MITSUBISHI

General Purpose AC Servo

MELSERVO-C Series

General Purpose Interface
MR-C□A
Instruction Manual

MITSUBISHI ELECTRIC C
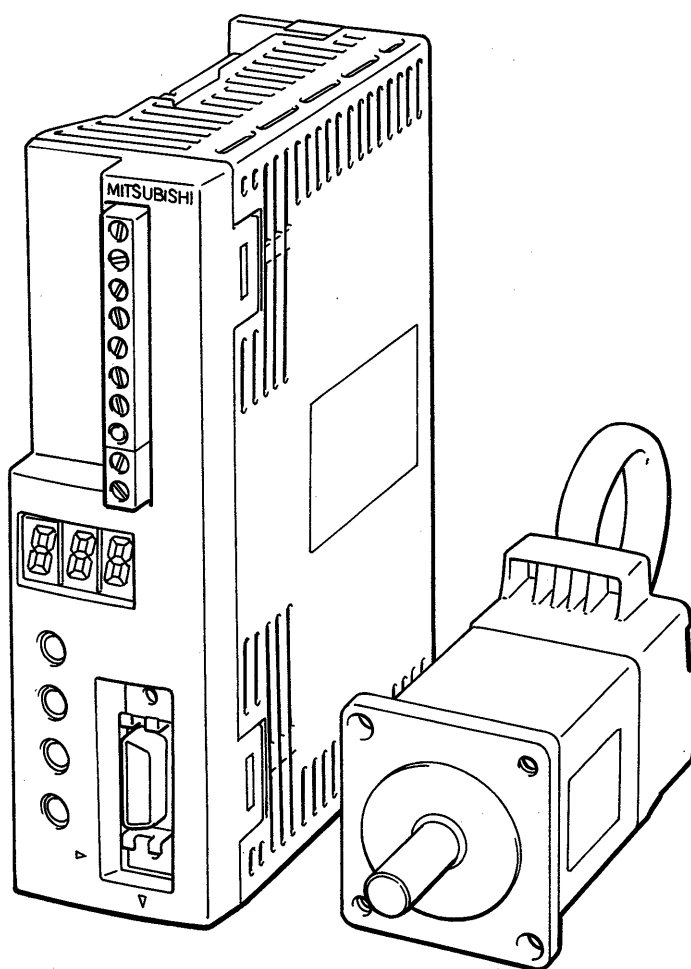
Thank you for choosing this Mitsubishi AC servo. This instruction manual gives handling information and precautions for using the servo amplifier and servo motor. Incorrect handling may cause an unexpected fault. Before using the servo amplifier and servo motor, please read this instruction manual, installation guide carefully to use the equipment to its optimum.
Please forward this instruction manual, installation guide to the end user.

Safety Instructions

Do not attempt to install, operate, maintain or inspect the servo amplifier and servo motor until you have read through this instruction manual, installation guide and appended documents carefully and can use the equipment correctly. Do not use the servo amplifier and servo motor until you have a full knowledge of the equipment, safety information and instructions.
In this instruction manual, the safety instruction levels are classified into "WARNING" and "CAUTION".

⚠ **WARNING**	Indicates that incorrect handling may cause hazardous conditions, resulting in death or severe injury.
⚠ **CAUTION**	Indicates that incorrect handling may cause hazardous conditions, resulting in medium or slight injury to personnel or may cause physical damage.

Note that the CAUTION level may lead to a serious consequence according to conditions. Please follow the instructions of both levels because they are important to personnel safety.

What must not be done and what must be done are indicated by the following diagrammatic symbols:

🚫 : Indicates what must not be done. For example, "No Fire" is indicated by ⊗ .

⬤ : Indicates what must be done. For example, grounding is indicated by ⏚ .

After reading this instruction manual, always keep it accessible to the operator.

In this instruction manual, instructions at a lower level than the above, instructions for other functions, and so on are classified into "NOTICE", "INFORMATION" and "MEMORANDUM".

NOTICE Indicates that incorrect handling may cause the servo amplifier to be faulty and may not lead to physical damage.

INFOR-MATION Indicates that parameter setting change, etc. will provide another function or there are other usages.

MEMO-RANDUM Indicates information needed for use of this equipment.

SAFETY INSTRUCTIONS

1. To prevent electric shock, note the following:

⚠ WARNING

⚠ Before wiring or inspection, switch power off and wait for more than 10 minutes. Then, confirm the voltage is safe with multi meter. Otherwise, you may get an electric shock.

⚠ Connect the servo amplifier and servo motor to ground.

⚠ Any person who is involved in wiring and inspection should be fully competent to do the work.

⚠ Do not attempt to wire the servo amplifier and servo motor until they have been installed. Otherwise, you may get an electric shock.

⚠ Operate the switches with dry hand to prevent an electric shock.

⚠ The cables should not be damaged, stressed, loaded or pinched. Otherwise, you may get an electric shock.

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2. To prevent fire, note the following:

⚠ CAUTION

⚠ Do not install the servo amplifier, servo motor and regenerative resistor on or near combustibles. Otherwise, a fire may cause.

⚠ When the servo amplifier has become faulty, switch off the main servo amplifier power side. Continuous flow of a large current may cause a fire.

⚠ When a regenerative resistor is used, use an alarm signal to switch main power off. Otherwise, a regenerative transistor fault or the like may overheat the regenerative resistor, causing a fire.

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3. To prevent injury, note the following:

⚠ CAUTION

⚠ Only the voltage specified in the installation guide should be applied to each terminals. Otherwise, a burst, damage, etc. may occur.

⚠ Connect the terminals correctly to prevent a burst, damage, etc.

⚠ Ensure that polarity (+, -) is correct. Otherwise, a burst, damage, etc. may occur.

⚠ During power on or for a while after power off, do not touch the servo amplifier fins, regenerative resistor, servo motor, etc. Their temperatures may be high and you may get burnt.

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4. Additional instructions

The following instructions should also be fully noted. Incorrect handling may cause a fault, injury, electric shock, etc.

(1) Transportation and installation

⚠ CAUTION

⚠ Stacking in excess of the specified number of products is not allowed.

⚠ Do not handle the motor by the cables, shaft or encoder.

⚠ Install the servo amplifier and servo motor in a load-bearing place in accordance with the instruction manuals.

⚠ Do not climb or stand on servo equipment. Do not put heavy objects on servo equipment.

⚠ The controller and servo motor must be installed in the specified direction.

⚠ Leave specified clearances between the servo amplifier and control enclosure walls or other equipment.

⚠ Do not install or operate the servo amplifier and servo motor which has been damaged or has any parts missing.

⚠ Provide adequate protection to prevent screws, and other conductive matter, oil and other combustible matter from entering the servo amplifier.

⚠ Do not drop or strike servo amplifier or servo motor. Isolate from all impact loads.

⚠ Use the servo amplifier and servo motor under the following environmental conditions:

Environment		Conditions	
		Servo Amplifier	Servo Motor
Ambient temperature	[°C]	0 to +50 (non-freezing)	0 to +40 (non-freezing)
	[°F]	32 to 122 (non-freezing)	32 to 104 (non-freezing)
Ambient humidity		90%RH or less (non-condensing)	80%RH or less (non-condensing)
Storage temperature	[°C]	-20 to +65 (non-freezing)	-15 to +70 (non-freezing)
	[°F]	-4 to 149 (non-freezing)	5 to 158 (non-freezing)
Storage humidity		90%RH or less (non-condensing)	
Ambience		Indoors (no direct sunlight) Free from corrosive gas, flammable gas, oil mist, dust and dirt.	
Altitude		Max. 1000m (3280ft) above sea level	
Vibration	[m/s²]	5.9 (0.6G) or less	X, Y: 19.6 (2G)
	[ft/s²]	19.4 (0.6G) or less	X, Y: 64 (2G)

⚠ Securely mount the servo motor to the machine. If mount insecurely, the servo motor may come off during operation.

⚠ The servo motor with reduction gear must be installed in the specified direction to prevent oil leakage.

⚠ For safety of personnel, always cover rotating and moving parts.

⚠ Never hit the servo motor or shaft, especially when coupling the servo motor to the machine.

⚠ Do not load the servo motor shaft to more than the permissible load. Otherwise, the shaft may break.

❗ When the equipment has been stored for an extended period of time, contact with Mitsubishi.

(2) Wiring

> ### ⚠ CAUTION
>
> ⚠ Wire the equipment correctly and securely. Otherwise, the servo motor may misoperate.
>
> ⚠ Do not install a power capacitor, surge absorber or radio noise filter (FR-BIF option) between the servo motor and servo amplifier.
>
> ⚠ Connect the output terminals (U, V, W) correctly. Otherwise, the servo motor will operate improperly.
>
> ⚠ Do not connect AC power directly to the servo motor. Otherwise, the servo motor may damage.
>
> ⚠ The surge absorbing diode installed on the DC output signal relay must be wired in the specified direction. Otherwise, the signal is not output due to a fault, disabling the emergency stop and other protective circuits may not operate.
>
> Servo amplifier
>
> SG
> V+
> ALM
> PF
> RA
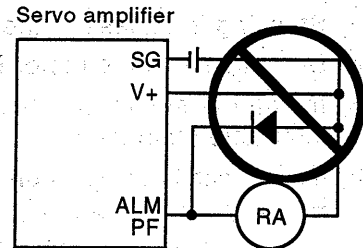
(3) Test run adjustment

> ### ⚠ CAUTION
>
> ⚠ Before operation, check the parameter settings. Improper settings may cause some machines to perform unexpected operation.
>
> ⚠ The parameter settings must not be changed excessively. Operation will be instable.

(4) Usage

> ### ⚠ CAUTION
>
> ❗ Provide an external emergency stop circuit to ensure that operation can be stopped and power switched off immediately.
>
> Ⓢ Any person who is involved in disassembly and repair should be fully competent to do the work.
>
> ⚠ Before resetting an alarm, make sure that the run signal is off to prevent an accident. A sudden restart is made if an alarm is reset with the run signal on.
>
> ⚠ Do not modify the equipment.
>
> ⚠ Use a noise filter, etc. to minimize the influence of electromagnetic interference, which may be caused by electronic equipment used near the servo amplifier.
>
> ⚠ Use the servo amplifier with the correct servo motor.
>
> Ⓢ The electromagnetic brake on the servo motor is designed to hold the motor shaft and should not be used for ordinary braking.
>
> ⚠ For such reasons as service life and mechanical structure (e.g. where a ballscrew and the servo motor are coupled via a timing belt), the electromagnetic brake may not hold the motor shaft. To ensure safety, install a stopper on the machine side.

(5) Just in case

⚠ CAUTION

⚠ When it is assumed that a hazardous condition may take place at the occure a power failure or a product fault, use a servo motor with electromagnetic brake or an external brake mechanism for the purpose of prevention.

⚠ Configure the electromagnetic brake circuit so that it is activated not only by the servo amplifier signals but also by an external emergency stop signal.

⚠ When any alarm has occurred, eliminate its cause, ensure safety, then reset the alarm, before restarting operation.

⚠ When power is restored after an instantaneous power failure, keep away from the machine because the machine may be restarted suddenly (design the machine so that it is secured against hazard if restarted).

Contacts must be open when servo is off or when an alarm (trouble) is present.

Circuit must be opened during emergency stop.

Servo motor

RA1   EMG

Electromagnetic brake

24VDC

---

(6) Maintenance, inspection and parts replacement

⚠ CAUTION

⚠ With age, the electrolytic capacitor will deteriorate. To prevent a secondary accident due to a fault, it is recommended to replace the electrolytic capacitor every 10 years when used in general environment. Please consult our sales representative.

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(7) Disposal

⚠ CAUTION

⚠ Dispose of the product as general industrial waste.

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(8) General instruction

To illustrate details, the equipment in the diagrams of this instruction manual may have been drawn without covers and safety guards. When the equipment is operated, the covers and safety guards must be installed as specified. Operation must be performed in accordance with this instruction manual.

COMPLIANCE WITH EC DIRECTIVES

1. WHAT ARE EC DIRECTIVES?

The EC Directives were issued to standardize the regulations of the EU countries and ensure smooth distribution of safety-guaranteed products.

In the EU countries, the Machinery Directive (effective in January, 1995), EMC Directive (effective in January, 1996) and Low Voltage Directive (effective in January, 1997) of the EC Directives require that products to be sold should meet their fundamental safety requirements and carry the CE marks (CE marking). CE marking applies to machines and equipment into which servo amplifiers have been installed.

The servo do not function independently but are designed for use with machines and equipment. Therefore, the EMC Directive does not apply to the servo but applies to the machines and equipment into which the servo are installed.

The EN Standard-compliant models conform to the standards related to the Low Voltage Directive to facilitate CE marking on machines and equipment into which the servo amplifiers will be installed. To ensure ease of compliance with the EMC Directive, Mitsubishi Electric prepared the "EMC INSTALLATION GUIDELINES" (IB(NA)67310) which provides servo amplifier installation, control box making and other procedures. Please contact your sales representative.

2. PRECAUTIONS FOR COMPLIANCE

Use the EN Standard-compliant models of servo amplifier and servo motor. In addition to the instructions provided in this instruction manual, also follow the instructions below. If the model is not specifically described to comply with the EN Standard in this instruction manual, it has the same specifications as those of the standard models:

(1) Structure
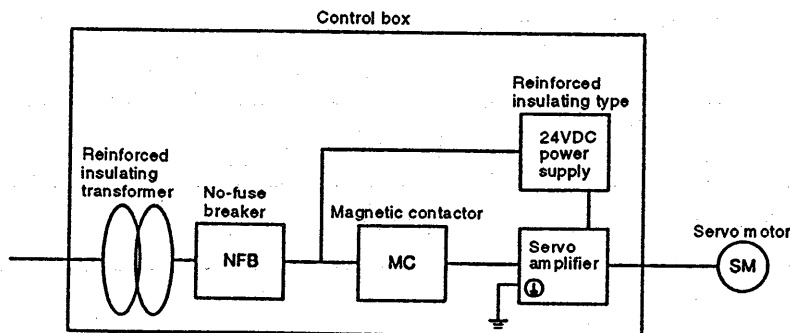
(2) Environment
Operate the servo amplifier at or above the contamination level 2 set forth in IEC664. For this purpose, install the servo amplifier in a control box which is protected against water, oil, carbon, dust, dirt, etc. (IP54).

(3) Power supply
1) Operate the servo amplifier to meet the requirements of the overvoltage category II set forth in IEC664. For this purpose, a reinforced insulating transformer conforming to the IEC or EN Standard should be used in the power input section.
2) When supplying interface power from external, use a 24VDC power supply which has been insulation-reinforced in I/O.

(4) Grounding
   1) To prevent an electric shock, always connect the protective earth (PE) terminal (marked⊕) of the servo amplifier to the protective earth (PE) of the control box.
   2) Do not connect two ground cables to the same protective earth (PE) terminal. Always connect the cables to the terminals one-to-one.

PE terminals   PE terminals
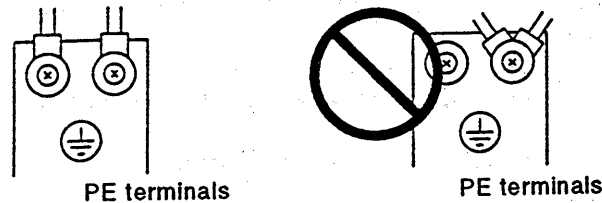
   3) If a leakage current breaker is used to prevent an electric shock, the protective earth (PE) terminals of the servo amplifier must be connected to the corresponding earth terminals.

(5) Wiring
   1) The cables to be connected to the terminal block of the servo amplifier must have crimping terminals provided with insulating tubes to prevent contact with adjacent terminals.

- Crimping terminal
- Insulating tube
- Cable
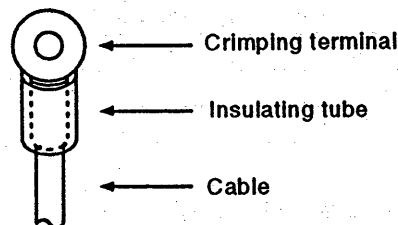
   2) Use a fixed terminal block to connect the power supply lead of the HC-PQ series servo motor to the servo amplifier. Do not connect cables directly.

Terminal block
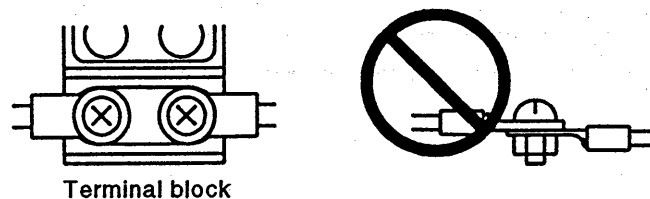
(6) Auxiliary equipment and options
   1) The no-fuse breaker and magnetic contactor used should be the EN/IEC Standard-compliant products of the models described in Section 6-2-1.
   2) The sizes of the cables described in Section 6-2-1 meet the following requirements. To meet the other requirements, follow Table 5 and Appendix C in EN60204.
      • Ambient temperature: 40 (104) [°C (°F)]
      • Sheath: PVC (polyvinyl chloride)
      • Installed on wall surface or open table tray
   3) When the EMC filter is used, the radio noise filter (FR-BIF) described in (5), Section 6-2-4 is not required.

(7) Servo motor
   For the outline dimension drawing, connector signal arrangement and encode cable, contact Mitsubishi.

(8) Performing EMC tests
   When EMC tests are run on a machine/device into which the servo amplifer has been installed, it must conform to the electromagnetic compatibility (immunity/emission) standards after it has satisfied the operating environment/electrical equipment specifications.
   For the other EMC Directive guidelines on the servo amplifier, refer to the "EMC INSTALLATION GUIDELINES".

CONFORMANCE WITH UL/C-UL STANDARD

Use the servo amplifiers and servo motors which comply with the UL/C-UL Standard.
Unless otherwise specified, the handling, performance, specifications, etc. of the UL/C-UL Standard-compliant models are the same as those of the EN Standard-compliant models.
When using the options and auxiliary equipment, use those which conform to the UL/C-UL Standard.

Guideline for compliant to UL/C-UL STANDARD
For compliant to UL/C-UL STANDARD, the following counter-measures are required.

(1) Set up
   The 100 CFM fan is set at 4 in above the amplifier or another cooling device which is equivalent or more effective is set.

(2) Short-circuit rating.
   The servo amplifier has been subjected to UL's short circuit test in the AC circuit whose peak current is limited to 5000A max., and conforms to this circuit.

(3) Motor flange
   Mount the servo motor on the flange which has the following size or provides an equivalent or higher heat dissipation effect.

Flange Size [mm]	Motor (HC-PQ series)
150 x 150 x 6	033·053·13
250 x 250 x 6	23
250 x 250 x 12	43

(4) Discharge time of Capacitor
   The discharge time of capacitor is shown as followings.
   For safety please do not touch those charged area during 10 minutes after power off.

Servo Amplifier model	Discharge time [min]
MR-C10A(1), 20A(1)	1
MR-C40A	2

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REVISIONS

CHAPTER 1
INTRODUCTION

This chapter provides basic information needed to use this servo.

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1. INTRODUCTION

1 – 1 Model Definition

(1) Servo amplifier

MR-C □ A □ □

- Series

Symbol	Compliance with Standard
None	Standard model (In Japan)
-UE	EN Standard, UL/C-UL Standard

Symbol	Power supply
None	Single-phase 200V
(Note) 1	Single-phase 100V

Note: Unavailable for MR-C40A.

Symbol	Applicable servo motor
10	HC-PQ033/053/13
20	HC-PQ23
40	HC-PQ43
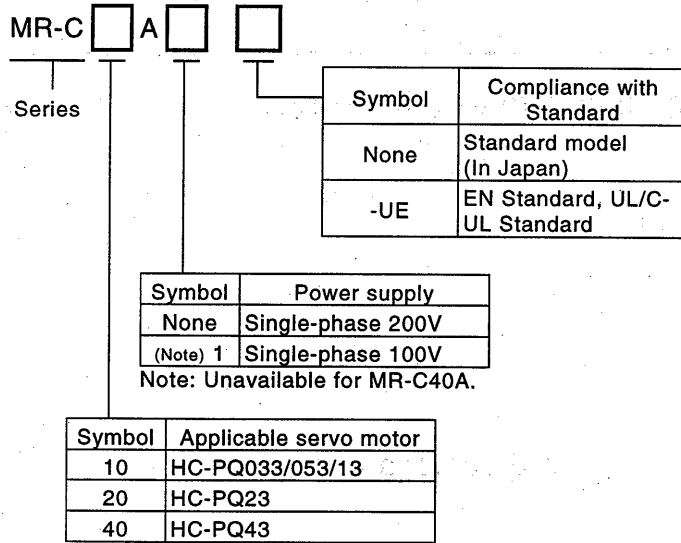
Name plate

MITSUBISHI	AC SERVO
MODEL	MR-C10A
POWER	100W
AC INPUT	AC200V-230V 50/60Hz
OUTPUT	6.0A
SERIAL	A5X0010022
	TC300A034G55

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- Serial number
- Rated output current
- Applicable power supply
- Capacity
- Model

(2) Servo motor

HC-PQ □ 3 □ □ □ □

- Series

Symbol	Compliance with Standard
None	Standard model (In Japan)
-UE	EN·UL/C-UL Standard

Symbol	Shaft
None	Straight shaft
K	With key (200W or more)
D	D cut
L	L cut (200W or more)

Symbol	Reduction gear
None	Without
G1	For general industrial machines
G2	For high precision

Note: HC-PQ033 with reduction gear is not available.

Symbol	Electromagnetic brake
None	Without
B	With

- Reted speed (3000r/min)

Symbol	Rated output [W]
03	30
05	50
1	100
2	200
4	400

MITSUBISHI	AC SERVO
MODEL	MR-C10A-UE
POWER : 100W	
INPUT : 3.2A 3PH +1PH 200-230V 50Hz	
	3PH +1PH 200-230V 60Hz
OUTPUT : 170V 0-360Hz	
	6.0A
SERIAL : TC 3XXAAAAG52	

MITSUBISHI ELECTRIC CORPORATION   MADE IN JAPAN NB

- Serial number
- Rated output current
- Applicable power supply
- Capacity
- Model

- Date of manufacture
- Serial number
- Model

Name plate
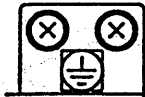
MITSUBISHI
AC SERVO MOTOR
HC-PQ053
SERIAL
DATE

MITSUBISHI ELECTRIC CORPORATION
895505 01

1. INTRODUCTION

1 – 2 Parts Identification and Application

1 – 2 – 1 Servo amplifier

Name/Application	Refer To
Main circuit terminal block (TE) Used to connect the power supply, servo motor, regenerative brake option and ground.	Section 3 – 1 – 1
Display The three-digit, seven-segment LED shows the servo status and alarm number.	Section 2 – 3
Operation section Used to perform status display, diagnostic, alarm and parameter setting operations. MODE ⊙ Used to change the mode. UP ⊙ DOWN ⊙ Used to change the display or data in each mode. SET ⊙ Used to set parameter data.	Section 2 – 3
Protective earth (PE) terminals (EN Standard-, UL/C-UL Standard-compliant models) When using the EN Standard-, UL/C-UL Standard-compliant models, use these terminals for grounding.	Section 1 – 3 – 2 EMC INSTALLATION GUIDELINES IB (NA) 67310
Name plate	Section 1 – 1
I/O signal connector (CN1) Used to connect digital I/O signals such as servo-on and trouble. Plug after peeling off the CAUTION seal.	Section 3 – 1 – 2
RS232C option unit connector (CN3)	Section 3 – 1 – 2 Section 6 – 1 – 4
Encoder connector (CN2) Connector for connection of the servo motor encoder	Section 3 – 1 – 2

(Note)

Note: Provided for EN Standard-, UL/C-UL Standard-compliant models and unavailable for standard models.

1. INTRODUCTION

1 – 2 – 2 Servo motor

Name/Application	Refer To
Encoder cable	Section 3 – 2
Encoder	Section 3 – 2 Section 10 – 1
Power cable • Power lead (U, V, W) • Ground lead • Electromagnetic brake lead (For the motor with electromagnetic brake)	Section 3 – 2
Servo motor shaft	Section 4 – 2 (4)
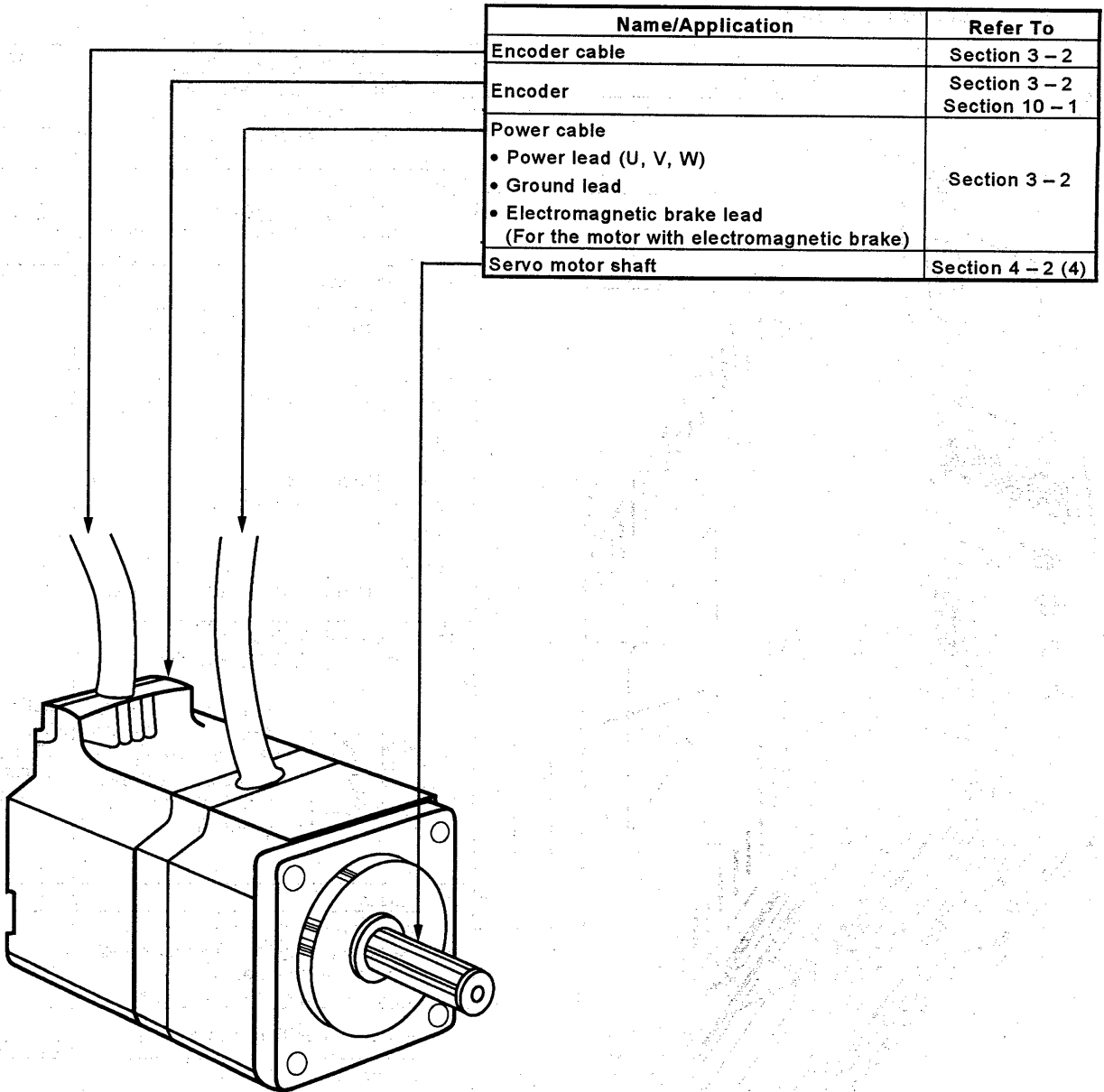
1. INTRODUCTION

1 – 3 Basic Configuration

1 – 3 – 1 Standard models

Options, Auxiliary Equipment	Refer To
No-fuse breaker	Section 6 – 2 – 1
Magnetic contactor	Section 6 – 2 – 1
Radio noise filter	Section 6 – 2 – 4
Regenerative brake option	Section 6 – 1 – 1
Wires	Section 6 – 2 – 1

Single-phase AC power supply
MR-C☐A : 200 to 230, 50/60Hz
MR-C☐A1: 100 to 120, 50/60Hz

No-fuse breaker (NFB) or fuse

Magnetic contactor (MC)

Line noise filter

TE

L₁
L₂
P
C
U
V
W

Radio noise filter

Regenerative brake option

Servo amplifier

Positioning unit

Operation panel

To CN2

U V W E

Servo motor
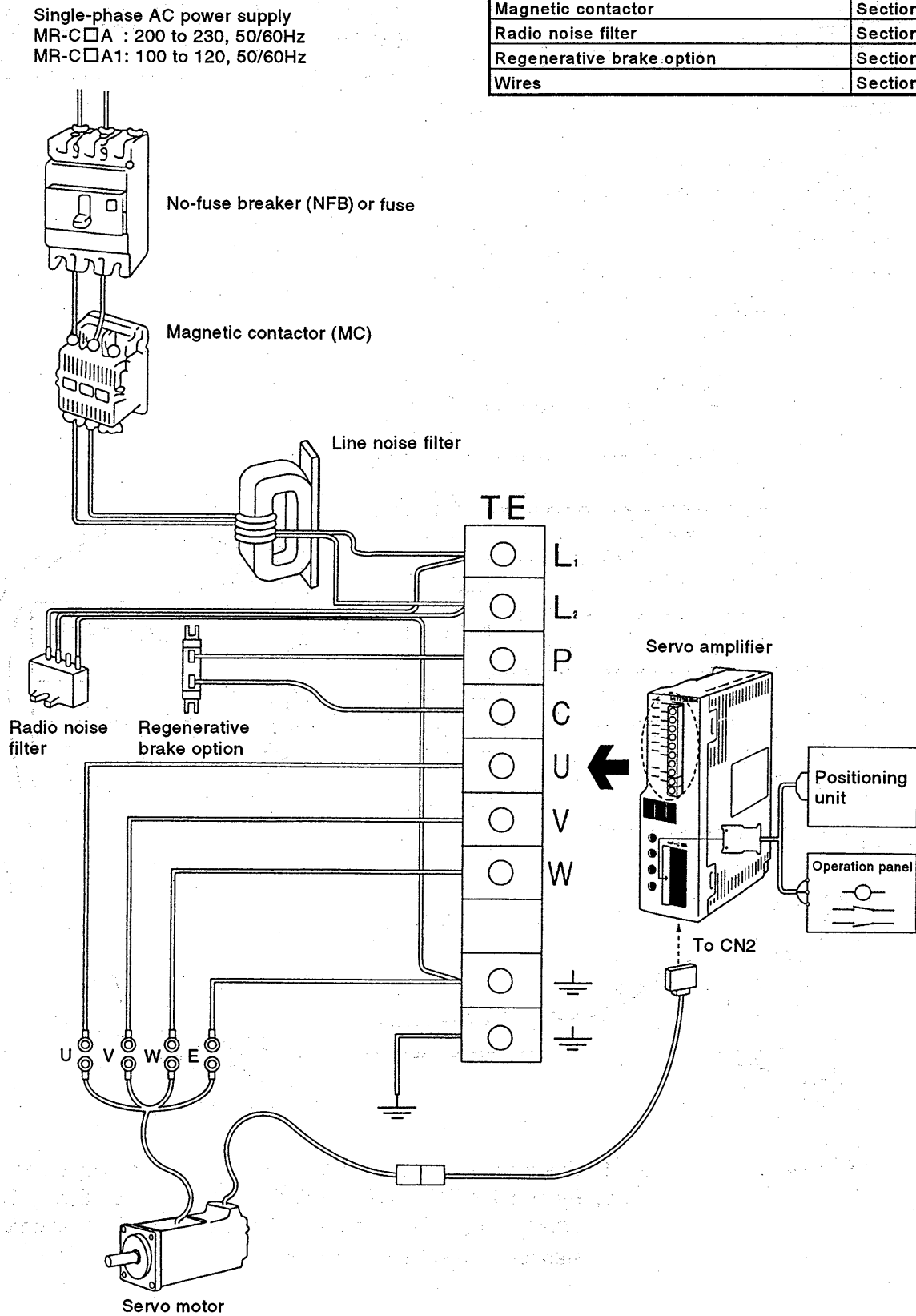
1. INTRODUCTION

1 – 3 – 2 EN Standard-, UL/C-UL Standard-compliant models

Single-phase AC power supply
MR-C□A : 200 to 230, 50/60Hz
MR-C□A1: 100 to 120, 50/60Hz

(Note 1)
No-fuse breaker (NFB) or fuse

(Note 1)
Magnetic contactor (MC)

(Note 2)
EMC filter
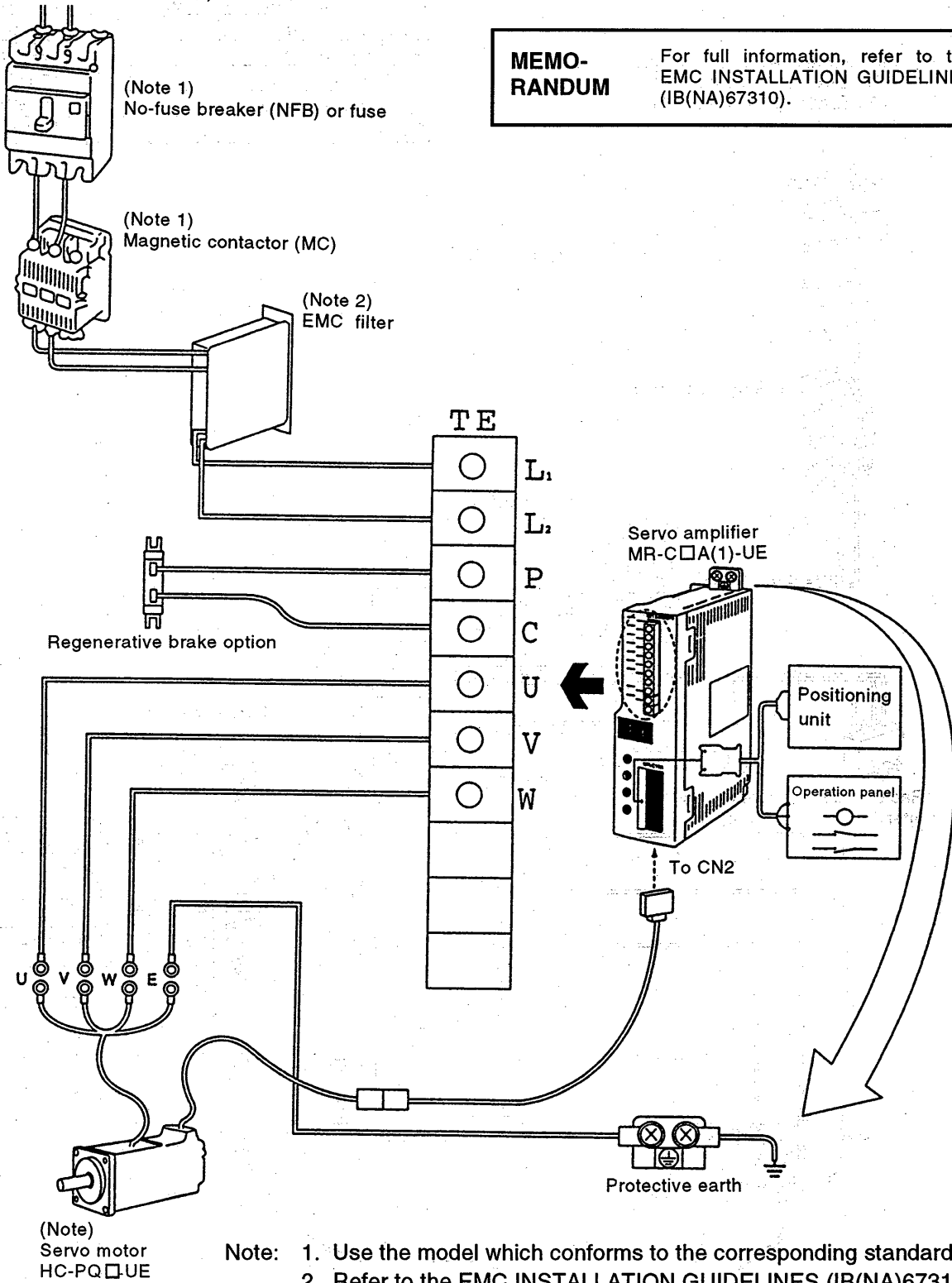
MEMO-RANDUM	For full information, refer to the EMC INSTALLATION GUIDELINES (IB(NA)67310).

TE

L₁
L₂
P
C
U
V
W

Servo amplifier
MR-C□A(1)-UE

Regenerative brake option

Positioning unit

Operation panel

To CN2

U V W E

Protective earth

(Note)
Servo motor
HC-PQ□UE

Note: 1. Use the model which conforms to the corresponding standard.
2. Refer to the EMC INSTALLATION GUIDELINES (IB(NA)67310). When the model complies with the UL/C-UL Standard, the standard line noise filter may be used.

CHAPTER 2
OPERATION

This chapter gives basic connection examples and operation procedure.

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2. OPERATION

2 – 1 Standard Connection Examples

⚠ **CAUTION** Always follow the wiring instructions in Chapter 3.

2 – 1 – 1 Connection with the FX-1GM

⚠ **CAUTION** Configure a sequence which switches off the MC at occurrence of an alarm.

⚠ **WARNING** Note 1. For the EN Standard model, always connect the protective earth (PE) terminal (marked ⏚) of the servo amplifier to the protective earth (PE) of the control box to prevent an electric shock.

⚠ **CAUTION** Note 2. Connect the diode in the correct direction. Otherwise, the servo amplifier will fail and will not output the connect signals, disabling the emergency stop and other protective circuits.

NOTICE Note 3. CN1 and CN2 have the same shape. Wrong connection of the connectors will cause a failure.

MEMO-RANDUM

Note 4. This wiring applies to the standard cable of less than 10m (32 ft).

5. The pins with the same signal name are connected together in the servo amplifier.

6. The trouble (ALM) signal conducts current when there is no alarm, i.e. in the normal state.
   When this signal is switched off (at occurrence of an alarm), the output of the controller must be stopped by the sequence program.

7. Since the LSP and LSN signals have been automatically switched on internally before shipment, set □0□ in parameter No. 6 to make the function valid.

8. For the servo motor with electromagnetic brake.

9. After making sure that the servo is without fault (ALM signal is on), configure a sequence which switches on the relay SVRDY.

2 – 1 – 2 Connection with the FX-1GP

⚠ **CAUTION** Configure a sequence which switches off the MC at occurrence of an alarm.

	Note 1. For the EN Standard model, always connect the protective earth (PE) terminal (marked ⏚) of the servo amplifier to the protective earth (PE) of the control box to prevent an electric shock.
◇ **WARNING**	

	Note 2. Connect the diode in the correct direction. Otherwise, the servo amplifier will fail and will not output the connect signals, disabling the emergency stop and other protective circuits.
⚠ **CAUTION**	

	Note 3. CN1 and CN2 have the same shape. Wrong connection of the connectors will cause a failure.
NOTICE	

MEMO- RANDUM	Note 4. This wiring applies to the standard cable of less than 10m (32 ft). 5. The pins with the same signal name are connected together in the servo amplifier. 6. The trouble (ALM) signal conducts current when there is no alarm, i.e. in the normal state. When this signal is switched off (at occurrence of an alarm), the output of the controller must be stopped by the sequence program. 7. Since the LSP and LSN signals have been automatically switched on internally before shipment, set □0□ in parameter No. 6 to make the function valid. 8. For the servo motor with electromagnetic brake.

2. OPERATION

2 – 1 – 3 Connection with the FX-20GM or E-20GM

⚠ **CAUTION** Configure a sequence which switches off the MC at occurrence of an alarm.

Regenerative brake option (Optional)

Power supply
MR-C☐A : Single-phase 200VAC
MR-C☐A1: Single-phase 100VAC

NFB   MC

L1 Servo amplifier MR-C☐A(1)   C P   U   U (red)   Servo motor HC-PQ
L2   V   V (white)
                                  W   W (black)
                                  E (green) SM

(Note 1)

24VDC B1
        B2

EMG Contacts must be open when servo is off or when an alarm (trouble) is present. (Note 8)

2m (6.5ft) or less

Controller FX-20GM E-20GM

	X axis	Y axis
SVRDY	1	1
COM2/6	2	2
SVEND	11	11
COM2/6	12	12
COM4/8	14	14
PGO	13	13
COM3/7	4	4
CLR	3	3
24⊕	7·17	7·17
FP	6	6
COM5/9	9·19	9·19
RP	16	16

(Note 9)

CN1 (Note 3)

V24	20
PF	3
V+	1
OP	4
SG	12
CR	13
OPC	19
PP	9
SG	5
NP	7
SD	11
V24	20
SG	12
SON	17
LSP	15
LSN	14
ALM	2

SG

CN2 (Note 3)

19	P5
11	LG
20	P5
12	LG
7	MR
17	MRR
6	MD
16	MDR
Plate	SD

(Note 4)

7	P5	7	P5
8	LG	8	LG
1	MR	1	MR
2	MRR	2	MRR
4	MD	4	MD
5	MDR	5	MDR
9	SHD	9	SHD

Encoder

Securely connect the shield to the ground plate in the connector.

SG

24VDC, 0.2A or more

24VDC power supply + −

Servo-on
(Note 7) Forward rotation stroke end
Reverse rotation stroke end
(Note 6) Trouble   RA1 (Note 2)

V +

10m (32ft) or less

⚠ **WARNING** Note 1. For the EN Standard model, always connect the protective earth (PE) terminal (marked ⊕) of the servo amplifier to the protective earth (PE) of the control box to prevent an electric shock.

⚠ **CAUTION** Note 2. Connect the diode in the correct direction. Otherwise, the servo amplifier will fail and will not output the connect signals, disabling the emergency stop and other protective circuits.

NOTICE Note 3. CN1 and CN2 have the same shape. Wrong connection of the connectors will cause a failure.

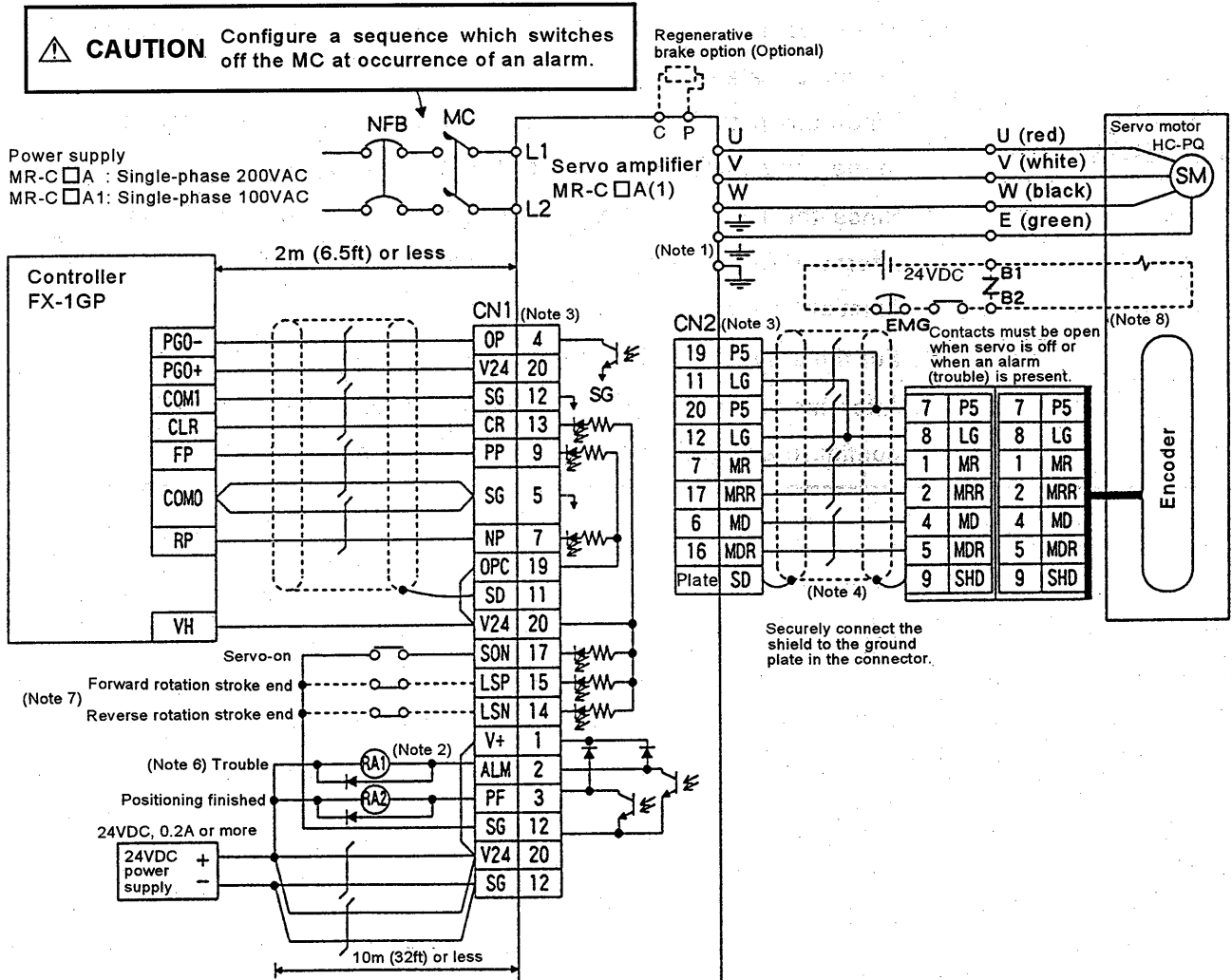| MEMO-RANDUM	Note 4. This wiring applies to the standard cable of less than 10m (32 ft).
	5. The pins with the same signal name are connected together in the servo amplifier.
	6. The trouble (ALM) signal conducts current when there is no alarm, i.e. in the normal state. When this signal is switched off (at occurrence of an alarm), the output of the controller must be stopped by the sequence program.
	7. Since the LSP and LSN signals have been automatically switched on internally before shipment, set □0□ in parameter No. 6 to make the function valid.
	8. For the servo motor with electromagnetic brake.
	9. After making sure that the servo is without fault (ALM signal is on), configure a sequence which switches on the relay SVRDY.

2 – 1 – 4 Connection with the AD75P☐ or A1SD75P☐

⚠ CAUTION	Configure a sequence which switches off the MC at occurrence of an alarm.

Note 1, 2, 3, 4, 6, 7, 8, 9 referenced in diagram.

◇ WARNING	Note 1. For the EN Standard model, always connect the protective earth (PE) terminal (marked ⊕) of the servo amplifier to the protective earth (PE) of the control box to prevent an electric shock.

⚠ CAUTION	Note 2. Connect the diode in the correct direction. Otherwise, the servo amplifier will fail and will not output the connect signals, disabling the emergency stop and other protective circuits.

NOTICE	Note 3. CN1 and CN2 have the same shape. Wrong connection of the connectors will cause a failure.

**MEMO-
RANDUM**

Note 4. This wiring applies to the standard cable of less than 10m (32 ft).

5. The pins with the same signal name are connected together in the servo amplifier.

6. The trouble (ALM) signal conducts current when there is no alarm, i.e. in the normal state.
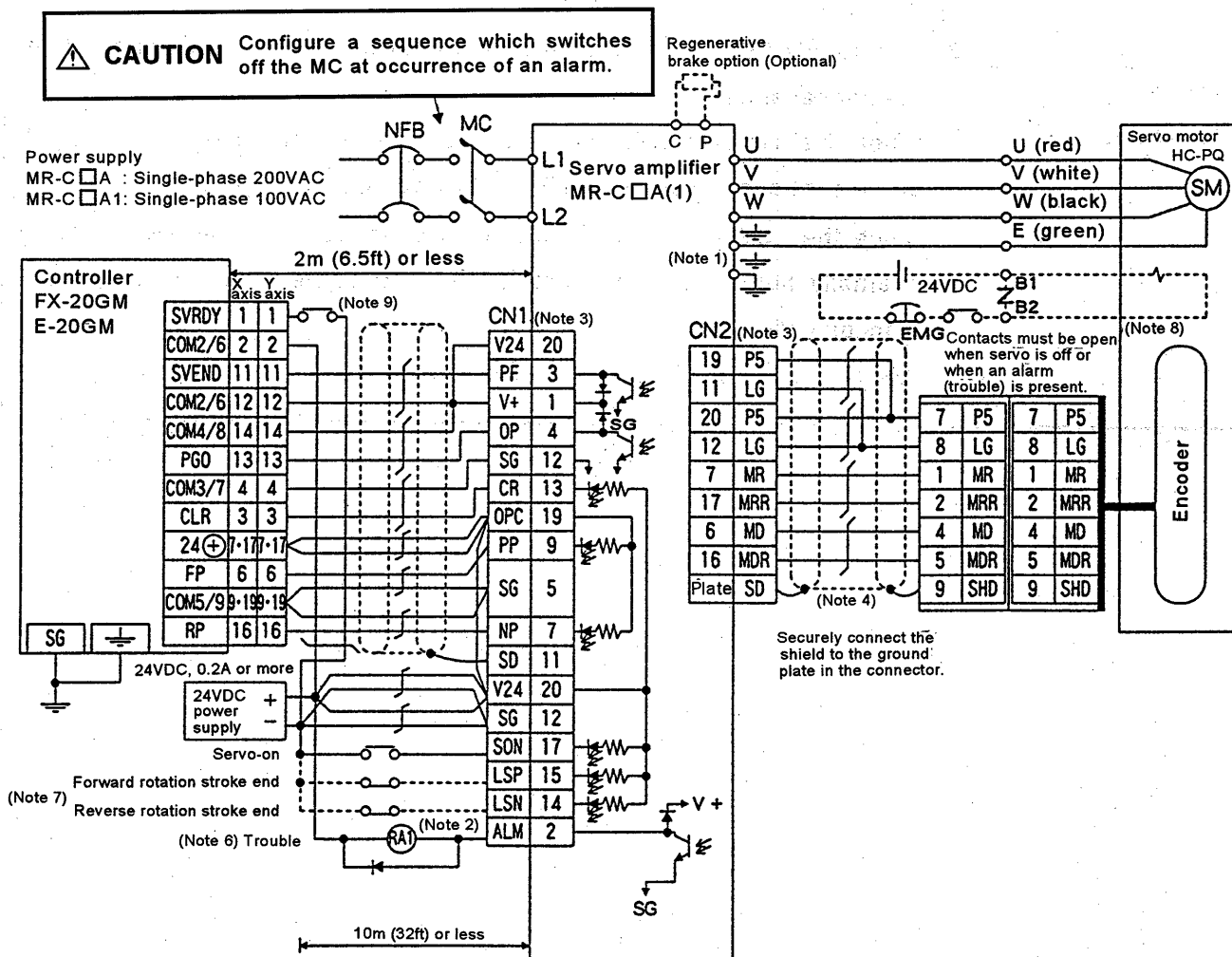   When this signal is switched off (at occurrence of an alarm), the output of the controller must be stopped by the sequence program.

7. Since the LSP and LSN signals have been automatically switched on internally before shipment, set □0□ in parameter No. 6 to make the function valid.

8. For the servo motor with electromagnetic brake.

9. After making sure that the servo is without fault (ALM signal is on), configure a sequence which switches on the relay RDY.

10. The upper limit signal (FLS) and lower limit signal (RLS) of the AD75P/A1SD75P are used for the zeroing retry function. Set them on the inside of the forward/reverse rotation stroke end of the servo amplifire.

2. OPERATION

2 – 2 Operation

2 – 2 – 1 Pre-operation checks

Before starting operation, check the following:

(1) Wiring

    1) A correct power supply is connected to the power input terminals (L1, L2) of the servo amplifier.

    2) The servo motor power supply terminals (U, V, W) of the servo amplifier match in phase with the power input terminals (U, V, W) of the servo motor.

    3) The servo amplifier and servo motor are grounded securely.

    4) The servo motor power supply terminals (U, V, W) of the servo amplifier are not connected to the power input terminals (L1, L2).

    5) When using the regenerative brake option, disconnect the lead across D-P of the main circuit terminal block. Also, twisted cables should be used for the wiring of the regenerative brake option.

    6) When stroke end limit switches are used, the signals across LSP-SG and LSN-SG of CN1 are on during operation.

    7) 24VDC or higher voltages are not applied to the pins of connector CN1.

    8) SD and SG of connector CN1 are not connected.

    9) The wiring cables are free from excessive force.

(2) Environment

    Ensure that signal and power cables are not shorted by wire offcuts, metallic clust, etc.

(3) Machine

    1) Ensure that all motor mounting screws and shaft-to-machine connections are tightened securely.

    2) Ensure that servo motor and machine are clear to operate.
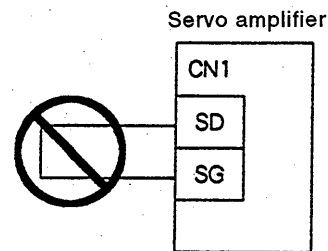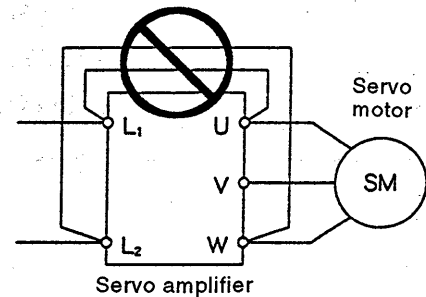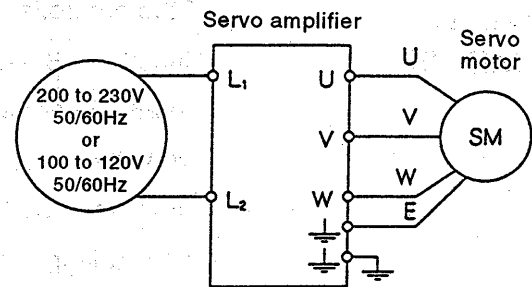
2. OPERATION

2 – 2 – 2 Operation procedure

⚠ **WARNING** Do not operate the switches with wet hands. You may get electric shock.

⚠ **CAUTION**

1. Before starting operation, check the parameters. Some machines may perform unexpected operation.

2. During power-on or soon after power-off, do not touch the servo amplifier heat sink, regenerative brake resistor, servo motor, etc. as they may be extremely hot! You may get burnt.

3. The specified combination of servo amplifier and servo motor must only be set. Otherwise, a fire may occur.

4. Do not plug or unplug the connectors (CN1, CN2) with power on. The amplifier or the equipment connected with the amplifier may fail.

Disconnect the servo motor from the machine, make sure that they operate properly. Then, connect the servo motor to the machine.

Power on

1) Switch on the servo-on signal (SON).

2) When power (NFB) is switched on, the display shows CL (lower 3 digits of the cumulative feedback pulses)
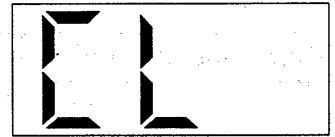
Input signal check

Using the external I/O display, check the digital I/O signal on/off states to see if operation can be performed. Make sure that the stroke end (LSP, LSN) signals are on.
(Refer to Section 2 – 5.)

Test operation

In the test operation mode, make sure that the servo motor operates.
(Refer to Section 2 – 7.)

Servo on

When the servo-on signal (SON) is switched on, the servo motor is ready to operate and the servo motor shaft is locked. (Servo lock state)

If the shaft is not servo-locked, the servo-on signal is not on. Check the external sequence up to the diagnostic display.

Confirmation method

Power on

⌐ ╵
╵ ╵

MODE
Press (●) once.

⌐ ◌ ⌐

Switch SON on.

⌐ ◌ ⌐

When SON is switched on, this display is shown.
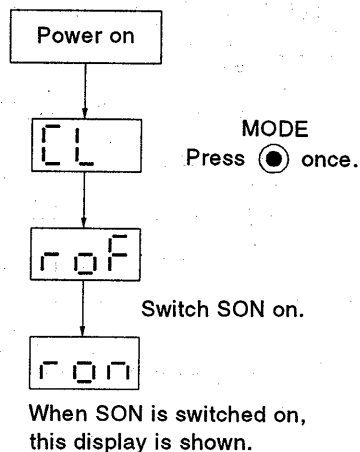
Command pulse train input

• When a pulse train is input from the positioning unit, the servo motor starts rotating. First, run the motor at low speed and check the rotation direction, etc. If the motor does not run as expected, recheck the input signals.

• On the status display, check the servo motor speed, command pulse frequency, load factors, etc.

Forward rotation CCW

Reverse rotation CW

• When machine operation check is over, confirm automatic operation with the positioning unit program.

• This servo amplifier contains the real-time auto tuning function under model adaptive control. Generally, therefore, gain adjustment is not needed, and starting servo operation automatically makes gain adjustment. Depending on the rigidity of the machine, however, response setting can be adjusted to provide the optimum tuning for the machine by changing the parameter No. 1 setting.
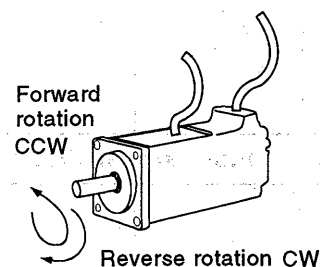
```
        |
        ↓
┌─────────────────────┐
│        Stop         │
└─────────────────────┘
```

Operation is interrupted and stopped by:

1) Servo off .... The base circuit is shut off and the servo motor coasts to a stop.

2) Stroke end off .... The servo motor comes to a sudden stop and is servo-locked. The servo motor is allowed to run in the opposite direction. (Set in parameter No. 6.)

3) Alarm .... When an alarm occurs, the base circuit is shut off.

2. OPERATION

2 – 2 – 3 Troubleshooting at start-up

⚠ CAUTION	Never adjust and change the parameter settings extremely. Otherwise, operation will be instable.

The following table lists faults that may occur in each step in the servo start-up sequence, and their check points and assumed causes. If an alarm occurs, refer to Chapter 8 and take the appropriate action.

