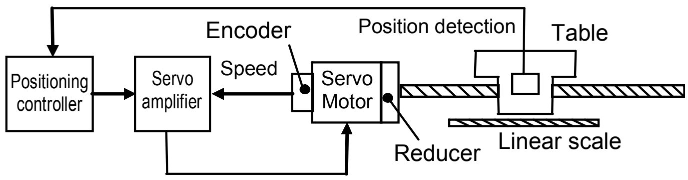
Classi-fication	Method	Description	Explanatory overview figure
Speed control method	Limit switch method	In this method, a limit switch is set where a moving object passes by, and the moving object operates the switch, whose signal performs stopping. In general, the speed is lowered by the first of two switches, the motor is turned OFF by the second switch, and the moving object is stopped by the application of brakes. Positioning equipment is not specifically required, and the device can be configured at a low price with simple controls. (Stopping precision reference ±0.5 to 5.0 mm) (Note)	
	Pulse count method	The position detector pulse encoder 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. With this method, a limit switch, etc., can be omitted, and position changing is easy. (A high-speed counter module can be used.) (Stopping precision reference ±0.5 to 5.0 mm) (Note)	
Position control method	Pulse command method	In a driven motor, an AC servo motor that rotates in proportion to the number of pulses input is used. 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.) (Stopping precision reference ±0.001 to 0.05 mm)	

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

Appendix 3.1.3 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 Appendix table 3.2. (The open loop method is not a servo, but it is shown as a comparison of closed loop.)

Appendix table 3.2 Position control method types

Loop method		Configuration	Characteristics
Open loop			● No feedback; not called a servo ● Loss in synchronism (operation stops) due to overloading ● Small capacity only
Semi-closed loop	Motor shaft detection		● Simple configuration ● Quickest response ● Stable control system that can be used safely ● Reducer backlash compensation is required
	Feed screw terminal detection		● 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			● 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.

The content from this page onward is performed in the servo practice course.

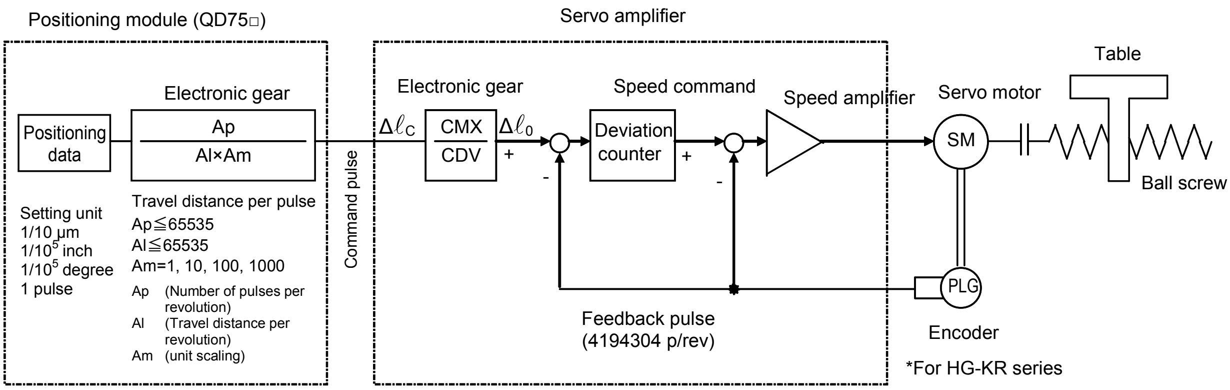
Appendix 3.2 Fundamentals of Positioning Control by AC Servo

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

Appendix 3.2.1 Position Detection and Number of Pulses per Motor Rotation

As explained in Appendix 3.1.3, 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 Appendix 2.3.3.)
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).

Appendix 3.2.2 Position Servo Concepts



Appendix figure 3.3 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×4194304 pulses=12582.912×10^6 pulses in 1 minute, and 12582.912×10^6/60=209715.2×10^3 pulses in 1 second (represented as 209715.2×10^3 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.

Appendix 3.3 Positioning Accuracy

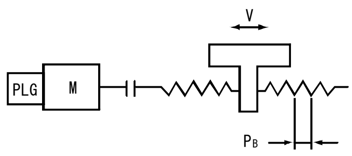
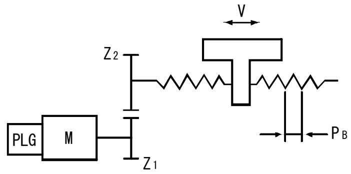
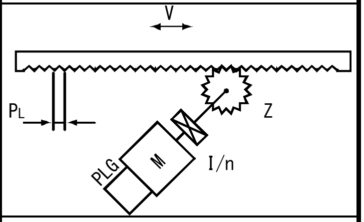
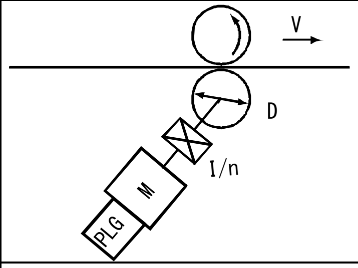
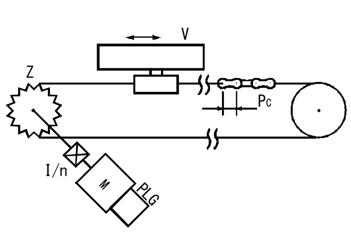
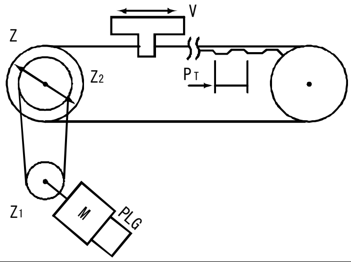
Appendix 3.3.1 Machine Feed Length per Pulse

The per-pulse feed length of a machine is the minimum increment the machine will travel. As shown in Appendix figure 3.4 (1), for mechanical systems with a ball screw but without a reducer, the per-pulse feed length of a machine $\Delta\ell_0$ 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 Appendix figure 3.4 is assigned to ΔS in formula (2-1), the feed length per pulse $\Delta\ell_0$ can be obtained.

$$\Delta\ell_0 = \frac{\Delta S}{P_{fo}} = \frac{\Delta S}{4194304} \text{ [mm/puls]} \qquad (2\text{-}1)$$

However, P_{fo}: Number of feedback pulses per motor rotation.
The value of P_{fo} 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]f or HC-SFS types, 262144 [pulse/rev] for all MELSERVO-J3 Series motors, and 4194304 [pulse/rev] for all MELSERVO-J4 Series motors.

Appendix figure 3.4 shows an example of the mechanical system and the calculation formula for ΔS.

	(1) Ball screw (direct connection)	(2) Ball screw (gear connection)	(3) Rack and pinion
Drive system			
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
	(4) Roll feed	(5) Chain-driven (direct connection)	(6) Chain, timing belt drive
Drive system			
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

Appendix figure 3.4 Feed length per motor rotation (ΔS) of various mechanical systems

Appendix 3.3.2 Overall Machine Accuracy and Electrical Side Accuracy

Overall machine accuracy Δε= 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 Δε results. Generally, the settings are configured so as to satisfy the following:

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

<Reference> Overall accuracy of machine Δε and feed length per pulse $\Delta\ell_0$
By considering the overall accuracy of the machine Δε, the per-pulse feed length $\Delta\ell_0$ can be obtained.

Appendix 3.4 Motor Speed for Machine High Speed

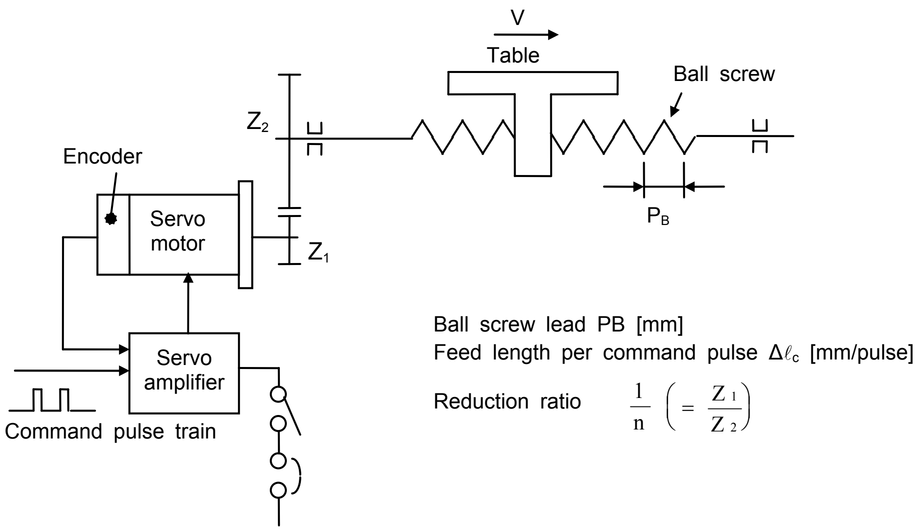
As shown in Appendix figure 3.5, when the speed is changed in mechanical systems using gears and driven by a ball screw, the motor speed V [mm/min] against the machine high speed N [r/min] becomes as shown in formula (2-3).

