



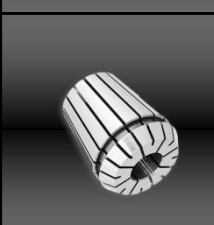
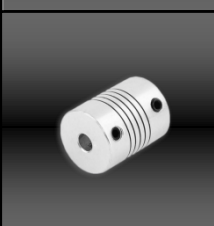
CNC PROM

# CNC PROM



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Інтернет – магазин комплектуючих для верстатів з ЧПУ



## Серводвигун Mitsubishi HC-PQ23



<https://cnc.prom.ua>



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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.

### **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.

### **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.

#### 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:

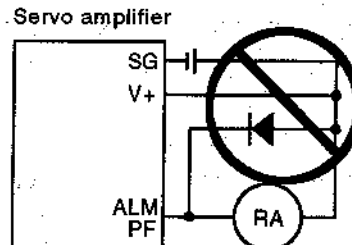
Environment		Conditions	
		Servo Amplifier	Servo Motor
Ambient temperature	[°C]	0 to +50 (non-freezing)	0 to +40 (non-freezing)
	[°F]	32 to 122 (non-freezing)	32 to 104 (non-freezing)
Ambient humidity		90%RH or less (non-condensing)	80%RH or less (non-condensing)
Storage temperature	[°C]	-20 to +65 (non-freezing)	-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/s <sup>2</sup> ]	5.9 (0.6G) or less	X, Y: 19.6 (2G)
	[ft/s <sup>2</sup> ]	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-B1F 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.



## (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.

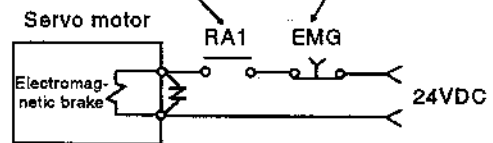
(5) Just in case

**⚠ CAUTION**

- ⚠ When it is assumed that a hazardous condition may take place at the occurrence of 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.



(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.

(7) Disposal

**⚠ CAUTION**

- ⚠ Dispose of the product as general industrial waste.

(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.

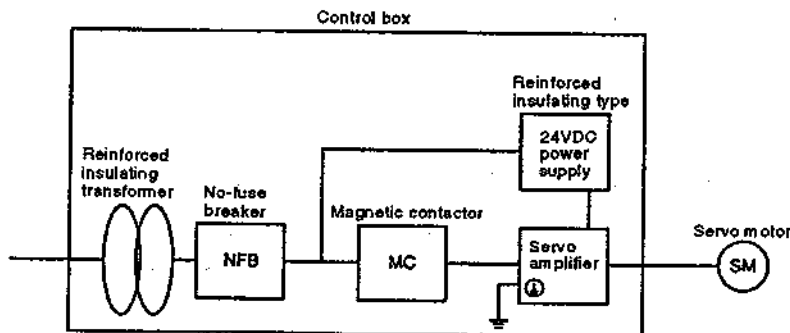
The servo do not function independently but are designed for use with machines and equipment. Therefore, the EMC Directive does not apply to the servo but applies to the machines and equipment into which the servo are installed.

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

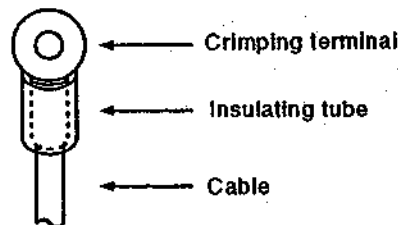
- 1) To prevent an electric shock, always connect the protective earth (PE) terminal (marked ⊕) of the servo amplifier to the protective earth (PE) of the control box.
- 2) Do not connect two ground cables to the same protective earth (PE) terminal. Always connect the cables to the terminals one-to-one.



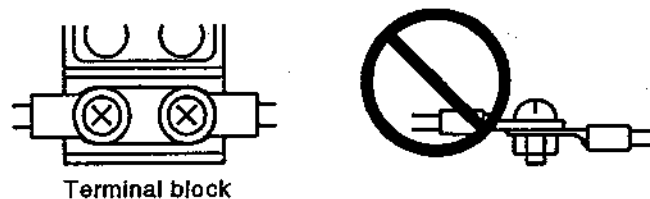
- 3) If a leakage current breaker is used to prevent an electric shock, the protective earth (PE) terminals of the servo amplifier must be connected to the corresponding earth terminals.

(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.



- 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.



(6) Auxilliary 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 amplifier 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 × 150 × 6	033-053-13
250 × 250 × 6	23
250 × 250 × 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

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This chapter provides basic information needed to use this servo.

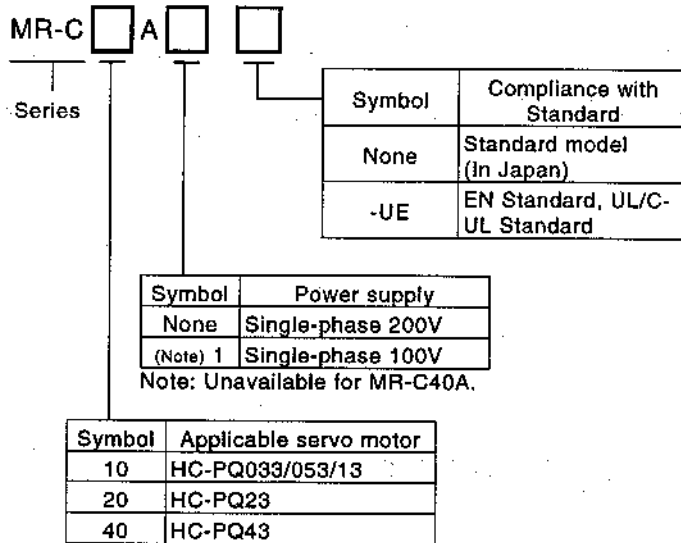
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# 1. INTRODUCTION

## 1-1 Model Definition

### (1) Servo amplifier



### Name plate

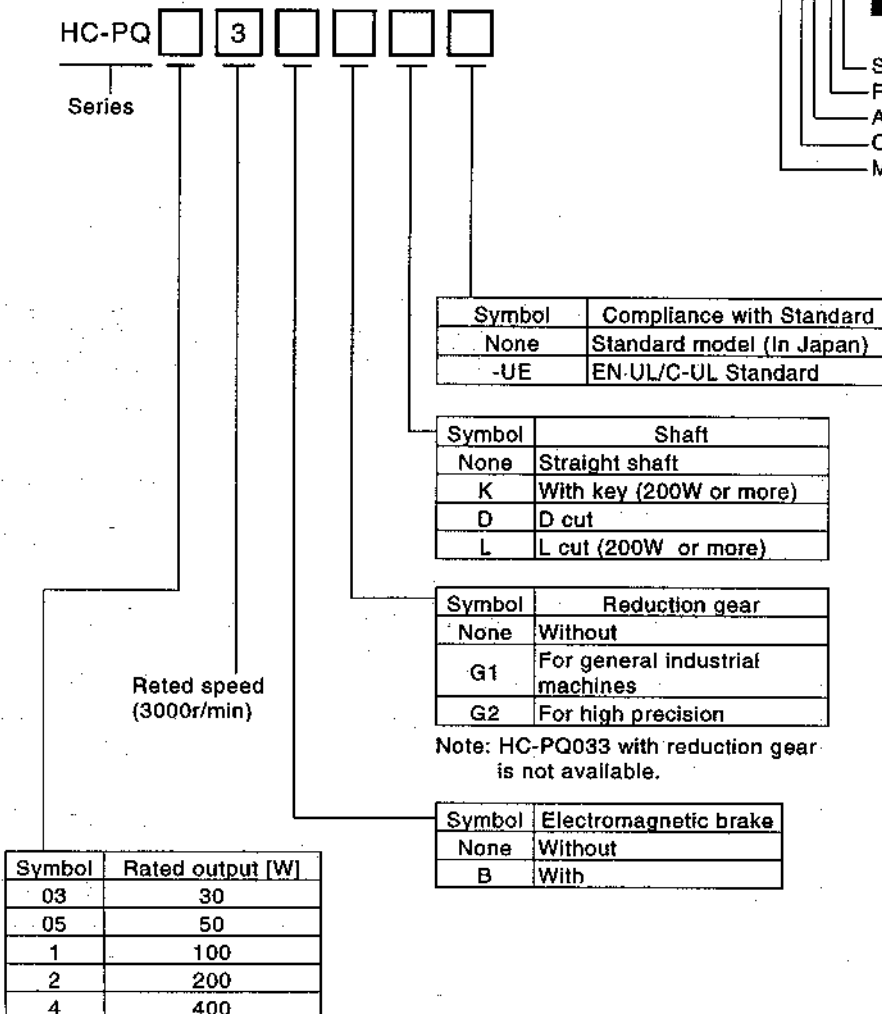
MITSUBISHI AC SERVO	
MODEL	MR-C10A
POWER	100W
AC INPUT	AC200V-230V 50/60Hz
OUTPUT	6.0A
SERIAL	A5X0010022 TC300A034G55
MITSUBISHI ELECTRIC CORPORATION MADE IN JAPAN	

Serial number  
Rated output current  
Applicable power supply  
Capacity  
Model

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	

Serial number  
Rated output current  
Applicable power supply  
Capacity  
Model

### (2) Servo motor



Date of manufacture  
Serial number  
Model

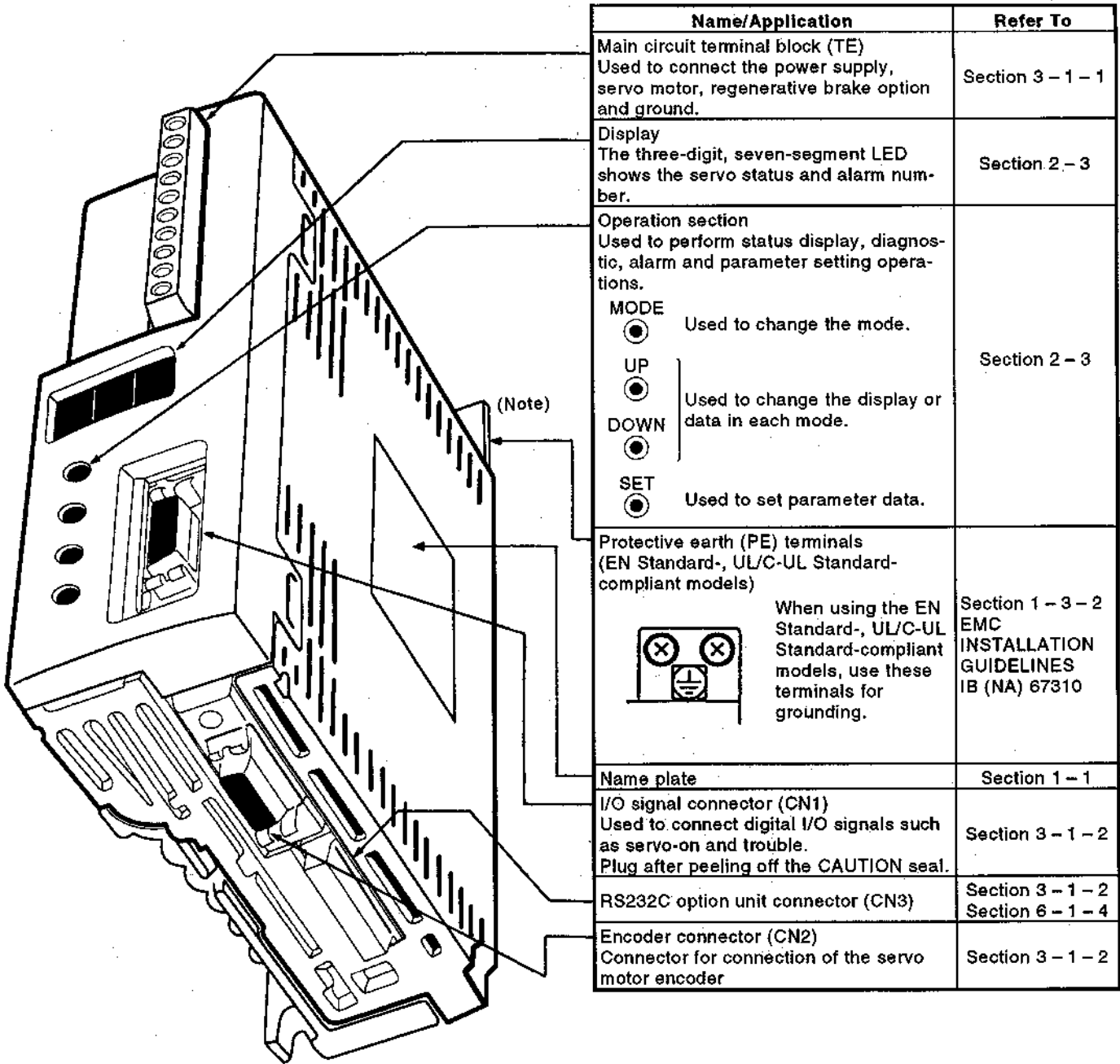
### Name plate

MITSUBISHI AC SERVO MOTOR	
MODEL	HC-PQ053
SERIAL	
DATE	
MITSUBISHI ELECTRIC CORPORATION 835506 01	

# 1. INTRODUCTION

## 1-2 Parts Identification and Application

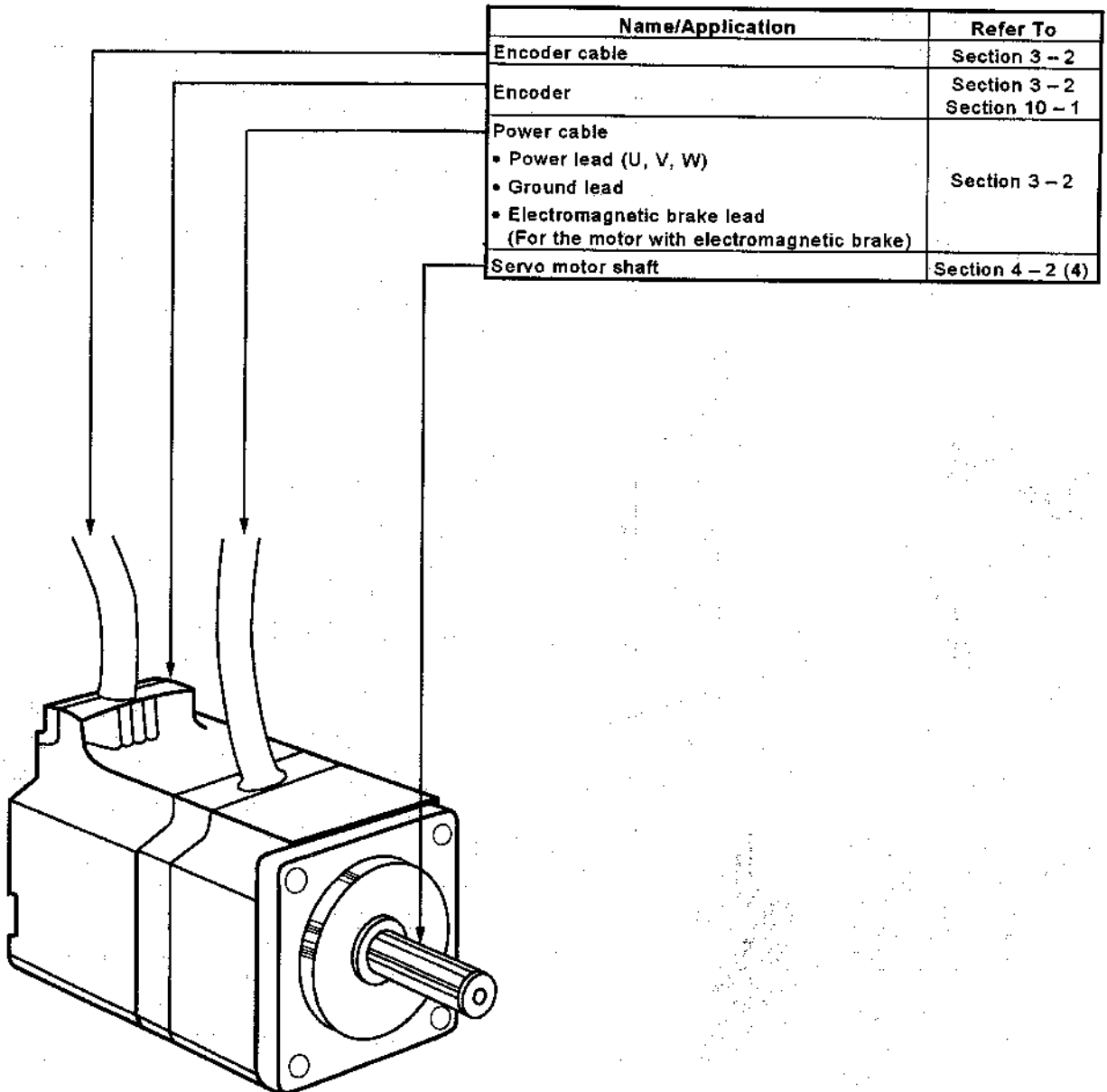
### 1-2-1 Servo amplifier



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

# 1. INTRODUCTION

## 1-2-2 Servo motor



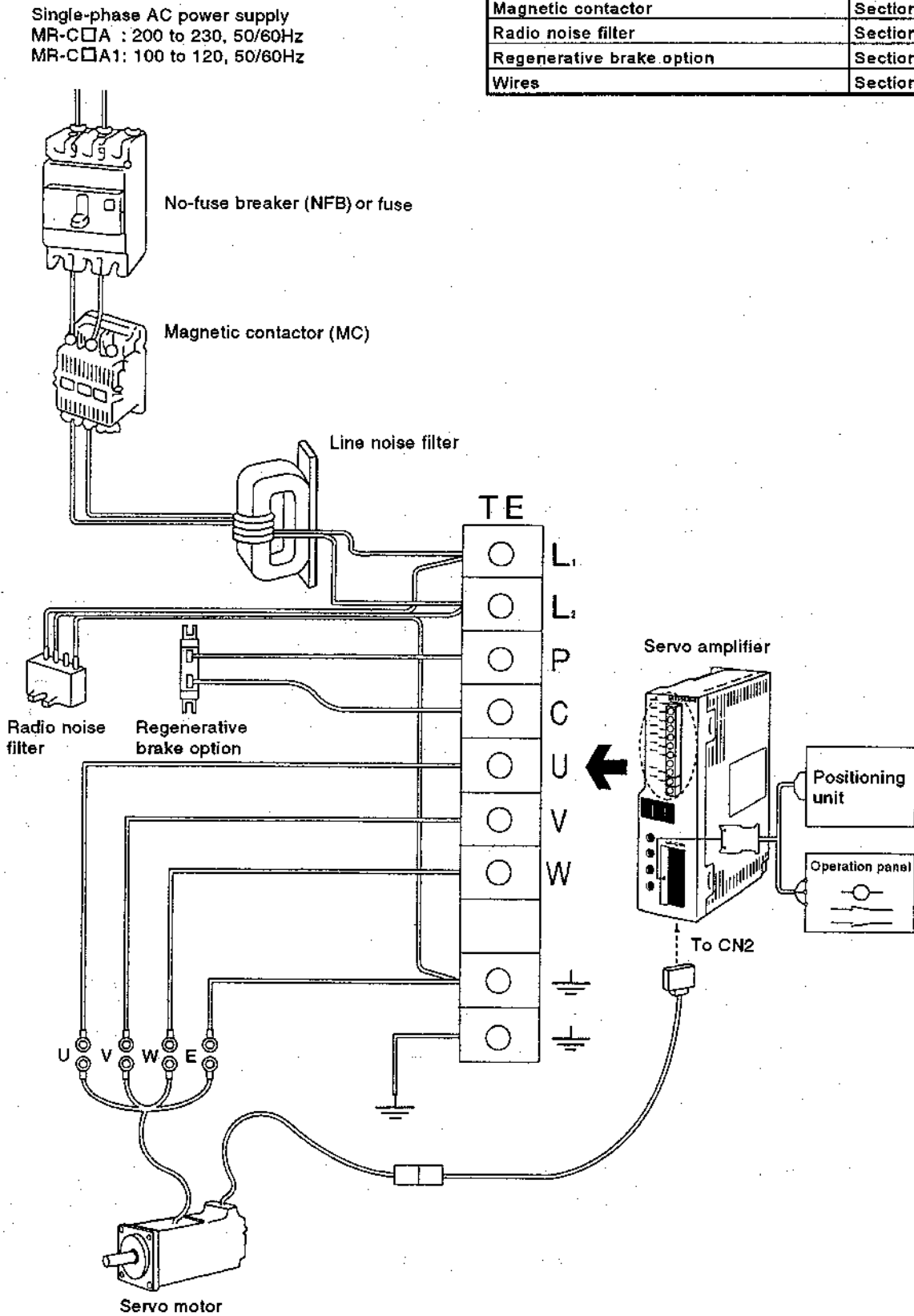


# 1. INTRODUCTION

## 1-3 Basic Configuration

### 1-3-1 Standard models

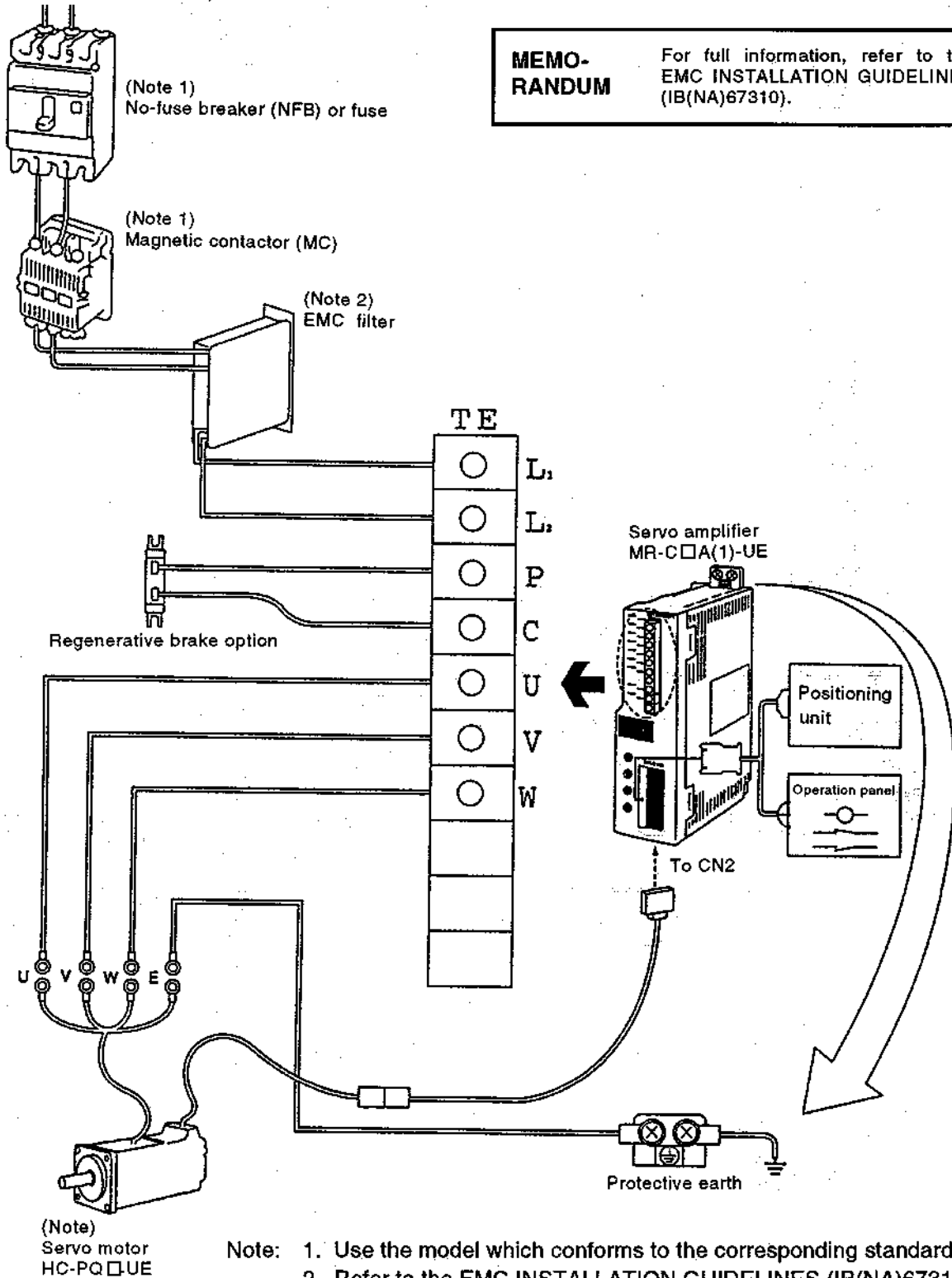
Options, Auxiliary Equipment	Refer To
No-fuse breaker	Section 6-2-1
Magnetic contactor	Section 6-2-1
Radio noise filter	Section 6-2-4
Regenerative brake option	Section 6-1-1
Wires	Section 6-2-1



# 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



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

- 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

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This chapter gives basic connection examples and operation procedure.

### 2 – 1 Standard Connection Examples

2 – 1 – 1 Connection with the FX-1GM

2 – 1 – 2 Connection with the FX-1GP

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

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

### 2 – 2 Operation

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2 – 2 – 2 Operation procedure

2 – 2 – 3 Troubleshooting at start-up

2 – 2 – 4 Determining the cause of a position offset

### 2 – 3 Display and Operation

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2 – 3 – 2 Status display

2 – 3 – 3 Diagnostic mode

2 – 3 – 4 Alarm mode

2 – 3 – 5 Parameter mode

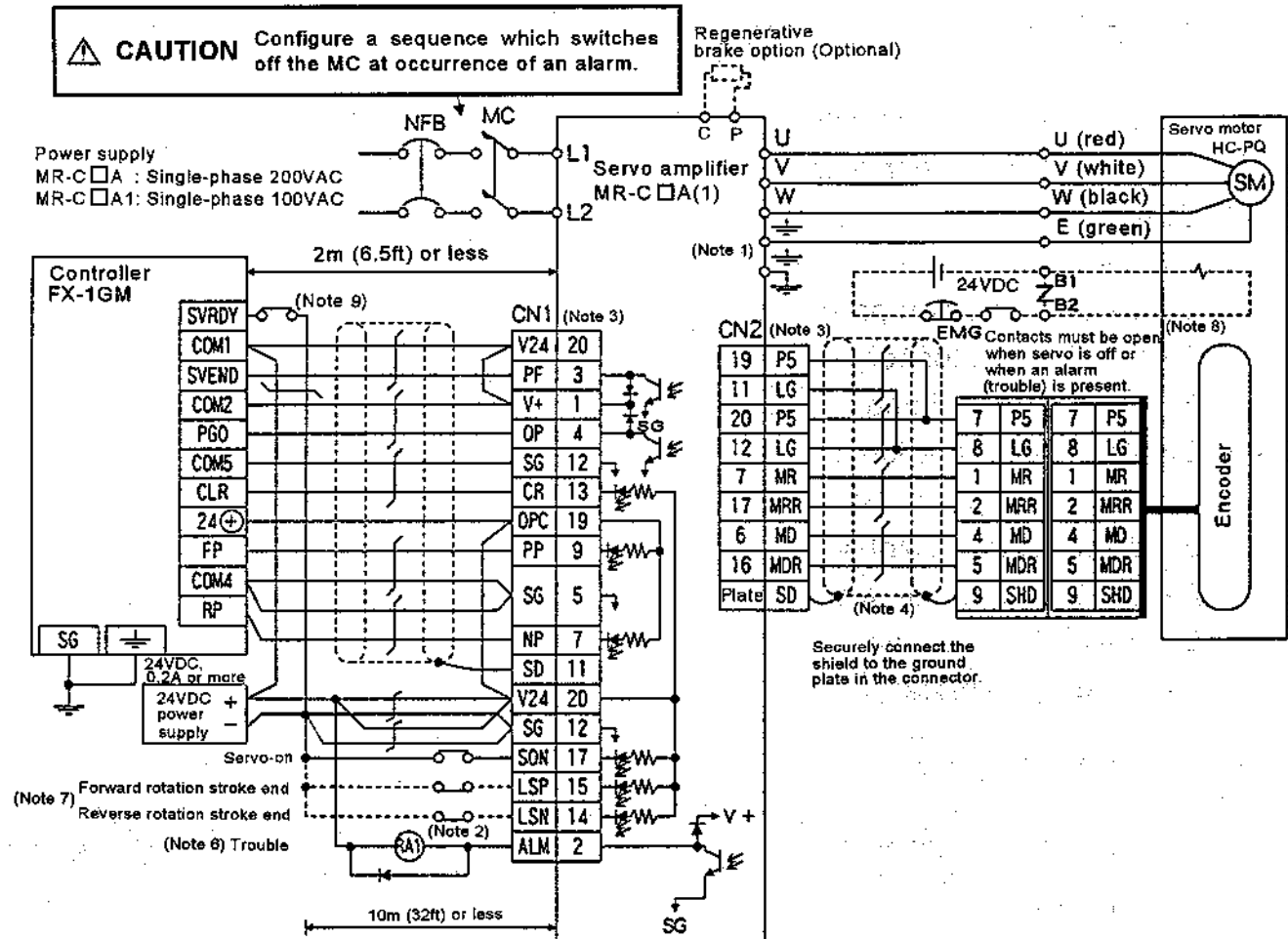
<b>INTRODUCTION</b>	<b>CHAPTER 1</b>
<b>OPERATION</b>	<b>CHAPTER 2</b>
<b>WIRING</b>	<b>CHAPTER 3</b>
<b>INSTALLATION</b>	<b>CHAPTER 4</b>
<b>ADJUSTMENTS AND APPLICATION OPERATIONS</b>	<b>CHAPTER 5</b>
<b>OPTIONS AND AUXILIARY EQUIPMENT</b>	<b>CHAPTER 6</b>
<b>MAINTENANCE AND INSPECTION</b>	<b>CHAPTER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

## 2. OPERATION

### 2-1 Standard Connection Examples

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

#### 2-1-1 Connection with the FX-1GM



**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.

## 2. OPERATION

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### MEMO- RANDUM

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

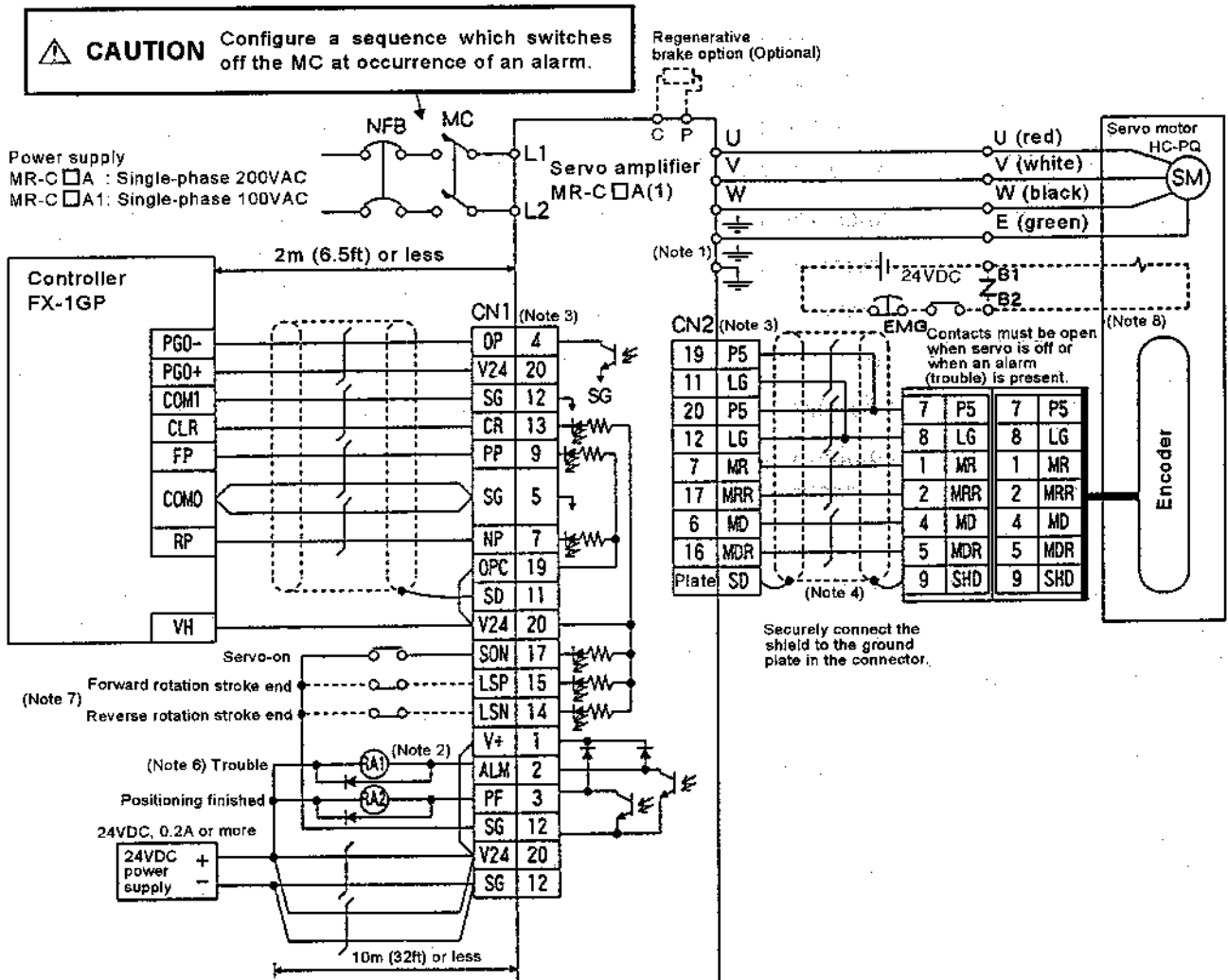
5. The pins with the same signal name are connected together in the servo amplifier.
6. The trouble (ALM) signal conducts current when there is no alarm, i.e. in the normal state.

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. OPERATION

### 2-1-2 Connection with the FX-1GP



**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.

## 2. OPERATION

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### 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.

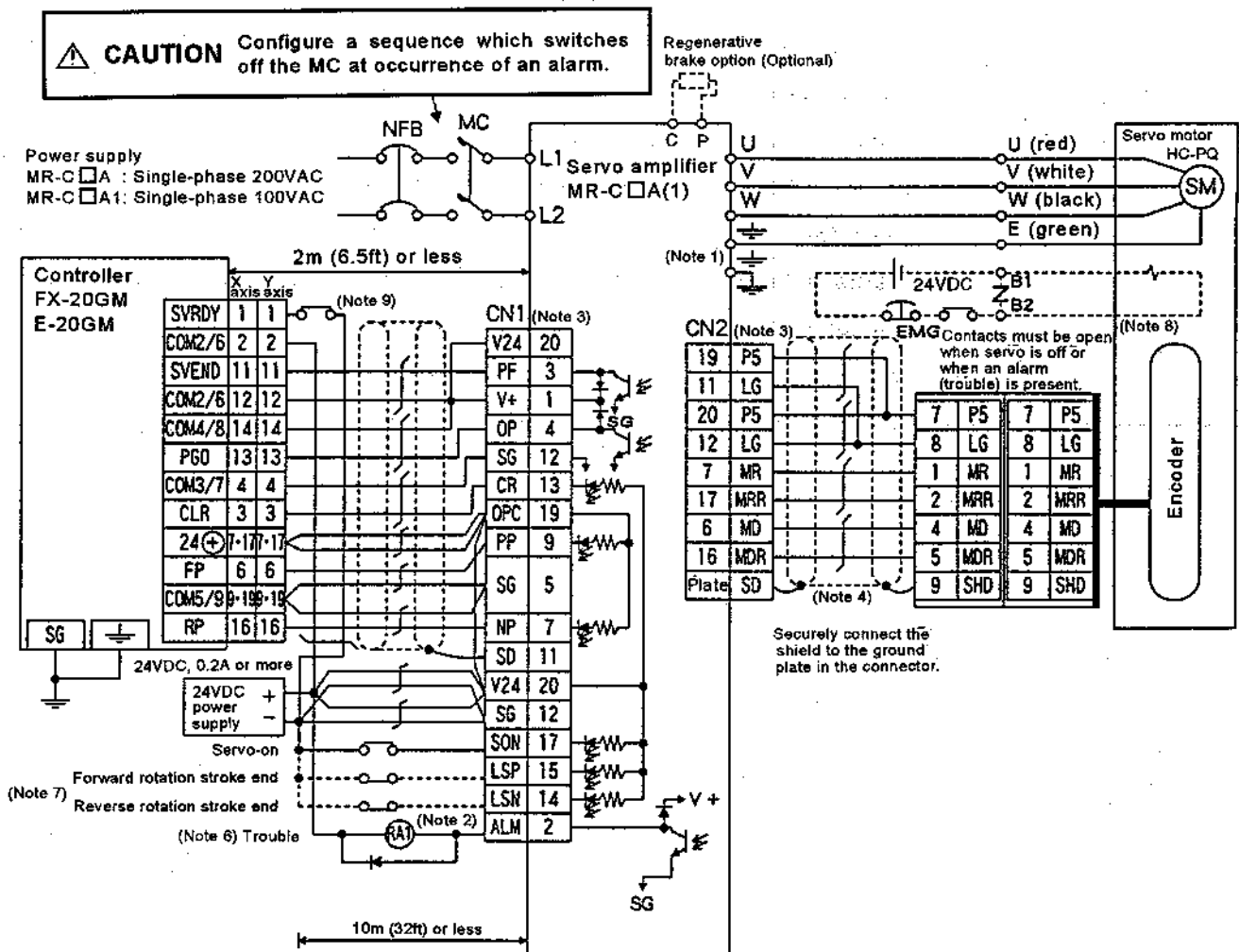
When this signal is switched off (at occurrence of an alarm), the output of the controller must be stopped by the sequence program.

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



**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.



## 2. OPERATION

### 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.

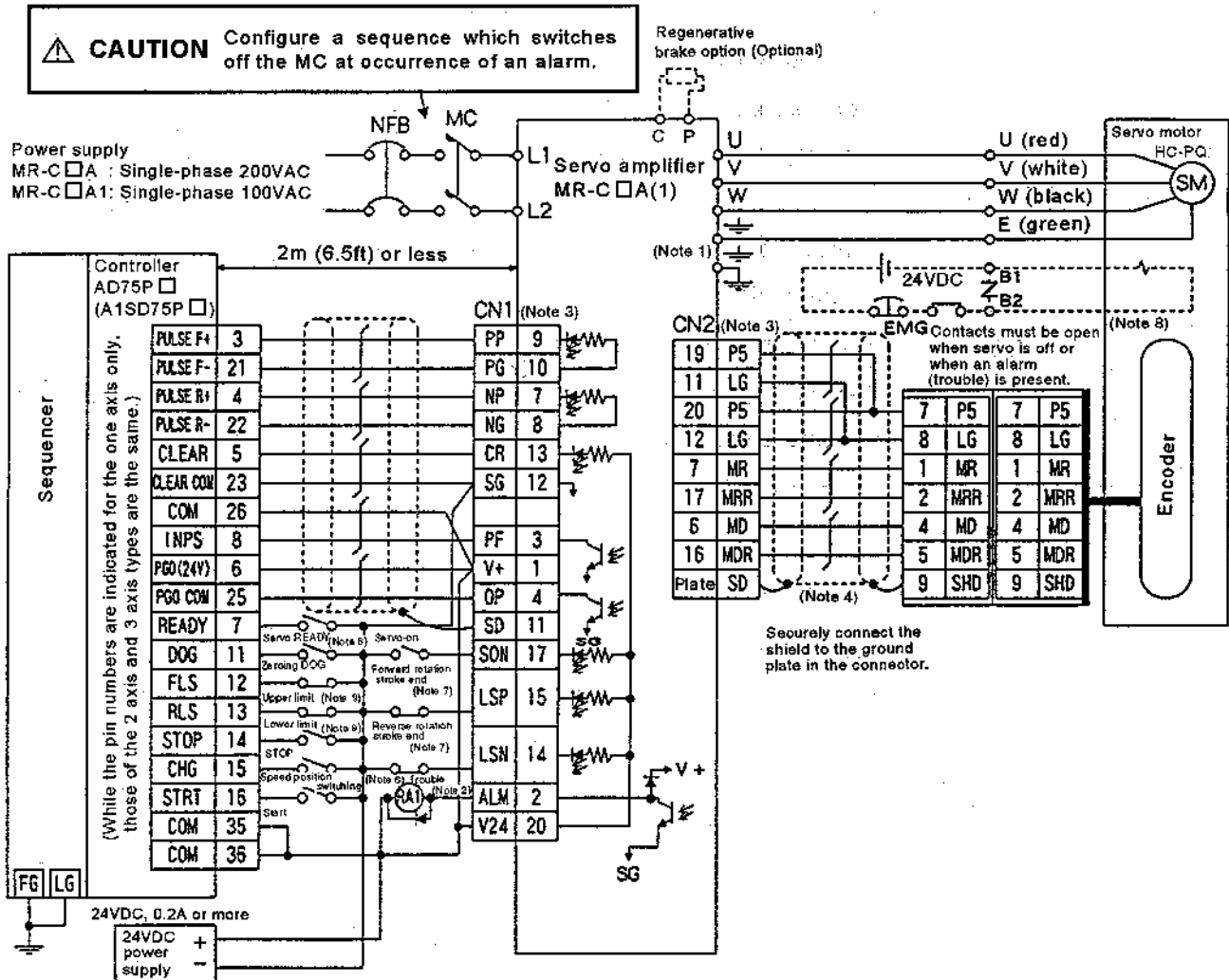
7. Since the LSP and LSN signals have been automatically switched on internally before shipment, set 0 in parameter No. 6 to make the function valid.