No.	Start-Up Sequence	Fault	Check Point	Assumed Cause	Refer To
1	Power on	• The LED is not lit. • The LED flickers.	Not improved when the connectors CN1 and CN2 are disconnected.	• Power supply voltage faulty. • Servo amplifier failure	—
			Improved when the connector CN1 is disconnected.	Short circuit in the power supply of the CN1 cable wiring	
			Improved when the connector CN2 is disconnected.	1) Short circuit in the power supply of the encoder cable wiring 2) Encoder failure	
		An alarm occurs.	Refer to Chapter 8 "TROUBLESHOOTING" and remove the cause.		Chapter 8
2	Servo-on signal is switched on.	An alarm occurs.	Refer to Chapter 8 "TROUBLESHOOTING" and remove the cause.		Chapter 8
		Servo is not locked. (The servo motor shaft is free.)	Confirm the external I/O signal display.	1) The servo ON signal is not input. (Wiring error) 2) V24 or V5 is not supplied with DC power.	Section 2 – 3

3	Position command is input (test run)	The servo motor does not rotate.	Confirm the cumulative command pulses.	1) Wiring error
				  (a) For the open collector pulse train input, OPC is not supplied with 24VDC.
				  (b) LSP or LSN and SG are not connected.
				2) Pulse is not input.
					Section 2 – 3

4	Gain adjustment	Rotation ripples are (speed fluctuation is) large at low speed.	Make gain adjustment in the following procedure: 1) Increase the response setting of auto tuning. 2) Repeat acceleration/ deceleration three or four times to complete auto tuning.	Gain adjustment fault	Section 5 – 1
		Due to large load inertia, the servo motor vibrates side to side.	Make gain adjustment in the following procedure: If operation can be performed safely, repeat acceleration/deceleration three or four times to complete auto tuning.	Gain adjustment fault	Section 5 – 1
5	Cyclic operation	A position offset occurs. (Position servo)	Confirm the controller's output counter, cumulative command pulses, cumulative feedback pulses and actual servo motor position.	Pulse mis-count due to noise, etc.	Section 2 – 2 – 4

2. OPERATION

2 − 2 − 4 Determining the cause of a position offset
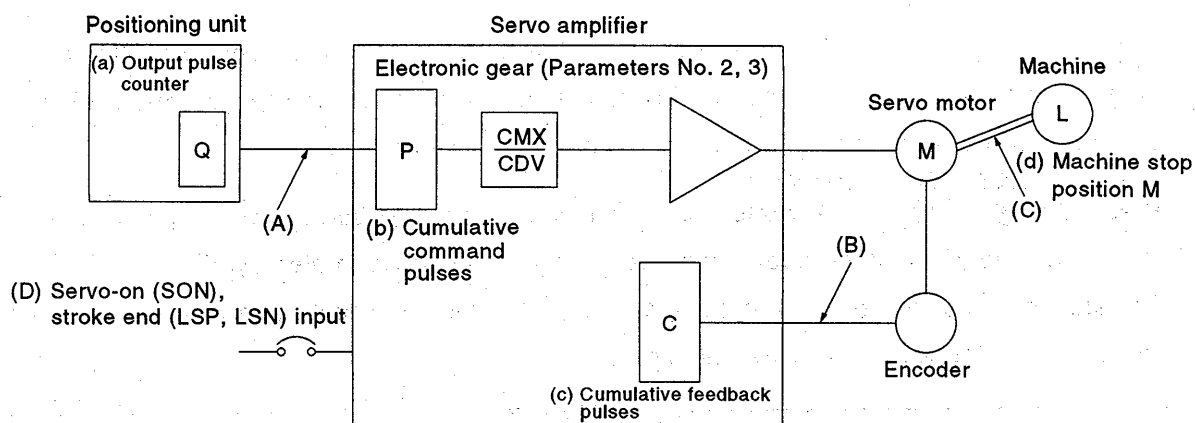
In the above diagram, the (a) output pulse counter, (b) cumulative command pulses (PL, PH) display, (c) cumulative feedback pulses (CL, CH) display, and (d) machine stop position represent points to be checked when a position offset occurs.

Also, (A), (B), (C) and (D) indicate places where position offset may occur. For example, (A) indicates the wiring between the positioning unit and servo amplifier where noise may be picked up. The noise may cause the mis-count of pulses.

In a normal operation without a position offset, the following relationships are established and maintained:

1) Q = P (output pulse counter value of the positioning unit

   = servo amplifier's cumulative command pulses)

2) $P \cdot \dfrac{CMX\,(Parameter No.\,2)}{CDV\,(Parameter No.\,3)} = C$ (cumulative command pulses × electronic gear ratio

   = cumulative feedback pulses)

3) C · Δ = M (cumulative feedback pulses × travel per pulse = machine position)

When a position offset occurs, check the following situations:

1) When Q ≠ P

   Noise picked up by the pulse train signal wiring between the positioning unit and servo amplifier may have caused a pulse count error. (Factor (A))

2) When $P \cdot \dfrac{CMX}{CDV} \neq C$

   The servo-on (SON) signal or forward/reverse run stroke end (LSP, LSN) signal may have switched off during operation, or the clear (CR) signal switched on. (Factor (D))

3) When C · Δ ≠ M

   Noise picked up by the encoder cable may have caused a count error, or mechanical slip may have occurred between the servo motor and machine.

2. OPERATION

2 – 3 Display and Operation

2 – 3 – 1 Display flowchart

Use the display (3-digit, 7-segment LED) on the front panel of the servo amplifier for status display, parameter setting, etc. Use the display to set the parameters before operation, diagnose an alarm, confirm external sequences, or confirm the operation status.

Press the ◉ (MODE), ◉ (UP) or ◉ (DOWN) button once to move to the next screen. When power is switched on, the symbol for the cumulative feedback pulses (lower 3 digits) CL is displayed.

To refer to or set the expansion parameters and application parameters, make them valid using parameter No. 12 (parameter write disable).

MODE button ◉

Status display	Diagnosis	Alarm	Basic parameter	Expansion parameter	Application parameter
Cumulative feedback pulses (lower 3 digits) [pulse]	Sequence	Current alarm	Regenerative brake option selection	Communication baudrate selection	Ratio of load inertia to motor inertia
Cumulative feedback pulses (upper 3 digits) [pulse]	External I/O signal display	Last alarm	Auto tuning	Status display selection, alarm history clear	Machine resonance suppression filter
Motor speed [r/min]	Output signal forced output	Second to last alarm	Electronic gear (Command pulse numerator)	Error excessive alarm output range setting	Position control gain 1
Droop pulses (lower 3 digits) [pulse]	Test operation	Third to last alarm	Electronic gear (Command pulse denominator)	Position/speed control mode selection	Position control gain 2
Droop pulses (upper 3 digits) [pulse]	Software version	Fourth to last alarm	Position acceleration/ deceleration time constant (Smoothing)	Speed command (1)	Speed control gain 1
Cumulative command pulses (lower 3 digits) [pulse]		Parameter error No.	In-position range	Speed command (2)	Speed control gain 2
Cumulative command pulses (upper 3 digits) [pulse]			Input signal selection 1	Speed acceleration/ deceleration time constant	Speed integral compensation
Command pulse frequency [kpps]			Command pulse input	Input signal function selection	Speed proportional control gain
Regenerative load ratio [%]			Spare	Output signal function selection	Slight vibration suppression control selection
Effective load ratio [%]			Torque limit value	Spare	For manufacturer setting
Peak load ratio [%]			Spare		Optional function
Load inertia ratio [times]			Spare		For manufacturer setting
			Parameter write disable		

UP ◉ DOWN ◉

NOTICE Usually, these parameters are not used. To use them, make them valid using parameter No. 12.

2. OPERATION

2 - 3 - 2 Status display

The servo status during operation is shown on the 3-digit, 7-segment LED display.

Press the ⊙(UP) or ⊙(DOWN) button to change display data as desired. When the required data is selected, the corresponding symbol is displayed. Press the ⊙(SET) button to display that data.
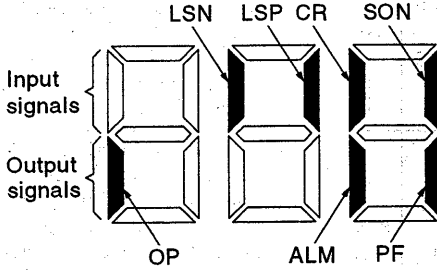
Name	Symbol	Display Range	Unit	Description
Cumulative feedback pulses (Lower 3 digits)	CL	-999999 to 999999	Pulse	After operation has been made ready, the travel distance of the servo motor is counted and displayed. When ±999999 is exceeded, the value begins with zero.
Cumulative feedback pulses (Upper 3 digits)	CH			Press the ⊙(SET) button to reset the display value to zero. When the servo motor is rotating in the reverse direction, the decimal points in all digits are lit.
Servo motor speed	r	-540 to 540	×10r/min	The servo motor speed is displayed. When the servo motor is rotating in the reverse direction, the decimal points in all digits are lit. The r/min value rounded off is displayed. (The display data is updated every 0.3s.) Hold down the ⊙(SET) button to display the value in r/min.
Droop pulses (Lower 3 digits)	EL	-999999 to 999999	Pulse	The number of droop pulses in the deviation counter is displayed. When ±999999 is exceeded, the value begins with zero. When the servo motor is rotating in the reverse direction, the decimal points in all digits are lit.
Droop pulses (Upper 3 digits)	EH			
Cumulative command pulses (Lower 3 digits)	PL	-999999 to 999999	Pulse	The position command input pulses are counted and displayed. As this value is displayed before it is multiplied by the electronic gear (CMX/CDV), it may not match the cumulative feedback pulses.
Cumulative command pulses (Upper 3 digits)	PH			Press the ⊙(SET) button to reset the display value to zero. When the servo motor is rotating in the reverse direction, the decimal points in all digits are lit.
Command pulse frequency	n	-200 to 200	kpps	The frequency of the position command input pulses is displayed in kpps which is represented by the decimal point. This value is displayed before it is multiplied by the electronic gear (CMX/CDV). When the servo motor is rotating in the reverse direction, the decimal points in all digits are lit. Hold down the ⊙(SET) button to display the value in 0.1kpps.
Regenerative load ratio	L	0 to 100	%	The ratio of regenerative power to permissible regenerative power is displayed in %. As the permissible regenerative power depends on whether there is the regenerative brake option or not, set parameter No. 0 correctly.
Effective load ratio	J	0 to 300	%	The continuous effective load torque is displayed. When rated torque is generated, this value is 100%. The display data is updated every 910.1 ms.
Peak load ratio	b	0 to 400	%	The maximum torque generated during acceleration/deceleration, etc. is displayed. When rated torque is generated, this value is 100%. The peak torque for the past 4 seconds is displayed. The display data is updated every 910.1ms.
Load inertia ratio	JL	0 to 100	Times	The estimated ratio of the load inertia to the inertia of the servo motor shaft is displayed. The display data is updated every 60ms.

2. OPERATION

2 – 3 – 3 Diagnostic mode

Name	Display	Description
Sequence		Not ready. Indicates that the unit is being initialized or an alarm has occurred.
		Ready. Indicates that the servo was switched on after completion of initialization and the unit is ready to operate.
External I/O signal display	Input signals / Output signals LSN LSP CR SON OP ALM PF	Indicates the on/off states of the external I/O signals. The upper segments correspond to the input signals and the lower segments to the output signals. Lit: ON Extinguished: OFF Refer to (1) in this section. The I/O signals can be changed using parameters No. 20 and 21. The ALM signal is ON when there is no alarm. Refer to Section 5 – 2 – 2.
Output signal forced output		The digital output signal can be forcibly switched on/off. For more information, refer to (2) in this section.
Test operation mode		The servo motor can be operated without pulse train input. During test operation, speed control servo is provided. The status display values of the droop pulses, cumulative command pulses and command pulse frequency do not change. For details, refer to (3) in this section.
Software version		Indicates the version of the software.

2. OPERATION

(1) External I/O signal display

MEMO-RANDUM	This function is available for the servo amplifier with software version A2 or later.

The on/off states of the digital I/O signals connected to the servo amplifier can be confirmed. In addition, the I/O signals displayed for parameters No. 20 and 21 can be changed. Refer to Section 5 − 2 − 2.

1) Operation

Display screen after power-on is shown.

MODE
Press ⦿ once.

UP
Press ⦿ once.

.....External I/O signal display screen
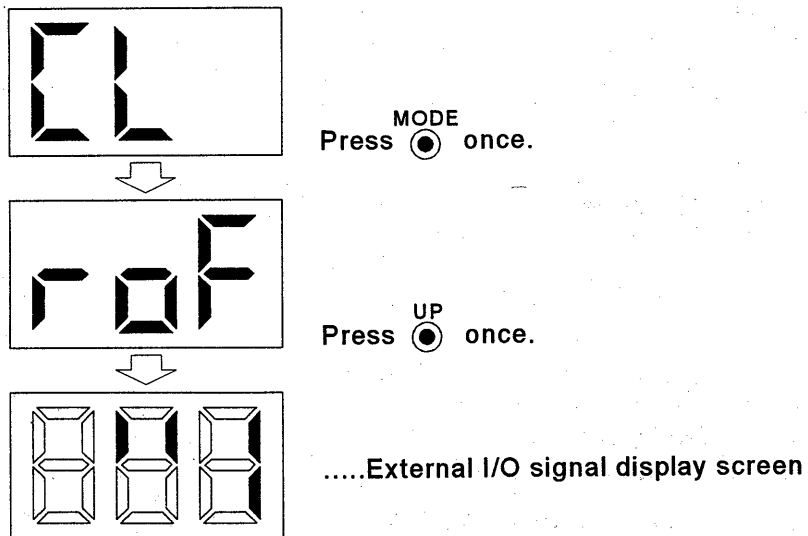
2) Display definition

Lit: ON
Not lit: OFF
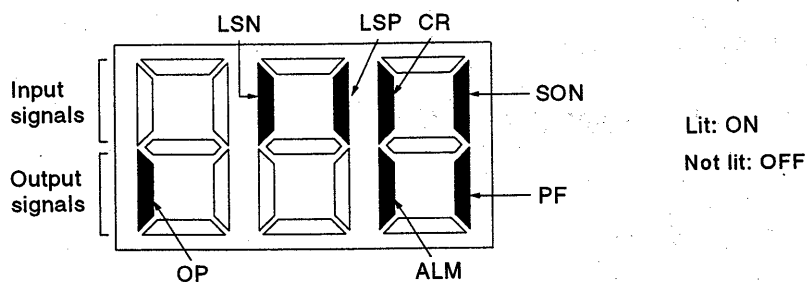
The 7-segment LED shown above indicates on/off.

Each segment at top indicates the input signal and each segment at bottom indicates the output signal.

Symbol	Signal
SON	Servo-on
LSP	Forward rotation stroke end
LSN	Reverse rotation stroke end
CR	Clear
ALM	Trouble (ON in normal state)
PF	Positioning finished
OP	Encoder Z-phase pulse

2. OPERATION

(2) Output signal forced output

MEMO-RANDUM	This function is available for the servo amplifier with software version A2 or later.

The output signal can be forcibly switched on/off independently of the servo status. This operation is used to check output signal wiring.

Display screen after power-on is shown.

MODE
Press ⦿ once.

UP
Press ⦿ twice.

SET
Press ⦿ for more than 2s.
.... Switch on/off the signal below the lit segment.
.... Indicates the on/off of the output signal. The correspondences between segments and signals are as in the output signals of the external I/O signal display.
(Lit: ON, Not lit: OFF)

MODE
Press ⦿ once.

.... The segment above ALM is lit.

UP
Press ⦿ once.

.... ALM is switched on.
(ALM-SG conducts.)

DOWN
Press ⦿ once.

.... ALM is switched off.

SET
Press ⦿ for more than 2s.

2. OPERATION

(3) Test operation mode

Jog operation can be performed without a pulse train input command unit.

1) Mode switching

Display screen after power-on is shown.

```
CL
```
⇩
MODE
Press ⊙ once.

```
roF
```
⇩
UP
Press ⊙ three times.

```
rSr
```
⇩
SET
Press ⊙ for more than 2s.

```
d01
```
.... When this screen is displayed, jog operation can be per-
formed.

└───── Flickers in the test operation mode.
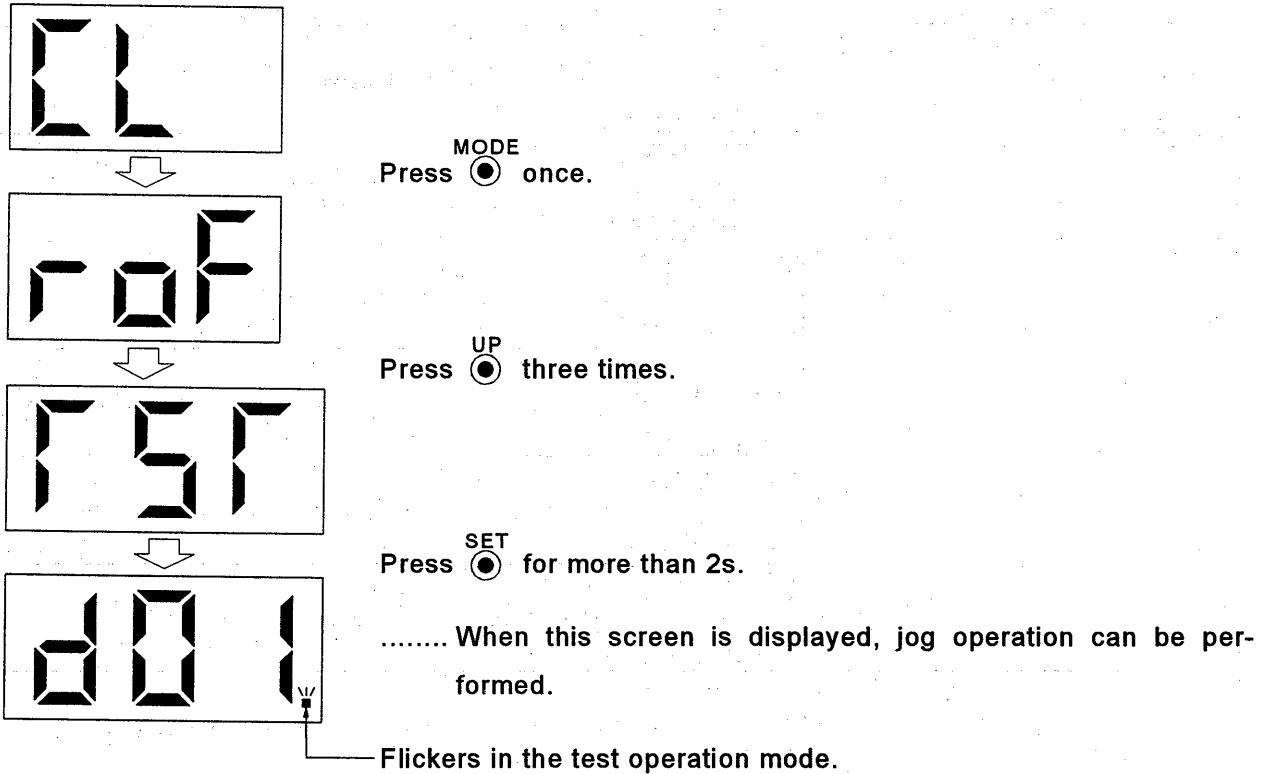
2) Starting method

Perform the following operation to rotate the servo motor at 200r/min.

At this time, the acceleration/deceleration time is 1s.

Rotation Direction	Operation
CCW	UP Press ⊙ .
CW	DOWN Press ⊙ .

To stop, release the corresponding button.

3) Status display

MODE
The servo status during test operation can be displayed. Press ⊙ to shift to the status dis-
play screen. The display data is the same as in the status display in Section 2 – 3 – 2.

4) Termination of test operation

MODE
To terminate the test operation, switch power off once, or press ⊙ to call the ⌐d01⌐ screen,
SET
then press ⊙ for more than 2s.

2. OPERATION

2 – 3 – 4 Alarm mode

The current alarm, past alarm history and parameter error are displayed. The corresponding alarm number or the parameter number in error is shown in the two least significant digits of the display. Display examples are listed in the following table:

Name	Display	Description
Current alarm		No occurrence of an alarm.
		Alarm 33 (overvoltage) occurred. Flickers at occurrence of the alarm.
Alarm history		The last alarm is alarm 50 (overload).
		The second alarm in the past is alarm 33 (overvoltage).
		The third alarm in the past is alarm 10 (undervoltage).
		There is no fourth alarm in the past.
Parameter error		No occurrence of alarm 37 (parameter error).
		The data of parameter No. 1 is faulty.

Functions at occurrence of an alarm

(1) The unit can enter the alarm mode from any screen.

(2) The other screen is visible during occurrence of an alarm. At this time, the decimal point in the third digit flickers.

(3) To clear any alarm, switch power on, then off or press the $\overset{SET}{\circledbullet}$ button on the current alarm screen. Note that this should be done after removing the cause of the alarm.

(4) Use parameter No. 14 to clear the alarm history.

2. OPERATION

2 – 3 – 5 Parameter mode

The basic parameter control block diagram is shown below. Set the parameters as required.
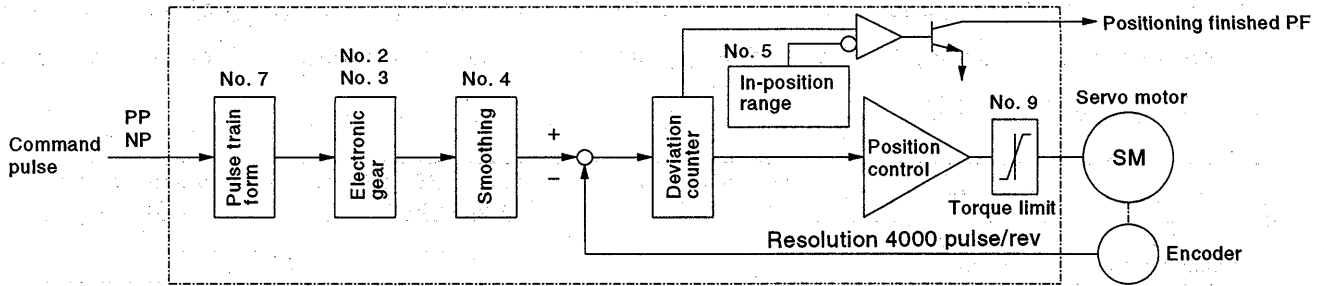
The parameter settings need not be changed to operate this servo. Note that the parameter settings should be changed when:

    1) The regenerative brake option is used;

    2) The stroke end function is used;

    3) The number of input pulses per servo motor revolution is changed

    4) The machine mounted servo motor hunts oscillates or performance need to be further improved.

(1) Operation example

When using the regenerative brake option (MR-RB013), call the display screen shown, after power-on.

Press ⊙ three times.
MODE

.... The parameter number is displayed.
Press ⊙ or ⊙ to change the number.
UP DOWN

Press ⊙ twice.
SET

.... The set value of the specified parameter number flickers.

Press ⊙ once.
SET

.... The set value flickering can be changed.
Use ⊙ or ⊙ .
UP DOWN

Press ⊙ to enter.
UP
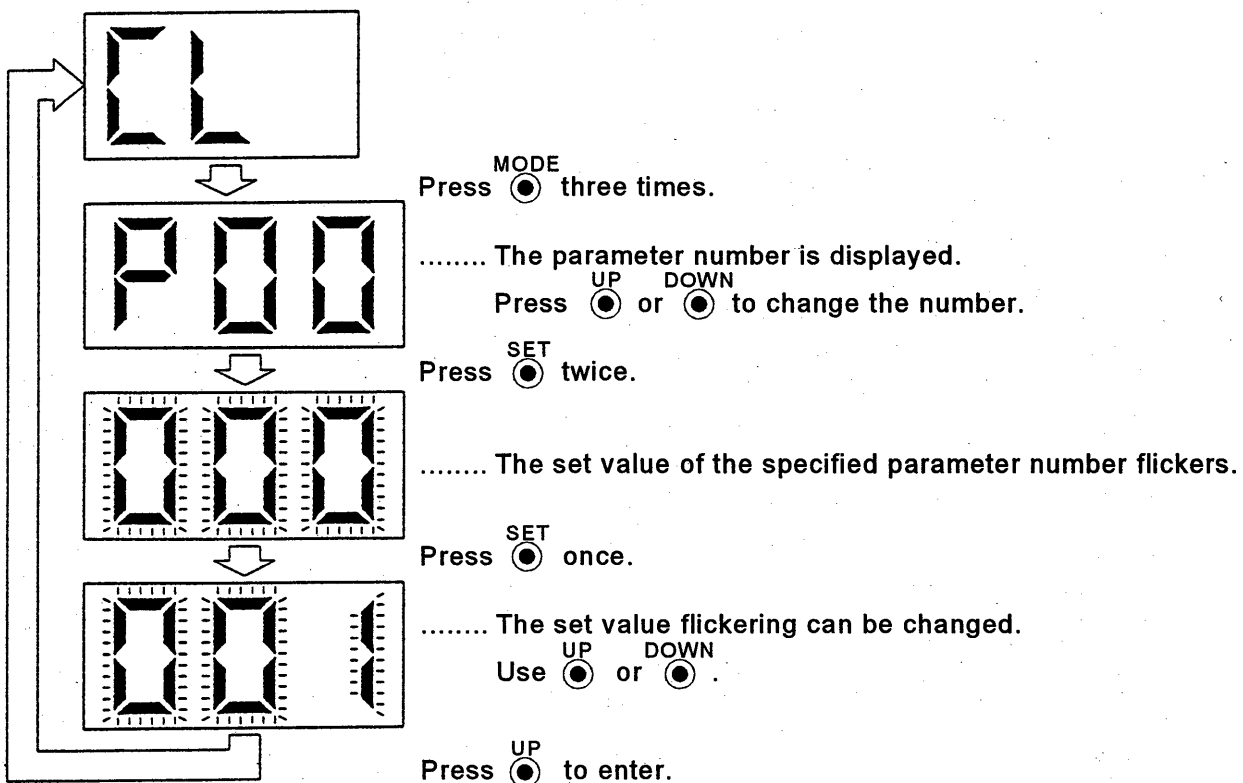
For the setting of parameter No. 0, change its set value, then switch power off once.

2. OPERATION

(2) Expansion and application parameters

These parameters are not used usually. The gains can be adjusted in the speed control mode or manually. To use the expansion and application parameters, change the setting of parameter No. 12 (parameter write disable). After setting parameter No. 12, switch power off once, then on to make the parameters valid.

Set Value	Operation	Basic Parameters No. 0 to 12	Expansion Parameters No. 13 to 22	Application Parameters No 23 to 34
000 (initial value)	Reference	O	x	x
	Write	O	x	x
00A	Reference	O	x	x
	Write	Allowed for No. 12 only.	x	x
00B	Reference	O	O	x
	Write	O	x	x
00C	Reference	O	O	x
	Write	O	O	x
00D	Reference	O	O	O
	Write	O	O	O

2. OPERATION

(3) Parameter list

Note: To make the parameter marked * valid, set the parameter, switch power off once, then switch power on again.

Class	No.	Symbol	Name	Initial Value	Unit	Customer Setting
Basic parameters	0	*REG	Regenerative brake option/Low acoustic mode selection	000		
	1	ATU	Auto tuning	002		
	2	CMX	Electronic gear (Command pulse multiplying factor numerator)	1		
	3	CDV	Electronic gear (Command pulse multiplying factor denominator)	1		
	4	PST	Position acceleration/deceleration time constant (Smoothing)	5	ms	
	5	INP	In-position range	100	pulse	
	6	*IP1	Input signal selection 1	010		
	7	*PLS	Command pulse input	010		
	8		Spare	0		
	9	TLL	Torque limit value	100	%	
	10		Spare	0		
	11		Spare	0		
	12	*BLK	Parameter write disable	000		
Expansion parameters	13	*SIO	Communication baudrate selection	000		
	14	*DMD	Status display selection, alarm history clear	000		
	15	ERZ	Error excessive alarm output range setting	50	kpulse	
	16	*OP1	Position/speed control mode selection	001		
	17	SC1	Speed command (1)	10	10r/min	
	18	SC2	Speed command (2)	100	10r/min	
	19	STC	Speed acceleration/deceleration time constant	0	10ms	
	20	*DIF	Input signal function selection	210		
	21	*DOF	Output signal function selection	010		
	22		Spare			
Application parameters	23	GD2	Ratio of load inertia to motor inertia	8		
	24	NCH	Machine resonance suppression filter	0		
	25	PG1	Position control gain 1 (model position gain)	70	rad/s	
	26	PG2	Position control gain 2 (actual position gain)	25	rad/s	
	27	VG1	Speed control gain 1 (model position gain)	120	× 10rad/s	
	28	VG2	Speed control gain 2 (actual position gain)	60	× 10rad/s	
	29	VIC	Speed integral compensation	20	ms	
	30	VDC	Speed proportional control gain	980		
	31	MVC	Slight vibration suppression control selection	000		
	32	MVP	For manufacturer setting	412		
	33	*OP2	Optional function	A00		
	34	VPI	For manufacturer setting	0	pulse	

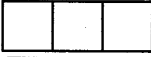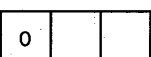| NOTICE	Usually, the expansion and application parameters are not used. To use them, make them valid using parameter No. 12.

(4) Detailed explanation of the parameters

Note: To make the parameter marked * valid, set the parameter, switch power off once, then switch power on again.

Class	No.	Symbol	Name	Initial Value	Unit	Setting Range
Basic parameters	0	*REG	Regenerative brake option/low acoustic noise mode selection: Used to select the regenerative brake option and low acoustic noise mode. （figure of parameter digits with "0" in center） — Select the regenerative brake option. 0: Not used 1: MR-RB013 2: MR-RB033 **NOTICE** If wrong setting is made, the regenerative brake option may overheat! — Low acoustic noise mode selection (software version A3 or later) By choosing the low acoustic noise mode, electromagnetic sound generated by the servo motor can be reduced by about 20dB. At this time, the torque characteristic of the servo motor changes. 0: non-low acoustic noise 1: low acoustic noise	000		000 to 102h
	1	ATU	Auto tuning: Used to set response for execution of auto tuning. — Auto tuning response setting	002		001 to 235h

Auto tuning response setting:

Set Value	Response
1	Slow response
2	to
3	Medium response
4	to
5	Fast response

- If the machine hunts or generates large gear sound, decrease the set value.
- To improve performance, e.g. shorten the set-

— Machine selection
Used to adjust the position setting characteristic according to the machine status.

		Position Setting Characteristic	
		Ordinary	Better (Note)
Machine friction	Small	0	2
	Large	1	3

Note: This setting is available for software version A3 or later.
Choosing "Better" automatically tunes the speed integral compensation (parameter No. 29) rather small.

— Auto tuning selection
0: Executed for both position and speed loops
1: Interpolation axis control (normally not set)
2: Not executed.

Class	No.	Symbol	Name	Initial Value	Unit	Setting Range
Basic parameters	2	CMX	Electronic gear (Command pulse multiplying factor, numerator): Used to set the multiplier of the command pulse input. Command pulse input f_1 → [CMX / CDV] → Position command $f_2 = f_1 \cdot \dfrac{CMX}{CDV}$ Note: Set in the range of $\dfrac{1}{50} < \dfrac{CMX}{CDV} < 20$. The setting of the number of input pulses per servo motor revolution can be changed by the following formula: $4000 \cdot \dfrac{CDV}{CMX}$ (pulse/rev) ⚠ **CAUTION** If a wrong setting is made, the servo motor way rotate at unexpectedly high speed, causing injury.	1		1 to 999
	3	CDV	Electronic gear (Command pulse multiplying factor, denominator): Used to set the divisor of the command pulse input.	1		1 to 999
	4	PST	Position command acceleration/deceleration time (smoothing): Used to set the time of a low pass filter to the position command. Example: When a command is received from a synchronizing encoder, synchronous operation can be started smoothly. Synchronizing encoder Start → Servo amplifier Servo motor Without time constant setting With time constant setting Servo motor speed ON Start OFF t	5	ms	0 to 999
	5	INP	In-position range: Used to set the range of droop pulses in which the positioning finished (PF) signal is output.	100	pulse	0 to 999

Class	No.	Symbol	Name	Initial Value	Unit	Setting Range
Basic parameters	6	*IP1	Input signal selection 1: Used to change the functions of the digital input signals. SON signal function selection 0: Servo is switched on when the signal across SON-SG is switched on. 1: Servo is switched on when the signal across SON-SG is switched off. **MEMO-RANDUM** When "1" is selected, note that the servo amplifier enters the servo-on status if the external 24V power is lost. LSP, LSN signal selection 0: Function valid (Invalid if the signal is not switched on in the external wiring.) 1: Normally on (When the limit switch is not used) Clear signal selection 0: Droop pulses are cleared on the leading edge. 1: Always cleared while on.	010		000 to 111h
	7	*OP1	Command pulse selection: Used to select the input form of the pulse train input signal. Refer to Section 5 – 2 – 1. 0 Command pulse input form 0: Forward/reverse rotation pulse train 1: Signed pulse train 2: A/B phase pulse train Pulse train logic selection 0: Positive logic 1: Negative logic	010		000 to 012h
	8		Spare:	0		
	9	TLL	Torque limit value: Set with the maximum torque being 100%. This parameter is set to limit the torque generated by the servo motor.	100	%	0 to 100
	10 11		Spare:			
	12	*BLK	Parameter write disable: Used to select the reference and write ranges of the parameters. <table><tr><th>Set Value</th><th>Reference Range</th><th>Write Range</th></tr><tr><td>000</td><td>No. 0 to 12</td><td>No. 0 to 12</td></tr><tr><td>00A</td><td>No. 0 to 12</td><td>No. 12</td></tr><tr><td>00B</td><td>No. 0 to 22</td><td>No. 0 to 12</td></tr><tr><td>00C</td><td>No. 0 to 22</td><td>No. 0 to 22</td></tr><tr><td>00D</td><td>No. 0 to 22</td><td>No. 0 to 34</td></tr></table>	000		000 to 00Dh

2. OPERATION

Class	No.	Symbol	Name	Initial Value	Unit	Setting Range
Expansion parameters	13	*SIO	Communication baudrate selection: Used to select the serial interface when the RS-232C option unit is fitted to use the communication function. `0 □ 0` └── Selection of baud rate when RS-232C is selected 0: 9600 (bps) 1: 19200 (bps) 2: 4800 (bps)	000		000 to 020h
	14	*DMD	Status display selection, alarm history clear: Used to select the status display shown at power-on. `□ 0 □` └── Status display at power-on 0: Cumulative feedback pulses (lower 3 digits) 1: Cumulative feedback pulses (upper 3 digits) 2: Servo motor speed 3: Droop pulses (lower 3 digits) 4: Droop pulses (upper 3 digits) 5: Cumulative command pulses (lower 3 digits) 6: Cumulative command pulses (upper 3 digits) 7: Command pulse frequency 8: Regenerative load factor 9: Effective torque A: Peak torque B: Load inertia └── Alarm history clear 0: Invalid 1: Valid When alarm history clear is selected, this function is made valid at next power-on. After the alarm history is cleared, the setting is automatically reset to zero.	000		000 to 10Ah
	15	ERZ	Excessive error output range setting: Used to set the range in which the excessive error alarm (A52) is output.	50	kpulse	1 to 999
	16	*OP1	Position/speed control mode selection: Used to select the optional function. `□ 0 1` └── Control mode selection 0: Position control 1: Speed control	001		001 to 101h
	17	SC1	Speed command (1): Used to set speed 1 of the internal speed command.	10	10r/min	0 to 450
	18	SC2	Speed command (2): Used to set speed 2 of the internal speed command.	100	10r/min	0 to 450

Class	No.	Symbol	Name	Initial Value	Unit	Setting Range
Expansion parameters	19	STC	Speed acceleration/deceleration time constant: Used to set the acceleration/deceleration time required to reach the rated speed in response to the speed command. ┌─Example──────────────────────────────┐ Set 300 (3s) to accelerate the HC-PQ series servo motor (rated speed: 3000r/min) from 0r/min to 1000r/min in 1s.	0	10ms	0 to 500
	20	*DIF	Input signal function selection: Used to select the input signal functions of pins No. 13, 14 and 15 on connector CN1. Pin 15 Set values and functions 0: LSP 3: ST1 6: PC 1: LSN 4: ST2 7: TL 2: CR 5: DI1 8: RES Pin 14 Set values and functions 0: LSP 3: ST1 6: PC 1: LSN 4: ST2 7: TL 2: CR 5: DI1 8: RES Pin 13 Set values and functions 0: LSP 3: ST1 6: PC 1: LSN 4: ST2 7: TL 2: CR 5: DI1 8: RES MEMO-RANDUM 1. Selection of the same function will result in a parameter error. 2. When automatic on of LSP/LSN is selected in parameter No. 6, LSP/LSN is always on independently of the function selected in parameter No. 20.	210		000 to 888h
	21	*DOF	Output signal function selection: Used to select the output signal functions of pins No. 3 and 4 on connector CN1. 0 Pin 4 Set values and functions 0: OP 2: RD 4: TLC 1: PF 3: ZSP 5: BRK Pin 3 Set values and functions 0: OP 2: RD 4: TLC 1: PF 3: ZSP 5: BRK MEMO-RANDUM Selection of the same function will result in a parameter error.	010		000 to 055h
	22		Spare:			

Class	No.	Symbol	Name	Initial Value	Unit	Setting Range
Application parameters	23	GD2	Ratio of load inertia to motor inertia: Used to set the ratio of the load inertia to the servo motor inertia. Note that when auto tuning is selected, the result of auto tuning is automatically set.	8		0 to 100
	24	NCH	Machine resonance suppression filter: Used to set the frequency that matches the resonance frequency of the mechanical system. 	Set Value	Machine Resonance Frequency [Hz]
---	---
0	Not used
1	1125
2	563
3	375
4	282
5	225
6	188
7	161		0		0 to 7
	25	PG1	Position control gain 1: Used to set the gain of the model position loop.	70	rad/s	4 to 999
	26	PG2	Position control gain 2: Used to set the gain of the actual position loop.	25	rad/s	1 to 500
	27	VG1	Speed control gain 1: Used to set the gain of the model speed loop. Higher setting increases response but is liable to generate vibration and noise.	120	10rad/s	10 to 500
	28	VG2	Speed control gain 2: Used to set the gain of the actual speed loop. Higher setting increases response but is liable to generate vibration and noise.	60	10rad/s	2 to 800
	29	VIC	Speed integral compensation: Used to set the time constant of integral compensation of the actual speed loop.	20		1 to 999
	30	VDC	Speed proportional control gain: Switch the proportional control input signal (PC) on to make this function valid.	980		0 to 999
	31	MVC	Slight vibration suppression control selection: Used to select ON-OFF of slight vibration suppression control. 0 0 └── Slight vibration suppression control 0: Not done. 1: Done.	000		000 to 001h
	32	MVP	For manufacturer setting:	412		
	33	*OP2	Optional function: Used to select the optional function. A 0 └── Selection of stop mode at LSP/LSN off under position control 0: Sudden stop 1: Slow stop (The servo motor is decelerated to a stop at the time constant set in parameter No. 4.)	A00		A00 to A01h
	34	VPI	For manufacturer setting:	0		

CHAPTER 3
WIRING

This chapter provides information required for wiring. Before wiring, always read this chapter.

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CHAPTER 4
INSTALLATION

This chapter deals with the installation and environmental conditions. Follow the instructions in this chapter when installing the equipment.

4 − 1 Servo Amplifier
4 − 2 Servo Motor

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4. INSTALATION

4 – 1 Servo Amplifier

(1) Environmental conditions

Environment	Conditions
Ambient temperature	0 to +50 [°C] (non-freezing)
	32 to 122 [°F] (non-freezing)
Ambient humidity	90%RH or less (non-condensing)
Storage temperature	−20 to +65 [°C] (non-freezing)
	−4 to 149 [°F] (non-freezing)
Storage humidity	90%RH or less (non-condensing)
Ambience	Indoors (no direct sunlight) Free from corrosive gas, flammable gas, oil mist, dust and dirt.
Altitude	Max. 1000m above sea level
Vibration	5.9 {0.6G} [m/s^2] or less
	194 [ft/s^2] or less

4. INSTALATION

(2) Installation direction and clearances

    1) Installation of one servo amplifier

Control panel

40mm (1.6in) or more

10mm (0.4in) or more

10mm (0.4in) or more

Top

Bottom

MR-C
MR-C-T01

100 mm (4in) or more
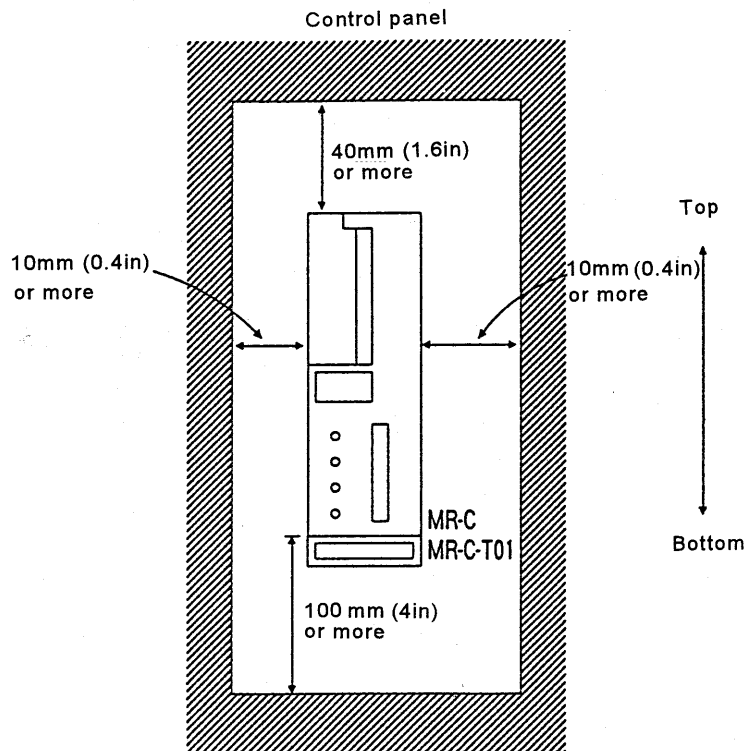
    2) Installation of two or more servo amplifiers

Allow clearance between the top of the servo amplifier and the internal surface of the control panel, and install a fan to prevent the internal temperature of the control enclosure from exceeding the environmental conditions.

    3) Others

When using heat generating equipment such as regenerative brake option, install them with full consideration of heat generation so that the servo amplifier is not affected.

Install the servo amplifier on a vertical surface so that it is located correctly.

(3) Keep out foreign materials

    1) When installing the unit on a panel or inside an enclosure, prevent drill chips and wire fragments from entering the servo amplifier.

    2) Prevent oil, water and metallic dust from entering the amplifier through openings in the enclosure.

    3) Provide positive pressure in control enclosure by forcing in clean, dry, cool, non-toxic, non-corrosive, non-explosive air.

4. INSTALATION

4 – 2 Servo Motor

⚠ CAUTION	1. Do not handle the motor by the cables, shaft or encoder. 2. Securely mount the servo motor to the machine. If mount insecurely, the servo motor may come off during operation. 3. Never hit the servo motor or shaft, especially when coupling the servo motor to the machine. The encoder may become faulty. 4. For safety of personnel, always cover rotating and moving parts. 5. Do not load the servo motor shaft to more than the permissible load. Otherwise, the shaft may break.

(1) Environmental conditions

Environment	Conditions
Ambient temperature	0 to +40 [°C] (non-freezing)
	32 to 104 [°F] (non-freezing)
Ambient humidity	80%RH or less (non-condensing)
Storage temperature	–15 to +70 [°C] (non-freezing)
	5 to 158 [°F] (non-freezing)
Storage humidity	90%RH or less (non-condensing)
Ambience	Indoors (no direct sunlight) Free from corrosive gas, flammable gas, oil mist, dust and dirt.
Altitud	Max. 1000m (3280 ft) above sea level
Vibration	X, Y: 19.6 [m/s^2] (2G)
	X, Y: 64.3 [ft/s^2]

Servo motor
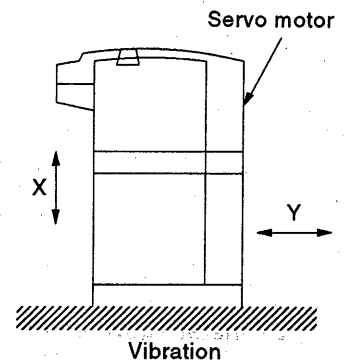
Vibration

Graph of servo motor vibration amplitude vs speed

Vibration amplitude (both amplitudes) [μm]

Maximum allowable

Speed [r/min]
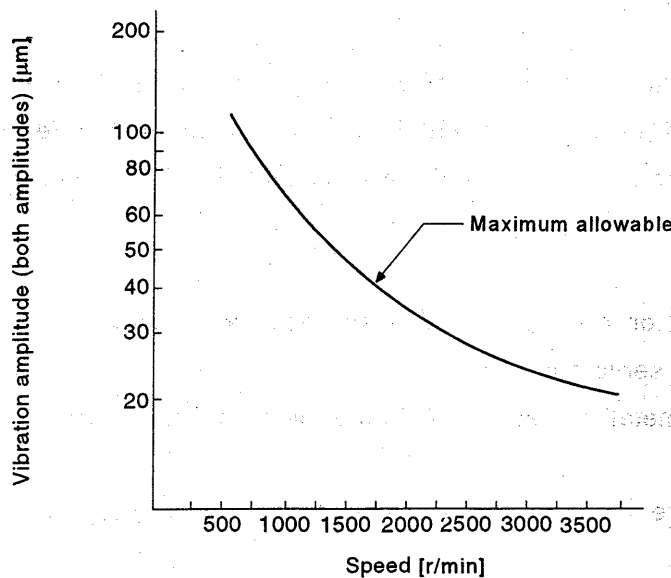
(2) Transportation

Do not carry the motor by the shaft or encoder or cables.

4. INSTALATION

(3) Servo motor load-mounting precautions

1) When mounting a pulley to the shaft of the servo motor with a keyway, use the screw hole on the end of the shaft. To install the pulley, first insert a threaded rod into the screw hole of the shaft, put a washer against the end face of the coupling, and insert and tighten a nut to force on the pulley.

2) When mounting a pulley to the shaft of the servo motor with a keyway, use the screw hole on the end of the shaft. For a shaft without a keyway, use a friction coupling or the like.

3) When removing the pulley, use a pulley remover to protect the shaft from impact.

4) For safety of personnel, a profective cover must be installed overall rotating and moving components.

5) When a shaft end threaded part is needed to mount a pulley on the shaft, please contact us.

6) During assembling, do not strike the shaft.

7) The orientation of the encoder on the servo motor cannot be changed.

8) For installation of the servo motor, use spring washers and fully tighten the bolts so that they do not become loose.
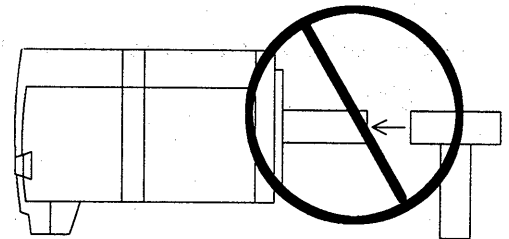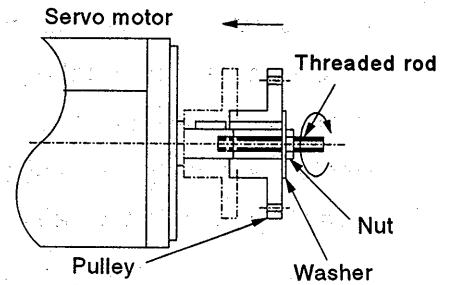
(4) Permissible load for the shaft

1) Use a flexible coupling and make sure that the misalignment of the shaft is less than the permissible radial load.

2) When using a pulley, sprocket or timing belt, select a diameter that will fit into the permissible radial load.

3) Do not use a rigid coupling as it will apply excessive bending load to the shaft, leading to shaft breakage.

Servo Motor	L		Permissible Radial Load			Permissible Thrust Load		
	[m]	[In]	[N]	[kgf]	[lb]	[N]	[kgf]	[lb]
HC-PQ033, 053, 13	25	1	88	9	19.8	59	6	13.2
HC-PQ23, 43	30	1.2	245	25	55	98	10	22

Note: For the symbols in the table, refer to the following diagram:
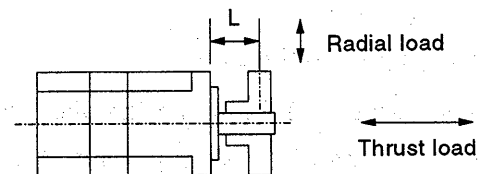
L: Distance from flange mounting surface to load center

(5) Oil and water protection

1) The servo motor is not waterproof (IP44). Prevent oil and water from entering the servo motor.

2) The HC-PQ series servo motor is not provided with an oil seal. Seal the gear box to prevent lubricating oil from entering the servo motor.

Oil or water
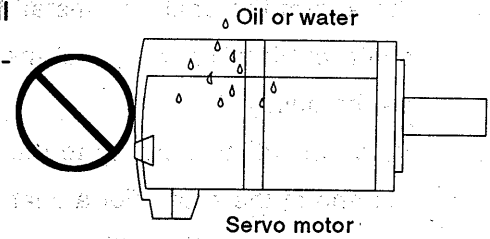
Servo motor

3) When installing the servo motor horizontally, direct the power cable and encoder cable downward. When installing the servo motor vertically or obliquely, provide a loop in the cable.

Loop in the cable
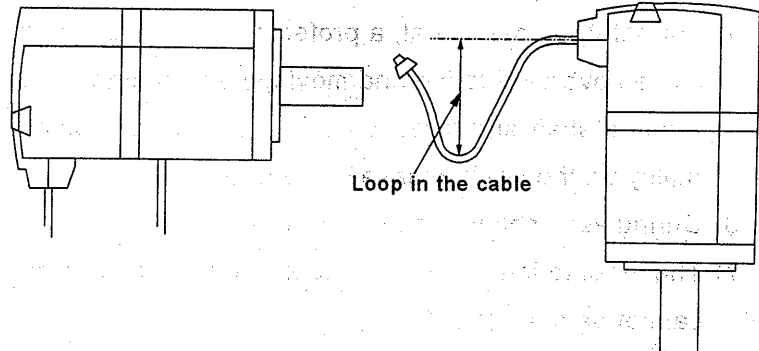
4) Do not allow cables to touch oil or water. (Figure on the right)

Cover

Servo motor

Oil/water
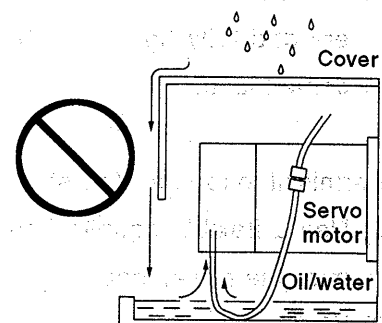
<Incorrect> Capillary action

5) When the servo motor is to be installed with the shaft up prevent oil from entering the servo motor from the gear box, etc.

Gear *Lubricating oil*
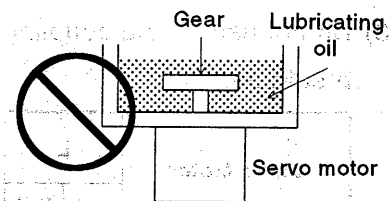
Servo motor

(6) Installation orientation

The servo motor may be installed in any orientation. When the servo motor with electromagnetic brake is installed with the shaft up, the brake plate may generate sliding sound. The servo motor with reduction gear may also be installed in any orientation.

(7) Cable stress

    1) The methed of clamping the cable must be fully examined so that flexing stress and cable's own weight stress are not applied to the cable connection.

    2) In any application where the servo motor moves, the cables should be free from excessive stress. When the servo motor moves, e.g. the encoder cable and motor cables are contained in cable bearers, run the cables so that their flexing portions fall within the optional encoder cable range and fix the encoder cable and power cable of the servo motor.

    3) Avoid any probability that the cable sheath might be cut by sharp objects, rubbed by a machine corner or walked on by workers or vehicles.

    4) The flexing life of the MR-CCBL□M-H encoder cable is shown below. It is 5000 times at the flexing radius of 10mm. In actuality, provide a little allowance for these values. For installation on a machine where the servo motor will move, the flexing radius should be as large as possible.
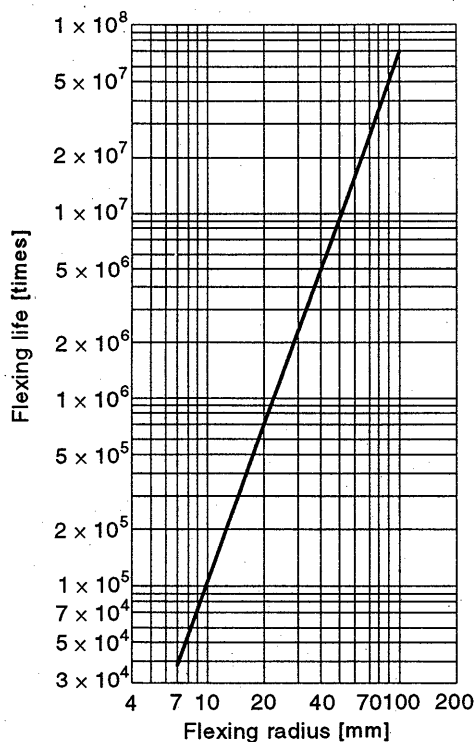
Note: This graph gives calculated values.

Flexing Life of MR-CCBL □ M-H Encoder Cable

CHAPTER 5
ADJUSTMENTS AND APPLICATION OPERATIONS

This chapter presents a servo gain adjustment procedure and expansion functions available by parameter setting.

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5. ADJUSTMENTS AND APPLICATION OPERATIONS

5 – 1 Adjustments

5 – 1 – 1 Auto tuning

In general machines, gains are automatically adjusted by auto tuning. As auto tuning has been made valid by parameter setting before shipment, the optimum gains for the machine are automatically achieved by merely operating the servo motor. Therefore, special operation or setting is not needed.

If you are not satisfied with machine motions at the time of operation, however, change and adjust the response setting (parameter No. 1) of auto tuning in the following procedure.

Actual Machine Motion	Ideal Machine Motion	Setting Method for Parameter No. 1
Stop setting time is long (Note 1)	Reduce stop setting time.	Increase the set value of response setting.
Overshoot is large at a stop.	Reduce overshoot.	Set the machine selection value to "1".
Overshoot is small at a stop but setting time is long. (Note 2)	Shorten the setting time.	Set the machine selection value to "2".
Overshoot is large at a stop and setting time is long, too. (Note 2)	Reduce overshoot and shorten the setting time.	Set the machine selection value to "3".
Gear noise is generated from the machine.	Reduce gear noise.	Decrease the set value of response setting.

Note 1: Stop setting time indicates a period of time from when the command pulse value is zeroed to when the servo motor comes to a stop.

2: Can be adjusted in software version A3 or later.

5 – 1 – 2 Manual gain setting

In most machines, gains can be adjusted automatically by performing auto tuning. In the following cases, however, the gains should be adjusted manually.

Manual Gain Adjustment Is Required When		Phenomenon	Adjustment Procedure
1)	The machine vibrates at a low-range resonance frequency.	The servo motor shaft vibrates at a high frequency (10Hz or more)	
		a. When the machine generates noise and vibrates, you can not ignore the motion of the servo motor shaft.	Adjustment 1
		b. When the response setting is increased by auto tuning, vibration increases.	Adjustment 2
2)	On a machine whose ratio of load inertia to motor inertia is 20 or more times, the servo motor vibrates.	The servo motor shaft vibrates at a low frequency (5Hz or less).	Adjustment 3
		a. When vibration occurs, you can ignore the lateral vibration of the servo motor shaft.	
		b. The ratio of load inertia to motor inertia is extremely large.	
3)	The stop setting time made available by auto tuning should be further decreased.		Adjustment 4
4)	The position control gain of each axis should be set to the same for interpolation operation with two or more axes.		Adjustment 5

5. ADJUSTMENTS AND APPLICATION OPERATIONS

The following parameters are used for manual gain adjustment. Note that 00D should be set in parameter No. 12 (parameter write disable) to make application parameter write-enabled.

Parameter No.	Name
No. 1	Auto tuning
No. 23	Ratio of load inertia to motor inertia
No. 24	Machine resonance suppression filter
No. 25	Position control gain 1
No. 26	Position control gain 2
No. 27	Speed control gain 1
No. 28	Speed control gain 2
No. 29	Speed integral compensation

Adjustment 1

Step	Operation	Description
1	Set 001 in parameter No. 1.	Auto tuning is selected. Response setting is set to slow response.
2	Set 001 in parameter No. 24.	Machine resonance frequency: 1125Hz
3	Switch servo on and perform operation several times.	Auto tuning is performed. Check to see if vibration reduced.
4	Increase the setting of parameter No. 24 sequentially and execute step 3.	The optimum value is achieved just before vibration begins to increase.
5	To reduce the stop setting time, increase the response setting of parameter No. 1 sequentially and execute steps 2 to 4.	

Adjustment 2

Step	Operation	Description
1	Set 001 in parameter No. 1.	Auto tuning is selected. Response setting is set to slow response.
2	Set the machine's load inertia to motor inertia in parameter No. 23. (When it is unclear, set an approximate value.)	When this parameter value is set, the following parameter values are set automatically. Each value provides an ideal, hunting-less gain for parameter No. 23 if machine resonance does not occur. • Parameter No. 25 • Parameter No. 26 • Parameter No. 27 • Parameter No. 28 • Parameter No. 29
3	Set 2 □□ in parameter No. 1.	Auto tuning is made invalid to enable manual setting of parameters No. 25 to 28.
4	In parameter No. 28, set a value about 100 smaller than the value set automatically in step 3.	The optimum value is achieved just before vibration begins to increase.
5	Execute steps 2 to 4 of Adjustment 1.	
6	When machine response does not occur any more, confirm the operating status, and at the same time, gradually return the setting of parameter No. 28 reduced in step 4.	Set a value which is about 50 to 100 smaller than the set value at which gear noise and vibration begins to be generated by machine resonance.
7	To reduce the stop setting time, increase the response setting of parameter No. 1 sequentially and execute steps 1 to 6.	

5. ADJUSTMENTS AND APPLICATION OPERATIONS

Adjustment 3

Step	Operation	Description
1	Set 001 in parameter No. 1.	Auto tuning is selected. Response setting is set to slow response.
2	Set the machine's load inertia to motor inertia in parameter No. 23. (When it is unclear, set an approximate value.)	When this parameter value is set, the following parameter values are set automatically. Each value provides an ideal, hunting-less gain for parameter No. 23 if machine resonance does not occur. • Parameter No. 25 • Parameter No. 26 • Parameter No. 27 • Parameter No. 28 • Parameter No. 29
3	Switch servo on and perform operation several times.	Auto tuning is performed.
4	If vibration still persists, re-set the parameter No. 23 value and execute steps 2 and 3.	
5	If vibration occurs due to machine resonance, make adjustment in the procedure of Adjustment 1 or 2.	

Adjustment 4

Step	Operation	Description
1	Set 001 in parameter No. 1.	Auto tuning is selected. Response setting is set to slow response.
2	Switch servo on and perform operation several times.	Auto tuning is performed. Check to see if vibration reduced.
3	Make gain adjustment in either of the following methods 1) and 2).	Temporary adjustment
	1) Set the machine's load inertia to motor inertia in parameter No. 23. (When it is unclear, set an approximate value.)	When this parameter value is set, the following parameter values are set automatically. Each value provides an ideal, hunting-less gain for parameter No. 23 if machine resonance does not occur. • Parameter No. 25 • Parameter No. 26 • Parameter No. 27 • Parameter No. 28 • Parameter No. 29
	2) Switch servo on and perform operation several times.	Auto tuning is performed.
4	Set 2 □□ in parameter No. 1.	Auto tuning is made invalid to enable manual setting of parameters No. 25 to 28.
5	While confirming the operating status, adjust the following parameters:	The optimum value is achieved just before vibration begins to increase.
	• Parameter No. 25 • Parameter No. 26	Increase the setting to reduce the stop setting time. Note that overshoot is more likely to occur.
	• Parameter No. 27 • Parameter No. 28	Increase the setting to improve servo response. Note that vibration is more likely to occur.
	• Parameter No. 29	Decrease the setting to keep the speed constant to load disturbance and increase holding force at a stop (servo rigidity). Note that overshoot is more likely to occur.