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

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

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

If the machine high 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 Nr [r/min], then high positioning accuracy can be obtained and the motor power can be used effectively.



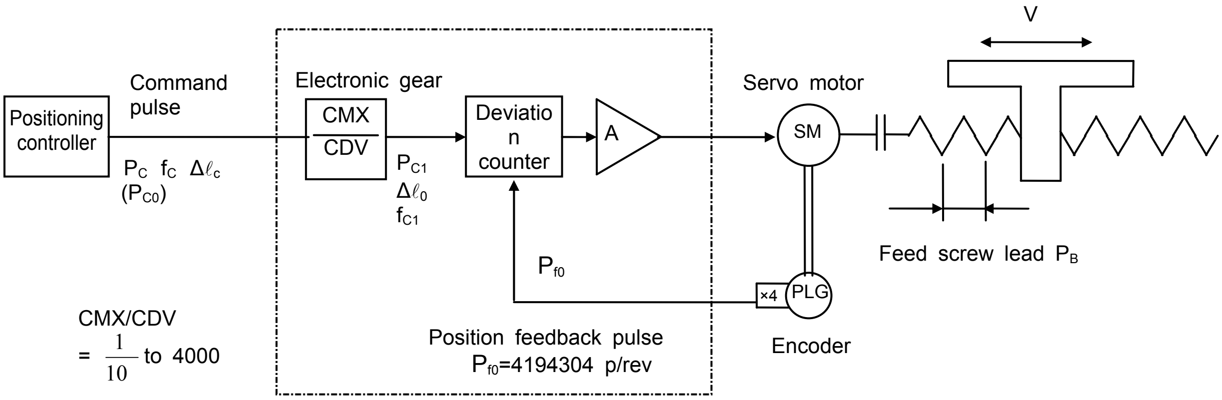
Appendix figure 3.5 Relationship between machine speed and motor speed

Appendix 3.5 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 per-pulse feed length of the machine (Appendix 3.3.1) and the minimum command unit for positioning, as well as whether the pulse frequency at high machine speed mutually satisfies the positioning controller and the servo amplifier.

Appendix 3.5.1 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.



Appendix figure 3.6 Explanation of electronic gear functions

A block diagram of the electronic gear function is shown in Appendix figure 3.6. 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]
- P_{C1}: Number of deviation counter input pulses [pulse]
- P_{f0}: Number of feedback pulses per motor rotation [pulse/rev]
- P_{C0}: Number of command pulses per motor rotation [pulse/rev]
- f_C: Command pulse frequency [pps]
- f_{C1}: Deviation counter input command pulse frequency [pps]
- $\Delta\ell_0$: Machine travel distance per feedback pulse [mm/pulse]
- $\Delta\ell_C$: Machine travel distance per command pulse [mm/pulse]
- CMX: Command pulse multiplication numerator
- CDV: Command pulse multiplication denominator

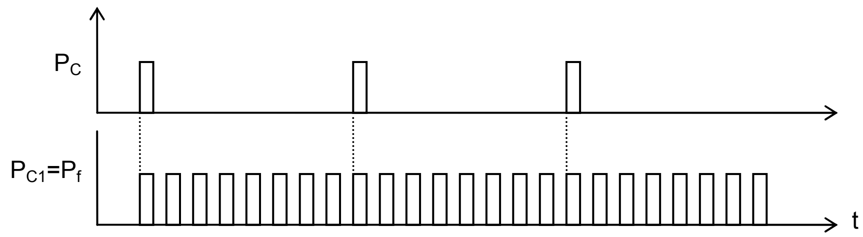
<Reference> Electronic gear function
An electronic gear function is present at the positioning controller side as well as the servo amplifier side.
Set the electronic gear of the servo amplifier so that the fraction of the encoder is rounded and does not exceed the maximum command pulse frequency. Also, 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 $\Delta\ell_0$ and set resolution $\Delta\ell_C$ can be set separately, and $\Delta\ell_C$ 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.

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

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

Appendix figure 3.7 shows the relationship between P_C and P_{C1} when the electronic gear ratio CMX/CDV=8.



Appendix figure 3.7 Relation of electronic gear setting part I/O when the electronic gear ratio is 8

2) The same applies to the pulse frequency.

$$f_{c1} = f_C \cdot \frac{CMX}{CDV} \qquad (2\text{-}6)$$

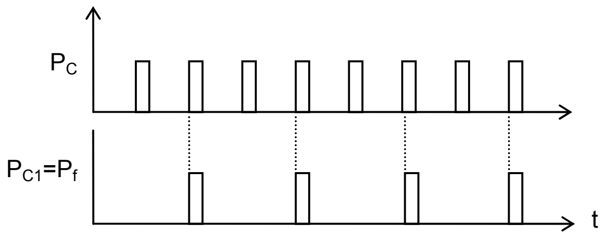
The following applies:
f_C: Command pulse frequency [pps]
f_{C1}: Deviation counter input pulse frequency [pps]

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.

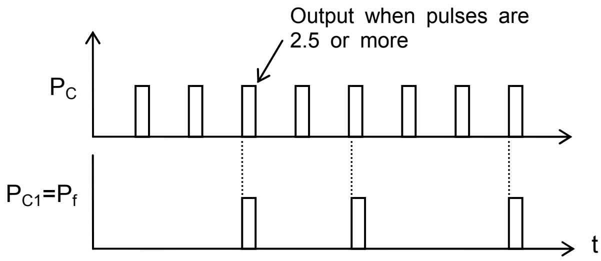
$$\left(\frac{1}{\text{Encoder resolution}} \times 360^\circ\right)$$

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

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.



Appendix figure 3.8 Electronic gear at 1/2 gear ratio related to setting part I/O



Appendix figure 3.9 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.

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

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.

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

* With an HG-KR motor, the encoder resolution becomes 4194304.

$$\Delta\ell_0 = \frac{P_B}{P_{f0}} = \frac{P_B}{\text{Encoder resolution}} \qquad (2\text{-}8)$$

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

Note: With the reduction ratio, $\Delta\ell_0 = \frac{P_B}{\text{Encoder resolution}} \cdot \frac{1}{n}$ $\frac{1}{n}$ = 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).

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

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

$$\Delta\ell_C = \frac{P_B}{P_{C0}} \qquad (2\text{-}8)'$$

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

$$\Delta\ell_c = \frac{P_B}{P_{C0}} = \frac{P_B}{P_{f0}} \cdot \frac{CMX}{CDV} = \Delta\ell_0 \cdot \frac{CMX}{CDV} \qquad (2\text{-}9)$$

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

$$\frac{CMX}{CDV} = \frac{\Delta\ell_C}{\Delta\ell_0} = \Delta\ell_c \cdot \frac{P_{f0}}{P_B} \qquad (2\text{-}10)$$

(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).

$$f_{c1} = f_c \cdot \frac{CMX}{CDV} = P_{fo} \cdot \frac{N}{60} \qquad (2\text{-}11)$$

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 fc is as follows:

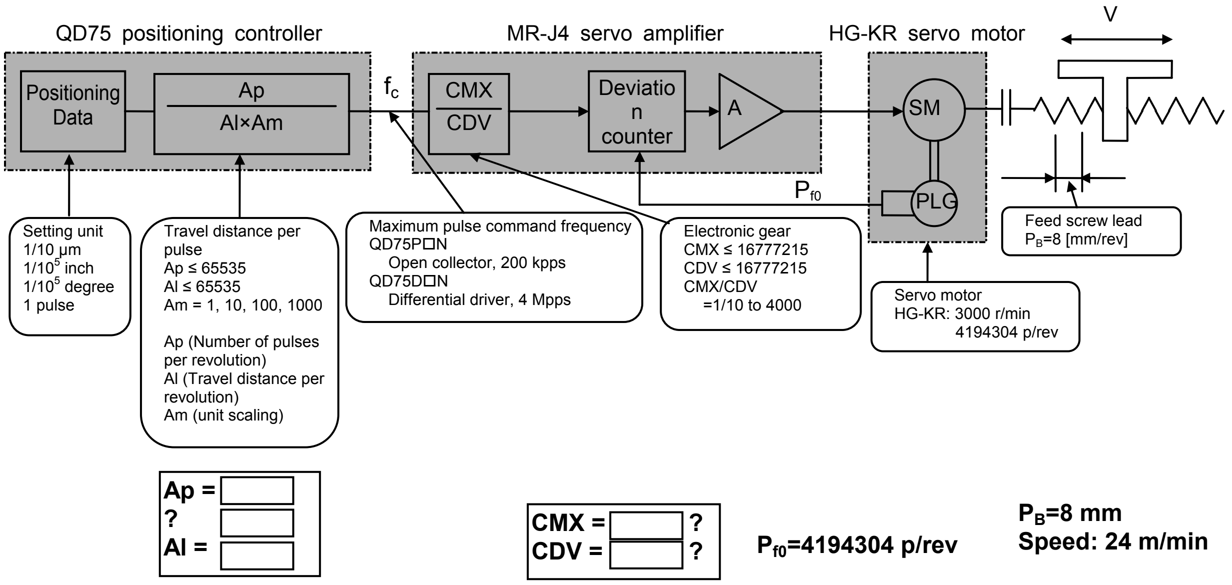
$$\frac{CMX}{CDV} = \frac{f_{C1}}{f_C} = \frac{1}{f_C} \cdot P_{fo} \cdot \frac{N}{60} \qquad (2\text{-}12)$$

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:

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

Example 3.1



Calculate assuming that the differential driver is used.