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. OPERATION

### 2-1-4 Connection with the AD75P □ or A1SD75P □



**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.

## 2. OPERATION

### 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 amplifier.

## 2. OPERATION

### 2-2 Operation

#### 2-2-1 Pre-operation checks

Before starting operation, check the following:

##### (1) Wiring

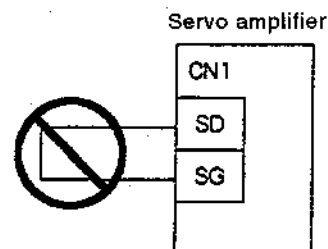
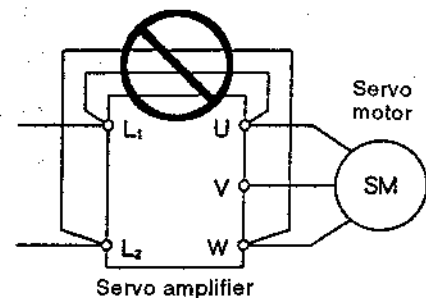
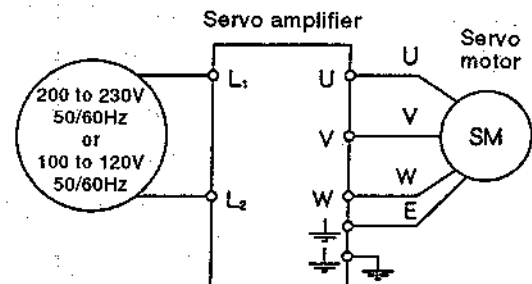
- 1) A correct power supply is connected to the power input terminals (L1, L2) of the servo amplifier.
- 2) The servo motor power supply terminals (U, V, W) of the servo amplifier match in phase with the power input terminals (U, V, W) of the servo motor.
- 3) The servo amplifier and servo motor are 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

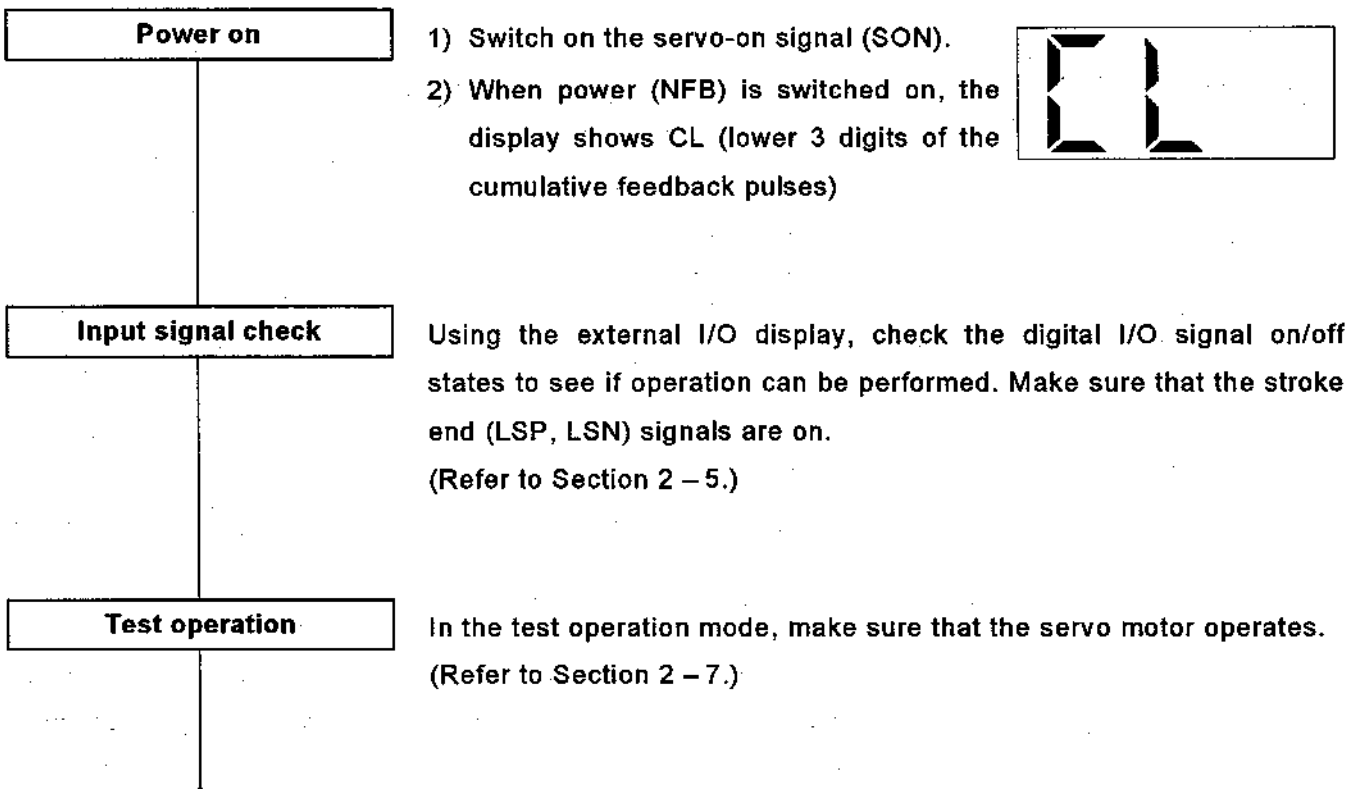
### 2-2-2 Operation procedure

**⚠ 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.



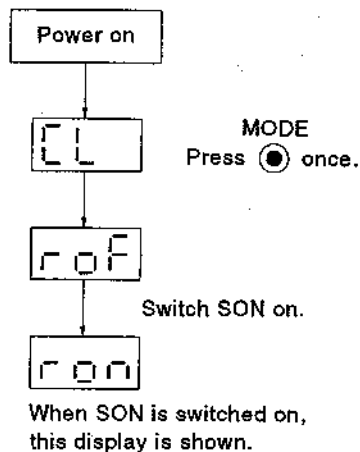
## 2. OPERATION

### 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)

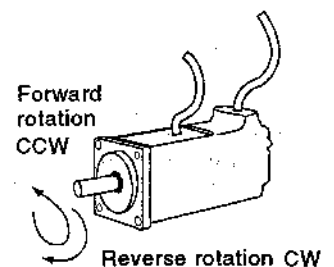
If the shaft is not servo-locked, the servo-on signal is not on. Check the external sequence up to the diagnostic display.

#### Confirmation method



### 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.
- 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.



## 2. OPERATION

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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.

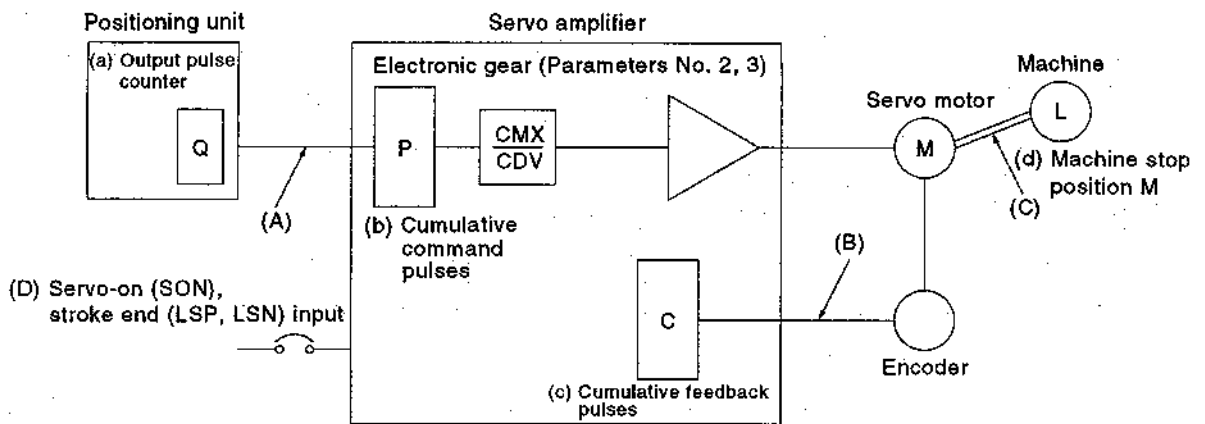
The following table lists faults that may occur in each step in the servo start-up sequence, and their check points and assumed causes. If an alarm occurs, refer to Chapter 8 and take the appropriate action.

No.	Start-Up Sequence	Fault	Check Point	Assumed Cause	Refer To
1	Power on	<ul style="list-style-type: none"> <li>• The LED is not lit.</li> <li>• The LED flickers.</li> </ul>	Not improved when the connectors CN1 and CN2 are disconnected.	<ul style="list-style-type: none"> <li>• Power supply voltage faulty.</li> <li>• Servo amplifier failure</li> </ul>	—
			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)  $P \cdot \frac{CMX(\text{Parameter No. 2})}{CDV(\text{Parameter No. 3})} = C$  (cumulative command pulses  $\times$  electronic gear ratio  
= cumulative feedback pulses)
- 3)  $C \cdot \Delta = M$  (cumulative feedback pulses  $\times$  travel per pulse = machine position)

When a position offset occurs, check the following situations:

- 1) When  $Q \neq P$   
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  $P \cdot \frac{CMX}{CDV} \neq C$   
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  $C \cdot \Delta \neq M$   
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

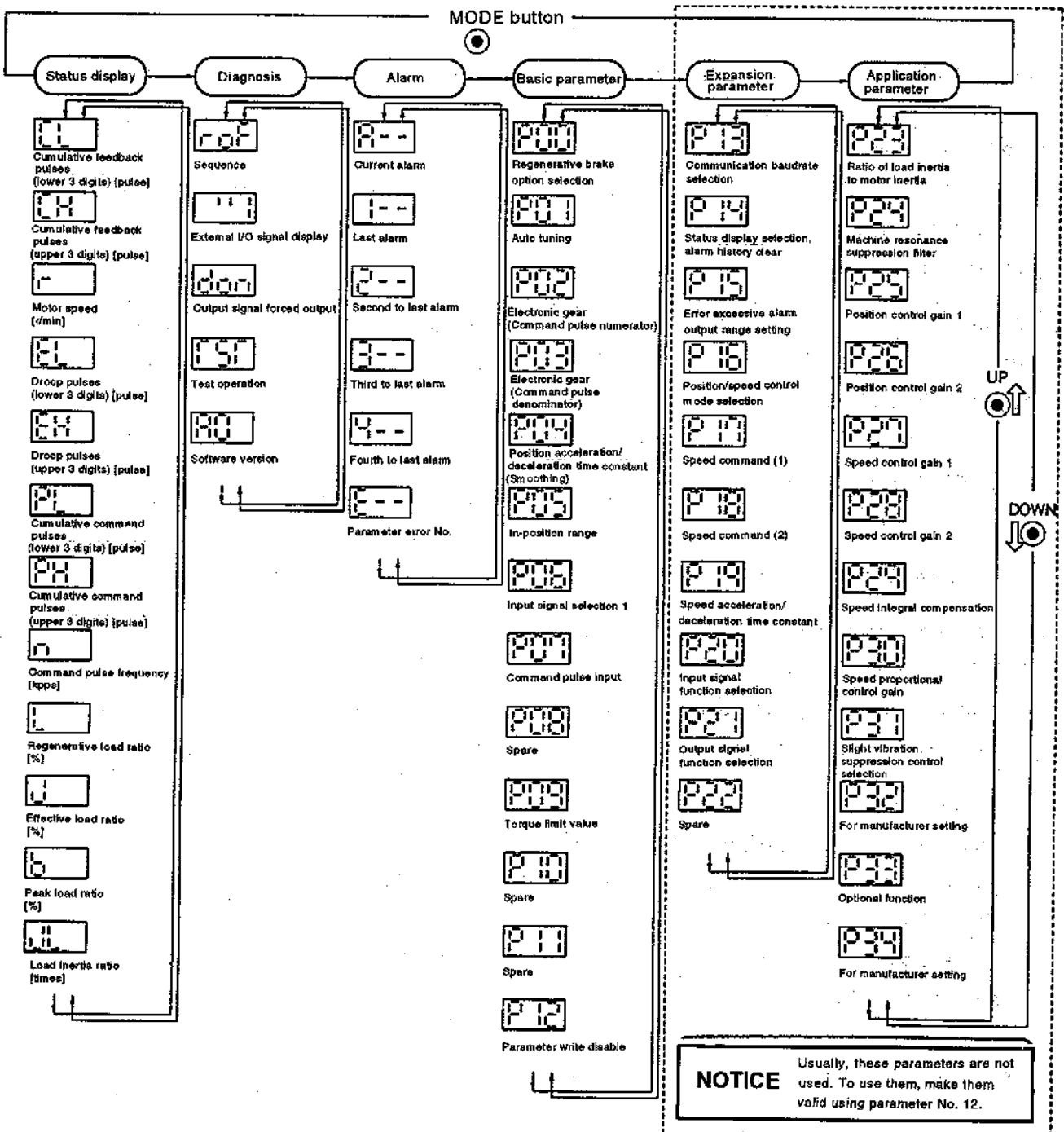
#### 2-3-1 Display flowchart

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.

MODE UP DOWN

Press the , or 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).



## 2. OPERATION

### 2-3-2 Status display


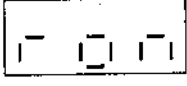
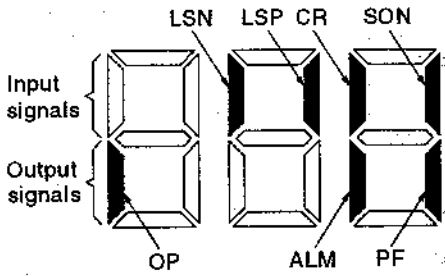



The servo status during operation is shown on the 3-digit, 7-segment LED display.

Press the  $\overset{\text{UP}}{\text{⊙}}$  or  $\overset{\text{DOWN}}{\text{⊙}}$  button to change display data as desired. When the required data is selected, the corresponding symbol is displayed. Press the  $\overset{\text{SET}}{\text{⊙}}$  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 $\pm 999999$ is exceeded, the value begins with zero.
Cumulative feedback pulses (Upper 3 digits)	CH			Press the $\overset{\text{SET}}{\text{⊙}}$ 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	$\times 10r/\text{min}$	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 $\overset{\text{SET}}{\text{⊙}}$ 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 $\pm 999999$ 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. Press the $\overset{\text{SET}}{\text{⊙}}$ 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.
Cumulative command pulses (Upper 3 digits)	PH			
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 $\overset{\text{SET}}{\text{⊙}}$ 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		<p>Indicates the on/off states of the external I/O signals.</p> <p>The upper segments correspond to the input signals and the lower segments to the output signals.</p> <p>Lit: ON Extinguished: OFF</p> <p>Refer to (1) in this section. The I/O signals can be changed using parameters No. 20 and 21.</p> <p>The ALM signal is ON when there is no alarm.</p> <p>Refer to Section 5-2-2.</p>
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

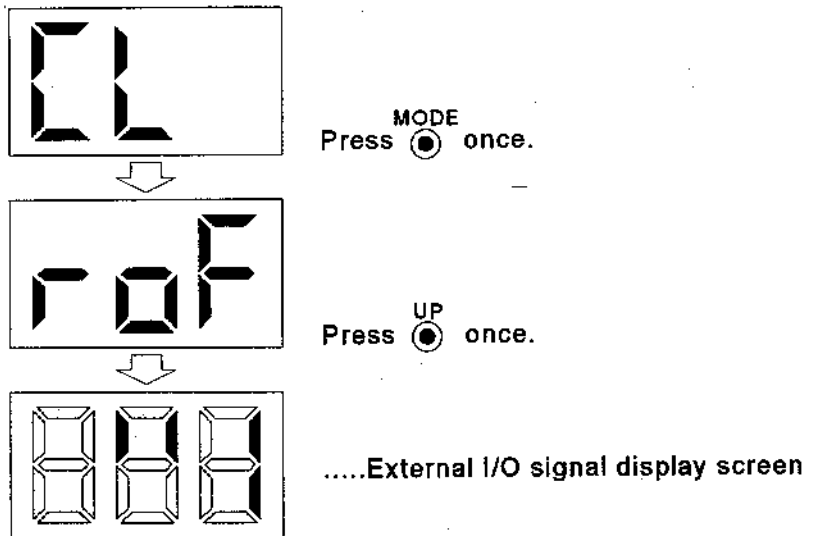
#### MEMO-RANDUM

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

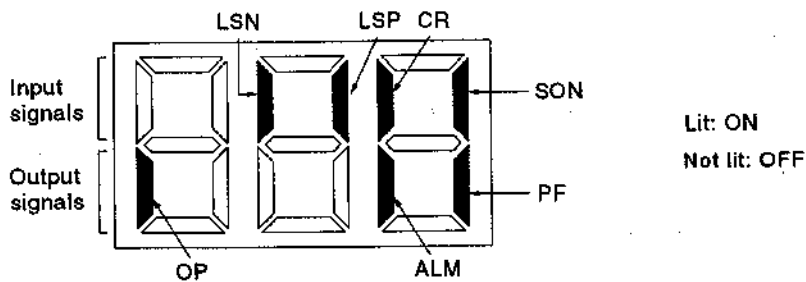
The on/off states of the digital I/O signals connected to the servo amplifier can be confirmed. In addition, the I/O signals displayed for parameters No. 20 and 21 can be changed. Refer to Section 5-2-2.

#### 1) Operation

Display screen after power-on is shown.



#### 2) Display definition



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

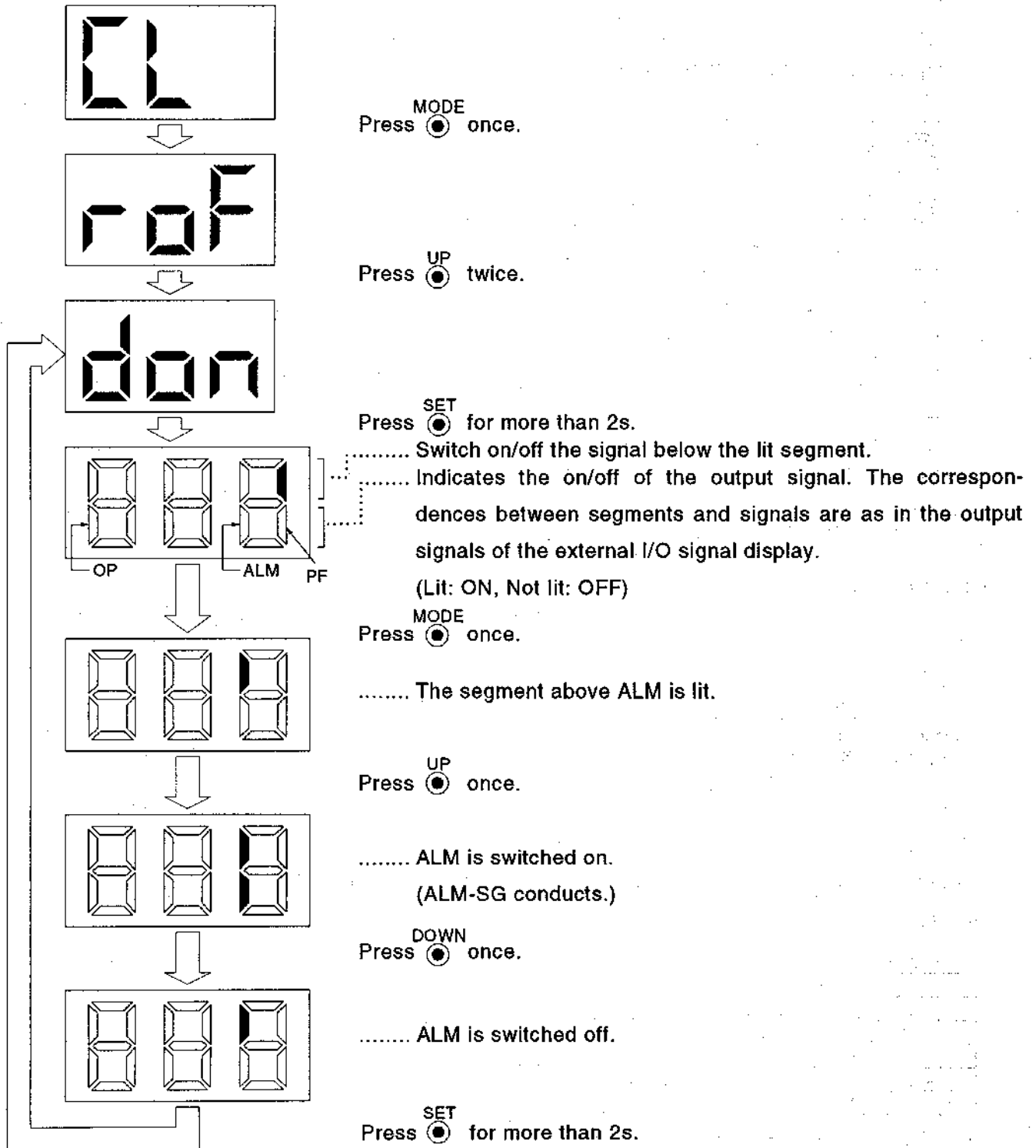
### (2) Output signal forced output

#### 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.



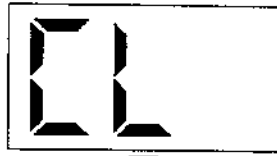
## 2. OPERATION

### (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.



MODE  
Press ● once.



UP  
Press ● three times.



SET  
Press ● for more than 2s.



..... When this screen is displayed, jog operation can be performed.

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

The servo status during test operation can be displayed. Press <sup>MODE</sup> ● to shift to the status display screen. The display data is the same as in the status display in Section 2-3-2.

#### 4) Termination of test operation

To terminate the test operation, switch power off once, or press <sup>MODE</sup> ● to call the  screen, then press <sup>SET</sup> ● 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

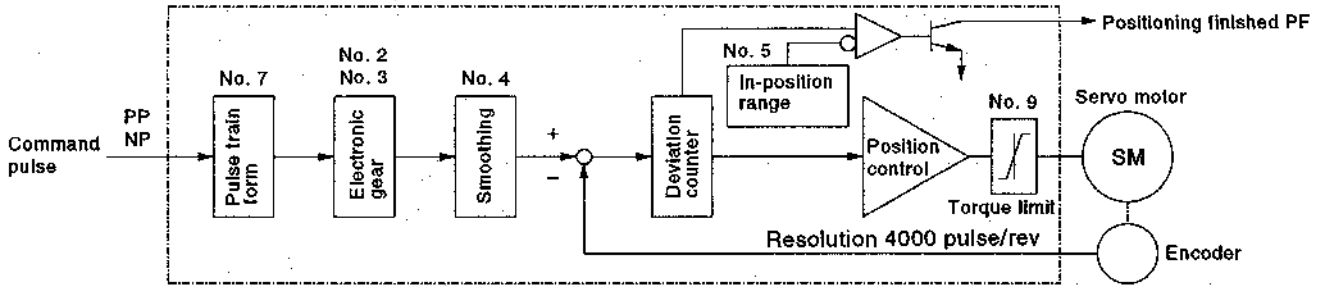
- (1) The unit can enter the alarm mode from any screen.
- (2) The other screen is visible during occurrence of an alarm. At this time, the decimal point in the third digit flickers.
- (3) To clear any alarm, switch power on, then off or press the <sup>SET</sup> button on the current alarm screen. Note 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.

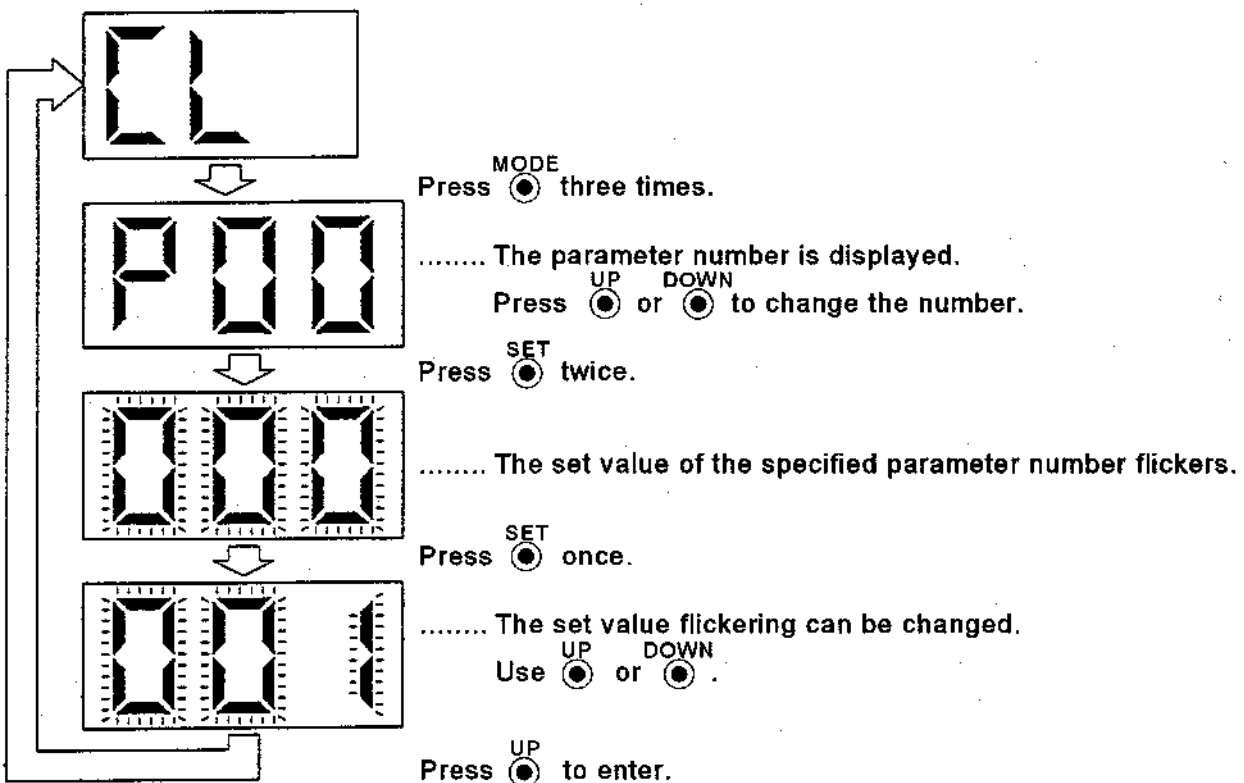


The parameter settings need not be changed to operate this servo. Note that the parameter settings should be changed when:

- 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.



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	○	×	×
	Write	○	×	×
00A	Reference	○	×	×
	Write	Allowed for No. 12 only.	×	×
00B	Reference	○	○	×
	Write	○	×	×
00C	Reference	○	○	×
	Write	○	○	×
00D	Reference	○	○	○
	Write	○	○	○

## 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	$\times 10$ rad/s	
	28	VG2	Speed control gain 2 (actual position gain)	60	$\times 10$ rad/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.

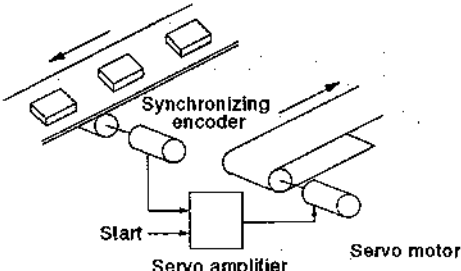
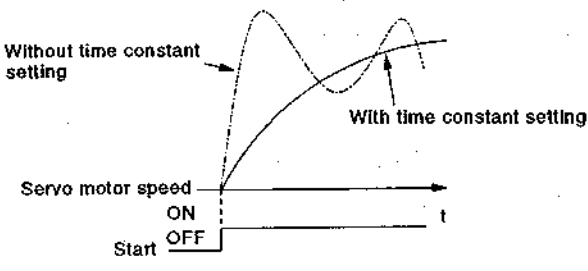
## 2. OPERATION

### (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	<p>Regenerative brake option/low acoustic noise mode selection: Used to select the regenerative brake option and low acoustic noise mode.</p> <div style="border: 1px solid black; padding: 5px; display: inline-block;"> <table border="1" style="border-collapse: collapse;"> <tr> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px; text-align: center;">0</td> <td style="width: 20px; height: 20px;"></td> </tr> </table> </div> <p>Select the regenerative brake option. 0: Not used 1: MR-RB013 2: MR-RB033</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <p><b>NOTICE</b> If wrong setting is made, the regenerative brake option may overheat!</p> </div> <p>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</p>		0		000		000 to 102h																								
		0																															
1	ATU	<p>Auto tuning: Used to set response for execution of auto tuning.</p> <div style="border: 1px solid black; padding: 5px; display: inline-block;"> <table border="1" style="border-collapse: collapse;"> <tr> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> </tr> </table> </div> <p>Auto tuning response setting</p> <table border="1" style="border-collapse: collapse; margin: 10px 0;"> <thead> <tr> <th>Set Value</th> <th>Response</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Slow response</td> </tr> <tr> <td>2</td> <td>to</td> </tr> <tr> <td>3</td> <td>Medium response</td> </tr> <tr> <td>4</td> <td>to</td> </tr> <tr> <td>5</td> <td>Fast response</td> </tr> </tbody> </table> <ul style="list-style-type: none"> <li>If the machine hunts or generates large gear sound, decrease the set value.</li> <li>To improve performance, e.g. shorten the set-</li> </ul> <p>Machine selection Used to adjust the position setting characteristic according to the machine status.</p> <table border="1" style="border-collapse: collapse; margin: 10px 0;"> <thead> <tr> <th colspan="2" rowspan="2"></th> <th colspan="2">Position Setting Characteristic</th> </tr> <tr> <th>Ordinary</th> <th>Better (Note)</th> </tr> </thead> <tbody> <tr> <td rowspan="2">Machine friction</td> <td>Small</td> <td>0</td> <td>2</td> </tr> <tr> <td>Large</td> <td>1</td> <td>3</td> </tr> </tbody> </table> <p>Note: This setting is available for software version A3 or later. Choosing "Better" automatically tunes the speed integral compensation (parameter No. 29) rather small.</p> <p>Auto tuning selection 0: Executed for both position and speed loops 1: Interpolation axis control (normally not set) 2: Not executed.</p>				Set Value	Response	1	Slow response	2	to	3	Medium response	4	to	5	Fast response			Position Setting Characteristic		Ordinary	Better (Note)	Machine friction	Small	0	2	Large	1	3	002		001 to 235h
Set Value	Response																																
1	Slow response																																
2	to																																
3	Medium response																																
4	to																																
5	Fast response																																
		Position Setting Characteristic																															
		Ordinary	Better (Note)																														
Machine friction	Small	0	2																														
	Large	1	3																														

## 2. OPERATION

Class	No.	Symbol	Name	Initial Value	Unit	Setting Range
Basic parameters	2	CMX	<p>Electronic gear (Command pulse multiplying factor, numerator): Used to set the multiplier of the command pulse input.</p> <p> <math display="block">\frac{\text{Command pulse input}}{f_1} \times \frac{\text{CMX}}{\text{CDV}} = \text{Position command } f_2 = f_1 \cdot \frac{\text{CMX}}{\text{CDV}}</math> </p> <p>Note: Set in the range of <math>\frac{1}{50} &lt; \frac{\text{CMX}}{\text{CDV}} &lt; 20</math>.</p> <p>The setting of the number of input pulses per servo motor revolution can be changed by the following formula:</p> $4000 \cdot \frac{\text{CDV}}{\text{CMX}} \text{ (pulse/rev)}$	1		1 to 999
	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> <p><b>⚠ CAUTION</b> If a wrong setting is made, the servo motor may rotate at unexpectedly high speed, causing injury.</p> </div>					
	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	<p>Position command acceleration/deceleration time (smoothing): Used to set the time of a low pass filter to the position command.</p> <p>Example: When a command is received from a synchronizing encoder, synchronous operation can be started smoothly.</p>	5	ms	0 to 999	
						
						
5	INP	<p>In-position range: Used to set the range of droop pulses in which the positioning finished (PF) signal is output.</p>	100	pulse	0 to 999	

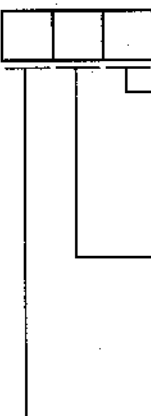
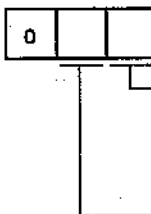
## 2. OPERATION

Class	No.	Symbol	Name	Initial Value	Unit	Setting Range																	
Basic parameters	6	*IP1	<p>Input signal selection 1: Used to change the functions of the digital input signals.</p>  <p>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.</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> <p><b>MEMO-RANDUM</b> When "1" is selected, note that the servo amplifier enters the servo-on status if the external 24V power is lost.</p> </div> <p>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)</p> <p>Clear signal selection 0: Droop pulses are cleared on the leading edge. 1: Always cleared while on.</p>	010		000 to 111h																	
	7	*OP1	<p>Command pulse selection: Used to select the input form of the pulse train input signal. Refer to Section 5-2-1.</p>  <p>Command pulse input form 0: Forward/reverse rotation pulse train 1: Signed pulse train 2: A/B phase pulse train</p> <p>Pulse train logic selection 0: Positive logic 1: Negative logic</p>	010		000 to 012h																	
	8		Spare:	0																			
	9	TLL	<p>Torque limit value: Set with the maximum torque being 100%. This parameter is set to limit the torque generated by the servo motor.</p>	100	%	0 to 100																	
	10 11		Spare:																				
12	*BLK	<p>Parameter write disable: Used to select the reference and write ranges of the parameters.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Set Value</th> <th>Reference Range</th> <th>Write Range</th> </tr> </thead> <tbody> <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> </tbody> </table>	Set Value	Reference Range	Write Range	000	No. 0 to 12	No. 0 to 12	00A	No. 0 to 12	No. 12	00B	No. 0 to 22	No. 0 to 12	00C	No. 0 to 22	No. 0 to 22	00D	No. 0 to 22	No. 0 to 34	000		000 to 00Dh
Set Value	Reference Range	Write Range																					
000	No. 0 to 12	No. 0 to 12																					
00A	No. 0 to 12	No. 12																					
00B	No. 0 to 22	No. 0 to 12																					
00C	No. 0 to 22	No. 0 to 22																					
00D	No. 0 to 22	No. 0 to 34																					

## 2. OPERATION

Class	No.	Symbol	Name	Initial Value	Unit	Setting Range
Expansion parameters	13	*SIO	<p>Communication baudrate selection: Used to select the serial interface when the RS-232C option unit is fitted to use the communication function.</p> <div style="border: 1px solid black; width: 60px; height: 20px; margin: 5px auto; display: flex; justify-content: space-around; align-items: center;"> <span>0</span><span> </span><span>0</span> </div> <p style="margin-left: 40px;">└─ Selection of baud rate when RS-232C is selected</p> <p style="margin-left: 40px;">0: 9600 (bps) 1: 19200 (bps) 2: 4800 (bps)</p>	000		000 to 020h
	14	*DMD	<p>Status display selection, alarm history clear: Used to select the status display shown at power-on.</p> <div style="border: 1px solid black; width: 60px; height: 20px; margin: 5px auto; display: flex; justify-content: space-around; align-items: center;"> <span> </span><span>0</span><span> </span> </div> <p style="margin-left: 40px;">└─ Status display at power-on</p> <p style="margin-left: 40px;">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</p> <p style="margin-left: 40px;">└─ Alarm history clear</p> <p style="margin-left: 40px;">0: Invalid 1: Valid</p> <p style="margin-left: 40px;">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.</p>	000		000 to 10Ah
	15	ERZ	<p>Excessive error output range setting: Used to set the range in which the excessive error alarm (A52) is output.</p>	50	kpulse	1 to 999
	16	*OP1	<p>Position/speed control mode selection: Used to select the optional function.</p> <div style="border: 1px solid black; width: 60px; height: 20px; margin: 5px auto; display: flex; justify-content: space-around; align-items: center;"> <span> </span><span>0</span><span> </span><span>1</span> </div> <p style="margin-left: 40px;">└─ Control mode selection</p> <p style="margin-left: 40px;">0: Position control 1: Speed control</p>	001		001 to 101h
	17	SC1	<p>Speed command (1): Used to set speed 1 of the internal speed command.</p>	10	10r/min	0 to 450
18	SC2	<p>Speed command (2): Used to set speed 2 of the internal speed command.</p>	100	10r/min	0 to 450	

## 2. OPERATION

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



## 2. OPERATION

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. <table border="1" data-bbox="383 459 957 739"> <thead> <tr> <th>Set Value</th> <th>Machine Resonance Frequency [Hz]</th> </tr> </thead> <tbody> <tr><td>0</td><td>Not used</td></tr> <tr><td>1</td><td>1125</td></tr> <tr><td>2</td><td>563</td></tr> <tr><td>3</td><td>375</td></tr> <tr><td>4</td><td>282</td></tr> <tr><td>5</td><td>225</td></tr> <tr><td>6</td><td>188</td></tr> <tr><td>7</td><td>161</td></tr> </tbody> </table>	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
	Set Value	Machine Resonance Frequency [Hz]																						
	0	Not used																						
	1	1125																						
	2	563																						
	3	375																						
	4	282																						
	5	225																						
	6	188																						
	7	161																						
	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. <table border="1" data-bbox="383 1243 534 1310"> <tr> <td>0</td> <td>0</td> <td></td> </tr> </table> Slight vibration suppression control 0: Not done. 1: Done.	0	0		000		000 to 001h																
0	0																							
32	MVP	For manufacturer setting:	412																					
33	*OP2	Optional function: Used to select the optional function. <table border="1" data-bbox="383 1512 534 1579"> <tr> <td>A</td> <td>0</td> <td></td> </tr> </table> 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.)	A	0		A00		A00 to A01h																
A	0																							
34	VPI	For manufacturer setting:	0																					

# CHAPTER 3

## WIRING

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

- 3 – 1 Servo Amplifier
  - 3 – 1 – 1 Terminal block
  - 3 – 1 – 2 Signal connectors
  - 3 – 1 – 3 Control I/O signals
  - 3 – 1 – 4 Interfaces
- 3 – 2 Servo Motor
  - 3 – 2 – 1 Connection instructions
  - 3 – 2 – 2 I/O terminals
- 3 – 3 Common Line
- 3 – 4 Grounding
- 3 – 5 Power Supply Circuit
- 3 – 6 Timing Chart at Alarm Occurrence
- 3 – 7 Servo Motor with Electromagnetic Brake

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

### 3. WIRING

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.

**⚠ WARNING** 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.

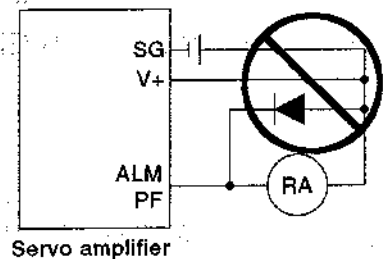
1. Wire the equipment correctly and securely. Otherwise, the servo motor may misoperate, resulting in injury.
2. Connect wires to correct terminals to prevent a burst, fault, etc.
3. Ensure that polarity (+, -) is correct. Otherwise, a burst, damage, etc. may occur.

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.

**⚠ CAUTION**

5. Use a noise filter, etc. to minimize electromagnetic interference, caused by electronic equipment used near the servo amplifier.



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

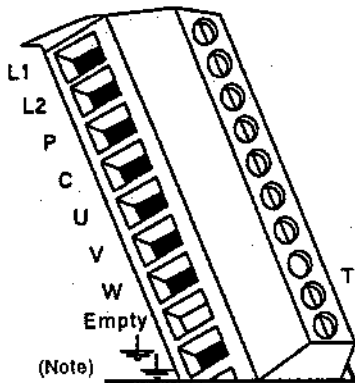
**⚠ CAUTION** Only the voltage specified in the instruction manual should be applied to each terminal. Otherwise, a burst, damage, etc. may occur.

##### 3-1-1 Terminal block

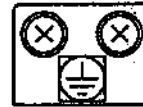
###### (1) Signal arrangement

1) Main circuit terminal block (TE)

2) Protective earth (PE) terminals



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.

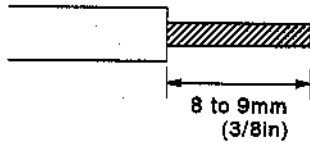
###### (2) Signals

Signal	Symbol	Description
Main circuit power supply	L <sub>1</sub> , L <sub>2</sub>	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 transformer 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.



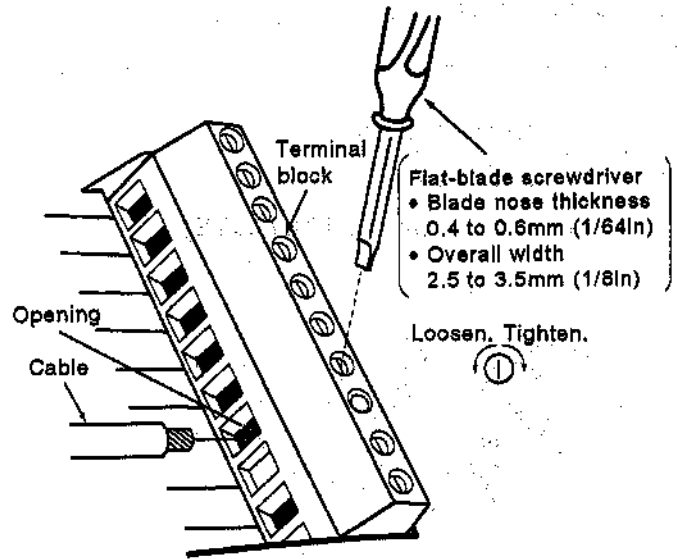
- 2) Insert the wire into the opening and tighten the corresponding screw with a flat-blade screwdriver so that the cable is not disconnected.

(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 1.25mm<sup>2</sup> (16 AWG)

or less, two cables can be inserted into one opening.



#### (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 4.0mm<sup>2</sup> (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 2.5mm<sup>2</sup> (23 to 13 AWG))

### 3. WIRING

#### 3-1-2 Signal connectors

##### (1) Connector pin layout (View from the cable side)

###### 1) CN1 (I/O signal connector)

	1		11
2	V+	12	SD
ALM	3	SG	13
4	PF	14	CR
OP	5	LSN	15
6	SG	16	LSP
	7	V5	17
8	NP	18	SON
NG	9		19
10	PP	20	OPC
PG		V24	

Molex make  
52986-2011 or equivalent

###### 2) CN2 (Encoder connector)

	1		11
2	LG	12	LG
LG	3	LG	13
4	LG	14	
	5		15
6		16	
MD	7	MDR	17
8	MR	18	MRR
	9	P5	19
10		20	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	PP	9	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
Reverse rotation pulse train	PG	10		
	NP	7		
	NG	8		

### 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	<p>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.</p> <p>24VDC, 24VDC ±10%, 200mA or more 5VDC, 5VDC ±5%, 100mA or more</p> <div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> <p><b>NOTICE</b> If power is supplied to both terminals V5 and V24, the servo amplifier will be faulty.</p> </div>	
Digital output power input	V+	1	<p>Digital output power input terminal.</p> <p>Supply power for driving the digital output section.</p>	
Power supply common	SG	5 12	<p>Common terminals.</p> <p>Common terminals for OPC, V24, V5 and V+. Connect the negative (-) terminal of the external power supply.</p>	
Shield	SD	11	<p>Shield terminal.</p> <p>Connect one end of the shield cable.</p>	

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).