5. ADJUSTMENTS AND APPLICATION OPERATIONS

Adjustment 5

Step	Operation	Description
1	Make gain adjustment of all axes in procedures 1 to 4.	Adjust the gain of each axis.
2	Set 1☐☐ or 2☐☐ in parameter No. 1.	1☐☐ "interpolation control" : The values of parameters No. 25 and 27 change in subsequent operation. 2☐☐ "no" : Auto tuning is made invalid to enable manual setting of parameters No. 25 to 29.
3	Set the following parameters for each axis to the minimum value of all interpolation-controlled axes: • Parameter No. 25 • Parameter No. 26	The gains for operation of all axes are set to the same value.

5. ADJUSTMENTS AND APPLICATION OPERATIONS

5 – 2 Application Operations

5 – 2 – 1 Changing the command pulse train input form

(1) Input pulse waveform selection

A position command pulse train can be input in any of three formats (forward/reverse pulse train, sign plus pulse train, A/B phase pulse train) and further positive or negative logic can be selected. On the basis of the following table, set parameter No. 7 according to the pulse train form of the command section.

Command Pulse Train Form			Forward Rotation	Reverse Rotation	Parameter No. 7 Setting
Negative logic	Forward rotation pulse train	PP			Factory setting
	Reverse rotation pulse train	NP			010
	Pulse train + sign	PP			011
		NP	L	H	
	A phase pulse train	PP			012
	B phase pulse train	NP			
Positive logic	Forward rotation pulse train	PP			000
	Reverse rotation pulse train	NP			
	Pulse train + sign	PP			001
		NP	H	L	
	A phase pulse train	PP			002
	B phase pulse train	NP			

Note: ⌐ ¬ indicate the timings at which the command pulses are imported.

5 – 6

5. ADJUSTMENTS AND APPLICATION OPERATIONS

(2) Connections and waveforms

    1) Open collector system

        Connect as shown below:
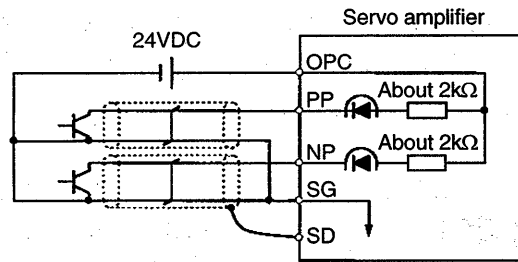
The explanation assumes that the input waveform has been set to the negative logic and forward and reverse rotation pulse trains (parameter No. 7 has been set to 010). The waveforms in the table in (1) of this section are voltage waveforms of PP and NP based on SG. Their relationships with transistor ON/OFF are as follows:
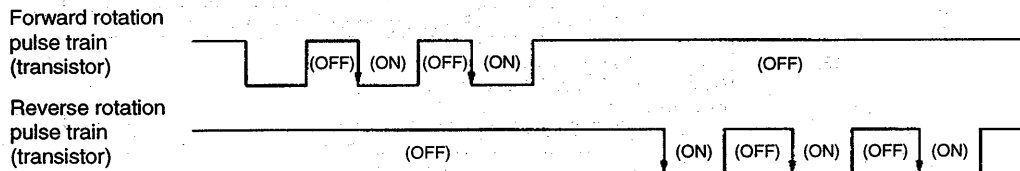
    2) Differential line driver system

        Connect as shown below:
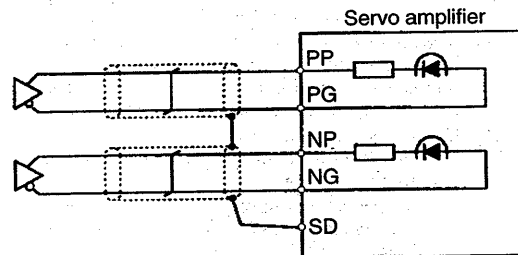
    The explanation assumes that the input waveform has been set to the negative logic and forward and reverse rotation pulse trains (parameter No. 7 has been set to 010). For the differential line driver, the waveforms in the table in (1) of this section are as follows.

    The waveforms of PP, PG, NP and NG are waveforms based on the ground of the differential line driver.
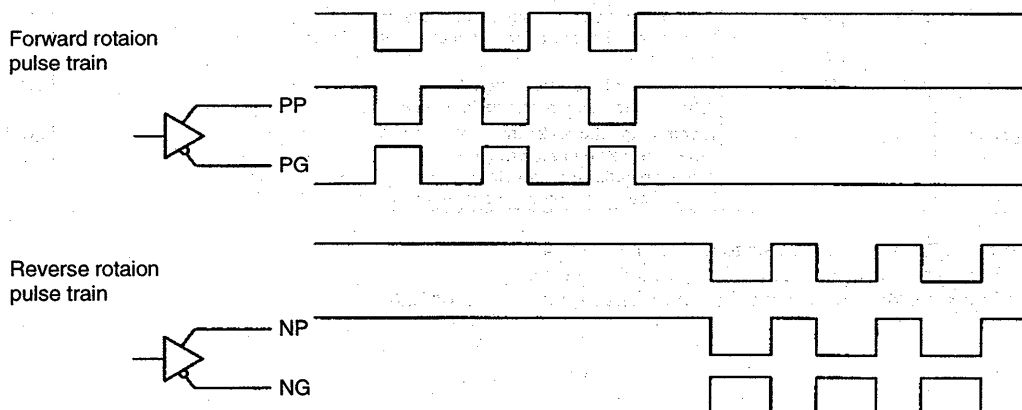
5. ADJUSTMENTS AND APPLICATION OPERATIONS

5 – 2 – 2 Changing the I/O signals

The input signal functions of the CN1 connector's pins 13, 14 and 15 and the output signal functions of pins 3 and 4 can be changed as indicated below. Use parameters No. 20 and 21 to change the functions of the I/O pins.

(1) Functions selectabl

1) I/O signals

<table>
<tr><th colspan="2">Signal Name</th><th>Symbol</th><th>Connector Pin No.</th><th>Functions/Applications</th><th>I/O Division (Note 1)</th><th>Control Mode (Note 2)</th></tr>
<tr><td rowspan="14">Input signals</td><td>Forward rotation start</td><td>ST1</td><td>(13, 14, 15)</td><td>Start signal input terminals.</td><td>DI-1</td><td>S</td></tr>
<tr><td>Reverse rotation start</td><td>ST1</td><td>(13, 14, 15)</td><td>In the speed control mode, connect ST1-SG to rotate the servo motor in the CCW direction, or connect ST2-SG to rotate it in the CW direction.
Disconnect both ST1 and ST2 from SG to bring the servo motor to a stop.
The servo motor will not rotate if the servo is not on.</td><td></td><td>S</td></tr>
<tr><td>Speed selection</td><td>DI1</td><td>(13, 14, 15)</td><td>Speed selection signal input terminal.
In the speed control mode, select the servo motor speed.
<table><tr><th>DI1-SG</th><th>Servo Motor Speed</th></tr><tr><td>Disconnected</td><td>Speed command (1) (parameter No. 17)</td></tr><tr><td>Connected</td><td>Speed command (2) (parameter No. 17)</td></tr></table></td><td>DI-11</td><td>S</td></tr>
<tr><td>Torque limit</td><td>TL</td><td>(13, 14, 15)</td><td>Torque limit selection signal input terminal.
Connect TL-SG to limit the torque according to the torque limit value (parameter No. 9).
<table><tr><th>TL-SG</th><th>Servo Motor Speed</th></tr><tr><td>Disconnected</td><td>Maximum torque</td></tr><tr><td>Connected</td><td>Torque limited by parameter No. 9 setting</td></tr></table>When the function of TL is not selected, the output torque is limited to the value set in parameter No. 9.</td><td>DI-1</td><td>P, S</td></tr>
<tr><td>Proportional control</td><td>PC</td><td>(13, 14, 15)</td><td>Proportional control selection signal input terminal.
Connect PC-SG to switch from the proportional integral type to the proportional type. Connect PC-SG when it is desired to suppress slight vibration during servo lock, for</td><td>DI-1</td><td>P, S</td></tr>
<tr><td>Reset</td><td>RES</td><td>(13, 14, 15)</td><td>Reset signal input terminal.
Connect RES-SG for more than 50ms to reset the alarm. The following alarms cannot be reset:
• Memory alarm 1 (A12)   • Encoder alarm 1 (A20)
• Memory alarm 2 (A15)   • Parameter alarm (A37)
• Board alarm 1 (A17)
Also, the regenerative alarm (A30) and overload (A50) cannot be reset until the regenerative brake resistor and power transistor are cooled, respectively.</td><td>DI-1</td><td>P, S</td></tr>
<tr><td rowspan="6">Output signals (Note 3)</td><td>Up-to-speed</td><td>PF</td><td>(3, 4)</td><td>Up-to-speed signal output terminal.
When the servo motor speed has nearly reached the preset speed, PF-SG are connected. They are kept connected when the preset speed is 50r/min or less. (Refer to 2) a. in this section.)</td><td>DO-1</td><td>S</td></tr>
<tr><td>Encoder Z-phase pulse</td><td>OP</td><td>3 (4)</td><td>Described in (2), Section 3 – 1 – 2.
The output pin can be changed to pin 4.</td><td></td><td>P, S</td></tr>
<tr><td>Ready</td><td>RD</td><td>(3, 4)</td><td>Ready signal output terminal.
When the servo is switched on and the servo motor is ready to operate, RD-SG are connected. (Refer to 2) b. in this section.)</td><td>DO-1</td><td>P, S</td></tr>
<tr><td>Zero speed detection</td><td>ZSP</td><td>(3, 4)</td><td>Zero speed detection signal output terminal.
When the servo motor speed is about 50r/min. or less, ZSP-SG are connected.</td><td>DO-1</td><td>P, S</td></tr>
<tr><td>Torque limit in progress</td><td>TLC</td><td>(3, 4)</td><td>Torque limit-in-progress signal output terminal.
When the torque limit range is reached, TLC-SG are connected.</td><td>DO-1</td><td>P, S</td></tr>
<tr><td>Electromagnetic brake interlock</td><td>BRK</td><td>(3, 4)</td><td>Electromagnetic brake interlock signal output terminal.
When the servo is switched off or an alarm occurs, BRK-SG are disconnected. When an alarm occurs, BRK-SG are disconnected independently of the base circuit state. (Refer to 2) c. in this section.)</td><td>DO-1</td><td>P, S</td></tr>
</table>

Note: 1. For the I/O interfaces, refer to Section 3 – 1 – 4.
     2. P: Position control mode, S: Speed control mode
     3. Available for the servo amplifier of software version A2 or later

5. ADJUSTMENTS AND APPLICATION OPERATIONS

2) Detailed description

a. Up-to-speed

Speed selection (DI1)	ON / OFF
Preset speed	Speed setting (1) / Speed setting (2)
Start (ST1, ST2)	ON / OFF
Servo motor speed	
Up-to-speed (PF)	ON / OFF

b. Ready

Servo-on (SON)	ON / OFF
Alarm	Yes / No
	25ms or less, 10ms or less, 10ms or less
Ready (RD)	ON / OFF

c. Electromagnetic brake interlock

Servo-on (SON)	ON / OFF
	100ms or less
Ready (RD)	ON / OFF
Alarm	Yes / No, 100ms or less
Electromagnetic brake interlock (BRK)	ON / OFF

Servo amplifier

Vt

BRK

SG

RA2

RA   EMG   B1

B2

Servo motor

Connection diagram

5 – 9
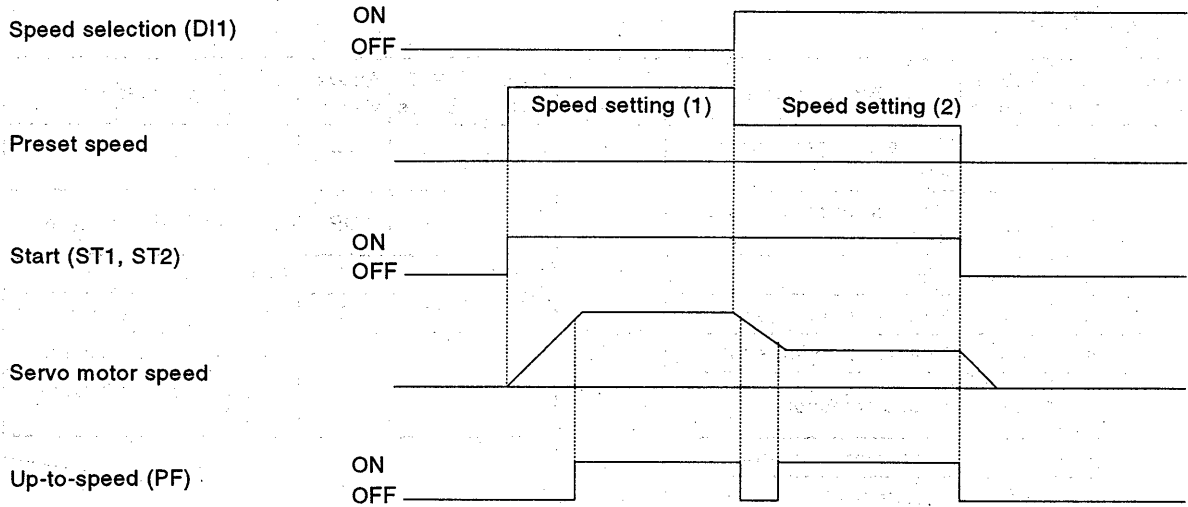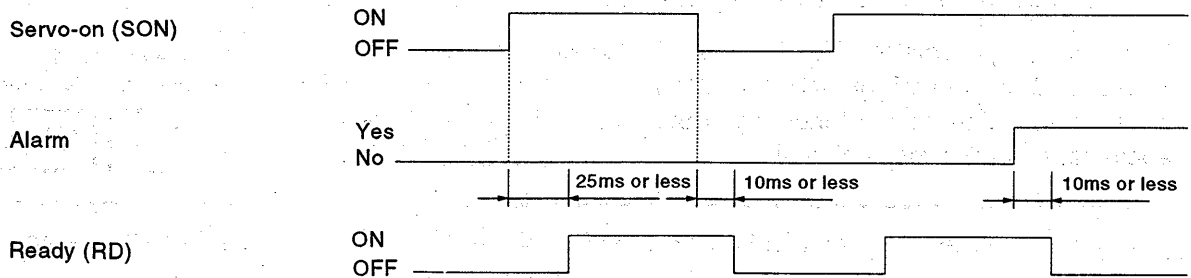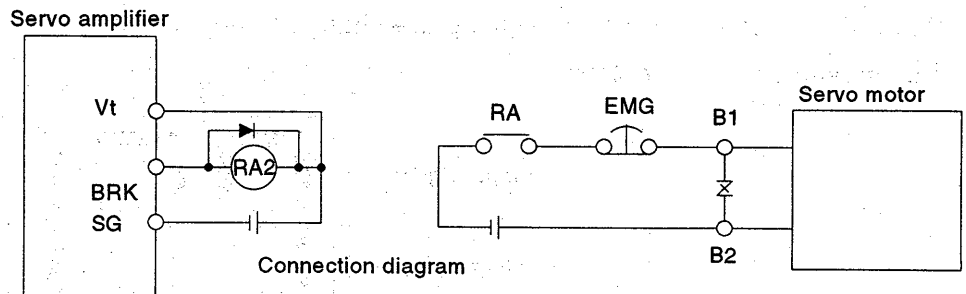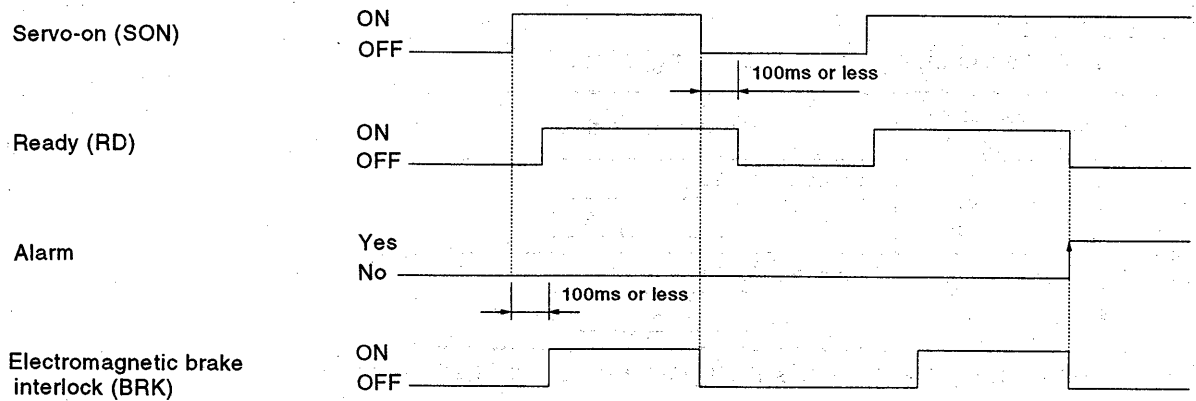
5. ADJUSTMENTS AND APPLICATION OPERATIONS

(2) To make the functions valid

Set the corresponding parameters. Three input signals (pins 13, 14, 15 of CN1) and two output signals (pins 3, 4 of CN1) can be selected as listed below. Use the parameters to select the required functions.

Parameter	Set Value	Abbreviation	Signal Name	CN1 Pin No.	Parameter	Set Value	Abbreviation	Signal Name	CN1 Pin No.
No. 20	0	LSP	Forward rotation stroke end	13, 14, 15	(Note) No. 21	0	PF	Up-to-speed	3, 4
	1	LSN	Reverse rotation stroke end			1	OP	Encoder Z-phase pulse	
	2	CR	Clear			2	RD	Ready	
	3	ST1	Forward rotation start			3	ZSP	Zero speed detection	
	4	ST2	Reverse rotation start			4	TLC	Torque limit in progress	
	5	DI1	Speed selection			5	BRK	Electromagnetic brake interlock	
	6	PC	Proportional control						
	7	TL	Torque limit						
	8	RES	Reset						

Note: Available for the servo amplifier of software version A2 or later.

The digits of parameters No. 20 and 21 correspond to the pins of CN1 as shown on the right. Allocate the functions in the above table for the respective pins.

Parameter No. 20
(Input signal function selection)

| Pin 13 | Pin 14 | Pin 15 |
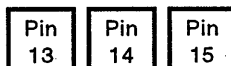
Parameter No. 21
(Output signal function selection)
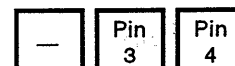
| — | Pin 3 | Pin 4 |

| **MEMO-RANDUM** | When LSP and LSN are not selected, set ☐ 1 ☐ in parameter No. 6 to automatically switch these signals on internally. Operation cannot be performed. |

Setting example

To select the I/O signals in the following table:

Pin No.	Abbreviation	Parameter Setting
13 14 15	TL RES CR	Parameter No. 20 `7 8 2`
3 4	TLC BRK	Parameter No. 21 `0 4 5`

After setting the parameters, switch power off once, then on again.

(3) External I/O signal display and output signal forced-output

When the functions of the I/O signals are changed, they correspond to the segments on the display screen as shown below:

Input signals

Output signals

TL ST2 PC LSN ST1 LSP CR RES

SON
DI1   Lit: ON
       Extinguished: OFF
Pin 3

Pin 4   ALM
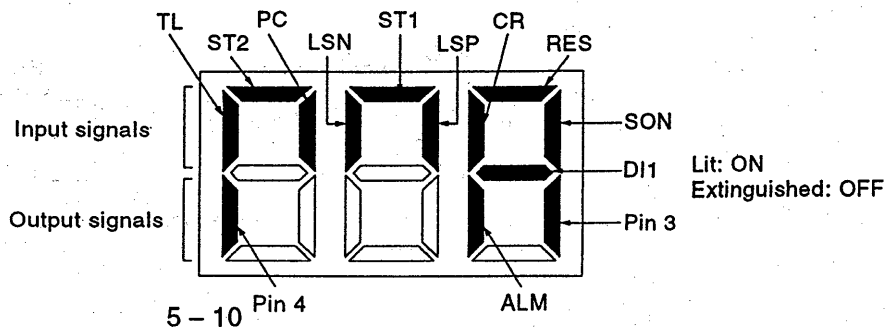
5. ADJUSTMENTS AND APPLICATION OPERATIONS

5 – 2 – 3 Speed control mode

The servo motor can be rotated at constant speed without the pulse train signal being input. To enter the speed control mode, change the settings of the following parameters. Note that 00C should be set in parameter No. 12 (parameter write disable) to make application parameter write-enabled.

Parameter	Name	Set Value	Description
No. 6	Input signal selection 1	□1□	LSP and LSN are automatically switched on internally.
No. 16	Position/speed control mode selection	101	Select the speed control mode.
No. 17	Speed command (1)	—	Set the servo motor speed.
No. 18	Speed command (2)	—	
No. 19	Speed acceleration/deceleration time constant	—	Set the acceleration/deceleration time constant
No. 20	Input signal function selection	345	Make ST1, ST2 and DI1 valid.
(Note) No. 21	Output signal function selection	003	Make PF and ZSP valid.

Note: Available for the servo amplifier of software version A2 or later.

MEMO-RANDUM	To use the equipment in the speed control mode, set the torque limit value (parameter No. 9) to 75 or less or the acceleration/deceleration time constant (parameter No. 19) to 50ms or more so that the output torque of the servo motor is not clamped at the maximum torque.

Timing chart
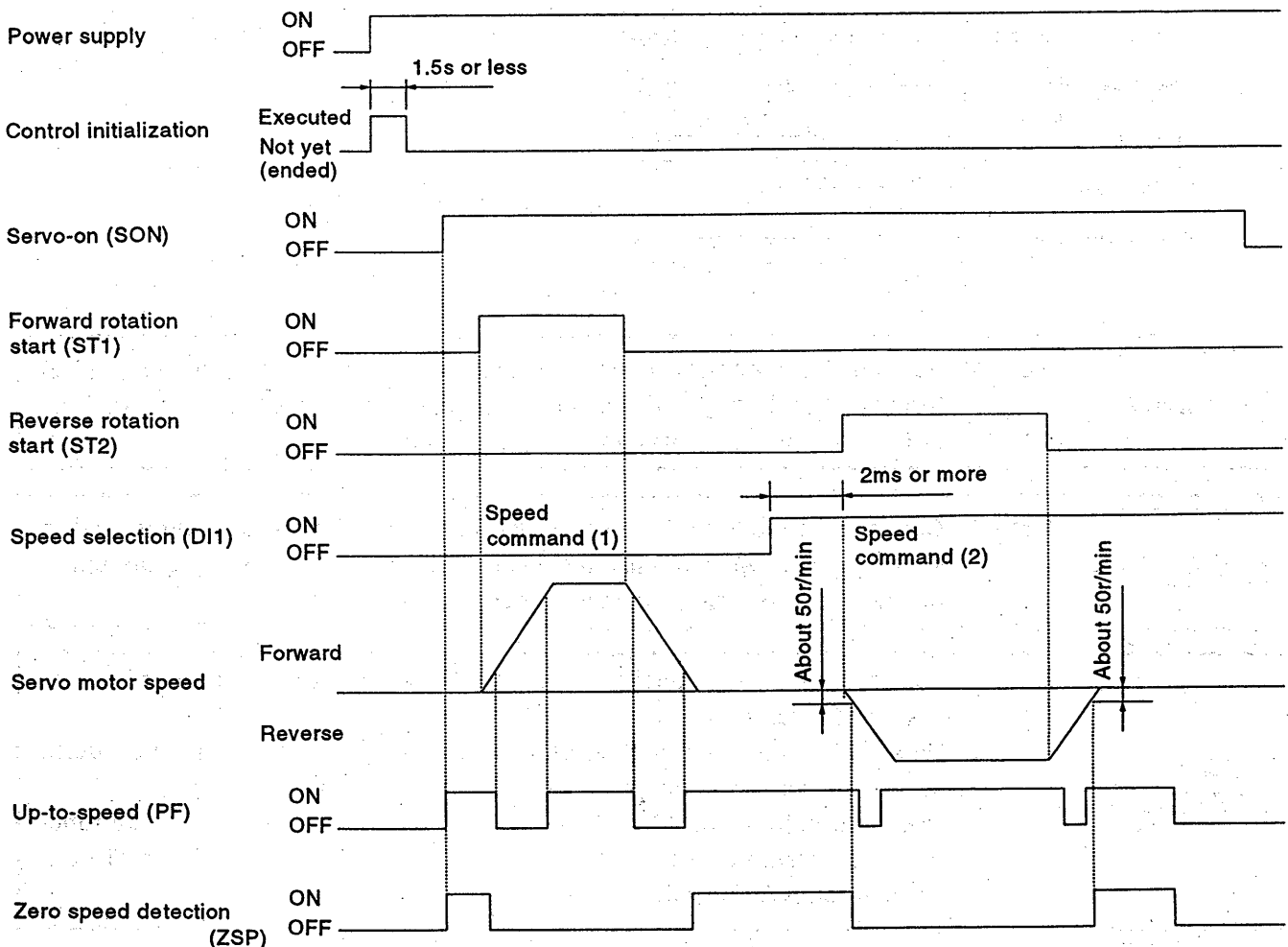
Connection example

⚠ **CAUTION** Always follow the instructions in Chapter 3.
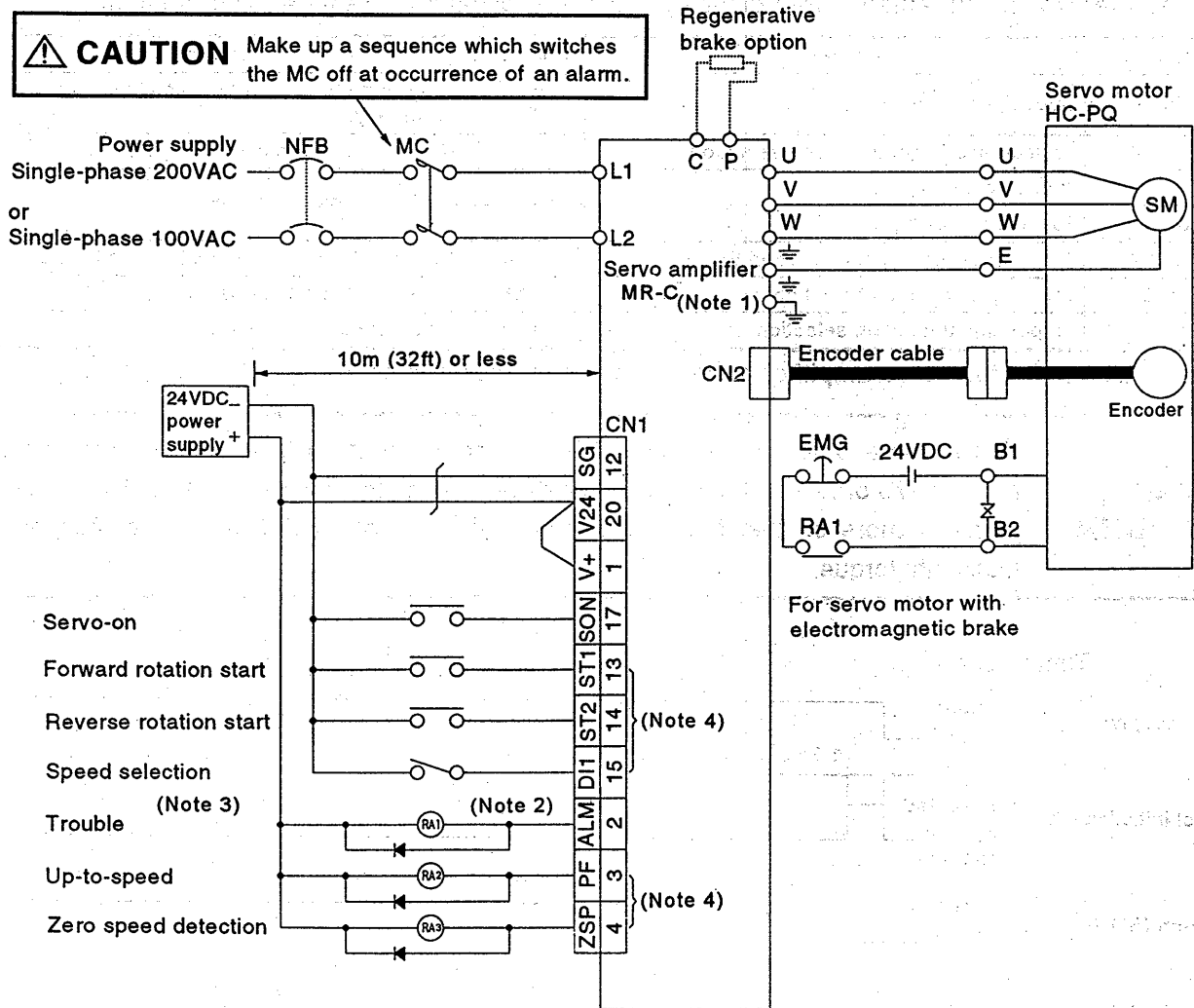
⚠ **CAUTION** Make up a sequence which switches the MC off at occurrence of an alarm.

⚠ **WARNING** Note 1. For the EN Standard model, always connect the protective earth (PE) terminal (marked ⊕) of the servo amplifier to the protective earth (PE) of the control box to prevent an electric shock.

⚠ **CAUTION** Note 2. Connect the diode in the correct direction. If it is connected reversely, the servo amplifier will be faulty and will not output signals, disabling the emergency stop and other protective circuits.

MEMO-RANDUM Note 3. The trouble (ALM) signal is in conduction when there is no alarm, i.e. in the normal state. When this signal is switched off (at occurrence of an alarm), the output of the controller should be stopped by the sequence program.
4. Use parameters No. 20 and 21 to set these signals. Note that the functions of parameter No. 21 are available for the servo amplifiers of software version A2 or later.

5. ADJUSTMENTS AND APPLICATION OPERATIONS

5 – 2 – 4 Torque limit

The maximum torque of the servo motor can be limited by setting parameter No. 9.

(1) To keep the maximum torque limited

Set the limit value in parameter No. 9 (torque limit value). The relationship between the parameter setting and approximate torque is shown on the right.
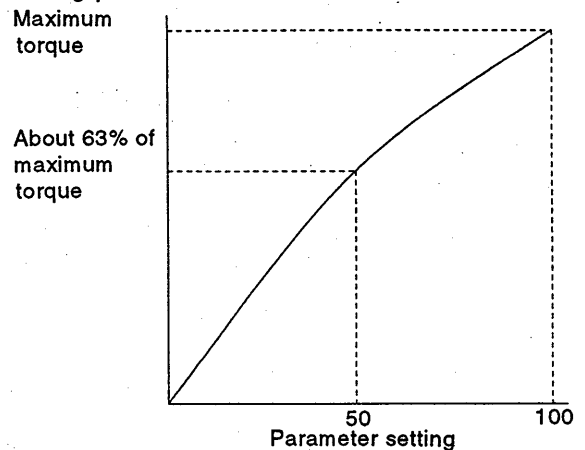
(2) Use the torque limit (TL) signal

When the torque limit (TL) signal is used, the torque limit function is activated or deactivated by switching TL on or off. Use parameter No. 20 to make TL valid.

TL-SG	Maximum Torque of Servo Motor
Disconnected	Maximum torque
Connected	Torque limited by the setting of parameter No. 9

5 – 2 – 5 Slight vibration suppression control

The slight vibration suppression control mode is used to reduce servo-specific ±1 pulse vibration at the time of a stop. This mode produces an effect especially when the ratio of load inertia to motor inertia is small (2 to 5 times). Note that when vibration is attributable to looseness (such as gear backlash) or machine resonance, use the machine resonance suppression filter (parameter No. 24). The slight vibration suppression control mode should be used after real-time auto tuning or manual gain adjustment.

Usage

First, perform real-time auto tuning or manual gain adjustment so that vibration falls within ±2 to 3 pulses.
Set 001 in parameter No. 31 to enter the slight vibration suppression control mode at the time of a stop.

Parameter No. 31

0	0	1

└──── Slight vibration suppression control execution
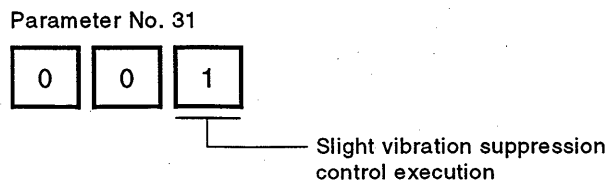
5 – 2 – 6 Low acoustic noise mode

By choosing the low acoustic noise mode in parameter No. 0, the electromagnetic noise of audible frequency generated by the servo motor can be suppressed by about 20dB.

Parameter No.0

└──→ Low acoustic noise mode selection
0: non-low acoustic noise
1: low acoustic noise
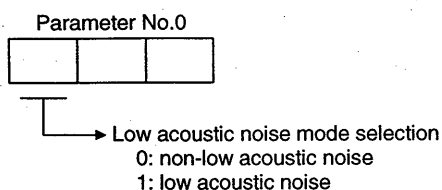
CHAPTER 6
OPTIONS AND AUXILIARY EQUIPMENT

This chapter describes how to use various options and auxiliary equipment.

6 – 1 Dedicated Options

     6 – 1 – 1 Regenerative brake options

     6 – 1 – 2 Cable connectors

     6 – 1 – 3 Junction terminal block

     6 – 1 – 4 Setup software

     6 – 1 – 5 RS-232C option unit (MR-C-T01)

     6 – 1 – 6 DIN rail option

6 – 2 Auxiliary Equipment

     6 – 2 – 1 Electric wires

     6 – 2 – 2 No-fuse breakers · fuses · magnetic contactors

     6 – 2 – 3 Power factor improving reactors

     6 – 2 – 4 Relays

     6 – 2 – 5 Surge absorbers

     6 – 2 – 6 Noise reduction techniques

     6 – 2 – 7 Leakage current breaker

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MAINTENANCE AND INSPECTION	CHAPTER 7
TROUBLESHOOTING	CHAPTER 8
CHARACTERISTICS	CHAPTER 9
SPECIFICATIONS	CHAPTER 10
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OPTIONAL PRODUCTS	CHAPTER 12

CHAPTER 10
SPECIFICATIONS

This chapter gives the specifications of the servo.

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10. SPECIFICATIONS

10 – 1 Standard Specifications

These specifications also apply to the EN and UL/C-UL Standard-compliant models.

(1) Servo amplifier

Item	Servo amplifier	MR-C10A	MR-C20A	MR-C40A	MR-C10A1	MR-C20A1
Power supply (Note 3)	Voltage/frequency	Single-phase 200 to 230VAC 50/60Hz			Single-phase 100 to 120VAC 50/60Hz	
	Permissible voltage fluctuation	Single-phase 170 to 253VAC			Single-phase 85 to 126VAC	
	Permissible frequency fluctuation	Within ±5%				
Control method		Sine-wave PWM control, current controlled system				
Control mode		Pulse train input position control				
Control theory		Model adaptive control				
Auto tuning		Real-time auto tuning				
Protective functions		Overcurrent protection, motor combination fault, overload shut off (electronic thermal relay), overvoltage protection, encoder alarm protection, regenerative alarm protection, undervoltage/ instantaneous power failure protection, overspeed protection, excessive error protection				
Position control specifications	Max. input pulse frequency	200kpps				
	Positioning feedback pulses	4000 pulse/rev servo motor revolution				
	Command pulse multiplication	Electronic gear A, B: 1 to 999 pulses 1/50 < A/B < 20				
	Positioning completion width setting	0 to 999 pulses				
	Excessive error	±50K pulses				
Interface power supply		24VDC or 5VDC power supplied from outside				
Communication with personal computer	Required option	RS-232C option unit (MR-C-T01), communication cable, setup software				
	Functions	Status display, diagnostic display, alarm display, parameter setting, operation waveform monitor				
Structure		Open				
Environment conditions		Refer to Section 4 – 1 (1).				
Weight	[kg]	0.6		1.0	0.6	
	[lb]	1.32		2.20	1.32	

(2) Servo motor

Item	Servo motor	HC-PQ series				
		033	053	13	23	43
Corresponding servo amplifier model		MR-C10A (1)			MR-C20A (1)	MR-C40A
Continuous characteristic (Note 2)	Rated output[W]	30	50	100	200	400
	Rated torque [N·m]	0.095	0.16	0.32	0.64	1.27
	[kgf·cm]	0.97	1.62	3.25	6.5	13.0
	[oz·in]	13.45	22.66	45.32	90.63	184.1
Max. torque (Note 2)	[N·m]	0.38	0.64	1.28	1.92	2.92
	[kgf·cm]	3.88	6.48	13	19.5	29.9
	[oz·in]	53.81	90.63	181.26	271.89	414
Rated speed[r/min]		3000				
Max. speed[r/min]		4500				
Instantaneous permissible speed[r/min]		5400				5175
Power rate at continuous rated torque[kw/s]		6.45	13.47	34.13	46.02	116.55
Moment of inertia (Note 7)	J [kg·cm^2]	0.014	0.019	0.03	0.089	0.145
	GD^2 [kgf·cm^2]	0.057	0.074	0.12	0.35	0.57
	WK^2 [oz·in^2]	0.077	0.104	0.164	0.487	0.793
Recommended load inertia to servo motor shaft inertia		30 or less times (Note 5)				
Rated output current [A]		0.85	0.85	0.85	1.5	2.8
Max. output current [A]		5.0	5.0	5.0	6.0	6.44
Regenerative brake duty [times/min] (Note 4)	Without option	Δ	Δ	(Note 4-1)	(Note 4-2)	(Note 4-3)
	MR-RB013 (10W)	Δ	Δ	4660	1400	800
	MR-RB033 (30w)	Δ	Δ	Δ	4300	2400
Power facility capacity [kVA]		0.1	0.2	0.3	0.5	0.9
Speed/position detector		Encoder (resolution 4000 [Pulse/rev])				
Accessories		Encoder, (serial communication system)				
Structure		Totally enclosed, natural air cooling (protection degree: IP44 (Note 8))				
Environmental condition (Note 1)		Refer to Section 4 – 2 (1)				
Weight (Note 7)	[kg]	0.32	0.37	0.50	0.96	1.42
	[lb]	0.71	0.82	1.1	2.12	3.13

10. SPECIFICATIONS

Note: 1. Special specifications will be required for the servo motor used in a site where it is exposed to oil or rain.

2. The output torque and rated speed are not guaranteed during a power voltage drop.

3. The power facility capacity will differ according to the impedance.

4. The regenerative brake duty is the permissible duty applied when the servo motor under no load is decelerated to a stop from the rated speed. For those marked Δ, there are no limits to the regenerative duty if the effective torque is not more than the rated torque.

   When a load is applied, the value is $1/(m+1)$ of the value in the table. (m = load inertia/motor inertia) If the speed exceeds the rated speed, the permissible number of times is in inverse proportion to the square of (running speed/rated speed). When the running speed frequently varies or when the regeneration state is constantly established as in vertical motion applications, calculate the amount of regenerative heat generated during the operation so that the amount of heat generated will not be larger than the permissible value.

   4-1 When the load inertia is 30 times or less, there is no limit to the regenerative brake duty if the effective torque is not more than the rated torque.

   4-2 When the load inertia is 10 times or less, there is no limit to the regenerative brake duty if the effective torque is not more than the rated torque.

   4-3 When the load inertia is 1 times or less, there is no limit to the regenerative brake duty if the effective torque is not more than the rated torque.

5. Please consult Mitsubishi when the load inertia ratio exceeds the value noted above.

6. For the servo motor with reduction gear, the ratio is 300% of the rated torque on the servo motor shaft.

7. For the servo motors with reduction gear and with electromagnetic brake, refer to the outline drawings.

8. Except the shaft through area and connector.

10. SPECIFICATIONS

10 – 2 Torque Characteristics

NOTICE	When the load is applied during a stop of the servo motor, use the servo motor at 70% of the rated torque.

MEMO-RANDUM	The short-time operation area of the servo motor with reduction gear is as indicated by the broken line.

10 – 2 – 1 Standard

[HC-PQ033]
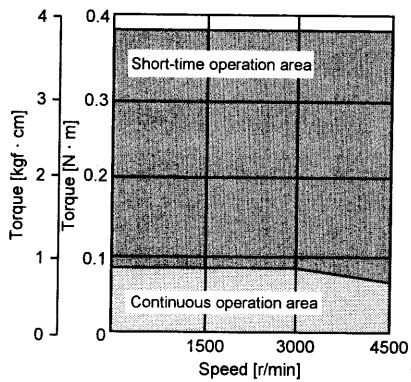
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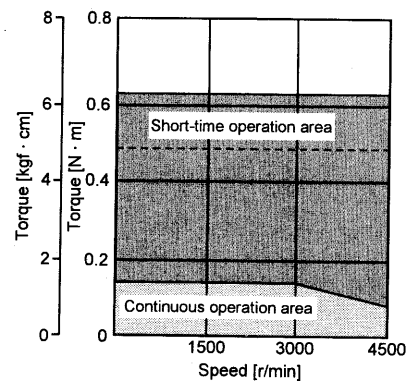
[HC-PQ13]
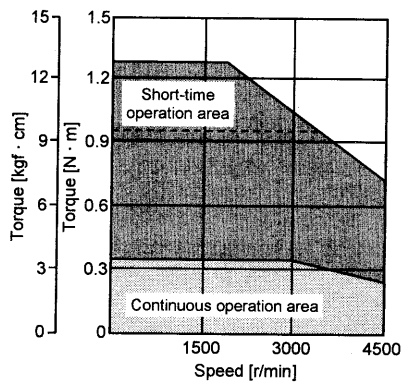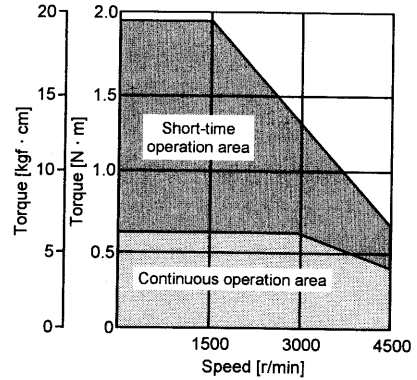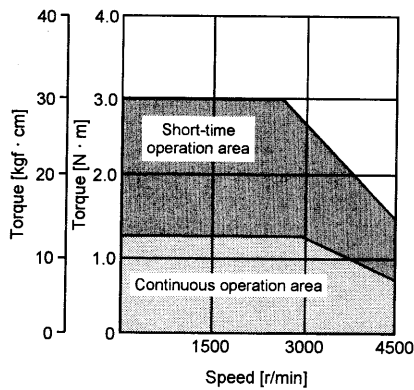
[HC-PQ23]

[HC-PQ43]

10. SPECIFICATIONS

10 – 2 – 2 Low acoustic noise mode (carrier frequency 9.0kHz)

[HC-PQ033]
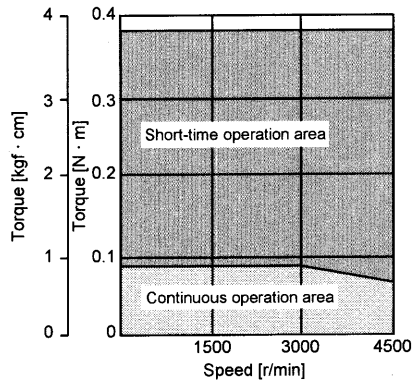
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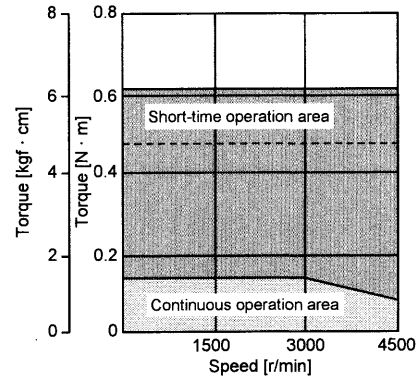
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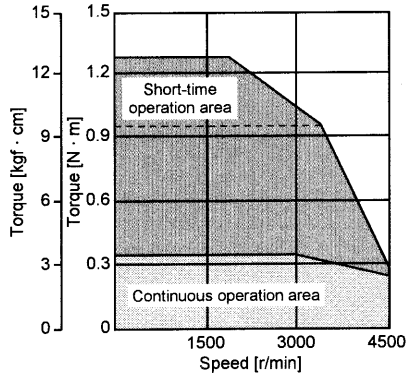
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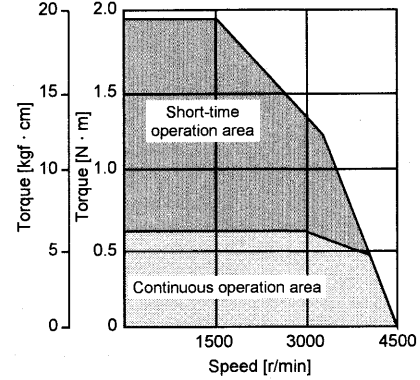
[HC-PQ43]
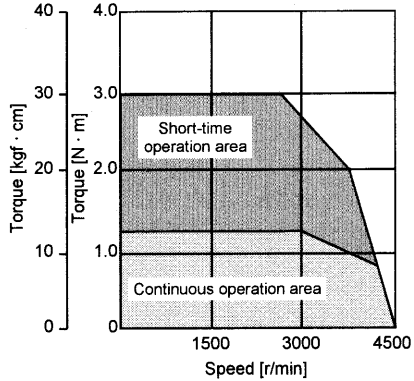
10. SPECIFICATIONS

10 – 3 Outline Drawings

10 – 3 – 1 Servo amplifiers

MR-C10A(1), MR-C20A(1)

[Unit: mm(in)]

φ5 Instalation hole

TE1

MR-C40A

[Unit: mm(in)]

φ6 Installation hole

60 (2.362)

4 (0.16) 40 (1.57)

5 (0.20)

MITSUBISHI

TE1

120 (4.72)

130 (5.12)

MODE MELSERVO
      MR-C□A□
UP
DOWN
SET
CN1
CN2

5 (0.20) 6 (0.236)

5 (0.20)

95 (3.74)   104 (4.09)

5 (0.20)

A ⇨

B ⇧

80 (3.15)
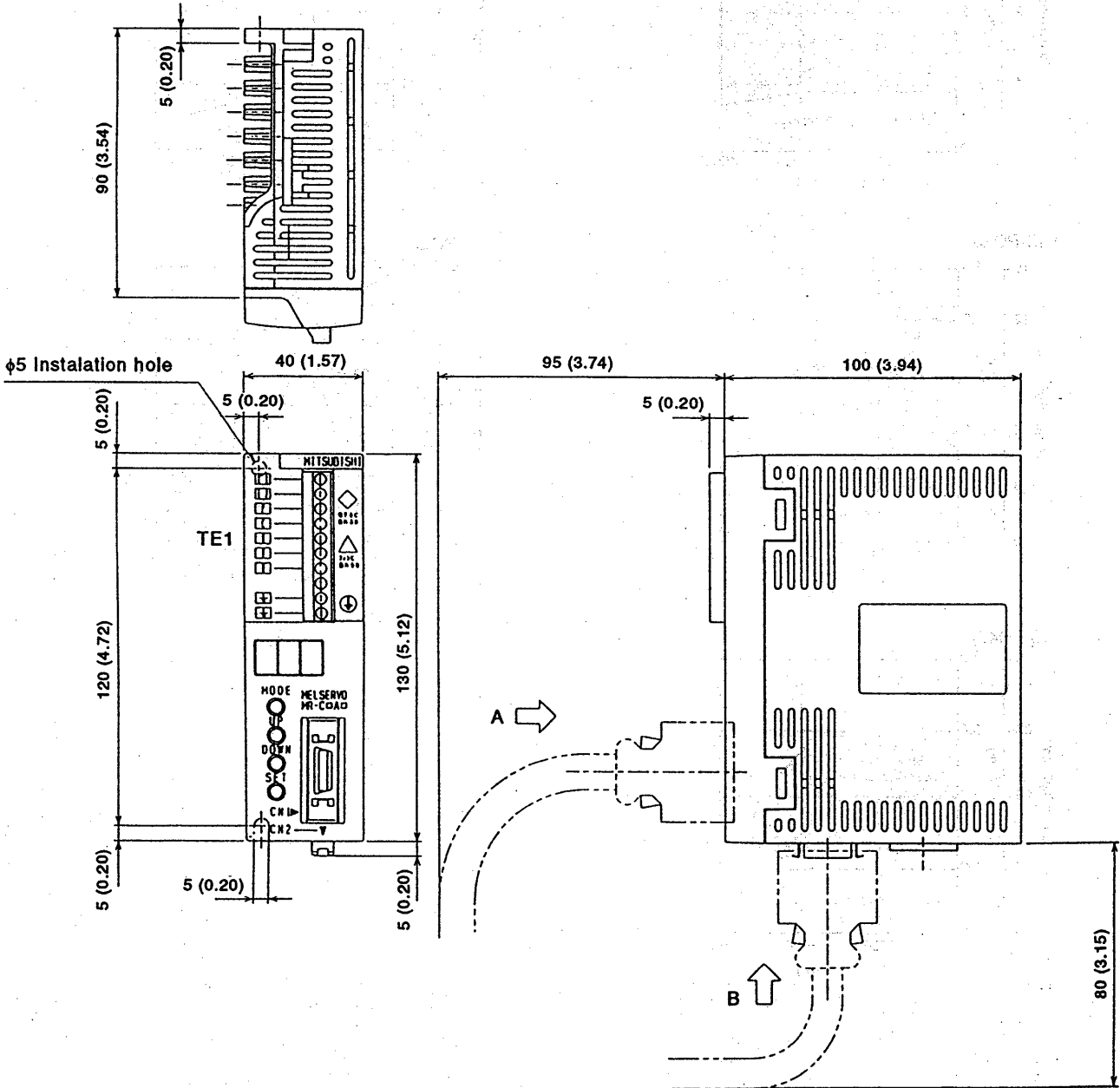
10. SPECIFICATIONS

MR-C10A(1)-UE, MR-C20A(1)-UE

[Unit: mm(in)]
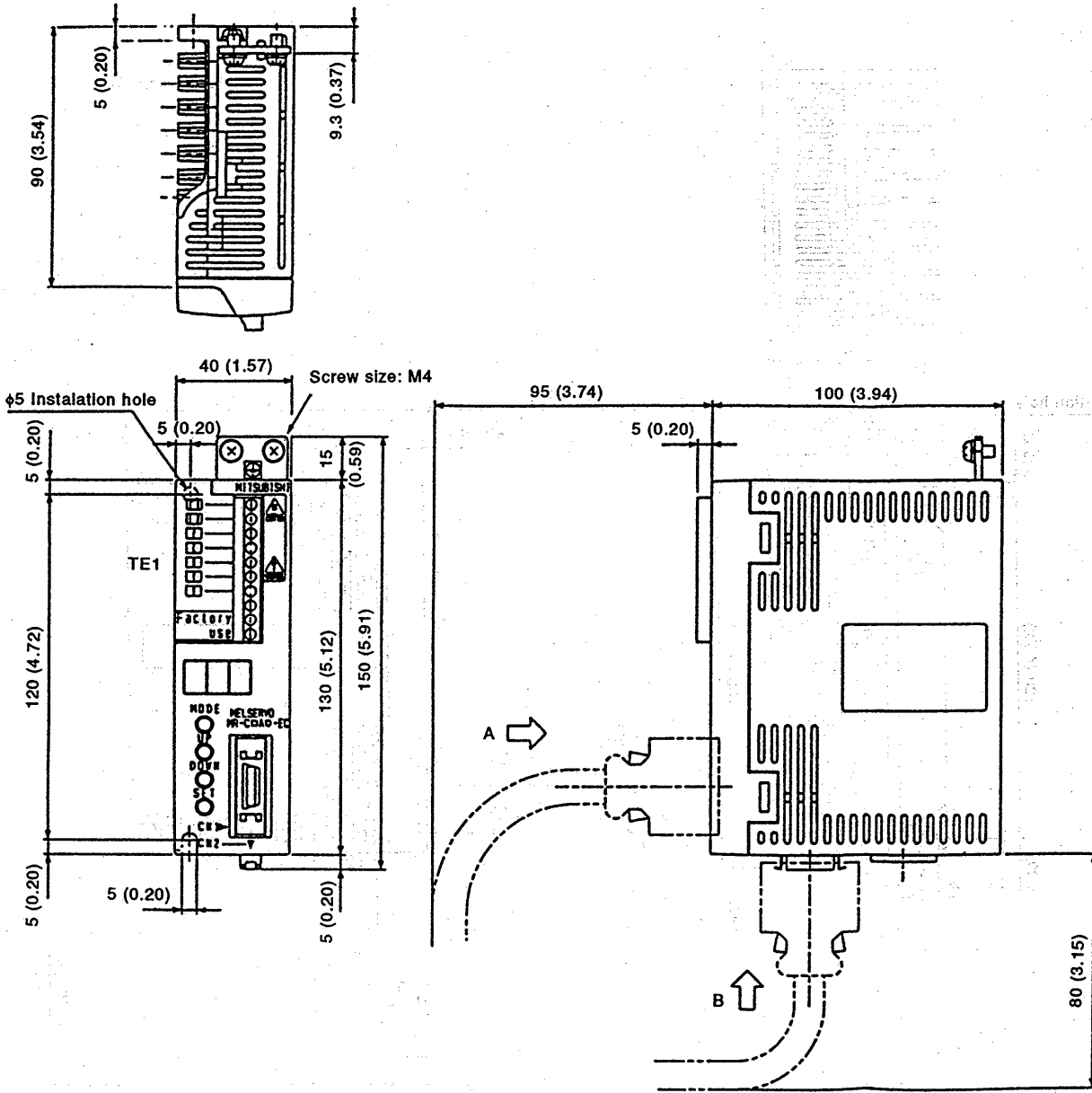
10. SPECIFICATIONS

MR-C40A-UE

[Unit: mm]
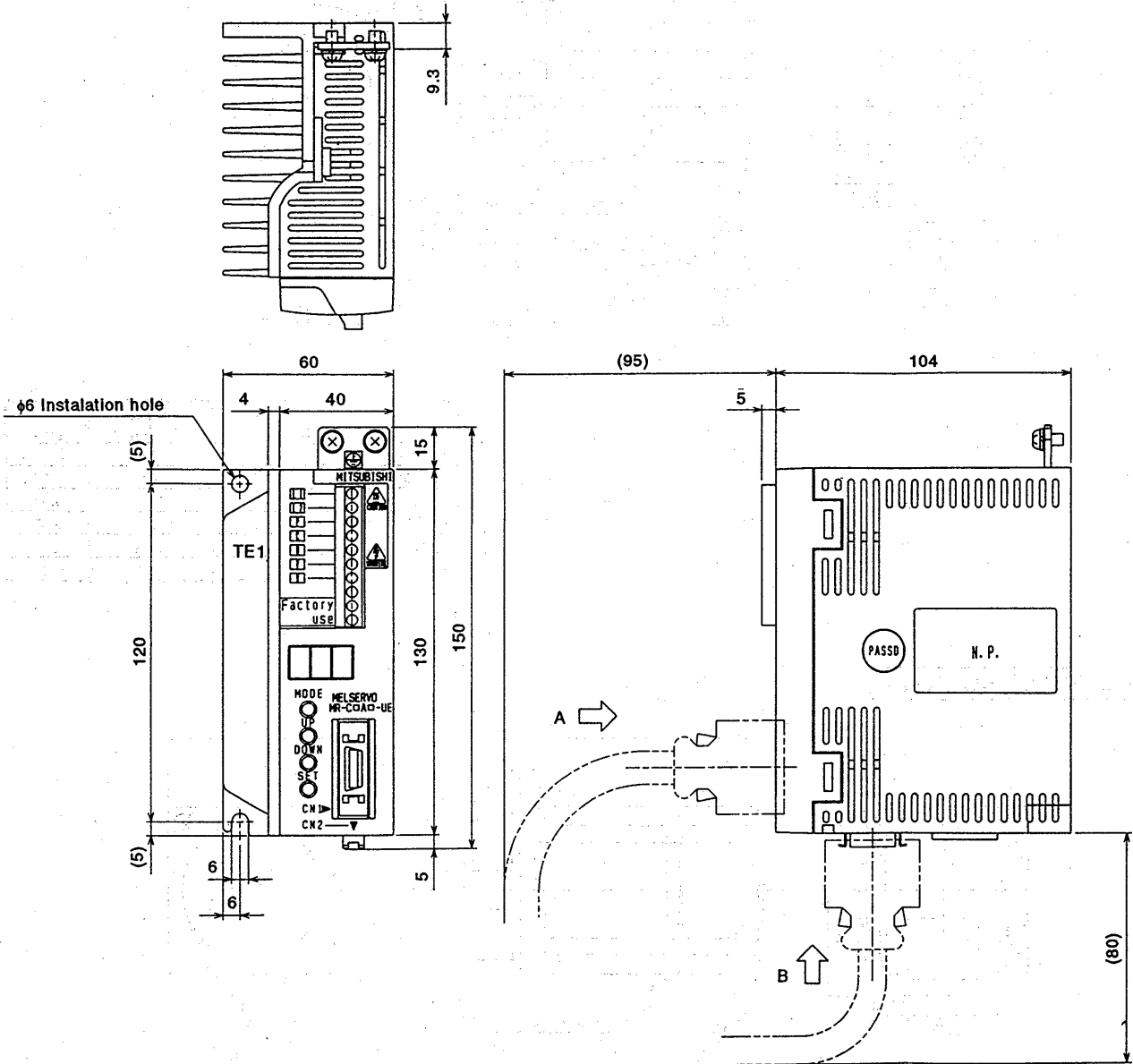
10 – 3 – 2 Servo motors

(1) Standard

HC-PQ033 to HC-PQ13

Encoder cable 0.3m
With connector
172169-9
(AMP make)

Power cable 4–AWG19 0.3m
(With insulation sleeved,
round solderless terminal
1.25–4)
Red   : U phase
White   : V phase
Black   : W phase
Green/   : Earth
yellow spiral
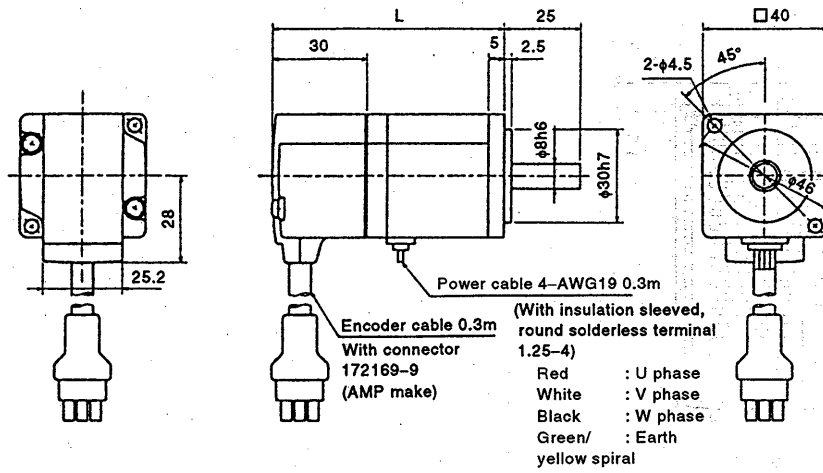
[Unit: mm]