Question 1: Find the machine travel distance $\Delta\ell_0$ per feedback pulse.

Question 2: Find the servo amplifier side electronic gear ratio K when the QD75-side electronic gear is 1/1 and the machine travel distance $\Delta\ell_C$=0.05 [μm/pulse].

Question 3: For K found in question (2), find the command pulse frequency fc when the motor operates at 3000 [r/min].

Question 4: Find the servo amplifier side electronic gear ratio K when the command pulse frequency is 4 Mpps.

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

$$\Delta\ell_0 = \frac{P_B}{P_{f0}} = \frac{8}{4194304} \approx 0.0019 \times 10^{-3} \text{[mm/pulse]}$$

* 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 (0.0019×10^{-3} [mm/pulse]) by the machine travel distance (0.05×10^{-3} [mm/pulse]) of the positioning device.

According to formula (2-10),

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

$\Delta\ell_C$ after putting the above-mentioned electronic gear is as follows:

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

* When the positioning is 300 mm, 300÷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.

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.)

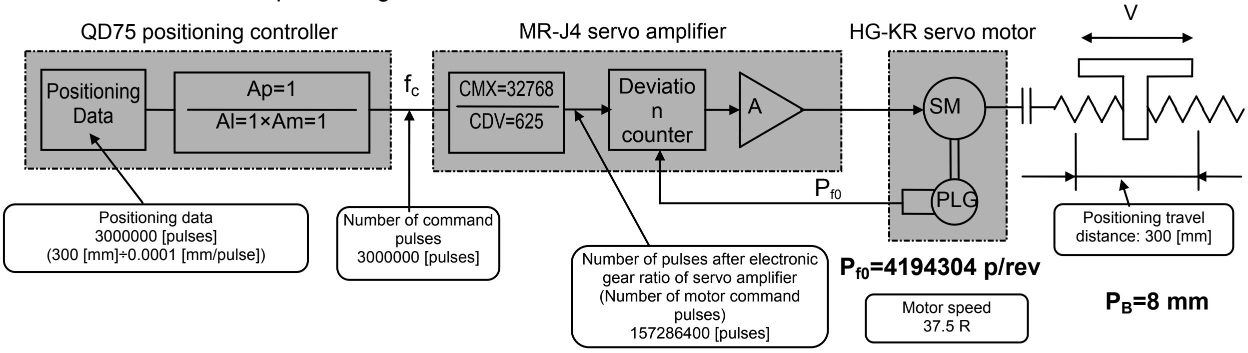
Question 4: According to formula (2-6), the following applies:

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

Check the positioning accuracy $\Delta\ell_0$ after placing the above-mentioned electronic gear.

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

Summary of example 3.1
Consider this when positioning is 300 mm.



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

Appendix 3.5.2 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.

Example 3.2
(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.

$$fC1 = P_{f0} \times \frac{3000}{60} = 4194304 \times \frac{3000}{60} = 209715.2 \times 10^3 \text{ pps} \quad 4000 > K \geq \frac{f_{C1}}{f_C} = \frac{209715.2\times10^3}{200\times10^3} = \frac{1048576}{1000}$$

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

Example 3.3
(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.

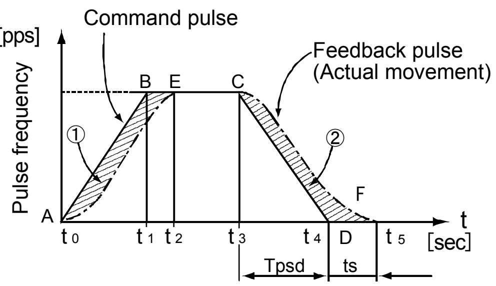
$$fC1 = P_{f0} \times \frac{3000}{60} = 4194304 \times \frac{3000}{60} = 209715.2 \times 10^3 \text{ pps} \quad 4000 > K \geq \frac{f_{C1}}{f_C} = \frac{209715.2\times10^3}{4\times10^6} = \frac{524288}{10000}$$

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

Appendix 3.6 Speed Pattern and Stop Settling Time

Appendix 3.6.1 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 Appendix figure 3.10.



Appendix figure 3.10 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.

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

PG1: Model loop gain

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

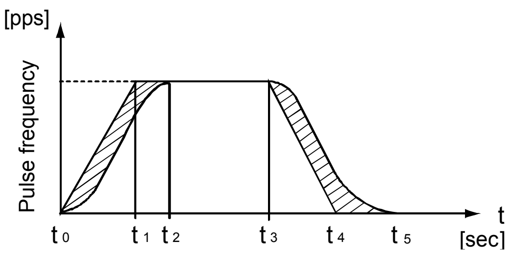
(2) Operation between t_2 and t_3
While maintaining the delay of droop pulse in formula (2-13), operation is performed through synchronization of the command pulse and the servo motor speed.

(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 pulse. The time between this t4 and t5 is called stop settling time ts.

(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)

Example 3.4



With PG1 = 36 [sec^{-1}] on the left, find droop pulse ε for the following deviation counter input.
$f_{C1} = K \cdot f_C$ = 180 k, 18 k, 0.9 k, 72 [pps]
Also covert the droop pulse into the feed length when $\Delta\ell_0$ = 0.01 [mm/pulse].
However, when an MR-J4 motor is used, the following applies:
(Electronic gear ratio K=1/16)

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

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

When K·fC = 18 kpps (132 r/min)

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

When K·fC = 0.9 kpps (6.6 r/min)

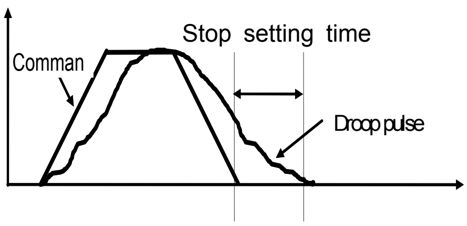
$\varepsilon = \frac{900}{36}$ = 25 [pulses], feed length conversion value 25×0.01=0.25 [mm]

When K·fC = 72 pps (0.53 r/min)

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

Appendix 3.6.2 Stop Settling Time ts

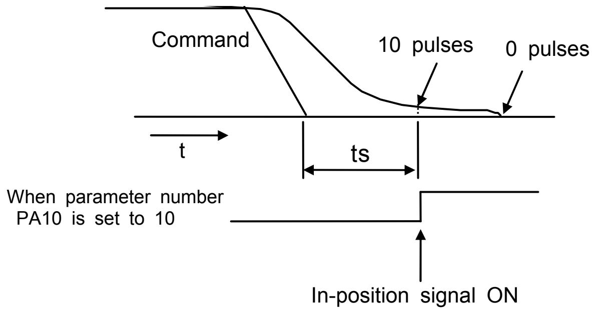
The stop settling time is the time from the end of command output until positioning is completed. For the part mounters such as the inserter and the mounter, the cycle time is determined by this settling time, thus time minimization is a very important factor.



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.

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

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.



Appendix 3.7 Relationship between Machine System and Response Level Setting

Appendix 3.7.1 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.

Appendix table 3.3 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.

Appendix 4. Positioning Controller

Appendix 4.1 Setting Data of Positioning Controller

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

Appendix 4.1.1 Basic Parameters/Detailed Parameters

Item		Setting range: mm	Setting range: inch	Setting range: degree	Setting range: pulse	Initial value
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 pulse output				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	1 to 8388608 ms				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 to 2147483647 × 10^{-1} μm	-2147483648 to 2147483647 × 10^{-5} inch	0 to 35999999 × 10^{-5} degree	-2147483648 to 2147483647 pulse	-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 b1 Upper limit b2 Drive unit ready	b3 Stop signal b4 External command b5 Zero-point signal	b6 Proximity b7, b9 to b15 not used b8 Manual pulse generator input	Each bit value is as follows. 0: Negative logic 1: Positive logic (Set unused bits to 0)	0
	Pr. 23 Output signal logic selection	b0 Command pulse signal b1 not used	b2 not used b3 not used	b4 Deviation counter clear b5 to b15 not used	Each bit value is as follows. 0: Negative logic 1: Positive logic (Set unused bits to 0)	0
	Pr. 24 Manual pulse generator input selection	0: Phase A and B multiplication by 4 2: Phase A and B multiplication by 1		1: Phase A and B multiplication by 2 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