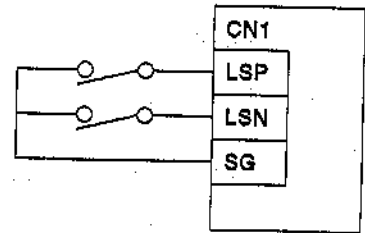


### 3. WIRING

#### 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.

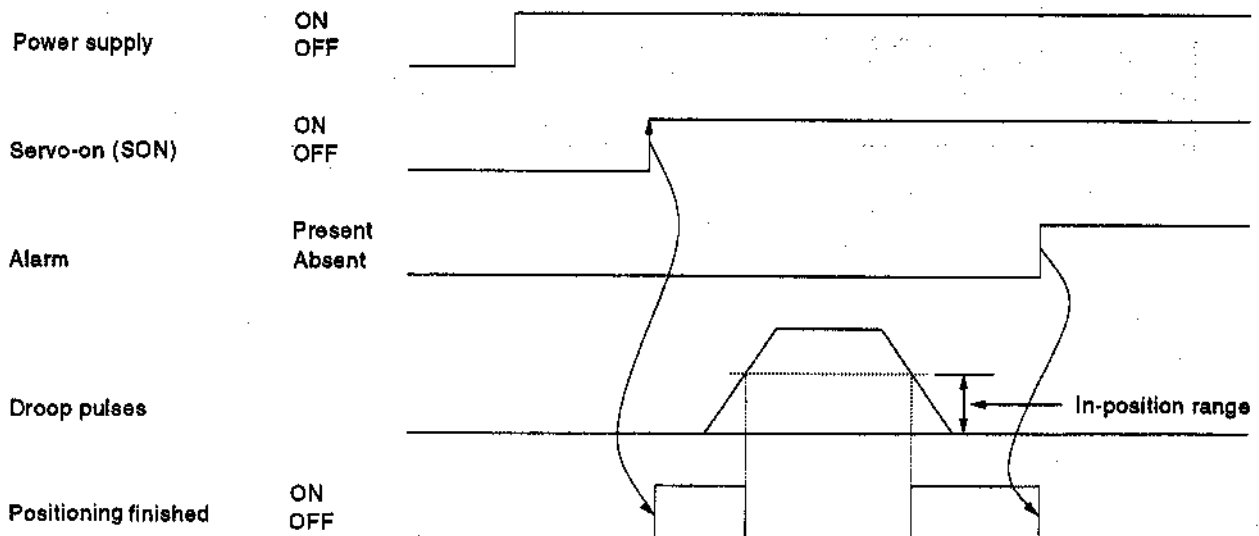


##### (2) Clear (CR)

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. WIRING

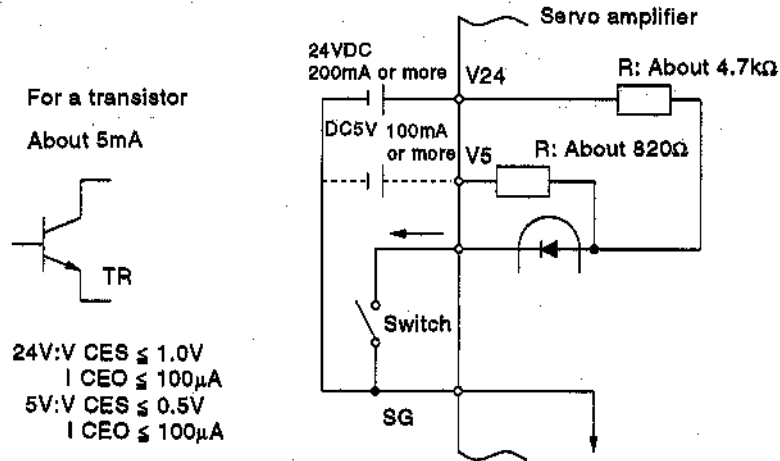
#### 3-1-4 Interfaces

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.



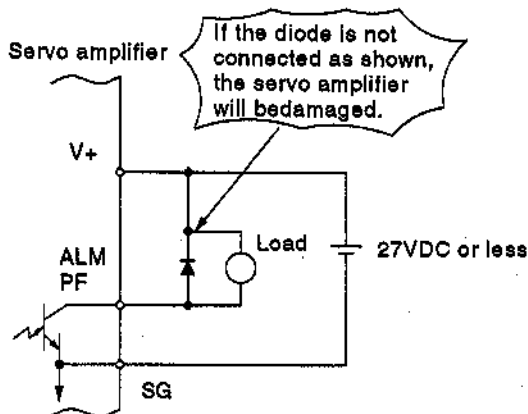
#### NOTICE

If power is supplied to both terminals V5 or V24, the servo amplifier will be faulty.

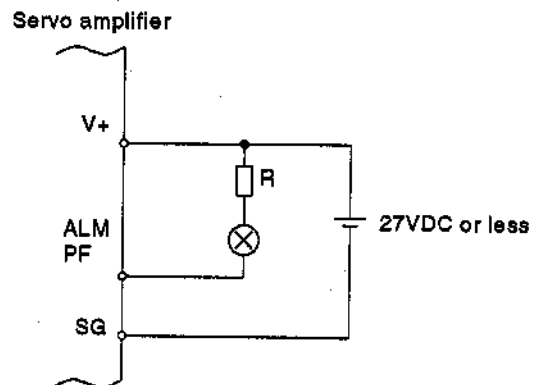
##### (2) Digital output interface DO-1

A lamp, relay or photocoupler can be driven. Provide a diode (D) for an inductive load, or an in-rush current suppressing resistor (R) for a lamp load. (Permissible current: 40mA or less, inrush current: 100mA or less)

##### (a) Inductive load



##### (b) Lamp load

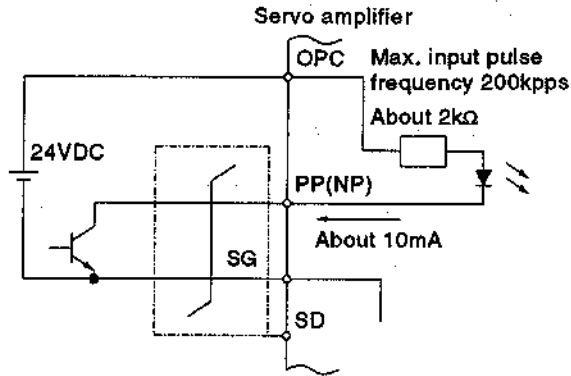


### 3. WIRING

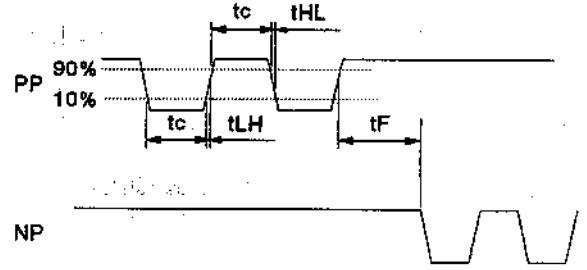
#### (3) Pulse train input interface DI-2

##### 1) Open collector system

- Interface example



- Input pulse specification



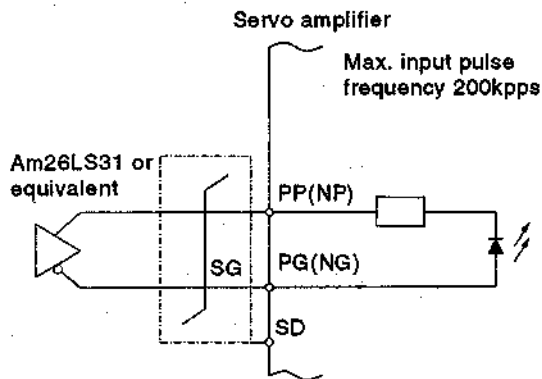
$$t_{LH}=t_{HL} < 0.2\mu s$$

$$t_c > 2\mu s$$

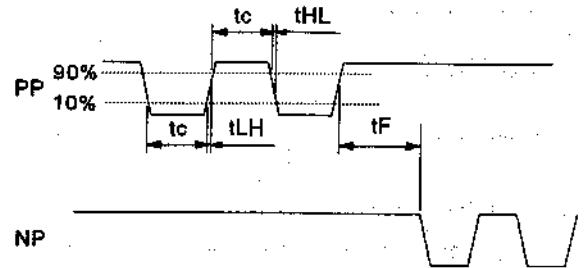
$$t_F > 3\mu s$$

##### 2) Differential line driver system

- Interface example



- Input pulse specification



$$t_{LH}=t_{HL} < 0.2\mu s$$

$$t_c > 2\mu s$$

$$t_F > 3\mu s$$

### 3. WIRING

#### 3-2 Servo Motor

##### 3-2-1 Connection instructions

**⚠ WARNING** Insulate the power connection terminals to prevent an electric shock.

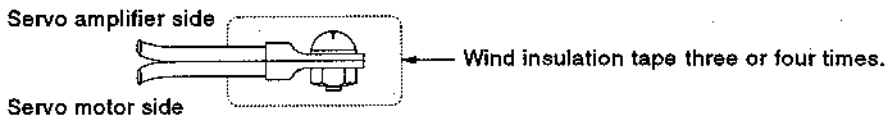
**⚠ CAUTION**

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.

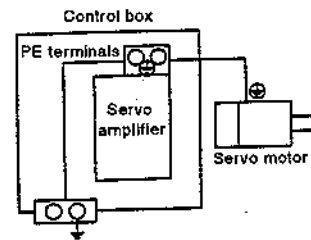
**NOTICE**

Do not run the power cable and encoder cable in parallel. Such wiring may cause a fault.

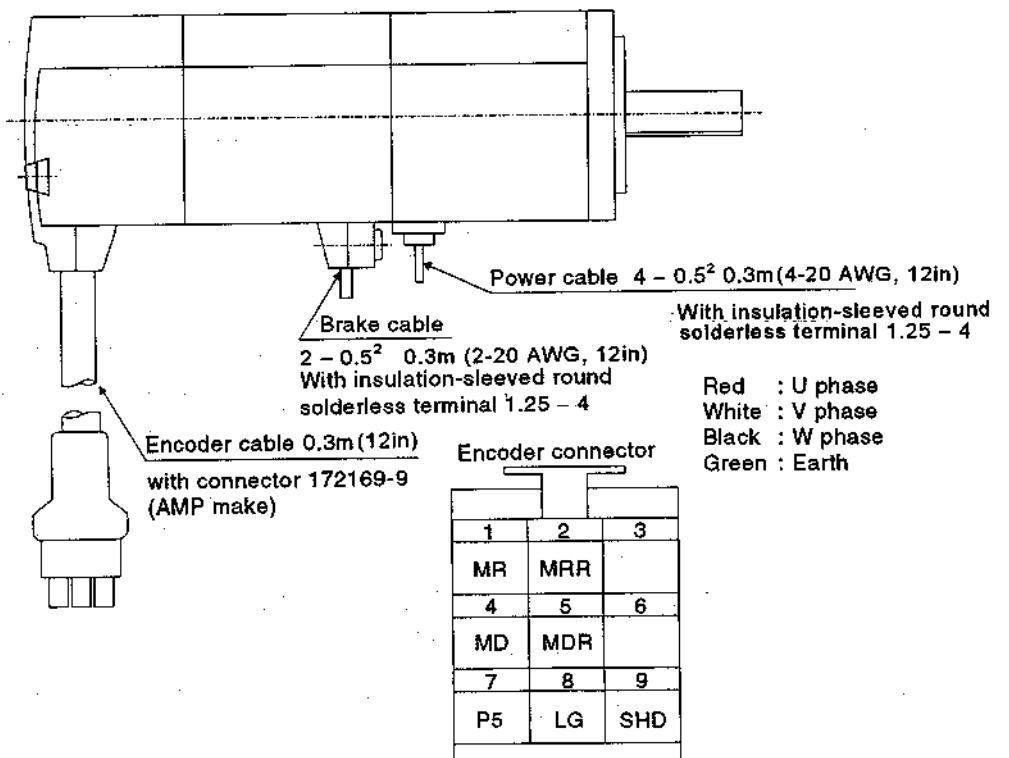
- 1) Wind insulation tape around the connection three or four times to ensure insulation. For the EN Standard-compliant models, make connection via a fixed terminal block.



- 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.



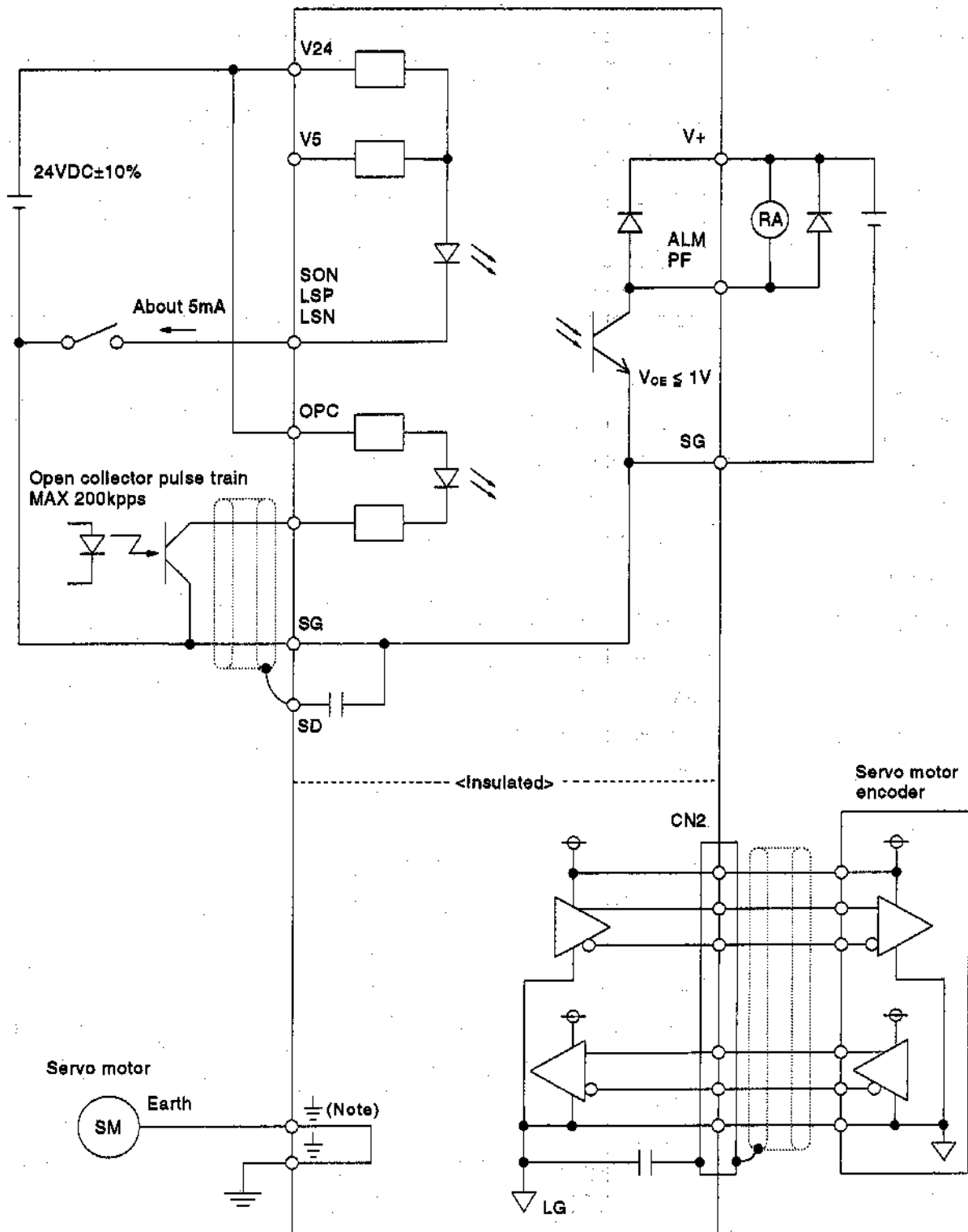
##### 3-2-2 I/O terminals



### 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. WIRING

#### 3-4 Grounding

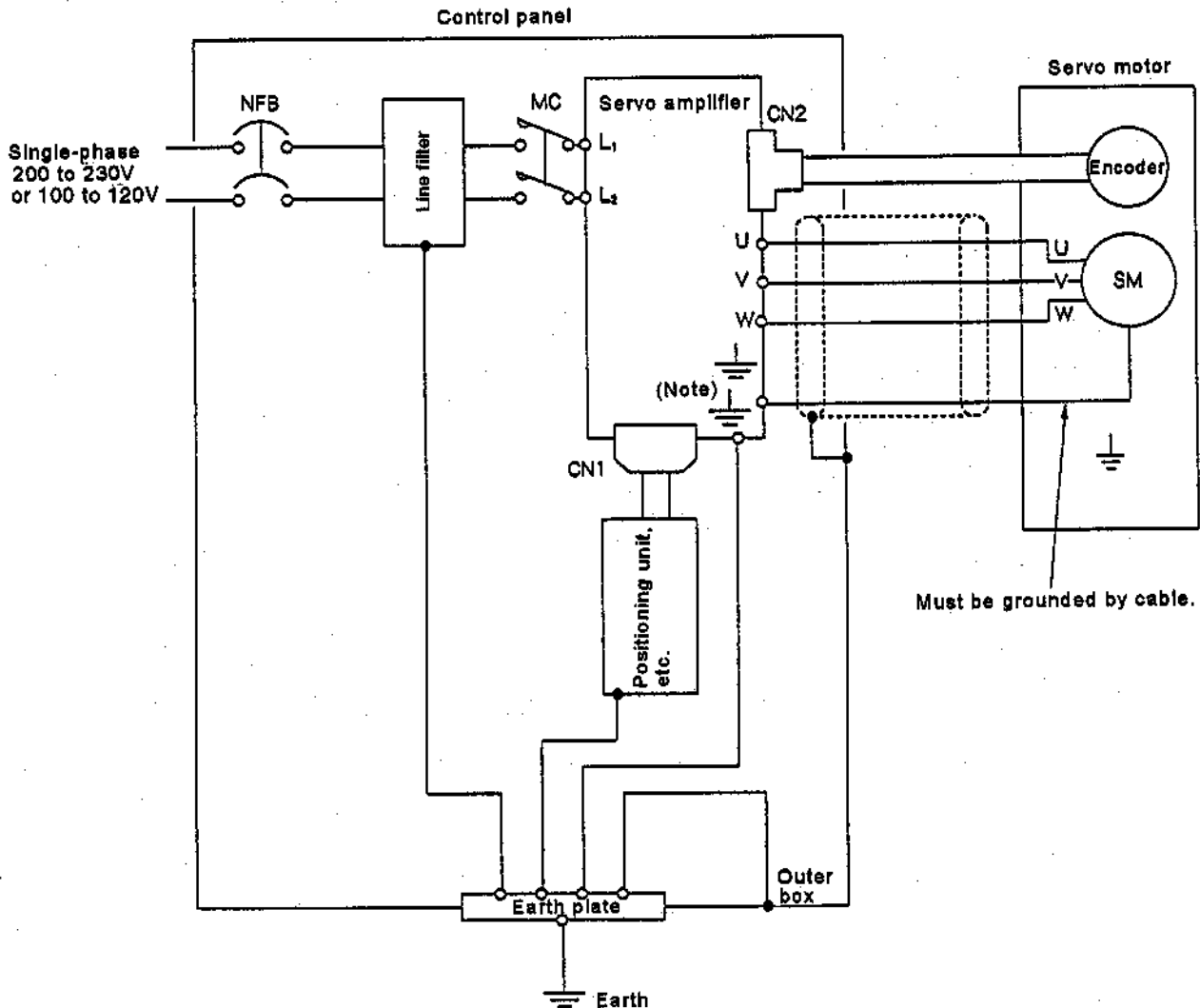
#### **⚠ WARNING**

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  $\oplus$ ) 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 ( $3.5\text{mm}^2$  (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

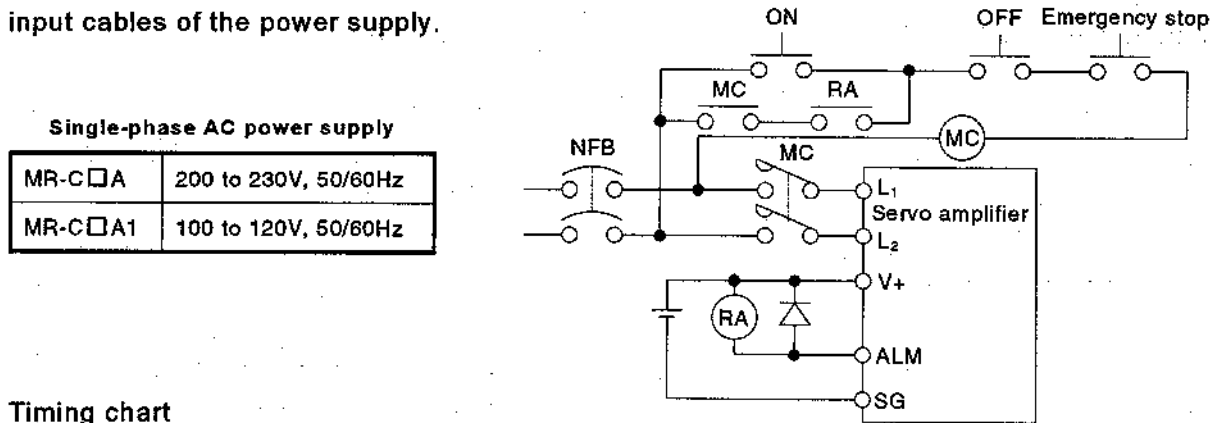
#### 3-5 Power Supply Circuit

**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.

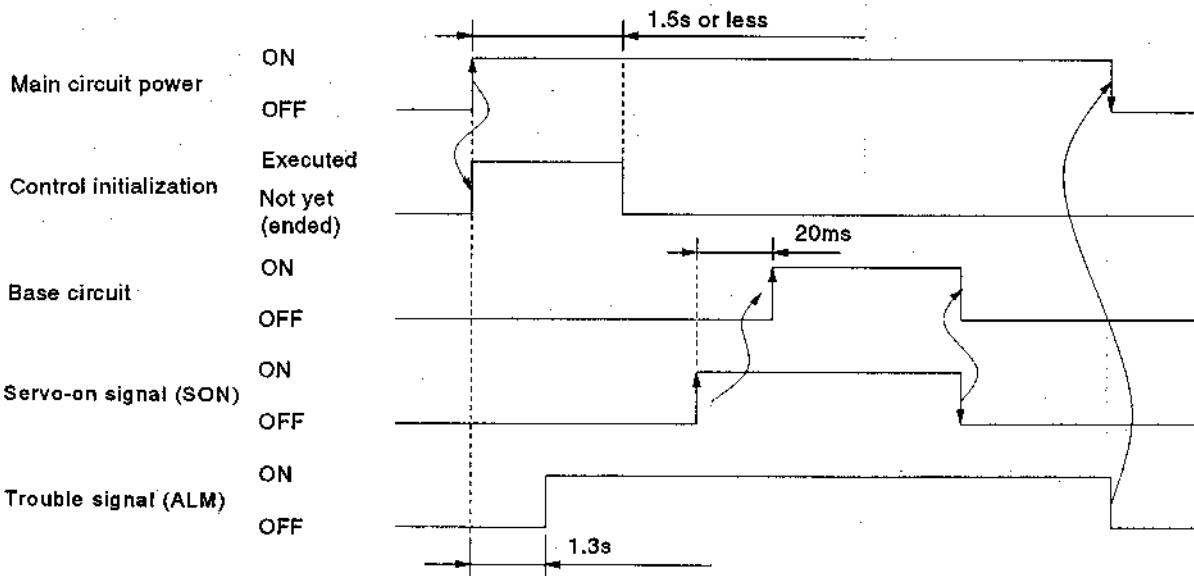
(1) Connection example

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.



(2) Timing chart

When power is applied to L<sub>1</sub> and L<sub>2</sub>, 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

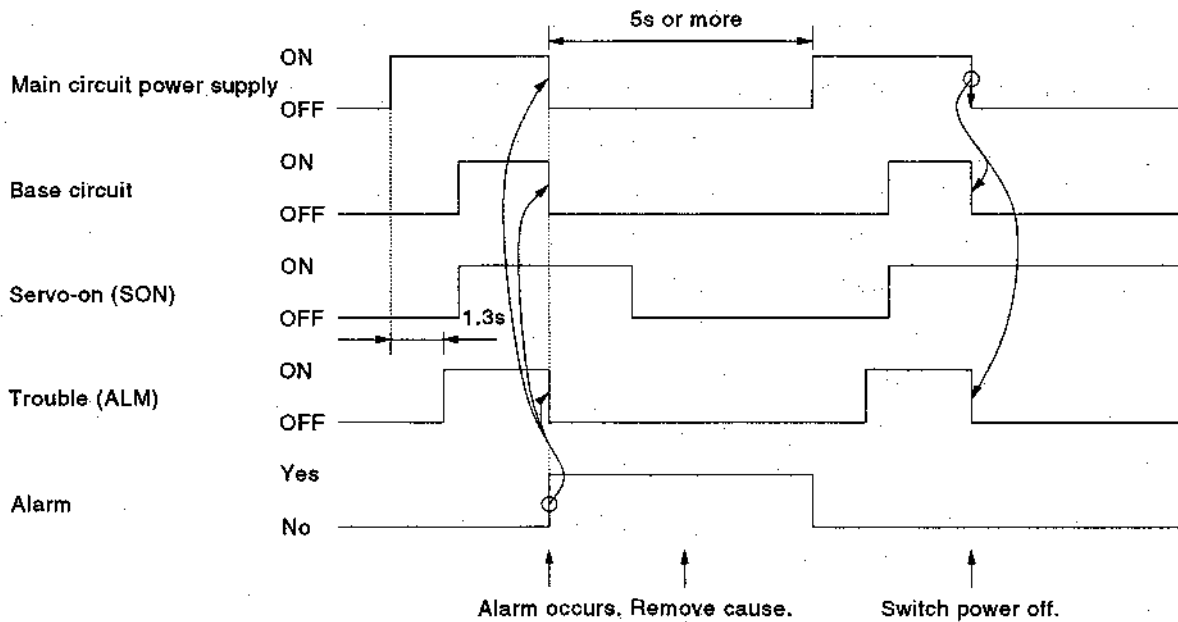
#### 3 - 6 Timing Chart at Alarm Occurrence



#### 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.



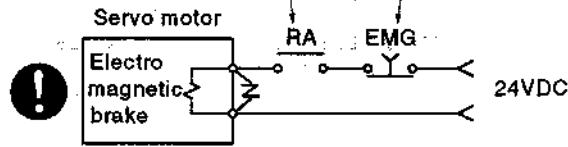
### 3. WIRING

#### 3-7 Servo Motor with Electromagnetic Brake

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.

**CAUTION**

Contacts must be open when servo is off or when an alarm (trouble) is present. Circuit must be opened during emergency stop.



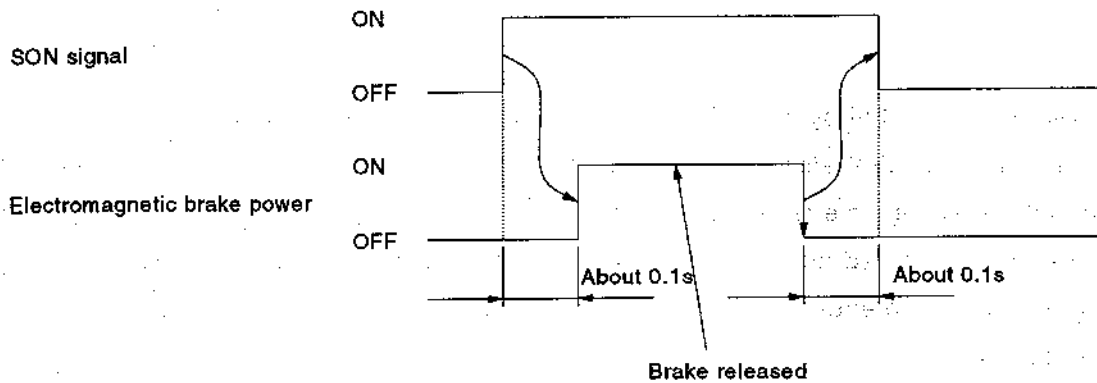
For applications requiring a brake to hold the motor shaft (vertical lift applications), a servo motor with electromagnetic brake should be used. Please note the following:

- 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:



Also, the electromagnetic brake interlock signal may be used by changing the setting of parameter No. 21. Refer to Section 5-2-2.

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## REVISIONS

# **CHAPTER 4**

## **INSTALLATION**

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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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<b>OPTIONAL PRODUCTS</b>	<b>CHAPTER 12</b>

## 4. INSTALATION

### ⚠ CAUTION

1. Stacking in excess of the limited number of products is not allowed.
2. Do not install the equipment on or near combustibles. Installing them directly or close to combustibles will cause a fire.
3. Install the equipment in a load-bearing place in accordance with the instruction manuals.
4. Do not climb or stand on servo equipment. Do not put heavy objects on servo equipment.
5. Use the equipment within the specified environmental range.
6. Provide adequate protection to prevent screws and other conductive matter, oil and other combustible matter from entering the servo amplifier.
7. Do not block the air intake/exhaust areas of the servo amplifier. Otherwise, a fault may occur.
8. Do not drop or strike servo amplifier or servo motor. Isolate from all impact loads.
9. Do not install or operate a faulty servo amplifier or servo motor.
10. When the product has been stored for an extended period of time, consult Mitsubishi.

### 4-1 Servo Amplifier

### ⚠ CAUTION

1. The equipment must be installed in the specified direction. Otherwise, a fault may occur.
2. Leave specified clearances between the servo amplifier and all other surface or equipment. Otherwise, a fault may occur.

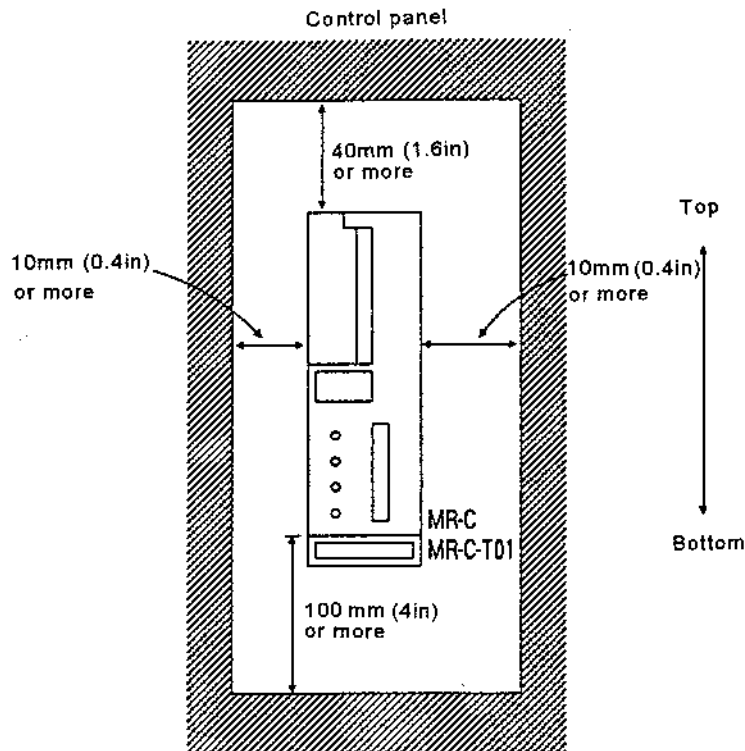
#### (1) Environmental conditions

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 <sup>2</sup> ] or less
	194 [ft/s <sup>2</sup> ] or less

## 4. INSTALATION

### (2) Installation direction and clearances

#### 1) Installation of one servo amplifier



#### 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

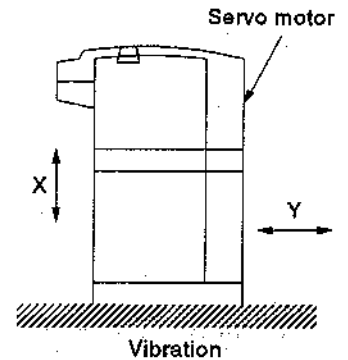
## 4 - 2 Servo Motor

### ⚠ CAUTION

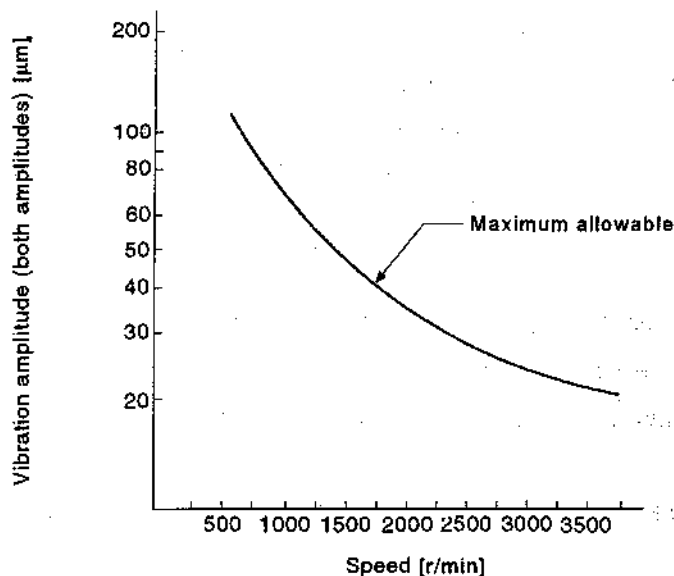
1. Do not handle the motor by the cables, shaft or encoder.
2. Securely mount the servo motor to the machine. If mount insecurely, the servo motor may come off during operation.
3. Never hit the servo motor or shaft, especially when coupling the servo motor to the machine. The encoder may become faulty.
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 <sup>2</sup> ] (2G)
	X, Y: 64.3 [ft/s <sup>2</sup> ]



Graph of servo motor vibration amplitude vs speed



### (2) Transportation

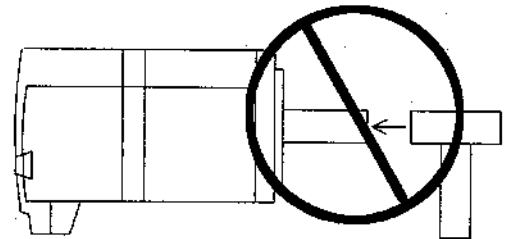
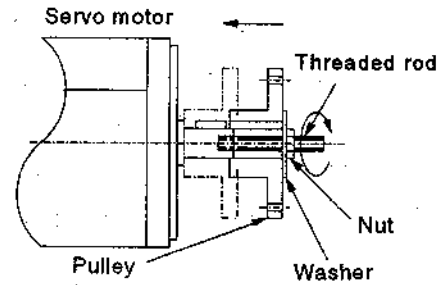
Do not carry the motor by the shaft or encoder or cables.



## 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 protective 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.

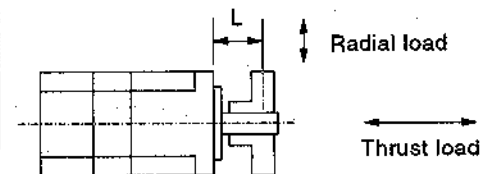


### (4) Permissible load for the shaft

- 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:

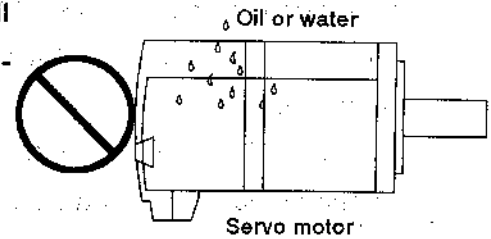


L: Distance from flange mounting surface to load center

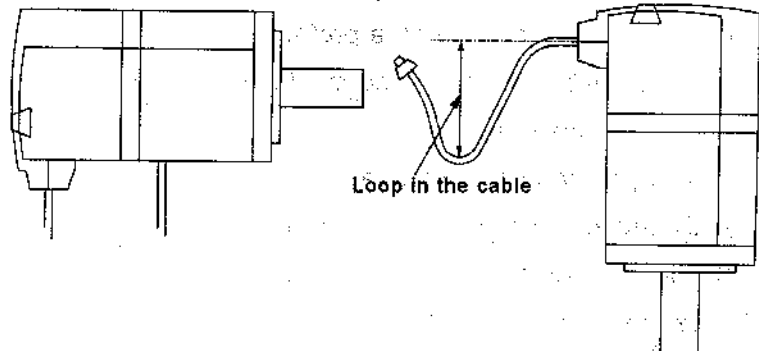
## 4. INSTALLATION

### (5) Oil and water protection

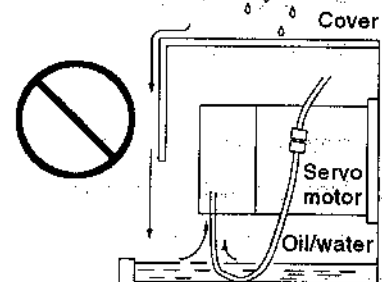
- 1) The servo motor is not waterproof (IP44). Prevent oil and water from entering the servo motor.
- 2) The HC-PQ series servo motor is not provided with an oil seal. Seal the gear box to prevent lubricating oil from entering the servo motor.



- 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.

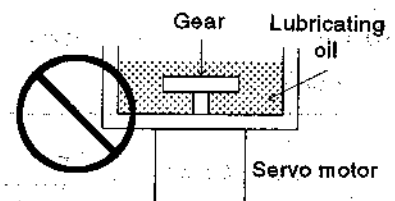


- 4) Do not allow cables to touch oil or water. (Figure on the right)



- 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.

<Incorrect> Capillary action



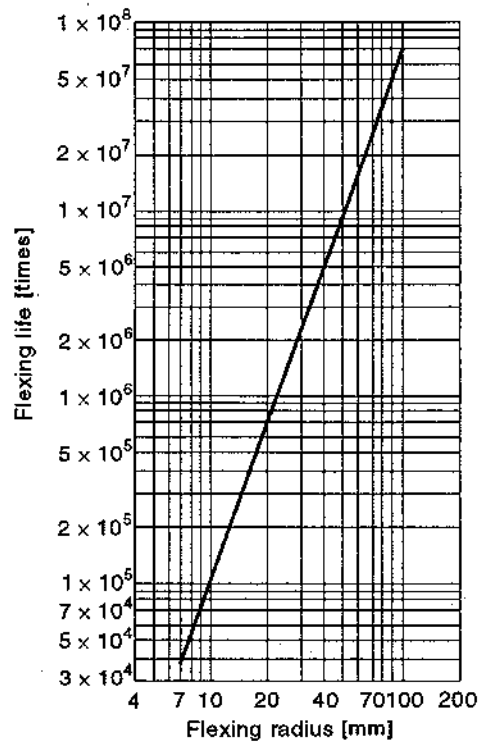
### (6) Installation orientation

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.

## 4. INSTALATION

### (7) Cable stress

- 1) The method 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**

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

### **5 – 1 Adjustments**

5 – 1 – 1 Auto tuning

5 – 1 – 2 Manual gain setting

### **5 – 2 Application Operations**

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

5 – 2 – 2 Changing the I/O signals

5 – 2 – 3 Speed control mode

5 – 2 – 4 Torque limit

5 – 2 – 5 Slight vibration suppression control

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

## 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. b. When the response setting is increased by auto tuning, vibration increases.	Adjustment 1  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). 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.	Adjustment 3
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. <ul style="list-style-type: none"> <li>• Parameter No. 25</li> <li>• Parameter No. 26</li> <li>• Parameter No. 27</li> <li>• Parameter No. 28</li> <li>• Parameter No. 29</li> </ul>
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. <ul style="list-style-type: none"> <li>• Parameter No. 25</li> <li>• Parameter No. 26</li> <li>• Parameter No. 27</li> <li>• Parameter No. 28</li> <li>• Parameter No. 29</li> </ul>
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. <ul style="list-style-type: none"> <li>• Parameter No. 25</li> <li>• Parameter No. 26</li> <li>• Parameter No. 27</li> <li>• Parameter No. 28</li> <li>• Parameter No. 29</li> </ul>
	2) Switch servo on and perform operation several times.	Auto tuning is performed.
4	Set 2 <input type="checkbox"/> <input type="checkbox"/> 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	Increase the setting to reduce the stop setting time. Note that overshoot is more likely to occur.
	• Parameter No. 26	Increase the setting to improve servo response. Note that vibration is more likely to occur.
	• Parameter No. 27	Increase the setting to improve servo response. Note that vibration is more likely to occur.
	• 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: <ul style="list-style-type: none"><li>• Parameter No. 25</li><li>• Parameter No. 26</li></ul>	The gains for operation of all axes are set to the same value.





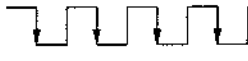
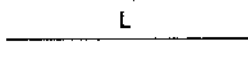
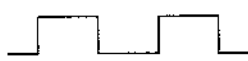

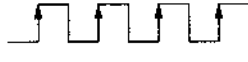
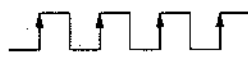
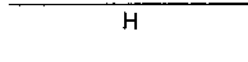
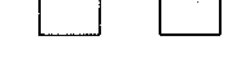

# 5. ADJUSTMENTS AND APPLICATION OPERATIONS



## 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 	Reverse rotation pulse train	Factory setting 010
	Reverse rotation pulse train	NP 		
	Pulse train + sign	PP  NP 	Reverse rotation pulse train	011
Positive logic	A phase pulse train	PP 	Reverse rotation pulse train	012
	B phase pulse train	NP 		
	Forward rotation pulse train	PP 	Reverse rotation pulse train	000
Positive logic	Pulse train + sign	PP  NP 	Reverse rotation pulse train	001
	A phase pulse train	PP 	Reverse rotation pulse train	002
	B phase pulse train	NP 		

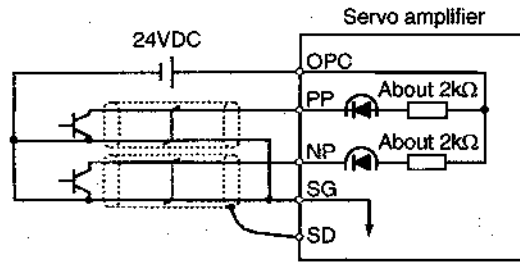
Note:   indicate the timings at which the command pulses are imported.