Model	Variable Dimension L	Inertia $J(\times10^{-4}kg \cdot m^2)$	Weight [kg]
HC-PQ033	65.5	0.014	0.32
HC-PQ053	71.5	0.019	0.37
HC-PQ13	86.5	0.03	0.50
HC-PQ033-UE	73.5	0.014	0.35
HC-PQ053-UE	79.5	0.019	0.4
HC-PQ13-UE	94.5	0.03	0.53

HC-PQ23 · HC-PQ43

Encoder cable 0.3m
With connector 172169-9
(AMP make)

Power cable 4–AWG19 0.3m
(With insulation sleeved, round
solderless terminal 1.25–4)
Red   : U phase
White   : V phase
Black   : W phase
Green/   : Earth
yellow spiral
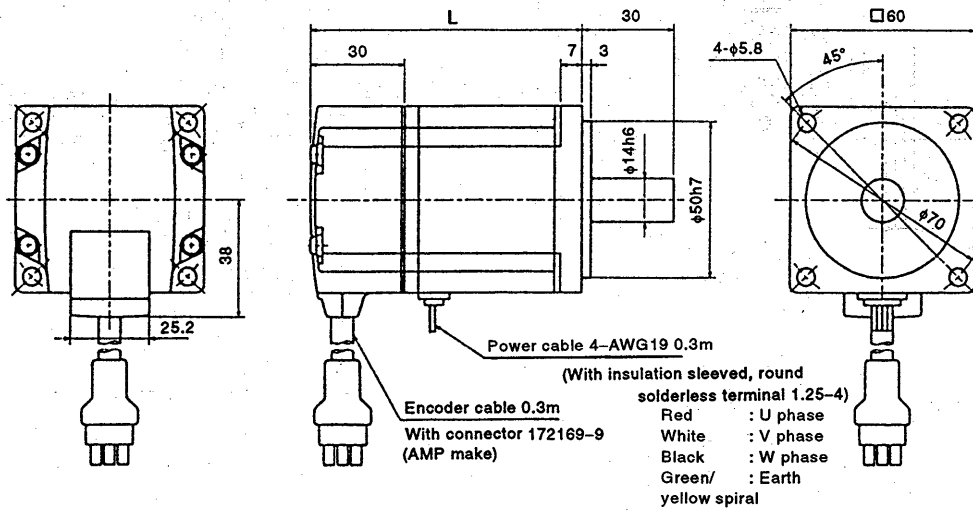
[Unit: mm]

Model	Variable Dimension L	Inertia $J(\times10^{-4}kg \cdot m^2)$	Weight [kg]
HC-PQ23	89	0.088	0.96
HC-PQ43	114	0.143	1.45
HC-PQ23-UE	98	0.088	0.99
HC-PQ43-UE	123	0.143	1.48

10. SPECIFICATIONS
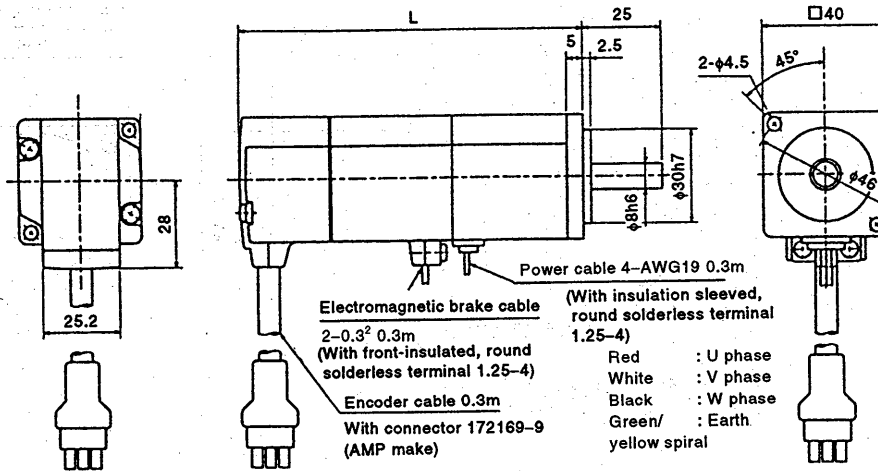
(2) With electromagnetic brake

HC-PQ033B to HC-PQ13B

Power cable 4–AWG19 0.3m
(With insulation sleeved, round solderless terminal 1.25–4)
Red : U phase
White : V phase
Black : W phase
Green/ : Earth
yellow spiral

Electromagnetic brake cable
2–0.3² 0.3m
(With front-insulated, round solderless terminal 1.25–4)

Encoder cable 0.3m
With connector 172169–9
(AMP make)

[Unit: mm]

Model	Variable Dimension L	Brake Static Friction Torque[N·m]	Inertia J(×10⁻⁴kg·m²)	Weight [kg]
HC-PQ033B	93.5	0.32	0.017	0.63
HC-PQ053B	99.5	0.32	0.022	0.69
HC-PQ13B	114.5	0.32	0.032	0.83
HC-PQ033B-UE	101.5	0.32	0.017	0.69
HC-PQ053B-UE	107.5	0.32	0.022	0.72
HC-PQ13B-UE	122.5	0.32	0.032	0.86

HC-PQ23B · HC-PQ43B
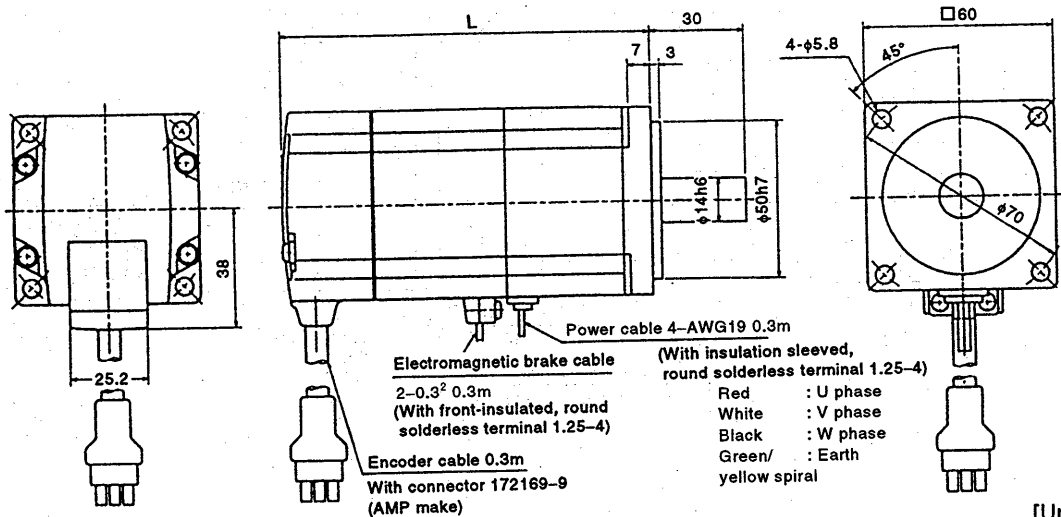
Power cable 4–AWG19 0.3m
(With insulation sleeved, round solderless terminal 1.25–4)
Red : U phase
White : V phase
Black : W phase
Green/ : Earth
yellow spiral

Electromagnetic brake cable
2–0.3² 0.3m
(With front-insulated, round solderless terminal 1.25–4)

Encoder cable 0.3m
With connector 172169–9
(AMP make)

[Unit: mm]

Model	Variable Dimension L	Brake Static Friction Torque[N·m]	Inertia J(×10⁻⁴kg·m²)	Weight [kg]
HC-PQ23B	121	1.3	0.136	1.6
HC-PQ43B	146	1.3	0.191	2.1
HC-PQ23B-UE	130	1.3	0.136	1.63
HC-PQ43B-UE	155	1.3	0.191	2.13

(3) With reduction gear for general industrial machine

HC-PQ053(B)G1

For reverse rotation command
For forward rotation command

Rotation direction
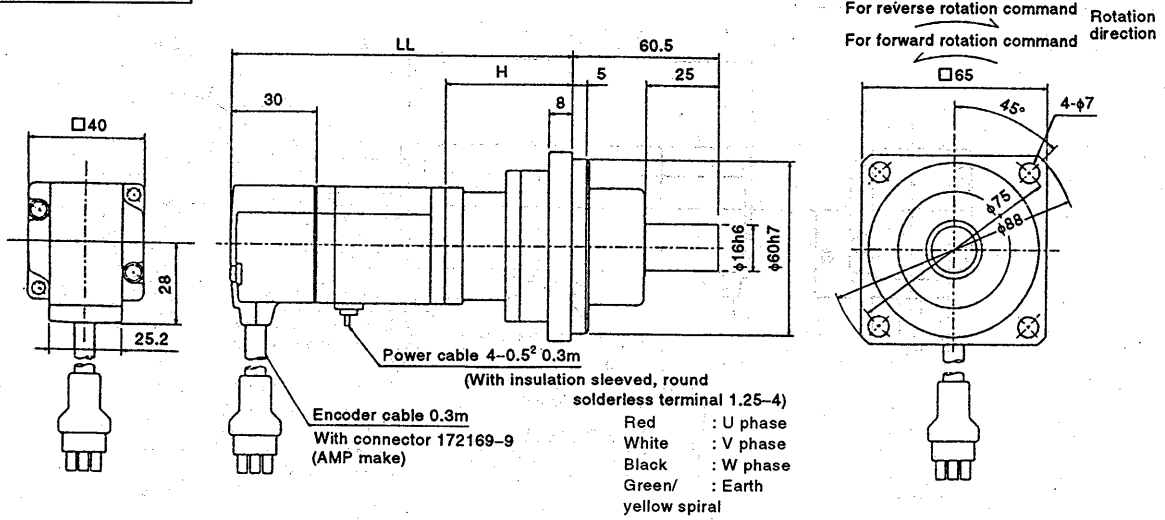
[Unit: mm]

Model	Reduction Ratio (Note 2)	Reduction Gear Model	Inertia J($\times 10^{-4}$kg·m²) (Note 1)	Variable Dimension (Note 1)		Weight [kg] (Note 1)
				LL	H	
HC-PQ053 (B)G1(-UE)	1/5	K6505	0.055 (0.058)	115.5 (143.5)	47.5	1.4 (1.7)
HC-PQ053 (B)G1(-UE)	1/12	K6512	0.077 (0.080)	134 (162)	64.5	1.8 (2.1)
HC-PQ053 (B)G1(-UE)	1/20	K6520	0.059 (0.062)	134 (162)	64.5	1.8 (2.1)

Note: 1. Value in parentheses is for the servo motor with electromagnetic brake.
2. These are nominal reduction ratios. For actual reduction ratios, refer to Section 10-4.
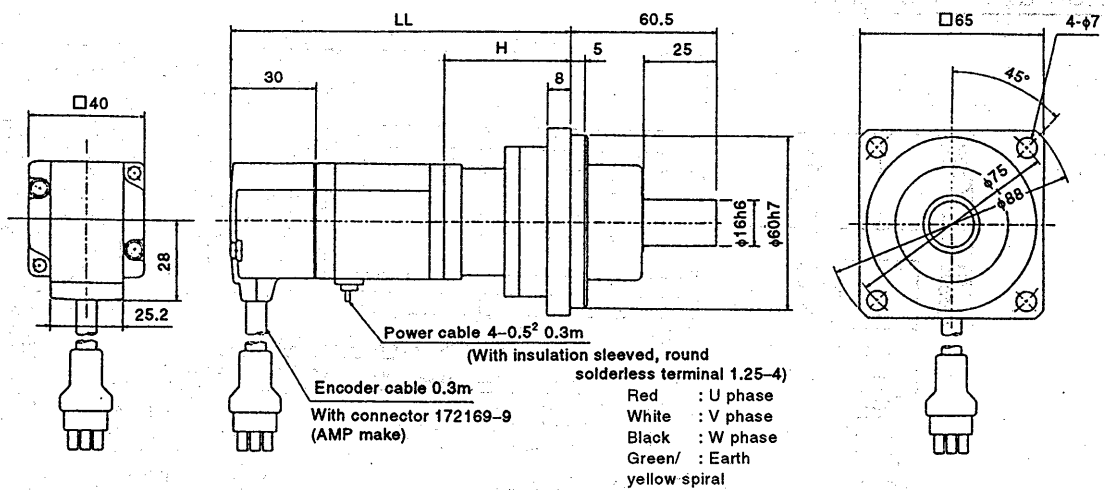
HC-PQ13(B)G1

[Unit: mm]

Model	Reduction Ratio (Note 2)	Reduction Gear Model	Inertia J($\times 10^{-4}$kg·m²) (Note 1)	Variable Dimension (Note 1)		Weight [kg] (Note 1)
				LL	H	
HC-PQ13 (B)G1(-UE)	1/5	K6505	0.066 (0.069)	130.5 (158.5)	47.5	1.5 (1.9)
HC-PQ13 (B)G1(-UE)	1/12	K6512	0.088 (0.091)	149 (177)	64.5	1.9 (2.3)
HC-PQ13 (B)G1(-UE)	1/20	K6520	0.07 (0.073)	149 (177)	64.5	1.9 (2.3)

Note: 1. Value in parentheses is for the servo motor with electromagnetic brake.
2. These are nominal reduction ratios. For actual reduction ratios, refer to Section 10-4.

HC-PQ23(B)G1

For reverse rotation command
For forward rotation command
Rotation direction

Power cable 4–AWG19 0.3m
(With insulation sleeved, round solderless terminal 1.25–4)
Red : U phase
White : V phase
Black : W phase
Green/ : Earth
yellow spiral

Encoder cable 0.3m
With connector 172169-9
(AMP make)
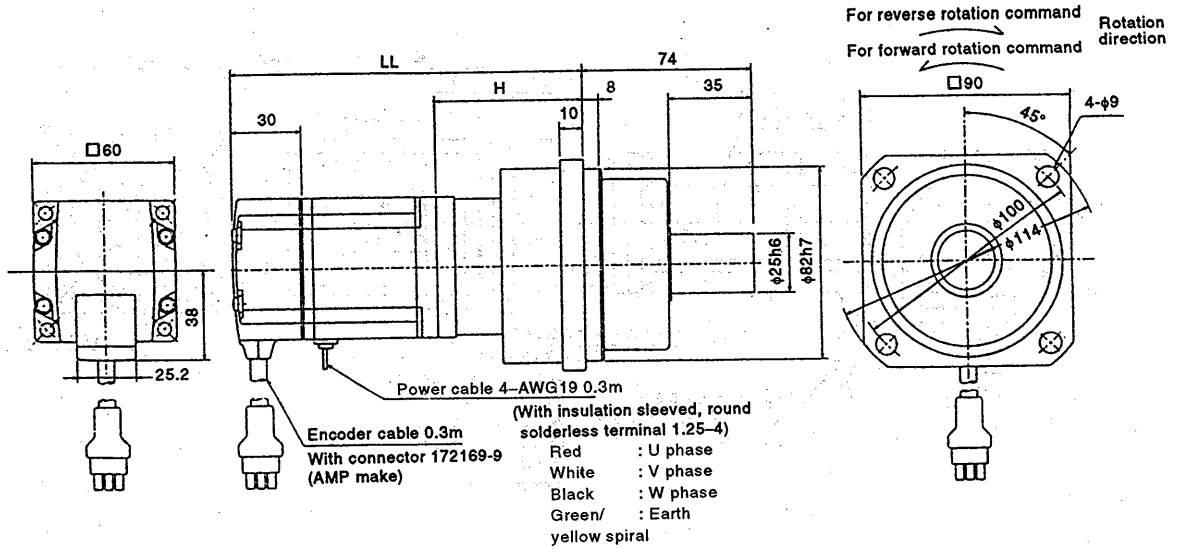
[Unit: mm]

Model	(Note 2) Reduction Ratio	Reduction Gear Model	(Note 1) Inertia J($\times 10^{-4}$kg·m^2)	(Note 1) Variable Dimension		(Note 1) Weight [kg]
				LL	H	
HC-PQ23 (B)G1(-UE)	1/5	K9005	0.249 (0.289)	142.5 (174.5)	56	3.3 (3.9)
HC-PQ23 (B)G1(-UE)	1/12	K9012	0.293 (0.333)	162 (194)	74	3.9 (4.5)
HC-PQ23 (B)G1(-UE)	1/20	K9020	0.266 (0.306)	162 (194)	74	3.9 (4.5)

Note: 1. Value in parentheses is for the servo motor with electromagnetic brake.
2. These are nominal reduction ratios. For actual reduction ratios, refer to Section 10-4.

HC-PQ43(B)G1

Power cable 4–AWG19 0.3m
(With insulation sleeved, round solderless terminal 1.25–4)
Red : U phase
White : V phase
Black : W phase
Green/ : Earth
yellow spiral

Encoder cable 0.3m
With Connector 172169-9
(AMP make)

M6 screw, depth 12
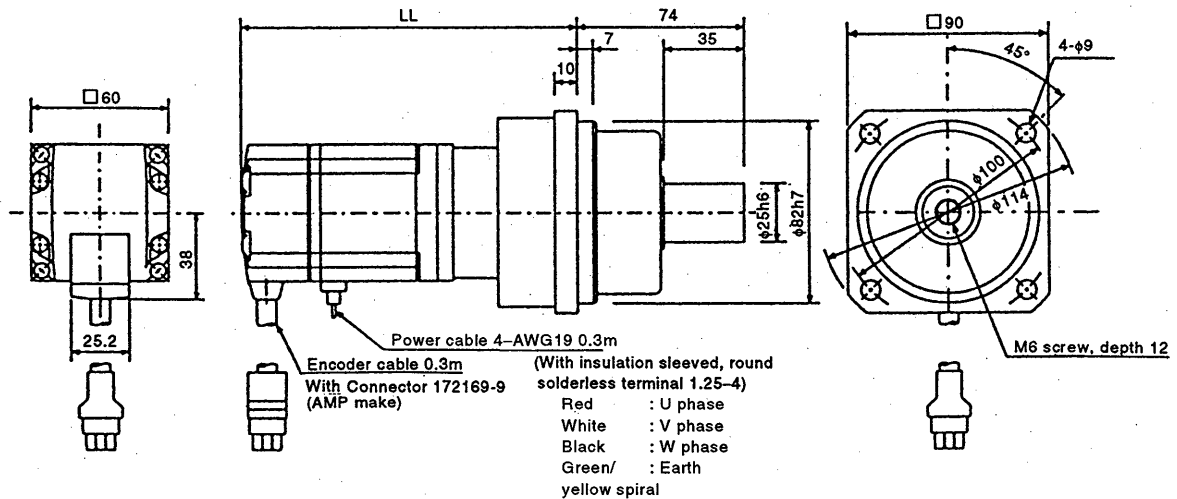
[Unit: mm]

Model	(Note 2) Reduction Ratio	Reduction Gear Model	(Note 1) Inertia J($\times 10^{-4}$kg·m^2)	(Note 1) Variable Dimension	(Note 1) Weight [kg]
				LL	
HC-PQ43 (B)G1(-UE)	1/5	K9005	0.296 (0.344)	168 (200)	3.8 (4.4)
HC-PQ43 (B)G1(-UE)	1/12	K9012	0.34 (0.388)	187 (219)	4.4 (5.0)

Note: 1. Value in parentheses is for the servo motor with electromagnetic brake.
2. These are nominal reduction ratios. For actual reduction ratios, refer to Section 10-4.

Motor name plate
(Opposite side)

Power cable 4–AWG19 0.3m
(With insulation sleeved, round
solderless terminal 1.25–4)
Red   : U phase
White   : V phase
Black   : W phase
Green/ : Earth
yellow spiral

Encoder cable 0.3m
With connector 172169–9
(AMP make)

M8 screw, depth 16

[Unit: mm]

Model	(Note 2) Reduction Ratio	Reduction Gear Model	(Note 1) Inertia J(×10⁻⁴kg·m²)	(Note 1) Variable Dimension LL	(Note 1) Weight [kg]
HC-PQ43 (B)G1(-UE)	1/20	K10020	0.653 (0.701)	191 (223)	5.5 (6.1)

Note: 1. Value in parentheses is for the servo motor with electromagnetic brake.
2. These are nominal reduction ratios. For actual reduction ratios, refer to Section 10-4.

(4) With reduction gear for precision operation

HC-PQ053(B)G2

Power cable 4–AWG19 0.3m
(With insulation sleeved, round solderless terminal 1.25–4)
Red : U phase
White : V phase
Black : W phase
Green/ : Earth
yellow spiral

Encoder cable 0.3m
With connector 172169–9
(AMP make)

For reverse rotation command / For forward rotation command   Rotation direction

M4 screw, depth 8
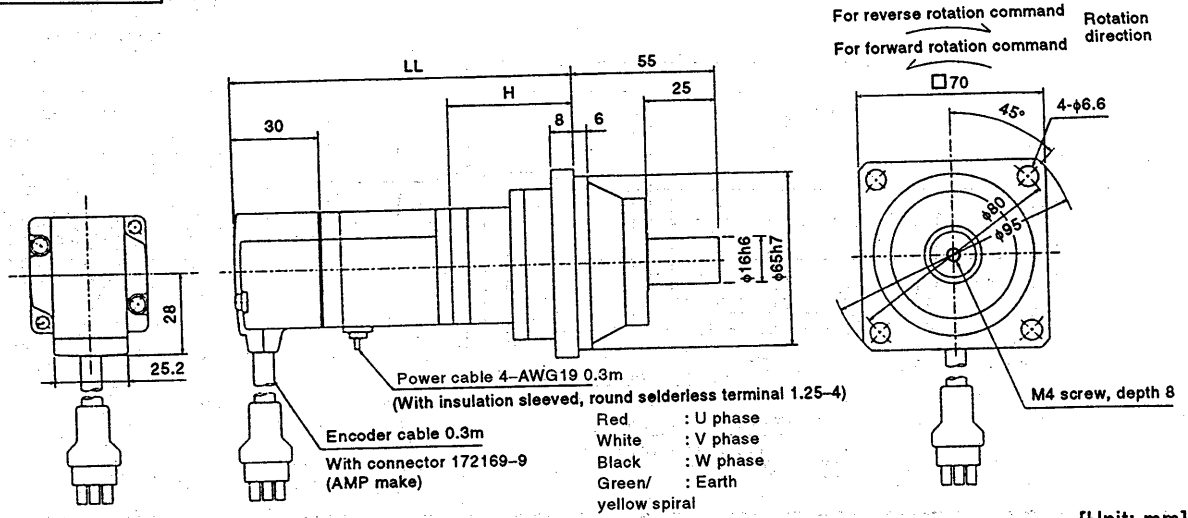
[Unit: mm]

Model	(Note 2) Reduction Ratio	Reduction Gear Model	(Note) Inertia J(×10⁻⁴kg·m²)	(Note) Variable Dimension		(Note) Weight [kg]
				LL	H	
HC-PQ053 (B)G2(-UE)	1/5	BK1-05B -A5MEKA	0.067 (0.07)	119.5 (147.5)	48	1.4 (1.7)
HC-PQ053 (B)G2(-UE)	1/9	BK1-09B -A5MEKA	0.06 (0.063)	135.5 (163.5)	64	1.7 (2.0)
HC-PQ053 (B)G2(-UE)	1/20	BK1-20B -A5MEKA	0.069 (0.072)	135.5 (163.5)	64	1.8 (2.1)
HC-PQ053 (B)G2(-UE)	1/29	BK1-29B -A5MEKA	0.057 (0.06)	135.5 (163.5)	64	1.8 (2.1)

Note: Value in parentheses is for the servo motor with electromagnetic brake.

HC-PQ13(B)G2

Power cable 4–AWG19 0.3m
(With insulation sleeved, round solderless terminal 1.25–4)
Red : U phase
White : V phase
Black : W phase
Green/ : Earth
yellow spiral

Encoder cable 0.3m
With connector 172169–9
(AMP make)

For reverse rotation command / For forward rotation command   Rotation direction

P screw, depth R

[Unit: mm]

Model	Reduction Ratio	Reduction Gear Model	(Note) Inertia J(×10⁻⁴kg·m²)	(Note) Variable Dimension										(Note) Weight [kg]
				LA	LB	LC	LD	LG	LL	H	LR	Q	S	P	R	
HC-PQ13 (B)G2(-UE)	1/5	BK1-05B -01MEKA	0.078 (0.080)	80	65h7	95	70	8	134.5 (162.5)	48	55	25	16h6	M4	8	1.5 (1.9)
HC-PQ13 (B)G2(-UE)	1/9	BK1-09B -01MEKA	0.072 (0.074)	80	65h7	95	70	8	150.5 (178.5)	64	55	25	16h6	M4	8	1.8 (2.2)
HC-PQ13 (B)G2(-UE)	1/20	BK1-20B -01MEKA	0.122 (0.124)	100	80h7	115	85	10	156.5 (184.5)	70	75	35	20h6	M5	10	3.0 (3.4)
HC-PQ13 (B)G2(-UE)	1/29	BK1-29B -01MEKA	0.096 (0.098)	100	80h7	115	85	10	156.5 (184.5)	70	75	35	20h6	M5	10	3.0 (3.4)

Note: Value in parentheses is for the servo motor with electromagnetic brake.

10. SPECIFICATIONS

HC-PQ23(B)G2

For reverse rotation command → Rotation direction
For forward rotation command ↙

Power cable 4–AWG19 0.3m
(With insulation sleeved, round solderless terminal 1.25–4)

Encoder cable 0.3m
With connector 172169–9
(AMP make)

Red	: U phase
White	: V phase
Black	: W phase
Green/yellow spiral	: Earth

P screw, depth R

[Unit: mm]

Model	Reduction Ratio	Reduction Gear Model	(Note) Inertia J(×10⁻⁴kg·m²)	Variable Dimension (Note)													(Note) Weight [kg]
				LA	LB	LC	LD	LE	LG	LL	H	LR	Q	S	P	R	
HC-PQ23 (B)G2(-UE)	1/5	BK1-05B -02MEKA	0.191 (0.239)	80	65h7	95	70	6	8	146 (178)	57	55	25	16h6	M4	8	2.1 (2.7)
HC-PQ23 (B)G2(-UE)	1/9	BK2-09B -02MEKA	0.208 (0.256)	100	80h7	115	85	6	10	164 (196)	75	75	35	20h6	M5	10	3.5 (4.1)
HC-PQ23 (B)G2(-UE)	1/20	BK3-20B -02MEKA	0.357 (0.405)	115	95h7	135	100	8	10	169 (201)	80	85	40	25h6	M6	12	5.0 (5.6)
HC-PQ23 (B)G2(-UE)	1/29	BK3-29B -02MEKA	0.276 (0.324)	115	95h7	135	100	8	10	169 (201)	80	85	40	25h6	M6	12	5.0 (5.6)

Note: Value in parentheses is for the servo motor with electromagnetic brake.

HC-PQ43(B)G2

Power cable 4–AWG19 0.3m
(With insulation sleeved, round solderless terminal 1.25–4)

Encoder cable 0.3m
With connector 172169–9
(AMP make)

Red	: U phase
White	: V phase
Black	: W phase
Green/yellow spiral	: Earth

P screw, depth R

[Unit: mm]

Model	Reduction Ratio	Reduction Gear Model	(Note) Inertia J(×10⁻⁴kg·m²)	Variable Dimension (Note)															(Note) Weight [kg]
				LA	LB	LC	LD	LE	LG	LH	LJ	LL	LR	LZ	Q	S	P	R	
HC-PQ43 (B)G2(-UE)	1/5	BK2-05B -04MEKA	0.295 (0.344)	100	80h7	115	85	6	10	38	60	174 (206)	75	6.6	35	20h6	M5	10	3.7 (4.4)
HC-PQ43 (B)G2(-UE)	1/9	BK3-09B -04MEKA	0.323 (0.372)	115	95h7	135	100	8	10	38	60	195 (227)	85	9	40	25h6	M6	12	5.3 (6.0)
HC-PQ43 (B)G2(-UE)	1/20	BK4-20B -04MEKA	0.426 (0.475)	135	110h7	155	115	8	12	38	60	201 (233)	100	11	50	32h6	M8	16	7.5 (8.2)
HC-PQ43 (B)G2(-UE)	1/29	BK4-29B -04MEKA	0.338 (0.386)	135	110h7	155	115	8	12	38	60	201 (233)	100	11	50	32h6	M8	16	7.5 (8.2)

Note: Value in parentheses is for the servo motor with electromagnetic brake.

10. SPECIFICATIONS

10 – 3 – 3 Servo motors (in inches)

(1) Standard

```
HC-PQ033 to HC-PQ13
```


Power cable 4–AWG19 11.8in
(With insulation sleeved, round solderless terminal 0.05–4)

Encoder cable 11.8in
With connector 172169–9
(AMP make)

Red	: U phase
White	: V phase
Black	: W phase
Green/ yellow spiral	: Earth
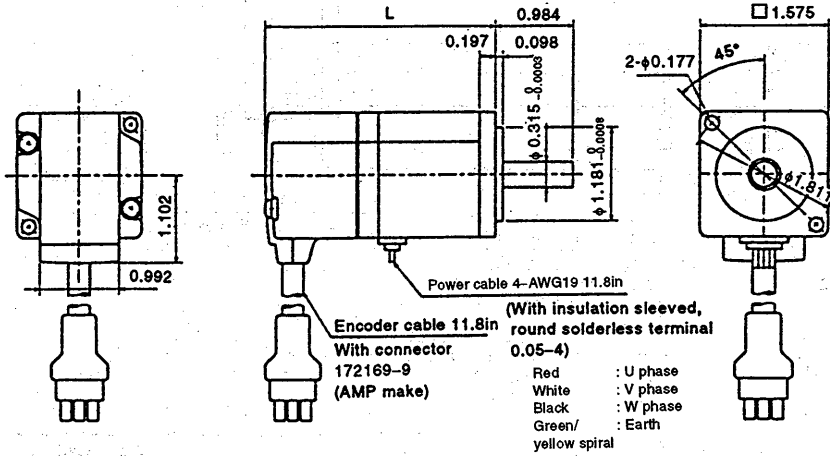
[Unit: in]

Model	Variable Dimension L	Inertia wk^2 [oz·in^2]	Weight [lb]
HC-PQ033	2.579	0.078	0.71
HC-PQ053	2.815	0.101	0.82
HC-PQ13	3.406	0.164	1.1
HC-PQ033-UE	2.894	0.078	0.77
HC-PQ053-UE	3.129	0.101	0.88
HC-PQ13-UE	3.720	0.164	1.17