Item		Setting range: mm	Setting range: inch	Setting range: degree	Setting range: pulse	Initial value
Detailed parameter 2	Pr. 25 Acceleration time 1	1 to 8388608 ms				1000
	Pr. 26 Acceleration time 2	1 to 8388608 ms				1000
	Pr. 27 Acceleration time 3	1 to 8388608 ms				1000
	Pr. 28 Deceleration time 1	1 to 8388608 ms				1000
	Pr. 29 Deceleration time 2	1 to 8388608 ms				1000
	Pr. 30 Deceleration time 3	1 to 8388608 ms				1000
	Pr. 31 JOG 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	20000
	Pr. 32 JOG operation acceleration time selection	0 to 3				0
	Pr. 33 JOG operation deceleration time selection	0 to 3				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	1% to 100%				100
	Pr. 36 Sudden stop deceleration time	1 to 8388608 ms				1000
	Pr. 37 Stop group 1 sudden stop selection	0: Normal deceleration stop 1: Sudden stop				0
	Pr. 38 Stop group 2 sudden stop selection	0: Normal deceleration stop 1: Sudden stop				0
	Pr. 39 Stop group 3 sudden stop selection	0: Normal deceleration stop 1: Sudden stop				0
	Pr. 40 Positioning complete signal output time	0 to 65535 ms				300
	Pr. 41 Circular interpolation error permissible range	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

Appendix 4.1.2 Home Position Return Basic Parameters/Home Position Return Detailed Parameters

Item		Setting range: mm	Setting range: inch	Setting range: degree	Setting range: pulse	Initial value
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 Home position address	-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 to 2000000000 × 10^{-2} mm/min	1 to 2000000000 × 10^{-3} inch/min	1 to 2000000000 × 10^{-3} degree/min	1 to 4000000 pulses/s	1
	Pr. 47 Creep speed	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/s	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 to 65535 ms				0
	Pr. 50 Travel distance setting after proximity dog signal is turned ON	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 to 3				0
	Pr. 52 Home position return deceleration time selection	0 to 3				0
	Pr. 53 Home position shift distance	-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 value	1% to 300%				300
	Pr. 55 Deviation counter clear signal output time	1 to 65535 ms				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 to 65535 ms				0

Appendix 4.1.3 Positioning Data

<table>
<tr><th rowspan="2">Item \ Unit</th><th colspan="4">Setting range</th><th rowspan="2">Initial value</th></tr>
<tr><th>mm</th><th>inch</th><th>degree</th><th>pulse</th></tr>
<tr><td>Operation pattern</td><td colspan="4">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)</td><td>Exit</td></tr>
<tr><td>Control method</td><td colspan="4">
<table>
<tr><th>Peripheral equipment display</th><th>Setup contents</th><th>Code number</th></tr>
<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 point specified circular interpolation control (INC, CW)</td><td>11H</td></tr>
<tr><td>I: INC circular arc left</td><td>Center point specified circular interpolation control (INC, CCW)</td><td>12H</td></tr>
<tr><td>J: Forward rotation, speed 2</td><td>Speed control of 2 axes (forward rotation)</td><td>13H</td></tr>
<tr><td>K: Reverse rotation, speed 2</td><td>Speed control of 2 axes (reverse rotation)</td><td>14H</td></tr>
<tr><td>L: ABS linear 3</td><td>Linear interpolation control of 3 axes (ABS)</td><td>15H</td></tr>
<tr><td>M: INC linear 3</td><td>Linear interpolation control of 3 axes (INC)</td><td>16H</td></tr>
<tr><td>N: Fixed feed 3</td><td>Fixed feed control by linear interpolation of 3 axes</td><td>17H</td></tr>
<tr><td>O: Forward rotation, speed 3</td><td>Speed control of 3 axes (forward rotation)</td><td>18H</td></tr>
<tr><td>P: Reverse rotation, speed 3</td><td>Speed control of 3 axes (reverse rotation)</td><td>19H</td></tr>
<tr><td>Q: ABS linear 4</td><td>Linear 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>
</table>
</td><td>-</td></tr>
<tr><td>Acceleration time No.</td><td colspan="4">0 to 3 (Select 0 to 3 for the acceleration time from basic parameter 2 and detailed parameter 2)</td><td>0</td></tr>
<tr><td>Deceleration time No.</td><td colspan="4">0 to 3 (Select 0 to 3 for the deceleration time from basic parameter 2 and detailed parameter 2)</td><td>0</td></tr>
</table>

Item		mm	inch	degree	pulse	Initial value
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 i nches	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

Appendix 5. Functions and Operations of MELSERVO-J4

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

Appendix 5.1 Function List

This section describes the MR-J4 function list.

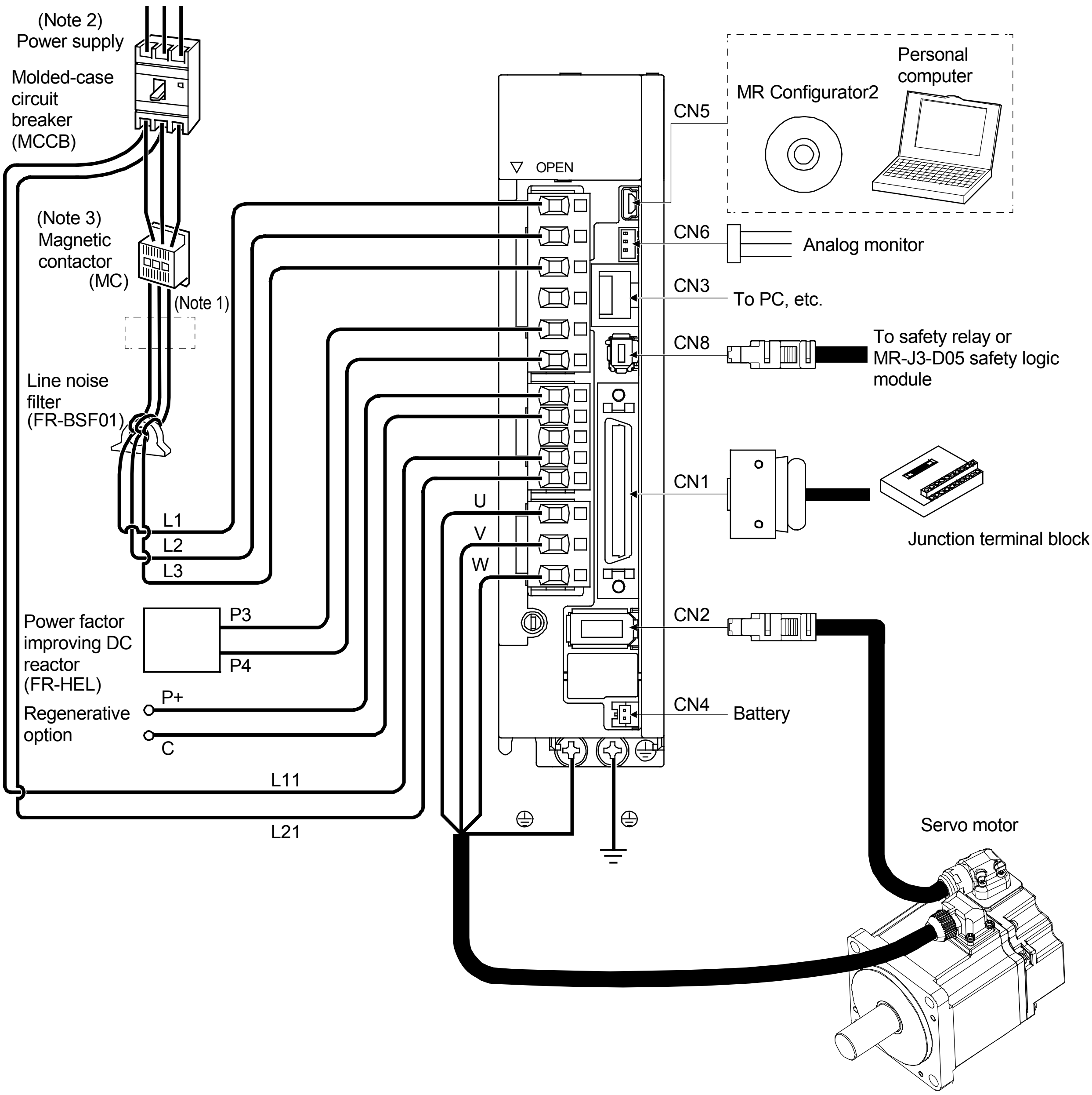
Function	Description
Position control mode	Used as position control servo.
Speed control mode	Used as speed control servo.
Torque control mode	Used as torque control servo.
Position/speed control switching mode	Position control and speed control can be switched at the input device.
Speed/torque control switching mode	Speed control and torque control can be switched at the input device.
Torque/position control switching mode	Torque control and position control can be switched at the input device.
High-resolution encoder	A high-resolution encoder capable of 4194304 pulses/rev is used as the encoder for the rotary servo motor compatible with the MELSERVO-J4 series.
Absolute position detection system	By setting the home position once, it will not be necessary to return to the home position each time the power is turned on.
Gain switching function	Gain can be switched during rotation and when stopped, and also when using the input device during the operation.
Advanced vibration suppression control II	This function controls residual vibration or vibration at the end of the arm.
Adaptive filter II	With this function, the servo amplifier detects machine resonance and sets filter properties automatically, and then controls the vibration of the machine system.
Low-pass filter	When a servo system response is raised, it suppresses the high-frequency resonance generated.
Machine analyzer function	The frequency properties of the machine system are analyzed by only connecting the servo amplifier and the personal computer where MR Configurator2 is installed. MR Configurator2 is necessary for this function.
Robust filter	If it is not possible to raise the response because the load to motor inertia ratio is high due to the roll feed shaft, etc., the disturbance response can be improved.
Slight vibration suppression control	A vibration of ±1 pulse is suppressed when the servo motor stops.
Electronic gear	The input pulse can be increased 4000 times from 1/10.
S-curve acceleration/ deceleration time constant	Performs acceleration and deceleration smoothly.
Auto tuning	Automatically adjusts the optimum servo gain even if the load applied on the servo motor shaft changes.
Brake unit	Used when there is insufficient regenerative ability in the regenerative option. A 5 kW or higher servo amplifier can be used.
Power regeneration converter	Used when there is insufficient regenerative ability in the regenerative option. A 5 kW or higher servo amplifier can be used.
Regenerative option	Used when the generated regenerative power is high and there is insufficient regenerative ability in the internal regenerative resistor of servo amplifier.
Alarm history clear	Deletes the alarm history.
Input signal selection (device settings)	Input devices such as ST1 (forward rotation start), ST2 (reverse rotation start), and SON (servo-on) can be assigned to a specific CN1 connector pin.
Output signal selection (device settings)	Output devices such as ALM (malfunction), and DB (dynamic brake interlock) can be assigned to a specific CN1 connector pin.
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.
Restart after instantaneous power supply failure	Even if an alarm occurs due to a decrease in input voltage, a restart is possible only by turning on the start signal once the power supply voltage returns to normal. (Available in the future.)
Command pulse selection	The shape of the command pulse train to be input can be selected from 3 types.
Torque limit	The servo motor torque can be limited.
Speed limit	The servo motor speed can be limited.
Status display	The servo status is displayed on the 5-digit, 7-segment LED indicator.
External I/O signals display	The on/off statuses of external I/O signals are displayed on the display.
VC automatic offset	If the motor does not stop even when the VC (analog speed command) or VLA (analog speed limit) is 0 V, the voltage is automatically offset to stop it.
Alarm code output	When an alarm occurs, an alarm number is output in 3-bit code.
Test operation mode	MR Configurator2 is required for JOG operation, positioning operation, motor-less operation, DO forced output, program operation, positioning operation, or program operation.
Analog monitor output	The voltage is output in real time for the servo status.
MR Configurator2	Parameter setting, test operation, monitoring, etc., can be performed using a personal computer.