# 5. ADJUSTMENTS AND APPLICATION OPERATIONS

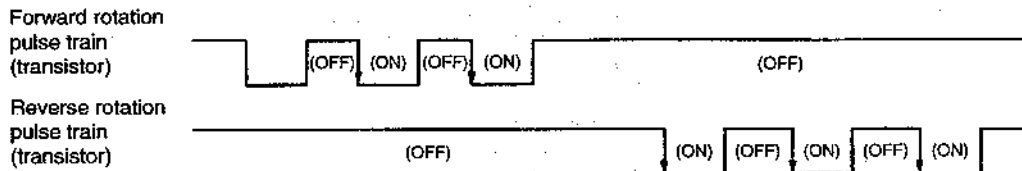
## (2) Connections and waveforms

### 1) Open collector system

Connect as shown below:

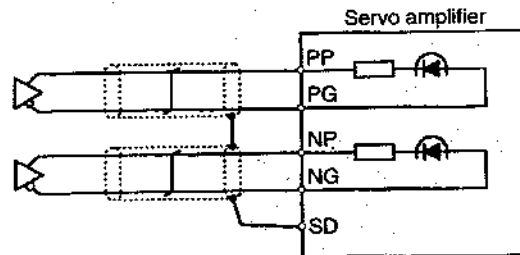


The explanation assumes that the input waveform has been set to the negative logic and forward and reverse rotation pulse trains (parameter No. 7 has been set to 010). The waveforms in the table in (1) of this section are voltage waveforms of PP and NP based on SG. Their relationships with transistor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



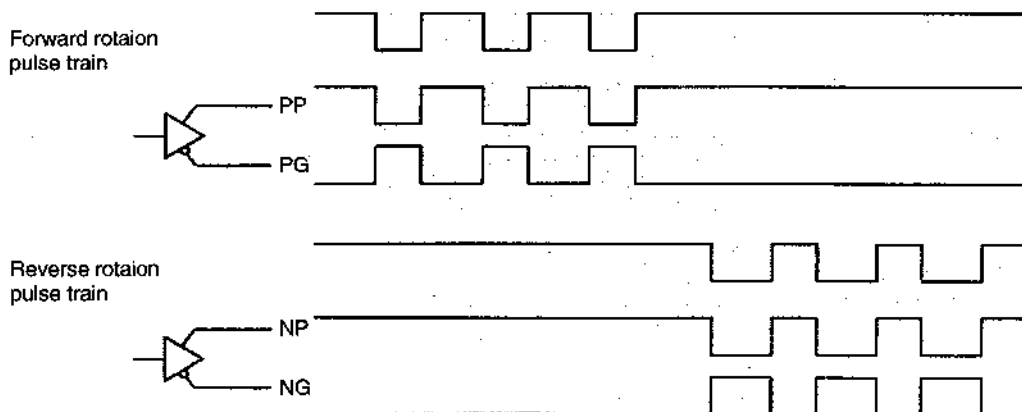
### 2) Differential line driver system

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 selectable

#### 1) I/O signals

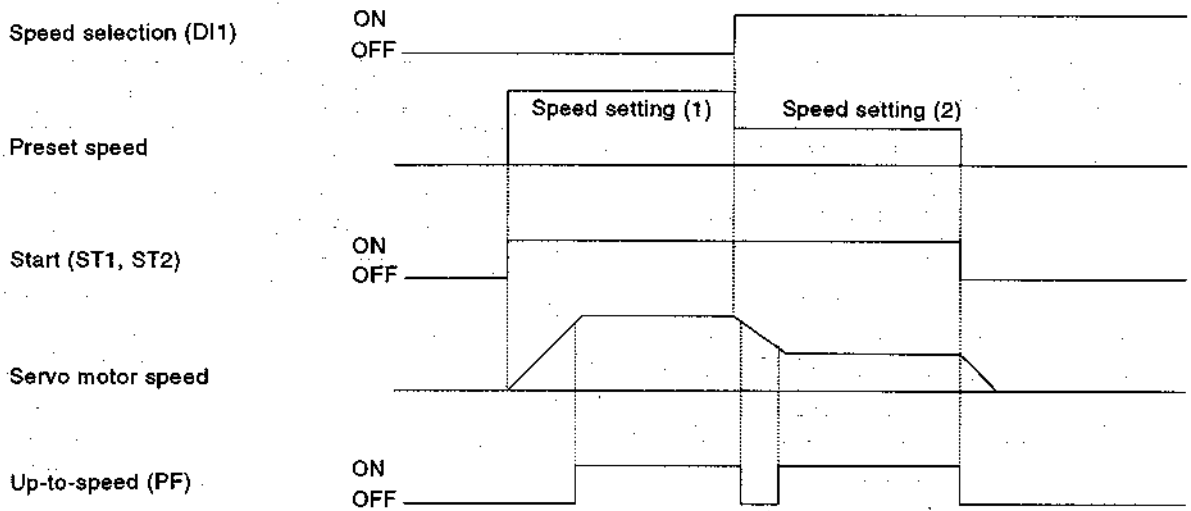
Signal Name	Symbol	Connector Pin No.	Functions/Applications	I/O Division (Note 1)	Control Mode (Note 2)							
Input signals	Forward rotation start	ST1	(13, 14, 15)	Start signal input terminals.	DI-1	S						
	Reverse rotation start	ST1	(13, 14, 15)	In the speed control mode, connect ST1-SG to rotate 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.								
	Speed selection	DI1	(13, 14, 15)	Speed selection signal input terminal. In the speed control mode, select the servo motor speed.	DI-11	S						
				<table border="1"> <thead> <tr> <th>DI1-SG</th> <th>Servo Motor Speed</th> </tr> </thead> <tbody> <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> </tbody> </table>	DI1-SG	Servo Motor Speed	Disconnected	Speed command (1) (parameter No. 17)	Connected	Speed command (2) (parameter No. 17)		
	DI1-SG	Servo Motor Speed										
	Disconnected	Speed command (1) (parameter No. 17)										
Connected	Speed command (2) (parameter No. 17)											
Torque limit	TL	(13, 14, 15)	Torque limit selection signal input terminal. Connect TL-SG to limit the torque according to the torque limit value (parameter No. 9).	DI-1	P, S							
			<table border="1"> <thead> <tr> <th>TL-SG</th> <th>Servo Motor Speed</th> </tr> </thead> <tbody> <tr> <td>Disconnected</td> <td>Maximum torque</td> </tr> <tr> <td>Connected</td> <td>Torque limited by parameter No. 9 setting</td> </tr> </tbody> </table>	TL-SG	Servo Motor Speed	Disconnected	Maximum torque	Connected	Torque limited by parameter No. 9 setting			
TL-SG	Servo Motor Speed											
Disconnected	Maximum torque											
Connected	Torque limited by parameter No. 9 setting											
			When the function of TL is not selected, the output torque is limited to the value set in parameter No. 9.									
	Proportional control	PC	(13, 14, 15)	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	DI-1	P, S						
	Reset	RES	(13, 14, 15)	Reset signal input terminal. Connect RES-SG for more than 50ms to reset the alarm. The following alarms cannot be reset: <ul style="list-style-type: none"> <li>• Memory alarm 1 (A12)</li> <li>• Memory alarm 2 (A15)</li> <li>• Board alarm 1 (A17)</li> <li>• Encoder alarm 1 (A20)</li> <li>• Parameter alarm (A37)</li> </ul> Also, the regenerative alarm (A30) and overload (A50) cannot be reset until the regenerative brake resistor and power transistor are cooled, respectively.	DI-1	P, S						
Output signals (Note 3)	Up-to-speed	PF	(3, 4)	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.)	DO-1	S						
	Encoder Z-phase pulse	OP	3 (4)	Described in (2), Section 3-1-2. The output pin can be changed to pin 4.		P, S						
	Ready	RD	(3, 4)	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.)	DO-1	P, S						
	Zero speed detection	ZSP	(3, 4)	Zero speed detection signal output terminal. When the servo motor speed is about 50r/min. or less, ZSP-SG are connected.	DO-1	P, S						
	Torque limit in progress	TLC	(3, 4)	Torque limit-in-progress signal output terminal. When the torque limit range is reached, TLC-SG are connected.	DO-1	P, S						
	Electromagnetic brake interlock	BRK	(3, 4)	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.)	DO-1	P, S						

- 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

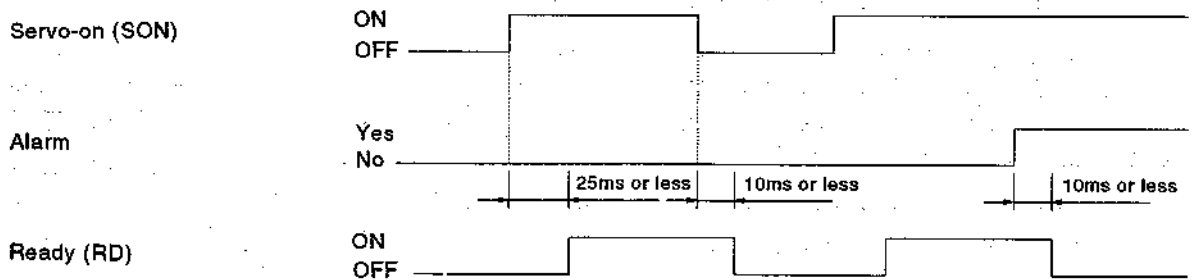
# 5. ADJUSTMENTS AND APPLICATION OPERATIONS

## 2) Detailed description

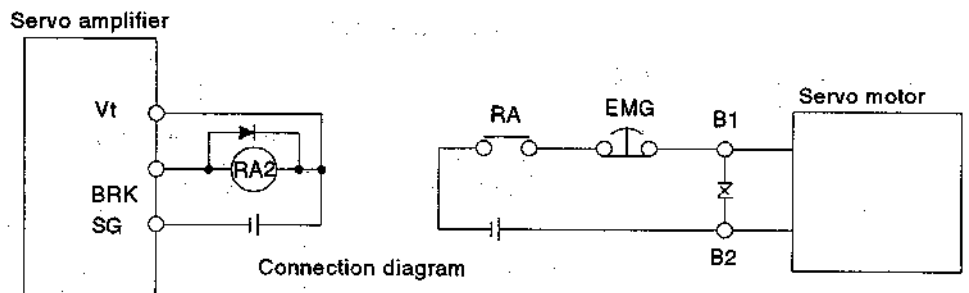
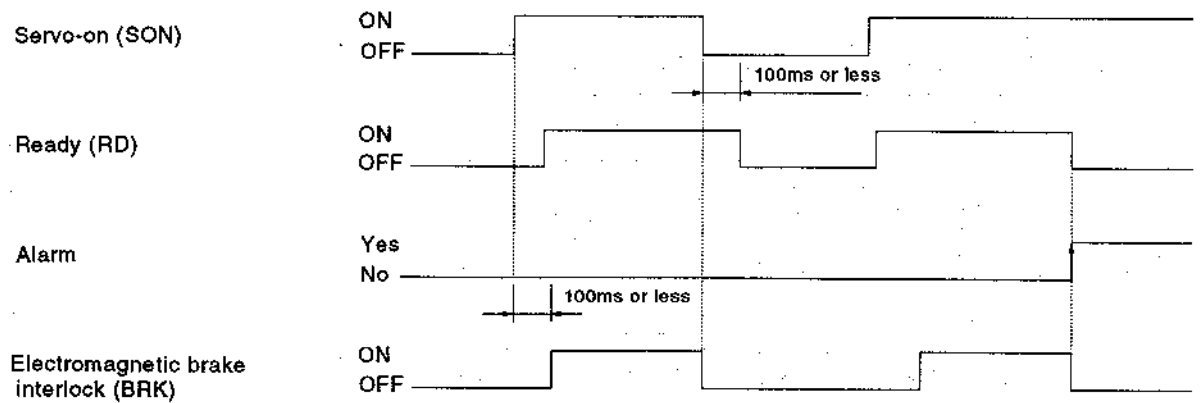
### a. Up-to-speed



### b. Ready



### c. Electromagnetic brake interlock



## 5. ADJUSTMENTS AND APPLICATION OPERATIONS

(2) To make the functions valid

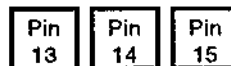
Set the corresponding parameters. Three input signals (pins 13, 14, 15 of CN1) and two output signals (pins 3, 4 of CN1) can be selected as listed below. Use the parameters to select the required functions.

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						

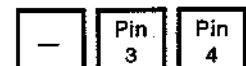
Note: Available for the servo amplifier of software version A2 or later.

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)



Parameter No. 21  
(Output signal function selection)



### 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

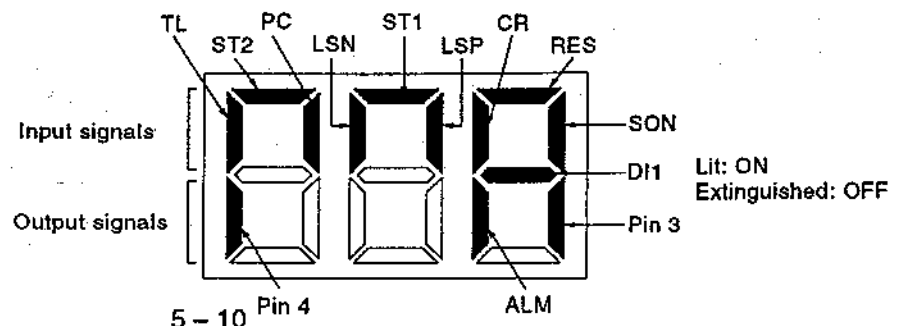
To select the I/O signals in the following table:

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:



## 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.

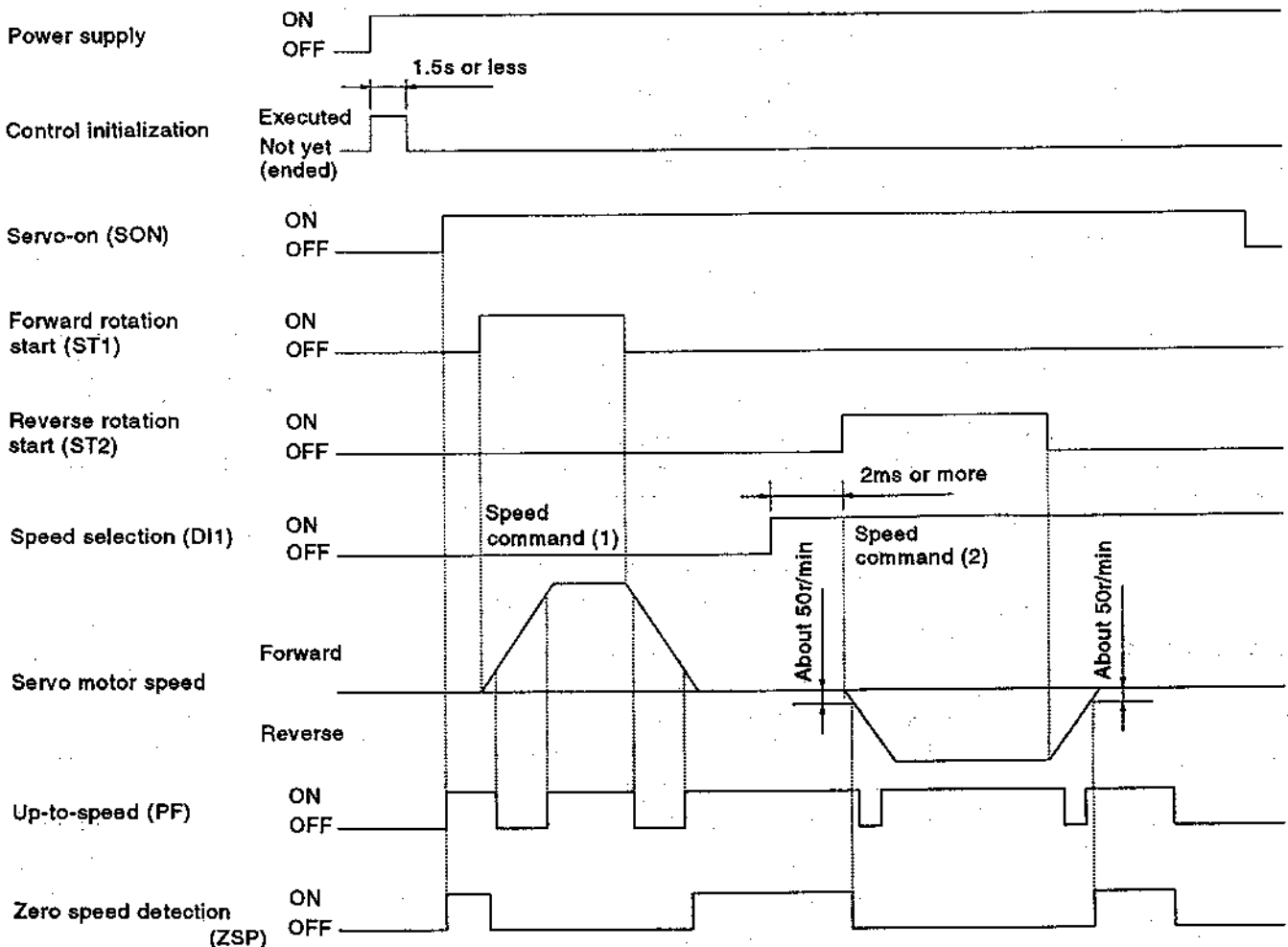
Parameter	Name	Set Value	Description
No. 6	Input signal selection 1	<input type="checkbox"/> 1 <input type="checkbox"/>	LSP and LSN are automatically switched on internally.
No. 16	Position/speed control mode selection	101	Select the speed control mode.
No. 17	Speed command (1)	—	Set the servo motor speed.
No. 18	Speed command (2)	—	Set the servo motor speed.
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





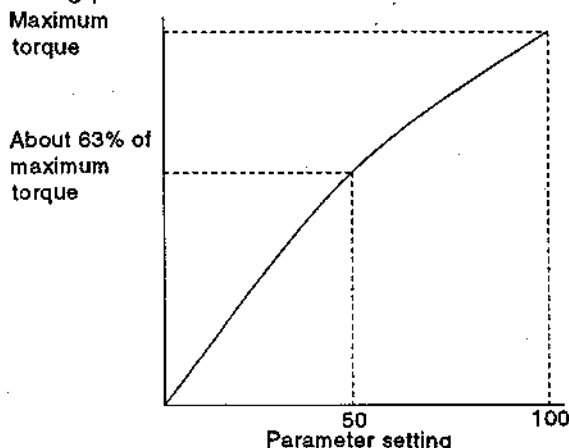
## 5. ADJUSTMENTS AND APPLICATION OPERATIONS

### 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.

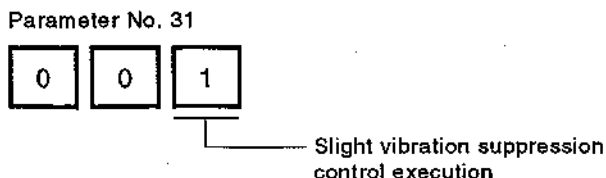
TL-SG	Maximum Torque of Servo Motor
Disconnected	Maximum torque
Connected	Torque limited by the setting of parameter No. 9

### 5-2-5 Slight vibration suppression control

The slight vibration suppression control mode is used to reduce servo-specific  $\pm 1$  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.

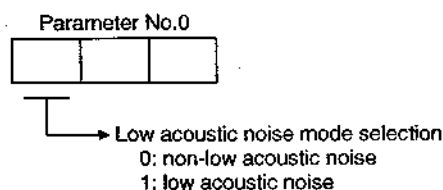
#### Usage

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



### 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.





# 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

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

## 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

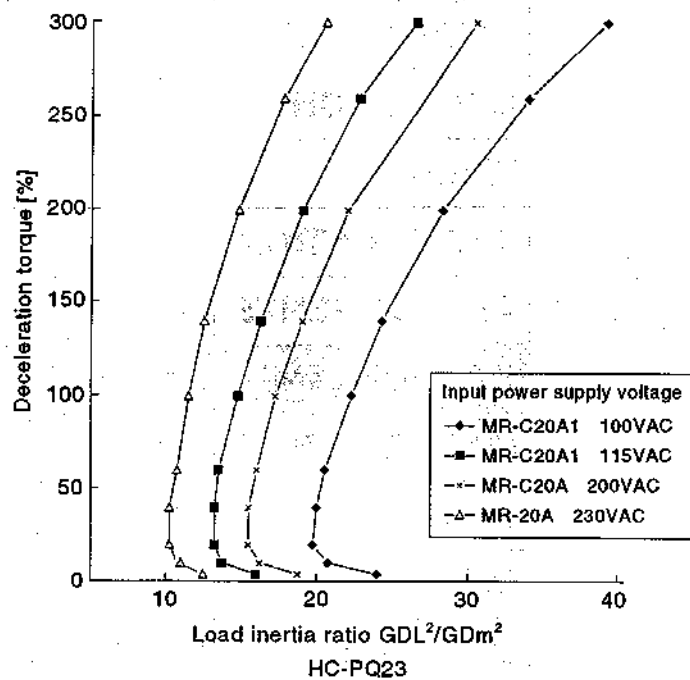
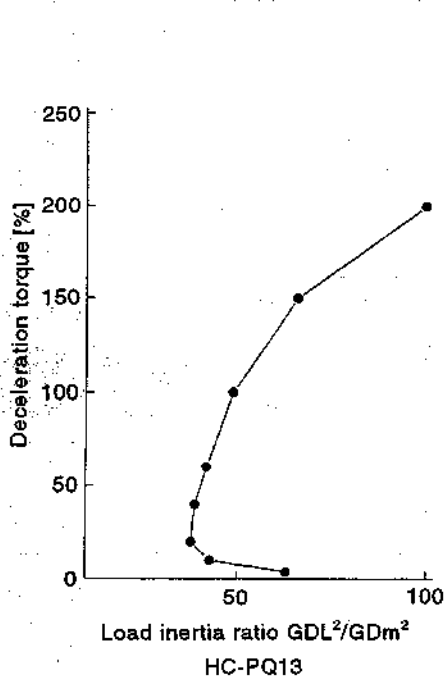
The regenerative brake option is not required for the servo motors in the following cases:

##### 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.

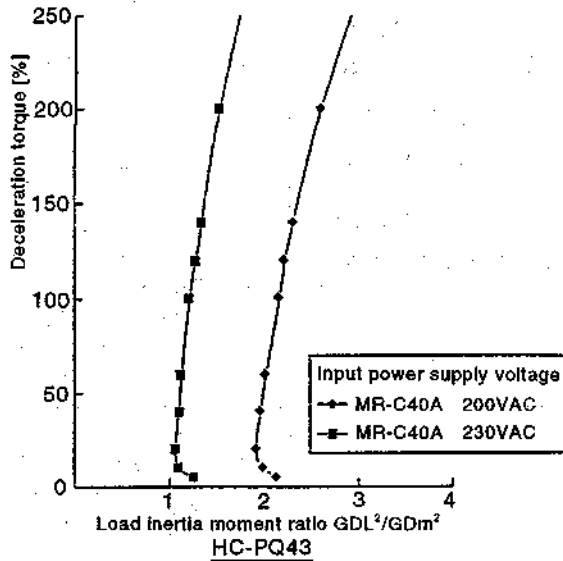
##### 2) HC-PQ13, 23, 43

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.)



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.

## 6. OPTIONS AND AUXILIARY EQUIPMENT



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  $m = \text{load inertia/servo motor inertia}$

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

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

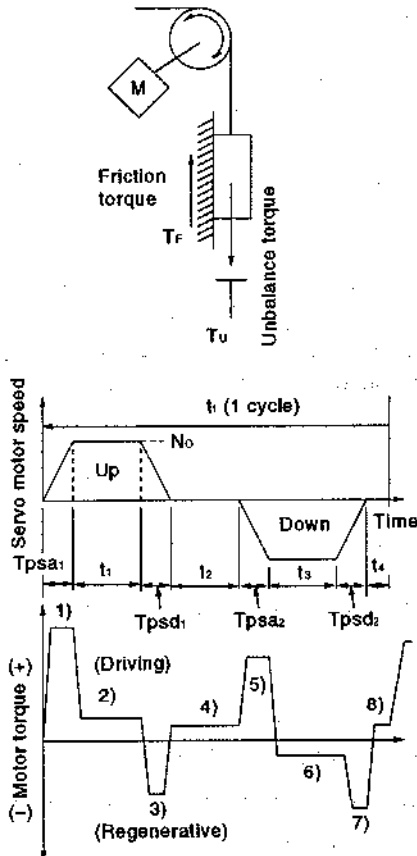
Between the MR-RB013 and MR-RB033, select the one which satisfies the above formula.

#### 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:

## 6. OPTIONS AND AUXILIARY EQUIPMENT

a) Use the following table to calculate the regenerative energy.



### Formulas for Calculating Torque and Energy for Operation

Operation Region	Torque Applied to Servo Motor T [N·m]	Energy E [J]
1)	$T_1 = \frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4} \cdot \frac{1}{T_{psa1}} + T_u + T_f$	$E_1 = \frac{0.1047}{2} \cdot N_o \cdot T_1 \cdot T_{psa1}$
2)	$T_2 = T_u + T_f$	$E_2 = 0.1047 \cdot N_o \cdot T_2 \cdot t_1$
3)	$T_3 = \frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4} \cdot \frac{1}{T_{psd1}} + T_u + T_f$	$E_3 = \frac{0.1047}{2} \cdot N_o \cdot T_3 \cdot T_{psd1}$
4), 8)	$T_4 = T_u$	$E_4 \geq 0$ (Not in regenerative mode.)
5)	$T_5 = \frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4} \cdot \frac{1}{T_{psa2}} - T_u + T_f$	$E_5 = \frac{0.1047}{2} \cdot N_o \cdot T_5 \cdot T_{psa2}$
6)	$T_6 = T_u + T_f$	$E_6 = 0.1047 \cdot N_o \cdot T_6 \cdot t_5$
7)	$T_7 = \frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4} \cdot \frac{1}{T_{psd2}} - T_u + T_f$	$E_7 = \frac{0.1047}{2} \cdot N_o \cdot T_7 \cdot T_{psd2}$
Sum total of regenerative energies $E_s$		Sum total of negative energies in 1) to 8) $E_s$

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	1	4
HC-PQ053	55		
HC-PQ13	55		
HC-PQ23	70		
HC-PQ43	85		

Inverse efficiency ( $\eta$ ) : 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 ( $E_c$ ) : 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.

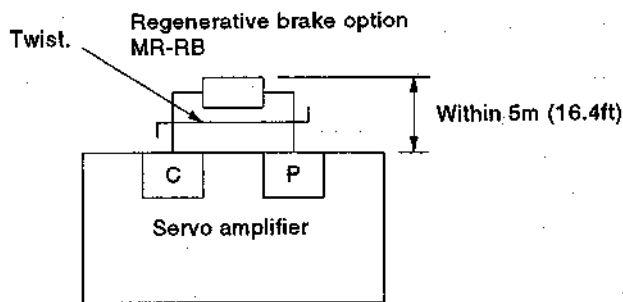
$$E_R [\text{Joule}] = \eta \cdot E_s - E_A - E_c$$

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.

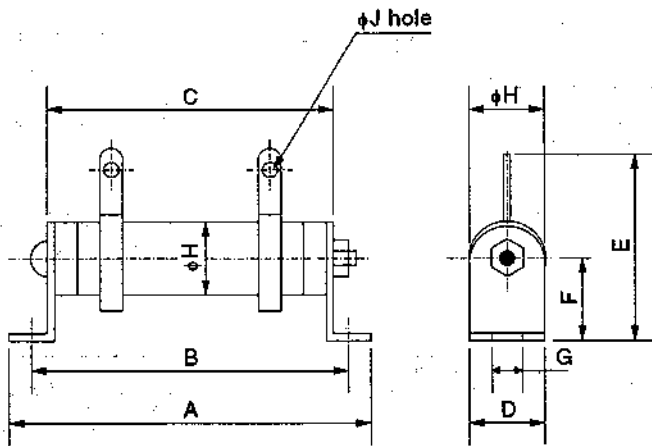
$$P_R [\text{W}] = E_R/t_f \dots\dots\dots(6-1)$$

### (3) Connection of the regenerative brake option

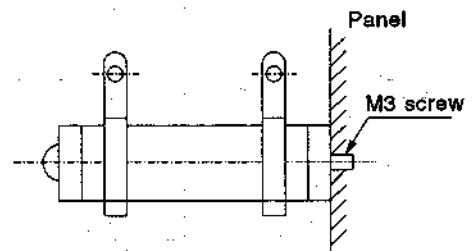
The regenerative brake option used should be connected as shown below:



### (4) Outline drawing



By removing the mounting brackets, the MR-RB013 can be installed as shown below.

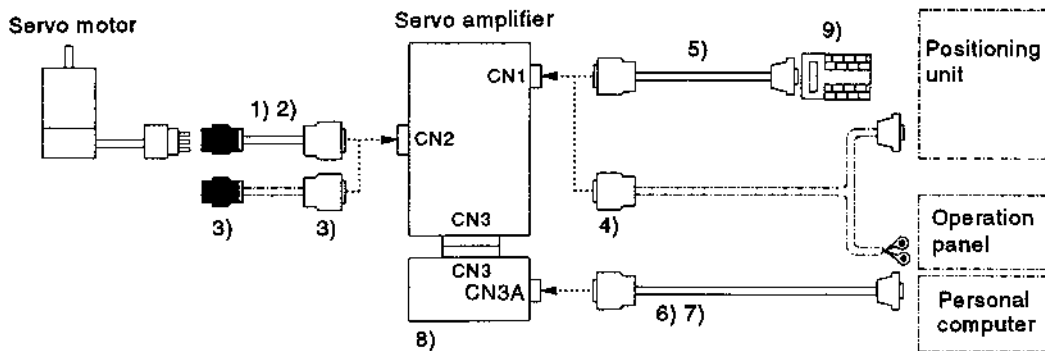


Regenerative Brake Option Model	Regenerative Power [W]	Variable Dimensions [mm] ([in])									Weight [kg] ([lb])	Resistance [ $\Omega$ ]
		A	B	C	D	E	F	G	H	J		
MR-RB013	10	110 (4.33)	101 (3.98)	85 (3.35)	18 (0.71)	35 (1.38)	16 (0.63)	4.5 (0.18)	18 (0.71)	3.2 (0.13)	0.1 (0.2)	52
MR-RB033	30	192 (7.56)	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 amplifier side connector (AMP make) 1-172161-9 (housing)
	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		
Use one of these for CN1	4) Select one of these for CN1	MR-CGN1		
	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) 10120-6000VE (connector) 10320-52F0-008 (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 Electronics) DE-25PF-N (Connector) DE-C2-J9 (Shell kit)
	7) Communication cable for DOS/V	MR-GPCATCBL3M 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 Electronics) 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.	

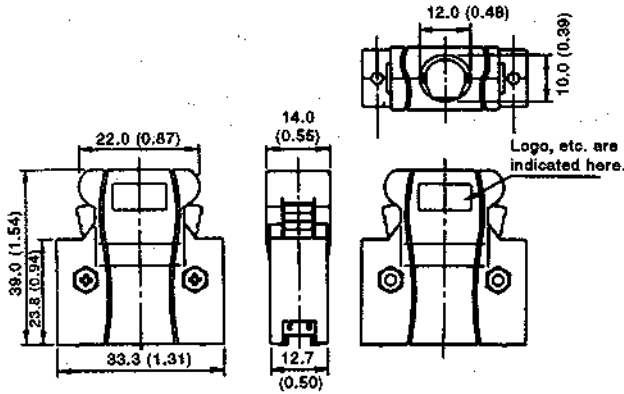
# 6. OPTIONS AND AUXILIARY EQUIPMENT

## (1) Connector outline drawings

[Unit: mm]

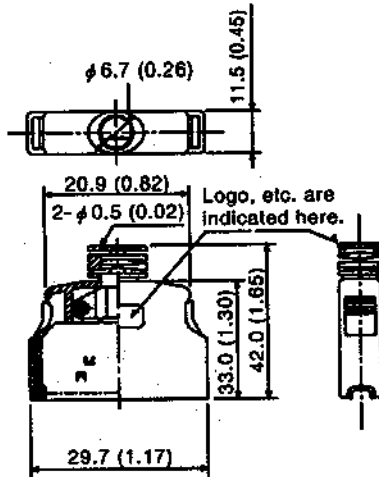
Servo amplifier Connector for CN1, CN2  
RS-232C option unit Connector for CN3A  
(Sumitomo 3M make)

Model  
Connector : 10120-3000VE  
Shell kit : 10320-52F0-008



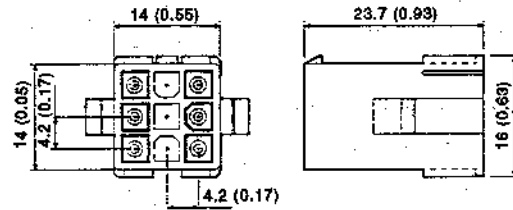
Model  
Connector : 10120-6000EL  
Shell kit : 10320-3210-000

[Unit: mm (in)]



Junction connector for encoder (Nippon AMP make)

Model  
Housing : 1-172161-9  
Connector pin : 170359-1  
Crimp termination tool : 755330-1



**MEMO** The crimp termination tool is required for wiring to the connector. For the crimp termination tool, contact Nippon AMP.

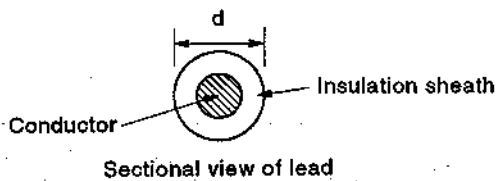
## 6. OPTIONS AND AUXILIARY EQUIPMENT

### (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.

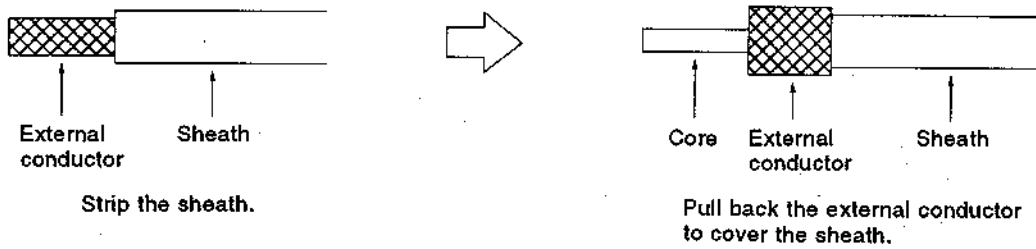
Size [mm <sup>2</sup> ]	Lead Insulation Sheath OD (Note) d[mm(in)]	Recommended Wire Model	Cable Type
0.2	0.9 to 1.27 (0.04 to 0.05)	UL2076 AWG28 7pair (BLACK)	Encoder cable Communication cable
0.3		UL2076 AWG24 7pair (BLACK)	Encoder cable

Note: d is as shown below.

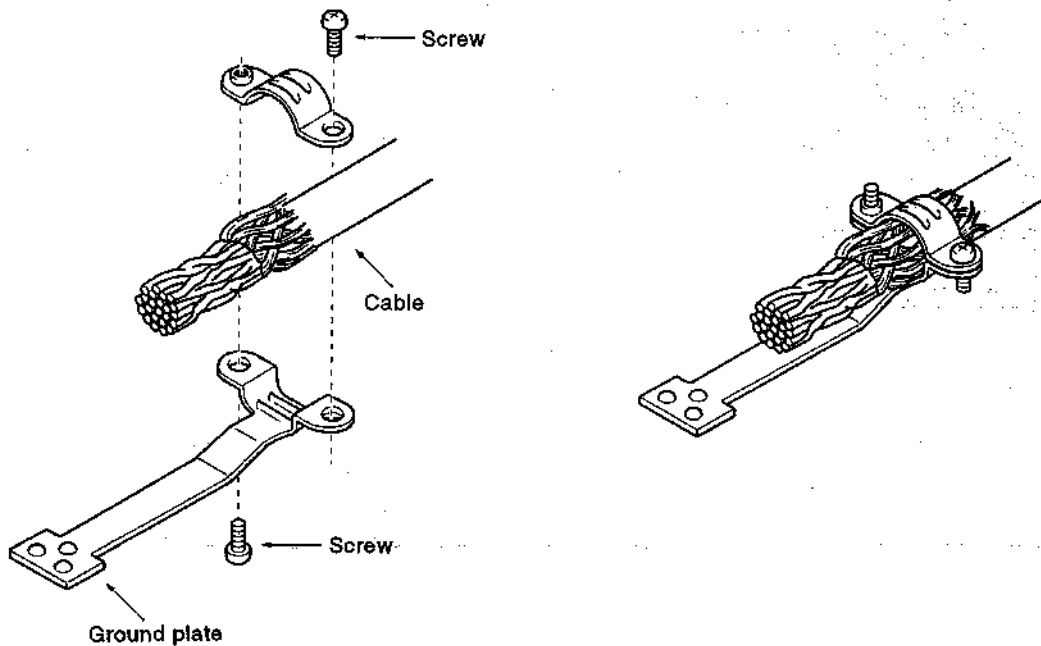


For the connector CN1, CN2 or CN3A, connect the external conductor of the shielded cable to the ground plate securely as shown below.

#### a. Termination of external conductor



#### b. Fitting of the ground plate





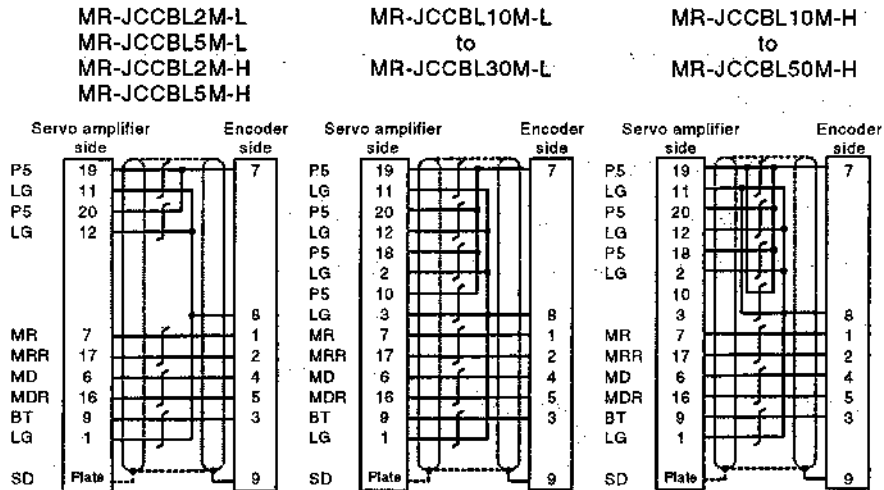
# 6. OPTIONS AND AUXILIARY EQUIPMENT

## 1) Encoder cable

### CAUTION

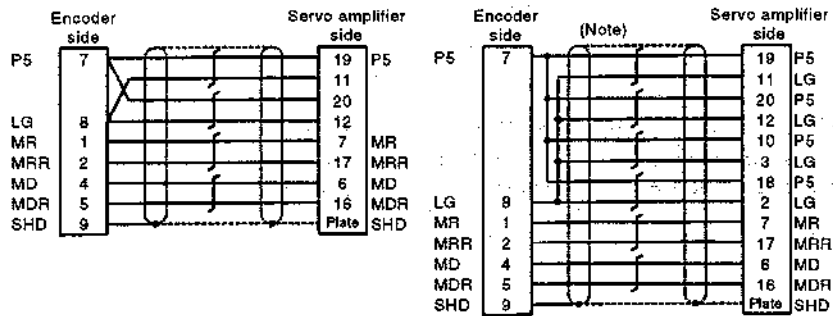
When fabricating the encoder cable, connect it correctly. Otherwise, misoperation may lead to injury.

#### Optional cables



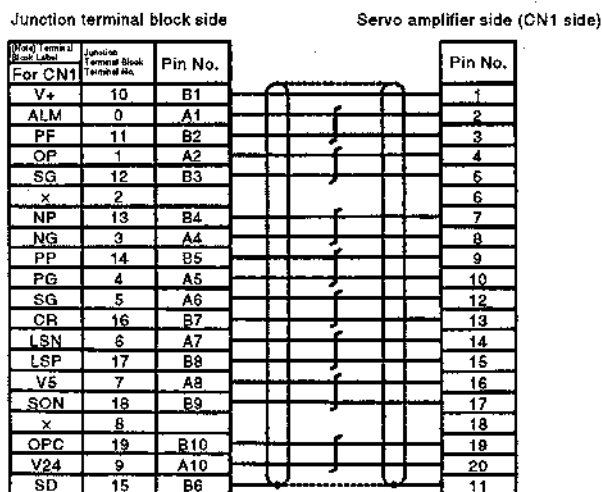
#### For fabrication

- Connection distance of less than 10m (32ft)
- Connection distance of 10m (32ft) to 50m (164ft)



Note: When 0.3mm<sup>2</sup> (AWG22) wires are used, three wires are connected to each of P5 and LG.

## 2) Junction terminal block cable



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.

## 6. OPTIONS AND AUXILIARY EQUIPMENT

### 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.

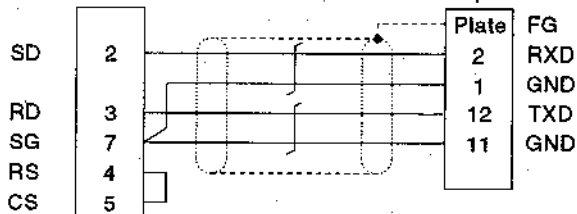
When fabricating the cable, refer to the connection diagram in this section. The following must be observed in fabrication:

- 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

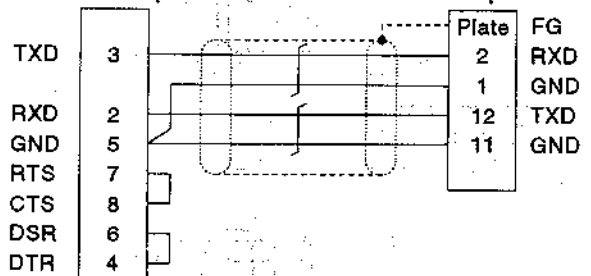


D-SUB25 pins (Note)

Half-pitch 20 pins

##### • MR-CPCATCBL3M

Personal computer side



D-SUB9 pins

Half-pitch 20 pins

Note: The PC98 Note also has the connector of half-pitch 14 pins.

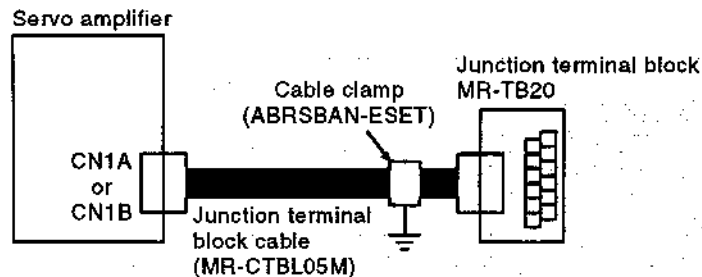
Confirm the shape of the RS-232C connector of the personal computer used.

## 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:

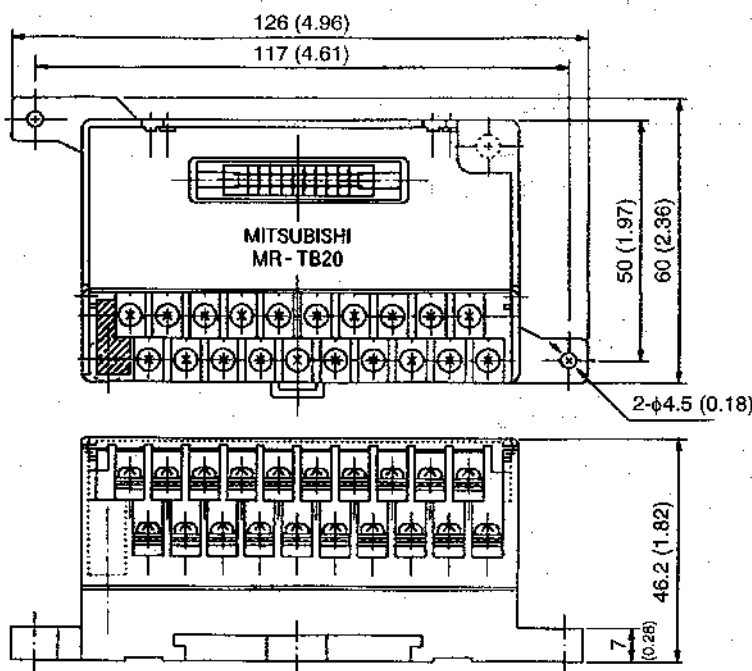


Ground the junction terminal block cable on the junction terminal block side with the standard accessory cable clamp fitting (AERSBAN-ESET). For the use of the cable clamp fitting, refer to (3), Section 6-2-4.