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HC-PQ23 · HC-PQ43
```


Power cable 4–AWG19 11.8in
(With insulation sleeved, round solderless terminal 0.05–4)

Encoder cable 11.8in
With connector 172169–9
(AMP make)

Red	: U phase
White	: V phase
Black	: W phase
Green/ yellow spiral	: Earth
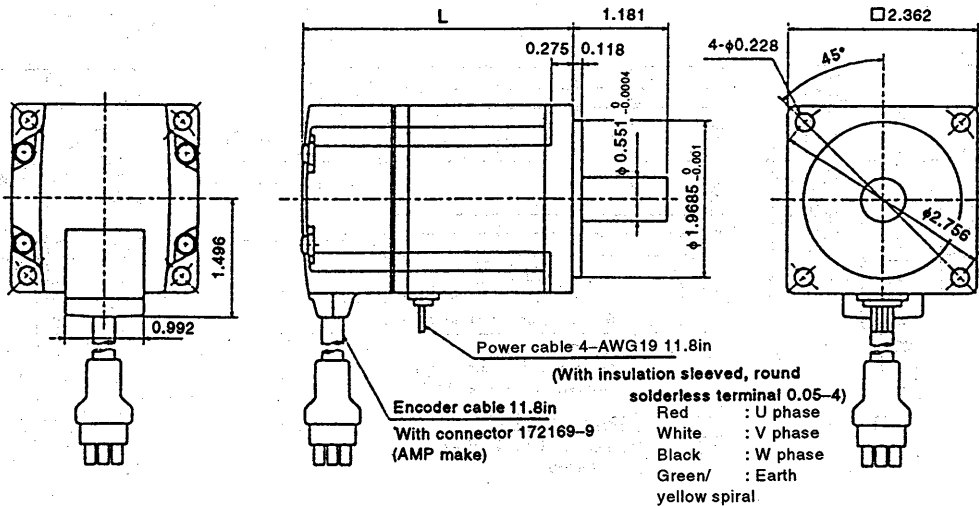
[Unit: in]

Model	Variable Dimension L	Inertia wk^2 [oz·in^2]	Weight [lb]
HC-PQ23	3.504	0.478	2.12
HC-PQ43	4.448	0.779	3.2
HC-PQ23-UE	3.858	0.478	2.18
HC-PQ43-UE	4.843	0.779	3.36

10. SPECIFICATIONS
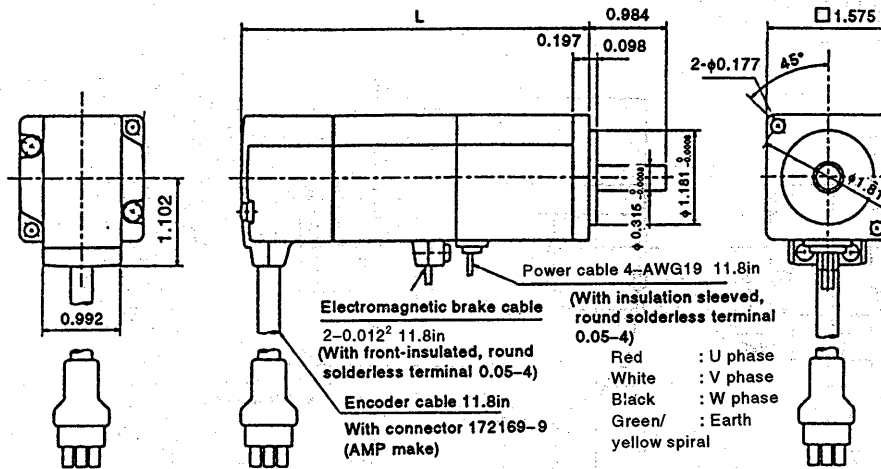
(2) With electromagnetic brake

HC-PQ033B to HC-PQ13B

Power cable 4-AWG19 11.8in
(With insulation sleeved, round solderless terminal 0.05-4)
Red : U phase
White : V phase
Black : W phase
Green/ : Earth
yellow spiral

Electromagnetic brake cable
2-0.012² 11.8in
(With front-insulated, round solderless terminal 0.05-4)

Encoder cable 11.8in
With connector 172169-9
(AMP make)

[Unit: in]

Model	Variable Dimension L	Brake Static Friction Torque[oz·in]	Inertia wk² [oz·in²]	Weight [lb]
HC-PQ033B	3.681	45.32	0.094	1.4
HC-PQ053B	3.917	45.32	0.101	1.5
HC-PQ13B	4.508	45.32	0.176	1.8
HC-PQ033B-UE	3.996	45.32	0.094	1.5
HC-PQ053B-UE	4.232	45.32	0.101	1.6
HC-PQ13B-UE	4.823	45.32	0.176	1.9

HC-PQ23B · HC-PQ43B
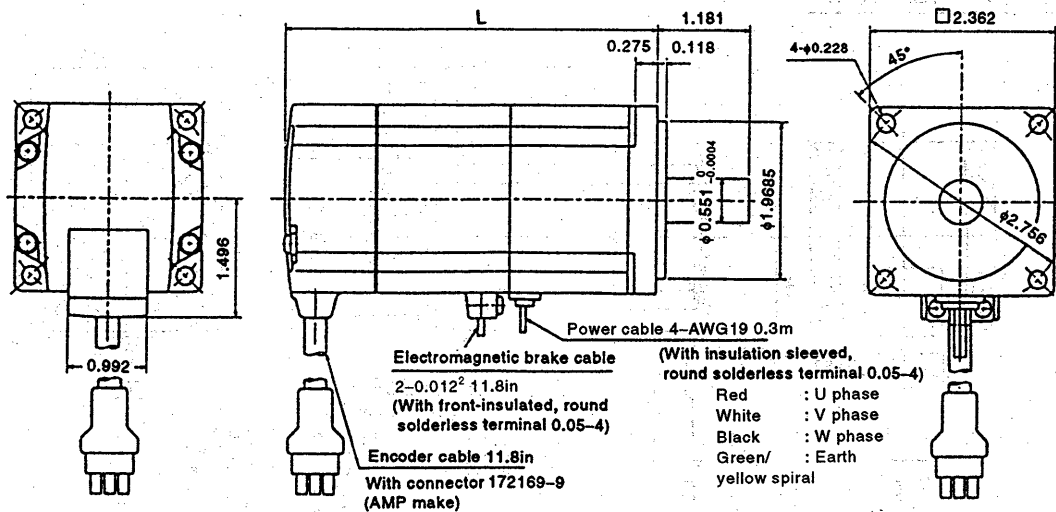
Power cable 4-AWG19 0.3m
(With insulation sleeved, round solderless terminal 0.05-4)
Red : U phase
White : V phase
Black : W phase
Green/ : Earth
yellow spiral

Electromagnetic brake cable
2-0.012² 11.8in
(With front-insulated, round solderless terminal 0.05-4)

Encoder cable 11.8in
With connector 172169-9
(AMP make)

[Unit: in]

Model	Variable Dimension L	Brake Static Friction Torque[oz·in]	Inertia wk² [oz·in²]	Weight [lb]
HC-PQ23B	4.763	184.1	0.478	3.53
HC-PQ43B	5.748	184.1	1.043	4.6
HC-PQ23B-UE	5.118	184.1	0.478	3.6
HC-PQ43B-UE	6.102	184.1	1.043	4.7

10. SPECIFICATIONS

(3) With reduction gear for general industrial machine
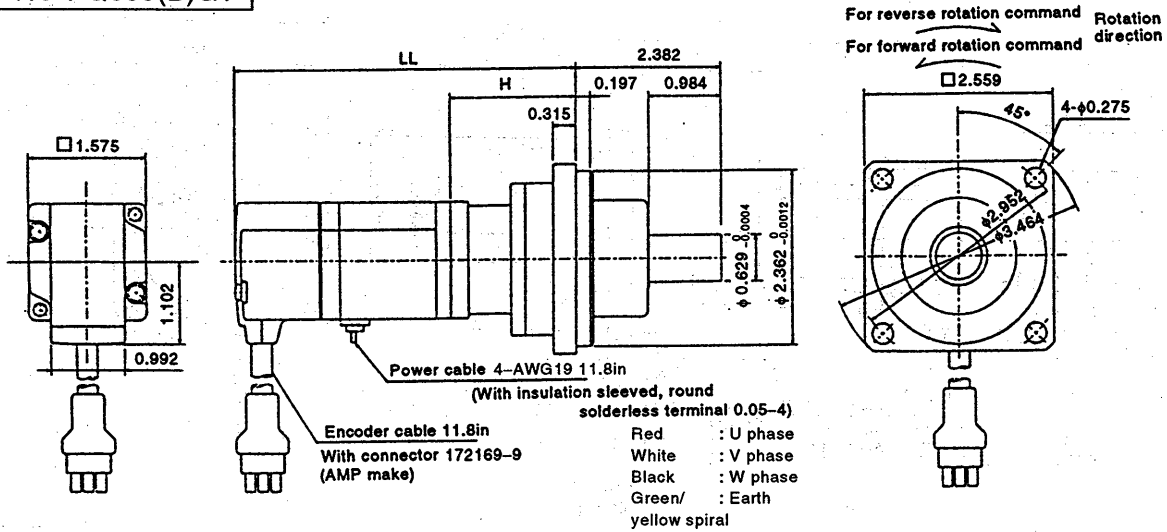
HC-PQ053(B)G1

For reverse rotation command Rotation
For forward rotation command direction

Power cable 4–AWG19 11.8in
(With insulation sleeved, round
solderless terminal 0.05–4)

Encoder cable 11.8in
With connector 172169-9
(AMP make)

Red   : U phase
White   : V phase
Black   : W phase
Green/   : Earth
yellow spiral

[Unit: in]

Model	(Note 2) Reduction Ratio	Reduction Gear Model	(Note 1) Inertia wk² [oz·in²]	(Note 1) Variable Dimension		(Note 1) Weight [lb]
				LL	H	
HC-PQ053 (B)G1(-UE)	1/5	K6505	0.302 (0.319)	4.547 (5.65)	1.87	3.1 (3.7)
HC-PQ053 (B)G1(-UE)	1/12	K6512	0.422 (0.440)	5.275 (6.378)	2.539	4.0 (4.6)
HC-PQ053 (B)G1(-UE)	1/20	K6520	0.324 (0.342)	5.275 (6.378)	2.539	4.0 (4.6)

Note: 1. Value in parentheses is for the servo motor with electromagnetic brake.
2. These are nominal reduction ratios. For actual reduction ratios, refer to Section 10-4.

HC-PQ13(B)G1

Power cable 4–AWG19 11.8in
(With insulation sleeved, round
solderless terminal 0.05–4)

Encoder cable 11.8in
With connector 172169-9
(AMP make)

Red   : U phase
White   : V phase
Black   : W phase
Green/   : Earth
yellow spiral
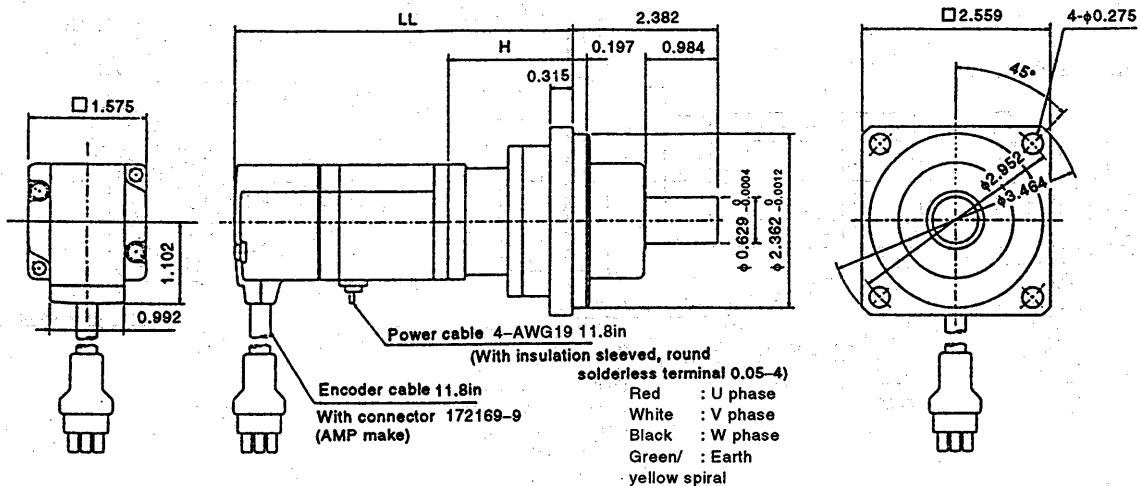
[Unit: in]

Model	(Note 2) Reduction Ratio	Reduction Gear Model	(Note 1) Inertia wk² [oz·in²]	(Note 1) Variable Dimension		(Note 1) Weight [lb]
				LL	H	
HC-PQ13 (B)G1(-UE)	1/5	K6505	0.361 (0.379)	5.1378 (6.24)	1.87	3.3 (4.2)
HC-PQ13 (B)G1(-UE)	1/12	K6512	0.481 (0.499)	5.866 (6.969)	2.539	4.2 (5.1)
HC-PQ13 (B)G1(-UE)	1/20	K6520	0.383 (0.400)	5.866 (6.969)	2.539	4.2 (5.1)

Note: 1. Value in parentheses is for the servo motor with electromagnetic brake.
2. These are nominal reduction ratios. For actual reduction ratios, refer to Section 10-4.

HC-PQ23(B)G1

For reverse rotation command
For forward rotation command
Rotation direction
□3.543
4-φ0.354

□2.362
1.496
0.992

LL
H
2.913
0.393
0.315
1.378

φ0.984 -0.0005
φ3.228 -0.0013

φ3.937
φ4.488
45°

Power cable 4-AWG19 11.8in
(With insulation sleeved, round solderless terminal 0.05-4)

Encoder cable 11.8in
With connector 172169-9
(AMP make)

Red   : U phase
White   : V phase
Black   : W phase
Green/   : Earth
yellow spiral

[Unit: in]

Model	Reduction Ratio (Note 2)	Reduction Gear Model	Inertia wk² [oz·in²] (Note 1)	(Note 1) Variable Dimension		Weight [lb] (Note 1)
				LL	H	
HC-PQ23 (B)G1(-UE)	1/5	K9005	1.363 (1.581)	5.61 (6.87)	2.205	7.3 (8.6)
HC-PQ23 (B)G1(-UE)	1/12	K9012	1.601 (1.819)	6.378 (7.638)	2.913	8.6 (9.9)
HC-PQ23 (B)G1(-UE)	1/20	K9020	1.453 (1.672)	6.378 (7.638)	2.913	8.6 (9.9)

Note: 1. Value in parentheses is for the servo motor with electromagnetic brake.
2. These are nominal reduction ratios. For actual reduction ratios, refer to Section 10-4.

HC-PQ43(B)G1

□2.362
1.496
0.992

LL
2.913
0.393
0.275
1.378

φ0.984 -0.0005
φ3.228 -0.0013

□3.543
45°
4-φ0.354

φ3.937
φ4.488

Power cable 4-AWG19 11.8in
(With insulation sleeved, round solderless terminal 0.05-4)

Encoder cable 11.8in
With connector 172169-9
(AMP make)

Red   : U phase
White   : V phase
Black   : W phase
Green/   : Earth
yellow spiral

M6 screw, depth 0.472

[Unit: in]

Model	Reduction Ratio (Note 2)	Reduction Gear Model	Inertia wk² [oz·in²] (Note 1)	(Note 1) Variable Dimension	Weight [lb] (Note 1)
				LL	
HC-PQ43 (B)G1(-UE)	1/5	K9005	1.62 (1.88)	6.614 (7.874)	8.4 (9.7)
HC-PQ43 (B)G1(-UE)	1/12	K9012	1.86 (2.12)	7.362 (8.622)	9.7 (11.0)

Note: 1. Value in parentheses is for the servo motor with electromagnetic brake.
2. These are nominal reduction ratios. For actual reduction ratios, refer to Section 10-4.

Motor name plate
(Opposite side)

LL

3.543

0.393 | 0.354

1.968

4-φ0.354

□3.94

45°

φ1.259 -0.001

φ2.874

φ3.386

φ3.228 -0.0013

1.496

0.992

Power cable 4–AWG19 11.8in
(With insulation sleeved, round
solderless terminal 0.05–4)
Red   : U phase
White   : V phase
Black   : W phase
Green/ : Earth
yellow spiral

Encoder cable 11.8in
With connector 172169-9
(AMP make)

M8 screw, depth 0.63

[Unit: in]

Model	(Note 2) Reduction Ratio	Reduction Gear Model	(Note 1) Inertia wk² [oz·in²]	(Note 1) Variable Dimension LL	(Note 1) Weight [lb]
HC-PQ43 (B)G1(-UE)	1/20	K10020	3.56 (3.83)	7.52 (8.78)	12.1 (13.4)

Note: 1. Value in parentheses is for the servo motor with electromagnetic brake.
      2. These are nominal reduction ratios. For actual reduction ratios, refer to Section 10-4.

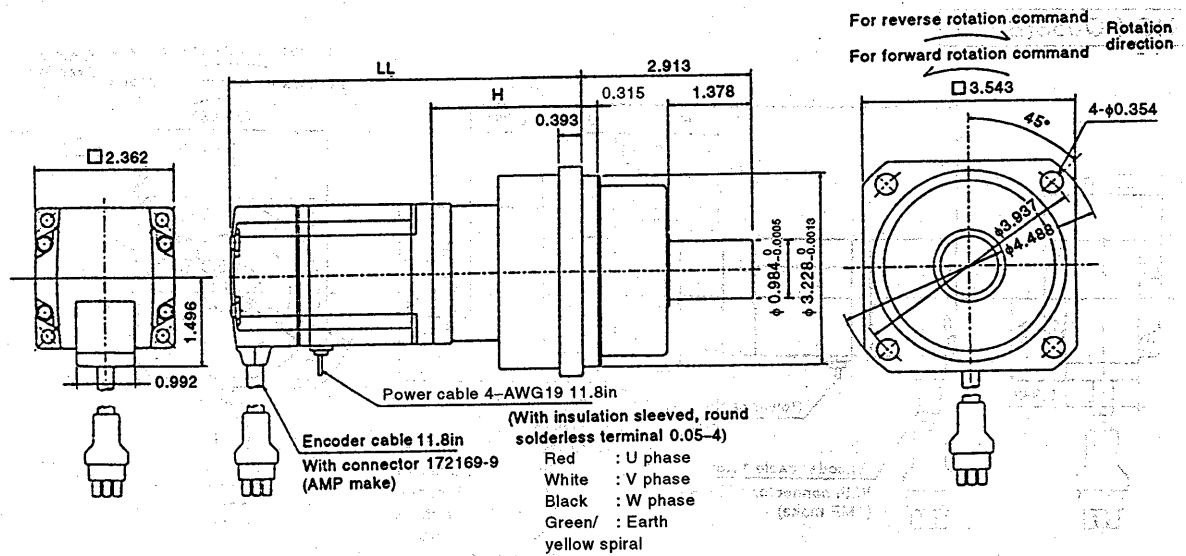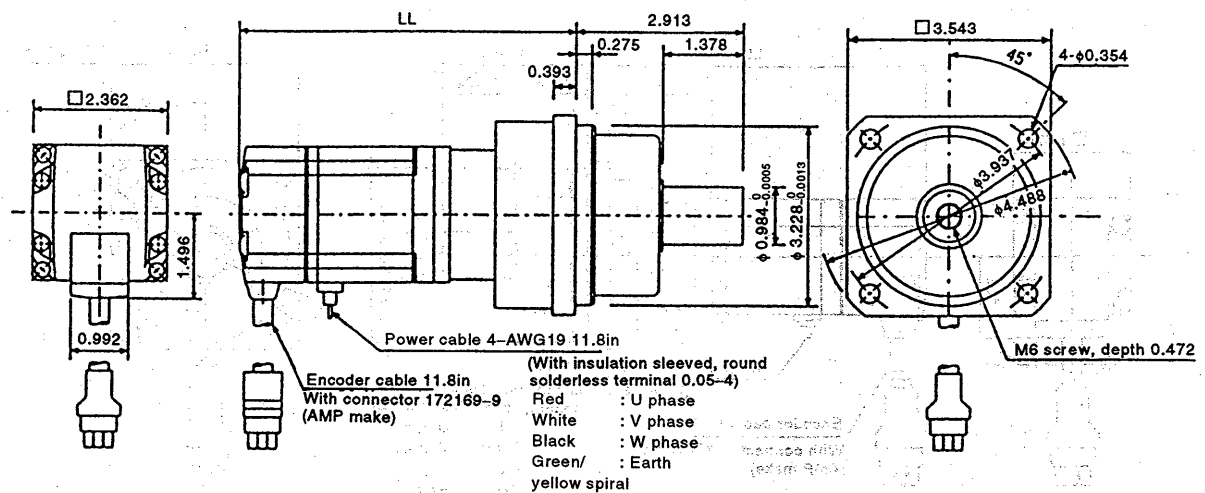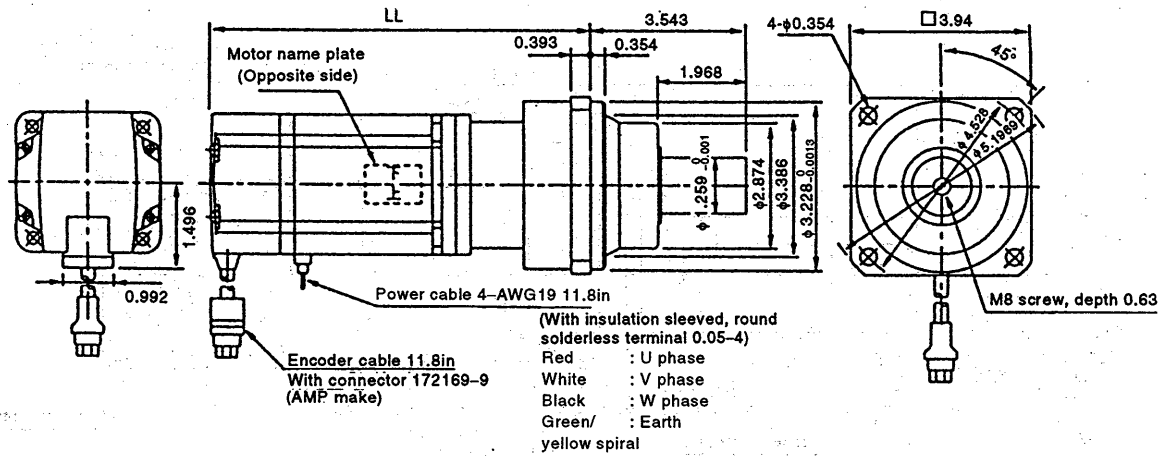## (4) With reduction gear for precision operation

HC-PQ053(B)G2

For reverse rotation command
For forward rotation command
Rotation direction

LL   2.165
H   0.984
0.315   0.236
□2.756
45°   4-φ0.259
1.102
0.992
φ0.629 -0.0004
φ2.559 -0.0012
φ3.149
φ3.740
M4 screw, depth 0.315

Power cable 4-AWG19 11.8in
(With insulation sleeved, round solderless terminal 0.05-4)
Encoder cable 11.8in
With connector 172169-9
(AMP make)

Red : U phase
White : V phase
Black : W phase
Green/ : Earth
yellow spiral
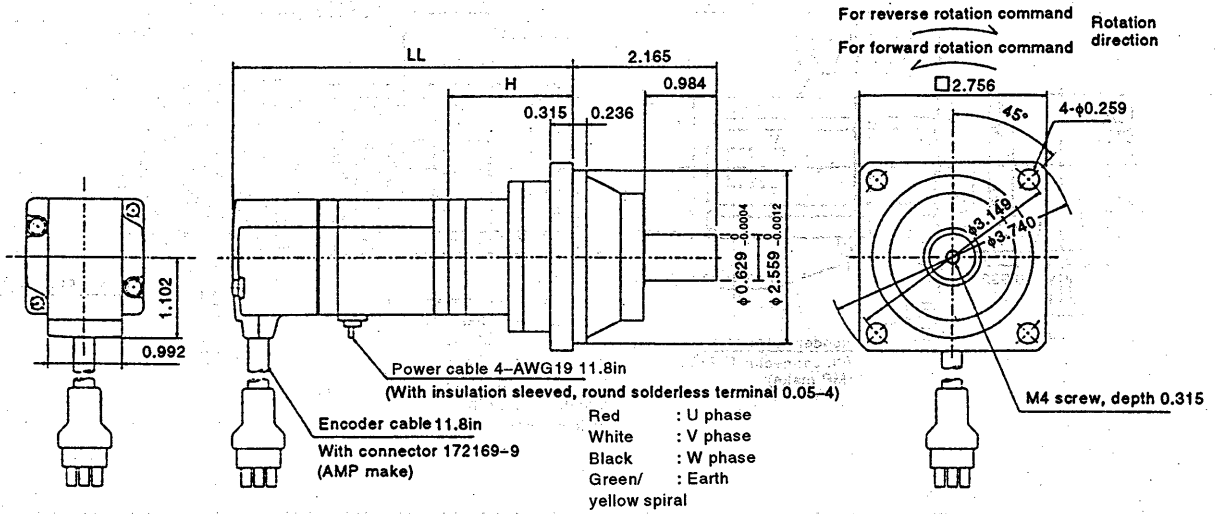
[Unit: in]

Model	Reduction Ratio	Reduction Gear Model	Inertia wk^2 [oz·in^2]	Variable Dimension		Weight [lb]
				LL	H	
HC-PQ053 (B)G2(-UE)	1/5	BK1-05B -A5MEKA	0.364 (0.379)	4.705 (5.807)	1.89	3.1 (3.7)
HC-PQ053 (B)G2(-UE)	1/9	BK1-09B -A5MEKA	0.328 (0.344)	5.335 (6.437)	2.52	3.7 (4.4)
HC-PQ053 (B)G2(-UE)	1/20	BK1-20B -A5MEKA	0.379 (0.395)	5.335 (6.437)	2.52	4.0 (4.6)
HC-PQ053 (B)G2(-UE)	1/29	BK1-29B -A5MEKA	0.312 (0.328)	5.335 (6.437)	2.52	4.0 (4.6)

Note: Value in parentheses is for the servo motor with electromagnetic brake.

HC-PQ13(B)G2

For reverse rotation command
For forward rotation command
Rotation direction

LL   LR
H   Q
LG   0.236
□LD   4-φ0.259
45°
1.102
0.992
φS
φLB
φLA
φLC
P screw, depth R

Power cable 4-AWG19 11.8in
(With insulation sleeved, round solderless terminal 0.05-4)
Encoder cable 11.8in
With connector 172169-9
(AMP make)

Red : U phase
White : V phase
Black : W phase
Green/ : Earth
yellow spiral

[Unit: in]

Model	Reduction Ratio	Reduction Gear Model	Inertia wk^2 [oz·in^2]	Variable Dimension												Weight [lb]
				LA	LB	LC	LD	LG	LL	H	LR	Q	S	P	R	
HC-PQ13 (B)G2(-UE)	1/5	BK1-05B -A5MEKA	0.426 (0.439)	3.15	2.559 -0.0012	3.74	2.756	0.315	5.295 (6.398)	1.89	2.165	0.984	0.63 -0.0004	M4	0.315	3.3 (4.2)
HC-PQ13 (B)G2(-UE)	1/9	BK1-09B -A5MEKA	0.391 (0.403)	3.15	2.559 -0.0012	3.74	2.756	0.315	5.925 (7.028)	2.52	2.165	0.984	0.63 -0.0004	M4	0.315	4.0 (4.8)
HC-PQ13 (B)G2(-UE)	1/20	BK1-20B -A5MEKA	0.664 (0.676)	3.937	3.15 -0.0014	4.528	3.346	0.394	6.161 (7.264)	2.756	2.953	1.378	0.787 -0.0005	M5	0.039	6.6 (7.5)
HC-PQ13 (B)G2(-UE)	1/29	BK1-29B -A5MEKA	0.522 (0.534)	3.937	3.15 -0.0014	4.528	3.346	0.394	6.161 (7.264)	2.756	2.953	1.378	0.787 -0.0005	M5	0.039	6.6 (7.5)

Note: Value in parentheses is for the servo motor with electromagnetic brake.

10. SPECIFICATIONS

HC-PQ23(B)G2

For reverse rotation command / For forward rotation command — Rotation direction

Power cable 4–AWG19 11.8in
(With insulation sleeved, round solderless terminal 0.05–4)
Red : U phase
White : V phase
Black : W phase
Green/yellow spiral : Earth

Encoder cable 11.8in
With connector 172169–9
(AMP make)

P screw, depth R

[Unit: in]

Model	Reduction Ratio	Reduction Gear Model	Inertia wk² [oz·in²]	LA	LB	LC	LD	LE	LG	LL	H	LR	Q	S	P	R	Weight [lb]
HC-PQ23 (B)G2(-UE)	1/5	BK1-05B -A5MEKA	1.043 (1.307)	3.15	$2.559^{0}_{-0.0012}$	3.74	2.756	0.236	0.315	5.748 (7.008)	2.244	2.165	0.984	$0.63^{0}_{-0.0004}$	M4	0.315	4.6 (5.9)
HC-PQ23 (B)G2(-UE)	1/9	BK2-09B -A5MEKA	1.137 (1.401)	3.937	$3.15^{0}_{-0.0014}$	4.528	3.346	0.236	0.394	6.457 (7.717)	2.953	2.953	1.378	$0.787^{0}_{-0.0005}$	M5	0.394	7.7 (9.0)
HC-PQ23 (B)G2(-UE)	1/20	BK3-20B -A5MEKA	1.949 (2.213)	4.528	$3.74^{0}_{-0.0014}$	5.315	3.937	0.315	0.394	6.654 (7.913)	3.15	3.346	1.575	$0.984^{0}_{-0.0005}$	M6	0.472	11 (12.3)
HC-PQ23 (B)G2(-UE)	1/29	BK3-29B -A5MEKA	1.509 (1.773)	4.528	$3.74^{0}_{-0.0014}$	5.315	3.937	0.315	0.394	6.654 (7.913)	3.15	3.346	1.575	$0.984^{0}_{-0.0005}$	M6	0.472	11 (12.3)

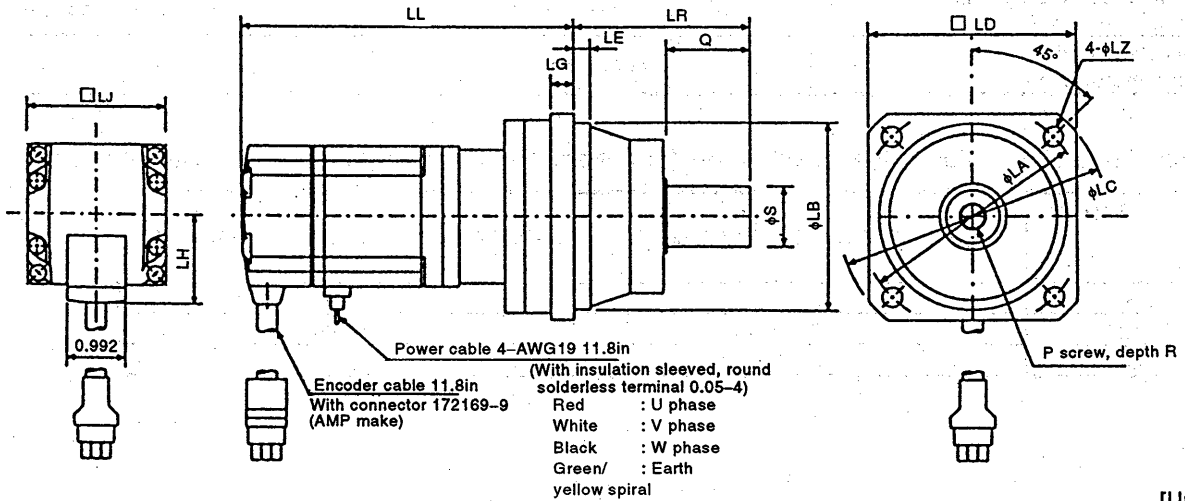Note: Value in parentheses is for the servo motor with electromagnetic brake.

HC-PQ43(B)G2

Power cable 4–AWG19 11.8in
(With insulation sleeved, round solderless terminal 0.05–4)
Red : U phase
White : V phase
Black : W phase
Green/yellow spiral : Earth

Encoder cable 11.8in
With connector 172169–9
(AMP make)

P screw, depth R

[Unit: in]

Model	Reduction Ratio	Reduction Gear Model	(Note) Inertia wk² [oz·in²]	LA	LB	LC	LD	LE	LG	LH	LJ	LL	LR	LZ	Q	S	P	R	(Note) Weight [lb]
HC-PQ43 (B)G2 (-UE)	1/5	BK2-05B -04MEKA	1.61 (1.88)	3.937	$3.15^{0}_{-0.0014}$	4.528	3.346	0.236	0.394	1.496	2.362	6.85 (8.11)	2.953	0.26	1.38	$0.79^{0}_{-0.0005}$	M5	0.39	8.2 (9.7)
HC-PQ43 (B)G2 (-UE)	1/9	BK3-09B -04MEKA	1.77 (2.03)	4.528	$3.74^{0}_{-0.0014}$	5.315	3.937	0.315	0.394	1.496	2.362	7.677 (8.937)	3.346	0.35	1.57	$0.98^{0}_{-0.0005}$	M6	0.47	11.7 (13.2)
HC-PQ43 (B)G2 (-UE)	1/20	BK4-20B -04MEKA	2.33 (2.59)	5.315	$4.33^{0}_{-0.0014}$	6.10	4.528	0.315	0.472	1.496	2.362	7.913 (9.173)	3.937	0.43	1.97	$1.26^{0}_{-0.0006}$	M8	0.63	16.5 (18.1)
HC-PQ43 (B)G2 (-UE)	1/29	BK4-29B -04MEKA	1.85 (2.11)	5.315	$4.33^{0}_{-0.0014}$	6.10	4.528	0.315	0.472	1.496	2.362	7.913 (9.173)	3.937	0.43	1.97	$1.26^{0}_{-0.0006}$	M8	0.63	16.5 (18.1)

Note: Value in parentheses is for the servo motor with electromagnetic brake.

10. SPECIFICATIONS

10 – 4 Servo Motor with Reduction Gear

The servo motors with reduction gears are available in two lines: 1) for general industrial machines; and 2) for high precision.

The servo motors with reduction gears marked (G1, G2) in the table will be manufactured. G1 and G2 are symbols appended to the servo motor model names. (Refer to section 1-1(2))

Reduction gear series	For General Industrial Machines			For High Precision			
Note: Reduction ratio	1/5	1/12	1/20	1/5	1/9	1/20	1/29
HC-PQ033☐	-	-	-	-	-	-	-
HC-PQ053☐	G1	G1	G1	G2	G2	G2	G2
HC-PQ13☐	G1	G1	G1	G2	G2	G2	G2
HC-PQ23☐	G1	G1	G1	G2	G2	G2	G2
HC-PQ43☐	G1	G1	G1	G2	G2	G2	G2

Note: Reduction ratios for general industrial machines are nominal values.
For actual reduction ratios, refer to the following table.

Reduction Gear Line		1) For General Industrial Machines		2) For High Precision
Method of mounting		Flange mounting		Flange mounting
Mounting direction		In any directions		In any directions
Lubrication		Grease lubrication (already pack)		Grease lubrication (already pack)
	Recommended grease	50 to 100W	200-400W	LDR101BV/America Oil Center Reseach
		Mobilplex46/Mobil	Mobiltac81/Mobil	
Output shaft rotation direction		In the same direction as that of the servo motor output shaft.		In the same direction as that of the servo motor output shaft.
With electromagnetic brake		Available		Available
Backlash		60 minutes or less on reduction gear output shaft		3 minutes or less on reduction gear output shaft
Permissible load inertia ratio (on servo motor shaft)		25 times or less		25 times or less
Permissible speed (on servo motor shaft)		4500 r/min		4500 r/min

The actual reduction ratios of the servo motors for general industrial machines are as listed below:

Nominal reduction ratio ＼ Servo motor	HC-PQ053(B)G1	HC-PQ13(B)G1	HC-PQ23(B)G1	HC-PQ43(B)G1
1/5	9/44		19/96	
1/12	49/576		25/288	
1/20	25/484		253/5000	

10. SPECIFICATIONS

10 – 5 Servo Motor with Special Shaft

In addition to the standard straight shaft without a key groove, shafts with key, D cut and L cut are also available. These shafts are not appropriate for applications where the servo motor with Special Shaft is started and stopped frequently. Since trouble such as broken shafts due to key looseness are not guaranteed, use a friction coupling or the like.

Servo Motor	Shaft Shape		
Model	With Key	D Cut	L Cut
HC-PQ033	x	O	x
HC-PQ053	x	O	x
HC-PQ13	x	O	x
HC-PQ23	O	O	O
HC-PQ43	O	O	O

Machining Dimension Diagram

[Unit: mm (in)]

With Key	D Cut	L Cut
30 (1.18) 27 (1.06) 20 (0.79) 3 (0.12) 5 (0.20) 3 (0.12) 5 (0.20) φ14h6 (φ0.55) M4×0.7 screw depth 15	R QK 1 (0.04) φSh6	30 (1.18) 25.5 (1) 1 (0.04) 1 (0.04) 1 (0.04) φ14h6 (0.55)

Capacity [W]	Variable Dimensions		
	R	QK	S
30, 50, 100	25 (0.98)	20.5 (0.81)	8 (0.31)
200, 400	30 (1.18)	25.5 (1)	14 (0.55)

CHAPTER 11
SELECTION

This chapter describes how to calculate the capacity of the servo motor needed for the machine used.

INTRODUCTION	CHAPTER 1
OPERATION	CHAPTER 2
WIRING	CHAPTER 3
INSTALLATION	CHAPTER 4
ADJUSTMENTS AND APPLICATION OPERATIONS	CHAPTER 5
OPTIONS AND AUXILIARY EQUIPMENT	CHAPTER 6
MAINTENANCE AND INSPECTION	CHAPTER 7
TROUBLESHOOTING	CHAPTER 8
CHARACTERISTICS	CHAPTER 9
SPECIFICATIONS	CHAPTER 10
SELECTION	CHAPTER 11
OPTIONAL PRODUCTS	CHAPTER 12

11. SELECTION

11 – 1 List of Specification Symbols

The following symbols are required for selecting the proper servo.

T_a	: Acceleration torque	[N·m]
T_b	: Deceleration torque	[N·m]
T_{Ma}	: Motor torque necessary for acceleration	[N·m]
T_{Mb}	: Motor torque necessary for deceleration	[N·m]
T_{LH}	: Torque applied when the servo motor is stopping	[N·m]
T_L	: Load torque converted into equivalent value on servo motor shaft	[N·m]
T_{LM}	: Load torque converted into equivalent value on servo motor shaft during stopping	[N·m]
T_U	: Unbalance torque	[N·m]
T_F	: Load friction torque	[N·m]
T_{LO}	Load torque on load shaft	[N·m]
T_{rms}	: Continuous effective load torque converted into equivalent value on servo motor shaft	[N·m]
J_L	: Load inertia converted into equivalent value on servo motor shaft	[kg·cm^2]
J_{LO}	: Load inertia on load shaft	[kg·cm^2]
J_M	: Servo motor's rotor inertia	[kg·cm^2]
N	: Servo motor speed	[r/min]
N_O	: Servo motor speed during fast feed	[r/min]
N_{LO}	: Load shaft speed during fast feed	[r/min]
V	: Motion part speed	[mm/min]
V_O	: Motion part speed during fast feed	[mm/min]
P_b	: Ball screw lead	[mm]
Z_1	: Number of gear teeth on servo motor shaft	
Z_2	: Number of gear teeth on load gear	
n	: Gear ratio $n = \dfrac{Z_2}{Z_1}$	
	Speed reduced when n>1, Speed increased when n<1	
η	: Drive part efficiency	
g	: Acceleration of gravity (9.8 [m/s^2])	
μ	: Friction coefficient	

|		
P_t	: Number of feedback pulses in position control mode	[pulse/rev]
f	: Input pulse frequency in position control mode	[pps]
f_o	: Input pulse frequency during fast feed in position control mode	[pps]
T_{psa}	: Acceleration time constant of frequency command in position control mode	[s]
T_{psb}	: Deceleration time constant of pulse frequency command in position control mode	[s]
K_P	: Position control gain 1 (Parameter No.6)	[rad/s]
T_P	: Position control time constant $(T_P = 1/K_P)$	[s]
K_v	: Speed control gain	[rad/s]
T_v	: Speed control time constant $(T_v = 1/K_v)$	[s]
Δ	: Movement amount per feedback pulse in position control mode	[mm/pulse]
Δ_o	: Movement amount per command pulse in position control mode	[mm/pulse]
	: Movement amount	[mm]
P	: Number of input command pulses in position control mode	[pulse]
t_s	: Stop setting time in position control mode	[s]
t_o	: Positioning time	[s]
t_c	: Time of constant speed of servo motor in 1 cycle	[s]
t	: Stopping time in 1 cycle	[s]
$\Delta \varepsilon$	: Positioning accuracy	[mm]
ε	: Number of droop pulses	[pulse]
$\Delta \theta$	: Load shaft rotation angle per pulse in position control mode	[degree/pulse]
e	: Euler constant = 2.71878	
ΔS	: Movement amount per servo motor revolution	[mm/rev]

11. SELECTION

11 – 2 Position Resolution and Electronic Gear Setting

The position resolution (movement amount per pulse $\Delta\ell$) is determined from the movement amount per servo motor revolution ΔS and the number of encoder feedback pulses P_t. The following equation shows this.

$$\Delta\ell = \frac{\Delta S}{P_t} \quad\text{...(11-1)}$$

$\Delta\ell$: movement amount per pulse　　　　　　　　　[mm]

ΔS: movement amount per servo motor revolution　[mm/rev]

P_t : number of feedback pulses　　　　　　　　　[pulse/rev]

The value for $\Delta\ell$ is related to the equation (11-1) and the value in the control system is fixed when the drive system and encoder are determined. However, the movement amount per command pulse can be set with the parameters.
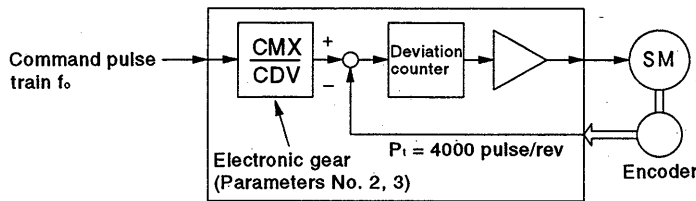
As shown above, the command pulse is multiplied by CMX/CDV to become the position control pulse. Therefore, the movement amount per command pulse $\Delta\ell_0$ is expressed with the following equation.

$$\Delta\ell_0 = \frac{\Delta S}{P_t} \cdot \frac{CMX}{CDV} = \Delta\ell \cdot \frac{CMX}{CDV} \quad\text{...(11-2)}$$

CMX: parameter No. 2

CDV: parameter No. 3

Using the above relation, the movement amount per command pulse can be set to a number without fraction.

[Setting example]

Obtain the parameter value for $\Delta\ell_0$= 0.01 [mm] in the drive system with a ball screw lead P_b = 10 [mm], reduction ratio 1/n = 1.

The encoder feedback pulse of the HC-PQ is P_t = 4000 [pulse/rev].

ΔS = 10 [mm/rev]. So, with equation (11-2), the following is obtained.

$$\frac{CMX}{CDV} = \Delta\ell_0 \cdot \frac{P_t}{\Delta S}$$

$$= 0.01 \cdot \frac{4000}{10} = 4$$

Therefore, the parameters are set as CMX=4 and CDV=1.

11. SELECTION

<Relation of position resolution Δ and total accuracy>

Total accuracy (machine's positioning accuracy) is the sum of the electrical error and mechanical error. Therefore, the electrical system error is normally set so that it does not influence overall error. Refer to the equation below as a guideline.

$$\Delta\ell < \left(\frac{1}{5} \text{ to } \frac{1}{10}\right) \cdot \Delta\varepsilon \quad \text{............(11-3)}$$

Here: $\Delta\ell$: Feed value per feedback pulse [mm/pulse]

$\Delta\varepsilon$: Positioning accuracy [mm]

11. SELECTION

11 – 3 Servo Motor Speed and Command Pulse Frequency

The servo motor is commanded to run at a speed where the command pulse and feedback pulse are equivalent. Therefore, the command pulse frequency and feedback pulse frequency are equivalent. The relation including the parameter command pulse multiplication set value (CMX, CDV) is shown below. (Refer to the figure below.)

$$f_o \cdot \frac{CMX}{CDV} = P_t \cdot \frac{N_o}{60} \quad\text{..(11-4)}$$

Here: f_o : Command pulse frequency [pps]

CMX : Electronic gear (Command pulse multiplication numerator) Parameter No. 2

CDV : Electronic gear (Command pulse multiplication denominator) Parameter No. 3

N_o : Servo motor speed [r/min]

P_t : Number of feedback pulses [pulse/rev]
(P_t = 4000 for HC-PQ)

According to Equation (11-4), the following equations may be used to find the electronic gear ratio and command pulse frequency required to rotate the servo motor at N_o:

• electronic gear

$$\frac{CMX}{CDV} = P_t \cdot \frac{N_o}{60} \cdot \frac{1}{f_o} \quad\text{..(11-5)}$$

• input pulse train frequency

$$f_o = P_t \cdot \frac{N_o}{60} \cdot \frac{CDV}{CMX} \quad\text{..(11-6)}$$

[Setting example]

Find the command pulse frequency required to run the HC-PQ at 4000[r/min].

Supposing that the electronic gear ratio is 1 (default parameter value), the above frequency is found as follows according to Equation (11-6):

$$f_o = 4000 \cdot \frac{N_o}{60} \cdot \frac{CDV}{CMX}$$

(input command pulse frequency)

$$= 4000 \cdot \frac{4000}{60} \cdot 1$$

$$= 266667 [pps]$$

However, 266667pps cannot be input because the maximum input command pulse frequency is 200kpps in the open collector system.

Hence, the electronic gear ratio must be changed to run the servo motor with not more than 200kpps at the speed of 4000[r/min]. Use Equation (11-5) to find this electronic gear ratio.

$$\frac{CMX}{CDV} = 4000 \cdot \frac{4000}{60} = 4000 \cdot \frac{1}{200 \cdot 10^3}$$

(electronic gear)

$$= \frac{4}{3}$$

Therefore, the parameter is set to CMX=4 and CDV=3.

11. SELECTION

11 – 4 Stopping Characteristics

(1) Droop pulses (ε)

When running the servo motor with a pulse train command, the encoder feedback pulses are delayed during acceleration. The difference between the command pulses and feedback pulses are called droop pulses. The droop pulses are accumulated in the servo amplifier's deviation counter. The following equation defines the relationship between the command pulse frequency (f), position loop gain (K_P), and the number of droop pulses (ε).

$$\varepsilon = \frac{f_o}{K_P} \text{ [pulse]} \dots\dots\dots(11\text{-}7)$$

In the MELSERVO-C, the initial value of the position control gain is 25[rad/s]. In this case, if the command pulse frequency is 200 [kpps], the droop pulses during operation will be as follows according to the above equation (11-7).

$$\varepsilon = \frac{200 \times 10^3}{25} = 8000 \text{ [pulse]}$$
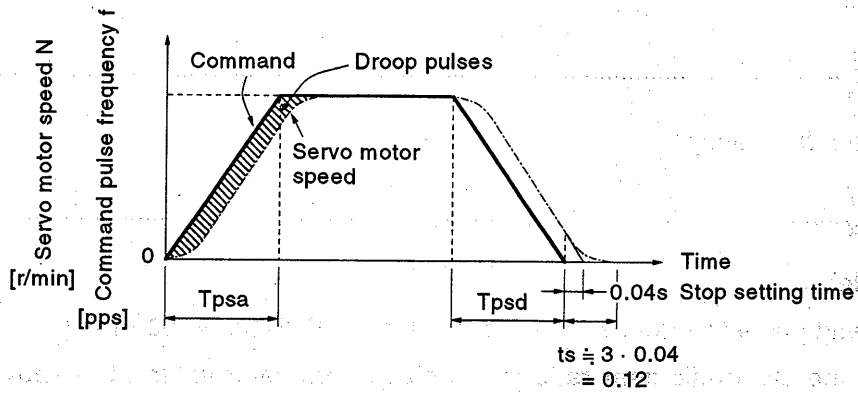
(2) Stop setting time (ts) during linear acceleration/deceleration

The servo amplifier during operation has droop pulses, so a stop setting time (ts) is required from the time the command reaches 0 to when the motor stops. Set the operation pattern while taking the stop setting time into consideration.

The ts value will be obtained in the following equation:

$$ts \fallingdotseq 3 \cdot T_P$$
$$= 3 \cdot \frac{1}{K_P} \text{ [s]} \dots\dots\dots(11\text{-}8)$$

*When K_P = 25 [rad/s] is used, ts $\fallingdotseq$ 0.12 [s]. (Refer to above diagram.)

Note: The stop setting time (ts) indicates the time required for the servo motor to stop in the necessary position accuracy range. This does not always mean that the servo motor has stopped completely. Thus, at high cycle rates, a larger value than the value obtained in the equation (11-8) must be considered when there is no allowance in the positioning accuracy for the movement amount per pulse (Δ). The ts will differ depending on the moving part conditions. If the load friction torque is especially large, the movement may be unstable near the stopping position.

11. SELECTION

11 – 5 Capacity selection method

To select a servo motor, the load conditions must first be calculated. Next, a servo motor is selected according to these initial calculations. Then, the load of the servo motor is included in further calculations to determine if the servo motor initially selected will provide the necessary performance.

(1) Initial selection of servo motor capacity

When the load torque (T_L) and load inertia (J_L) have been calculated, select a servo motor using servo motor rated torque > T_L, servo motor J_M > $J_L/3$ as a guideline.

Find the torque for acceleration/deceleration, and the continuous effective load torque following the steps in (2) and then, verify the selection.

For frequent positioning, the J_L value should be as small as possible. If positioning is infrequent such as in line control, the J_L value can be slightly larger than the above conditions.

(2) Acceleration/deceleration torque

The equation for obtaining the acceleration/deceleration torque with the following pattern is shown.
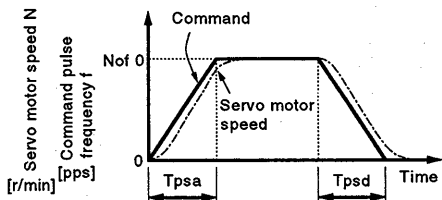
- Acceleration torque

$$T_a = \frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4} \cdot \frac{1}{Tpsa} \quad\quad\quad (11\text{-}9)$$
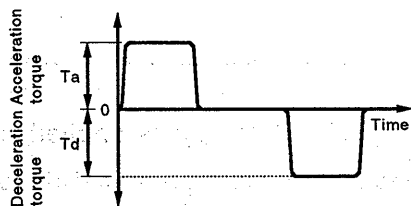
- Deceleration torque

$$T_b = \frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4} \cdot \frac{1}{Tpsd} \quad\quad\quad (11\text{-}10)$$

(3) Torque required for operation

The highest torque is applied to the servo motor during acceleration. If the torque required for the servo motor during acceleration obtained in the following equation exceeds the maximum servo motor torque, acceleration will not be possible in the commanded time. Confirm that the calculated value is lower than the servo motor's maximum torque. Normally, a friction load is applied during deceleration, so only the acceleration torque needs to be considered.
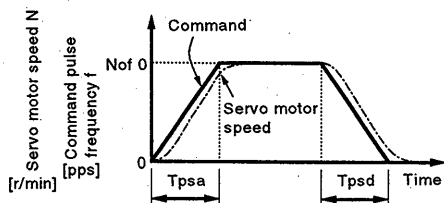
$$T_1 = T_{Ma} = T_a + T_L \quad\quad\quad\quad\quad\quad (11\text{-}11)$$

$$T_2 = T_L \quad\quad\quad\quad\quad\quad\quad\quad\quad (11\text{-}12)$$

$$T_3 = T_{Md} = -T_d + T_L \quad\quad\quad\quad\quad (11\text{-}13)$$
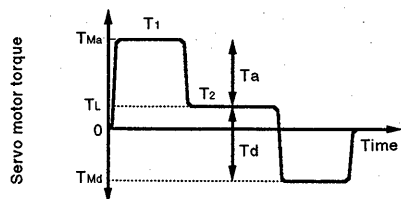
Note: The regenerative status will be indicated if the value obtained in the equation (11-13) is a negative value.

11. SELECTION

(4) Continuous effective load torque

If the torque required for the servo motor changes with time, the continuous effective load torque obtained in the following equation must be lower than the servo motor's rated torque.

There may be a servo motor torque delay at acceleration or deceleration due to a delay in the control system. But, to simplify the calculation, the calculation assumes that a constant acceleration/deceleration torque is applied during Tpsa and Tpsd. The equation for the continuous effective load torque for the following operation pattern is given below.
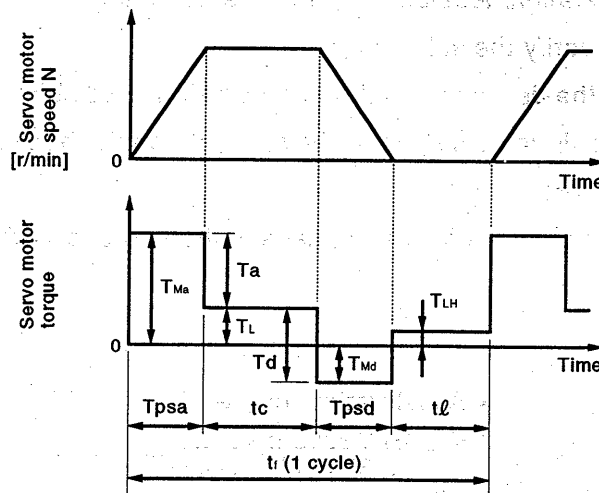
$$T_{rms} = \sqrt{\frac{T_{Ma}^2 \cdot T_{psa} + T_L^2 \cdot tc + T_{Md}^2 \cdot T_{psd} + T_{LH}^2 \cdot t}{t_f}} \quad\quad \text{.............(11-14)}$$
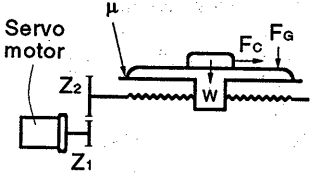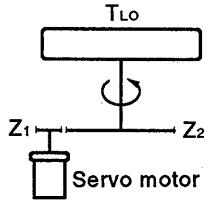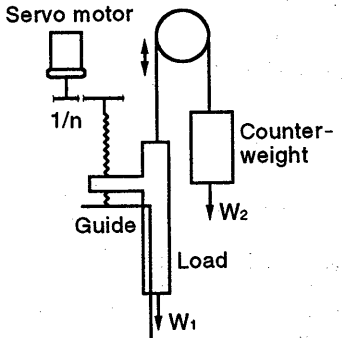
Note: T_{LH} in the diagram shows the torque applied during stopping. A torque is applied to the servo motor especially when stopping during vertical operations. During vertical drive, the unbalanced torque T_U will be T_{LH}.

11. SELECTION

11 – 6 Load Torque Equations

The main load torque equations are shown below.
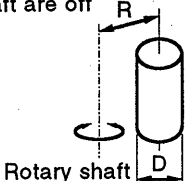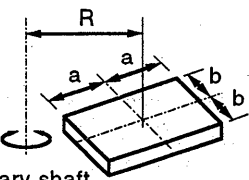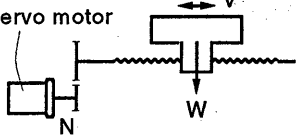
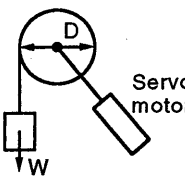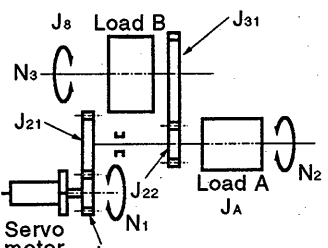Load Torque Equations
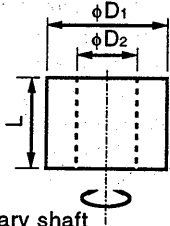
Type	Mechanism	Equation
Linear movement		$$T_L = \frac{F}{2 \times 10^3 \cdot \pi \cdot \eta} \cdot \frac{V}{N} = \frac{F \cdot \Delta S}{2 \times 10^3 \cdot \pi \cdot \eta} \quad \text{...............} (11\text{-}15)$$ F : Shaft direction force of the machine in linear motion [N] F in Equation (11-15) is obtained with Equation (11-16) when moving a table, for example, as shown in the diagram. $$F = F_C + \mu \cdot (W \cdot g + F_G) \quad \text{....................} (11\text{-}16)$$ F_C : Shaft direction force applied on moving part [N] F_G : Tightening force of the table guide surface [N] W : Total weight of the moving part [kg]
Rotary movement		$$T_L = \frac{1}{n} \cdot \frac{1}{\eta} \cdot T_{LO} + T_F \quad \text{.......................} (11\text{-}17)$$ T_F : Load friction torque converted into equivalent value on servo motor shaft [N·m]
Vertical movement		During rising $$T_L = T_U + T_F \quad \text{.............................} (11\text{-}18)$$ During lowering $$T_L = -T_U \cdot \eta^2 + T_F \quad \text{.....................} (11\text{-}19)$$ T_F : Friction torque of the moving part [N·m] $$T_U = \frac{(W_1 - W_2) \cdot g}{2 \times 10^3 \cdot \pi \cdot \eta} \cdot \frac{V}{N} = \frac{(W_1 - W_2) \cdot g \cdot \Delta S}{2 \times 10^3 \cdot \pi \cdot \eta} \quad \text{..........} (11\text{-}20)$$ $$T_F = \frac{\mu \cdot (W_1 + W_2) \cdot g \cdot \Delta S}{2 \times 10^3 \cdot \pi \cdot \eta} \quad \text{..................} (11\text{-}21)$$ W_1 : Load weight [kg] W_2 : Counterweight [kg]

11 – 7 Load Inertia Equations

The main load inertia equations are shown below.

Load Inertia Equations

Type	Mechanism	Equation
Cylinder	Rotary shaft is at cylinder center Rotary shaft	$J_{LO} = \dfrac{\pi \cdot \rho \cdot L}{32} \cdot (D_1^4 - D_2^4) = \dfrac{W}{8} \cdot (D_1^2 + D_2^2)$ .... (11-22) ρ : Cylinder material density [kg·cm²] L : Cylinder length [cm] D_1 : Cylinder outer diameter [cm] D_2 : Cylinder inner diameter [cm] W : Cylinder weight [kg] Reference data material density : Steel : 7.8×10^{-3} [kg/cm³] Aluminum : 2.7×10^{-3} [kg/cm³] Copper : 8.96×10^{-3} [kg/cm³]
	When rotary shaft and cylinder shaft are off Rotary shaft	$J_{LO} = \dfrac{W}{8} (D^2 + 8R^2)$ .... (11-23)
Square block	Rotary shaft	$J_{LO} = W \cdot \left(\dfrac{a^2 + b^2}{3} + R^2 \right)$ .... (11-24) W : Square block weight [kg] a, b, R : Left diagram [cm]
Object which moves linearly	Servo motor N W	$J_L = W \cdot \dfrac{V}{600\omega} = W \cdot \left(\dfrac{1}{2 \cdot \pi \cdot N} \cdot \dfrac{V}{10} \right)^2 = W \cdot \left(\dfrac{\Delta S}{20 \cdot \pi} \right)^2$ .... (11-25) V : Speed of object moving linearly [mm/min] ΔS : Movement amount of object moving linearly per servo motor revolution [mm/rev] W : Object weight [kg]
Object that is hung with pulley	Servo motor W	$J_L = W \cdot \left(\dfrac{D}{2} \right)^2 + J_P$ .... (11-26) J_P : Pulley inertia [kg·cm²] D : Pulley diameter [cm] W : Object weight [kg]
Converted load	J_B Load B J_{31} N_3 J_{21} J_{22} Load A J_A N_2 N_1 Servo motor J_{11}	$J_L = J_{11} + (J_{21} + J_{22} + J_A) \cdot \left(\dfrac{N_2}{N_1} \right)^2 + (J_{31} + J_B) \cdot \left(\dfrac{N_3}{N_1} \right)^2$ .... (11-27) J_A, J_B : Load A, B inertia [kg·cm²] J_{11} to J_{31} : Inertia [kg·cm²] N_1 to N_3 : Speed of each shaft [r/min]

11. SELECTION

11 – 8 Zeroing Instructions