Function	Description
One-touch tuning	Gain adjustment of the servo amplifier is possible only by operation of the push button or by one click of the button on MR Configurator2.
Tough drive function	It is usually possible to continue operation so that the device does not stop even when alarm is about to occur. There are two types of tough drive functions, vibration tough drive and instantaneous power failure tough drive.
Drive recorder function	By always monitoring the servo status, this function allows fixed time recording of status transitions before and after an alarm occurs. The recorded data can be checked by clicking the wave-form display button on the drive recorder screen of MR Configurator2. However, 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".
STO function	The STO functions are available as IEC/EN 61800-5-2 safety functions. A device safety system can be easily constructed.
Servo amplifier life diagnosis function	The accumulated energization time and the number of times the burst relay is turned on and off can be checked. This acts as a measure of time if amplifier parts such as capacitor and relay need to be replaced according to their life expectancies before malfunctioning. MR Configurator2 is necessary for this function.
Power monitoring function	The power running power and regenerative power are calculated from data in the servo amplifier, including speed and current. Power consumption, etc., can be displayed in MR Configurator2.
Machine diagnosis function	Faulty machine parts such as ball screws and bearings can be detected by presuming friction and vibration elements of the device actuator from data in the servo amplifier. MR Configurator2 is necessary for this function.

Appendix 5.2 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

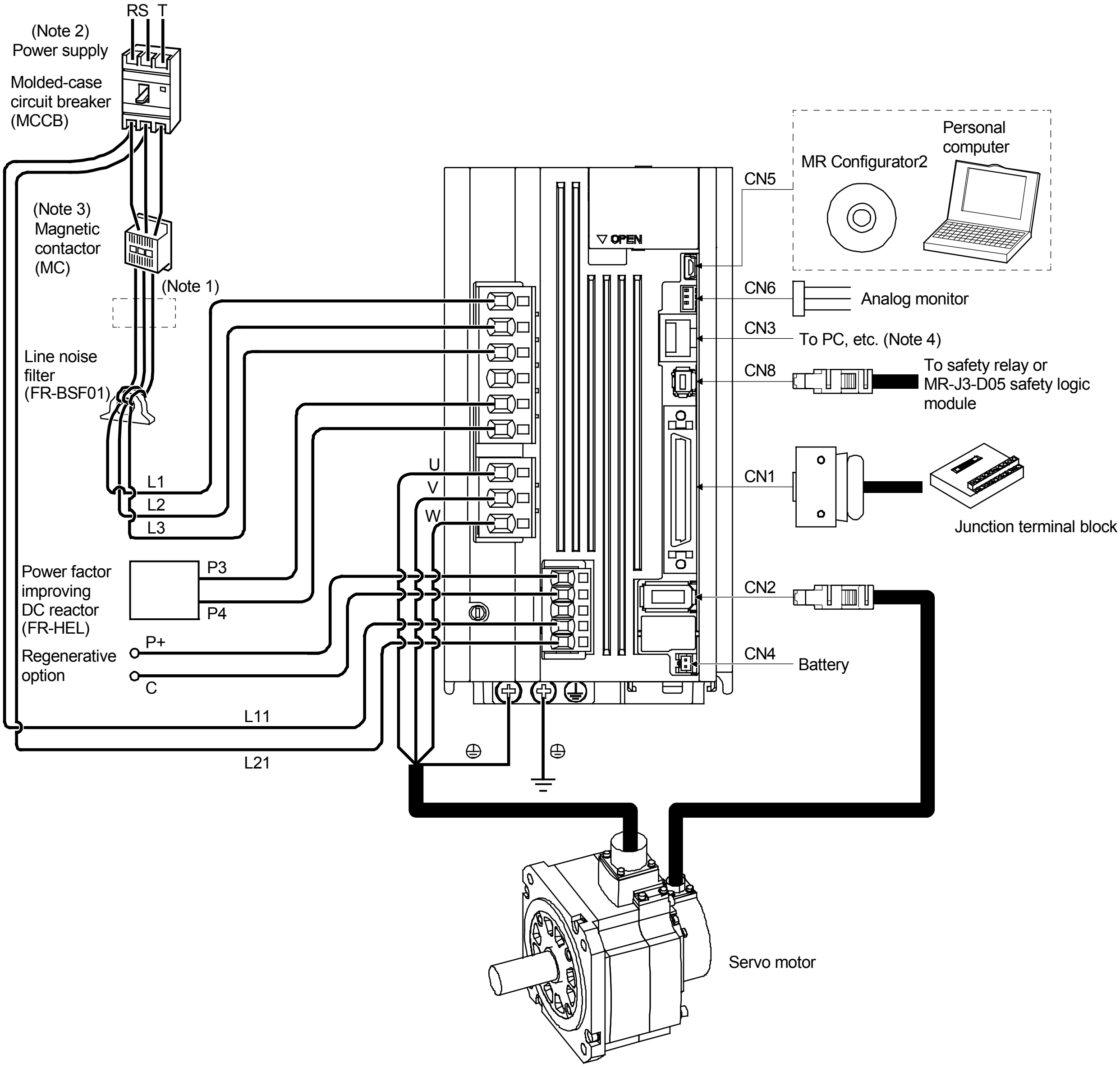


Note 1: The power factor improving AC reactor can also be used. In this case, the pow er factor improving DC reactor cannot be used. Short P3 and P4 when not using the power factor improving DC reactor.

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 operat ion 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.

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



Note 1: The power factor improving AC reactor can also be used. In this case, the pow er factor improving DC reactor cannot be used. Short P3 and P4 when not using the power factor improving DC reactor.
2. For power supply specifications, refer to the MR-J4-□ servo amplifier instruction manual.
3. Bus voltage decreases according to the voltage and operat ion 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. The RS-422 communication function is compatible with Ver.A3 and later.

Appendix 6. Terminology

Adaptive vibration suppression control

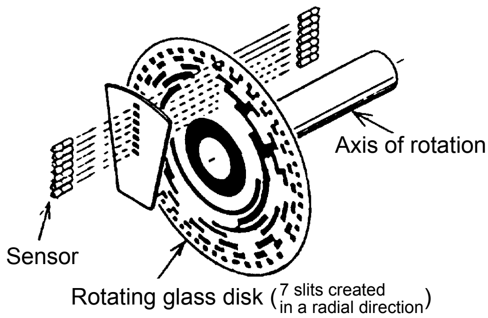
If there is a specific resonance point in the mechanical system and if the servo system response is increased, the mechanical system may resonate (vibration or abnormal noise) at that resonance frequency. With the adaptive vibration suppression control function, the servo amplifier detects machine resonance 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.



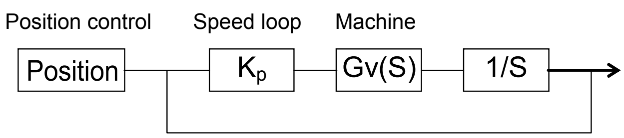
Example of absolute position encoder structure

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.
Position loop gain = $K_p \cdot Gv(s)$
= K_p (1/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 = ωpc (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 2πf rad/sec.