#### (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 seals 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

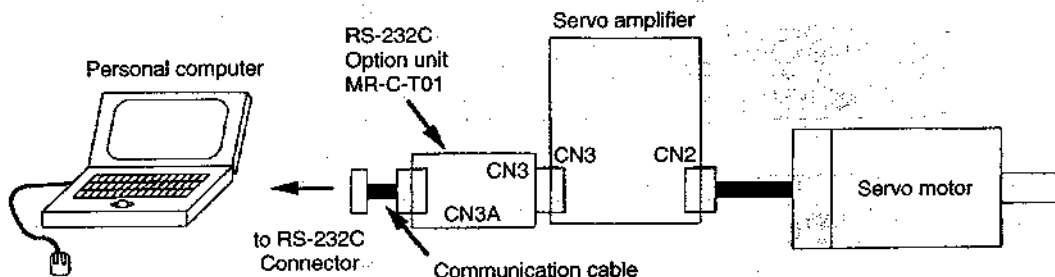
##### 1) Components

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 × 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.

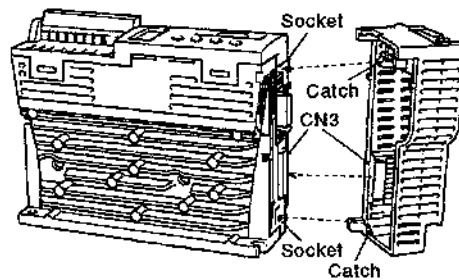
#### (1) Installation and removal of the unit

#### 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.

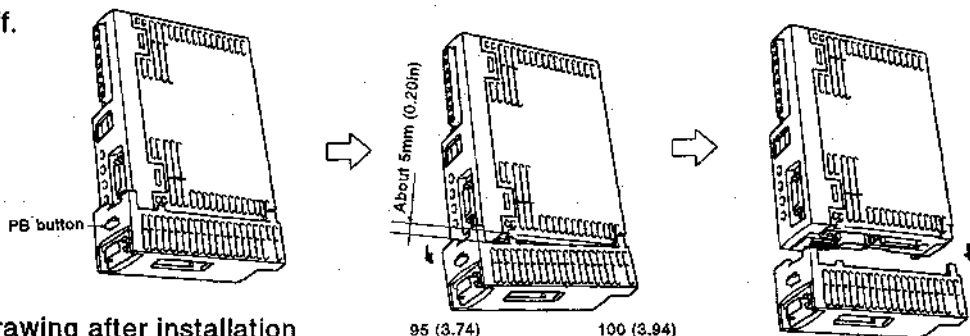


#### MEMO-RANDUM

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.

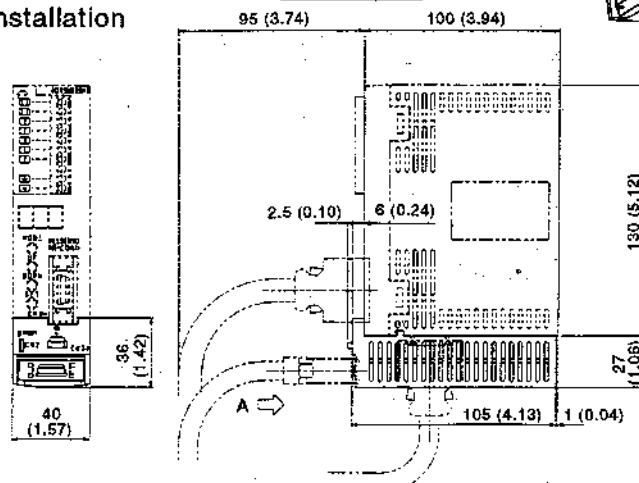
#### 2) Removal

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



[Unit: mm (in)]

#### (2) Outline drawing after installation



## 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.

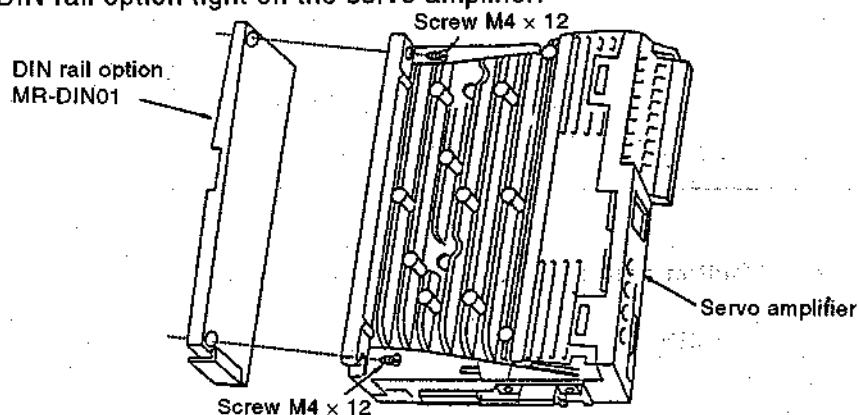
#### (1) Outline drawing

Details not yet determined

#### (2) How to use the option

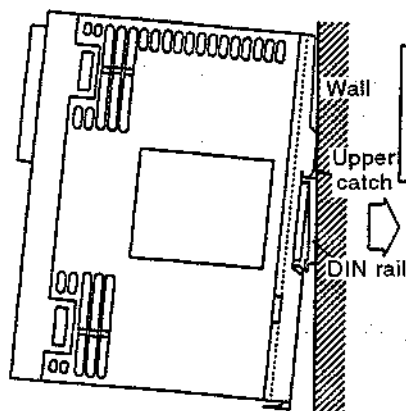
##### 1) Installation to the servo amplifier

Screw the DIN rail option tight on the servo amplifier.



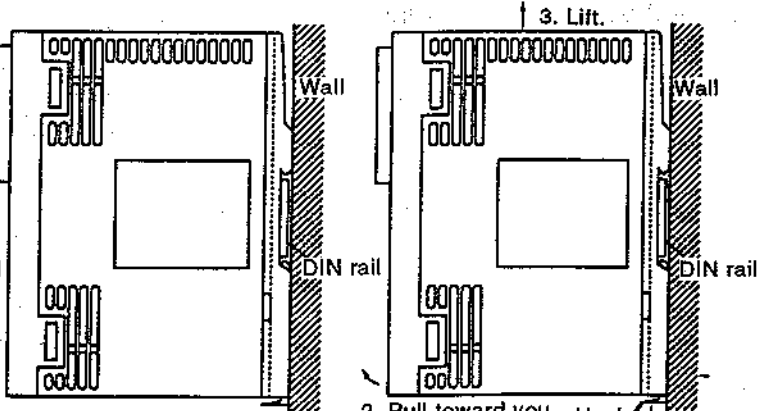
##### 2) Fitting into the DIN rail

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.



## 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 [mm <sup>2</sup> ]				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.

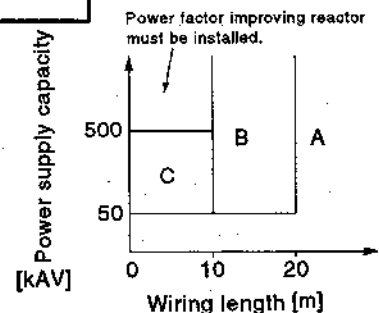
2. Twist the wires for connection of the regenerative brake option (P, C).

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

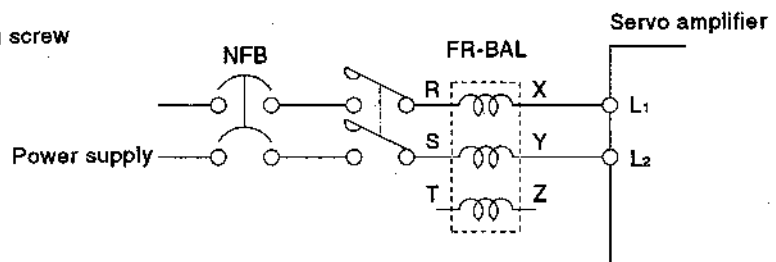
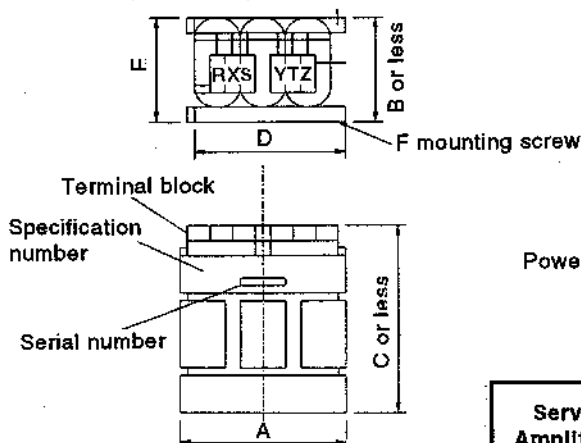
Servo Amplifier	No-Fuse Breaker	Fuse			Magnetic Contactor		
		Class	Current [A]	Voltage [V]	A	B	C
MR-C10A MR-C20A MR-C10A1	NF30 type 5A	K5	10	AC250	S-N18	S-N21	S-N21
MR-C20A1 MR-C40A	NF30 type 10A						

#### 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.



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.

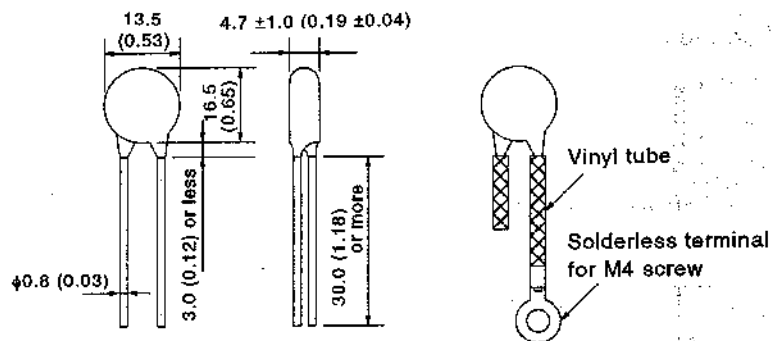
Maximum Rating					Maximum Limit Voltage		Static Capacity (Reference value)	Varistor Voltage Rating (Range) $V_{1mA}$
Permissible Circuit Voltage		Surge Immunity	Energy Immunity	Rated Power				
AC[V <sub>rms</sub> ]	DC[V]	[A] (Note)	[J]	[W]	[A]	[V]	[pF]	[V]
140	180	500/time	5	0.4	25	360	300	220 (198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

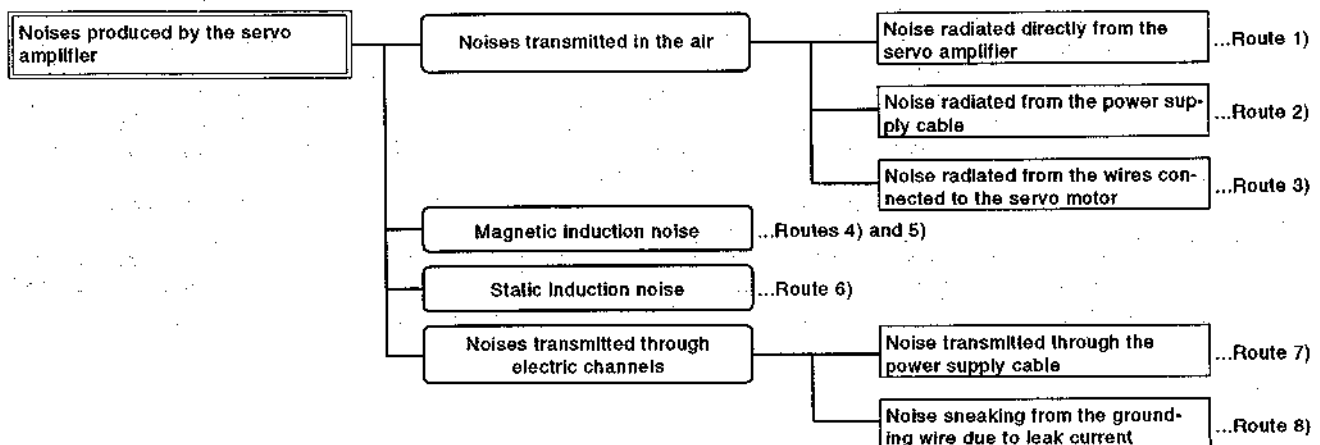
#### 2) Reduction techniques for external noises that cause the servo amplifier to malfunction

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.

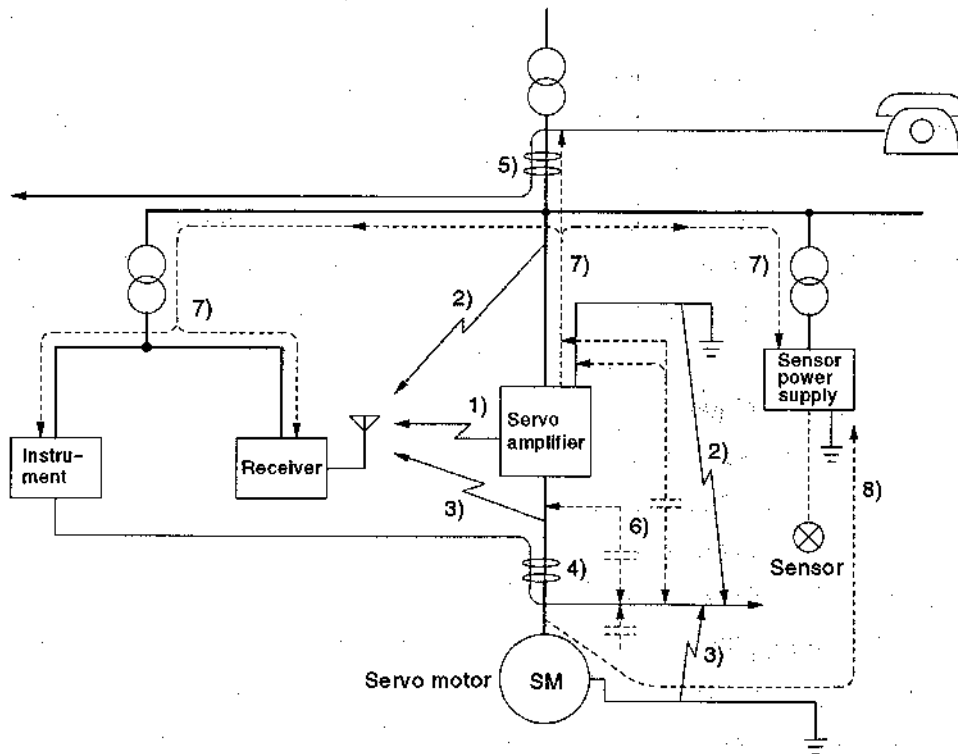
- Provide surge absorbers on the noise sources to suppress noises.
- Attach data line filters to the signal cables
- Ground the shields of the encoder connecting wire and the control signal cables with cable clamp fittings.

#### 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.



## 6. OPTIONS AND AUXILIARY EQUIPMENT



Noise Transmission Route	Countermeasures
1) 2) 3)	<p>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.</p> <ol style="list-style-type: none"> <li>(1) Provide maximum clearance between the devices which are liable to be influenced by noise and a servo amplifier.</li> <li>(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.</li> <li>(3) Avoid laying the power lines (I/O cables of the servo amplifier) and signal cables side by side or bundling them together.</li> <li>(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.</li> <li>(5) Use shielded wires for signal and power cables or put cables in separate metal conduits.</li> </ol>
4) 5) 6)	<p>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.</p> <ol style="list-style-type: none"> <li>(1) Provide maximum clearance between the devices which are liable to be influenced by noise and a servo amplifier.</li> <li>(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.</li> <li>(3) Avoid laying the power lines (I/O cables of the servo amplifier) and signal cables side by side or bundling them together.</li> <li>(4) Use shielded wires for signal and power cables or put the cables in separate metal conduits.</li> </ol>
7)	<p>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.</p> <ol style="list-style-type: none"> <li>(1) Insert a radio frequency noise filter (FR-BIF) on the power cables (I/O cables) of the servo amplifier.</li> <li>(2) Insert a line noise filter (FR-BSF01) on the power cables of the servo amplifier.</li> </ol>
8)	<p>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.</p>



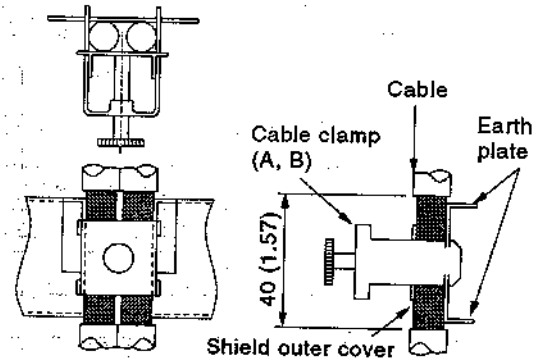
## 6. OPTIONS AND AUXILIARY EQUIPMENT

### (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.

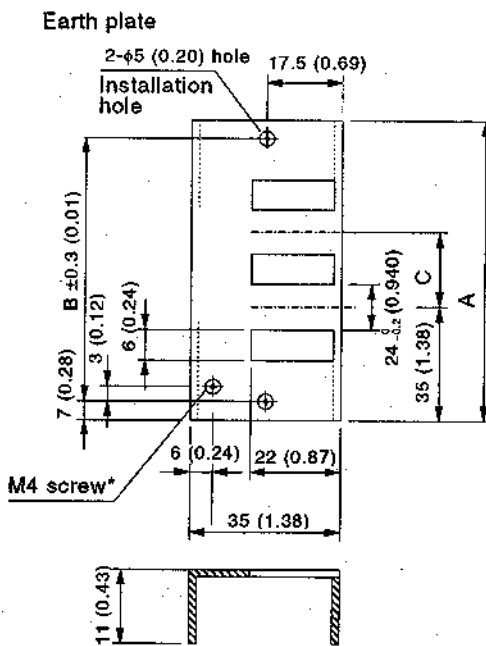
Install the earth plate near the servo amplifier for the encoder cable. Peel part of the cable sheath to expose the shield, and insert that part into the earth plate with the cable clamp. If the cable is thin, clamp several cables in a bunch.

The clamp comes as a set with the earth plate.



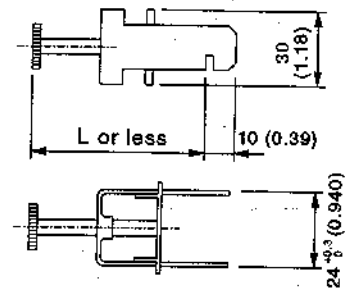
Clamp section diagram

#### • Outline drawing



Cable clamp

[Unit: mm (in)]



- 1) Always wire from the earth plate to the cabinet ground.
- 2) \*Screw hole for wiring to cabinet ground.

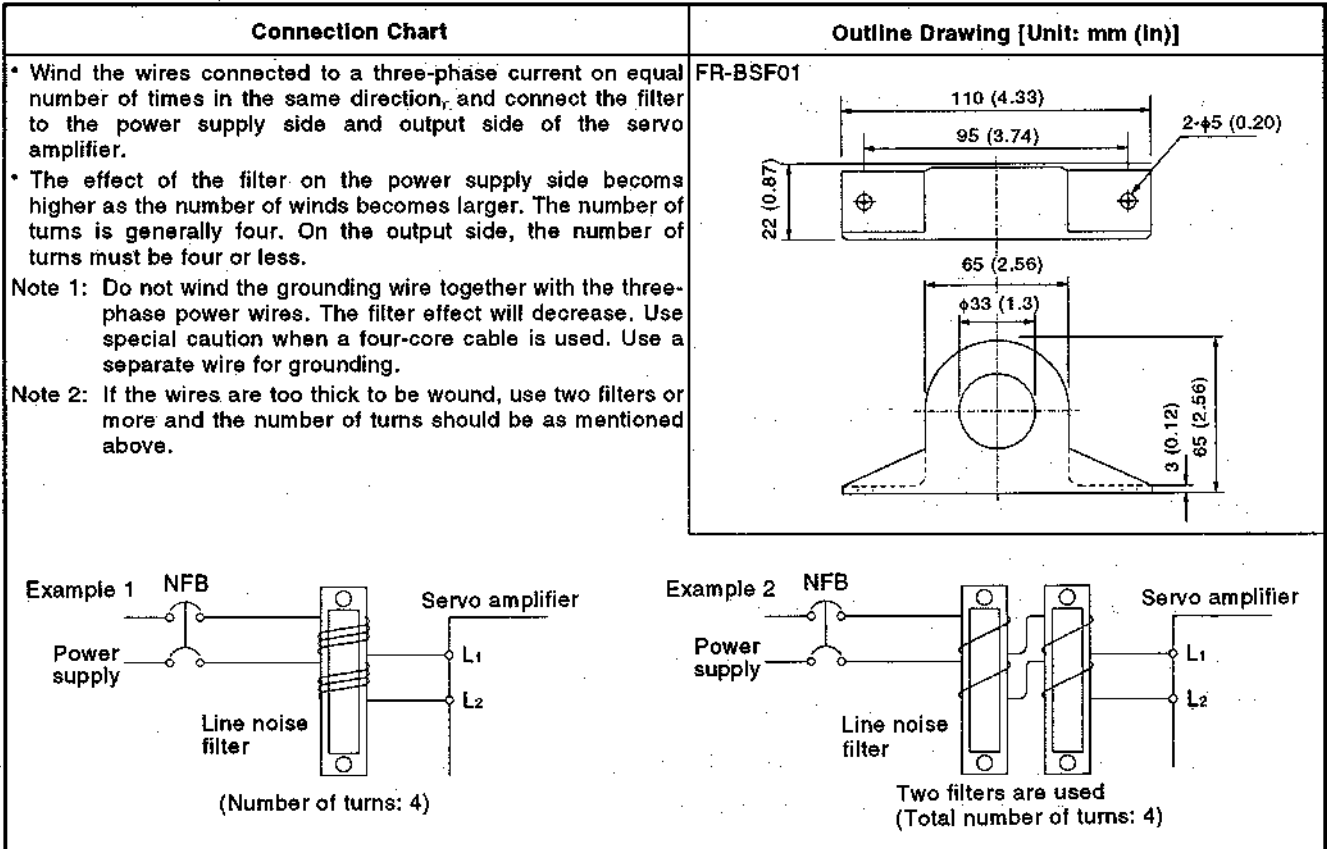
	A	B	C	Enclosed Fittings
AERSBAN-DSET	100 (3.94)	86 (3.39)	30 (1.18)	Clamp A : 2pcs.
AERSBAN-ESET	70 (2.76)	56 (2.20)	-	Clamp B : 1pc.

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

## 6. OPTIONS AND AUXILIARY EQUIPMENT

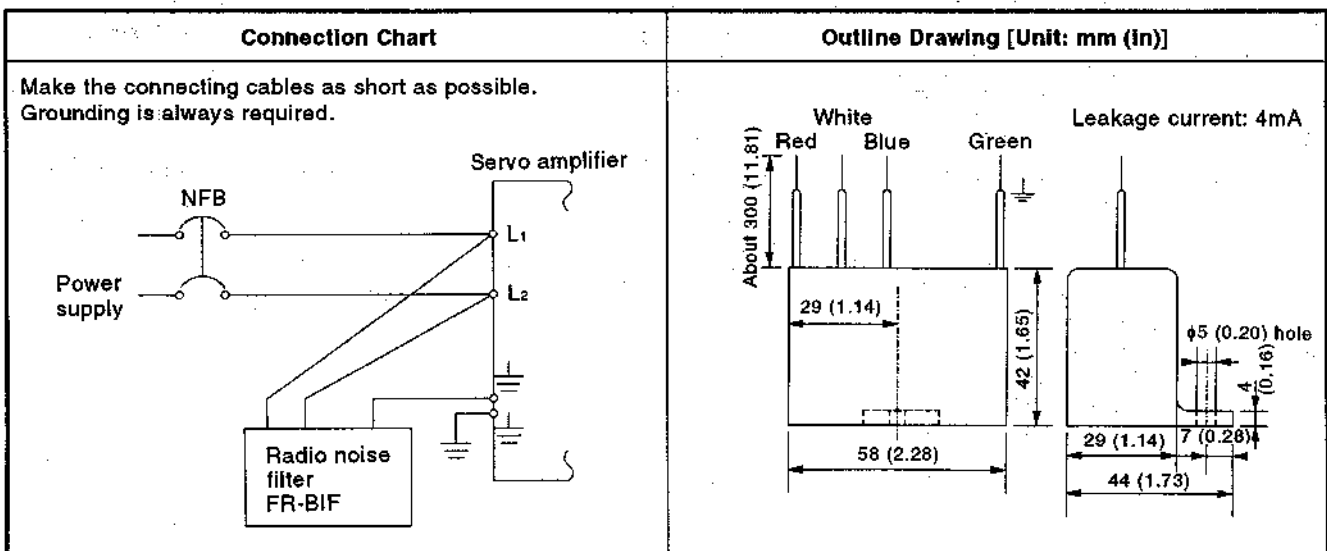
### (4) Line noise filter (FR-BSF01)

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.



### (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.



## 6. OPTIONS AND AUXILIARY EQUIPMENT

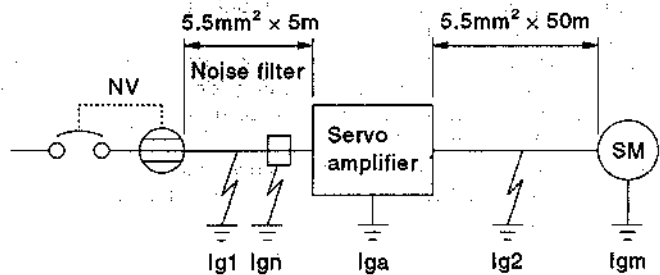
### 6-2-7 Leakage current breaker

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:  $I_{g1}$  [mA] (Obtain from Fig. 6-1.)
- Leakage current on the electric channel from the output terminal of the servo amplifier to the servo motor:  $I_{g2}$  [mA] (Obtain from Fig. 6-1.)
- Leakage current when a filter is connected to the input side:  $I_{gn}$  [mA] (4.4[mA] per one FR-BIF)
- Leakage current of the servo amplifier:  $I_{ga}$  [mA] (2[mA])
- Leakage current of the servo motor:  $I_{gm}$  [mA] (Obtain from Table 6-1.)



$$\text{Rated sensitivity current} \geq 10 \cdot \{ I_{g1} + I_{gn} + I_{ga} + K \cdot ( I_{g2} + I_{gm} ) \} \text{ [mA]}$$

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) :  $K=3$

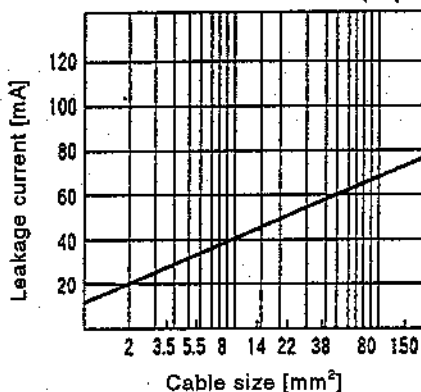


Fig. 6-1 Leakage Current per 1km ( $I_{g1}$ ,  $I_{g2}$ ) when CV Cable Is Laid in a Metal Conduit

Table 6-1 Leakage Current of Servo Motor ( $I_{gm}$ )

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 Breaker [mA]
MR-C10A(1) to MR-C20A(1)	15
MR-C40A	

# **CHAPTER 7**

## **MAINTENANCE AND INSPECTION**

---

This chapter describes maintenance items.

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

## 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**

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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

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

## 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<sub>1</sub>, L<sub>2</sub>) 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	<ol style="list-style-type: none"> <li>1. Power supply voltage is low.</li> <li>2. Power switched on within 5s after it had switched off.</li> <li>3. Instantaneous power failure of 16ms or longer occurred.</li> <li>4. Shortage of power supply capacity caused the power supply voltage to drop at start, etc.</li> <li>5. Faulty parts in the servo amplifier</li> </ol> <div style="border: 1px solid black; padding: 5px; margin-top: 5px;"> <p>— Checking method — If all connectors have been disconnected and power switched on, the alarm (A10) occurs.</p> </div>	<p>Review the power supply.</p> <p>Change the servo amplifier.</p>
A12	Memory error 1	RAM/ROM memory error	<p>Faulty parts in the servo amplifier</p> <div style="border: 1px solid black; padding: 5px; margin-top: 5px;"> <p>— Checking method — If all connectors have been disconnected and power switched on, the alarm (any of A12, A14 and A15) occurs.</p> </div>	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.	<ol style="list-style-type: none"> <li>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).</li> <li>2. Encoder fault</li> </ol>	<p>Use correct combination as in Section 10 - 1.</p> <p>Change the servo motor.</p>

## 8. TROUBLESHOOTING

Display	Alarm Name	Definition	Cause	Action
A17	Board error	CPU/parts error	Faulty parts in the servo amplifier  <div style="border: 1px solid black; padding: 2px;">                     Checking method                      If all connectors have been disconnected and power switched on, the alarm (A17) occurs.                 </div>	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.  <div style="border: 1px solid black; padding: 2px;">                     Checking method                      Use the status display to check the regenerative load factor.                 </div>	1. Reduce the frequency of positioning. 2. Use larger regenerative brake option. 3. Reduce the load.
		Regenerative transistor error	Regenerative transistor faulty.  <div style="border: 1px solid black; padding: 2px;">                     Checking method                      1) The regenerative brake option has overheated abnormally.                      2) The alarm occurs after removal of the regenerative brake option.                 </div>	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.  <div style="border: 1px solid black; padding: 2px;">                     Checking method                      If all connectors have been disconnected and power switched on, the alarm (A10) occurs.                 </div>	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.
			4. Machine struck something.	1. Review operation pattern. 2. Provide limit switches.

(Refer to Section 5 - 1.)

Parameter	Adjustment
No. 26	Decrease
No. 27	Increase
No. 29	Increase

## 8. TROUBLESHOOTING

Display	Alarm Name	Definition	Cause	Action
A50			5. Encoder faulty. <div style="border: 1px solid black; padding: 5px; margin-top: 5px;"> <p>— 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.</p> </div>	Change the servo motor.
A52	Excessive error	Value of the deviation counter exceeded 50k pulse.	1. Acceleration/deceleration time is too small. 2. Torque limit value (parameter No. 9) is too small. 3. Start not allowed by torque shortage due to power supply voltage drop. 4. Machine struck something. 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.	Increase the acceleration/deceleration time. Increase the torque limit value. 1. Review the power supply equipment capacity. 2. Increase the servo motor capacity. 1. Review operation pattern. 2. Provide limit switches. Connect correctly.
			6. Encoder faulty.	Change the servo motor.

# CHAPTER 9

## CHARACTERISTICS

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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

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

# 9. CHARACTERISTICS

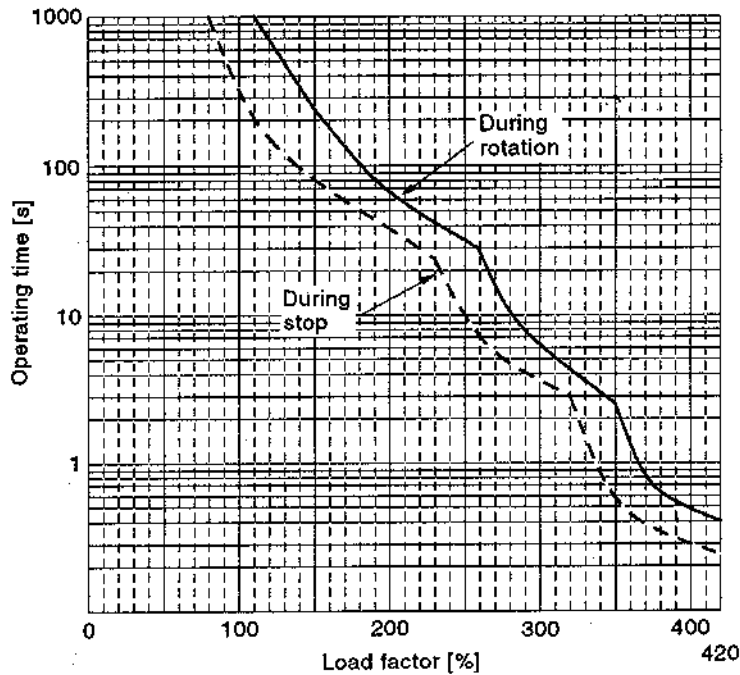
## 9-1 Overload Protection Characteristics

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.

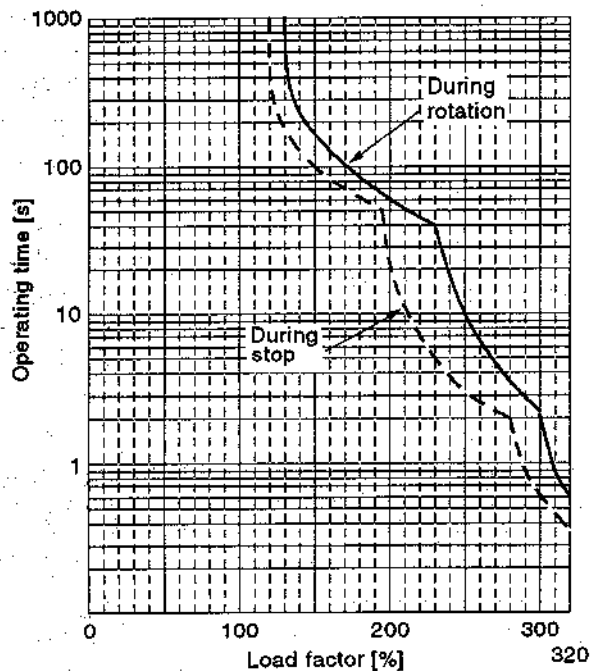
Overload 1 alarm (A50) is displayed to indicate that overload operation has been performed above the electronic thermal relay protection curve shown below or that the maximum current flew continuously for several seconds because the machine struck something, for example. Use the equipment on the left-hand 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

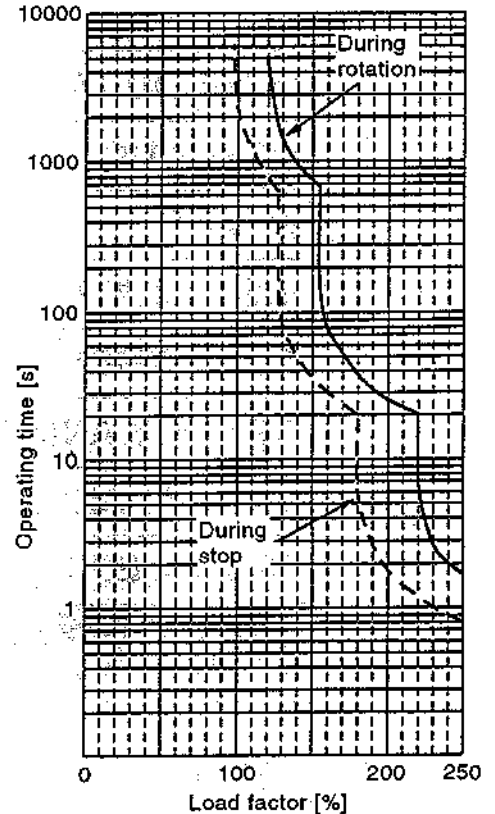


Fig. 9-1 Electronic Thermal Relay Protection Characteristics

## 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 <sup>2</sup> ]	[ft <sup>2</sup> ]
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:

$$A = \frac{P}{K \cdot \Delta T} \dots \dots \dots (9-1)$$

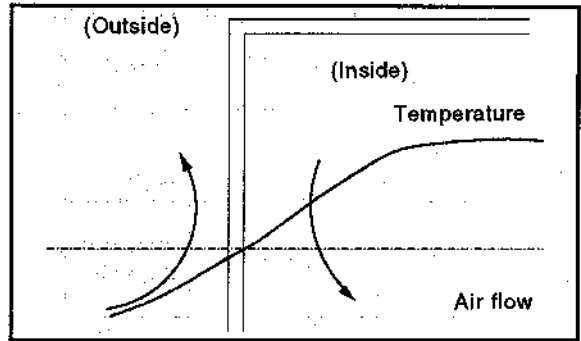
- where,
- A: Heat dissipation area [m<sup>2</sup>]
  - P: Loss generated in the control box [W]
  - ΔT: Difference between internal and ambient temperatures [°C]
  - K: Heat dissipation coefficient [5 to 6]

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.

"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).



**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.

# 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**

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 <sup>2</sup> ]	3.1 × 10 <sup>-3</sup>			4.0 × 10 <sup>-2</sup>		
	GD <sup>2</sup> [kgf·cm <sup>2</sup> ]	1.24 × 10 <sup>-2</sup>			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 rattle 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.

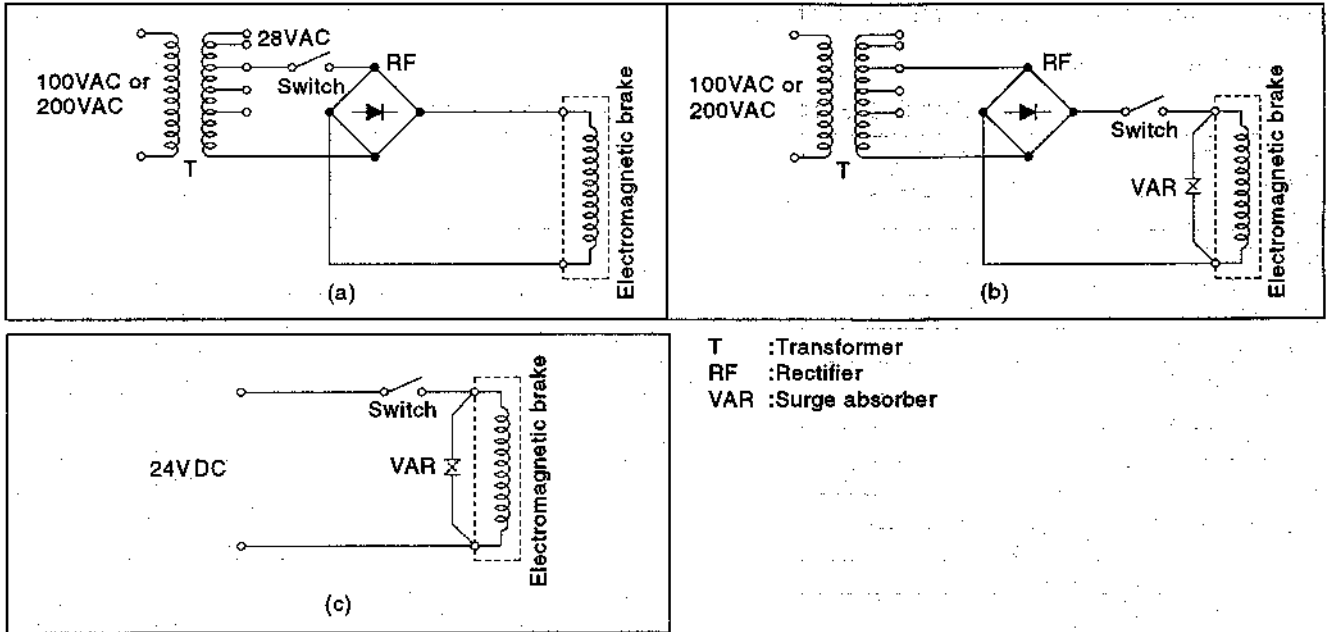


Fig. 9-3 Connection Examples

### (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),  $L_{max}$ , 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.

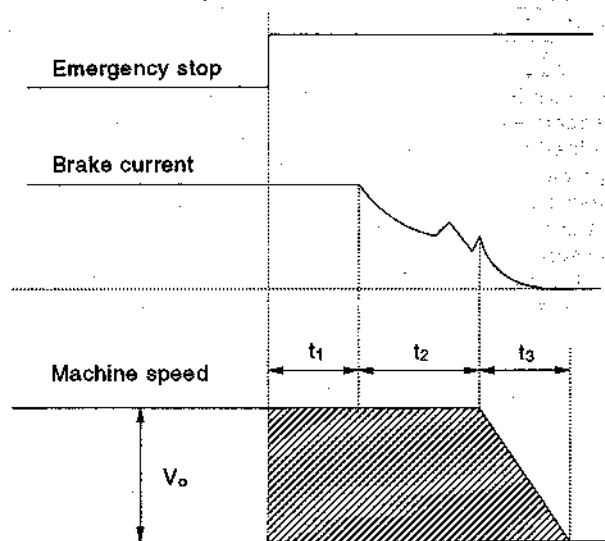


Fig. 9-4 Coasting Distance during Emergency Stop

## 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]

$$t_3 = \frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4 \cdot (T_L + 0.8T_B)}$$

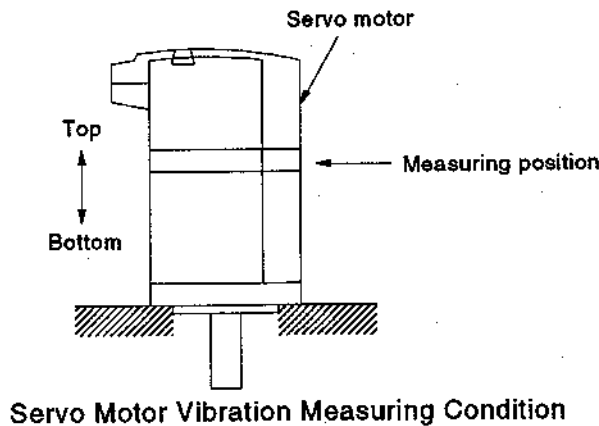
$J_L$	: load inertia converted into equivalent value on servo motor shaft	[kg·cm <sup>2</sup> ]
$J_M$	: Servo motor inertia	[kg·cm <sup>2</sup> ]
$N_o$	: Servo motor speed during fast feed	[r/min]
$T_L$	: Load torque converted into equivalent value on servo motor shaft	[N·m]
$T_B$	: Brake static friction 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.



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## REVISIONS

# CHAPTER 10

## SPECIFICATIONS

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This chapter gives the specifications of the servo.

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- 10 – 3 Outline Drawings
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<b>OPTIONAL PRODUCTS</b>	<b>CHAPTER 12</b>



# 10. SPECIFICATIONS

## 10 - 1 Standard Specifications

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

### (1) Servo amplifier

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 $\pm 5\%$				
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	$\pm 50K$ 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

Servo motor		HC-PQ series					
Item		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]		8.45	13.47	34.13	46.02	116.55	
Moment of inertia (Note 7)	J [kg·cm <sup>2</sup> ]	0.014	0.019	0.03	0.089	0.145	
	GD <sup>2</sup> [kgf·cm <sup>2</sup> ]	0.057	0.074	0.12	0.35	0.57	
	WK <sup>2</sup> [oz·in <sup>2</sup> ]	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

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- 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  $\Delta$ , 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

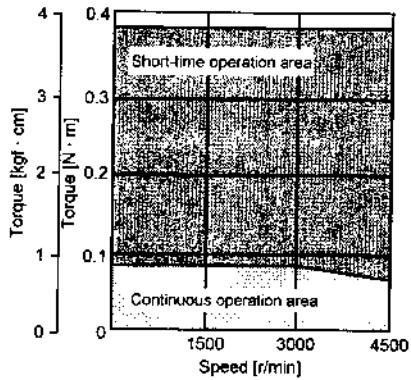
## 10 - 2 Torque Characteristics

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

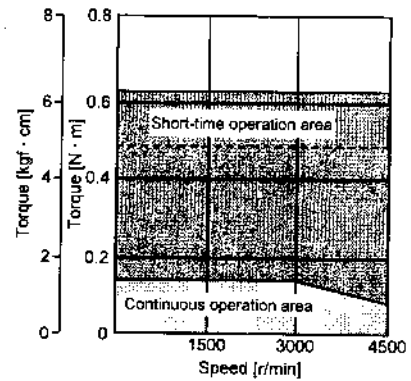
**MEMO-RANDUM** The short-time operation area of the servo motor with reduction gear is as indicated by the broken line.