To return the system to the home position with the MELSERVO-C, use a zeroing dog or actuator. The method and precautions for setting the mechanical origin are given below. In the following zeroing, an actuator and the zero pulse signal (encoder Z-phase pulse OP) of a servo motor encoder are used to set the mechanical origin. Whether the encoder Z-phase pulse signal (OP) is on or off can be confirmed on the external I/O signal display.

When a general positioning module (AD75 etc.) is used, the sequence of events is as shown in Fig. 11-1.
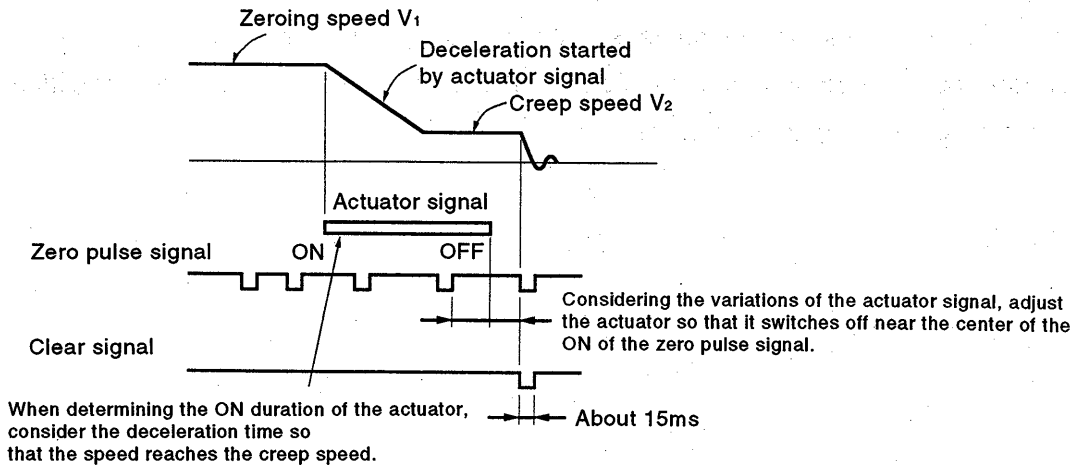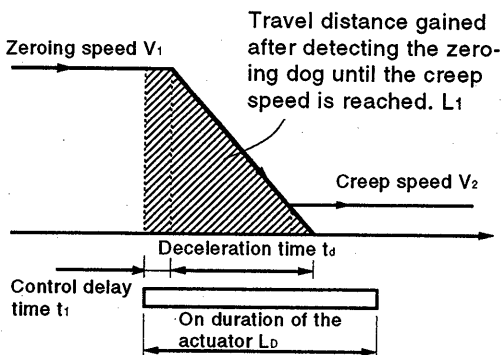

Fig. 11-1 Zeroing Using the Actuator

(1) When determining the on duration of the actuator, consider the delay time of the control section and the deceleration time so that the creep speed is attained. If the actuator signal switches off during deceleration, precise home position return cannot be performed.

- Travel distance L_1 in the chart can be obtained by Formula (11-28)

- On duration of the actuator L_D [mm] must be longer than L_1 obtainedby formula (11-28) as in Formula (11-29).

$$L_1 = \frac{1}{60} \cdot V_1 \cdot t_1 + \frac{1}{120} \cdot V_1 \cdot t_d \cdot \left\{1 - \left(\frac{V_2}{V_1}\right)^2\right\}$$

$$+ \frac{1}{60} \cdot V_1 \cdot T_P \quad \cdots\cdots\cdots\cdots\cdots (11\text{-}28)$$

$$L_D > L_1 \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots (11\text{-}29)$$

where,

V_1, V_2 : as shown in the chart [mm/min]

t_1, t_d : same as above   [s]

L_1 : same as above   [mm]

L_D : same as above   [mm]

11. SELECTION

(2) Set the end (off position) of the actuator signal at the middle of two on positions (Lows) of the zero pulse signal. If it is set near either on position of the zero pulse signal, the positioning module is liable to misdetect the zero pulse signal.

In this case, a fault will occur, e.g. the home position will shift by one revolution of the servo motor.

The zero pulse output position can be confirmed by OP (Encoder Z-phase pulse) on the external I/O signal display.
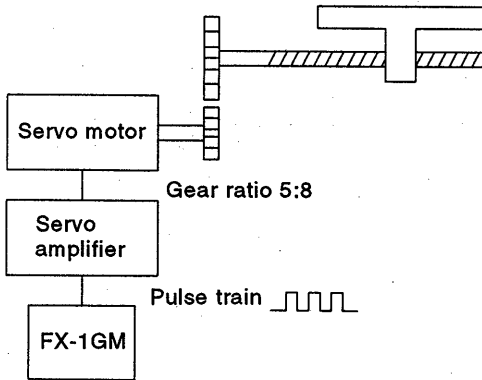
(3) Set the creep speed so that the machine is not shocked when the operation comes to a stop.

The operation instantly stops since the clear (CR) signal is given to the servo amplifier immediately when a zero pulse signal is detected.

11. SELECTION

11 – 9 Selection Example

Machine specifications

Gear ratio 5:8

Pulse train ⎍⎍⎍⎍

FX-1GM

Speed of moving part during fast feed	V_o	= 30000[mm/min]
Movement amount per pulse	$\Delta \ell$	= 0.005[mm]
Movement amount	ℓ	= 400[mm]
Positioning time	t_o	= 1[s] or less
Number of feeds		40[times/min.]
(Operation cycle	t_f	= 1.5[s]
Gear ratio	n	= 8/5
Moving part weight	W	= 60[kg]
Drive system efficiency	η	= 0.8
Friction coefficient	μ	= 0.2
Ball screw lead	P_b	= 16[mm]
Ball screw diameter		20[mm]
Ball screw length		500[mm]
Gear diameter (servo motor)		25[mm]
Gear diameter (load shaft)		40[mm]
Gear tooth width		10[mm]

(1) Selection of control parameter

   1) Setting of electronic gear (pulse multiplication numerator, denominator)

   The following relation is established between the multiplication setting and movement amount per pulse $\Delta \ell$.

$$\Delta \ell = \frac{(\text{ball screw read})}{4000 \times (\text{gear ratio})} \times \frac{CMX}{CDV}$$

   When the machining specification is substituted for the above equation:

$$\frac{CMX}{CDV} = 0.005 \cdot \frac{4000 \cdot 8/5}{16} = 2$$

   OK if the $\frac{CMX}{CDV}$ ratio is within $\frac{1}{50}$ to 20.

   2) Input pulse train frequency for fast feed f_o

$$f_o = \frac{V_o}{60 \cdot \Delta \ell} = \frac{30000}{60 \cdot 0.005} = 10000 \ [\text{pps}]$$

   OK if f_o is 200kpps or less.

(2) Servo motor speed

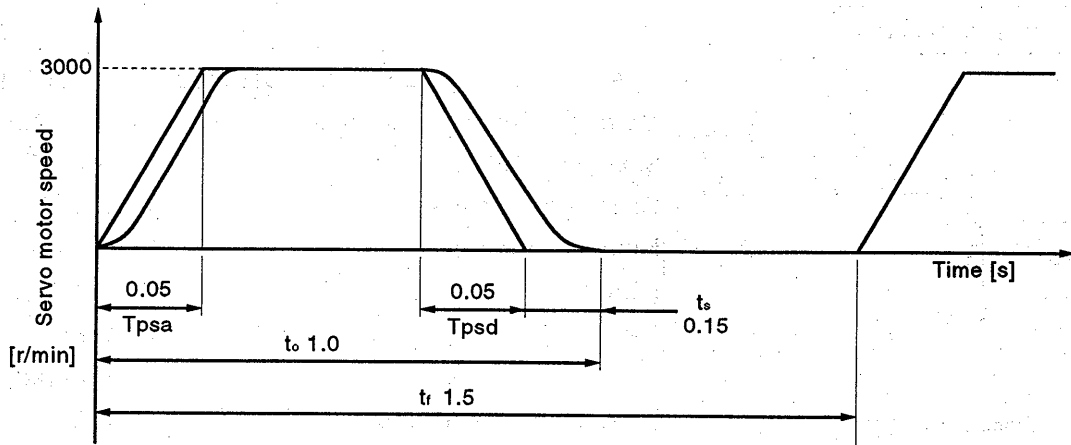$$N_o = \frac{V_o}{P_b} \cdot n = 3000 \ [\text{r/min}]$$

(3) Acceleration/deceleration time constant

$$T_{psa} = T_{psd} = t_o - \frac{\ell}{V_o / 60} - ts = 0.05 \ [\text{s}]$$

   *ts: stop setting time. Here, this is assumed to be 0.15s.

11. SELECTION

(4) Operation pattern

(5) Load torque (converted into equivalent value on servo motor shaft)

Movement amount per servo motor revolution

$$\Delta S = P_b \cdot \frac{1}{n} = 10 \text{ [mm]}$$

$$T_L = \frac{\mu \cdot W \cdot g \cdot \Delta S}{2 \times 10^3 \cdot \pi \cdot \eta} = 0.23 \text{ [N·m]}$$

For gravitational system of units

$$T_L = \frac{\mu \cdot W \cdot \Delta S}{20 \cdot \pi \cdot \eta} = 2.4 \text{ [kgf·cm]}$$

(6) Load inertia (converted into equivalent value on servo motor shaft)

Moving part

$$J_{L1} = W \cdot \left(\frac{\Delta S}{20 \cdot \pi}\right)^2 = 1.52 \text{ [kg·cm}^2\text{]}$$

Ball screw

$$J_{L2} = \frac{\pi \cdot \rho \cdot L}{32} \cdot D^4 \cdot \left(\frac{1}{n}\right)^2 = 0.24 \text{ [kg·cm}^2\text{]}$$

* $\rho = 7.8 \times 10^{-3}$ [kg/cm^3] (iron)

Gear (servo motor shaft)

$$J_{L3} = \frac{\pi \cdot \rho \cdot L}{32} \cdot D^4 = 0.03 \text{ [kg·cm}^2\text{]}$$

Gear (load shaft)

$$J_{L4} = \frac{\pi \cdot \rho \cdot L}{32} \cdot D^4 \cdot \left(\frac{1}{n}\right)^2 = 0.8 \text{ [kg·cm}^2\text{]}$$

Full load inertia (converted into equivalent value on servo motor shaft)

$$J_L = J_{L1} + J_{L2} + J_{L3} + J_{L4} = 1.9 \text{ [kg·cm}^2\text{]}$$

For gravitational system of units

$$GD^2 = 4 \cdot J = 7.6 \text{ [kgf·cm}^2\text{]}$$

(7) Temporary selection of servo motor

Selection conditions

1) Load torque < servo motor rated torque

2) Full load inertia < 10 × servo motor inertia

From the above, the HC-PQ23 (200W) is temporarily selected.

11. SELECTION

(8) Acceleration/deceleration torque

Torque required for servo motor during acceleration

$$T_{Ma} = \frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4 \cdot T_{psa}} + T_L = 1.7 \text{ [N·m]}$$

Torque required for servo motor during deceleration

$$T_{Md} = -\frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4 \cdot T_{psd}} + T_L = -1.2 \text{ [N·m]}$$

For gravitational system of units

$$T_{Ma} = \frac{(GD_L^2 + GD_M^2) \cdot N_o}{37500 \cdot T_{psa}} + T_L = 17.2 \text{ [kgf·cm]}$$

$$T_{Md} = \frac{(GD_L^2 + GD_M^2) \cdot N_o}{37500 \cdot T_{psd}} + T_L = -12.4 \text{ [kgf·cm]}$$

The torque required for the servo motor during acceleration/deceleration must be lower than the servo motor's maximum torque.
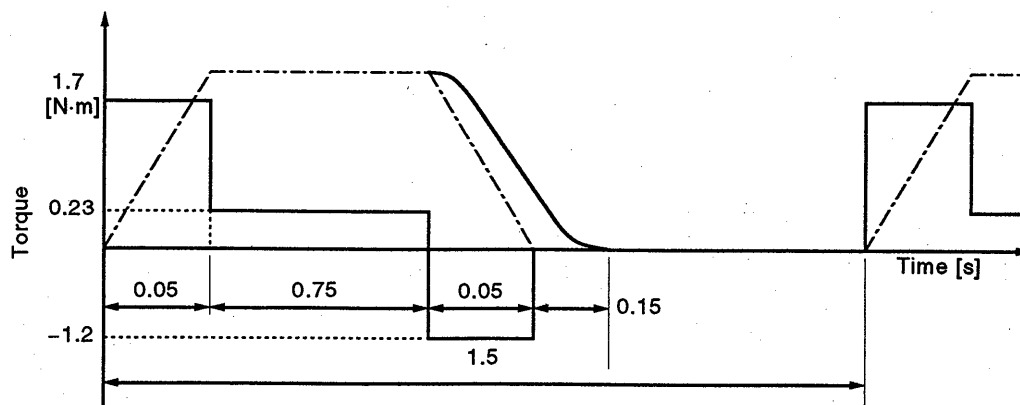
(9) Continuous effective load torque

$$T_{rms} = \sqrt{\frac{T_{Ma}^2 \cdot T_{psa} + T_L^2 \cdot t_c + T_{Md}^2 \cdot T_{psd}}{t_f}} = 0.41 \text{ [N·m]}$$

For gravitational system of units

4.2 [kgf·cm]

The continuous effective load torque must be lower than the servo motor's rated torque.

(10) Torque pattern

(11) Selection results

The servo motor HC-PQ23 and servo amplifier MR-C20A(1) are selected with the above conditions.

1) Electronic gear setting

Parameter No. 2	Command pulse multiplication numerator (CMX)	2
Parameter No. 3	Command pulse multiplication denominator (CDV)	1

2) During fast feed

- Servo motor speed............................$N_o = 3000$ r/min
- Input pulse train frequency..............$f_o = 100$ kpps

3) Acceleration/deceleration time constant

$T_{psa} = T_{psd} = 0.05$s

CHAPTER 12
OPTIONAL PRODUCTS

Products given in this chapter are available as options.
Please contact us for delivery time, prices, etc.
Items that are not described in this chapter are the same as in the standard models.

INTRODUCTION	CHAPTER 1
OPERATION	CHAPTER 2
WIRING	CHAPTER 3
INSTALLATION	CHAPTER 4
ADJUSTMENTS AND APPLICATION OPERATIONS	CHAPTER 5
OPTIONS AND AUXILIARY EQUIPMENT	CHAPTER 6
MAINTENANCE AND INSPECTION	CHAPTER 7
TROUBLESHOOTING	CHAPTER 8
CHARACTERISTICS	CHAPTER 9
SPECIFICATIONS	CHAPTER 10
SELECTION	CHAPTER 11
OPTIONAL PRODUCTS	CHAPTER 12

12. OPTIONAL PRODUCTS

12 – 1 Servo Motors with Special Flanges

The NEMA and stepping motor intercompatibility series are available as servo motors equipped with special flanges.
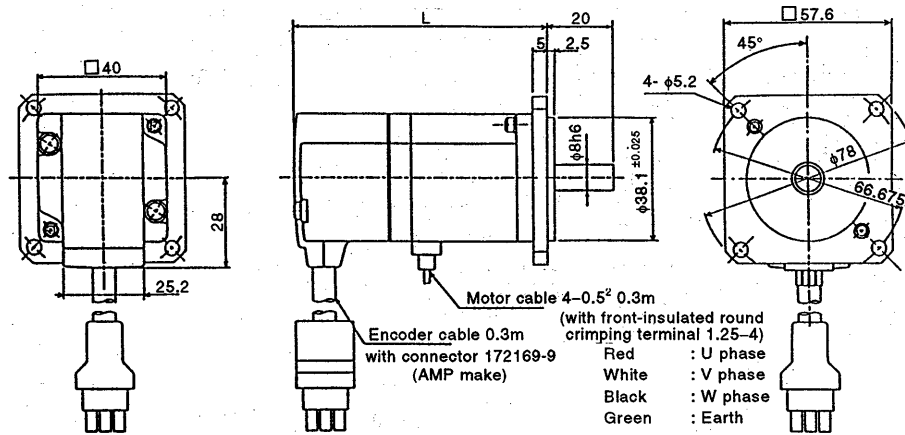
12 – 1 – 1 Model definition

HC-PQ ☐ 3 ☐ ☐ ☐

Series

Symbol	Description
-S1	NEMA flange type
-S5	NEMA flange type, UL/C-UL Standard-compliant
-S2	Stepping motor intercompatibility series
-S3	Stepping motor intercompatibility series, EN Standard-compliant
-S4	Stepping motor intercompatibility series, UL/C-UL Standard-compliant

Symbol	Shaft
None	Straight shaft
K	With key (200W or more)
D	D cut
L	L cut (200W or more)

Symbol	Electromagnetic brake
None	Without
B	With

Rated speed (3000r/min)

Symbol	Rated output [W]
03	30
05	50
1	100
2	200
4	400

12. OPTIONAL PRODUCTS

12 – 1 – 2 NEMA flange type

(1) Standard

> HC-PQ033-S1/-S5 to HC-PQ13-S1/-S5

Motor cable 4-0.5² 0.3m
(with front-insulated round crimping terminal 1.25–4)
Red   : U phase
White : V phase
Black : W phase
Green : Earth

Encoder cable 0.3m
with connector 172169-9
(AMP make)

[Unit: mm]

Model	Variable Dimension L	Inertia Moment GD²[kgf·cm²]	Weight [kg]
HC-PQ033-S1/-S5	70.5	0.057	0.37
HC-PQ053-S1/-S5	76.5	0.074	0.42
HC-PQ13-S1/-S5	91.5	0.12	0.55

> HC-PQ23-S1/-S5 · HC-PQ43-S1/-S5

Motor cable 4-0.5² 0.3m
(with front-insulated round crimping terminal 1.25–4)
Red   : U phase
White : V phase
Black : W phase
Green : Earth

Encoder cable 0.3m
with connector 172169-9
(AMP make)
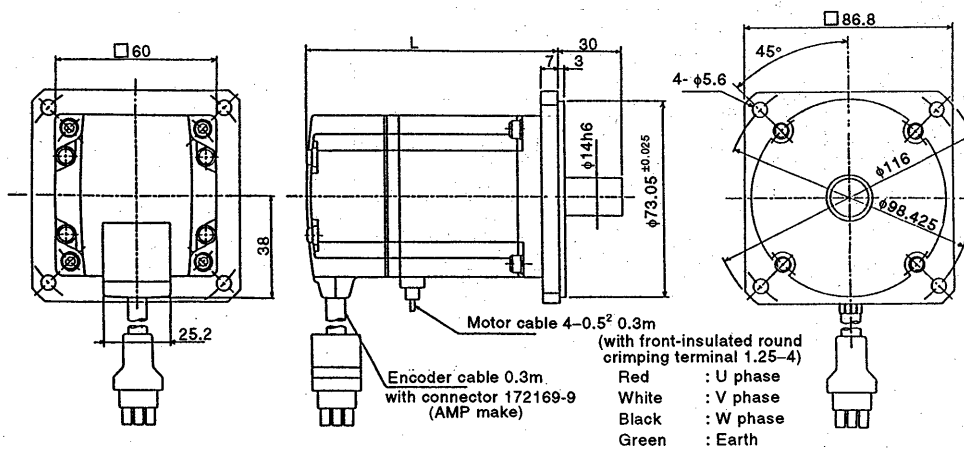
[Unit: mm]

Model	Variable Dimension L	Inertia Moment GD²[kgf·cm²]	Weight [kg]
HC-PQ23-S1/-S5	94	0.383	1.1
HC-PQ43-S1/-S5	119	0.383	1.55

12. OPTIONAL PRODUCTS
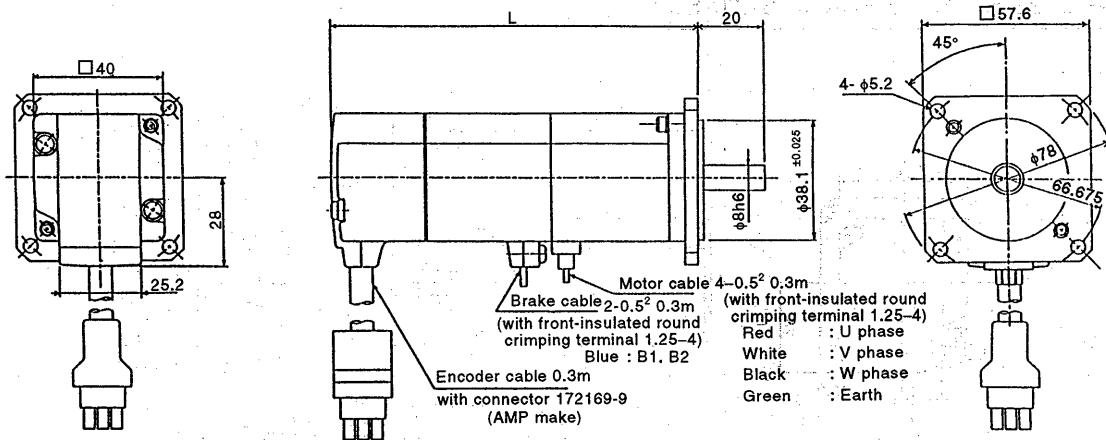
(2) With electromagnetic brake

HC-PQ033B-S1/-S5 to HC-PQ13B-S1/-S5

□40

28

25.2

L   20

φ38.1 ±0.025

φ8h6

□57.6

45°

4- φ5.2

φ78

66.67.5

Motor cable 4-0.5² 0.3m
(with front-insulated round
crimping terminal 1.25–4)
Red   : U phase
White   : V phase
Black   : W phase
Green   : Earth

Brake cable 2-0.5² 0.3m
(with front-insulated round
crimping terminal 1.25–4)
Blue : B1, B2

Encoder cable 0.3m
with connector 172169-9
(AMP make)

[Unit: mm]

Model	Variable Dimension L	Brake Static Friction Torque [N·m]	Inertia Moment GD²[kgf·cm²]	Weight [kg]
HC-PQ033B-S1/-S5	98.5	0.32	0.069	0.68
HC-PQ053B-S1/-S5	104.5	0.32	0.086	0.74
HC-PQ13B-S1/-S5	119.5	0.32	0.129	0.88

HC-PQ23B-S1/-S5 · HC-PQ43B-S1/-S5
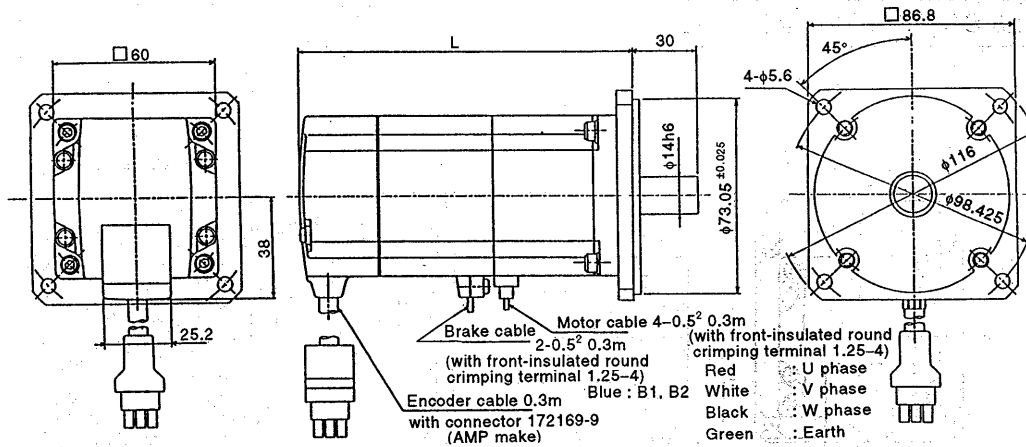
□60

38

25.2

L   30

φ14h6

φ73.05 ±0.025

□86.8

45°

4-φ5.6

φ116

φ98.425

Motor cable 4-0.5² 0.3m
(with front-insulated round
crimping terminal 1.25–4)
Red   : U phase
White   : V phase
Black   : W phase
Green   : Earth

Brake cable 2-0.5² 0.3m
(with front-insulated round
crimping terminal 1.25–4)
Blue : B1, B2

Encoder cable 0.3m
with connector 172169-9
(AMP make)

[Unit: mm]

Model	Variable Dimension L	Brake Static Friction Torque [N·m]	Inertia Moment GD²[kgf·cm²]	Weight [kg]
HC-PQ23B-S1/-S5	126	1.3	0.576	1.75
HC-PQ43B-S1/-S5	151	1.3	0.576	2.2

12. OPTIONAL PRODUCTS

12 – 1 – 3 NEMA flange type (in inches)

(1) Standard

HC-PQ033-S1/-S5 to HC-PQ13-S1/-S5

Motor cable 4–0.02² 11.8in
(with front-insulated round
crimping terminal 0.05–4)
Red   : U phase
White   : V phase
Black   : W phase
Green   : Earth

Encoder cable 11.8in
with connector 172169-9
(AMP make)
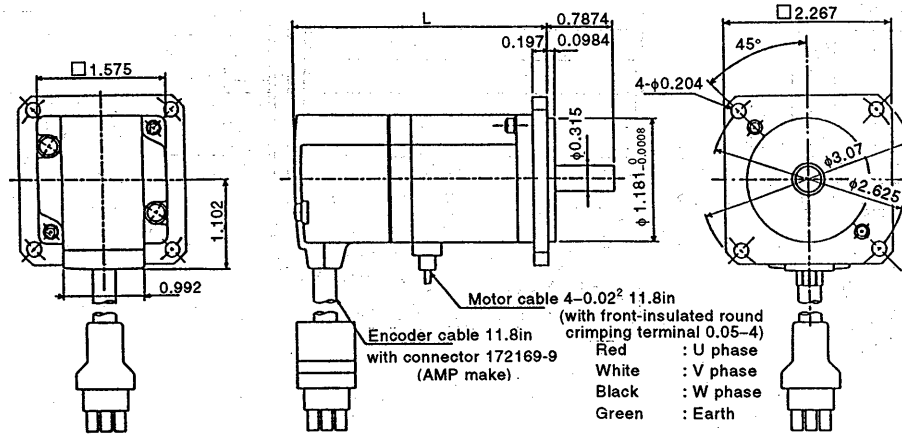
[Unit: in]

Model	Variable Dimension L	Inertia Moment GD²[oz·in²]	Weight [lb]
HC-PQ033-S1/-S5	2.775	0.077	0.82
HC-PQ053-S1/-S5	3.011	0.104	0.93
HC-PQ13-S1/-S5	3.602	0.164	1.2

HC-PQ23-S1/-S5 · HC-PQ43-S1/-S5

Motor cable 4–0.02² 11.8in
(with front-insulated round
crimping terminal 0.05–4)
Red   : U phase
White   : V phase
Black   : W phase
Green   : Earth

Encoder cable 11.8in
with connector 172169-9
(AMP make)
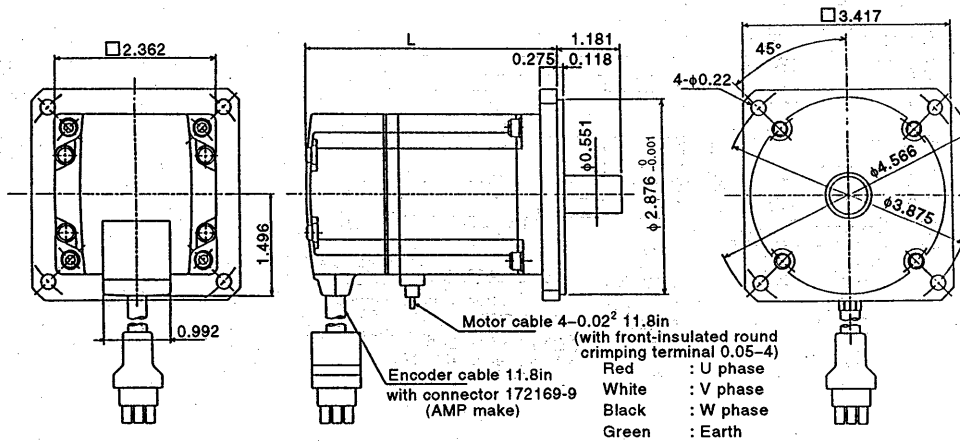
[Unit: in]

Model	Variable Dimension L	Inertia Moment GD²[oz·in²]	Weight [lb]
HC-PQ23-S1/-S5	3.701	0.487	2.4
HC-PQ43-S1/-S5	4.685	0.793	3.4

12. OPTIONAL PRODUCTS
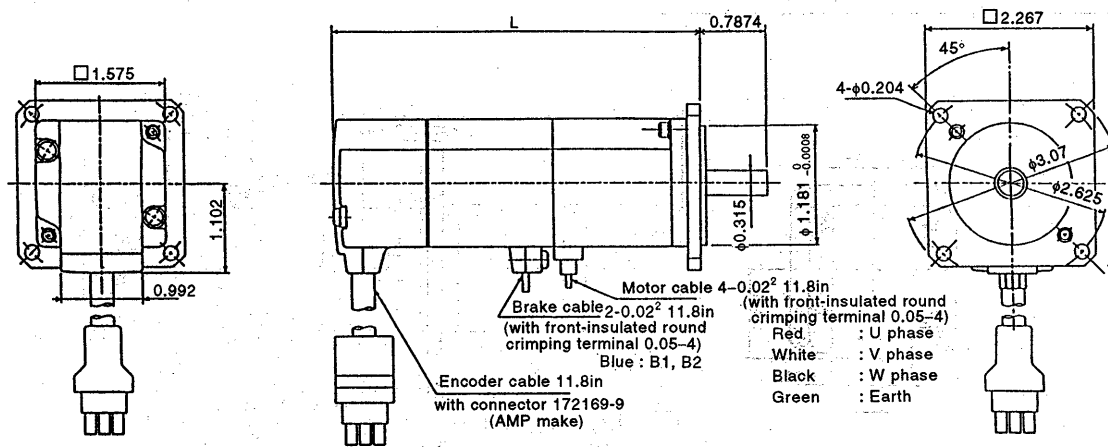
(2) With electromagnetic brake

HC-PQ033B-S1/-S5 to HC-PQ13B-S1/-S5

Brake cable 2-0.02² 11.8in
(with front-insulated round
crimping terminal 0.05-4)
Blue : B1, B2

Motor cable 4-0.02² 11.8in
(with front-insulated round
crimping terminal 0.05-4)
Red : U phase
White : V phase
Black : W phase
Green : Earth

Encoder cable 11.8in
with connector 172169-9
(AMP make)

[Unit: in]

Model	Variable Dimension L	Brake Static Friction Torque [oz·in]	Inertia Moment GD²[oz·in²]	Weight [lb]
HC-PQ033B-S1/-S5	3.878	45.3	0.094	1.5
HC-PQ053B-S1/-S5	4.114	45.3	0.117	1.6
HC-PQ13B-S1/-S5	4.705	45.3	0.176	1.9

HC-PQ23B-S1/-S5 · HC-PQ43B-S1/-S5
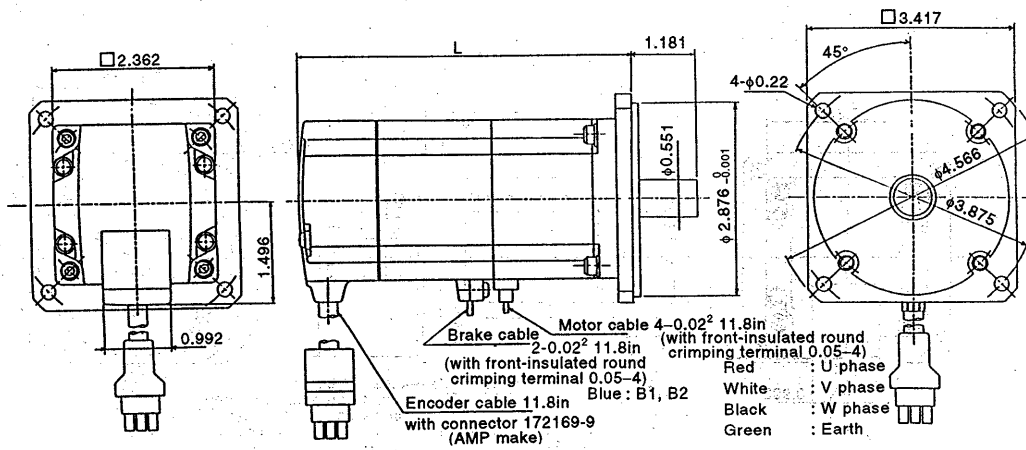
Brake cable 2-0.02² 11.8in
(with front-insulated round
crimping terminal 0.05-4)
Blue : B1, B2

Motor cable 4-0.02² 11.8in
(with front-insulated round
crimping terminal 0.05-4)
Red : U phase
White : V phase
Black : W phase
Green : Earth

Encoder cable 11.8in
with connector 172169-9
(AMP make)

[Unit: in]

Model	Variable Dimension L	Brake Static Friction Torque [oz·in]	Inertia Moment GD²[oz·in²]	Weight [lb]
HC-PQ23B-S1/-S5	4.961	184	0.790	3.86
HC-PQ43B-S1/-S5	5.945	184	0.790	4.85

12. OPTIONAL PRODUCTS

12 – 1 – 4 Stepping motor intercompatibility series

(1) Standard

| HC-PQ033-S2/-S3/-S4 to HC-PQ13-S2/-S3/-S4 |

Motor cable 4–0.5² 0.3m
(with front-insulated round crimping terminal 1.25–4)
Red : U phase
White : V phase
Black : W phase
Green : Earth

Encoder cable 0.3m with connector 172169-9 (AMP make)
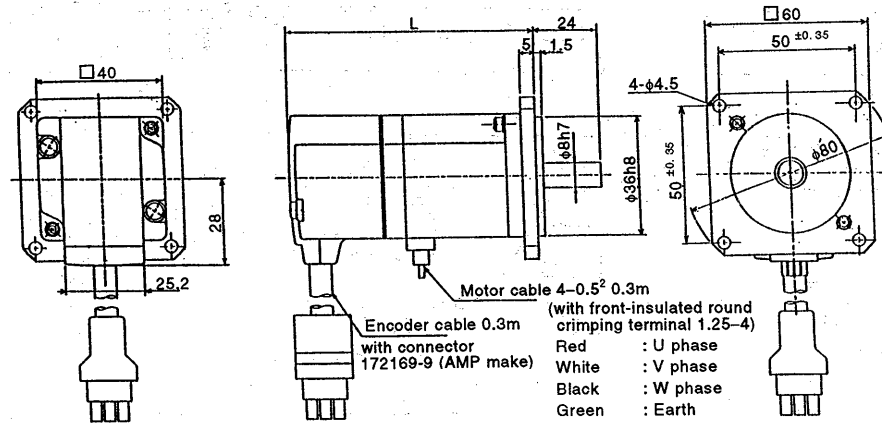
[Unit: mm]

Model	Variable Dimension L	Inertia Moment GD²[kgf·cm²]	Weight [kg]
HC-PQ033-S2/-S4	70.5	0.057	0.37
HC-PQ053-S2/-S4	76.5	0.074	0.42
HC-PQ13-S2/-S4	91.5	0.12	0.55
HC-PQ033-S3	78.5	0.057	0.4
HC-PQ053-S3	84.5	0.074	0.45
HC-PQ13-S3	99.5	0.12	0.58

| HC-PQ23-S2/-S3/-S4 · HC-PQ43-S2/-S3/-S4 |

Motor cable 4–0.5² 0.3m
(with front-insulated round crimping terminal 1.25–4)
Red : U phase
White : V phase
Black : W phase
Green : Earth

Encoder cable 0.3m with connector 172169-9 (AMP make)
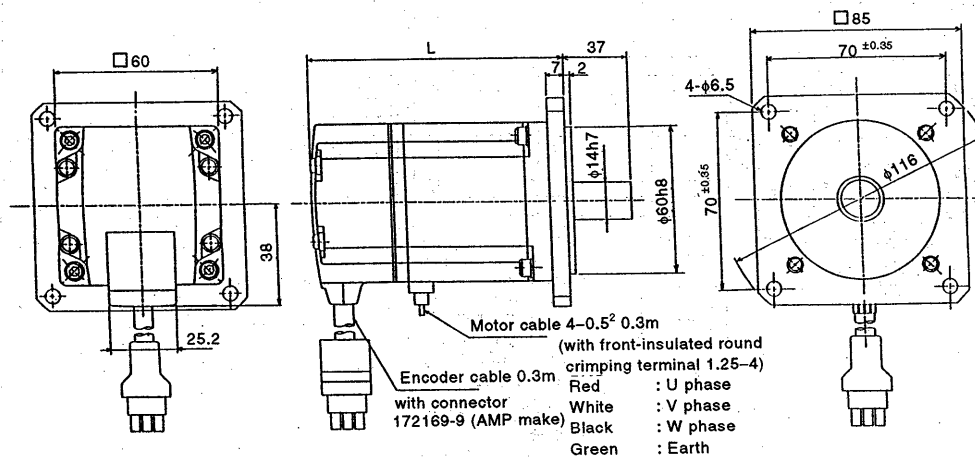
[Unit: mm]

Model	Variable Dimension L	Inertia Moment GD²[kgf·cm²]	Weight [kg]
HC-PQ23-S2/-S4	94	0.383	1.1
HC-PQ43-S2/-S4	119	0.383	1.55
HC-PQ23-S3	103	0.383	1.13
HC-PQ43-S3	128	0.383	1.58

(2) With electromagnetic brake

HC-PQ033B-S2/-S3/-S4 to HC-PQ13B-S2/-S3/-S4

Brake cable
2-0.5² 0.3m
(with front-insulated round
crimping terminal 1.25–4)
Blue : B1, B2

Motor cable 4-0.5² 0.3m
(with front-insulated round
crimping terminal 1.25–4)
Red   : U phase
White   : V phase
Black   : W phase
Green   : Earth

Encoder cable 0.3m
with connector
172169-9 (AMP make)
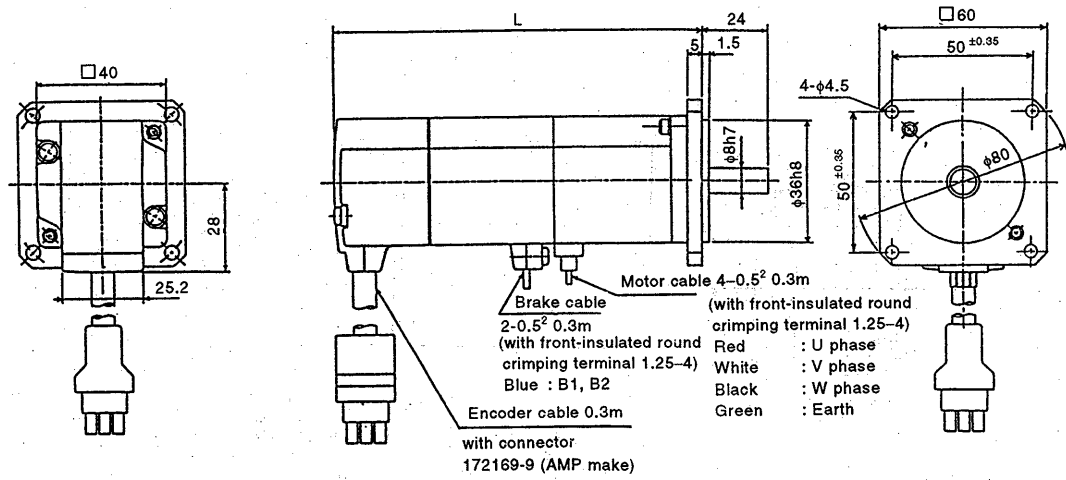
[Unit: mm]

Model	Variable Dimension L	Brake Static Friction Torque [N·m]	Inertia Moment GD²[kgf·cm²]	Weight [kg]
HC-PQ033B-S2/-S4	98.5	0.32	0.069	0.68
HC-PQ053B-S2/-S4	104.5	0.32	0.086	0.74
HC-PQ13B-S2/-S4	119.5	0.32	0.129	0.88
HC-PQ033B-S3	106.5	0.32	0.069	0.71
HC-PQ053B-S3	112.5	0.32	0.086	0.77
HC-PQ13B-S3	127.5	0.32	0.129	0.91

HC-PQ23B-S2/-S3/-S4 · HC-PQ43B-S2/-S3/-S4
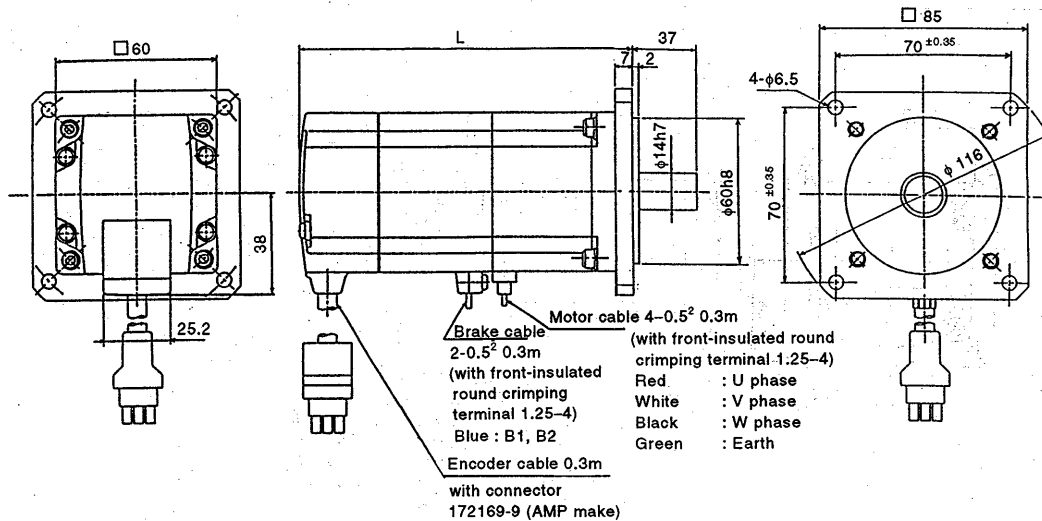
Brake cable
2-0.5² 0.3m
(with front-insulated
round crimping
terminal 1.25–4)
Blue : B1, B2

Motor cable 4-0.5² 0.3m
(with front-insulated round
crimping terminal 1.25–4)
Red   : U phase
White   : V phase
Black   : W phase
Green   : Earth

Encoder cable 0.3m
with connector
172169-9 (AMP make)

[Unit: mm]

Model	Variable Dimension L	Brake Static Friction Torque [N·m]	Inertia Moment GD²[kgf·cm²]	Weight [kg]
HC-PQ23B-S2/-S4	126	1.3	0.576	1.75
HC-PQ43B-S2/-S4	151	1.3	0.576	2.2
HC-PQ23B-S3	135	1.3	0.576	1.78
HC-PQ43B-S3	160	1.3	0.576	2.23

12. OPTIONAL PRODUCTS

12 – 1 – 5 Stepping motor intercompatibility series (in inches)

(1) Standard

HC-PQ033-S2/-S3/-S4 to HC-PQ13-S2/-S3/-S4
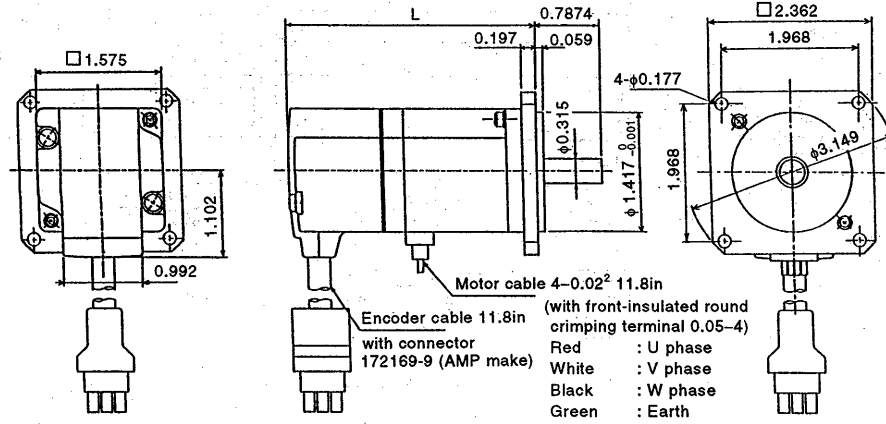
[Unit: in]

Model	Variable Dimension L	Inertia Moment GD²[oz·in²]	Weight [lb]
HC-PQ033-S2/-S4	2.775	0.0779	0.82
HC-PQ053-S2/-S4	3.012	0.1011	0.93
HC-PQ13-S2/-S4	3.602	0.164	1.2
HC-PQ033-S3	3.091	0.0779	0.88
HC-PQ053-S3	3.327	0.1011	1.0
HC-PQ13-S3	3.917	0.164	1.3

HC-PQ23-S2/-S3/-S4 · HC-PQ43-S2/-S3/-S4
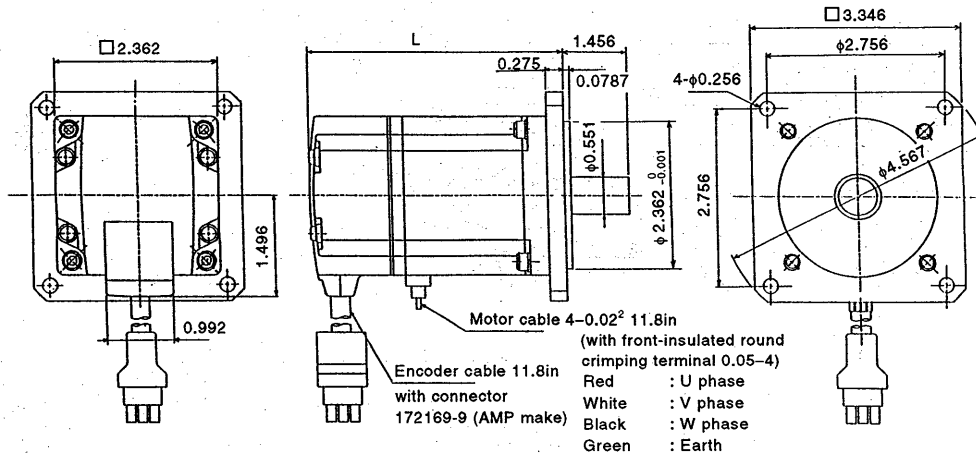
[Unit: in]

Model	Variable Dimension L	Inertia Moment GD²[oz·in²]	Weight [lb]
HC-PQ23-S2/-S4	3.7	0.478	2.4
HC-PQ43-S2/-S4	4.685	0.478	3.4
HC-PQ23-S3	4.055	0.478	2.5
HC-PQ43-S3	5.039	0.478	3.5

12. OPTIONAL PRODUCTS
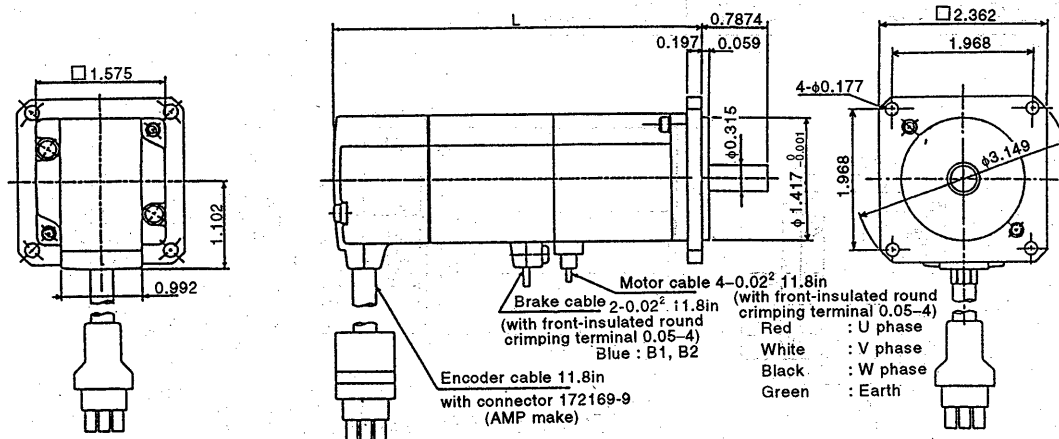
(2) With electromagnetic brake

HC-PQ033B-S2/-S3/-S4 to HC-PQ13B-S2/-S3/-S4

Motor cable 4-0.02² 11.8in
(with front-insulated round
crimping terminal 0.05-4)
Red : U phase
White : V phase
Black : W phase
Green : Earth

Brake cable 2-0.02² 11.8in
(with front-insulated round
crimping terminal 0.05-4)
Blue : B1, B2

Encoder cable 11.8in
with connector 172169-9
(AMP make)

[Unit: in]

Model	Variable Dimension L	Brake Static Friction Torque [oz·in]	Inertia Moment GD²[oz·in²]	Weight [lb]
HC-PQ033B-S2/-S4	3.878	45.3	0.094	1.5
HC-PQ053B-S2/-S4	4.114	45.3	0.117	1.6
HC-PQ13B-S2/-S4	4.704	45.3	0.176	1.9
HC-PQ033B-S3	4.193	45.3	0.094	1.6
HC-PQ053B-S3	4.429	45.3	0.117	1.7
HC-PQ13B-S3	5.020	45.3	0.176	2.0

HC-PQ23B-S2/-S3/-S4 · HC-PQ43B-S2/-S3-/S4
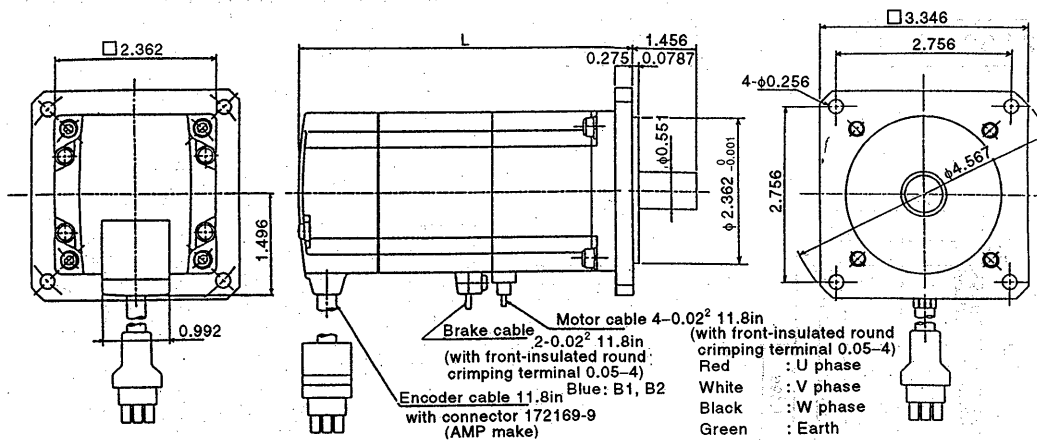
Motor cable 4-0.02² 11.8in
(with front-insulated round
crimping terminal 0.05-4)
Red : U phase
White : V phase
Black : W phase
Green : Earth

Brake cable 2-0.02² 11.8in
(with front-insulated round
crimping terminal 0.05-4)
Blue : B1, B2

Encoder cable 11.8in
with connector 172169-9
(AMP make)

[Unit: in]

Model	Variable Dimension L	Brake Static Friction Torque [oz·in]	Inertia Moment GD²[oz·in²]	Weight [lb]
HC-PQ23B-S2/-S4	5.039	184	0.790	3.9
HC-PQ43B-S2/-S4	5.945	184	0.790	4.9
HC-PQ23B-S3	5.315	184	0.790	4.0
HC-PQ43B-S3	6.299	184	0.790	4.9

12. OPTIONAL PRODUCTS

12 – 2 5V Pulse Train Input Servo Amplifiers

Servo amplifiers with 5V pulse train input are available.

12 – 2 – 1 Model definition

MR-C☐A☐☐☐

Series

Symbol	Compliance with Standard
None	Standard (in Japan)
-UE	EN Standard-, UL/C-UL Standard-compliant models

Symbol	Input Pulse Train Voltage
None	Standard (24V)
-L	5V

Symbol	Power supply
None	Single-phase 200V
(Note) 1	Single-phase 100V

Note: Unavailable for MR-C40A.

Symbol	Applicable servo motor
10	HC-PQ033/53/13
20	HC-PQ23
40	HC-PQ43
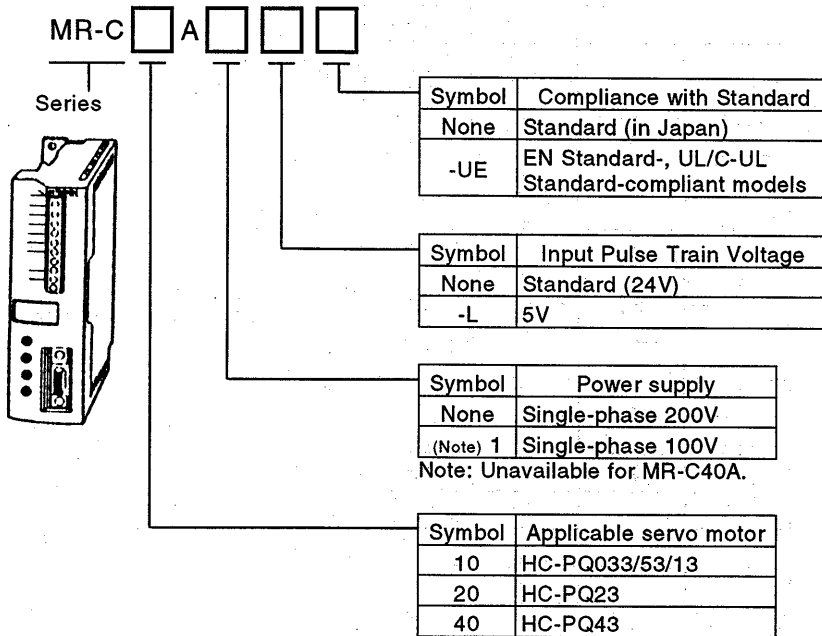
12. OPTIONAL PRODUCTS

12 – 2 – 2 Signal connectors

(1) Connector pin layout

CN1 (I/O signal connector)
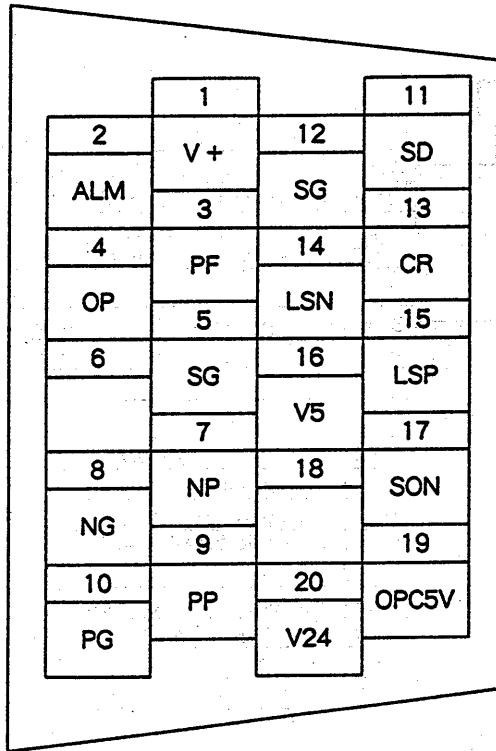
Molex make
52986-2011 or equivalent

MEMO-RANDUM	The connector pin layouts are views looked from the cable connector wiring section.

(2) Explanation of the connector pins (CN1A)

Signal	Symbol	Connector Pin No.	Functions/Applications	I/O Division (Note)
Open collector power input	OPC5V	19	When inputting a pulse train in the open collector system, supply this terminal with (+) 5VDC.	

12 – 2 – 3 Inter faces

Pulse train input interface DI-2 [Open collector system]

- Interface example
- Input pulse specification

Servo amplifier

Max. input pulse frequency 200kpps
About 150Ω
About 10mA

$tLH = tHL < 0.2 \mu s$
$tc > 2 \mu s$
$tF > 3 \mu s$
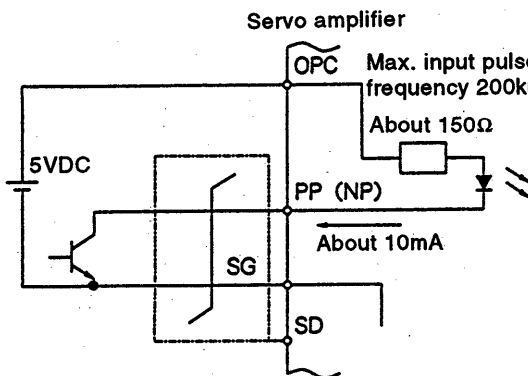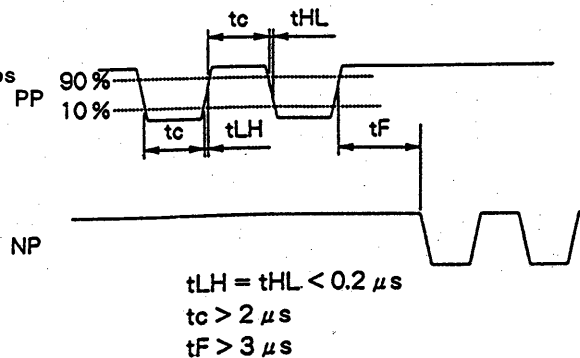
12. OPTIONAL PRODUCTS

12 – 2 – 4 Common Line

The power supply and its common line are shown below.
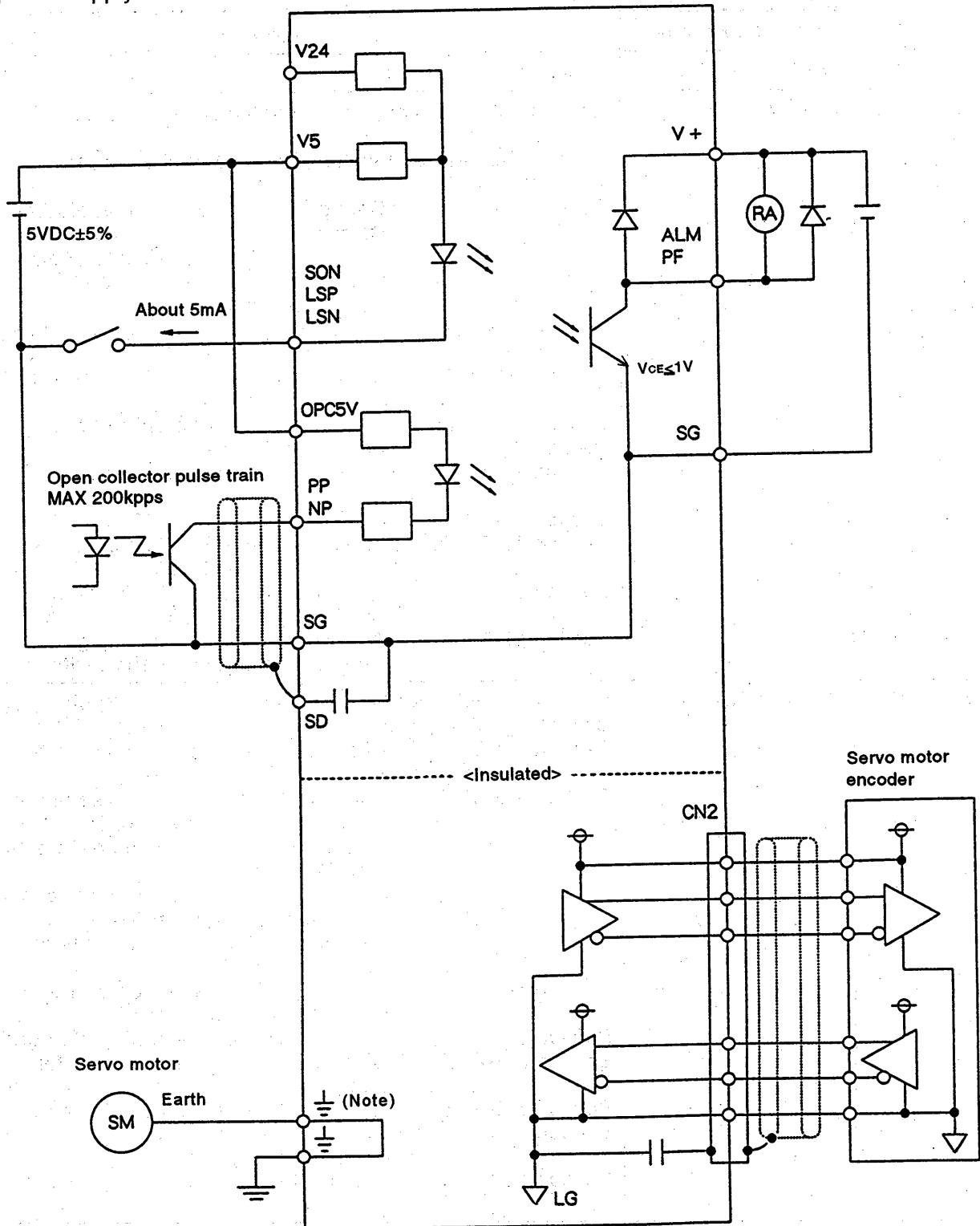
Note: When using EN Standard-, UL/C-UL Standard-compliant models, use the protective earth (PE) terminals.

REVISIONS

Print Date	*Manual Number	Revision
Dec., 1996	SH (NA) 3167-A	First edition
Aug., 1997	SH (NA) 3167-B	Addition of instructions for conformance with the UL/C-UL Standard Specification value of single-phase 100V changed to 100-120VAC Section 2-1-4 : Change made to connection diagram Section 2-3-5 (4) : Correction made to SON signal function selection in parameter No. 6 Section 3-1-2 (2), 1): Correction made to LSP, LSN parameter settings Section 3-1-3 (1) : Correction made to parameter No. 6 setting Section 6-1-2 : Change made to encoder cables in 1), 2) Section 6-1-2 (2), 1): Addition of MR-JCCBL2M-L/H Section 6-2-1 : Addition of torque Section 10-1 (2) : Change made to max. torque of HC-PQ43 Section 10-3-1 : Addition of MR-C40A-UE Section 10-3-2 (2) : Change made to inertia moment of HC-PQ13B/HC-PQ43B Section 10-3-2 (3) : Change made to LL dimension of HC-PQ43(B)G1(-EC/UL) Section 10-5 : Correction made to machining dimension diagram for shaft with key
Feb., 1999	SH(NA)3167-C	Conformity with the EC Directives: Chapter 1, (8) changed Conformity with the UL/C-UL Standard: (2) changed. Section 1-1 (2) : Change made to the models for the EN·UL/C-UL Standard. Section 2-3-5 (4) : Addition of low acoustic noise mode selection to parameter No. 0 Change made to machine selection in parameter No. 1 Change made to machine resonance frequency in parameter No. 24 Reconsideration of the contents of parameter No. 30 Section 3-1-1 (2) : Addition to the description of the main circuit power supply Section 5-1-1 : Addition of response setting changes Section 5-2-2 (1) 1) : Change made to Control Mode for proportional control Section 5-2-6 : Addition of low acoustic noise mode Section 10-2 : Correction made to the torque characteristic graph Section 10-2-2 : Addition of data in the low acoustic noise mode

6. OPTIONS AND AUXILIARY EQUIPMENT

⚠ WARNING	Before connecting any option or auxiliary equipment, confirm the voltage, etc. with a tester more than 10 minutes after power-off. Otherwise, you may get an electric shock.

⚠ CAUTION	Use the specified auxiliary equipment and options. Unspecified ones may lead to a fault or fire.

6 – 1 Dedicated Options

6 – 1 – 1 Regenerative brake option

(1) Judgment of whether this option is required or not

The regenerative brake option is not required for the servo motors in the following cases:

1) HC-PQ033, 053

Except for continuous occurrence of regeneration in a vertical motion application or the like, the regenerative brake option is not required. At this time, there is no limit to the frequency of regeneration.

2) HC-PQ13, 23, 43

Except for continuous occurrence of regeneration in a vertical motion application or the like, the regenerative brake option is not required when the servo motor is run in the left-hand side area of the curves in the following chart. At this time, there is no limit to the frequency of regeneration. (For the HC-PQ23, the characteristic varies according to the input power supply voltage.)
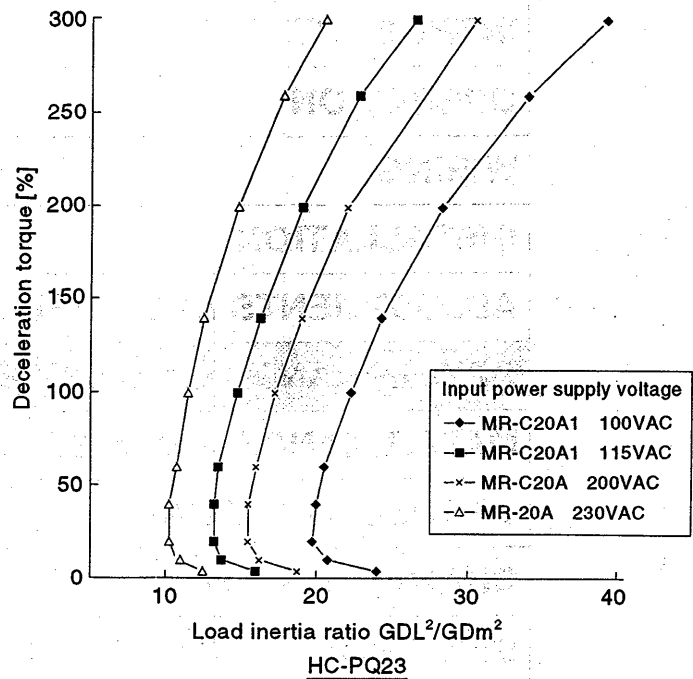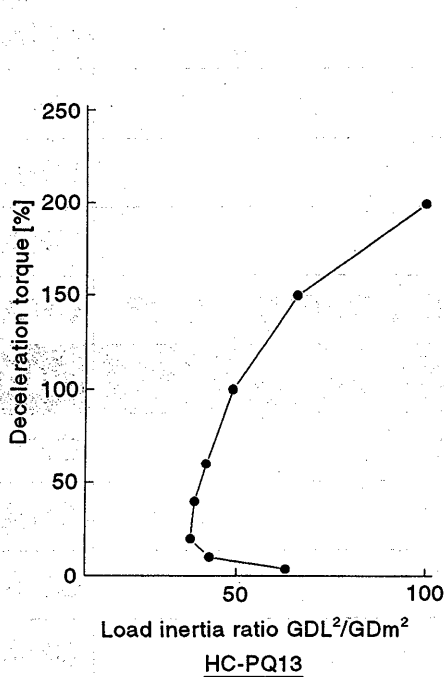
HC-PQ13

Input power supply voltage
—◆— MR-C20A1 100VAC
—■— MR-C20A1 115VAC
—×— MR-C20A 200VAC
—△— MR-20A 230VAC

HC-PQ23

Note: If the input power supply voltage may become higher than the power supply voltage indicated in this graph, reduce the load inertia ratio or use the regenerative brake option.

Input power supply voltage
- ◆ MR-C40A 200VAC
- ■ MR-C40A 230VAC

Load inertia moment ratio GDL²/GDm²
HC-PQ43
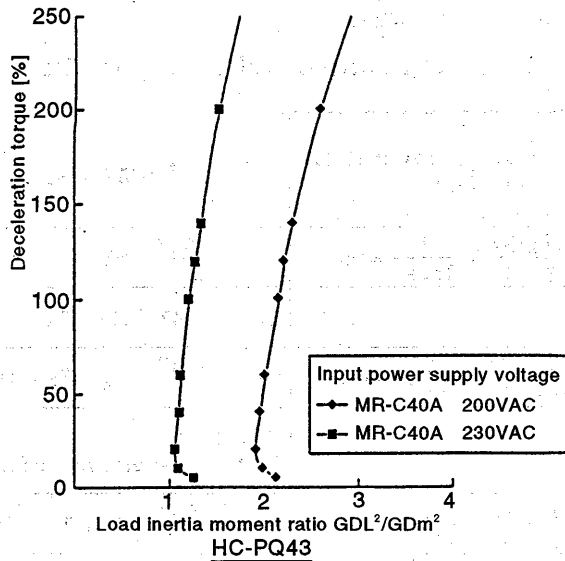
Note: If the input power supply voltage may become higher than the power supply voltage indicated in this graph, reduce the load inertia ratio or use the regenerative brake option.

(2) Selection of the regenerative brake option

When it has been determined that the regenerative brake option is required in (1), select the regenerative brake option as described below.

1) Simple selection method

In horizontal motion applications, select the regenerative brake option as described below:

When the servo motor is run alone in the regenerative mode from the running speed to a stop, the permissible duty is as indicated in Section 10-1 "Standard Specifications". When a load is connected, the permissible duty changes according to the inertia of the load and can be calculated by the following formula:

$$\text{Permissible duty} = \frac{\text{permissible duty for operation of the servo motor alone (value indicated in Section 10-1)}}{(m+1)} \times \left(\frac{\text{rated speed}}{\text{running speed}}\right)^2 \text{ [times/minute]}$$

where m = load inertia/servo motor inertia

From the permissible duty, find whether the regenerative brake option is required or not.

Permissible duty > number of positioning times n1 [times/minute]

Between the MR-RB013 and MR-RB033, select the one which satisfies the above formula.

2) To make selection according to regenerative energy

Use the following method when regeneration occurs continuously in vertical motion applications or when it is desired to make an in-depth selection of the regenerative brake option:

a) Use the following table to calculate the regenerative energy.
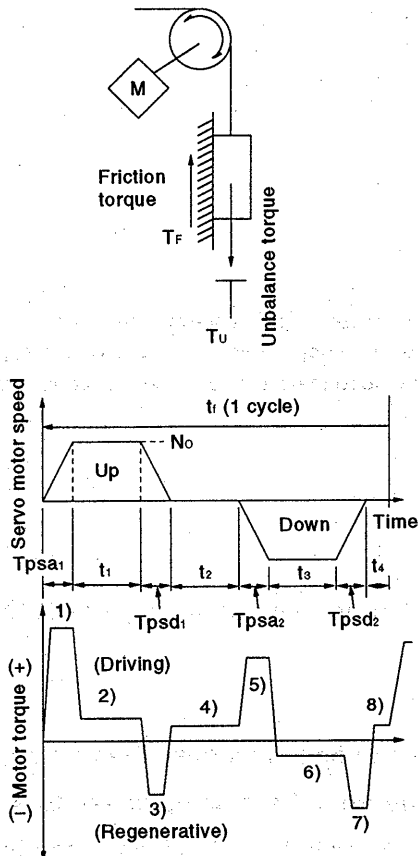
Formulas for Calculating Torque and Energy for Operation

Opera-tion Region	Torque Applied to Servo Motor T [N·m]	Energy E [J]
1)	$T_1 = \dfrac{(J_L+J_M) \cdot N_0}{9.55 \times 10^4} \cdot \dfrac{1}{T_{psa1}} + T_U + T_F$	$E_1 = \dfrac{0.1047}{2} \cdot N_0 \cdot T_1 \cdot T_{psa1}$
2)	$T_2 = T_U + T_F$	$E_2 = 0.1047 \cdot N_0 \cdot T_2 \cdot t_1$
3)	$T_3 = \dfrac{(J_L+J_M) \cdot N_0}{9.55 \times 10^4} \cdot \dfrac{1}{T_{psd1}} + T_U + T_F$	$E_3 = \dfrac{0.1047}{2} \cdot N_0 \cdot T_3 \cdot T_{psd1}$
4), 8)	$T_4 = T_U$	$E_4 \geq 0$ (Not in regenerative mode.)
5)	$T_5 = \dfrac{(J_L+J_M) \cdot N_0}{9.55 \times 10^4} \cdot \dfrac{1}{T_{psa2}} - T_U + T_F$	$E_5 = \dfrac{0.1047}{2} \cdot N_0 \cdot T_5 \cdot T_{psa2}$
6)	$T_6 = T_U + T_F$	$E_6 = 0.1047 \cdot N_0 \cdot T_6 \cdot t_3$
7)	$T_7 = \dfrac{(J_L+J_M) \cdot N_0}{9.55 \times 10^4} \cdot \dfrac{1}{T_{psd2}} - T_U + T_F$	$E_7 = \dfrac{0.1047}{2} \cdot N_0 \cdot T_7 \cdot T_{psd2}$
Sum total of regenerative energies Es		Sum total of negative energies in 1) to 8) Es

b) Losses of servo motor and servo amplifier in regenerative mode

The following table lists the efficiencies and other data of the servo motor and servo amplifier in the regenerative mode.

Servo Motor	Inverse Efficiency [%]	Amplifier Loss [W]	Capacitor Charging [J]
HC–PQ033	35		
HC–PQ053	55		
HC–PQ13	55	1	4
HC–PQ23	70		
HC–PQ43	85		8

Inverse efficiency (η) : Efficiency including some efficiencies of the servo motor and servo amplifier when rated (regenerative) torque is generated at rated speed. Since the efficiency changes according to the speed and generated torque, allow for about 10%.

Servo amplifier loss (E_A): Loss consumed in the servo amplifier. Convert this loss into regenerative energy in accordance with the following expression:

$$E_A \text{ [Joule]} = P \text{ [W]} \cdot t \text{ [s]}$$

where t : regenerative operation time, not including driving time

6. OPTIONS AND AUXILIARY EQUIPMENT

Capacitor charging (Ec) : Energy charged into the electrolytic capacitor in the servo amplifier.

Subtract the servo amplifier loss from the inverse efficiency to calculate the energy consumed by the regenerative brake option.

$$E_R \text{ [Joule]} = \eta \cdot E_S - E_A - E_C$$

Calculate the consumption power of the regenerative brake option on the basis of single-cycle operation period t_f [s] to select the regenerative brake option.
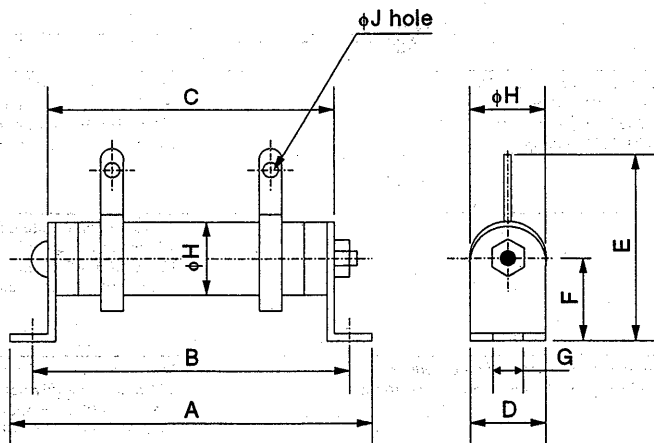
$$P_R \text{ [W]} = E_R/t_f \text{ ....(6-1)}$$

(3) Connection of the regenerative brake option

The regenerative brake option used should be connected as shown below:
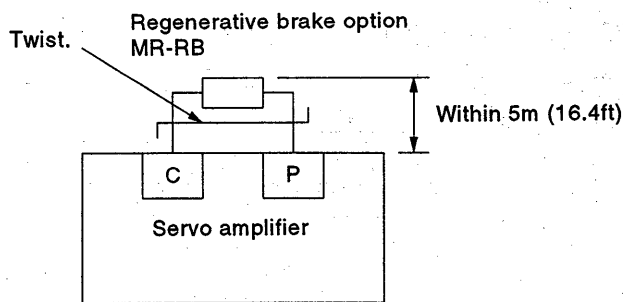
(4) Outline drawing

By removing the mounting brackets, the MR-RB013 can be installed as shown below.
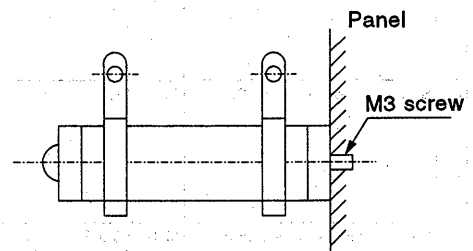
Regenerative Brake Option Model	Regenerative Power [W]	Variable Dimensions [mm] ([in])									Weight [kg] ([lb])	Resistance [Ω]
		A	B	C	D	E	F	G	H	J		
MR-RB013	10	110 (4.33)	101 (3.98)	85 (3.35)	18 (0.71)	35 (1.38)	16 (0.63)	4.5 (0.18)	18 (0.71)	3.2 (0.13)	0.1 (0.2)	52
MR-RB033	30	192 (7.56)	173 (6.81)	152 (5.98)	26 (1.02)	54 (2.13)	22 (0.87)	6 (0.24)	26 (1.02)	3.2 (0.13)	0.2 (0.4)	52

6. OPTIONS AND AUXILIARY EQUIPMENT

6 – 1 – 2 Cable connectors

- Use the encoder cable 1) or 2) after confirming the required wiring length. When the encoder cable is to be fabricated by yourself, use the encoder connector set 3) and refer to (2) in this section.

- To connect the control signals, they may either be exported directly using the CN1 connector 4) or via the CN1-junction terminal block cable 5) to the junction terminal block 9). Use the options according to the connection method.

- To use the RS-232C communication function, use the RS-232C option unit 8) and the communication cable 6) or 7) which matches the personal computer used.
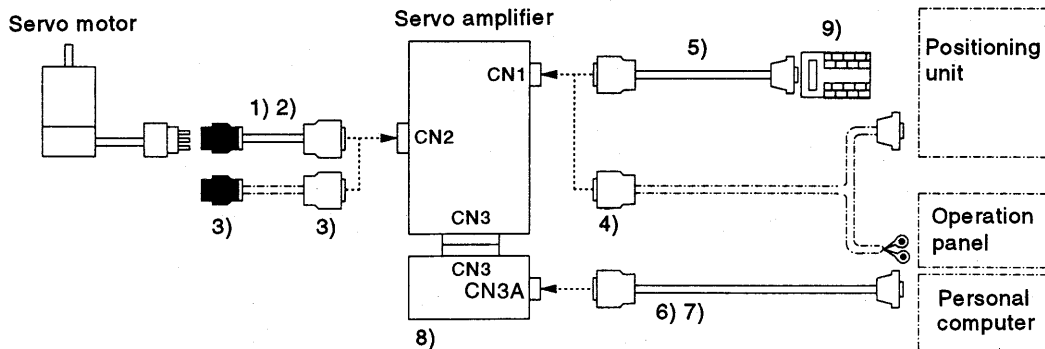
		Model	Product	Description		
Use one of these for CN2	1)	Standard encoder cable for HC-PQ series	MR-JCCBL□M-L Cable length in □: 2, 5, 10, 20, 30 [m]	Servo motor encoder	Servo motor encoder side connector (AMP make) 1-172161-9 (housing)	Servo amplifier side connector (3M make or equivalent) 10120-3000VE (connector) 10320-52F0-008 (Shell kit)
	2)	Highly-flexible, long-life encoder cable for HC-PQ series	MR-JCCBL□M-H Cable length in □: 2, 5, 10, 20, 30, 40, 50 [m]			
	3)	Encoder connector for HC-PQ series	MR-CCNS	Junction connector (AMP make) 1-172161-9 (housing) 170359-1 (connector) MTI-0002 (clamp)		Servo amplifier side connector (3M make or equivalent) 10120-3000VE (connector) 10320-52F0-008 (Shell kit)
Use one of these for CN1	4)	Select one of these for CN1	MR-CCN1			Servo amplifier side connector (3M make or equivalent) 10120-3000VE (connector) 10320-52F0-008 (Shell kit)
	5)	Cable for junction terminal block	MR-CTBL05M Cable length: 0.5[m]	Junction terminal block side connector HIF3BA-20D-2.54R (Horose Electric make)		Servo amplifier side connector (3M make or equivalent) 10120-6000EL (connector) 10320-3210-000 (shell kit)
For CN3	6)	Communication cable for PC98	MR-CPC98CBL3M Cable length: 3[m]	RS-232C option side connector (3M make or equivalent) 10120-6000VE(Connector) 10320-3210-000 (Shell kit)		PC98 series personal computer side connector (Japan Aviation Electonics) DE-25PF-N (Connector) DE-C2-J9 (Shell kit)
	7)	Communication cable for DOS/V	MR-CPCATCBL3M Cable length: 3[m]	RS-232C option side connector (3M make or equivalent) 10120-6000VE(Connector) 10320-3210-000 (Shell kit)		DOS/V personal computer side connector (Japan Aviation Electonics) DE-9SF-N (Connector) DE-C1-J6-S6 (Shell kit)
	8)	RS-232C option unit	MR-C-T01	Refer to Section 6 – 1 – 5.		
	9)	Junction terminal block	MR-TB20	Refer to Section 6 – 1 – 3.		

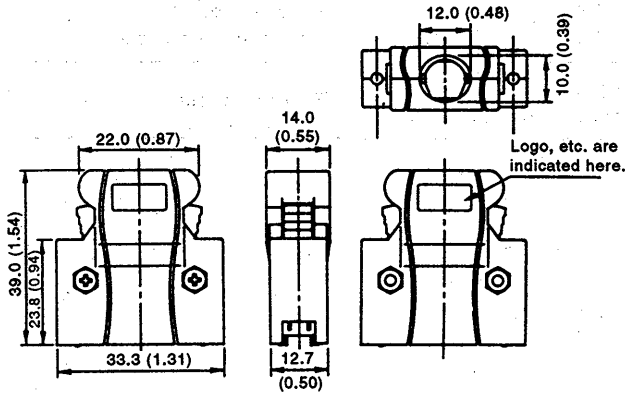# 6. OPTIONS AND AUXILIARY EQUIPMENT

(1) Connector outline drawings

[Unit: mm]

Servo amplifier Connector for CN1, CN2 RS-232C option unit Connector for CN3A (Sumitomo 3M make)	Junction connector for encoder (Nippon AMP make)
Model Connector : 10120-3000VE Shell kit : 10320-52F0-008	Model Housing : 1-172161-9 Connector pin : 170359-1 Crimp termination tool : 755330-1

12.0 (0.48) 10.0 (0.39)

14.0 (0.55)

22.0 (0.87)

Logo, etc. are indicated here.

39.0 (1.54) 23.8 (0.94)

33.3 (1.31) 12.7 (0.50)

14 (0.55) 23.7 (0.93)

14 (0.05) 4.2 (0.17) 16 (0.63)

4.2 (0.17)

Model
Connector : 10120-6000EL
Shell kit : 10320-3210-000

[Unit: mm (in)]
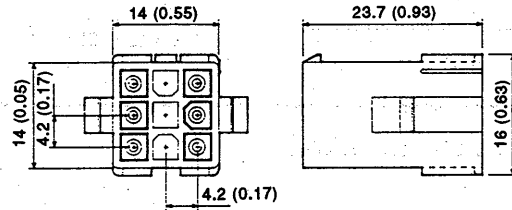
MEMO RANDUM The crimp termination tool is required for wiring to the connector. For the crimp termination tool, contact Nippon AMP.

φ6.7 (0.26) 11.5 (0.45)

20.9 (0.82)