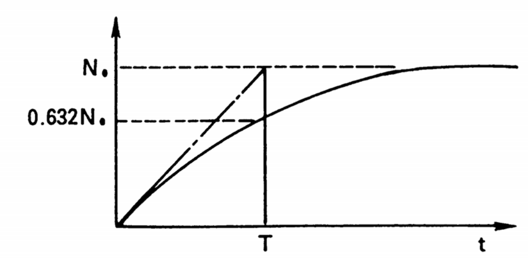
Acceleration time

The acceleration time is the time needed between the current speed and the next speed when changing the motor speed.

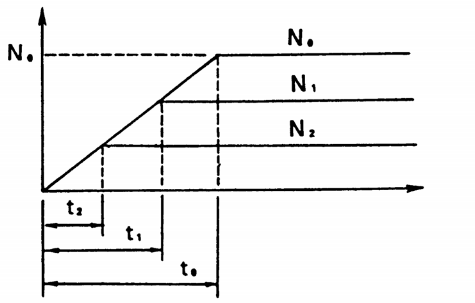
Acceleration time constant

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 63.2% 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_O: 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 GD2 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

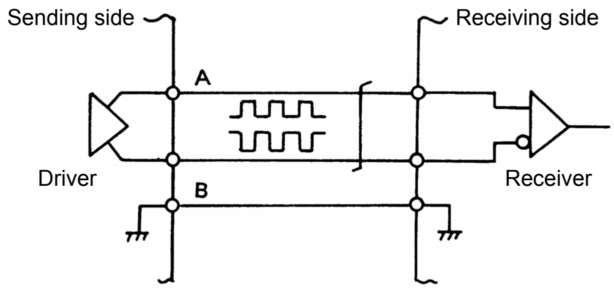
The gain that improves the settling characteristics can be found automatically. (Enabled only in position control mode)
While automatically changing the gain, the gain with the shortest settling time and smallest overshoot is searched for.
This works well when a high level of adjustment is required.
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 load system.

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 fc (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.

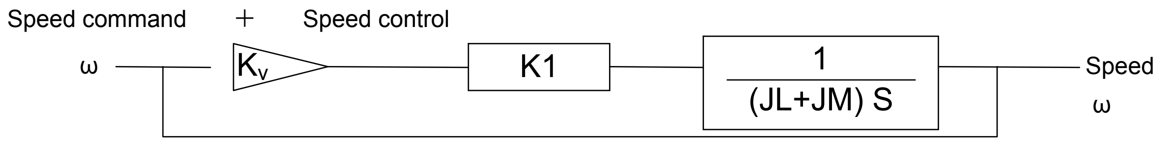
Meanwhile, with the presence of a stroke end similar to a rotary table, the machine may have disadvantages. In this case, use the stroke end terminal of the positioning controller or the servo amplifier by short-circuiting. Also, with the response from the positioning controller, there are some items 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:

$$\text{Speed loop gain} = \frac{K1 \cdot KV}{JM + JL}$$

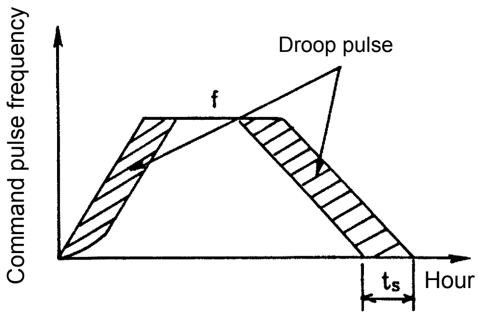
KV: Speed amplifier gain
JL: Load inertia
JM: Motor inertia

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 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/°C, and for rare-earth magnets it is -0.33/°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·cm^2]

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 $Y=\varepsilon K_p$. 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

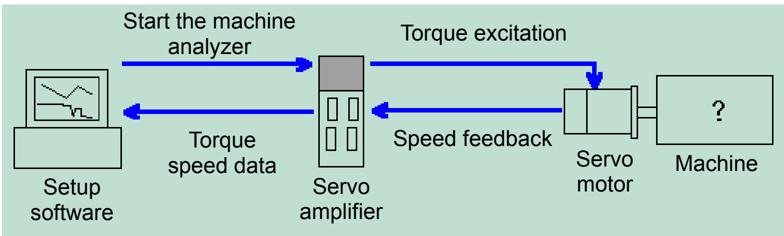
Feed forward control refers to control that sends a speed command before a droop pulse increase when the pulse command is input during position loop control.

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.

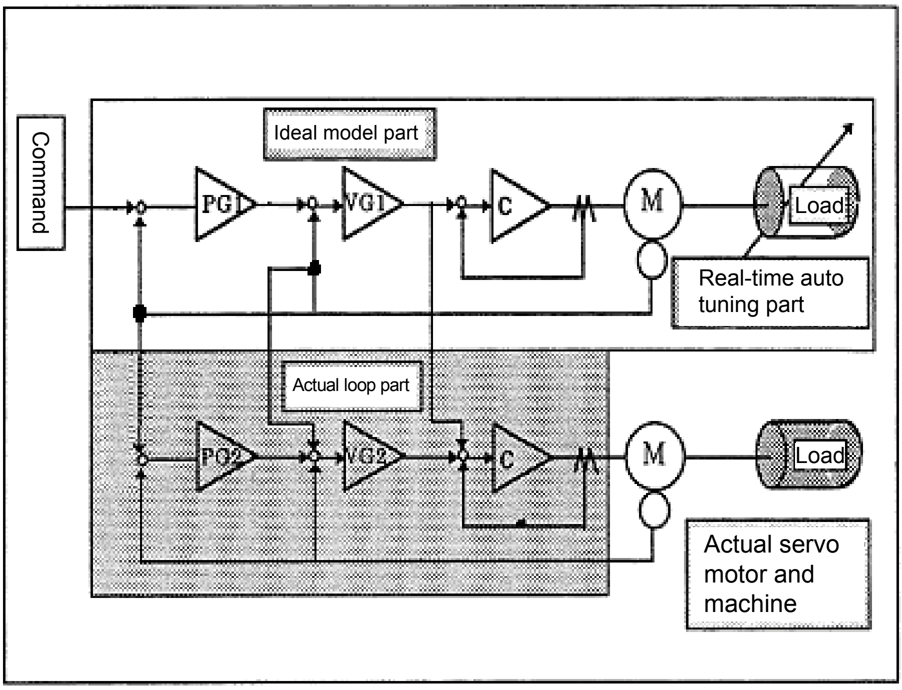
Machine analyzer

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 original 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 7. QD75D1N Setting Values (Training Machine)

(1) Parameter (Axis 1)

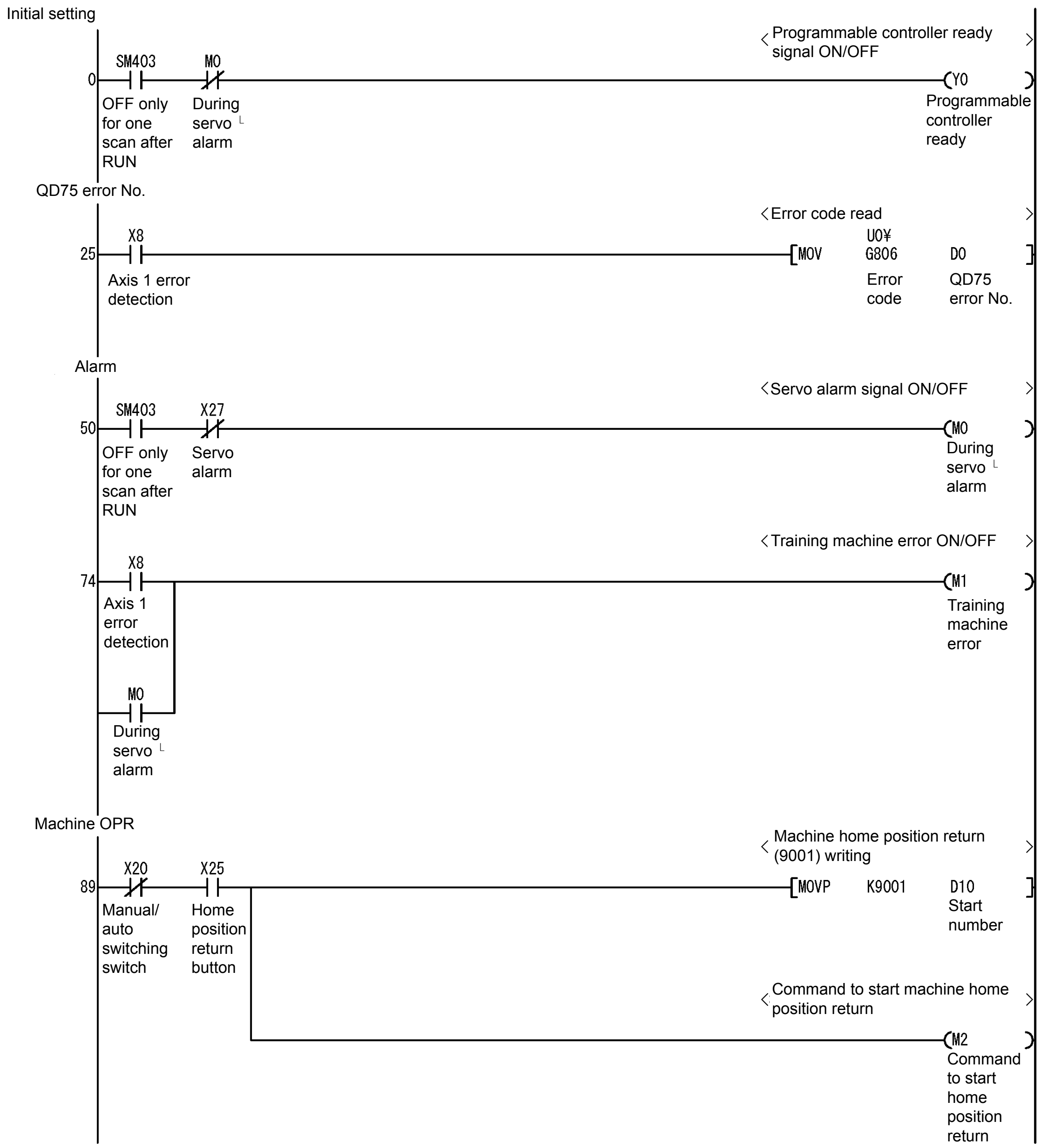
Item		Setting value	Remarks
Basic parameter 1	Unit setting	0	mm
	Number of pulses per rotation	1 pulse	
	Travel distance per 1 revolution	10.0 µm	
	Unit scaling	1	×1
	Pulse output mode	1	CW/CCW mode
	Rotation direction setting	0	Current value increment with forward rotation pulse output
	Bias speed at 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)