### 10 - 2 - 1 Standard

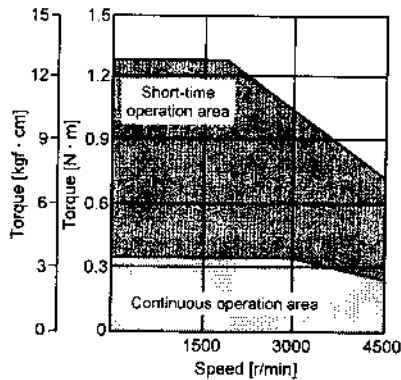
[HC-PQ033]



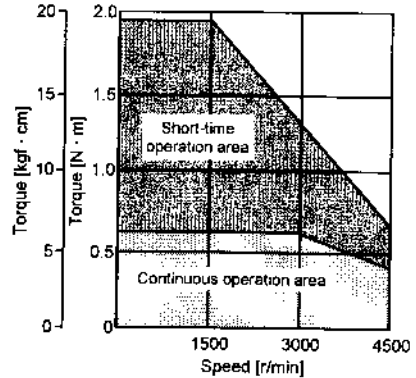
[HC-PQ053]



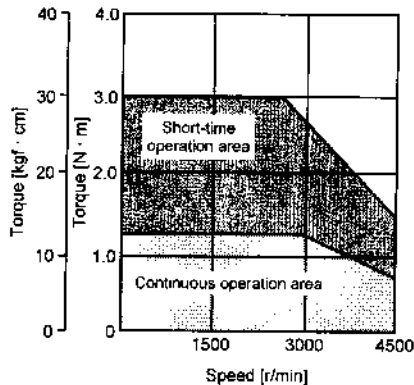
[HC-PQ13]



[HC-PQ23]



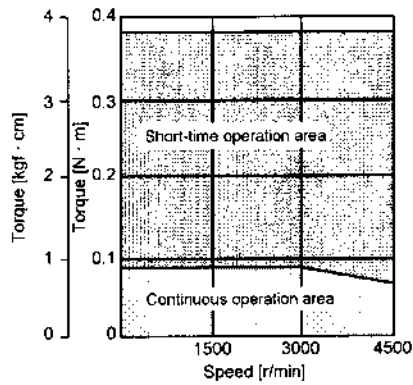
[HC-PQ43]



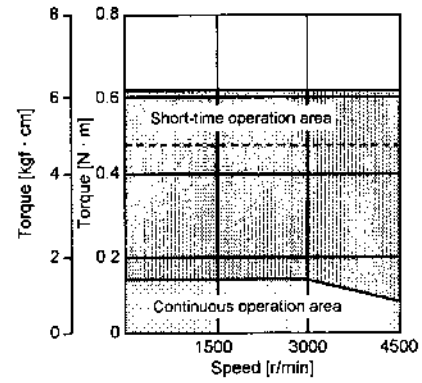
# 10. SPECIFICATIONS

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

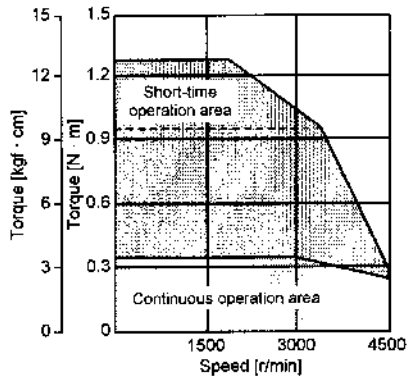
[HC-PQ033]



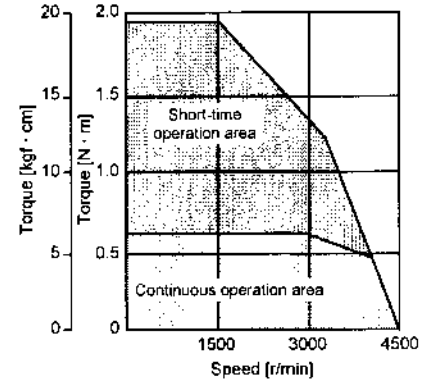
[HC-PQ053]



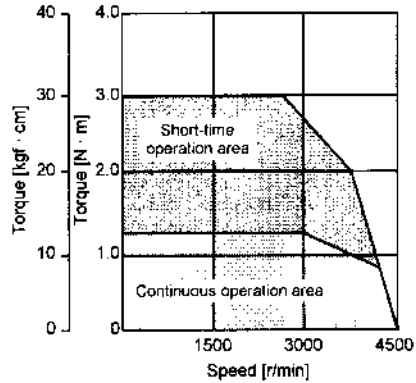
[HC-PQ13]



[HC-PQ23]



[HC-PQ43]



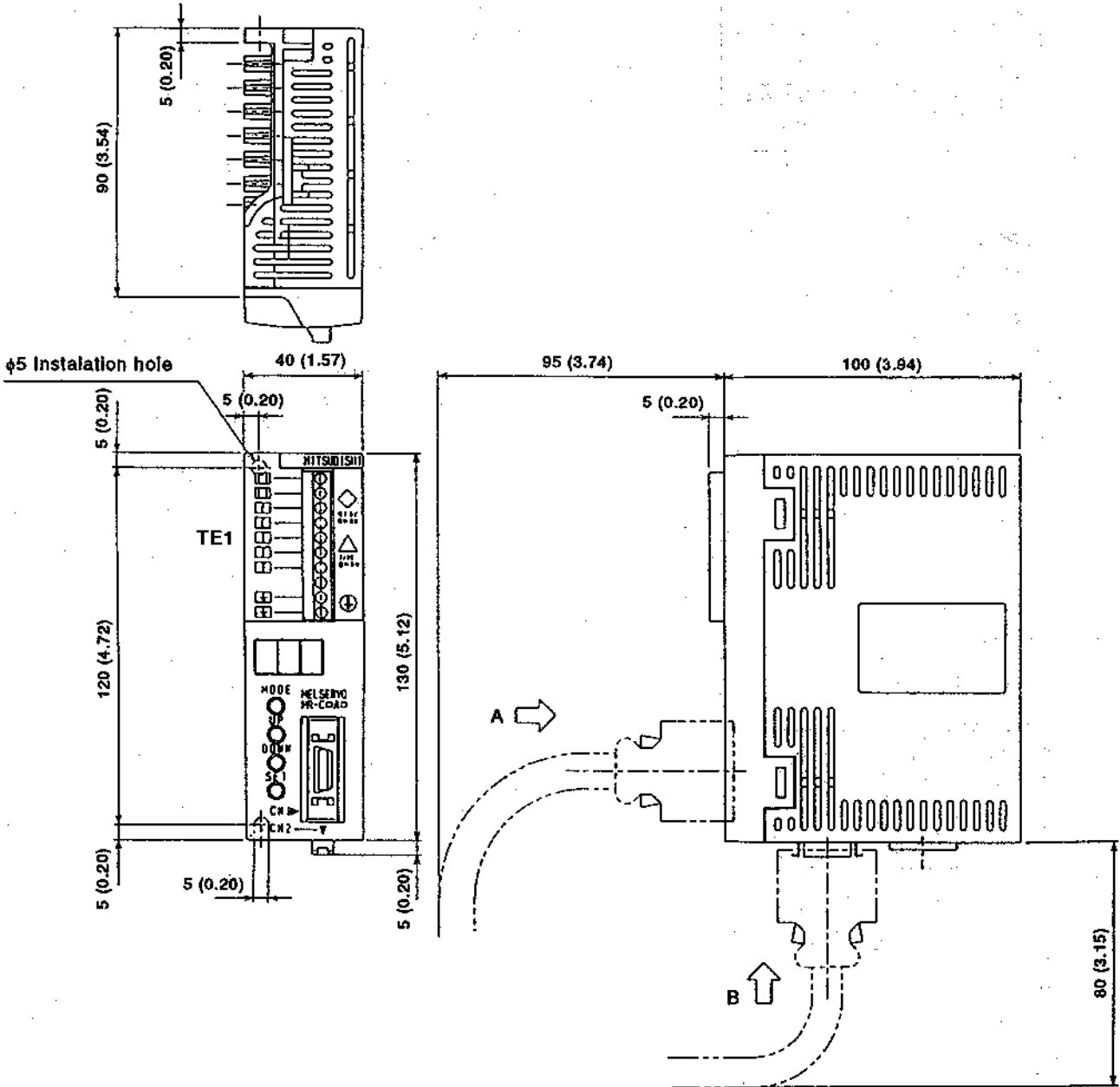
# 10. SPECIFICATIONS

## 10 - 3 Outline Drawings

### 10 - 3 - 1 Servo amplifiers

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

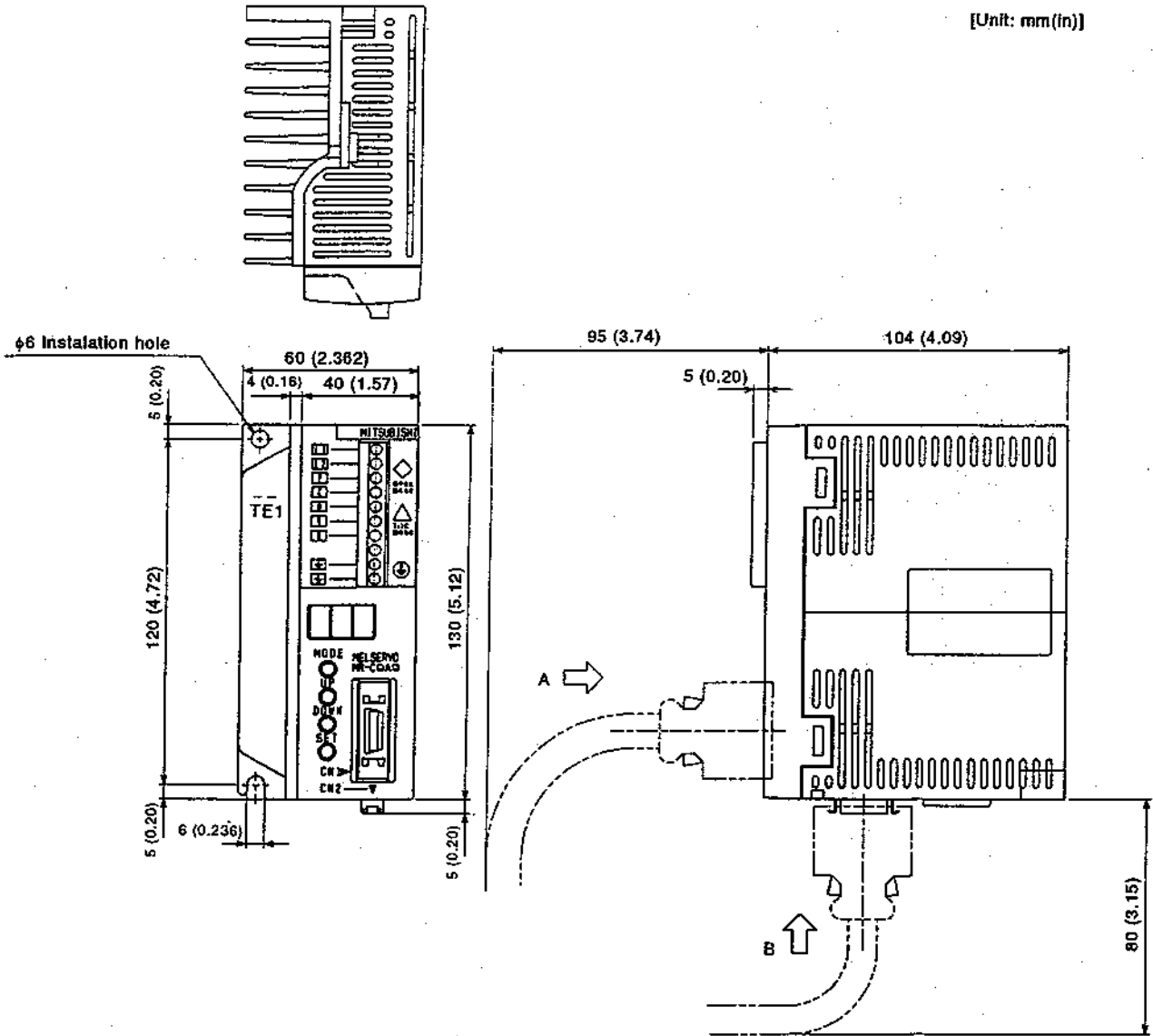
[Unit: mm(in)]



# 10. SPECIFICATIONS

MR-C40A

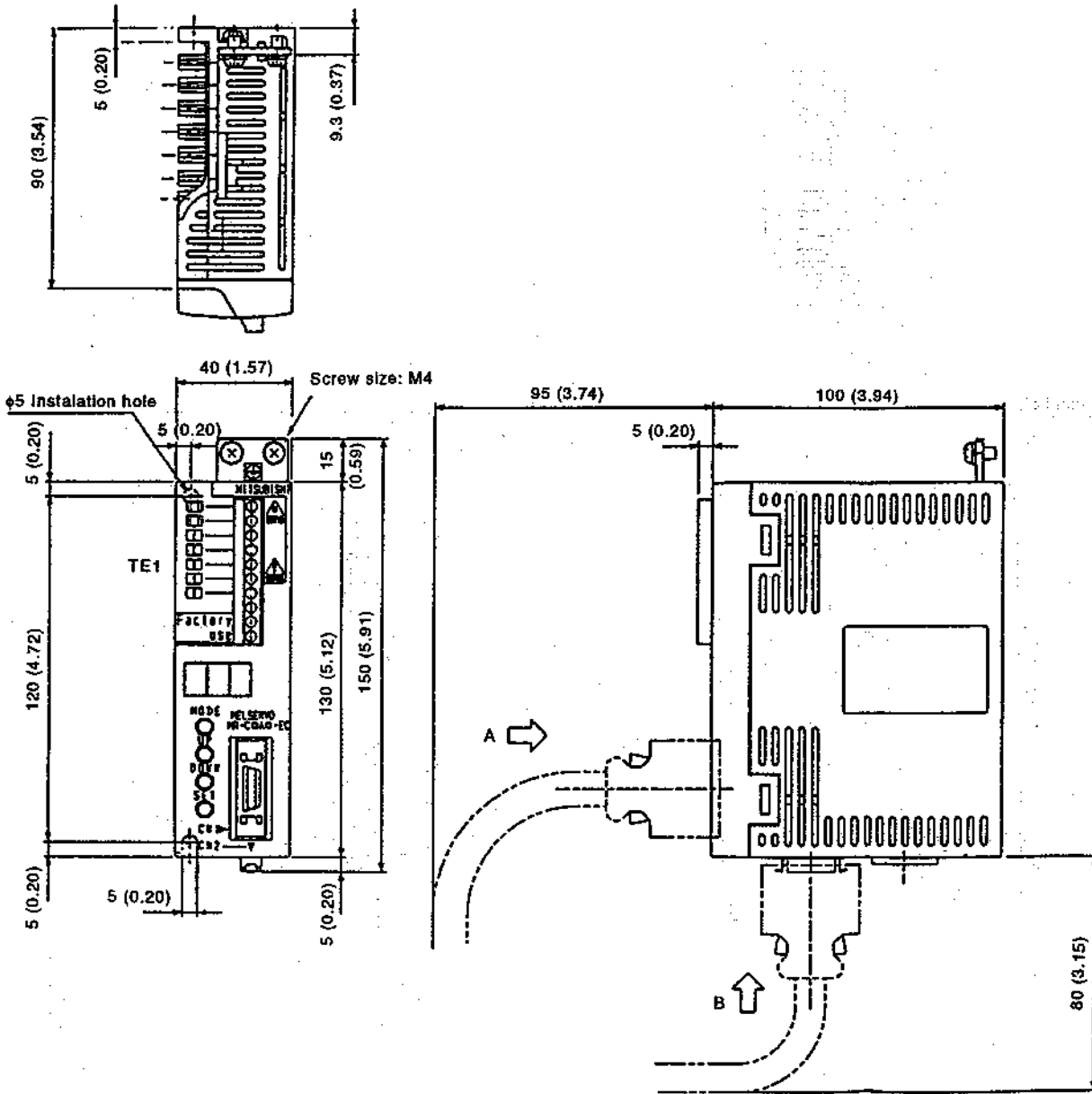
[Unit: mm(in)]



# 10. SPECIFICATIONS

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

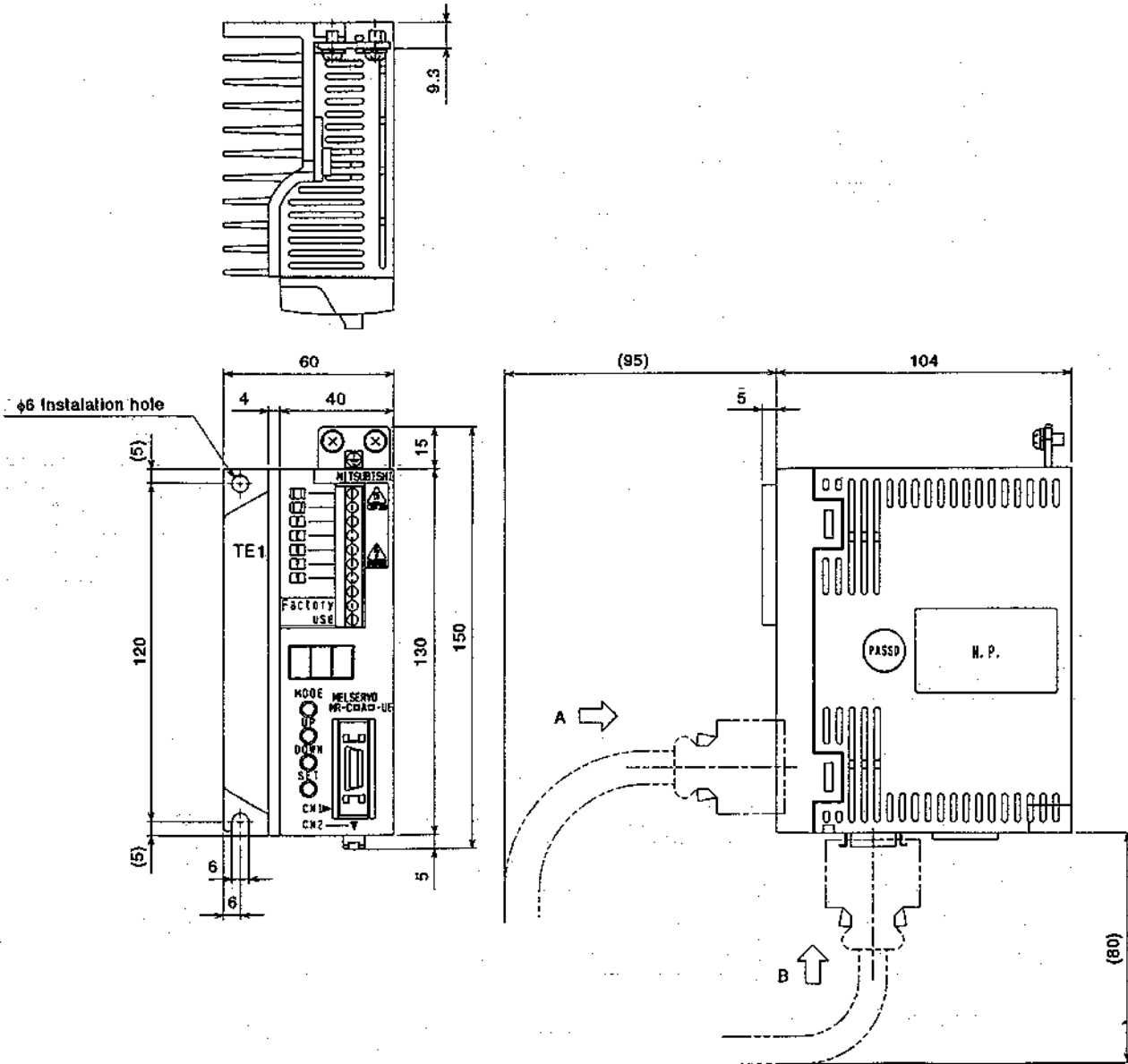
[Unit: mm(in)]



# 10. SPECIFICATIONS

MR-C40A-UE

[Unit: mm]



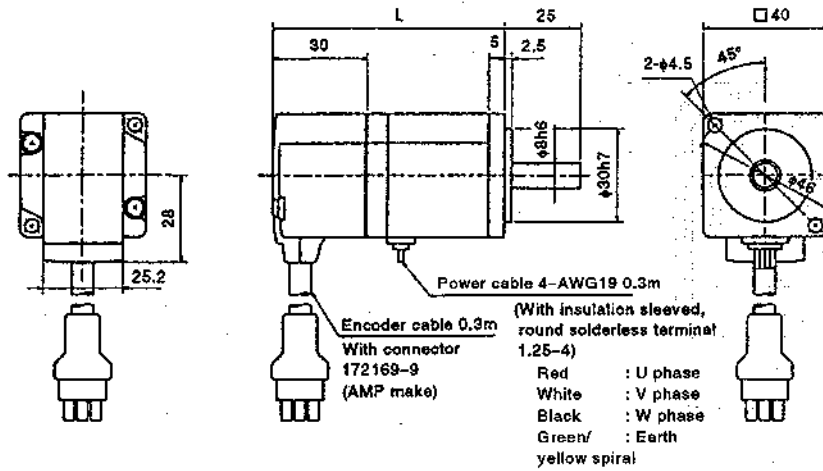


# 10. SPECIFICATIONS

## 10-3-2 Servo motors

### (1) Standard

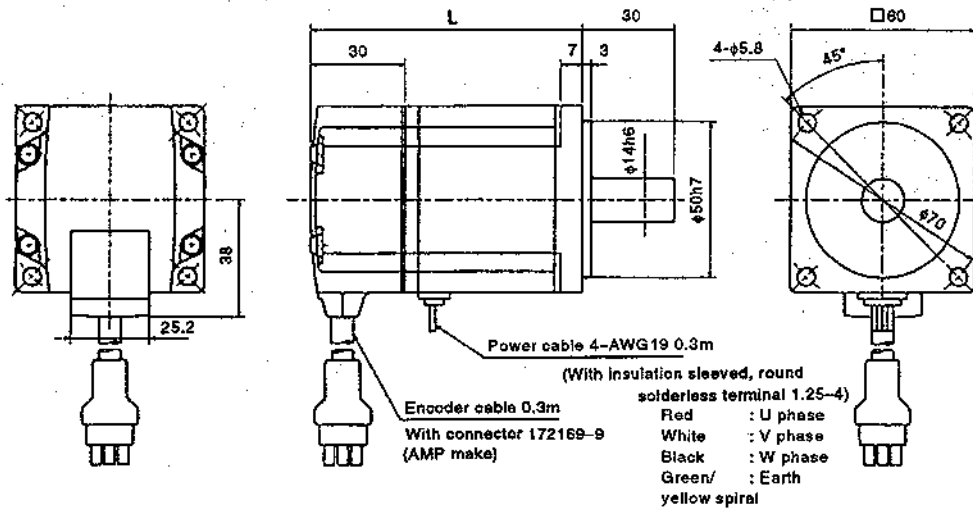
#### HC-PQ033 to HC-PQ13



[Unit: mm]

Model	Variable Dimension L	Inertia $J(\times 10^{-4}\text{kg}\cdot\text{m}^2)$	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	0.36
HC-PQ053-UE	79.5	0.019	0.4
HC-PQ13-UE	94.5	0.03	0.53

#### HC-PQ23 · HC-PQ43



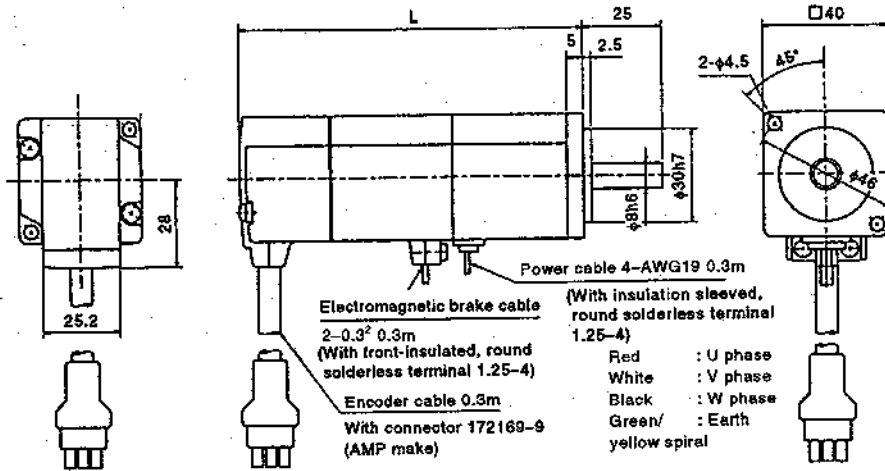
[Unit: mm]

Model	Variable Dimension L	Inertia $J(\times 10^{-4}\text{kg}\cdot\text{m}^2)$	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

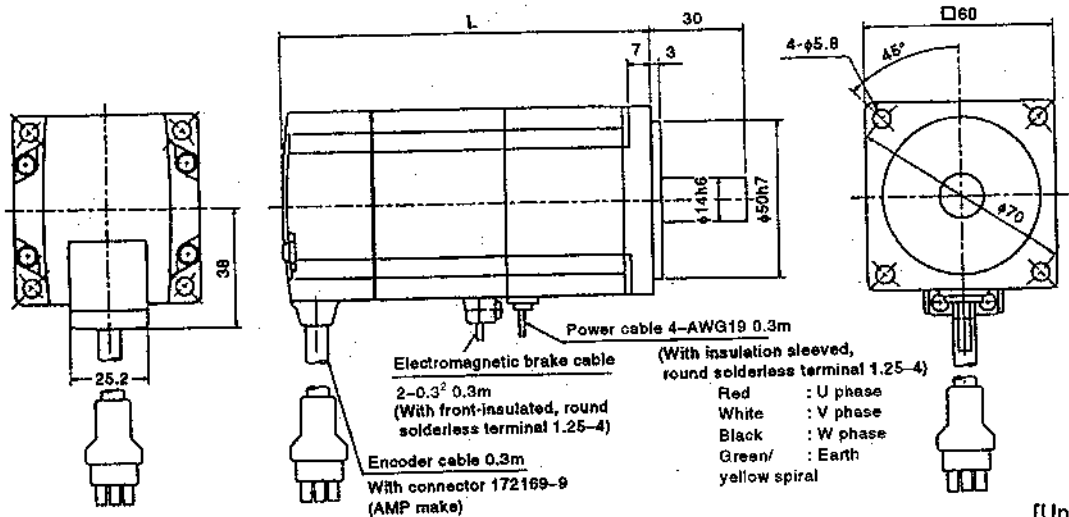
HC-PQ033B to HC-PQ13B



[Unit: mm]

Model	Variable Dimension L	Brake Static Friction Torque(N·m)	Inertia J( $\times 10^{-4}$ kg·m <sup>2</sup> )	Weight [kg]
HC-PQ033B	83.5	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



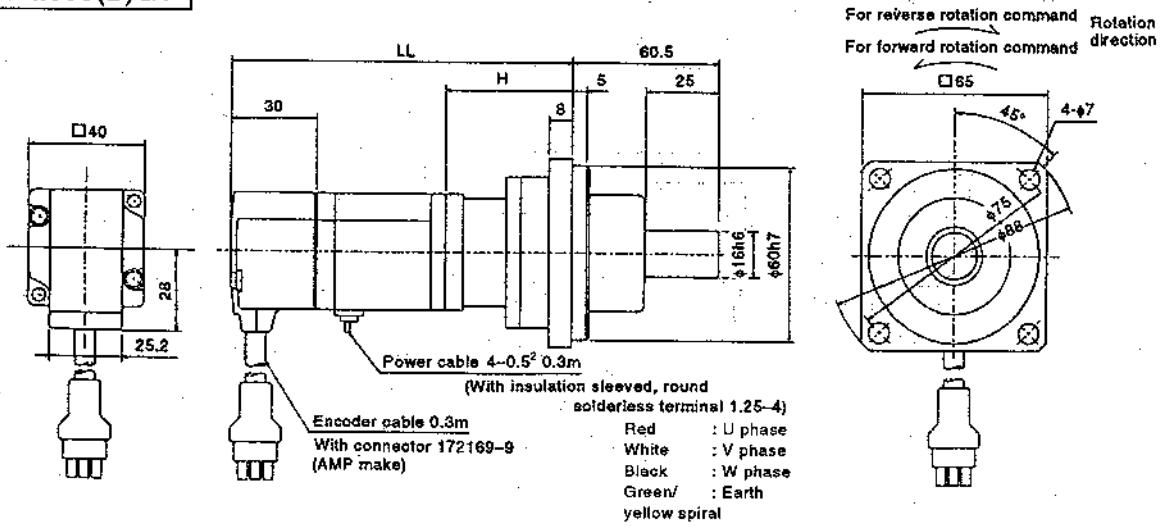
[Unit: mm]

Model	Variable Dimension L	Brake Static Friction Torque(N·m)	Inertia J( $\times 10^{-4}$ kg·m <sup>2</sup> )	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

# 10. SPECIFICATIONS

(3) With reduction gear for general industrial machine

## HC-PQ053(B)G1



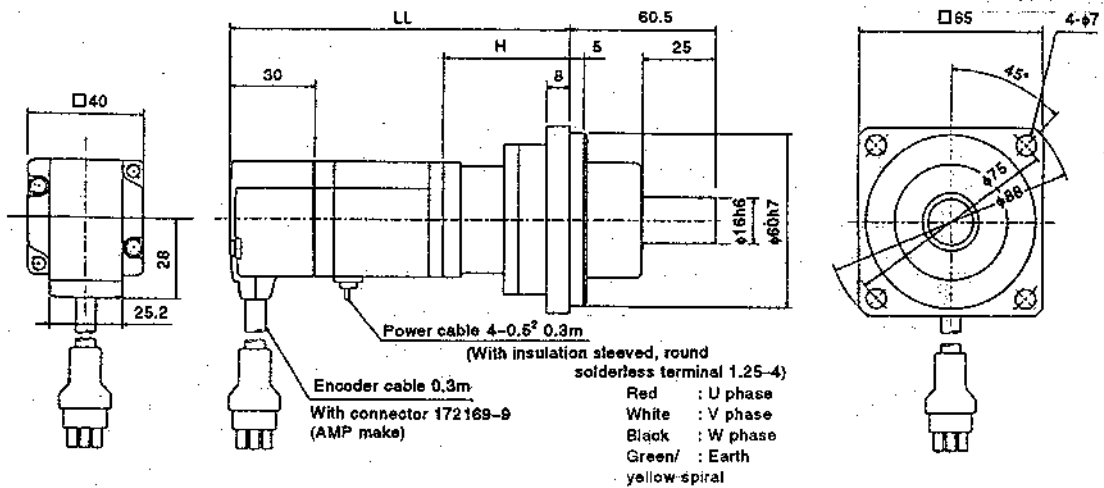
[Unit: mm]

Model	Reduction Ratio (Note 2)	Reduction Gear Model	Inertia J (×10 <sup>-4</sup> kg·m <sup>2</sup> ) (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]

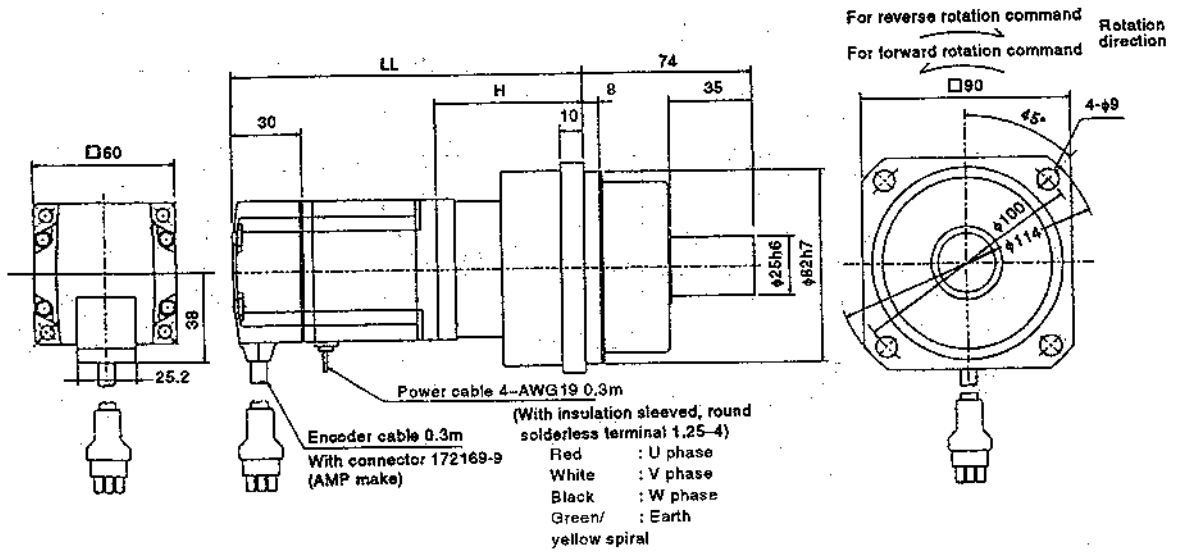
Model	Reduction Ratio (Note 2)	Reduction Gear Model	Inertia J (×10 <sup>-4</sup> kg·m <sup>2</sup> ) (Note 1)	Variable Dimension (Note 1)		Weight [kg] (Note 1)
				LL	H	
HC-PQ13 (B)G1(-UE)	1/5	K6505	0.066 (0.069)	130.5 (158.5)	47.5	1.5 (1.9)
HC-PQ13 (B)G1(-UE)	1/12	K6512	0.088 (0.091)	149 (177)	64.5	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.

# 10. SPECIFICATIONS

## HC-PQ23(B)G1



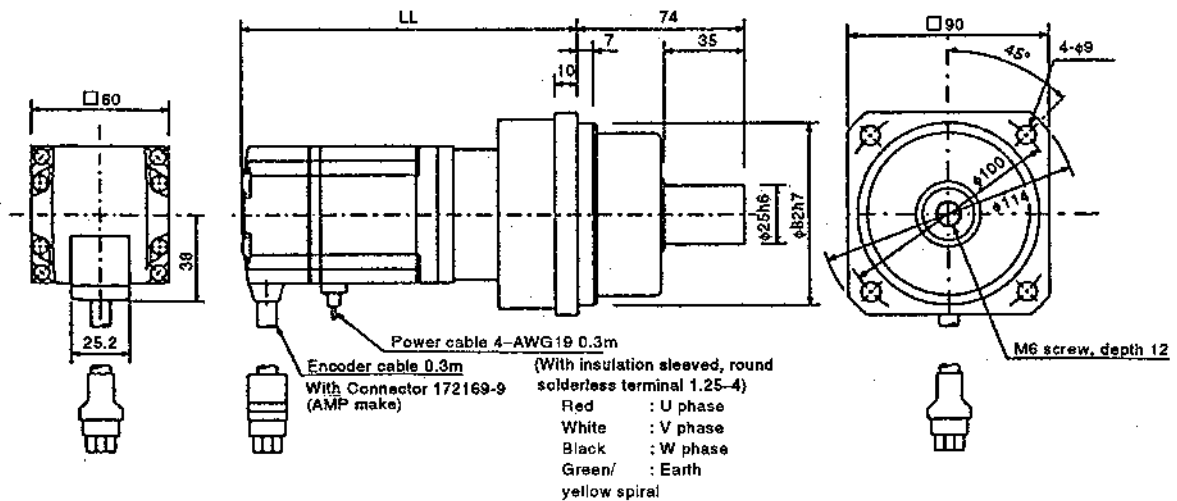
[Unit: mm]

Model	Reduction Ratio (Note 2)	Reduction Gear Model	Inertia J ( $\times 10^{-4} \text{kg} \cdot \text{m}^2$ ) (Note 1)	(Note 1) Variable Dimension		Weight [kg] (Note 1)
				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



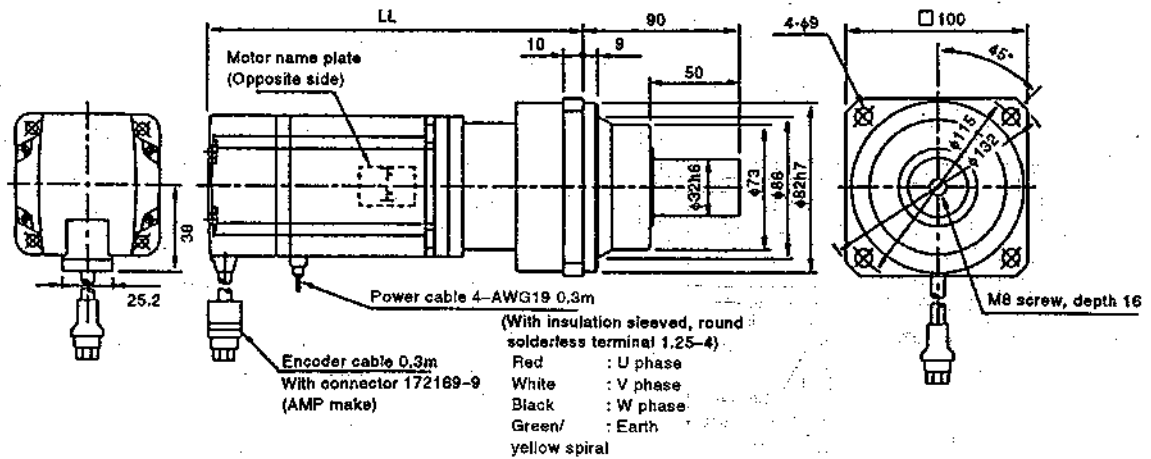
[Unit: mm]

Model	Reduction Ratio (Note 2)	Reduction Gear Model	Inertia J ( $\times 10^{-4} \text{kg} \cdot \text{m}^2$ ) (Note 1)	(Note 1) Variable Dimension	Weight [kg] (Note 1)
				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.

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[Unit: mm]

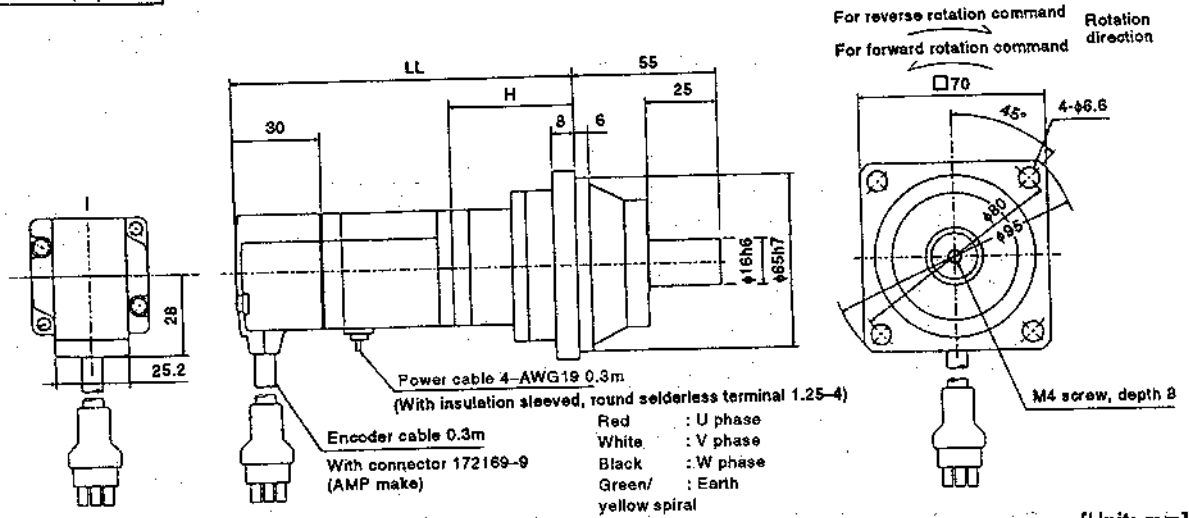
Model	Reduction Ratio <sup>(Note 2)</sup>	Reduction Gear Model	Inertia J( $\times 10^{-4}$ kg·m <sup>2</sup> ) <sup>(Note 1)</sup>	Variable Dimension <sup>(Note 1)</sup>		Weight [kg] <sup>(Note 1)</sup>
				LL		
HC-PQ43 (B)G1(-UE)	1/20	K10020	0.653 (0.701)	191 (223)		5.5 (6.1)

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.