2-φ0.5 (0.02)

Logo, etc. are indicated here.

33.0 (1.30) 42.0 (1.65)

29.7 (1.17)

6. OPTIONS AND AUXILIARY EQUIPMENT

(2) Assembling of cable

The specifications and connection of each cable are indicated below. A fabricated cable should be as specified in this section or equivalent and connected correctly. Use the cable conforming to the following list.

Size [mm²]	Lead Insulation Sheath OD (Note) d[mm(in)]	Recommended Wire Model	Cable Type
0.2	0.9 to 1.27 (0.04 to 0.05)	UL2076 AWG28 7pair (BLACK)	Encoder cable Communication cable
0.3		UL2076 AWG24 7pair (BLACK)	Encoder cable

Note: d is as shown below.

Sectional view of lead
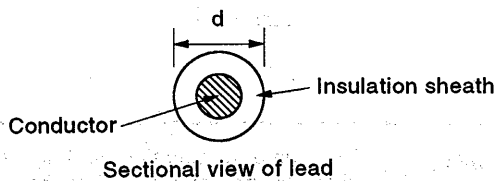
For the connector CN1, CN2 or CN3A, connect the external conductor of the shielded cable to the ground plate securely as shown below.

a. Termination of external conductor

Strip the sheath.

Pull back the external conductor to cover the sheath.
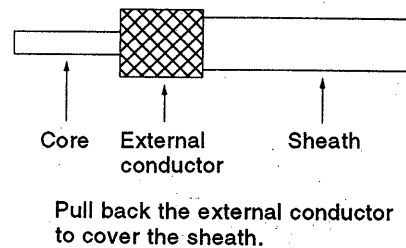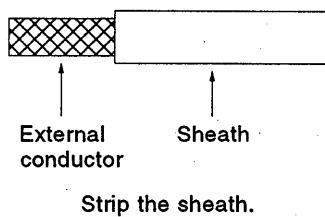
b. Fitting of the ground plate
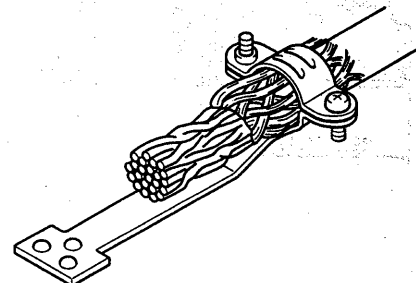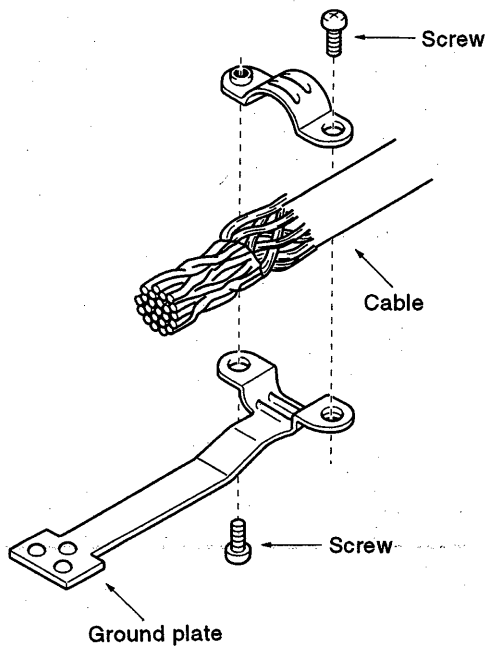
6. OPTIONS AND AUXILIARY EQUIPMENT

1) Encoder cable

Optional cables

MR-JCCBL2M-L	MR-JCCBL10M-L	MR-JCCBL10M-H
MR-JCCBL5M-L	to	to
MR-JCCBL2M-H	MR-JCCBL30M-L	MR-JCCBL50M-H
MR-JCCBL5M-H		

Servo amplifier side / Encoder side

First diagram:
P5 19 — 7
LG 11
P5 20
LG 12
MR 7 — 8/1
MRR 17 — 2
MD 6 — 4
MDR 16 — 5
BT 9 — 3
LG 1
SD Plate — 9

Second diagram:
P5 19 — 7
LG 11
P5 20
LG 12
P5 18
LG 2
P5 10
LG 3 — 8
MR 7 — 1
MRR 17 — 2
MD 6 — 4
MDR 16 — 5
BT 9 — 3
LG 1
SD Plate — 9

Third diagram:
P5 19 — 7
LG 11
P5 20
LG 12
P5 18
LG 2
10
3 — 8
MR 7 — 1
MRR 17 — 2
MD 6 — 4
MDR 16 — 5
BT 9 — 3
LG 1
SD Plate — 9
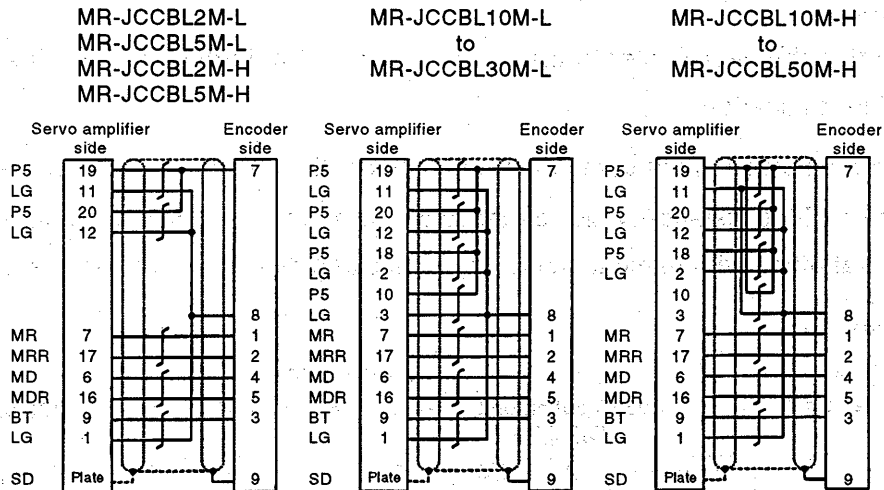
For fabrication

• Connection distance of less than 10m (32ft)

Encoder side / Servo amplifier side

P5 7 — 19 P5 / 11 / 20 / 12
LG 8
MR 1 — 7 MR
MRR 2 — 17 MRR
MD 4 — 6 MD
MDR 5 — 16 MDR
SHD 9 — Plate SHD

• Connection distance of 10m (32ft) to 50m (164ft)

Encoder side / (Note) / Servo amplifier side

P5 7 — 19 P5 / 11 LG / 20 P5 / 12 LG / 10 P5 / 3 LG / 18 P5 / 2 LG
LG 8
MR 1 — 7 MR
MRR 2 — 17 MRR
MD 4 — 6 MD
MDR 5 — 16 MDR
SHD 9 — Plate SHD
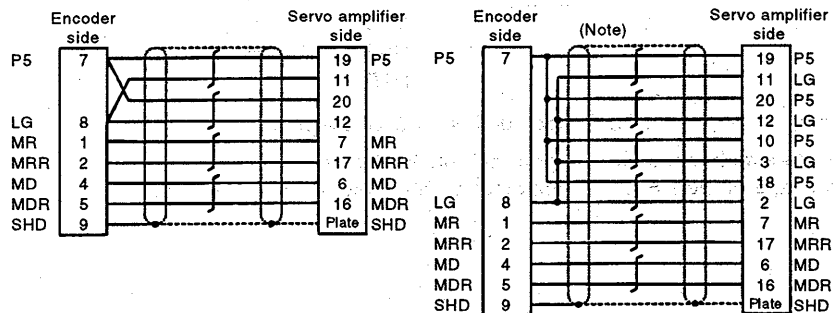
Note: When 0.3mm² (AWG22) wires are used, three wires are connected to each of P5 and LG.

2) Junction terminal block cable

Junction terminal block side / Servo amplifier side (CN1 side)

(Note) Terminal Block Label For CN1	Junction Terminal Block Terminal No.	Pin No.		Pin No.
V+	10	B1		1
ALM	0	A1		2
PF	11	B2		3
OP	1	A2		4
SG	12	B3		5
x	2			6
NP	13	B4		7
NG	3	A4		8
PP	14	B5		9
PG	4	A5		10
SG	5	A6		12
CR	16	B7		13
LSN	6	A7		14
LSP	17	B8		15
V5	7	A8		16
SON	18	B9		17
x	8			18
OPC	19	B10		19
V24	9	A10		20
SD	15	B6		11
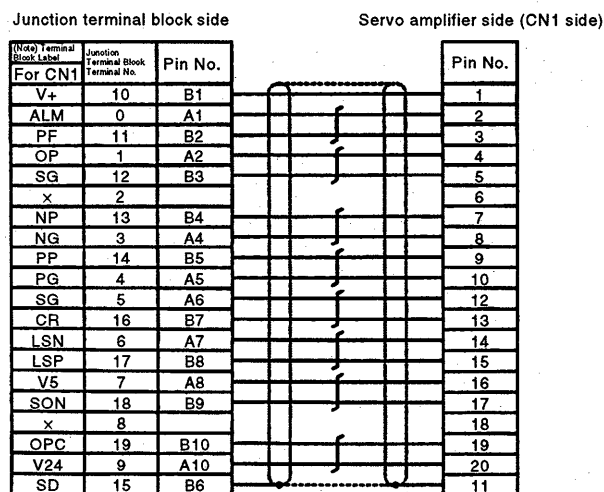
Note: Label for position control mode.
Signals change with the parameter setting and control mode.
Use the accessory signal seals to change the signal abbreviations.

3) Communication cable

NOTICE	This cable may not be used with some personal computers. After fully examining the signals of the RS-232C connector, refer to this section and fabricate the cable.

Select the communication cable according to the RS-232C connector shape of the personal computer used.

When fabricating the cable, refer to the connection diagram in this section. The following must be observed in fabrication:

• Always use a shielded, multi-core cable and connect the shield with FG securely.

• The maximum wiring distance, which depends on the surrounding environment, is 15m in a well-environmental office with minimal noise. Use the cable over the shortest possible distance.

Connection diagram

• MR-CPC98CBL3M

Personal computer side			RS232C option unit
		Plate	FG
SD	2	2	RXD
		1	GND
RD	3	12	TXD
SG	7	11	GND
RS	4		
CS	5		
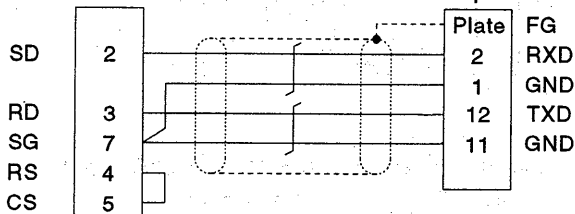
D-SUB25 pins (Note)   Half-pitch 20 pins

• MR-CPCATCBL3M

Personal computer side			RS232C option unit
		Plate	FG
TXD	3	2	RXD
		1	GND
RXD	2	12	TXD
GND	5	11	GND
RTS	7		
CTS	8		
DSR	6		
DTR	4		
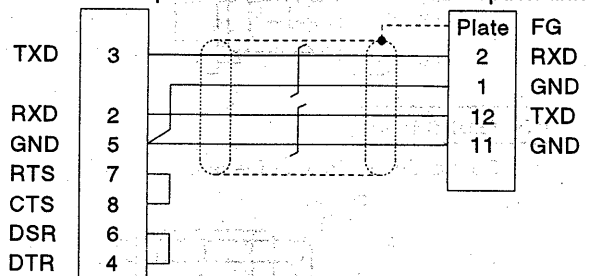
D-SUB9 pins   Half-pitch 20 pins

Note: The PC98 Note also has the connector of half-pitch 14 pins.
Confirm the shape of the RS-232C connector of the personal computer used.

6. OPTIONS AND AUXILIARY EQUIPMENT

6 – 1 – 3 Junction terminal block

(1) How to use the junction terminal block

Always use the junction terminal block (MR-TB20) with the junction terminal block cable(MR-CTBL05M) as a set. A connection example is shown below:
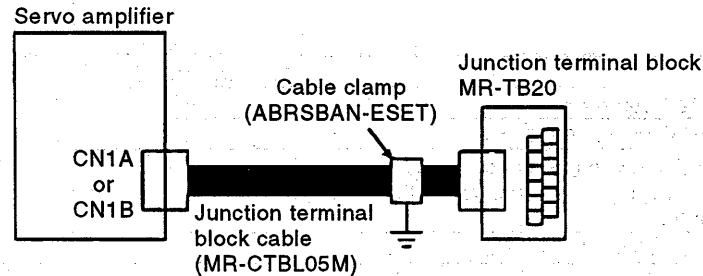
Ground the junction terminal block cable on the junction terminal block side with the standard accessory cable clamp fitting (AERSBAN-ESET). For the use of the cable clamp fitting, refer to (3), Section 6 – 2 – 4.

(2) Terminal labels

The junction terminal block has three terminal block labels which indicate signal arrangement. Out of these labels, use the one for MR-C. This label is for use in the position control mode. When the parameter settings of I/O signals have been changed or the position control mode is switched to the speed or torque control mode, refer to (2) in Section 6 – 1 – 2 or (2) in Section 3 – 1 – 2 and apply the accessory signal seales to the labels.

(3) Outline drawing
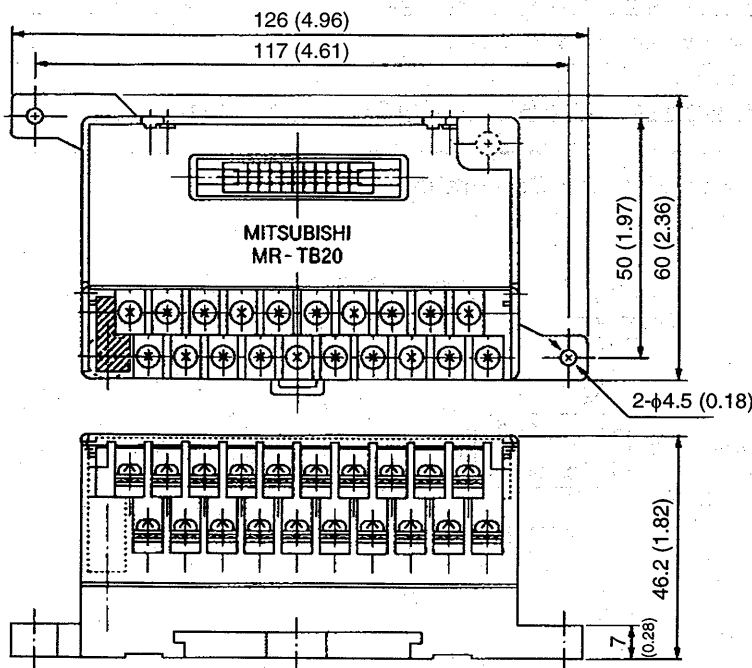
Terminal screw : M3.5
Applicable cable: Max. 2mm
(Crimping terminal width:
    7.2mm (0.283in) max.)

6. OPTIONS AND AUXILIARY EQUIPMENT

6 – 1 – 4 Setup software

The setup software (MR-ZJW3-SETUP31E or later) uses the communication function of the servo amplifier to perform parameter setting changes, graph display, test operation, etc. on a personal computer.

(1) Specifications

Item	Description
Communication signal	RS-232C standard
Baudrate	DOS/V system: 19200bps
Monitor	Batch display, high-speed display Graph display (minimum resolution changes according to the processing speed of the personal computer)
Alarm	Alarm display, alarm history
Diagnosis	DI/DO display, software number display, tuning data display
Parameters	Data setting, list display, change list display, detailed information display
Test operation	Jog operation, DO forced output (output signal forced output)
File operation	Data read, storage, printing
Others	Help display

Note: On some personal computers, setup software may not run properly.

(2) System configuration

    1) Components

        To use setup software, the following components are required in addition to the servo amplifier and servo motor. Make up a system in accordance with the installation guide of each equipment.

Model	Description
Personal computer	Which contains a 80386 or more CPU and on which Windows 3.1-95 runs (80486 or more recommended). Memory : 8MB or more, hard disk : 1MB or more, serial port used.
OS	Windows 3.1-95
Display	640 x 400 or more color or 16-tone monochrome display which can be used with Windows 3.1-95.
Keyboard	Which can be connected to the personal computer.
Mouse	Which can be used with Windows 3.1-95. Note that a serial mouse is not used.
Printer	Which can be used with Windows 3.1-95.
Communication cable	MR-CPCATCBL3M When these cannot be used, refer to Section 6 – 1 – 2 and fabricate.
RS-232C option unit	MR-C-T01

Note: Windows is the trade mark of Microsoft Corporation, U.S.A.

    2) Configuration diagram
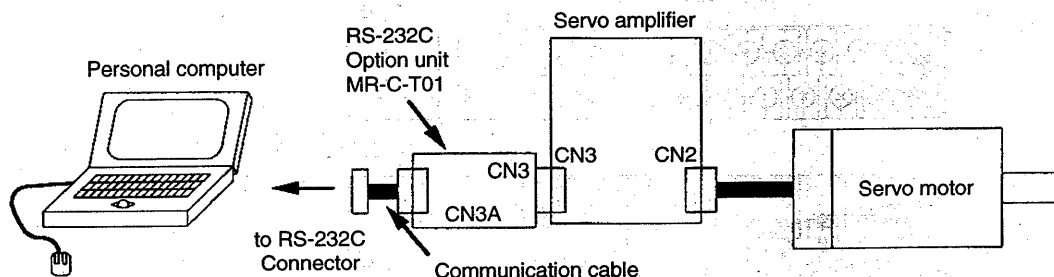
6. OPTIONS AND AUXILIARY EQUIPMENT

6 – 1 – 5 RS-232C option unit (MR-C-T01)

This unit is required to use the setup software.

(1) Installation and removal of the unit

NOTICE	Install or remove option unit as vertically as possible to or from the servo amplifier. If it is installed or removed diagonally, the connector CN3 may be damaged.

1) Installation

Install the unit after disconnecting the encoder cable from CN2. Securely insert the two catches of the MR-C-T01 into the sockets of the servo amplifier.
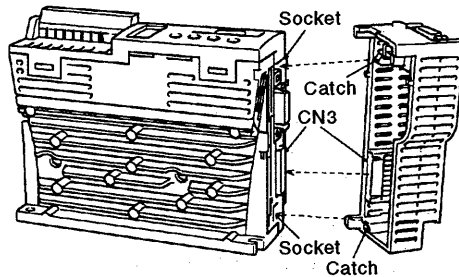
MEMO-RANDUM	Install option unit after fixing the servo amplifier on the control box. After installation, the servo amplifier fixing holes are covered by the option unit and the servo amplifier cannot be fixed to the control box.

2) Removal

Hold down the PB button and pull the front side down about 5mm (0.20). Then, pull the back side off.
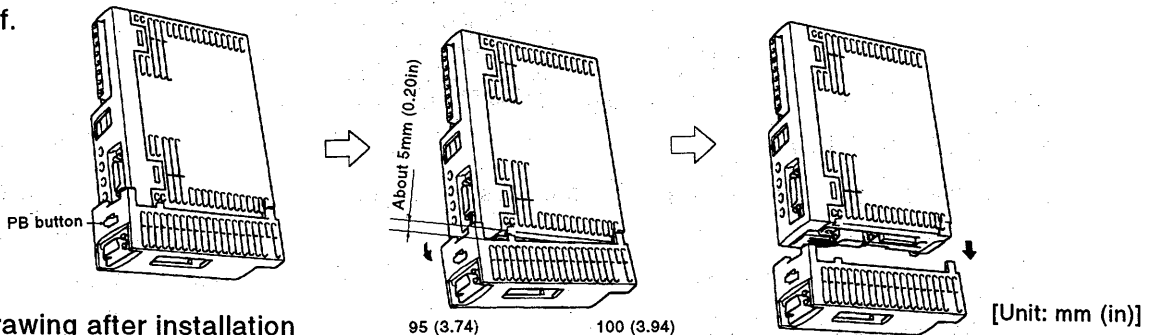
(2) Outline drawing after installation

[Unit: mm (in)]
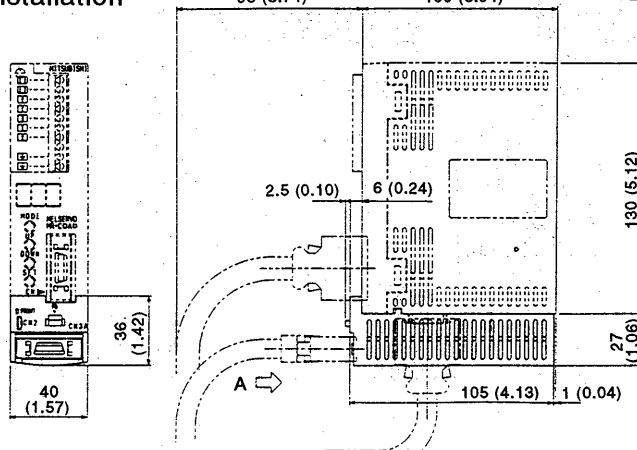
6. OPTIONS AND AUXILIARY EQUIPMENT

6 – 1 – 6 DIN rail option (released soon)

For ease of installation, use the DIN rail option (MR-DIN01) when installing more than one servo amplifier on a wall.

(1) Outline drawing

Details not yet determined

(2) How to use the option

    1) Installation to the servo amplifier

       Screw the DIN rail option tight on the servo amplifier.

DIN rail option MR-DIN01

Screw M4 × 12

Servo amplifier

Screw M4 × 12
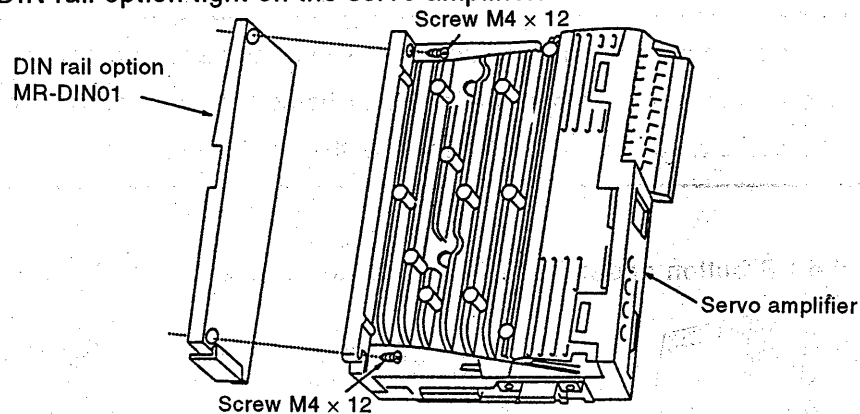
2) Fitting into the DIN rail

   Hitch the upper catch in the DIN rail. Push the catch in until it clicks.
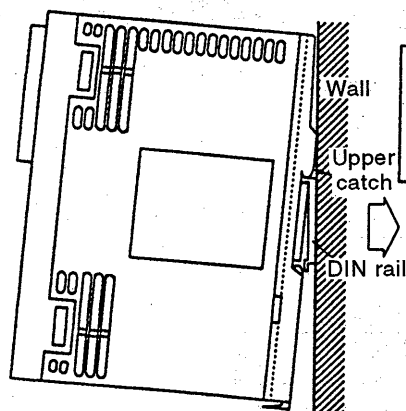
3) Removal from DIN rail

   After pulling the hook down, pull the servo amplifier toward you and lift it to remove.

Wall

Upper catch

DIN rail

Wall

DIN rail

3. Lift.

Wall

DIN rail

2. Pull toward you. Hook

1. Pull down hook.
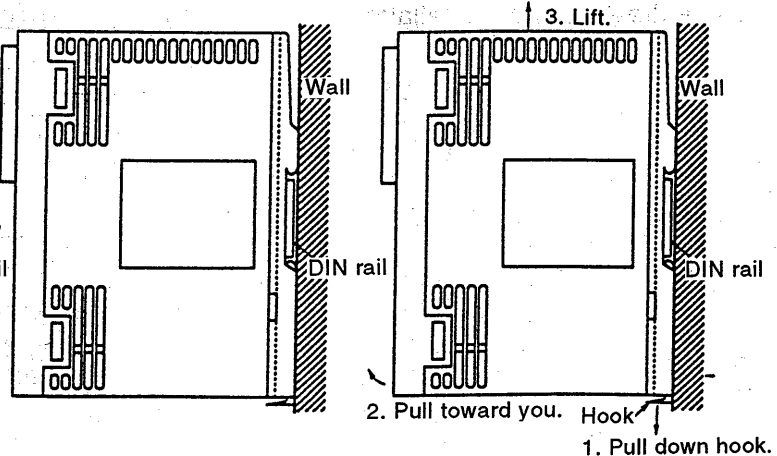
6. OPTIONS AND AUXILIARY EQUIPMENT

6 – 2 Auxiliary Equipment

The auxiliary equipment used must be those specified in this section or equivalent. To comply with the EN or UL/C-UL Standard, use the equipment which conform to the corresponding standard.

6 – 2 – 1 Electric wires

Servo Amplifier	(Note 1) Wire [mm²]				Torque (pound inch)
	L1,L2 ⏚	U,V,W ⏚	P,C	Electromagnetic brake	
MR-C10A MR-C20A MR-C10A1 MR-C20A1	0.75 (AWG18)	0.75 (AWG18)	(Note 2) 0.75 (AWG18)	0.75 (AWG18)	5.6
MR-C40A		1.25 (AWG16)			

Note: 1. The wires are based on the 600V vinyl wires. The wires (U, V, W) in the table assume that the distance between the servo motor and servo amplifier is 30m or less.

2. Twist the wires for connection of the regenerative brake option (P, C).

6 – 2 – 2 No-fuse breakers · fuses · magnetic contactors

Servo Amplifier	No-Fuse Breaker	Fuse			Magnetic Contactor		
		Class	Current [A]	Voltage [V]	A	B	C
MR-C10A MR-C20A MR-C10A1	NF30 type 5A	K5	10	AC250	S-N18	S-N21	S-N21
MR-C20A1 MR-C40A	NF30 type 10A						

6 – 2 – 3 Power factor improving reactors

When connecting directly to a large capacity power transformer (500kVA or more, with wiring 10m or less), an excessive current will flow when the power is switched on, and may damage the converter section. In such a case, install a power factor improving reactor (FR-BAL) to suppress the current.

Power factor improving reactor must be installed.
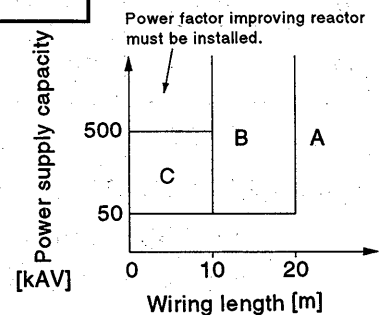
Outline drawing and connection diagram of the power factor improving reactor
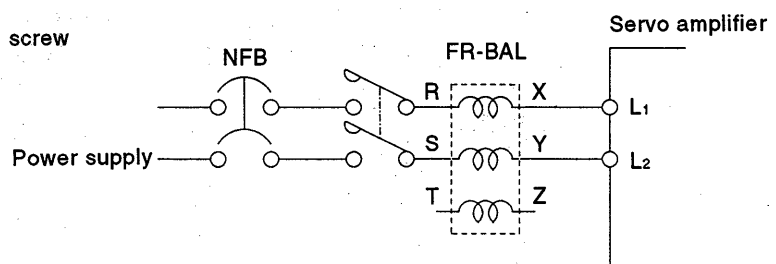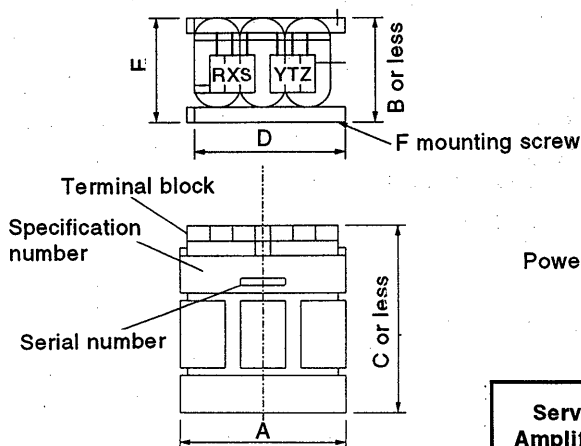
Servo Amplifier	Model	Dimensions [mm (in)]						Weight [kg (lb)]
		A	B	C	D	E	F	
MR-C10A MR-C20A MR-C10A1	FR-BAL-0.4K	135 (5.31)	64 (2.52)	120 (4.72)	120 (4.72)	45 (1.77)	M4	2 (4.4)
MR-C20A1 MR-C40A	FR -BAL-0.75K	135 (5.31)	74 (2.91)	120 (4.72)	120 (4.72)	57 (2.24)	M4	3 (6.6)

6. OPTIONS AND AUXILIARY EQUIPMENT

6 – 2 – 4 Relays

The following relays should be used with the interfaces:

Interface	Selection Example
Relay used especially for switching analog input command and digital input command (interface DI-1)	Relay used for switching signals on/off To prevent defective contacts, use a relay for small signal (twin contacts). (Ex.) OMRON : type G2A,MY
Relay used for digital output signals (interface DO-1)	Small relay with 12VDC or 24VDC of 40mA or less (Ex.) OMRON : type MY

6 – 2 – 5 Surge absorbers

When wiring the electromagnetic brake, always use a surge absorber. Use the following surge absorber or equivalent.

Insulate the wiring as shown in the diagram.

Maximum Rating				Maximum Limit Voltage		Static Capacity (Reference value)	Varistor Voltage Rating (Range) V_{1mA}
Permissible Circuit Voltage		Surge Immunity	Energy Immunity	Rated Power			
AC[V_{rms}]	DC[V]	[A] (Note)	[J]	[W]	[A]	[V]	[pF]	[V]
140	180	500/time	5	0.4	25	360	300	220 (198 to 242)

Note: 1 time = 8 · 20µs

(Example) ERZ-C10DK221 (Matsushita Electric make)

  TNR-12G221K (Marcon Electronics make)

  Outline drawing [mm (in)] (ERZ-C10DK221)
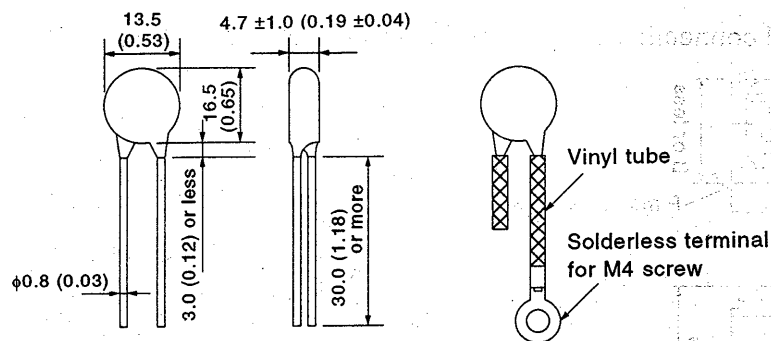
6. OPTIONS AND AUXILIARY EQUIPMENT

6 – 2 – 6 Noise reduction techniques

Noises are classified into external noises which enter the servo amplifier to cause it to malfunction and those radiated by the servo amplifier to cause peripheral devices to malfunction. Since the servo amplifier is an electronic device which uses small signals, it requires general noise reduction as mentioned below.

And, since the output of the servo amplifier is chopped by high carrier frequencies, the servo amplifier can be a source of noise. If peripheral devices malfunction due to noises produced by the servo amplifier, noise preventive measures must be provided. The measures will vary slightly according to the route of noise transmission.

1) General reduction techniques

- Avoid laying power lines (input and output cables) and signal cables side by side or do not bundle them together. Separate power lines from signal cables.

- Use shielded twisted-wire pair cables for connecting to an encoder and for control signal transmission, and connect the shield to the SD terminal.

- Ground the servo amplifier, servo motor, etc. together at one point (refer to Section 3 – 4).

2) Reduction techniques for external noises that cause the servo amplifier to malfunction

If there are noise sources (such as magnetic contactor, magnetic brake, and a large number of relays) which make a large amount of noise near the servo amplifier and the servo amplifier may malfunction, the following countermeasures are required.

- Provide surge absorbers on the noise sources to suppress noises.

- Attach data line filters to the signal cables

- Ground the shields of the encoder connecting wire and the control signal cables with cable clamp fittings.

3) Techniques for noises radiated by the servo amplifier that cause peripheral devices to malfunction

Noises which the servo amplifier produces are classified into those which are radiated from the cables connected to the servo amplifier body and the servo amplifier main circuits (input and output circuits), those which are induced electromagnetically or statically by the signal cables of the peripheral devices which are located close to the main circuit wires, and those which are transmitted through the power supply cables.

Noises produced by the servo amplifier			
	Noises transmitted in the air	Noise radiated directly from the servo amplifier	...Route 1)
		Noise radiated from the power supply cable	...Route 2)
		Noise radiated from the wires connected to the servo motor	...Route 3)
	Magnetic induction noise	...Routes 4) and 5)	
	Static induction noise	...Route 6)	
	Noises transmitted through electric channels	Noise transmitted through the power supply cable	...Route 7)
		Noise sneaking from the grounding wire due to leak current	...Route 8)

6. OPTIONS AND AUXILIARY EQUIPMENT

Noise Transmission Route	Countermeasures
1) 2) 3)	When measuring instruments, receivers, sensors, etc. which handle weak signals and may malfunction due to noise and their signal cables are installed on a panel together with a servo amplifier or close to a servo amplifier, such devices may malfunction due to noise transmitted through the air. The following techniques are required. (1) Provide maximum clearance between the devices which are liable to be influenced by noise and a servo amplifier. (2) Provide maximum clearance between the signal cables which are liable to be influenced by noise and the I/O cables of the servo amplifier. (3) Avoid laying the power lines (I/O cables of the servo amplifier) and signal cables side by side or bundling them together. (4) Insert a line noise filter FR-BSF01 to the I/O cables or a radio frequency noise filter (FR-BIF) on the input line. (5) Use shielded wires for signal and power cables or put cables in separate metal conduits.
4) 5) 6)	When the power lines and the signal cables are laid side by side or bundled together, magnetic induction noise and static induction noise will be transmitted through the signal cables and malfunction may occur. The following are required. (1) Provide maximum clearance between the devices which are liable to be influenced by noise and a servo amplifier. (2) Provide maximum clearance between the signal cables which are liable to be influenced by noise and the I/O cables of the servo amplifier. (3) Avoid laying the power lines (I/O cables of the servo amplifier) and signal cables side by side or bundling them together. (4) Use shielded wires for signal and power cables or put the cables in separate metal conduits.
7)	When the power supply of peripheral devices is connected to the power supply of the servo amplifier system, noises produced by the servo amplifier may be transmitted backward through the power supply cable and the devices may malfunction. The following techniques are required. (1) Insert a radio frequency noise filter (FR-BIF) on the power cables (I/O cables) of the servo amplifier. (2) Insert a line noise filter (FR-BSF01) on the power cables of the servo amplifier.
8)	When the cables of peripheral devices are connected to the servo amplifier to make a closed loop circuit, leakage current may flow to malfunction the peripheral devices. In that case, malfunction may be prevented by disconnecting the grounding wire of the peripheral device.

6. OPTIONS AND AUXILIARY EQUIPMENT

(1) Data line filter

Noise can be prevented by installing a data line filter onto encoder cable, etc.

Example   Data line filter: ZCAT3035-1330 [TDK make]

                              ESD-SR-25   [Tokin make]

Impedance specifications (ZCAT3035-1330)

Impedance [Ω]	
10 to 100MHz	100 to 500MHz
80	150

The above impedance value includes the impedance of the cable (measured value) and isnot a guaranteed value.

Outline drawing (ZCAT3035-1330)
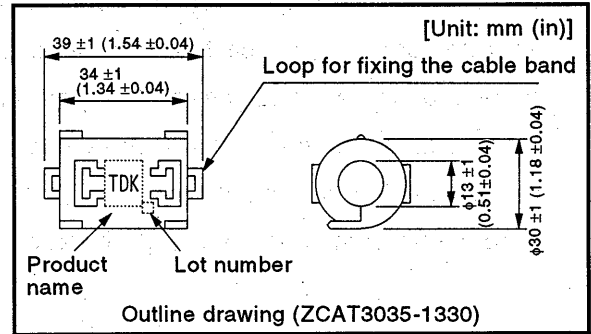
(2) Surge suppressor

The recommended surge suppressor for installation to an AC relay, AC valve, AC electromagnetic brake or the like near the servo amplifier is shown below. Use this product or equivalent.
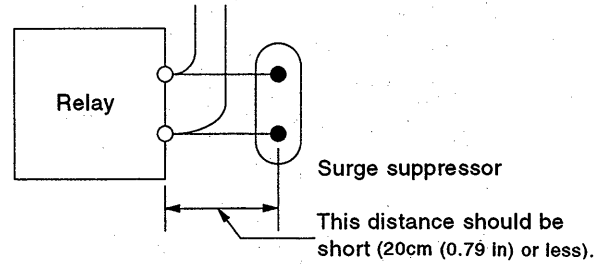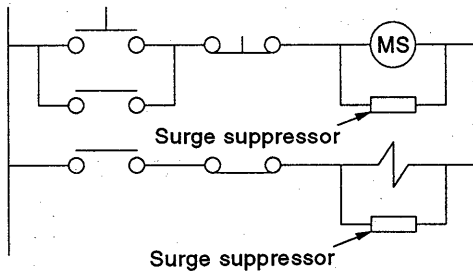
(Ex.) 972A-2003 504 11
(Matsuo Electric make ... 200VAC rating)

Rated Voltage [V]	C [μF]	R [Ω]	Test Voltage [V]
200	0.5	50 (1W)	Across T-C 1000 (1 to 5s)
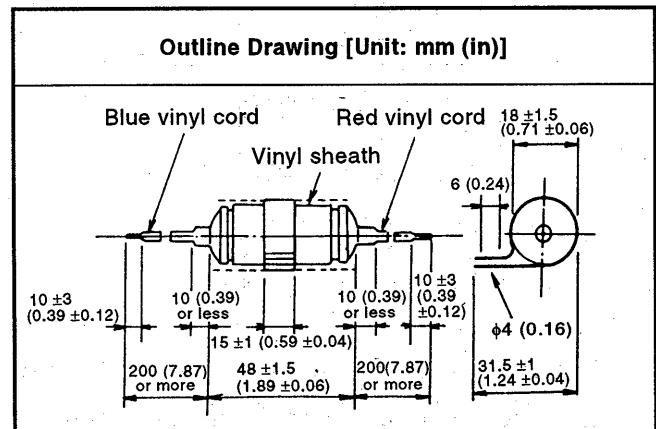
Note that a diode should be installed to a DC relay, DC valve or the like.

Maximum voltage : Not less than 4 times the drive voltage of the relay or the like

Maximum current : Not less than twice the drive current of the relay or the like
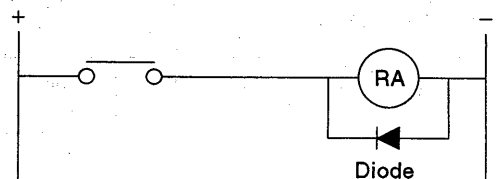
6. OPTIONS AND AUXILIARY EQUIPMENT

(3) Cable clamp fitting (AERSBAN-□SET)

The shield wire earth plate normally only needs to be connected to the connector's SD terminal. However, the effect can be increased by directly connecting the wire to an earth plate as shown below.
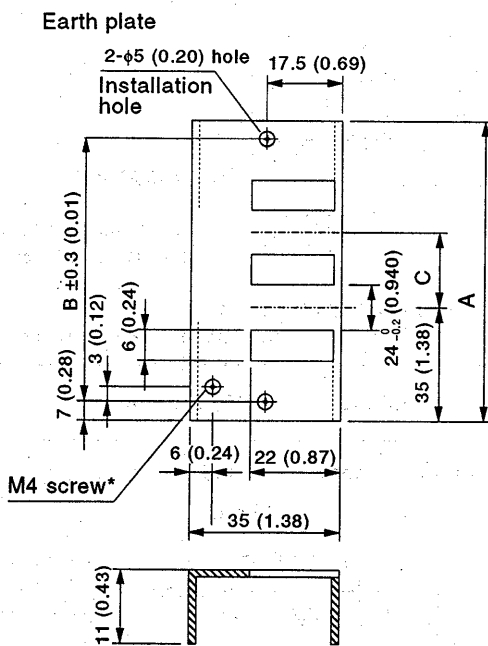
Install the earth plate near the servo amplifier for the encoder cable. Peel part of the cable sheath to expose the shield, and insert that part into the earth plate with the cable clamp. If the cable is thin, clamp several cables in a bunch.

The clamp comes as a set with the earth plate.
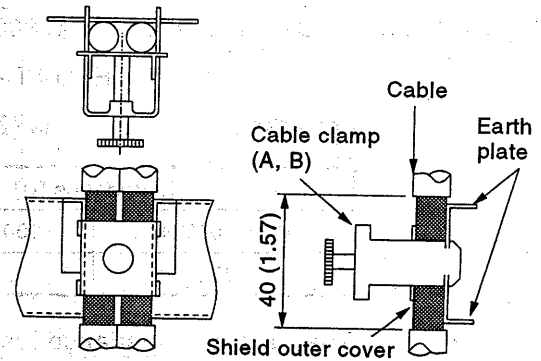
Clamp section diagram

- Outline drawing

Earth plate

[Unit: mm (in)]

Cable clamp
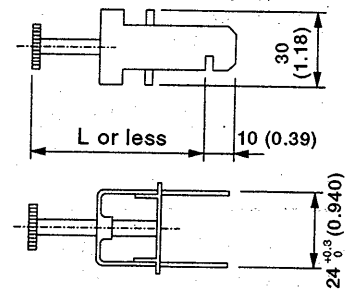
1) Always wire from the earth plate to the cabinet ground.

2) *Screw hole for wiring to cabinet ground.
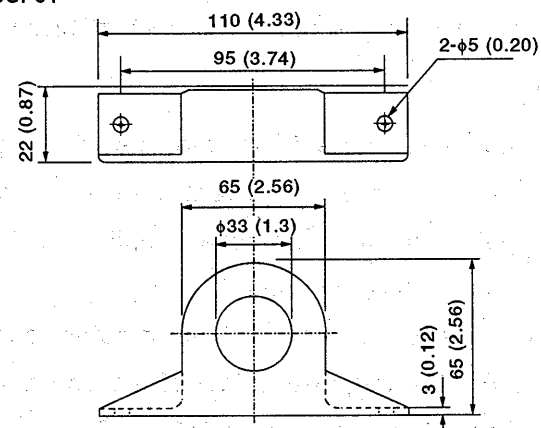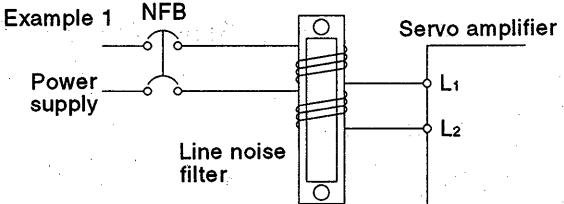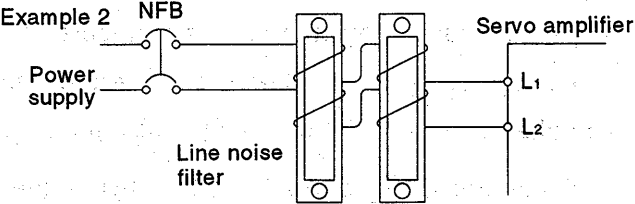
	A	B	C	Enclosed Fittings
AERSBAN-DSET	100 (3.94)	86 (3.39)	30 (1.18)	Clamp A : 2pcs.
AERSBAN-ESET	70 (2.76)	56 (2.20)	–	Clamp B : 1pc.

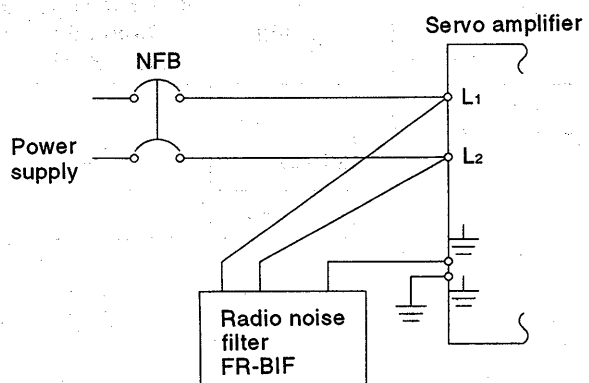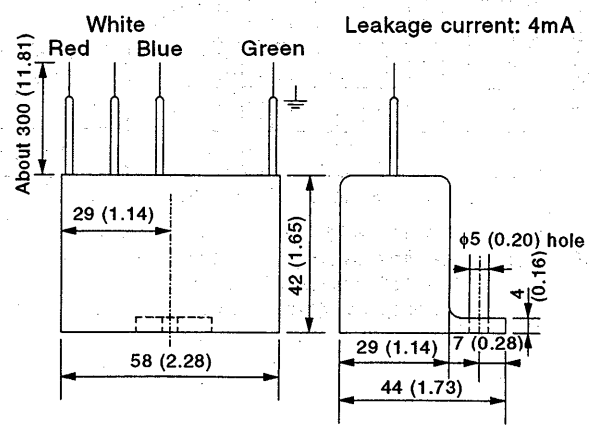| Clamp	L
A	70 (2.76)
B	45 (1.77)

(4) Line noise filter (FR-BSF01)

This filter is effective in suppressing noises radiated from the power supply side and output side of the servo amplifier and also in suppressing high-frequency leakage current (zero-phase current) especially within 0.5MHz to 5MHz band.

Connection Chart	Outline Drawing [Unit: mm (in)]
• Wind the wires connected to a three-phase current on equal number of times in the same direction, and connect the filter to the power supply side and output side of the servo amplifier. • The effect of the filter on the power supply side becoms higher as the number of winds becomes larger. The number of turns is generally four. On the output side, the number of turns must be four or less. Note 1: Do not wind the grounding wire together with the three-phase power wires. The filter effect will decrease. Use special caution when a four-core cable is used. Use a separate wire for grounding. Note 2: If the wires are too thick to be wound, use two filters or more and the number of turns should be as mentioned above.	FR-BSF01

Example 1

(Number of turns: 4)

Example 2

Two filters are used
(Total number of turns: 4)

(5) Radio noise filter (FR-BIF)...exclusively for the input side

This filter is effective in suppressing noises radiated from the power supply side of the servo amplifier especially in 10MHz and lower radio frequency band. The FR-BIF is designed for three-pole input. When the FR-BIF is used with this servo amplifier, insulate the unused terminals.

| Connection Chart	Outline Drawing [Unit: mm (in)]
Make the connecting cables as short as possible. Grounding is always required. 	Leakage current: 4mA

6. OPTIONS AND AUXILIARY EQUIPMENT

6 – 2 – 7 Leakage current breaker

High-frequency chopper current controlled by pulse width modulation flows in the AC servo circuit. Leakage current containing the harmonic contents is larger than that of a motor which is run with a commercial power supply.

Select a leakage current breaker as mentioned below, and ground the servo amplifier, servo motor, etc. securely. Make the input and output cables as short as possible, and also make the grounding wire as long as possible (about 30cm(11.8in)) to minimize leakage currents.

Selection

- Leakage current on the electric channel from the leakage current breaker to the input terminal of the servo amplifier: Ig1 [mA] (Obtain from Fig. 6-1.)

- Leakage current on the electric channel from the output terminal of the servo amplifier to the servo motor: Ig2 [mA] (Obtain from Fig. 6-1.)

- Leakage current when a filter is connected to the input side: Ign [mA]   (4.4[mA] per one FR-BIF)

- Leakage current of the servo amplifier: Iga [mA] (2[mA])

- Leakage current of the servo motor: Igm [mA] (Obtain from Table 6-1.)
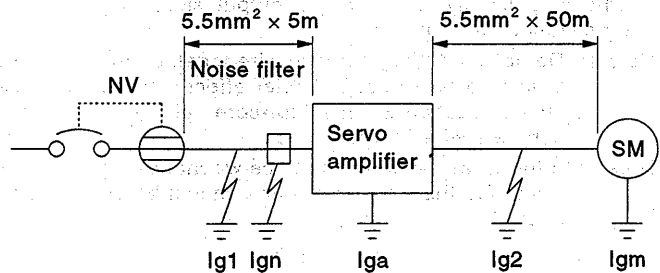
  Rated sensitivity current $\geq 10 \cdot \{ \text{Ig1} + \text{Ign} + \text{Iga} + K \cdot (\text{Ig2} + \text{Igm}) \}$ [mA]

  K: Constant considering the harmonic contents

  (varies according to the frequency characteristics of the leakage circuit breaker)

  Models provided with countermeasures against harmonics and surge: K=1

  (equivalent to MITSUBISHI NV-SF or CF)

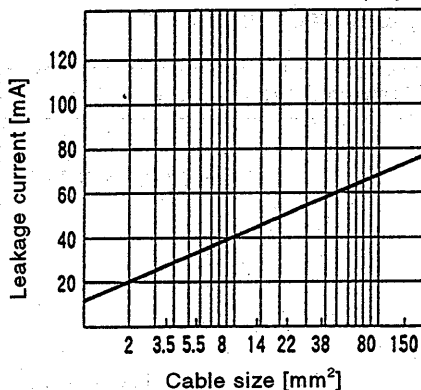 General models (equivalent to MITSUBISHI NV-CA, CS or SS)   : K=3

Fig. 6-1 Leakage Current per 1km (Ig1, Ig2) when CV Cable is Laid in a Metal Conduit

Table 6-1 Leakage Current of Servo Motor (Igm)

Servo Motor [kW]	Leakage Current [mA]
0.03 to 0.4	0.1

Table 6-2 Leakage Circuit Breaker Selection Example

Servo Amplifier	Rated Sensitivity Current of Leakage Circuit Breake [mA]
MR-C10A(1) to MR-C20A(1)	15
MR-C40A	

CHAPTER 7
MAINTENANCE AND INSPECTION

This chapter describes maintenance items.

7. MAINTENANCE AND INSPECTION

⚠ WARNING	1. Before starting maintenance or inspection, switch power off and wait for more than 10 minutes. Then, confirm the voltage is zero with multi meter. Otherwise, you may get an electric shock. 2. Any person who is involved in maintenance and inspection should be fully competent to do the work. Otherwise, you may get an electric shock. For repair and parts replacement, contact our safes representative.

NOTICE	1. Do not test the control circuit of the servo amplifier with a megger (measure insulation resistance)! 2. Do not disassemble or repair on the customer side.

(1) Check areas

It is recommended to make the following checks periodically;

1) Check for loose terminal block screws. Retighten any loose screws.

2) Check the servo motor bearings, brake section, etc. for unusual noise.

3) Check that there are no scratches or cracks in the cables (especially the encoder cable). Carry out the periodic inspection according to the usage conditions for the moving parts.

4) Check the servo motor shaft and coupling for misalignment.

(2) Life

The servo amplifier and servo motor have the following standard lives. Which will vary according to the usage and environmental conditions.

Replacement Parts		Standard Life	Remarks
Servo amplifier		10 years	Standard life is a reference value. When the standard life is not reached, change the parts as soon as possible if a fault is found.
Servo motor	Without reduction gear	20,000 to 30,000 hours	
	With reduction gear	20,000 hours	

1) Servo amplifier : The characteristics of the smoothing capacitor will deteriorate because of effects from the ripple current. The life of the capacitor will differ greatly according to the ambient temperature and usage conditions. When operated under normal environmental conditions, the life will be approximately 10 years.

2) Servo motor : Under the rated speed and rated load, the life of the bearings on the servo motor without reduction gear is 20,000 to 30,000 hours and that of the bearings on the servo motor with reduction gear is 20,000 hours. This will differ on the operation conditions, but the servo motor should be replaced when abnormal sound or vibration is found.

CHAPTER 8
TROUBLESHOOTING

This chapter gives the alarm codes, their definitions and corrective actions. When any alarm has occurred, refer to this chapter and take the corresponding action.

Alarm List

INTRODUCTION	**CHAPTER 1**
OPERATION	**CHAPTER 2**
WIRING	**CHAPTER 3**
INSTALLATION	**CHAPTER 4**
ADJUSTMENTS AND APPLICATION OPERATIONS	**CHAPTER 5**
OPTIONS AND AUXILIARY EQUIPMENT	**CHAPTER 6**
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8. TROUBLESHOOTING

⚠ CAUTION	When any alarm has occurred, eliminate its cause, ensure safety, then reset the alarm, and restart operation.

NOTICE	When the regeneration fault (A30) or overload (A50) alarm has occurred, always remove the cause of occurrence before restarting operation. If operation is repeated by switching power off to reset the alarm, the servo motor, servo amplifier and regenerative brake option will fail!

When an alarm occurs, the trouble signal (ALM) switches off. Therefore, the magnetic contactor installed before the power input terminals (L$_1$, L$_2$) switches off and power is switched off. For several seconds after that, the corresponding alarm code is displayed and then disappears.

Switch power on again, refer to the alarm history, and confirm the alarms that have occurred. The alarm definitions and their corrective actions are as follows.

Display	Alarm Name	Definition	Cause	Action
A10	Undervoltage	Power supply voltage dropped. MR-C□A : 165V or less MR-C□A1: 83V or less	1. Power supply voltage is low.	Review the power supply.
			2. Power switched on within 5s after it had switched off.	
			3. Instantaneous power failure of 15ms or longer occurred.	
			4. Shortage of power supply capacity caused the power supply voltage to drop at start, etc.	
			5. Faulty parts in the servo amplifier ⎯ Checking method ⎯ If all connectors have been disconnected and power switched on, the alarm (A10) occurs.	Change the servo amplifier.
A12	Memory error 1	RAM/ROM memory error	Faulty parts in the servo amplifier ⎯ Checking method ⎯ If all connectors have been disconnected and power switched on, the alarm (any of A12, A14 and A15) occurs.	Change the servo amplifier.
A14	Watchdog	CPU/parts error		
A15	Memory error 2	EEPROM error		
A16	Motor combination error	The combination of servo amplifier and servo motor is not correct.	1. The 200W servo motor is connected with the servo amplifier MR-C10A(1). The 100W or less servo motor is connected with the servo amplifier MR-C20A(1).	Use correct combination as in Section 10 – 1.
			2. Encoder fault	Change the servo motor.

8. TROUBLESHOOTING

Display	Alarm Name	Definition	Cause	Action
A17	Board error	CPU/parts error	Faulty parts in the servo amplifier ┌── Checking method ──┐ If all connectors have been disconnected and power switched on, the alarm (A17) occurs.	Change the servo amplifier.
A20	Encoder error	A communication error occurred between the encoder and servo amplifier.	1. Encoder connector disconnected.	Connect correctly.
			2. Encoder cable fault (wire breakage or short)	Repair or change the cable.
A30	Regeneration error	Excessive regeneration	1. Wrong setting of parameter No. 0	Set correctly.
			2. High-duty operation or continuous regenerative operation. ┌── Checking method ──┐ Use the status display to check the regenerative load factor.	1. Reduce the frequency of positioning. 2. Use larger regenerative brake option. 3. Reduce the load.
		Regenerative transistor error	Regenerative transistor faulty. ┌── Checking method ──┐ 1) The regenerative brake option has overheated abnormally. 2) The alarm occurs after removal of the regenerative brake option.	Change the servo amplifier.
A31	Overspeed	Speed has exceeded the instantaneous permissible speed.	1. Electronic gear ratio is large (parameters No. 2, 3).	Set correctly.
			2. Small acceleration/deceleration time caused overshoot to be large.	Increase the acceleration/deceleration time.
			3. Encoder faulty.	Change the servo motor.
A32	Overcurrent	Excessive amplifier currents	1. Short occurred in phases U, V and W of the servo amplifier output.	Correct the wiring.
			2. Ground fault occurred in phases U, V and W of the servo amplifier output.	
			3. Transistor (IPM) of the servo amplifier faulty. ┌── Checking method ──┐ If all connectors have been disconnected and power switched on, the alarm (A10) occurs.	Change the servo amplifier.
			4. External noise caused the overcurrent detection circuit to misoperate.	Eliminate noise

8. TROUBLESHOOTING

Display	Alarm Name	Definition	Cause	Action
A33	Overvoltage	Converter bus voltage exceeded 400V.	1. Power supply voltage exceeded the following value: MR-C☐A : 260V MR-C☐A1: 130V	Verify the power supply.