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	

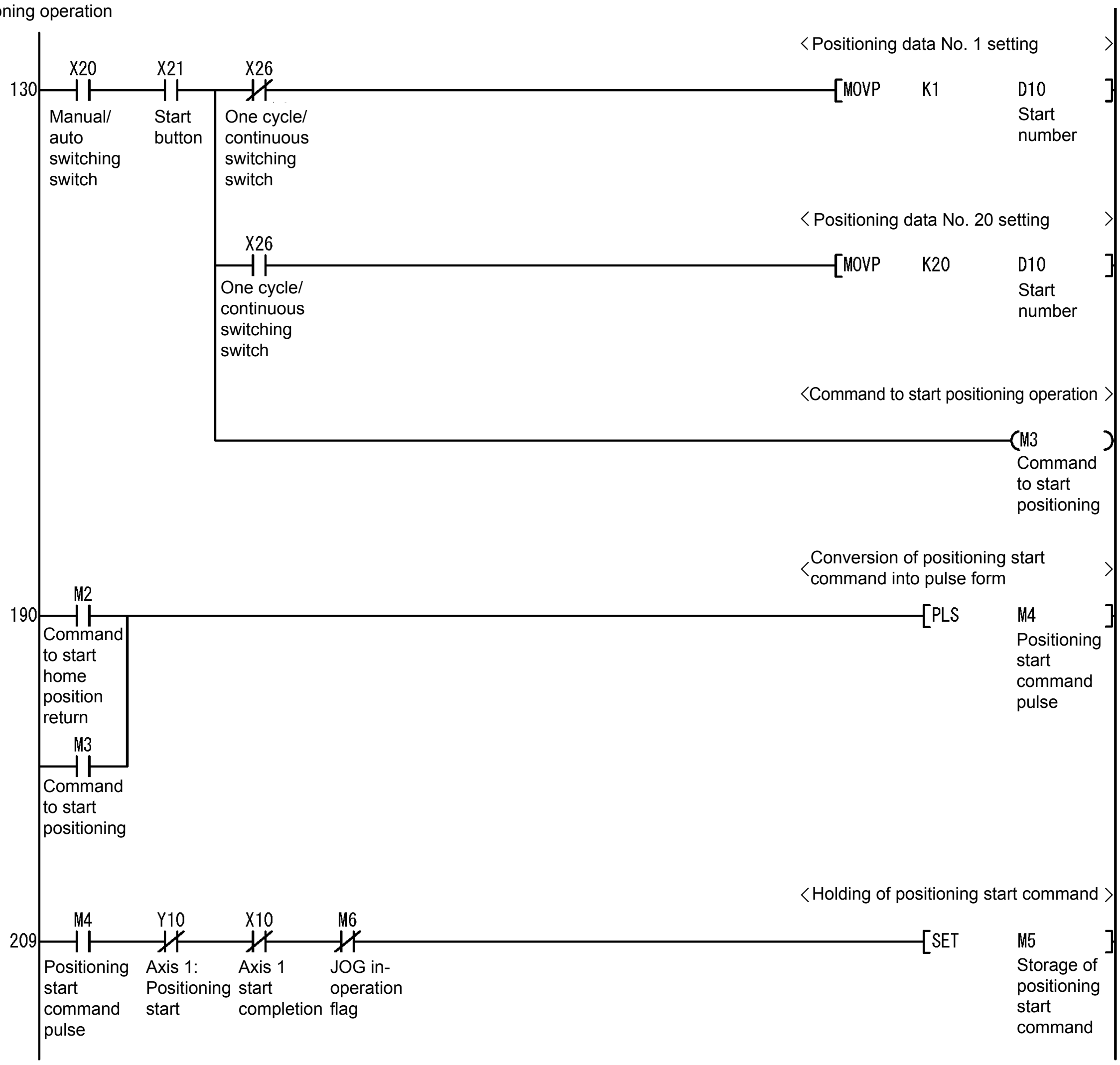
(2) Positioning data (Axis 1)

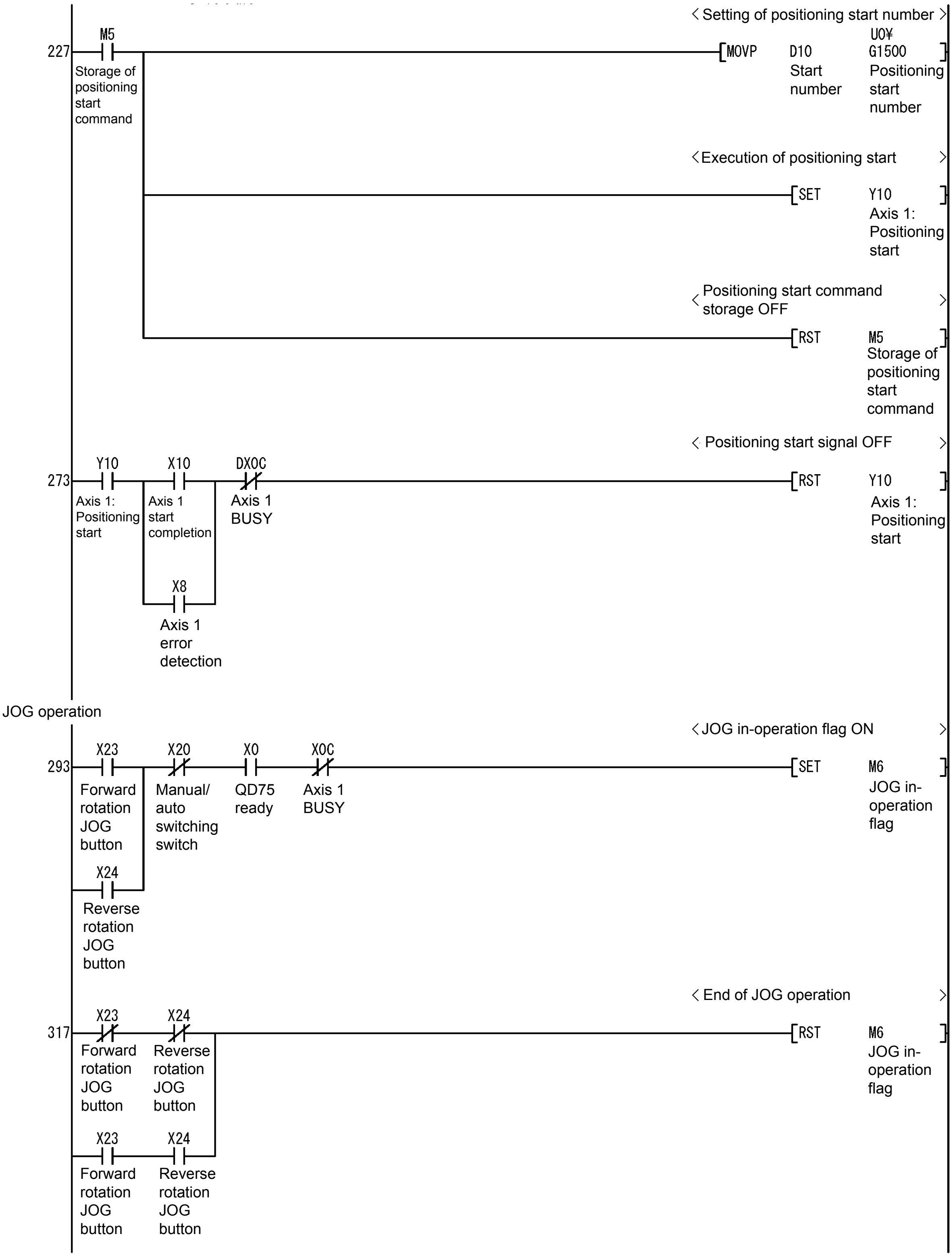
Data No.	Operation pattern	Control method	Acceleration time	Deceleration time	Interpolation target axis	Positioning address	Command speed	Dwell time	M code
1	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	-50000.0	50000.00	500	0
2	1: Continuous	02: INC linear 1	0: 100 ms	0: 100 ms	-	50000.0	50000.00	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