# 10. SPECIFICATIONS

(4) With reduction gear for precision operation

## HC-PQ053(B)G2

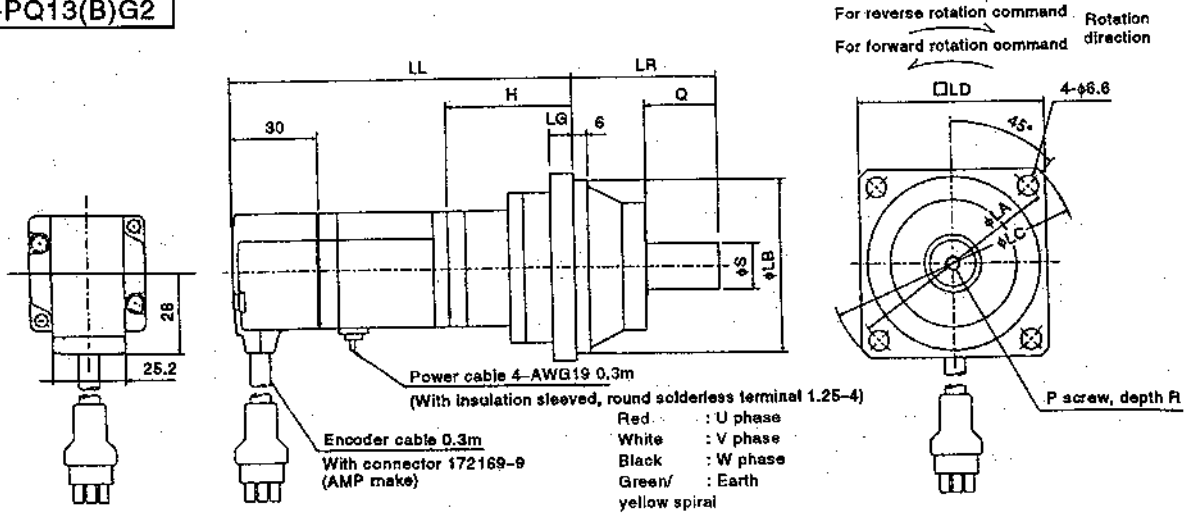


[Unit: mm]

Model	Reduction Ratio (Note 2)	Reduction Gear Model	Inertia J(x10 <sup>-4</sup> kg·m <sup>2</sup> ) (Note)	Variable Dimension (Note)		Weight [kg] (Note)
				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



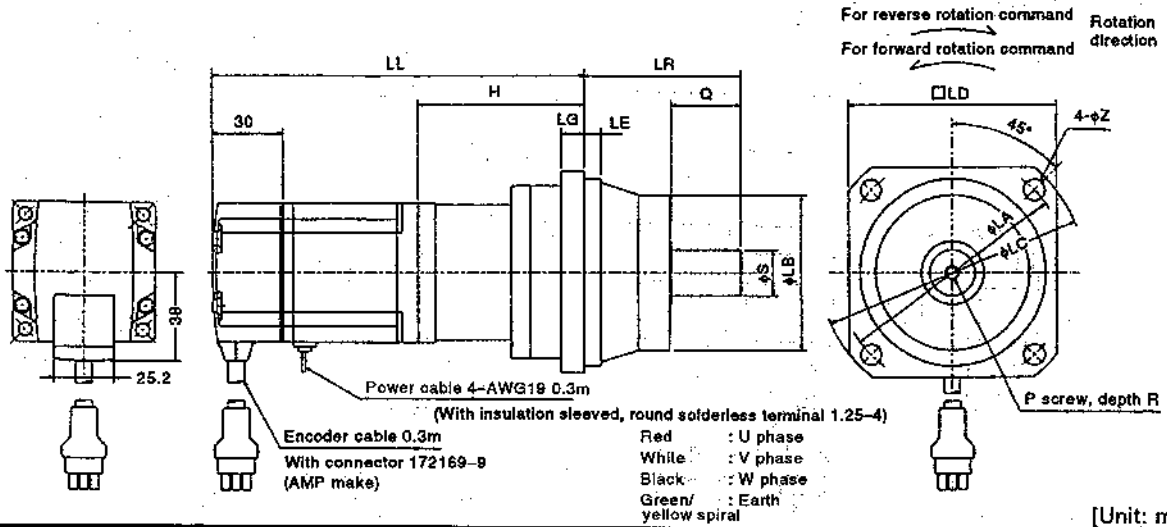
[Unit: mm]

Model	Reduction Ratio	Reduction Gear Model	Inertia J(x10 <sup>-4</sup> kg·m <sup>2</sup> ) (Note)	Variable Dimension (Note)											Weight [kg] (Note)	
				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	158.5 (184.5)	70	75	35	20h6	M5	10	3.0 (3.4)
HC-PQ13 (B)G2(-UE)	1/29	BK1-29B -01MEKA	0.098 (0.098)	100	80h7	115	85	10	158.5 (184.5)	70	75	35	20h6	M5	10	3.0 (3.4)

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

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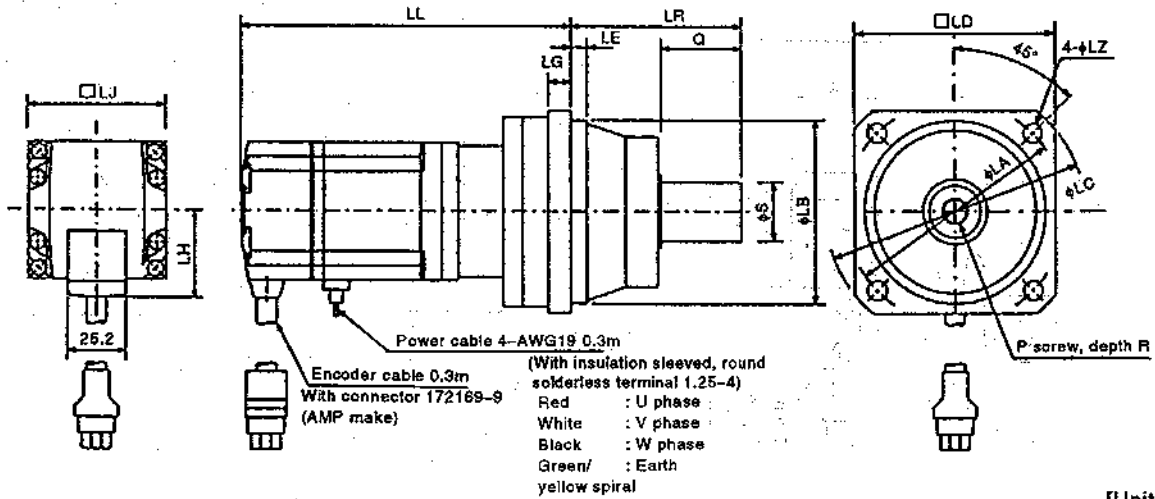
## HC-PQ23(B)G2



Model	Reduction Ratio	Reduction Gear Model	Inertia J (x10 <sup>-4</sup> kg·m <sup>2</sup> ) <small>(Note)</small>	<small>(Note)</small> Variable Dimension													Weight [kg] <small>(Note)</small>
				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



Model	Reduction Ratio	Reduction Gear Model	Inertia J (x10 <sup>-4</sup> kg·m <sup>2</sup> ) <small>(Note)</small>	<small>(Note)</small> Variable Dimension													Weight [kg] <small>(Note)</small>		
				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)

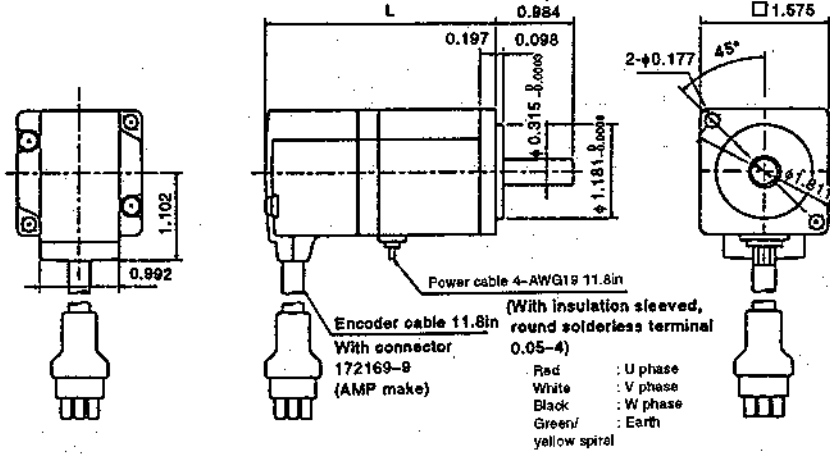
Note: Value in parentheses is for the servo motor with electromagnetic brake.

# 10. SPECIFICATIONS

## 10-3-3 Servo motors (in inches)

### (1) Standard

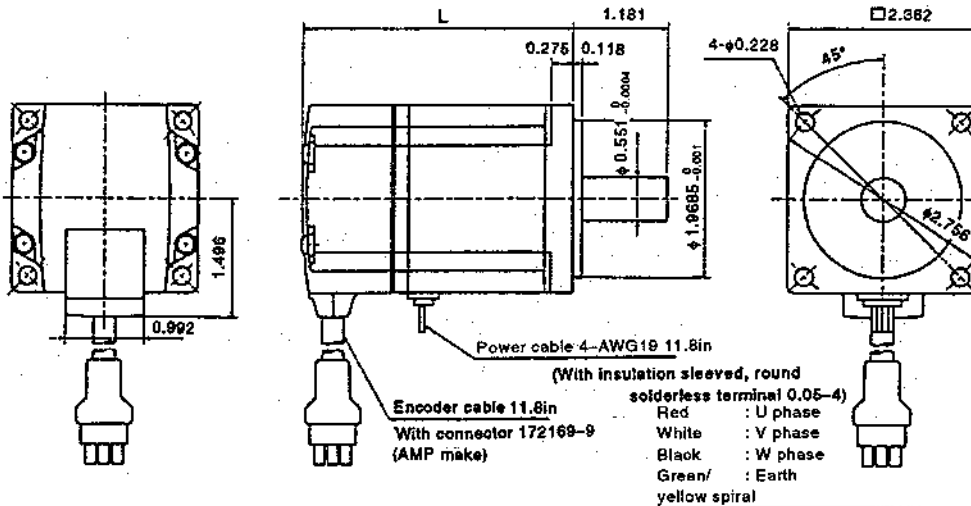
#### HC-PQ033 to HC-PQ13



[Unit: in]

Model	Variable Dimension L	Inertia $wk^2$ [oz·in <sup>2</sup> ]	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

#### HC-PQ23 · HC-PQ43



[Unit: in]

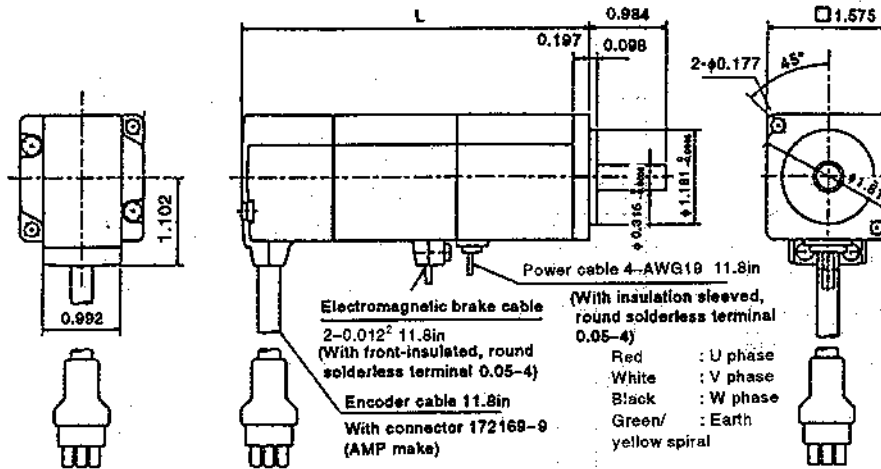
Model	Variable Dimension L	Inertia $wk^2$ [oz·in <sup>2</sup> ]	Weight [lb]
HC-PQ23	3.504	0.478	2.12
HC-PQ43	4.448	0.779	3.2
HC-PQ23-UE	3.858	0.478	2.18
HC-PQ43-UE	4.843	0.779	3.36



# 10. SPECIFICATIONS

(2) With electromagnetic brake

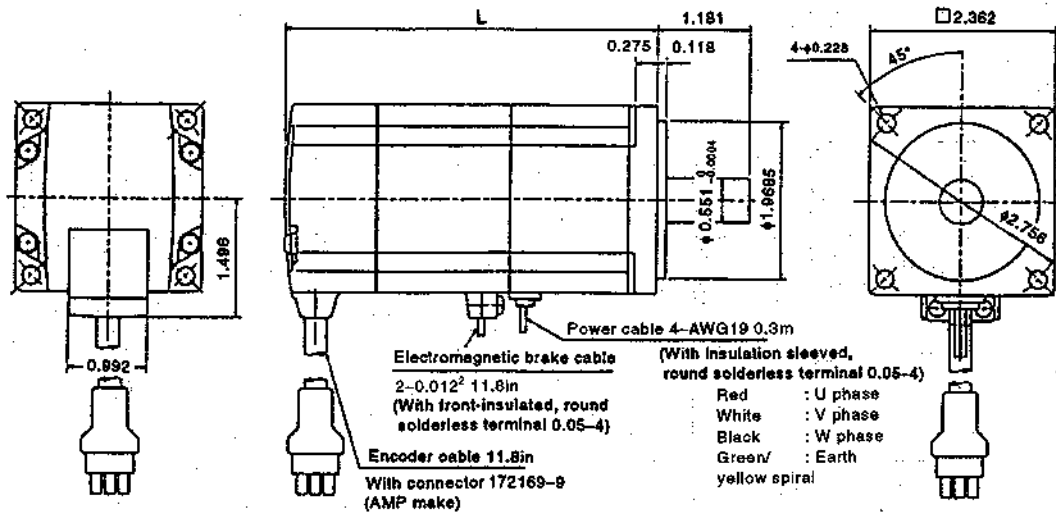
## HC-PQ033B to HC-PQ13B



[Unit: in]

Model	Variable Dimension L	Brake Static Friction Torque[oz.in]	Inertia wk <sup>2</sup> [oz.in <sup>2</sup> ]	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



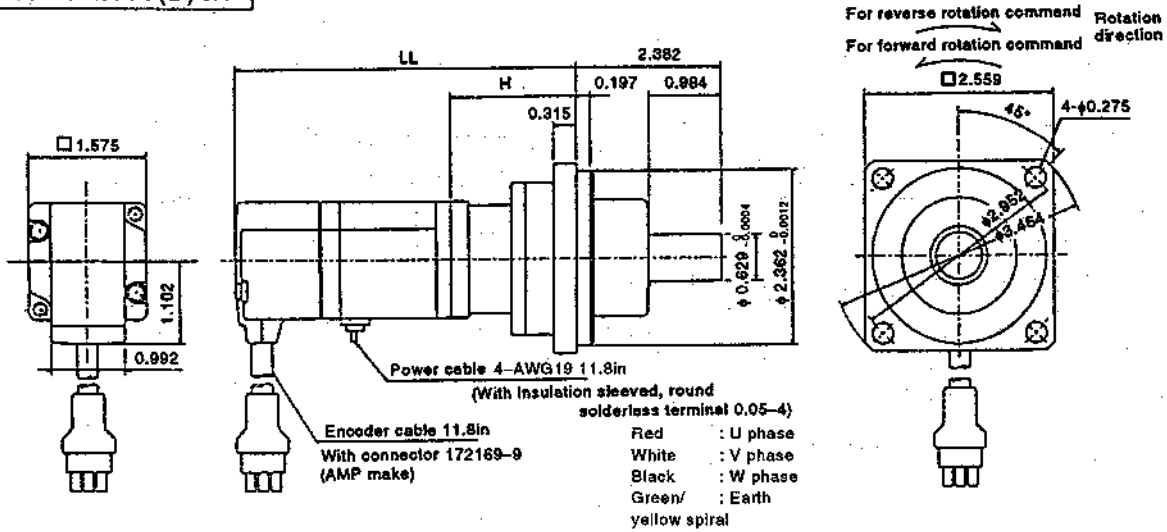
[Unit: in]

Model	Variable Dimension L	Brake Static Friction Torque[oz.in]	Inertia wk <sup>2</sup> [oz.in <sup>2</sup> ]	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



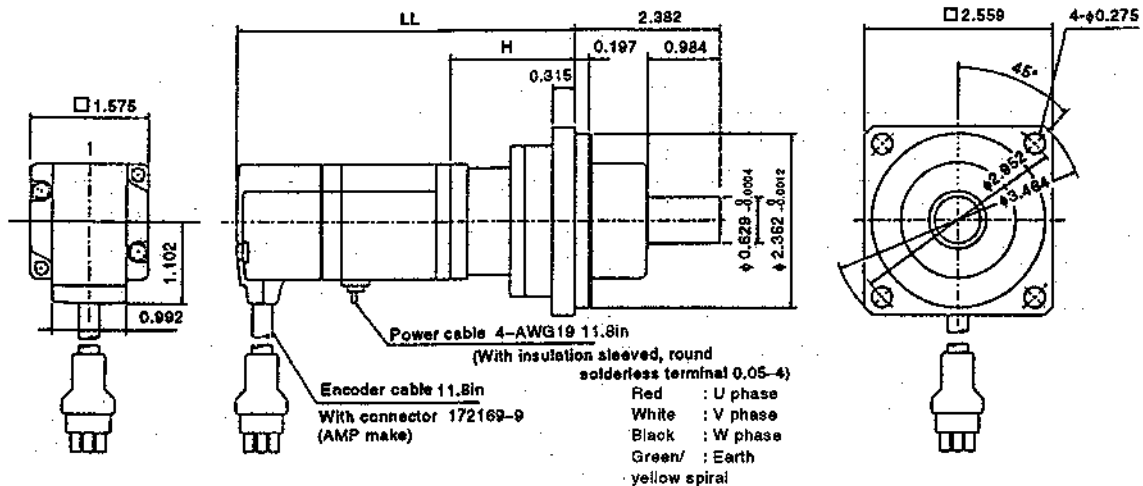
[Unit: in]

Model	Reduction Ratio <sup>(Note 2)</sup>	Reduction Gear Model	Inertia wk <sup>2</sup> [oz-in <sup>2</sup> ] <sup>(Note 1)</sup>	Variable Dimension <sup>(Note 1)</sup>		Weight [lb] <sup>(Note 1)</sup>
				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



[Unit: in]

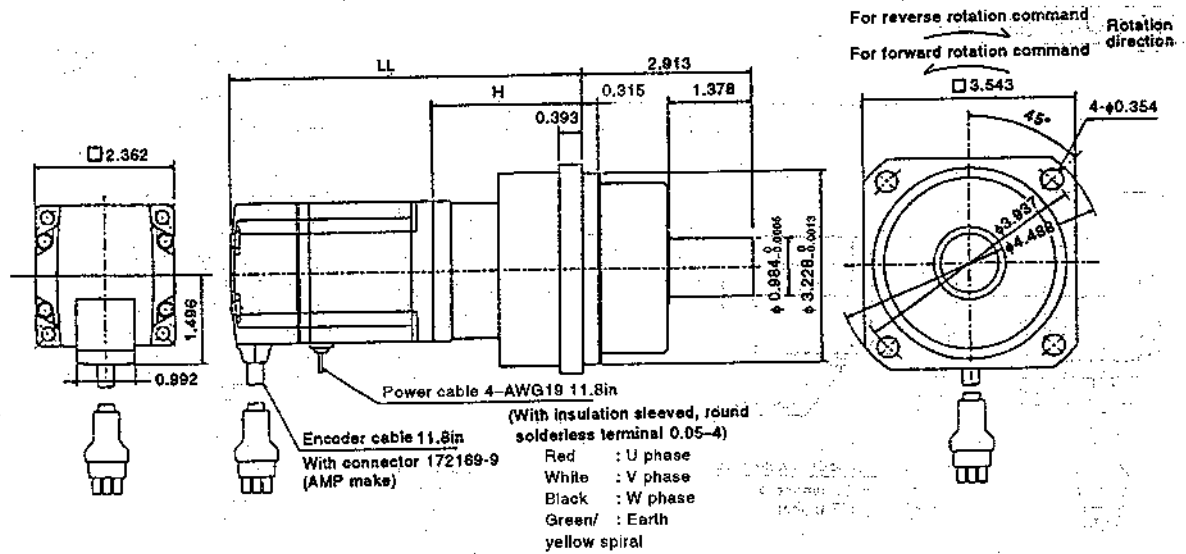
Model	Reduction Ratio <sup>(Note 2)</sup>	Reduction Gear Model	Inertia wk <sup>2</sup> [oz-in <sup>2</sup> ] <sup>(Note 1)</sup>	Variable Dimension <sup>(Note 1)</sup>		Weight [lb] <sup>(Note 1)</sup>
				LL	H	
HC-PQ13 (B)G1(-UE)	1/5	K6505	0.361 (0.379)	5.1378 (6.24)	1.87	3.3 (4.2)
HC-PQ13 (B)G1(-UE)	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.

# 10. SPECIFICATIONS

## HC-PQ23(B)G1



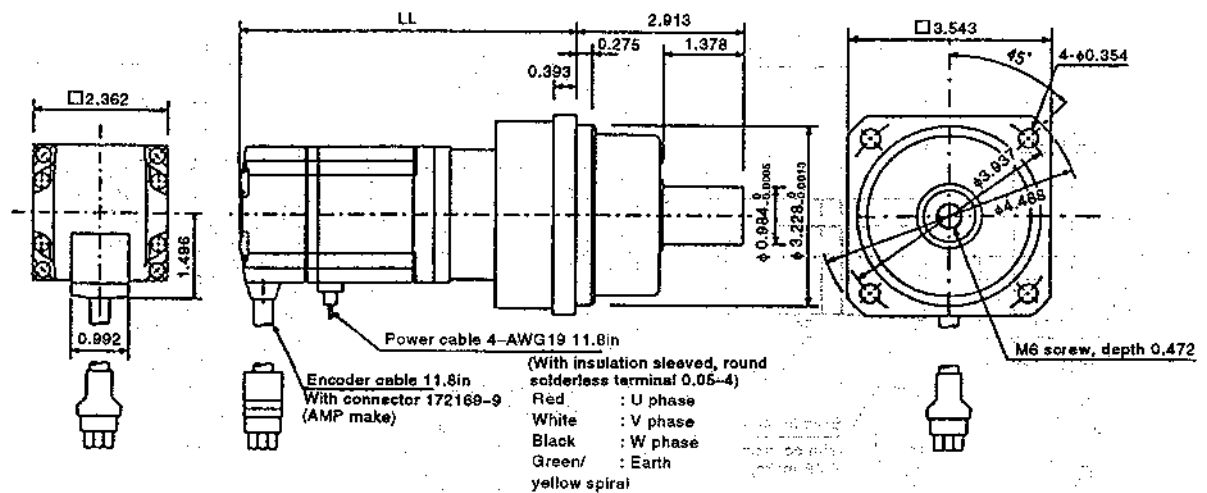
[Unit: in]

Model	Reduction Ratio (Note 2)	Reduction Gear Model	Inertia wk <sup>2</sup> [oz·in <sup>2</sup> ] (Note 1)	Variable Dimension (Note 1)		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



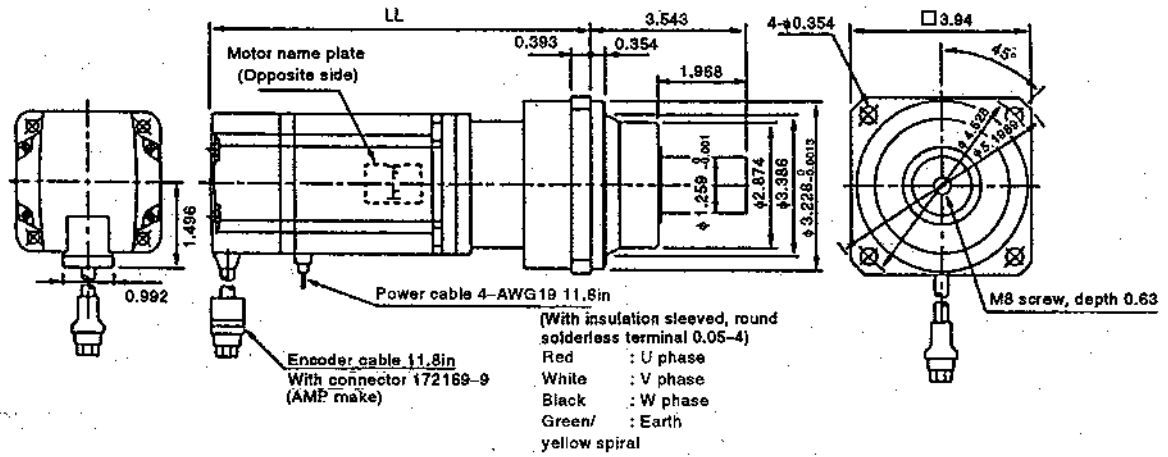
[Unit: in]

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

# 10. SPECIFICATIONS



[Unit: in]

Model	Reduction Ratio (Note 2)	Reduction Gear Model	Inertia $wk^2$ [oz·in <sup>2</sup> ] (Note 1)	(Note 1) Variable Dimension	Weight [lb] (Note 1)
				LL	
HC-PQ43 (B)G1(-UE)	1/20	K10020	3.56 (3.83)	7.52 (8.78)	12.1 (13.4)

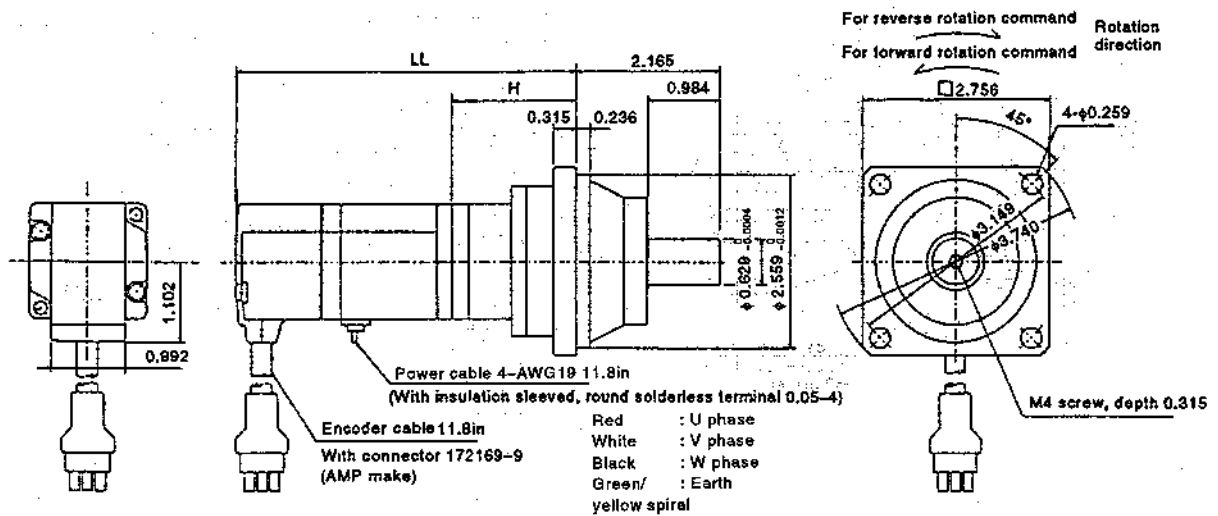
Note: 1. Value in parentheses is for the servo motor with electromagnetic brake.

2. These are nominal reduction ratios. For actual reduction ratios, refer to Section 10-4.

# 10. SPECIFICATIONS

## (4) With reduction gear for precision operation

### HC-PQ053(B)G2

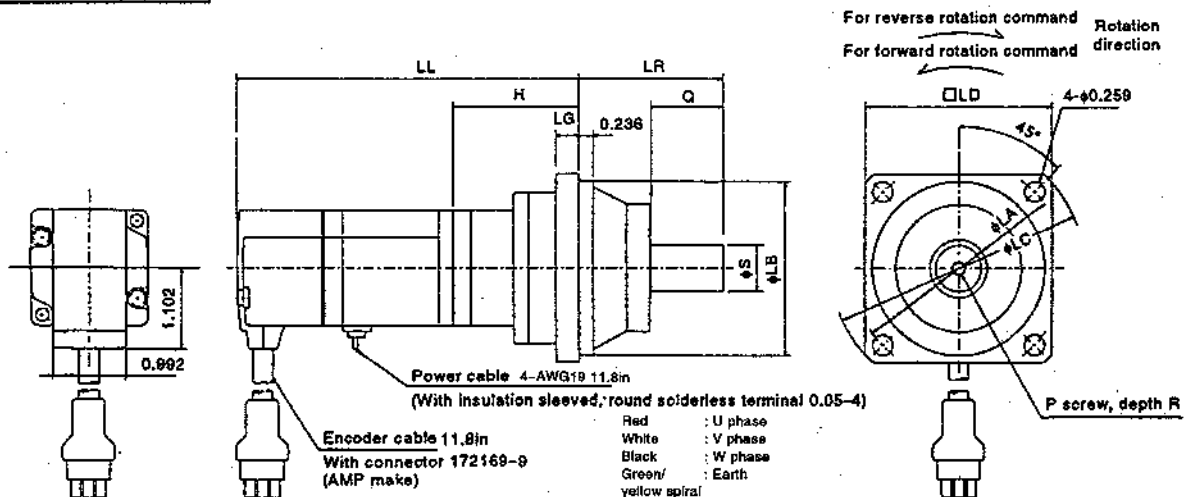


[Unit: in]

Model	Reduction Ratio	Reduction Gear Model	Inertia $wk^2$ [oz·in <sup>2</sup> ]	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



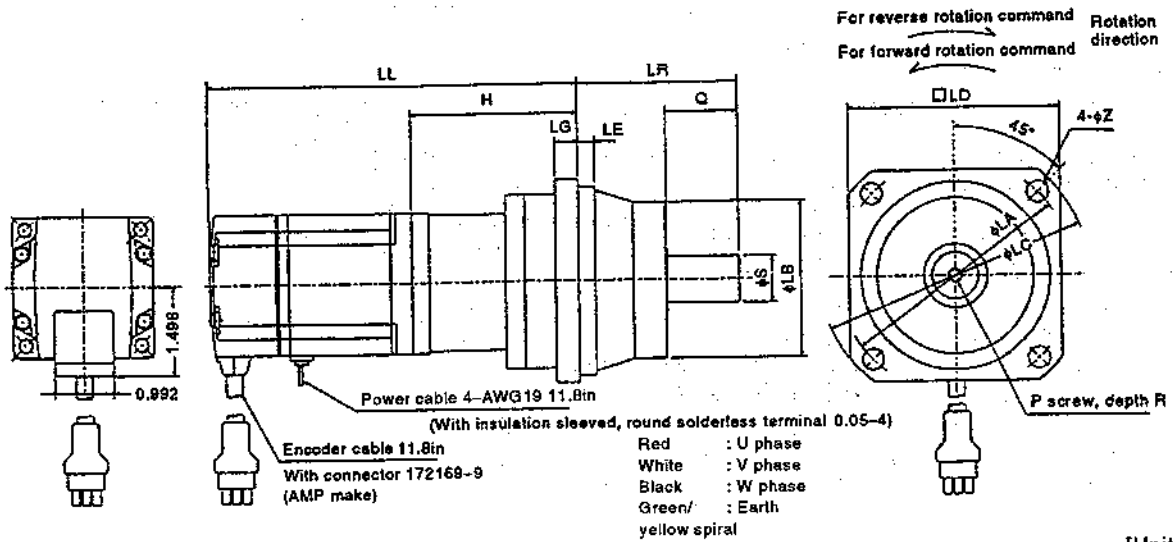
[Unit: in]

Model	Reduction Ratio	Reduction Gear Model	Inertia $wk^2$ [oz·in <sup>2</sup> ]	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 <sub>-0.0012</sub>	3.74	2.756	0.315	5.295 (6.398)	1.89	2.165	0.984	0.63 <sub>-0.0004</sub>	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 <sub>-0.0012</sub>	3.74	2.756	0.315	5.925 (7.028)	2.52	2.165	0.984	0.63 <sub>-0.0004</sub>	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 <sub>-0.0014</sub>	4.528	3.346	0.394	6.161 (7.264)	2.756	2.953	1.378	0.787 <sub>-0.0005</sub>	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 <sub>-0.0014</sub>	4.528	3.346	0.394	6.161 (7.264)	2.756	2.953	1.378	0.787 <sub>-0.0005</sub>	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

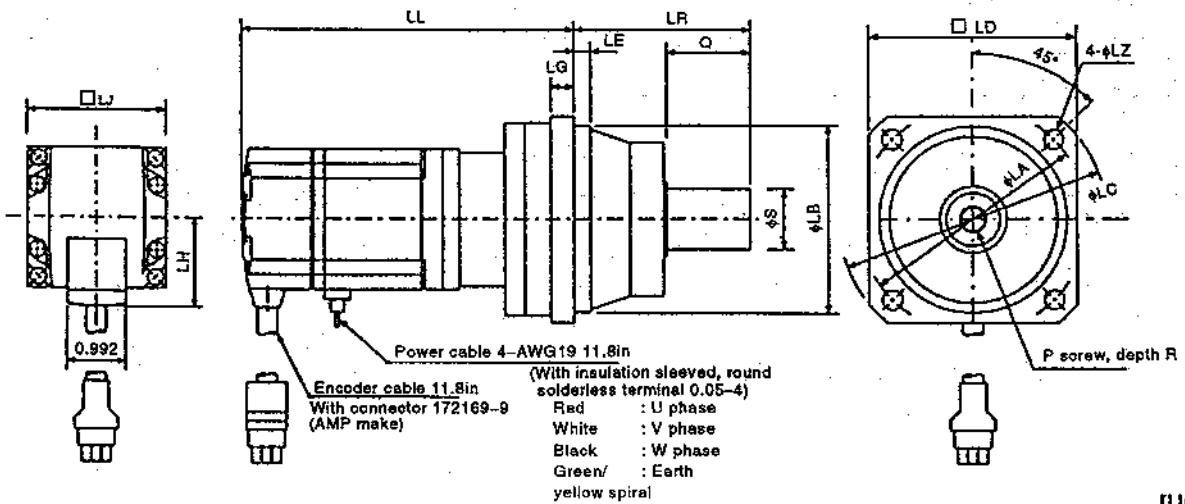


[Unit: in]

Model	Reduction Ratio	Reduction Gear Model	Inertia $wk^2$ [oz·in <sup>2</sup> ]	Variable Dimension													Weight [lb]
				LA	LB	LC	LD	LE	LG	LL	H	LR	Q	S	P	R	
HC-PQ23 (B)G2(-UE)	1/5	BK1-05B -A5MEKA	1.043 (1.307)	3.15	2.559 <sub>±0.0012</sub>	3.74	2.756	0.236	0.315	5.748 (7.008)	2.244	2.165	0.984	0.63 <sub>±0.0004</sub>	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 <sub>±0.0014</sub>	4.528	3.346	0.236	0.394	6.457 (7.717)	2.953	2.953	1.378	0.787 <sub>±0.0005</sub>	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 <sub>±0.0014</sub>	5.315	3.937	0.315	0.394	6.654 (7.913)	3.15	3.346	1.575	0.984 <sub>±0.0005</sub>	M6	0.472	11 (12.3)
HC-PQ23 (B)G2(-UE)	1/29	BK3-29B -A5MEKA	1.509 (1.773)	4.528	3.74 <sub>±0.0014</sub>	5.315	3.937	0.315	0.394	6.654 (7.813)	3.15	3.346	1.575	0.984 <sub>±0.0005</sub>	M6	0.472	11 (12.3)

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

## HC-PQ43(B)G2



[Unit: in]

Model	Reduction Ratio	Reduction Gear Model	Inertia $wk^2$ [oz·in <sup>2</sup> ]	Variable Dimension													Weight [lb]		
				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	1.61 (1.88)	3.937	3.15 <sub>±0.0014</sub>	4.528	3.346	0.236	0.394	1.496	2.362	6.85 (8.11)	2.953	0.26	1.38	0.79 <sub>±0.0005</sub>	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 <sub>±0.0014</sub>	5.315	3.937	0.315	0.394	1.496	2.362	7.677 (8.937)	3.346	0.35	1.57	0.98 <sub>±0.0006</sub>	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 <sub>±0.0014</sub>	6.10	4.528	0.315	0.472	1.496	2.362	7.913 (9.173)	3.937	0.43	1.97	1.26 <sub>±0.0006</sub>	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 <sub>±0.0014</sub>	6.10	4.528	0.315	0.472	1.496	2.362	7.913 (9.173)	3.937	0.43	1.97	1.26 <sub>±0.0006</sub>	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			
	1/5	1/12	1/20	1/5	1/9	1/20	1/29
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 Research	
	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:

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

# 10. SPECIFICATIONS

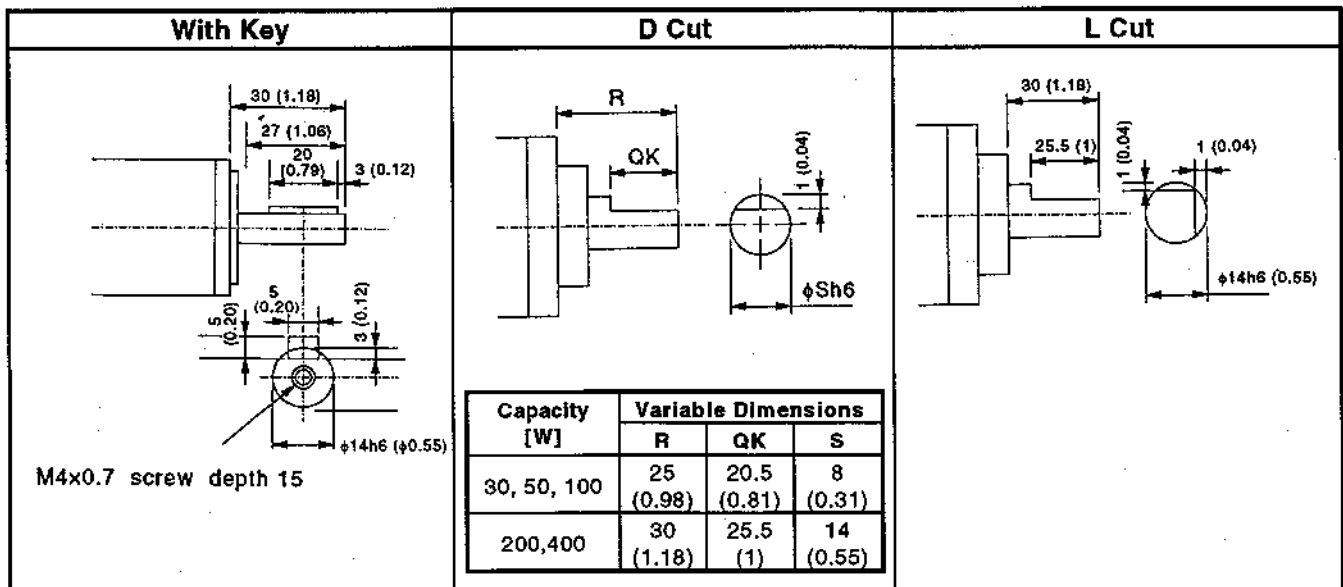
## 10 – 5 Servo Motor with Special Shaft

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

Machining Dimension Diagram

[Unit: mm (in)]





# CHAPTER 11

## SELECTION

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

- 11 – 1 List of Specification Symbols
- 11 – 2 Position Resolution and Electronic Gear Setting
- 11 – 3 Servo Motor Speed and Command Pulse Frequency
- 11 – 4 Stopping Characteristics
- 11 – 5 Capacity selection method
- 11 – 6 Load Torque Equations
- 11 – 7 Load Inertia Equations
- 11 – 8 Zeroing Instructions
- 11 – 9 Selection Example

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

# 11. SELECTION

## 11 - 1 List of Specification Symbols

The following symbols are required for selecting the proper servo.

$T_a$ : Acceleration torque	[N·m]	$P_t$ : Number of feedback pulses in position control mode	[pulse/rev]
$T_b$ : Deceleration torque	[N·m]	$f$ : Input pulse frequency in position control mode	[pps]
$T_{Ma}$ : Motor torque necessary for acceleration	[N·m]	$f_o$ : Input pulse frequency during fast feed in position control mode	[pps]
$T_{Mb}$ : Motor torque necessary for deceleration	[N·m]	$T_{paa}$ : Acceleration time constant of frequency command in position control mode	[s]
$T_{LH}$ : Torque applied when the servo motor is stopping	[N·m]	$T_{pab}$ : Deceleration time constant of pulse frequency command in position control mode	[s]
$T_L$ : Load torque converted into equivalent value on servo motor shaft	[N·m]	$K_p$ : Position control gain 1 (Parameter No.6)	[rad/s]
$T_{LM}$ : Load torque converted into equivalent value on servo motor shaft during stopping	[N·m]	$T_p$ : Position control time constant ( $T_p = 1/K_p$ )	[s]
$T_u$ : Unbalance torque	[N·m]	$K_v$ : Speed control gain	[rad/s]
$T_f$ : Load friction torque	[N·m]	$T_v$ : Speed control time constant ( $T_v = 1/K_v$ )	[s]
$T_{Lo}$ : Load torque on load shaft	[N·m]	$\Delta$ : Movement amount per feedback pulse in position control mode	[mm/pulse]
$T_{rms}$ : Continuous effective load torque converted into equivalent value on servo motor shaft	[N·m]	$\Delta_o$ : Movement amount per command pulse in position control mode	[mm/pulse]
$J_L$ : Load inertia converted into equivalent value on servo motor shaft	[kg·cm <sup>2</sup> ]	$\Delta$ : Movement amount	[mm]
$J_{Lo}$ : Load inertia on load shaft	[kg·cm <sup>2</sup> ]	$P$ : Number of input command pulses in position control mode	[pulse]
$J_M$ : Servo motor's rotor inertia	[kg·cm <sup>2</sup> ]	$t_s$ : Stop setting time in position control mode	[s]
$N$ : Servo motor speed	[r/min]	$t_o$ : Positioning time	[s]
$N_o$ : Servo motor speed during fast feed	[r/min]	$t_c$ : Time of constant speed of servo motor in 1 cycle	[s]
$N_{Lo}$ : Load shaft speed during fast feed	[r/min]	$t$ : Stopping time in 1 cycle	[s]
$V$ : Motion part speed	[mm/min]	$\Delta\varepsilon$ : Positioning accuracy	[mm]
$V_o$ : Motion part speed during fast feed	[mm/min]	$\varepsilon$ : Number of droop pulses	[pulse]
$P_b$ : Ball screw lead	[mm]	$\Delta\theta$ : Load shaft rotation angle per pulse in position control mode	[degree/pulse]
$Z_1$ : Number of gear teeth on servo motor shaft		$e$ : Euler constant = 2.71878	
$Z_2$ : Number of gear teeth on load gear		$\Delta S$ : Movement amount per servo motor revolution	[mm/rev]
$n$ : Gear ratio $n = \frac{Z_2}{Z_1}$ Speed reduced when $n > 1$ , Speed increased when $n < 1$			
$\eta$ : Drive part efficiency			
$g$ : Acceleration of gravity (9.8 [m/s <sup>2</sup> ])			
$\mu$ : Friction coefficient			

# 11. SELECTION

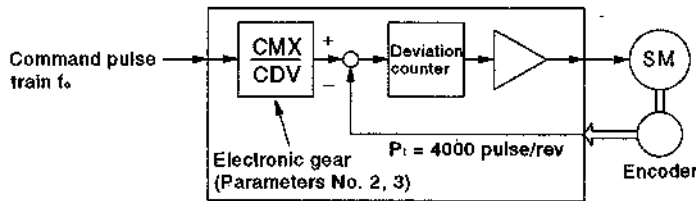
## 11-2 Position Resolution and Electronic Gear Setting

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

$$\Delta l = \frac{\Delta S}{P_t} \dots\dots\dots(11-1)$$

- $\Delta l$  : movement amount per pulse [mm]
- $\Delta S$  : movement amount per servo motor revolution [mm/rev]
- $P_t$  : number of feedback pulses [pulse/rev]

The value for  $\Delta l$  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  $\Delta l_o$  is expressed with the following equation.

$$\Delta l_o = \frac{\Delta S}{P_t} \cdot \frac{CMX}{CDV} = \Delta l \cdot \frac{CMX}{CDV} \dots\dots\dots(11-2)$$

- 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  $\Delta l_o = 0.01$  [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].

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

$$\begin{aligned} \frac{CMX}{CDV} &= \Delta l_o \cdot \frac{P_t}{\Delta S} \\ &= 0.01 \cdot \frac{4000}{10} = 4 \end{aligned}$$

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

# 11. SELECTION

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<Relation of position resolution  $\Delta l$  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.

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

Here:  $\Delta l$  : 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.)