			2. Large spikes on power supply caused the capacitor to over charge. (When the regenerative brake option is not used)	1. Use the FR-BAL. 2. Provide a power supply different from the one used with equipment that generates distortion.
			3. Broken regenerative brake wires.	Change the regenerative brake option.
			4. The lead of the regenerative brake option is broken or disconnected.	1. Change the lead. 2. Connect correctly.
A35	Command pulse alarm	Input command pulse exceeded 250kpps.	1. Command pulse frequency exceeded 250kpps.	Reduce the command pulse frequency to 200kpps or less.
			2. Noise affecting the command pulse.	Eliminate noise.
			3. Command unit faulty.	Change the command unit.
A37	Parameter error	Parameter setting is wrong.	1. Servo amplifier fault caused the parameter setting to be rewritten.	Change the servo amplifier.
			2. The same signals have been made valid for different pins in parameters No. 20 or 21.	Set correctly.
A50	Overload	Overload protection is exceeded. Load factor 300%: 4s or more Load factor 200%: 4s or more Servo motor locked: 0.3s or more	1. Wrong connection of the servo motor. The output terminals U, V, W of the servo amplifier do not match the input terminals U, V, W of the servo motor.	Connect correctly.
			2. Continuous output current of the servo amplifier is exceeded.	1. Review operation pattern. 2. Increase the servo motor capacity.
			3. Servo system is unstable and hunting.	1. Repeat acceleration/deceleration and execute auto tuning. 2. Using parameter No. 1, change response setting. 3. Using parameter No. 1, set auto tuning to off and make gain adjustment manually. (Refer to Section 5 – 1.) | Parameter	Adjustment
---	---
No. 26	Decrease
No. 27	Increase
No. 29	Increase	
			4. Machine struck something.	1. Review operation pattern. 2. Provide limit switches.

Display	Alarm Name	Definition	Cause	Action
A50			5. Encoder faulty.	Change the servo motor.
			─── Checking method ─── When the servo motor shaft is rotated slowly in the servo off state, the cumulative feedback pulse value should vary in proportion to the angular value. If its reading skips or returns at any point, the encoder is faulty.	
A52	Excessive error	Value of the deviation counter exceeded 50k pulse.	1. Acceleration/deceleration time is too small.	Increase the acceleration/deceleration time.
			2. Torque limit value (parameter No. 9) is too small.	Increase the torque limit value.
			3. Start not allowed by torque shortage due to power supply voltage drop.	1. Review the power supply equipment capacity. 2. Increase the servo motor capacity.
			4. Machine struck something.	1. Review operation pattern. 2. Provide limit switches.
			5. Wrong connection of the servo motor. The output terminals U, V, W of the servo amplifier do not match the input terminals U, V, W of the servo motor.	Connect correctly.
			6. Encoder faulty.	Change the servo motor.

CHAPTER 9
CHARACTERISTICS

This chapter provides the characteristics and data of the servo.

9 – 1 Overload Protection Characteristics
9 – 2 Losses Generated in the Servo Amplifier
9 – 3 Electromagnetic Brake Characteristics
9 – 4 Vibration Rank

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9. CHARACTERISTICS

9 – 1 Overload Protection Characteristics

An electronic thermal relay is built in the servo amplifier to protect the servo motor and servo amplifier from overloads. The operation characteristics of the electronic thermal relay are shown below.
Overload 1 alarm (A50) is displayed to indicate that overload operation has been performed above the electronic thermal relay protection curve shown below or that the maximum current flew continuously for several seconds because the machine struck something, for example. Use the equipment on the left-hand side area of the continuous or broken line in the graph.
If load is applied at a stop (during servo lock), 70% of the rated torque must not be exceeded.

a. HC-PQ033 to 13
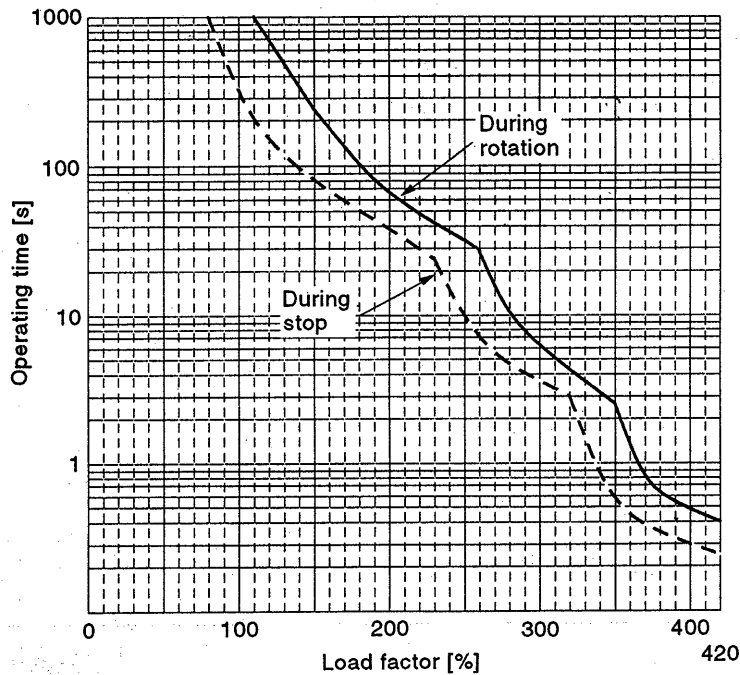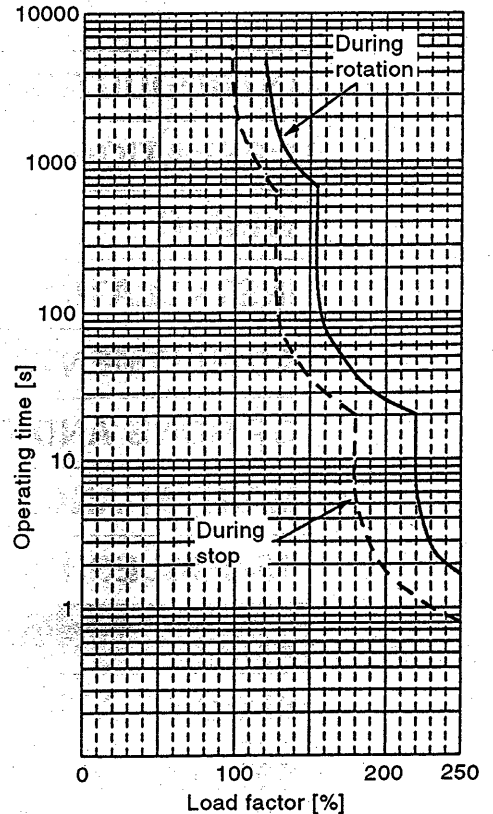
b. HC-PQ23
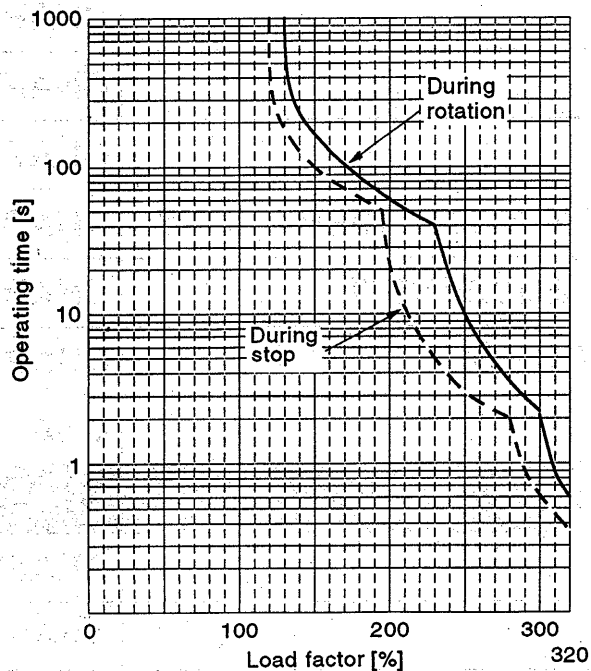
c. HC-PQ43

Fig. 9-1 Electronic Thermal Relay Protection Characteristics

9. CHARACTERISTICS

9 – 2 Losses Generated in the Servo Amplifier

(1) Amount of heat generated by the servo amplifier

The losses generated during the servo amplifier's rated load operation and the power capacities are shown below. Use the size of closed-type control box under the worst usage conditions. The actual amount of generated heat will be a value between the rated output and zero torque according to the duty used. The servo motor's nominal output will decrease when the servo motor is not used at maximum speed. The power capacity is lower than the values given below. However, the servo amplifier's generated heat will not change.

Table 9-1 Power Capacity and Generated Heat Amount Per Servo Amplifier

Servo Amplifier	Servo Motor	Power Supply Capacity [kVA]	Servo Amplifier-Generated Heat		Area Required for Heat Dissipation	
			At Rated Output [W]	At Zero Torque [W]	$[m^2]$	$[ft^2]$
MR-C10A	HC-PQ033	0.1	20	4	0.4	4.3
MR-C10A1	HC-PQ053	0.2	20	4	0.4	4.3
MR-C20A	HC-PQ13	0.3	20	4	0.4	4.3
MR-C20A1	HC-PQ23	0.5	25	4	0.5	5.3
MR-C40A	HC-PQ43	0.9	30	4	0.6	6.4

Note: 1. Sufficient heat-related capacity (kVA) values are indicated in Table 9-1 for the power supply. However, peak power that is 2 to 2.5 times higher than the rated will be required during the servo motor acceleration. Therefore, select a power supply which shows minimum voltage fluctuation so that the voltage range 170V to 253V for the 200V class or 85V to 126V for the 100V class can be attained at the servo amplifier terminals. The necessary power facility capacity will change according to the impedance.
2. Refer to the above for the current capacity of the power supply.
3. When using multi-axes, add the power capacity per axis.
4. The heat generated during regeneration is not included in the servo amplifier's generated heat amount. Use Equation (6-1) in Section 6 – 1 – 1 to calculate the heat generated by the regenerative brake option.

9. CHARACTERISTICS

(2) Heat dissipation area for enclosed servo amplifier

An enclosure for the servo amplifier should be designed to operate in an ambient temperature of 40°C (104°F) and allow no more than a temperature rise of +10°C (50°F). (With a about 5°C (41°F) safety margin, the system should operate within a maximum 50°C (122°F) limit.) The necessary enclosure heat dissipation area can be calculated by the following equation:

$$A = \frac{P}{K \cdot \Delta T} \quad \text{.............(9-1)}$$

where,   A: Heat dissipation area [m^2]

P: Loss generated in the control box [W]

ΔT: Difference between internal and ambient temperatures [°C]

K: Heat dissipation coefficient [5 to 6]

The heat dissipation area calculated in equation (9-1) should be calculated so that P is the sum of all losses generated in the enclosure. For the heat generated amount of the servo amplifier, refer to Table 9-1.

Fig. 9-2 Distribution of Temperature in Enclosure

When air is flown along the outer wall of the enclosure, effective heat exchange will be possible, because the temperature slope inside and outside the enclosure will be large.

"A" indicates the effective area for heat dissipation, but if the enclosure is directly installed on an insulated wall, that extra amount must be added to the enclosure's surface area.

The required heat dissipation area will differ according to the conditions in the enclosure. If the convection in the enclosure is poor and the heat builds up, effective heat dissipation will not be possible. Therefore, arrangement of the equipment in the enclosure and the use of a fan should be considered.

Table 9-1 lists the enclosure surface area for each servo amplifier when the servo amplifier is operated at an ambient temperature of 40°C (104°F).
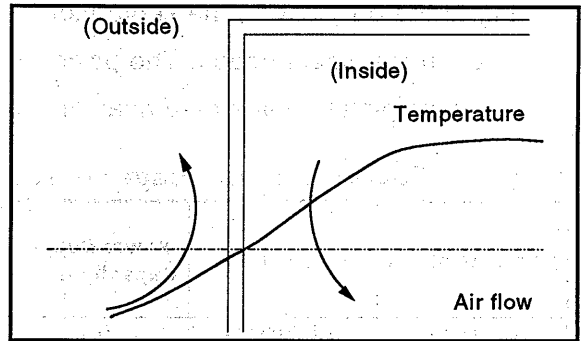
9. CHARACTERISTICS

9 – 3 Electromagnetic Brake Characteristics

> ⚠ **CAUTION** The electromagnetic brake is designed to hold a load. Do not use it for braking.

An electromagnetic brake is used in vertical motion applications to hold the load when power is removed from the drive. It is also used in conjunction with dynamic braking during an emergency stop. The characteristics of the electromagnetic brake are shown in the table below.

(1) Characteristics

Table 9-2 Electromagnetic Brake Characteristics

Item \ Servo motor			HC-PQ033B	HC-PQ053B	HC-PQ13B	HC-PQ23B	HC-PQ43B
Type			Spring-loaded safety brake				
Rated voltage (Note 1)			24VDC				
Rated current at 20°C [A]			0.26			0.33	
Excitation coil resistance at 20°C [Ω]			91			73	
Capacity [W]			6.3			7.9	
ON current [A]			0.18			0.18	
OFF current [A]			0.06			0.11	
Static friction torque	[N·m]		0.32			1.3	
	[kgf·cm]		3.3			13.3	
Inertia (Note 2)	J[kg·cm^2]		3.1 ö 10^{-3}			4.0 × 10^{-2}	
	GD^2[kgf·cm^2]		1.24 ö 10^{-2}			0.16	
Release delay time [S] (Note 3)			0.03			0.03	
Braking delay time [S] (Note 3)	AC off		0.08			0.10	
	DC off		0.01			0.02	
Permissible braking work	Per braking	[N·m]	5.6			22	
		[kgf·cm]	57.1			224.5	
		[oz·in]	793.6			3117.6	
	Per hour	[N·m]	56			220	
		[kgf·cm]	571			2245	
		[oz·in]	7936			31176	
Brake looseness at motor shaft [degrees]			0.19 to 2.5			0.12 to 1.2	
Brake life (Note 4)	Frequency [times]		20000			20000	
	Work per braking	[N·m]	4			15	
		[kgf·cm]	41			153	
		[oz·in]	567			2126	

Note: 1. A manual releasing mechanism is not installed. When the servo motor shaft is required to turn for core alignment of the machine, etc., use a separate 24VDC power and open the brake electrically.
2. This value is added to the inertia of the servo motor without a brake.
3. The value for initial suction gap at 20°C.
4. The brake gap will increase due to wear of the brake lining. The brake gap cannot be adjusted. Therefore, it is assumed that the brake life will expire when adjustment is required.
5. The interface power in the servo amplifier's (VDD: +24V) cannot be used. Always use a separate power source.
6. A leakage magnetic flux will occur at the shaft end of the servo motor with electromagnetic brake.
7. Though the brake lining may rattile during low-speed operation, it poses no functional problem.

9. CHARACTERISTICS

(2) Electromagnetic brake power supply

Prepare the following power supply for use with the electromagnetic brake only.

Examples of connection of the brake power supply are shown in Fig. 9-3 (a) to (c). (a) is for AC off, and (b) and (c) for DC off. When the DC is off, the braking delay time will be shortened, but a surge absorber must be installed on the brake terminal. For the selection of the surge absorber, refer to Section 6 – 2 – 3.

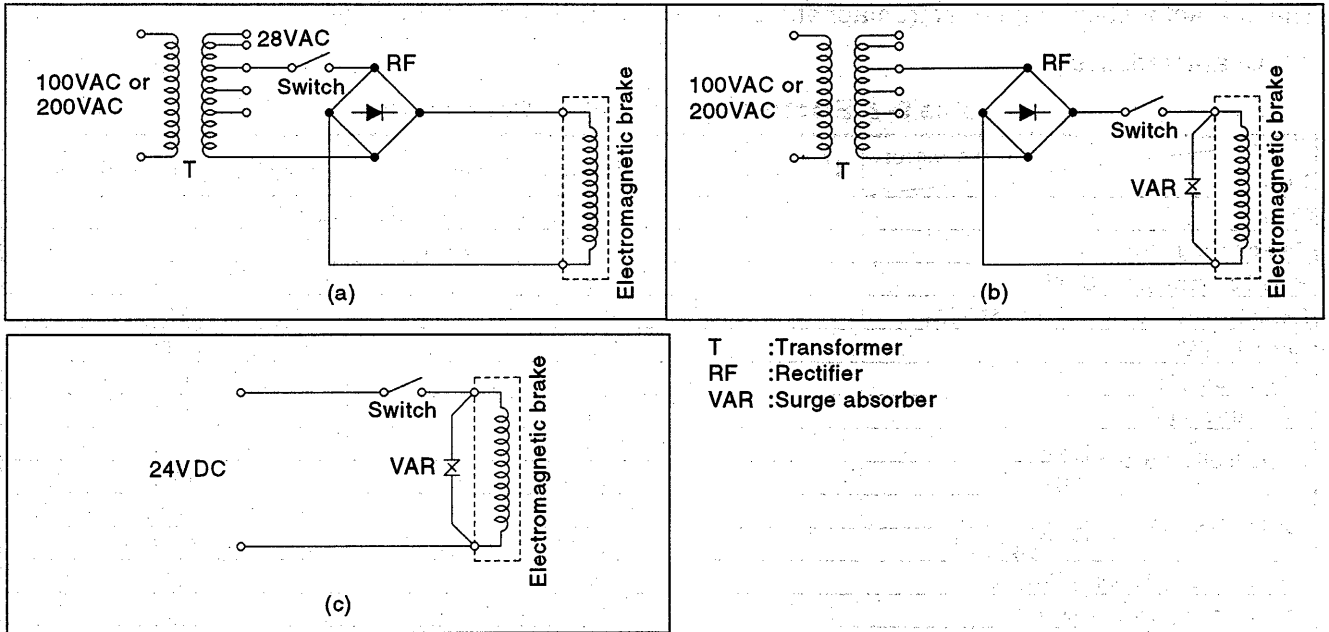T   :Transformer
RF   :Rectifier
VAR :Surge absorber

Fig. 9-3 Connection Examples

(3) Coasting distance

During an emergency stop, the servo motor will decelerate to a stop in the following pattern. Here, the maximum coasting distance (during fast feed), Lmax, will be the area shown with the diagonal line in the figure, and can be calculated with the following equation. The effect of the load torque is greater near the stopping area. When the load torque is large, the servo motor will stop faster than the value obtained in the equation.
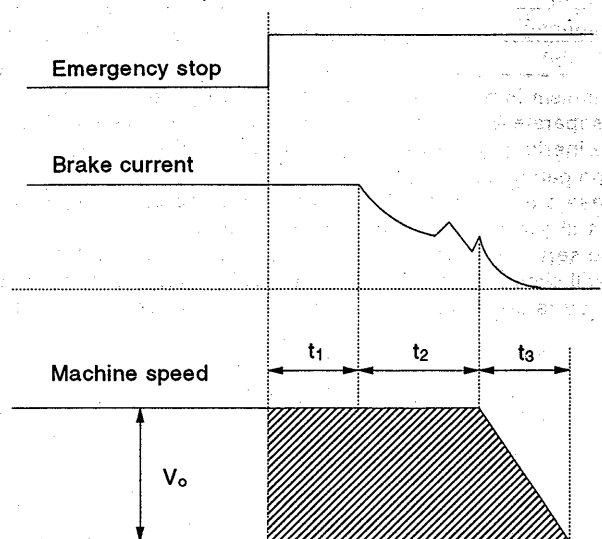

Fig. 9-4 Coasting Distance during Emergency Stop

9. CHARACTERISTICS

$$L_{max} = \frac{V_o}{60} \cdot (t_1 + t_2 + \frac{t_3}{2})$$

Here,

L_{max}	:	Maximum coasting distance	[mm]
V_o	:	Machine's fast feed speed	[mm/min]
t_1	:	Delay time of control section	[s]
t_2	:	Braking delay time of brake (*)	[s]
t_3	:	Braking time	[s]

$$t_3 = \frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4 \cdot (T_L + 0.8T_B)}$$

J_L	:	load inertia converted into equivalent value on servo motor shaft	[kg·cm^2]
J_M	:	Servo motor inertia	[kg·cm^2]
N_o	:	Servo motor speed during fast feed	[r/min]
T_L	:	Load torque converted into equivalent value on servo motor shaft	[N·m]
T_B	:	Brake static friction torque (*)	[N·m]

*: t_2 and T_B are the values noted in Table 9-2

Characteristics. J_L is the sum of the electromagnetic brake's inertia (Table 9-2) and the motor's inertia.

9 – 4 Vibration Rank

The servo motor vibration rank is V-10 at the rated speed. The servo motor installation position and measuring position at the time of measurement are shown below.

Servo Motor Vibration Measuring Condition
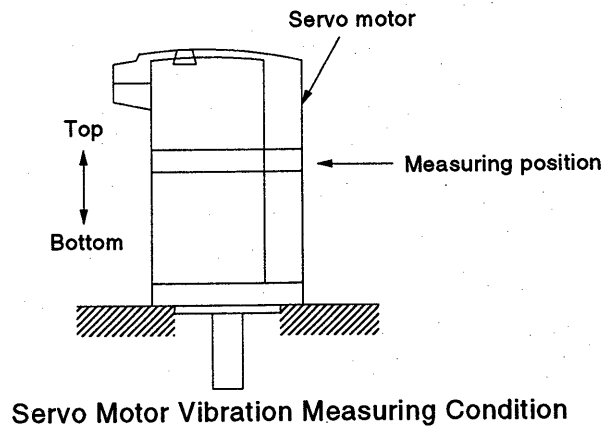
3. WIRING

⚠ **WARNING**

1. All wiring must be done by competent personnel.
2. Before starting wiring, switch power off and wait for more than 10 minutes. Then, confirm that the voltage is zero with a voltage tester. Otherwise, you may get an electric shock.
3. Ground the servo amplifier and the servo motor.
4. Do not attempt to wire the servo amplifier and servo motor until they have been properly installed. Otherwise, you may get an electric shock.
5. The wires should not be damaged, stressed, loaded or pinched. Otherwise, you may get an electric shock.
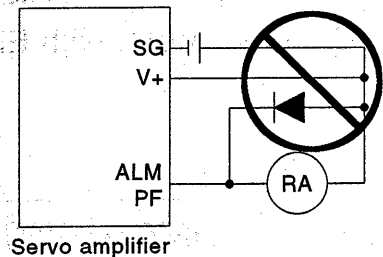
⚠ **CAUTION**

1. Wire the equipment correctly and securely. Otherwise, the servo motor may misoperate, resulting in injury.
2. Connect wires to correct terminals to prevent a burst, fault, etc.
3. Ensure that polarity (+, −) is correct. Otherwise, a burst, damage, etc. may occur.
4. The surge absorbing diode installed on the DC output signal relay must be wired in the specified direction.
   Otherwise, the emergency stop and other protective circuits may not operate.

Servo amplifier

5. Use a noise filter, etc. to minimize electromagnetic interference, caused by electronic equipment used near the servo amplifier.
6. Do not install a power capacitor, surge absorber or radio noise filter (FR-BIF option) between the servo amplifier and servo motor.
7. Use the fault signal to switch power off. Otherwise, the fault of the regenerative brake transistor or the like may overheat the regenerative brake resistor, causing a fire.
8. Do not modify the equipment.

NOTICE

CN1 and CN2 have the same shape. Wrong connection made to the connectors may cause a failure. Connect them correctly.
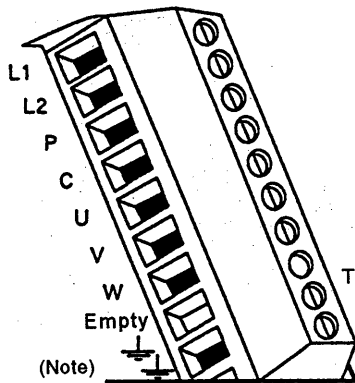
3. WIRING

3 – 1 Servo Amplifier

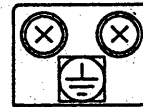| ⚠ CAUTION	Only the voltage specified in the instruction manual should be applied to each terminal. Otherwise, a burst, damage, etc. may occur.

3 – 1 – 1 Terminal block

(1) Signal arrangement

    1) Main circuit terminal block (TE)   2) Protective earth (PE) terminals

L1
L2
P
C
U
V
W
Empty
(Note)

Tightening torque: 5 to 8 [kgf•cm]
(4 to 7 [lb-in])

Terminal screw: M4
Tightening torque: 13 [kgf•cm]
(11 [lb-in])

Note: Unavailable for the EN Standard- and UL/C-UL
Standard-compliant models.

(2) Signals

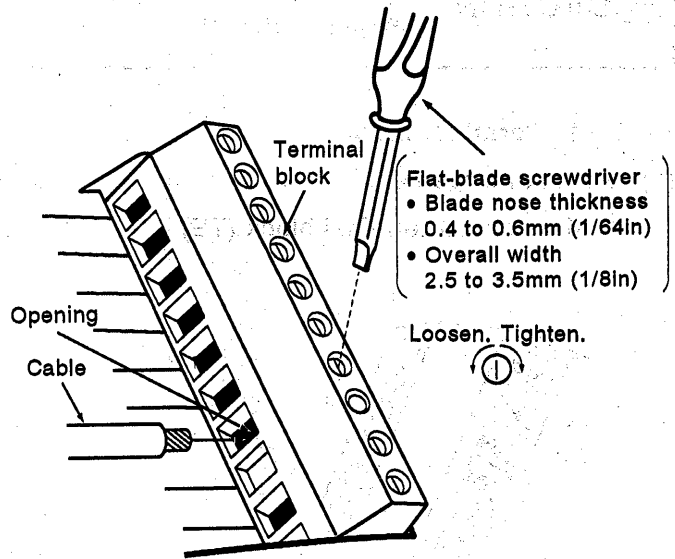| Signal	Symbol	Description
Main circuit power supply	L_1, L_2	Power input terminals. MR-C □A: Single-phase 200 to 230VAC, 50/60Hz MR-C □A1: Single-phase 100 to 120VAC, 50/60Hz When the servo amplifier is connected near a large-capacity power transformer (500kVA or more in the transfomer wiring distance of not more than 10m), an excessive peak current may flow in the power input circuit, failing the amplifier. In such a case, install the power factor improving reactor.
Regenerative brake option	P, C	Regenerative brake option connection terminals. Connect the regenerative brake option.
Servo motor power	U, V, W	Servo motor power terminals. Connect to the servo motor power supply terminals (U, V, W).
Ground		Ground terminals. Connect one to the servo motor and the other one to the ground. For the EN Standard- and UL/C-UL Standard-compliant models, do not use this terminal.
Protective earth (PE) terminals	⏚	Ground terminals For the EN Standard-, UL/C-UL Standard-compliant models, use the protective earth (PE) terminals for grounding. Connect one of the two terminals to the servo motor and the other to the protective earth of the control box.

3. WIRING

(3) Connection method

1) Strip the insulation from the wire.

8 to 9mm
(3/8in)
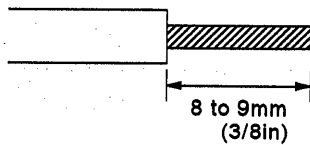
2) Insert the wire into the opening and tighten the corresponding screw with a flat-blade screwdriver so that the cable is not disconnected.

(Tightening torque: 5 to 8kg-cm (4-7 lb-in))

Before inserting the cable into the opening, make sure that the screw of the corresponding terminal is fully loose.

When using a cable of 1.25mm² (16 AWG) or less, two cables can be inserted into one opening.

Terminal block

Opening

Cable

Flat-blade screwdriver
• Blade nose thickness
  0.4 to 0.6mm (1/64in)
• Overall width
  2.5 to 3.5mm (1/8in)

Loosen. Tighten.

(4) Termination of the cables

1) Solid wire ...... After the insulation has been stripped, the cable can be used as it is. (Wire size: 0.2 to 4.0mm² (24-11 AWG))

2) Twisted wire ... Use the cable after stripping the insulation and twisting the wire. At this time, note the short-circuit with the adjoining terminal by loose wires. Do not solder the core as it may cause a contact fault. (Wire size: 0.25 to 2.5mm² (23 to 13 AWG))

3 – 1 – 2 Signal connectors

(1) Connector pin layout (View from the cable side)

1) CN1 (I/O signal connector)

2	1	12	11
ALM	V+	SG	SD
4	3	14	13
OP	PF	LSN	CR
6	5	16	15
	SG	V5	LSP
8	7	18	17
NG	NP		SON
10	9	20	19
PG	PP	V24	OPC

Molex make
52986-2011 or equivalent

2) CN2 (Encoder connector)

2	1	12	11
LG	LG	LG	LG
4	3	14	13
	LG		
6	5	16	15
MD		MDR	
8	7	18	17
	MR	P5	MRR
10	9	20	19
P5		P5	P5

Molex make
52986-2011 or equivalent

MEMO-RANDUM	The connector pin layouts are views looked from the cable connector wiring section.

3. WIRING

(2) Explanation of the connector pins

1) CN1

Signal	Symbol	Connector Pin No.	Functions/Applications	I/O Division (Note)
Servo on	SON	17	Servo start signal terminal. Connect SON-SG to switch on the base circuit (servo on). Disconnect SON-SG to shut off the base circuit (servo off) and coast the servo motor. Set □□1 in parameter No. 6 to change the setting as follows: Disconnect SON-SG to switch servo on and connect SON-SG to switch servo off.	DI-1
Forward rotation stroke end	LSP	15	Forward rotation stroke end signal input terminal. This terminal cannot be used in the factory setting. To use this terminal, set □0□ in parameter No. 6. In this case, when LSP-SG are disconnected, the servo motor cannot be run in the CCW direction. The servo motor can be run in the CW direction. When LSP-SG are disconnected, an alarm does not occur but the home position is lost and zeroing is required again.	DI-1
Reverse rotation stroke end	LSN	14	Reverse rotation stroke end signal input terminal. This terminal cannot be used in the factory setting. To use this terminal, set □0□ in parameter No. 6. In this case, when LSN-SG are disconnected, the servo motor cannot be run in the CW direction. The servo motor can be run in the CCW direction. When LSN-SG are disconnected, an alarm does not occur but the home position is lost and zeroing is required again.	DI-1
Clear	CR	13	Clear signal input terminal. Connect CR-SG to clear the position control counter on the leading edge of the signal. Using parameter No. 6, the setting can be changed to always clear the position counter during connection of CR-SG. The pulse width should be 10ms or more.	DI-1
Trouble	ALM	2	Trouble signal output terminal. ALM-SG are disconnected when power is switched off or the protective circuit is activated to shut off the base circuit. Normally, ALM-SG are connected within 1.5s after power on. Connect the regenerative brake option or the like with a temperature detector to make up a protective circuit.	DO-1
Positioning finished	PF	3	Positioning finished signal output terminal. PF-SG are connected when the number of droop pulses is in the preset in-position range. The in-position range can be changed with parameter No. 5.	DO-1
Encoder Z-phase pulse	OP	4	Outputs the zero-point signal of a encoder. One pulse is output per servo motor revolution. The minimum pulse width is about 800μs. For zeroing using this pulse, set the creep speed to 100r/min or less.	DO-1

Forward rotation pulse train
Reverse rotation pulse train
	PP
	PG
	NP
	NG
		9
		10
		7
		8
			Command pulse train input terminals.
			Input command pulse trains.
			In the open collector system:
			  Forward pulse train across PP-SG
			  Reverse pulse train across NP-SG
			In the differential receiver system:
			  Forward pulse train across PP-NG
			  Reverse pulse train across NP-NG
				DI-2

3. WIRING

Signal	Symbol	Connector Pin No.	Functions/Applications	I/O Division (Note)
Open collector power input	OPC	19	When inputting a pulse train in the open collector system, supply this terminal with (+) 24VDC.	
Interface power input	V24 V5	20 16	Interface power input terminals. 24VDC or 5VDC can be used as an external power supply for interface in the digital input section. Connect the positive (+) terminal of the external supply to V24 when using 24VDC or to V5 when using 5VDC. Supply either of 24VDC and 5VDC to the power supply. Do not supply both at the same time. 24VDC, 24VDC ±10%, 200mA or more 5VDC, 5VDC ±5%, 100mA or more **NOTICE** If power is supplied to both terminals V5 and V24, the servo amplifier will be faulty.	
Digital output power input	V+	1	Digital output power input terminal. Supply power for driving the digital output section.	
Power supply common	SG	5 12	Common terminals. Common terminals for OPC, V24, V5 and V+. Connect the negative (-) terminal of the external power supply.	
Shield	SD	11	Shield terminal. Connect one end of the shield cable.	

Note: Refer to Section 3 − 1 − 4.

2) CN2, CN3

Connector	Function/Application
CN2	Connect with the servo motor encoder. CN1 and CN2 have the same shape. Wrong connection to the connectors may cause a failure.
CN3	Connect the RS-232C option unit (MR-C-T01).

3. WIRING

3 – 1 – 3 Control I/O signals

(1) Forward, reverse rotation stroke ends (LSP, LSN)

To use these signals, set □0□ in parameter No. 6. To perform operation, connect LSP-SG or LSN-SG using a limit switch or the like. When the stroke end terminal (LSP during CCW rotation or LSN during CW rotation) is disconnected during operation, the servo motor is brought to a sudden stop and then servo-locked. At this time, the deviation counter is cleared.
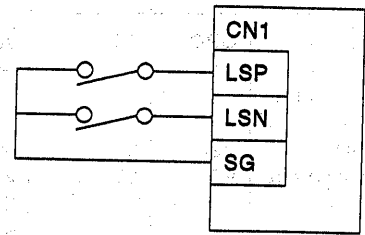
(2) Clear (CR)

When CR-SG are connected, the deviation counter is cleared on the leading edge of its signal. By setting 1□□ in parameter No. 6, the deviation counter is kept cleared during connection of this terminal. Disconnect this terminal when operation is to be performed.

(3) Positioning finished (PF)

This signal is switched on when the droop pulse value of the deviation counter is within the preset in-position range (parameter No. 5). If a large value has been set in the in-position range (parameter No. 5), the PF signal may remain on during low-speed operation where the droop pulse value is small.
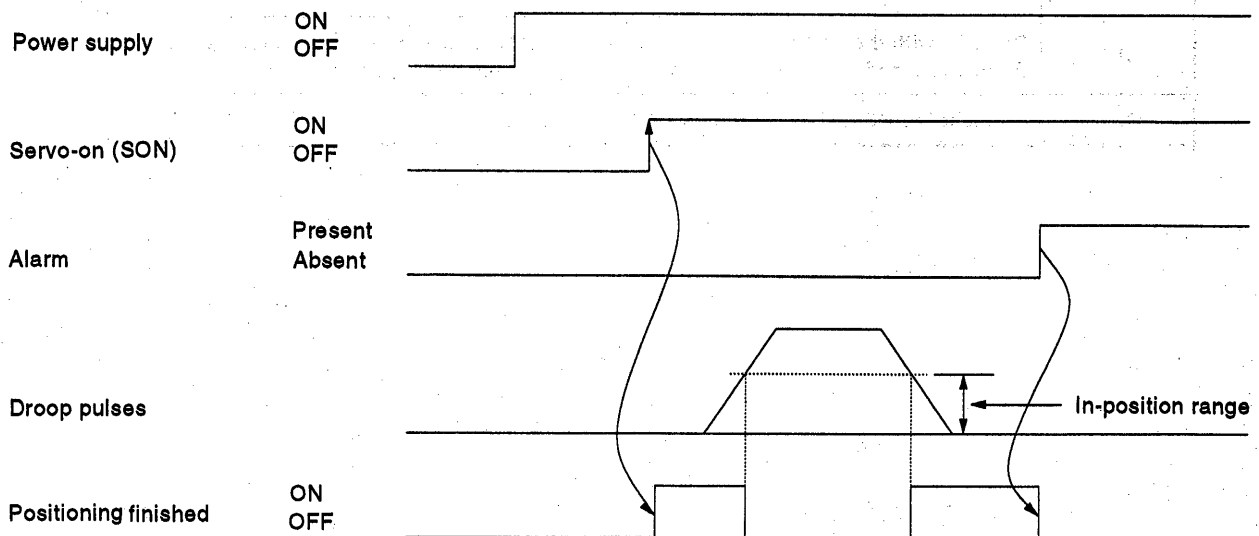
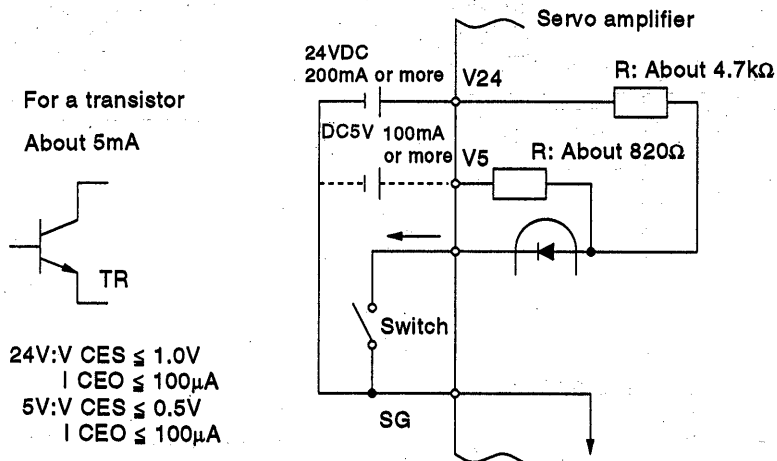### 3 – 1 – 4 Interfaces

The details of the interfaces (refer to I/O Section in the table) to the signals indicated in Section 3 – 1 – 2 (2) are given below. Refer to the following to connect to external equipment.

(1) Digital input interface DI-1

Supply a signal with a relay or open collector transistor.

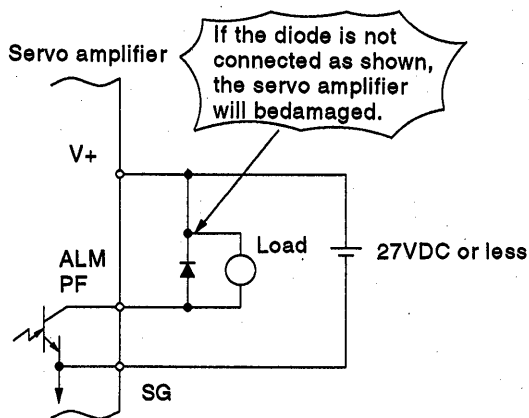Supply either of 24VDC and 5VDC to the power supply. Do not supply both at the same time.

For a transistor

About 5mA

TR

24V:V CES ≦ 1.0V
   I CEO ≦ 100µA
5V:V CES ≦ 0.5V
   I CEO ≦ 100µA

NOTICE	If power is supplied to both terminals V5 or V24, the servo amplifier will be faulty.

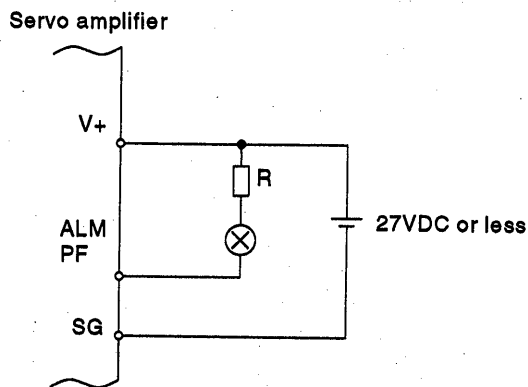(2) Digital output interface DO-1

A lamp, relay or photocoupler can be driven. Provide a diode (D) for an inductive load, or an inrush current suppressing resistor (R) for a lamp load. (Permissible current: 40mA or less, inrush current: 100mA or less)

(a) Inductive load

If the diode is not connected as shown, the servo amplifier will bedamaged.

(b) Lamp load

3. WIRING

(3) Pulse train input interface DI-2

  1) Open collector system

    • Interface example

Servo amplifier

OPC Max. input pulse frequency 200kpps

About 2kΩ

24VDC

PP(NP)

About 10mA

SG

SD

    • Input pulse specification

$$tLH = tHL < 0.2\mu s$$
$$tc > 2\mu s$$
$$tF > 3\mu s$$

  2) Differential line driver system

    • Interface example

Servo amplifier

Max. input pulse frequency 200kpps

Am26LS31 or equivalent

PP(NP)

SG PG(NG)

SD

    • Input pulse specification

$$tLH = tHL < 0.2\mu s$$
$$tc > 2\mu s$$
$$tF > 3\mu s$$

3. WIRING

3 – 2 Servo Motor

3 – 2 – 1 Connection instructions

> ⚠ **WARNING**   Insulate the power connection terminals to prevent an electric shock.

> ⚠ **CAUTION**
> 1. Connect the output terminals (U, V, W) correctly. Otherwise, the servo motor will not operate correctly.
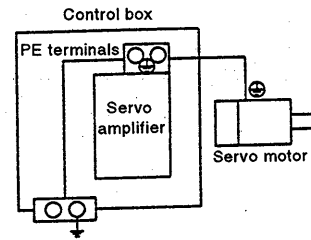> 2. Do not connect AC power supply directly to the servo motor. Otherwise, a fault may occur.

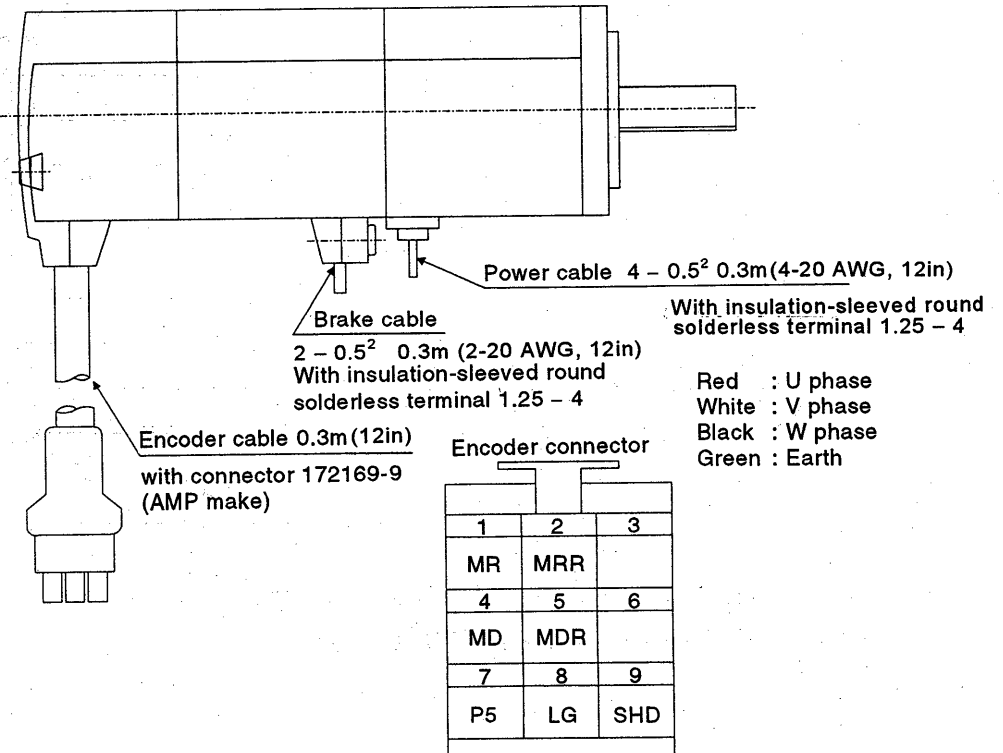> **NOTICE**   Do not run the power cable and encoder cable in parallel. Such wiring may cause a fault.

1) Wind insulation tape around the connection three or four times to ensure insulation. For the EN Standard-compliant models, make connection via a fixed terminal block.

Servo amplifier side
Servo motor side
Wind insulation tape three or four times.
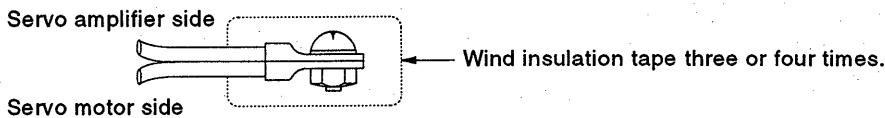
2) For grounding, make connection via the protective earth (PE) terminals of the servo amplifier, and connect the protective earth of the control box to the ground.

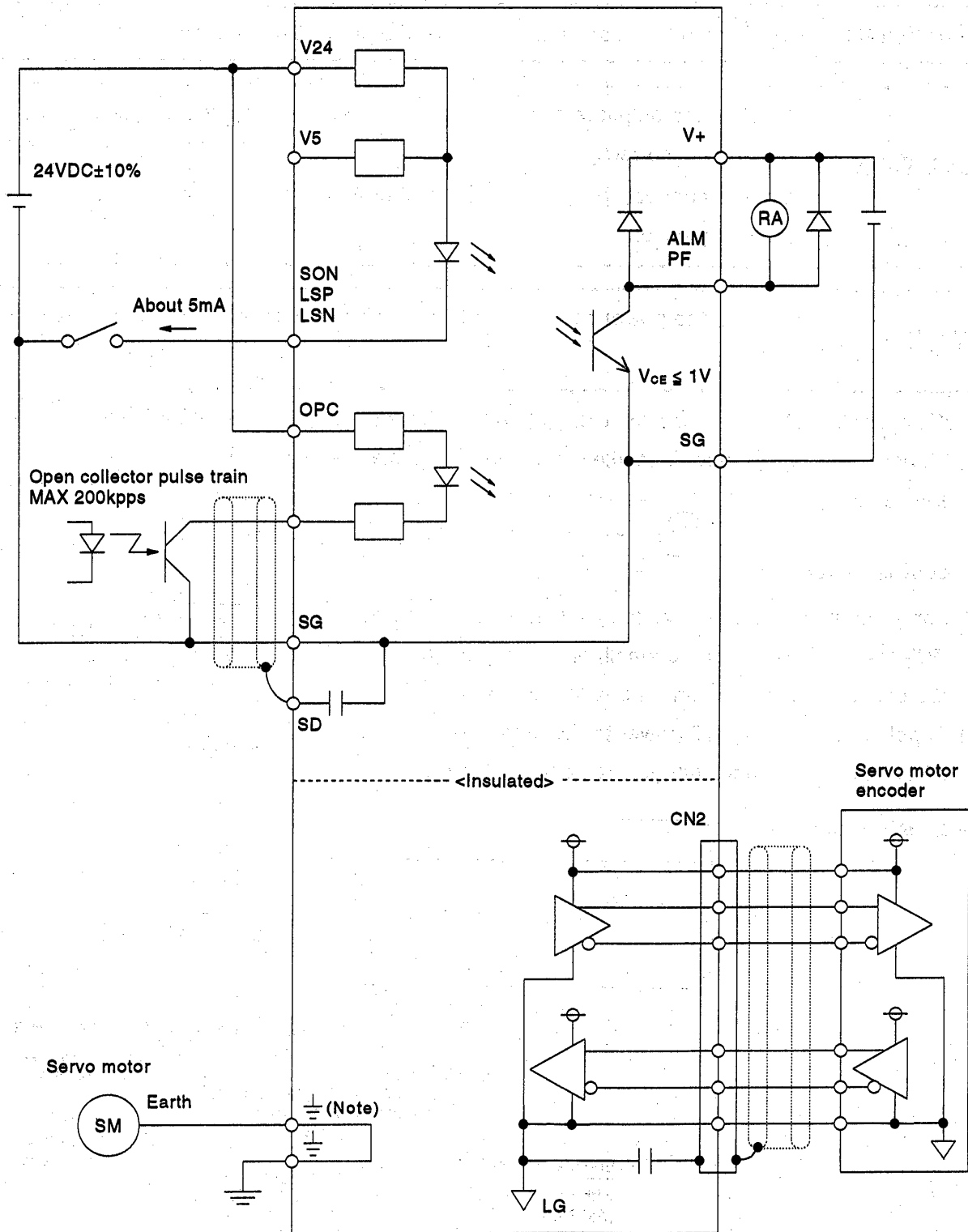3) Supply exclusive 24VDC power to the brake leads of the servo motor equipped with electromagnetic brake.

Control box
PE terminals
Servo amplifier
Servo motor

3 – 2 – 2 I/O terminals

Power cable 4 – 0.5² 0.3m (4-20 AWG, 12in)
With insulation-sleeved round solderless terminal 1.25 – 4

Brake cable
2 – 0.5² 0.3m (2-20 AWG, 12in)
With insulation-sleeved round solderless terminal 1.25 – 4

Encoder cable 0.3m (12in)
with connector 172169-9
(AMP make)

Red   : U phase
White : V phase
Black : W phase
Green : Earth

Encoder connector

1	2	3
MR	MRR	
4	5	6
MD	MDR	
7	8	9
P5	LG	SHD

3. WIRING

3 – 3 Common Line

The power supply and its common line are shown below.

Note: When using the EN Standard-, UL/C-UL Standard-compliant model, use the protective earth (PE) terminals.

3 - 4 Grounding

⚠ WARNING	1. Connect the servo amplifier and servo motor to ground. 2. For the EN Standard-compliant model, always connect the protective earth (PE) terminal (marked ⏚) of the servo amplifier to the protective earth (PE) of the control box to prevent an electric shock.

The servo amplifier switches the power transistor on-off to supply power to the servo motor. Depending on the wiring and ground cable routing, the servo amplifier may be affected by the switching noise (due to di/dt and dv/dt) of the transistor. To prevent a fault, always follow the grounding and wiring instructions.

Refer to the following diagram and run the ground cable, such as a flat mesh copper cable, as large as possible (3.5mm^2 (12 AWG) or more is desirable).

To conform to the EMC Directive, refer to the EMC INSTALLATION GUIDELINES (IB(NA)67310).
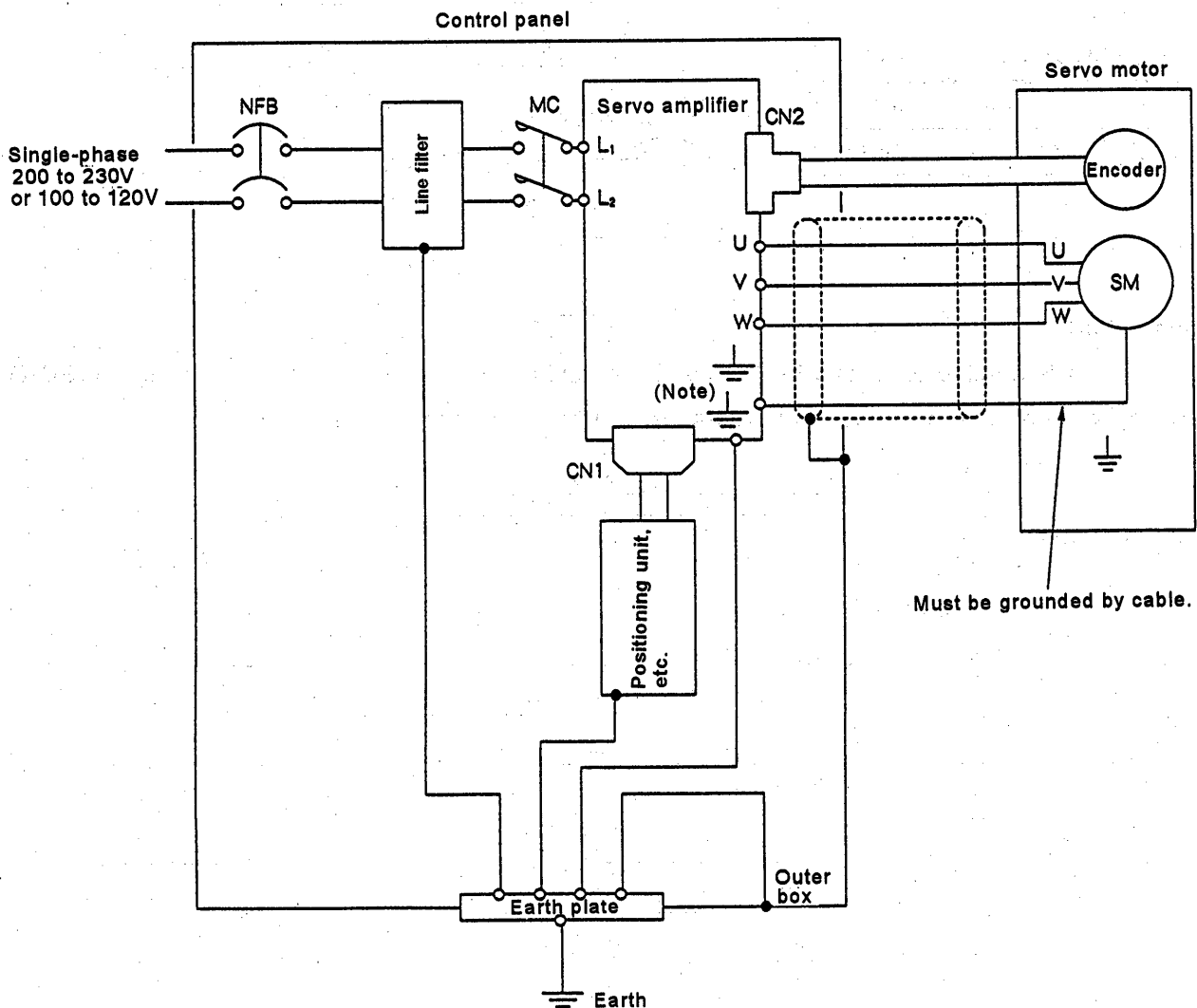
Note: When using the EN Standard-, UL/C-UL Standard-compliant model, use the protective earth (PE) terminals.

3. WIRING

3 – 5 Power Supply Circuit

| ⚠ CAUTION	1. If you suspect faulty operation, immediately switch the power off. Continuous flow of a large current may cause a fire. 2. When a regenerative brake resistor is used, use an alarm signal to switch power off. Otherwise, a regenerative brake transistor fault may overheat the regenerative brake resistor and cause a fire. 3. If a 200V power supply is used with the servo amplifier designed for 100V power supply (MR-C□A1), the internal capacitor will explode, causing injury.

(1) Connection example

Wire the power and main circuits as shown below. A no-fuse breaker (NFB) must be used with the input cables of the power supply.

Single-phase AC power supply

MR-C□A	200 to 230V, 50/60Hz
MR-C□A1	100 to 120V, 50/60Hz
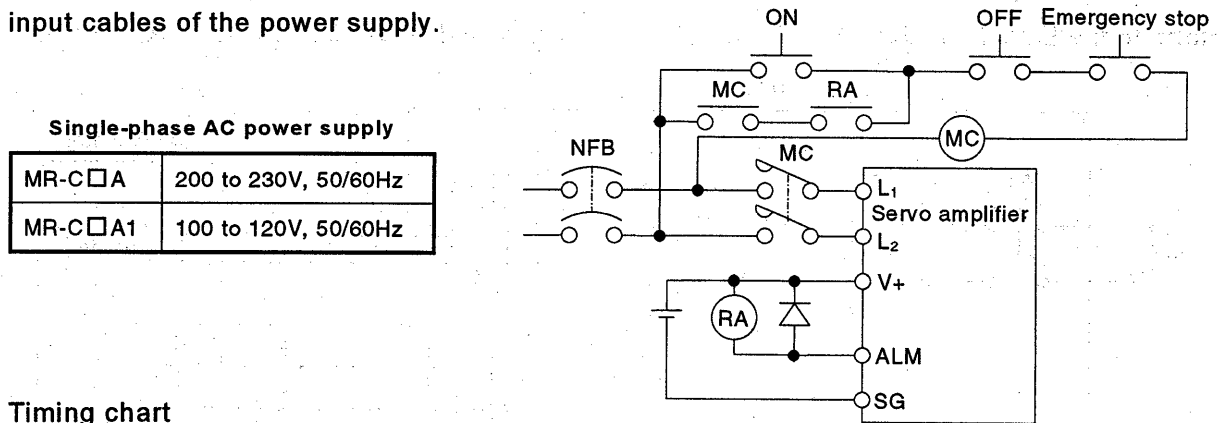
(2) Timing chart

When power is applied to L_1 and L_2, the control circuit is switched on. The servo-on signal (SON) is switched on after about 1.5s, then operation can be performed.
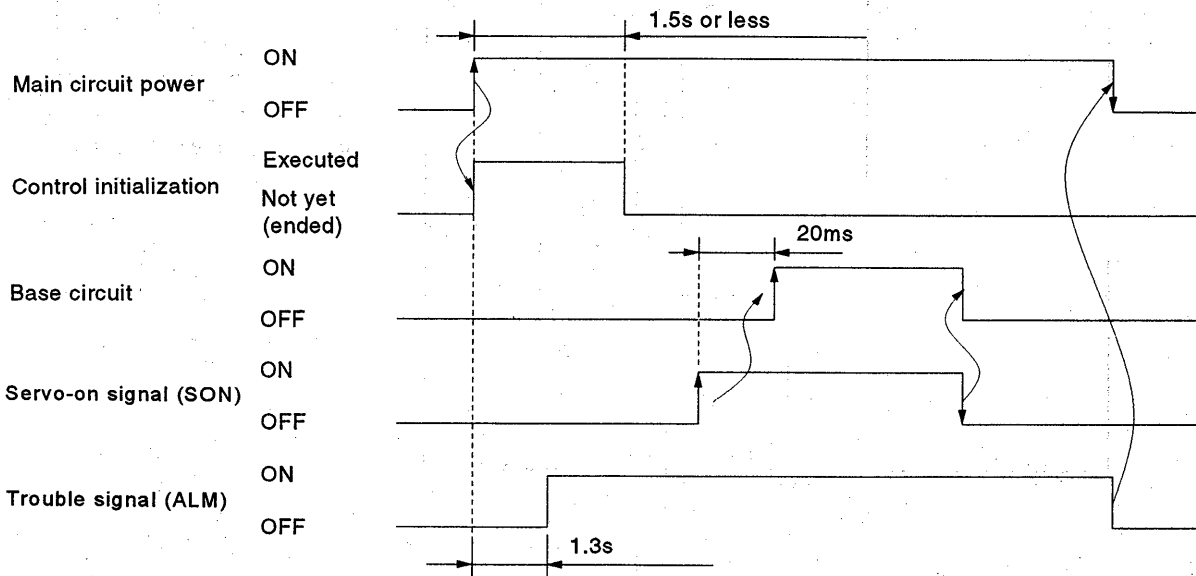
| MEMO-RANDUM	Switching power on within 5s after power-off will cause the undervoltage alarm (A10).

3. WIRING

3 – 6 Timing Chart at Alarm Occurrence

⚠ CAUTION	When an alarm has occurred, remove its cause, make sure that the operation signal is not being input, ensure safety, and reset the alarm before restarting operation.

When an alarm occurs in the servo amplifier, the base circuit is shut off and the servo motor is coated to a stop. Switch power off in the external sequence. To reset the alarm, remove the cause of the alarm and switch power on.
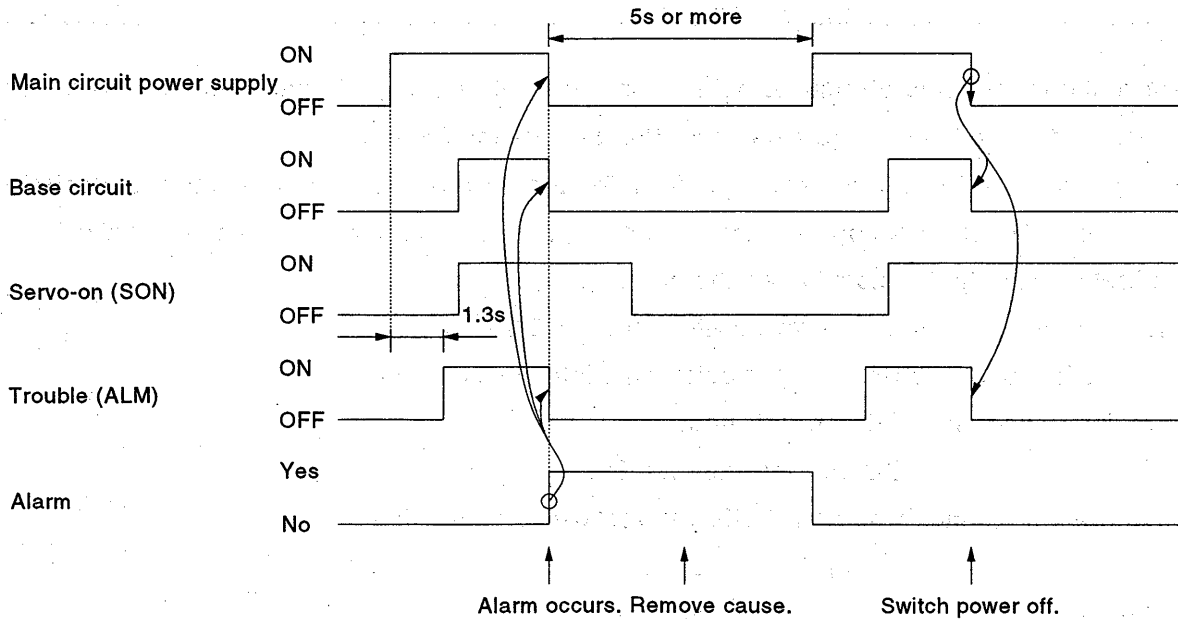
1) If operation is repeated by switching power off, then on after the occurrence of the overcurrent (A32) or overload (A50) alarm, without the cause of the alarm removed, the servo amplifier and servo motor may become faulty due to temperature rise.

2) If operation is repeated by switching power off, then on after the occurrence of the regenerative (A30) alarm, the external regenerative brake resistor will generate heat, resulting in a hazardous accident.
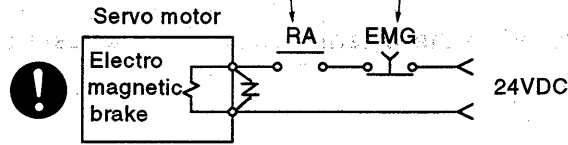
3 – 7 Servo Motor with Electromagnetic Brake

⚠ CAUTION	Configure the electromagnetic brake circuit so that it is activated not only by the servo amplifier signals but also by an external emergency stop signal.

Contacts must be open when servo is off or when an alarm (trouble) is present.

Circuit must be opened during emergency stop.

Servo motor

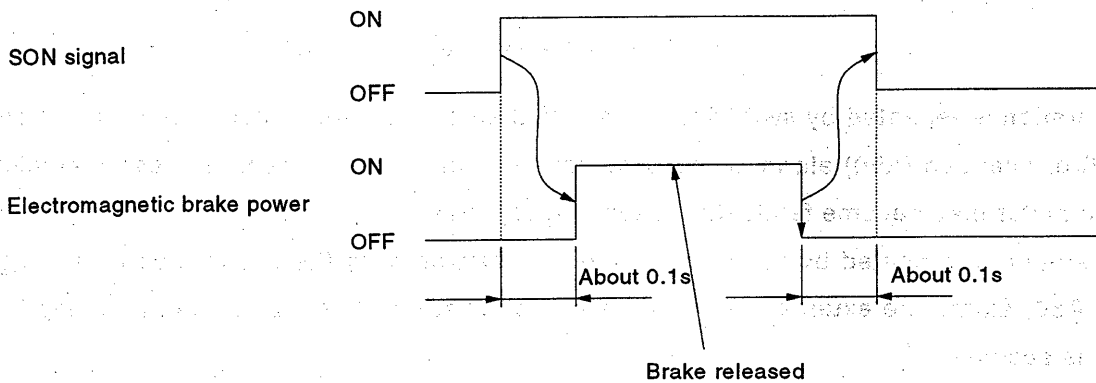Electro magnetic brake

RA   EMG

24VDC

For applications requiring a brake to hold the motor shaft (vertical lift applications), a servo motor with electromagnetic brake should be used. Please note the following:

1) Do not share the 24VDC power supply for interface between the interface and the electromagnetic brake. An exclusive power supply must be provided for the electromagnetic brake.

2) The brake will stop the motor when the power (24VDC) is off.

3) When operating the brake, always switch off the SON signal.

4) In all applications, take the braking delay time into consideration.

Braking delay time   AC shut-off: About 0.1s

DC shut-off: About 0.03s

5) Configure a sequence which will satisfy the following timing chart:

SON signal
ON
OFF

Electromagnetic brake power
ON
OFF

About 0.1s   About 0.1s

Brake released

Also, the electromagnetic brake interlock signal may be used by changing the setting of parameter No. 21. Refer to Section 5 – 2 – 2.