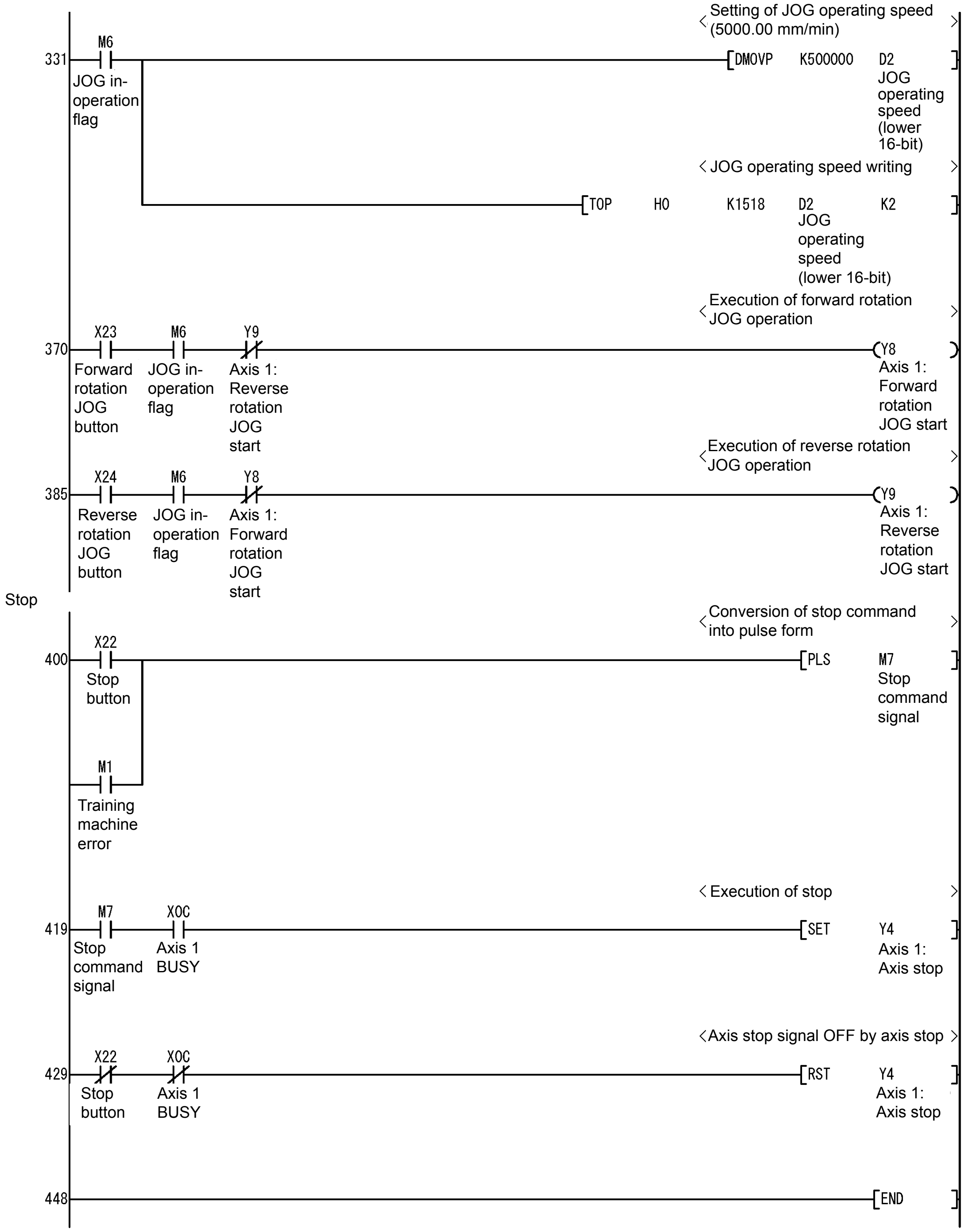


Positioning operation





Setting of positioning start number
227
M5
Storage of positioning start command
MOVP
D10
Start number
U0¥
G1500
Positioning start number
Execution of positioning start
SET
Y10
Axis 1: Positioning start
Positioning start command storage OFF
RST
M5
Storage of positioning start command
Positioning start signal OFF
273
Y10
Axis 1: Positioning start
X10
Axis 1 start completion
DX0C
Axis 1 BUSY
X8
Axis 1 error detection
RST
Y10
Axis 1: Positioning start
JOG operation
JOG in-operation flag ON
293
X23
Forward rotation JOG button
X20
Manual/ auto switching switch
X0
QD75 ready
X0C
Axis 1 BUSY
X24
Reverse rotation JOG button
SET
M6
JOG in-operation flag
End of JOG operation
317
X23
Forward rotation JOG button
X24
Reverse rotation JOG button
X23
Forward rotation JOG button
X24
Reverse rotation JOG button
RST
M6
JOG in-operation flag


Setting of JOG operating speed (5000.00 mm/min)
331
M6
JOG in-operation flag
DMOVP K500000 D2
JOG operating speed (lower 16-bit)
JOG operating speed writing
TOP H0 K1518 D2 K2
JOG operating speed (lower 16-bit)
Execution of forward rotation JOG operation
370
X23 M6 Y9
Forward rotation JOG button
JOG in-operation flag
Axis 1: Reverse rotation JOG start
Y8
Axis 1: Forward rotation JOG start
Execution of reverse rotation JOG operation
385
X24 M6 Y8
Reverse rotation JOG button
JOG in-operation flag
Axis 1: Forward rotation JOG start
Y9
Axis 1: Reverse rotation JOG start
Stop
Conversion of stop command into pulse form
400
X22
Stop button
PLS M7
Stop command signal
M1
Training machine error
Execution of stop
419
M7 X0C
Stop command signal
Axis 1 BUSY
SET Y4
Axis 1: Axis stop
Axis stop signal OFF by axis stop
429
X22 X0C
Stop button
Axis 1 BUSY
RST Y4
Axis 1: Axis stop
448
END

Appendix 8. Servo Amplifier Inspection Request

（出張・持込）修理・点検・調査・検品　依頼書

（依頼元控）

顧客名（持込）・不具合発生場所（出張）	住　所	〒
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	ご担当	部　課　様
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ご依頼番号	
ご依頼日	年　月　日
SC受付番号	
受付日	年　月　日
出張指定日	月　日　時　分

〒461-8675 名古屋市東区矢田南5-1-14
三菱電機システムサービス株式会社
FA事業センター
機電修理センター（中部G）
TEL. 052 (722) 7610
FAX. 052 (712) 2487

費用請求先

依頼品情報					
機種名		製造番号		バージョン	
形名		発生台数		不具合発生日	
仕様・定格		納入日・台数		稼動開始日	
用途・装置名		現品返却	□有り　□無し	返却予定日	
報告書期限		付属品			

①ご依頼内容・要望（下記項目もマーキング願います）　　別紙添付有無（□有り　□無し）

②不具合が発生した時の詳細（不具合発生時の状況をなるべく詳しく、FA機器は発生したアラーム番号・エラーコードも記入願います）

不具合品	□修理後返却　□調査のみで返却　□A級修理　□調査後修理判断（有償時調査費用発生します）
取替部品	□調査・修理後返却（有償時）□調査・修理後SCにて廃却
報告書	修理・調査依頼　■診断・修理報告書　□SC別紙調査報告書　□製作所調査報告書
	(解約)検品依頼　■診断・修理報告書　□SC別紙調査報告書　□製作所調査報告書
費用処理	□見積不要　□事前見積り要　□指値額（　）円以内対応希望　支払条件　日〆　日払い
発生時期	□開梱時　□初回通電時　□据付調整時　□稼動中（　年位使用）□その他（　）
発生状況	□常時　□１回のみ　□操作毎　□月／週／日／サイクル毎に（　）回　□アラーム番号（　）
	バックアップ時間　、出力断　有・無、　警報音　有・無、　発煙　有・無　、　発音　有・無
現在の状態	□システム停止　□継続運転中　□応急処置済
復旧処置	□リセット操作　□システム再起動　□プログラム再書込み　□代品交換　□その他（　）
使用負荷	□ファン　□ポンプ　□コンベア　□昇降機　□工作機　□その他（　）
電源	相数　、線式　、電圧　V、電流　A、周波数　Hz
	電圧変動程度　、瞬停　有・無、電源系統　、ノイズ源近傍　有・無
現地環境	□屋内　□屋外　□クリーンルーム　□高温　□多湿　□振動　□ガス・粉塵　□その他（　）

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受付者

53A

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

MODEL	
MODEL CODE	
SH-030147ENG-A (1509) MEE	

MITSUBISHI ELECTRIC CORPORATION

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