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

- 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

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

- input pulse train frequency

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

[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)

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

$$= 266667[\text{pps}]$$

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

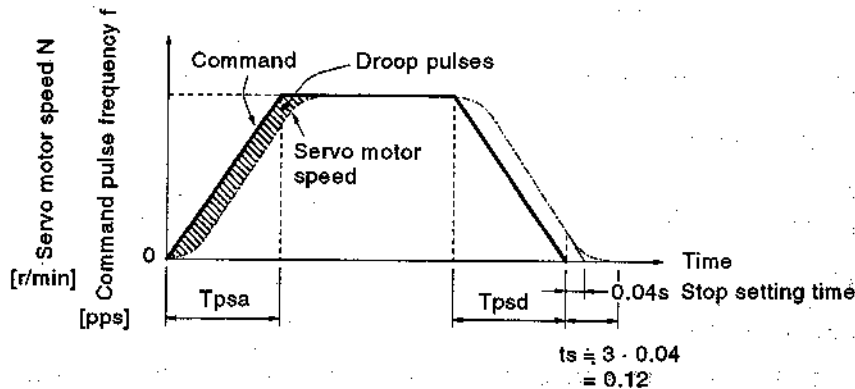
### (1) Droop pulses ( $\epsilon$ )

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 ( $\epsilon$ ).

$$\epsilon = \frac{f_0}{K_p} \text{ [pulse]} \dots\dots\dots(11-7)$$

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).

$$\epsilon = \frac{200 \times 10^3}{25} = 8000 \text{ [pulse]}$$



### (2) Stop setting time ( $t_s$ ) during linear acceleration/deceleration

The servo amplifier during operation has droop pulses, so a stop setting time ( $t_s$ ) 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  $t_s$  value will be obtained in the following equation:

$$t_s \approx 3 \cdot T_p = 3 \cdot \frac{1}{K_p} \text{ [s]} \dots\dots\dots(11-8)$$

\*When  $K_p = 25$  [rad/s] is used,  $t_s \approx 0.12$  [s]. (Refer to above diagram.)

Note: The stop setting time ( $t_s$ ) 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 ( $\Delta$ ). The  $t_s$  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

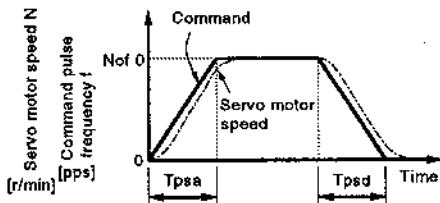
When the load torque ( $T_L$ ) and load inertia ( $J_L$ ) have been calculated, select a servo motor using servo motor rated torque  $> T_L$ , servo motor  $J_M > J_L/3$  as a guideline.

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.

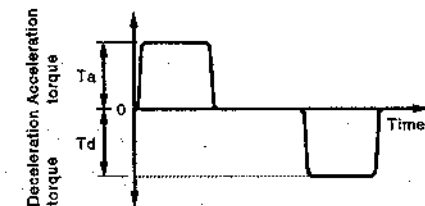
### (2) Acceleration/deceleration torque

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



• Acceleration torque

$$T_a = \frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4} \cdot \frac{1}{T_{psa}} \dots (11-9)$$

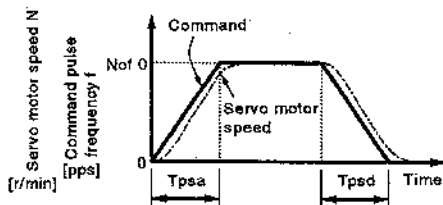


• Deceleration torque

$$T_b = \frac{(J_L + J_M) \cdot N_o}{9.55 \times 10^4} \cdot \frac{1}{T_{psd}} \dots (11-10)$$

### (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.

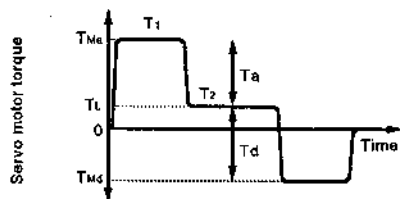


$$T_1 = T_{Me} = T_a + T_L \dots (11-11)$$

$$T_2 = T_L \dots (11-12)$$

$$T_3 = T_{Md} = -T_d + T_L \dots (11-13)$$

Note: The regenerative status will be indicated if the value obtained in the equation (11-13) is a negative value.

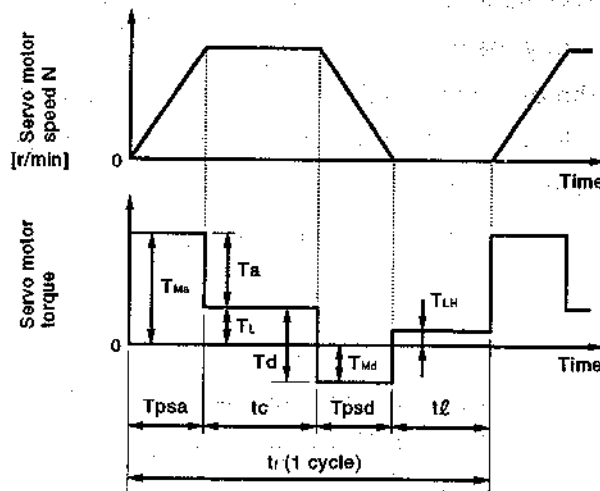


## 11. SELECTION

### (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  $T_{psa}$  and  $T_{psd}$ . The equation for the continuous effective load torque for the following operation pattern is given below.



$$T_{rms} = \sqrt{\frac{T_{Ma}^2 \cdot T_{psa} + T_L^2 \cdot t_c + T_{Md}^2 \cdot T_{psd} + T_{LH}^2 \cdot t_l}{t_l}} \quad \text{..... (11-14)}$$

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

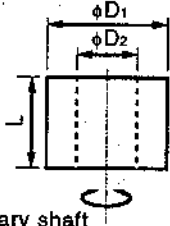
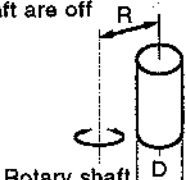
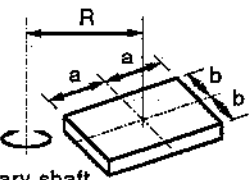
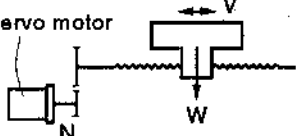
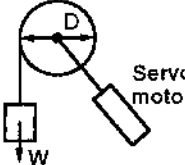
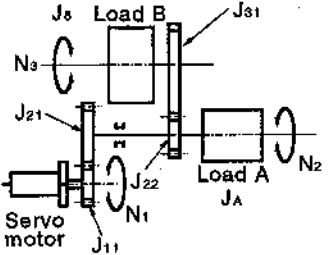
Type	Mechanism	Equation
Linear movement		$T_L = \frac{F}{2 \times 10^3 \cdot \pi \cdot \eta} \cdot \frac{V}{N} = \frac{F \cdot \Delta S}{2 \times 10^3 \cdot \pi \cdot \eta} \dots \dots \dots (11-15)$ <p>F : Shaft direction force of the machine in linear motion [N]            F in Equation (11-15) is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

# 11. SELECTION

## 11 - 7 Load Inertia Equations

The main load inertia equations are shown below.

### Load Inertia Equations

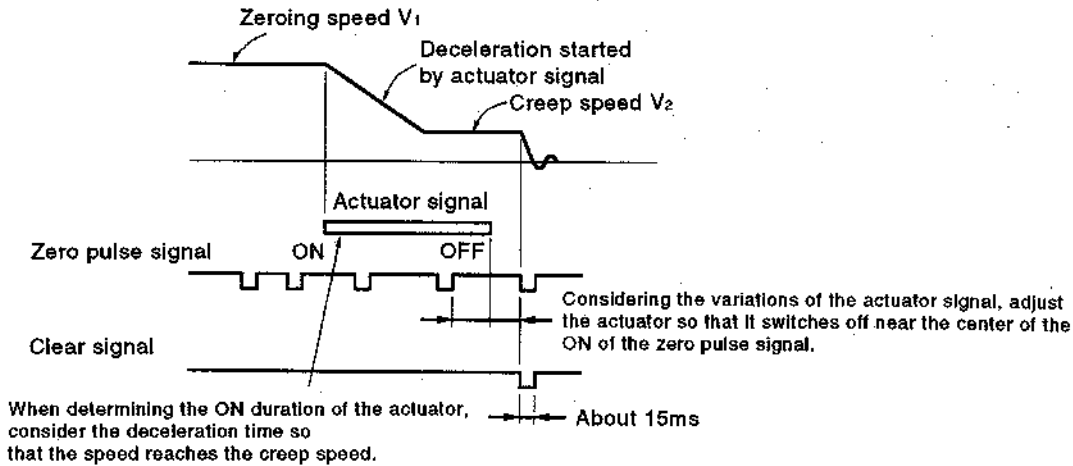
Type	Mechanism	Equation									
Cylinder	Rotary shaft is at cylinder center 	$J_{Lo} = \frac{\pi \cdot \rho \cdot L}{32} \cdot (D_1^4 - D_2^4) = \frac{W}{8} \cdot (D_1^2 + D_2^2) \dots\dots\dots (11-22)$ <p> <math>\rho</math> : Cylinder material density [kg-cm<sup>3</sup>]  <math>L</math> : Cylinder length [cm]  <math>D_1</math> : Cylinder outer diameter [cm]  <math>D_2</math> : Cylinder inner diameter [cm]  <math>W</math> : Cylinder weight [kg]           </p> <p>Reference data material density :</p> <table style="margin-left: 200px;"> <tr> <td>Steel</td> <td>: 7.8 × 10<sup>-3</sup></td> <td>[kg/cm<sup>3</sup>]</td> </tr> <tr> <td>Aluminum</td> <td>: 2.7 × 10<sup>-3</sup></td> <td>[kg/cm<sup>3</sup>]</td> </tr> <tr> <td>Copper</td> <td>: 8.96 × 10<sup>-3</sup></td> <td>[kg/cm<sup>3</sup>]</td> </tr> </table>	Steel	: 7.8 × 10 <sup>-3</sup>	[kg/cm <sup>3</sup> ]	Aluminum	: 2.7 × 10 <sup>-3</sup>	[kg/cm <sup>3</sup> ]	Copper	: 8.96 × 10 <sup>-3</sup>	[kg/cm <sup>3</sup> ]
	Steel	: 7.8 × 10 <sup>-3</sup>	[kg/cm <sup>3</sup> ]								
Aluminum	: 2.7 × 10 <sup>-3</sup>	[kg/cm <sup>3</sup> ]									
Copper	: 8.96 × 10 <sup>-3</sup>	[kg/cm <sup>3</sup> ]									
	When rotary shaft and cylinder shaft are off 	$J_{Lo} = \frac{W}{8} (D^2 + 8R^2) \dots\dots\dots (11-23)$									
Square block		$J_{Lo} = W \cdot \left( \frac{a^2 + b^2}{3} + R^2 \right) \dots\dots\dots (11-24)$ <p> <math>W</math> : Square block weight [kg]  <math>a, b, R</math> : Left diagram [cm]           </p>									
Object which moves linearly		$J_L = W \cdot \frac{V}{600\omega} = W \cdot \left( \frac{1}{2 \cdot \pi \cdot N} \cdot \frac{V}{10} \right)^2 = W \cdot \left( \frac{\Delta S}{20 \cdot \pi} \right)^2 \dots\dots\dots (11-25)$ <p> <math>V</math> : Speed of object moving linearly [mm/min]  <math>\Delta S</math> : Movement amount of object moving linearly per servo motor revolution [mm/rev]  <math>W</math> : Object weight [kg]           </p>									
Object that is hung with pulley		$J_L = W \cdot \left( \frac{D}{2} \right)^2 + J_p \dots\dots\dots (11-26)$ <p> <math>J_p</math> : Pulley inertia [kg-cm<sup>2</sup>]  <math>D</math> : Pulley diameter [cm]  <math>W</math> : Object weight [kg]           </p>									
Converted load		$J_L = J_{11} + (J_{21} + J_{22} + J_A) \cdot \left( \frac{N_2}{N_1} \right)^2 + (J_{31} + J_B) \cdot \left( \frac{N_3}{N_1} \right)^2 \dots\dots\dots (11-27)$ <p> <math>J_A, J_B</math> : Load A, B inertia [kg-cm<sup>2</sup>]  <math>J_{11}</math> to <math>J_{31}</math> : Inertia [kg-cm<sup>2</sup>]  <math>N_1</math> to <math>N_3</math> : Speed of each shaft [r/min]           </p>									

# 11. SELECTION

## 11-8 Zeroing Instructions

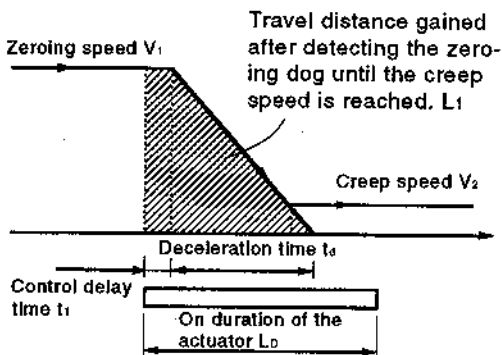
To return the system to the home position with the MELSERVO-C, use a zeroing dog or actuator. The method and precautions for setting the mechanical origin are given below. In the following zeroing, an actuator and the zero pulse signal (encoder Z-phase pulse OP) of a servo motor encoder are used to set 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  $L_1$  obtained by formula (11-28) as in Formula (11-29).

$$L_1 = \frac{1}{60} \cdot V_1 \cdot t_1 + \frac{1}{120} \cdot V_1 \cdot t_d \cdot \left\{ 1 - \left( \frac{V_2}{V_1} \right)^2 \right\} + \frac{1}{60} \cdot V_1 \cdot T_p \dots\dots\dots (11-28)$$

$$L_D > L_1 \dots\dots\dots (11-29)$$

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

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(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.

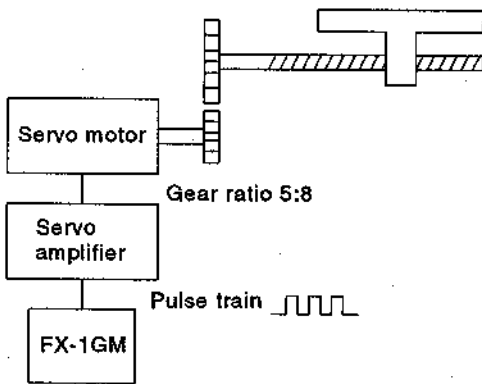
(3) Set the creep speed so that the machine is not shocked when the operation comes to a stop.

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



Speed of moving part during fast feed $V_o$	= 30000[mm/min]
Movement amount per pulse $\Delta l$	= 0.005[mm]
Movement amount $l$	= 400[mm]
Positioning time $t_o$	= 1[s] or less
Number of feeds (Operation cycle $t_f$ )	40[times/min.]
Gear ratio $n$	= 8/5
Moving part weight $W$	= 60[kg]
Drive system efficiency $\eta$	= 0.8
Friction coefficient $\mu$	= 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  $\Delta l$ .

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

When the machining specification is substituted for the above equation:

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

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

#### 2) Input pulse train frequency for fast feed $f_o$

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

OK if  $f_o$  is 200kpps or less.

### (2) Servo motor speed

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

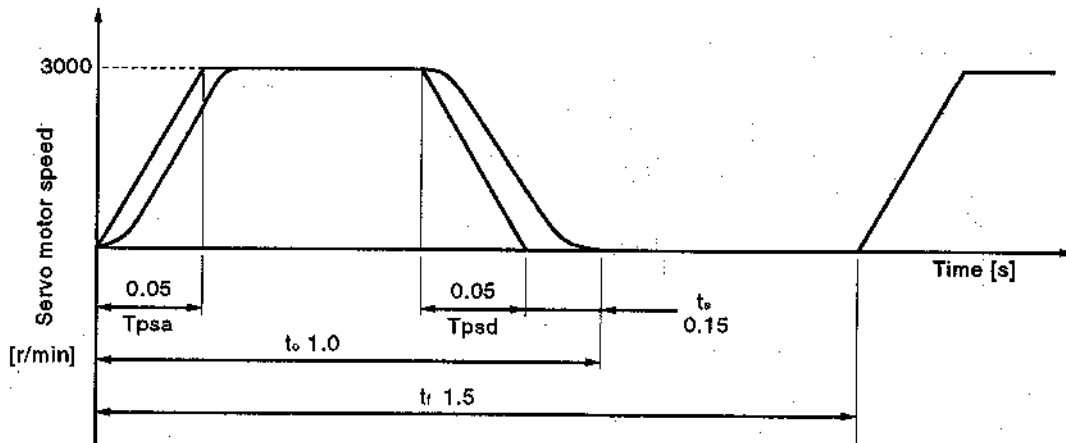
### (3) Acceleration/deceleration time constant

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

\* $t_s$ : 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

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

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

For gravitational system of units

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

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

Moving part

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

Ball screw

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

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

Gear (servo motor shaft)

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

Gear (load shaft)

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

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

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

For gravitational system of units

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

## (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

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

For gravitational system of units

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

Torque required for servo motor during deceleration

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

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

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

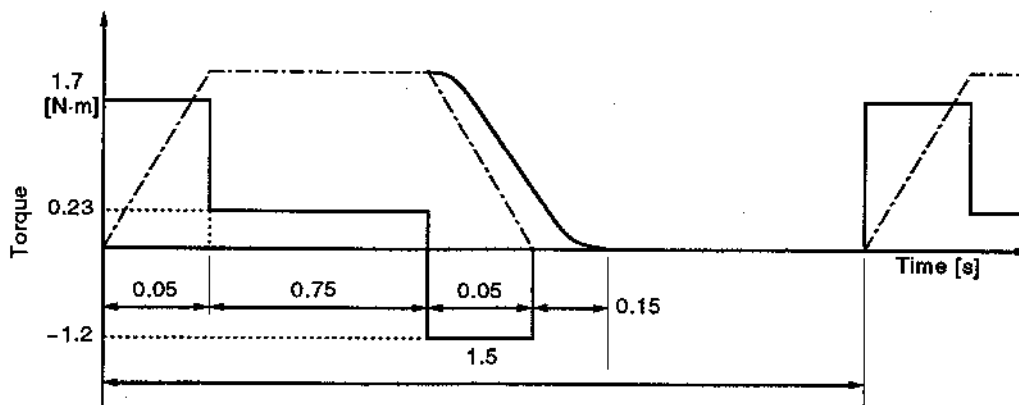
$$T_{rms} = \sqrt{\frac{T_{Ma}^2 \cdot T_{psa} + T_L^2 \cdot t_c + T_{Md}^2 \cdot T_{psd}}{t_f}} = 0.41 \text{ [N}\cdot\text{m]}$$

For gravitational system of units

$$4.2 \text{ [kgf}\cdot\text{cm]}$$

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 .....  $N_o = 3000 \text{ r/min}$
- Input pulse train frequency .....  $f_o = 100 \text{ kpps}$

### 3) Acceleration/deceleration time constant

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

# CHAPTER 12

## OPTIONAL PRODUCTS

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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.

### 12 – 1 Servo Motors with Special Flanges

- 12 – 1 – 1 Model definition
- 12 – 1 – 2 NEMA flange type
- 12 – 1 – 3 NEMA flange type (in inches)
- 12 – 1 – 4 Stepping motor intercompatibility series
- 12 – 1 – 5 Stepping motor intercompatibility series (in inches)

### 12 – 2 5V Pulse Train Input Servo Amplifiers

- 12 – 2 – 1 Model definition
- 12 – 2 – 2 Signal connectors
- 12 – 2 – 3 Interfaces
- 12 – 2 – 4 Common Line

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

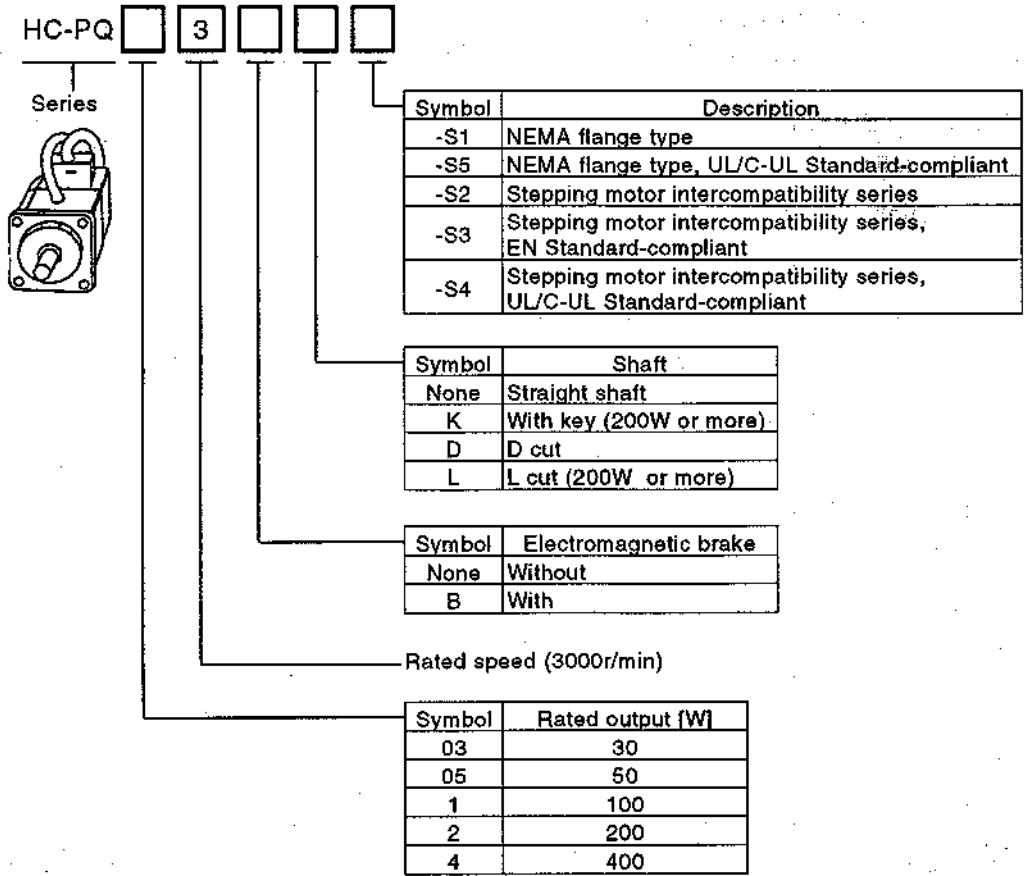


## 12. OPTIONAL PRODUCTS

### 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

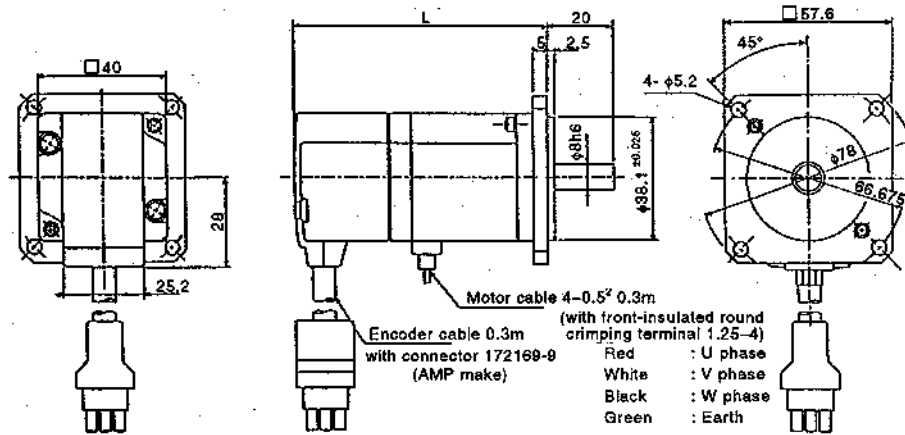


## 12. OPTIONAL PRODUCTS

### 12-1-2 NEMA flange type

#### (1) Standard

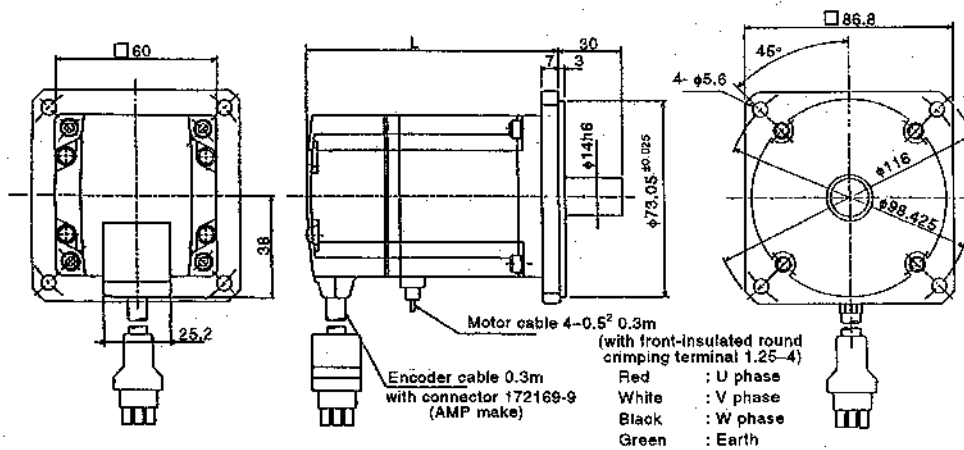
HC-PQ033-S1/-S5 to HC-PQ13-S1/-S5



[Unit: mm]

Model	Variable Dimension L	Inertia Moment GD <sup>2</sup> [kgf·cm <sup>2</sup> ]	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



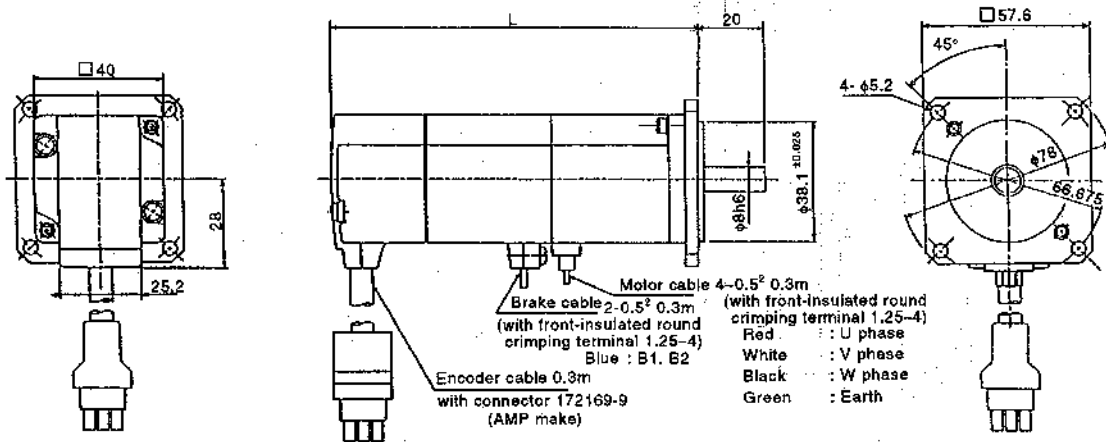
[Unit: mm]

Model	Variable Dimension L	Inertia Moment GD <sup>2</sup> [kgf·cm <sup>2</sup> ]	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

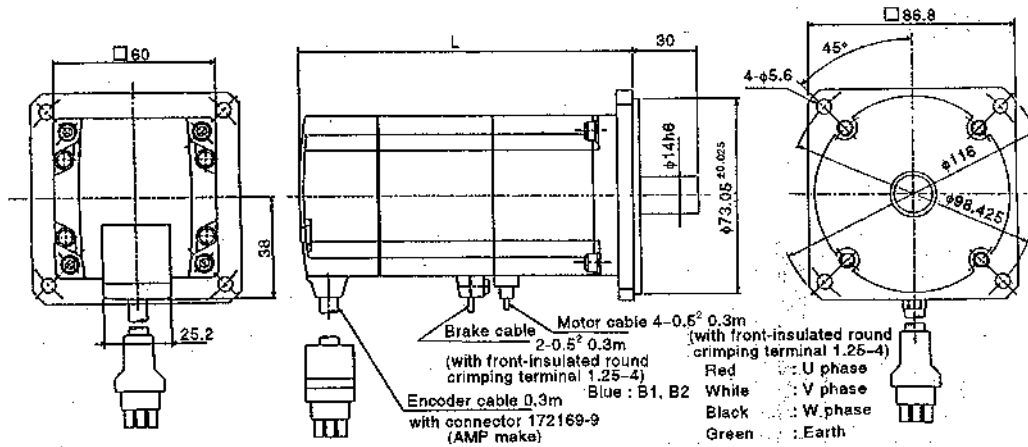
#### HC-PQ033B-S1/-S5 to HC-PQ13B-S1/-S5



[Unit: mm]

Model	Variable Dimension L	Brake Static Friction Torque [N·m]	Inertia Moment GD <sup>2</sup> [kgf·cm <sup>2</sup> ]	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	118.5	0.32	0.129	0.88

#### HC-PQ23B-S1/-S5 · HC-PQ43B-S1/-S5



[Unit: mm]

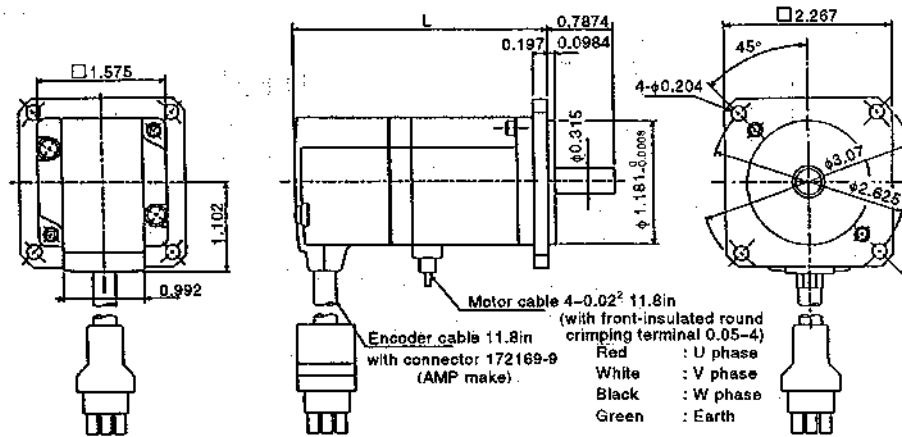
Model	Variable Dimension L	Brake Static Friction Torque [N·m]	Inertia Moment GD <sup>2</sup> [kgf·cm <sup>2</sup> ]	Weight [kg]
HC-PQ23B-S1/-S5	126	1.3	0.576	1.75
HC-PQ43B-S1/-S5	151	1.3	0.576	2.2

## 12. OPTIONAL PRODUCTS

### 12 - 1 - 3 NEMA flange type (in inches)

#### (1) Standard

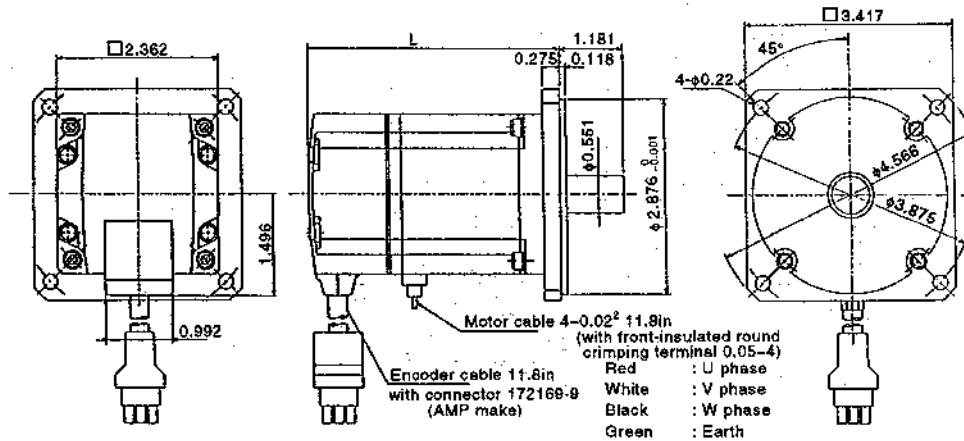
HC-PQ033-S1/-S5 to HC-PQ13-S1/-S5



[Unit: in]

Model	Variable Dimension L	Inertia Moment $GD^2$ (oz·in <sup>2</sup> )	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



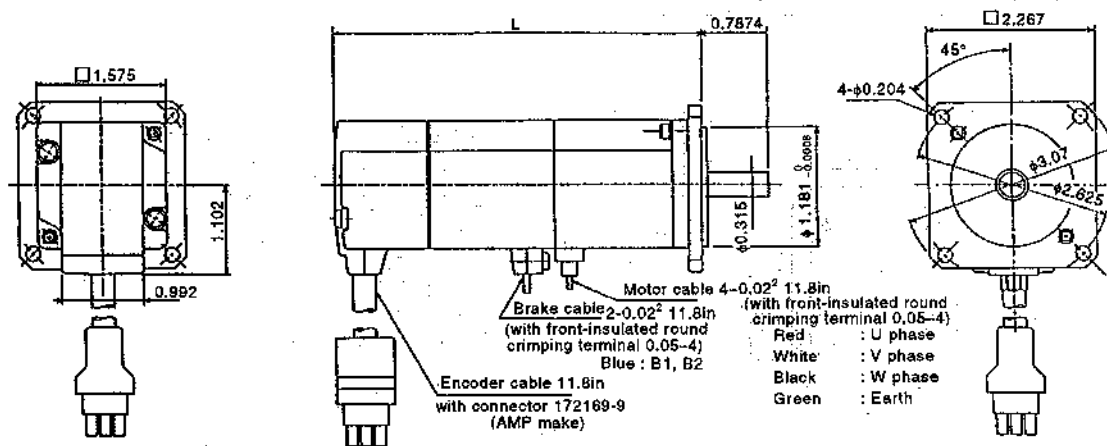
[Unit: in]

Model	Variable Dimension L	Inertia Moment $GD^2$ (oz·in <sup>2</sup> )	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

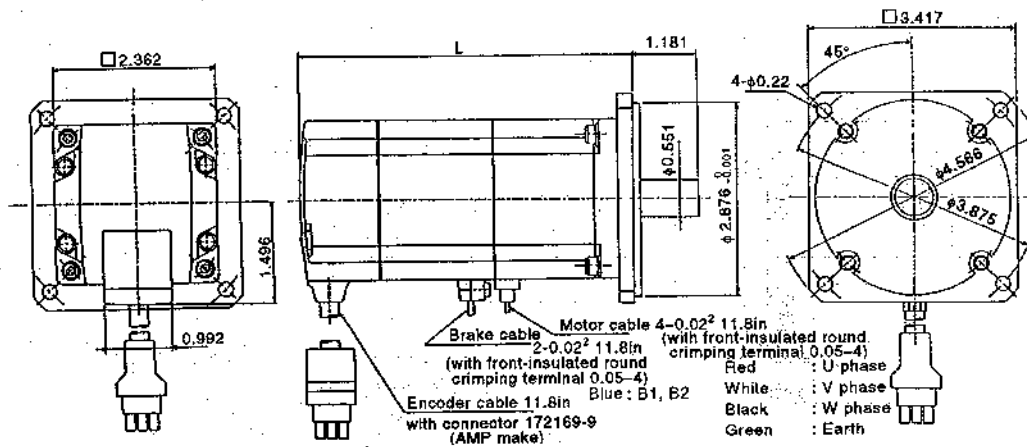
HC-PQ033B-S1/-S5 to HC-PQ13B-S1/-S5



[Unit: in]

Model	Variable Dimension L	Brake Static Friction Torque [oz·In]	Inertia Moment GD <sup>2</sup> [oz·In <sup>2</sup> ]	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	0.178	1.9

HC-PQ23B-S1/-S5 · HC-PQ43B-S1/-S5



[Unit: in]

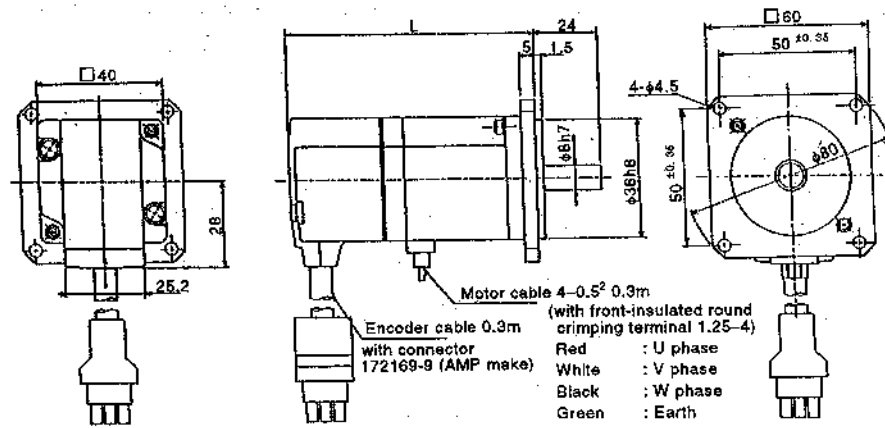
Model	Variable Dimension L	Brake Static Friction Torque [oz·In]	Inertia Moment GD <sup>2</sup> [oz·In <sup>2</sup> ]	Weight [lb]
HC-PQ23B-S1/-S5	4.961	184	0.790	3.88
HC-PQ43B-S1/-S5	5.945	184	0.790	4.85

# 12. OPTIONAL PRODUCTS

## 12-1-4 Stepping motor intercompatibility series

### (1) Standard

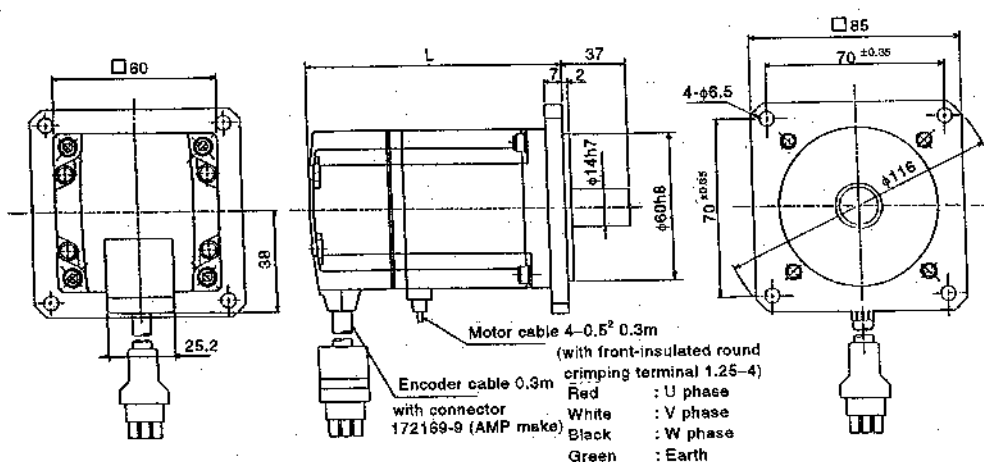
HC-PQ033-S2/-S3/-S4 to HC-PQ13-S2/-S3/-S4



[Unit: mm]

Model	Variable Dimension L	Inertia Moment GD <sup>2</sup> [kgf·cm <sup>2</sup> ]	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



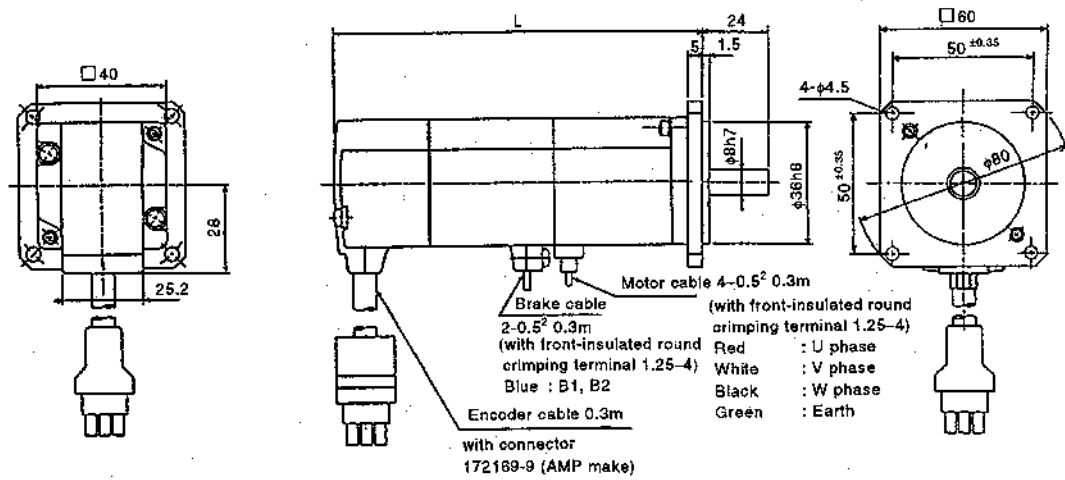
[Unit: mm]

Model	Variable Dimension L	Inertia Moment GD <sup>2</sup> [kgf·cm <sup>2</sup> ]	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

## 12. OPTIONAL PRODUCTS

(2) With electromagnetic brake

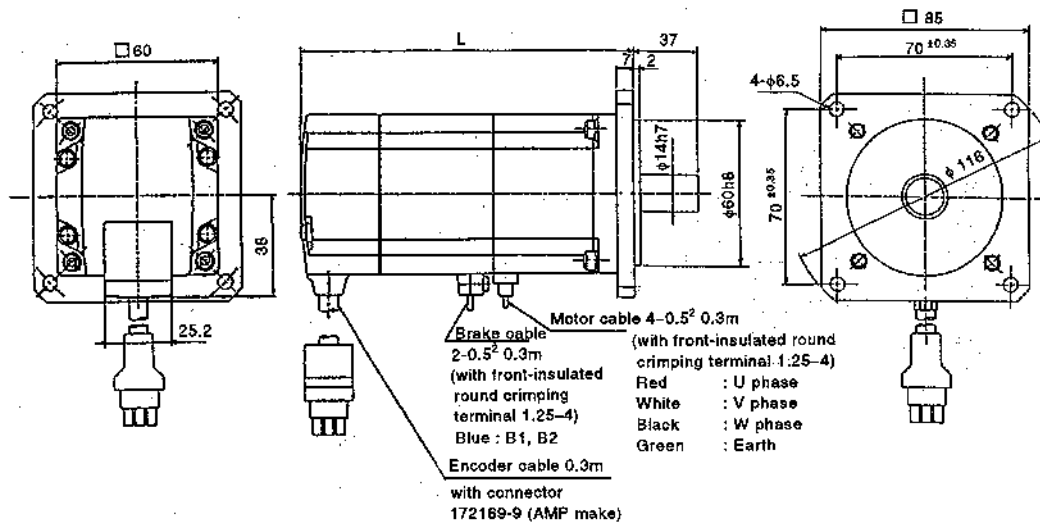
HC-PQ033B-S2/-S3/-S4 to HC-PQ13B-S2/-S3/-S4



[Unit: mm]

Model	Variable Dimension L	Brake Static Friction Torque [N.m]	Inertia Moment GD <sup>2</sup> [kgf·cm <sup>2</sup> ]	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



[Unit: mm]

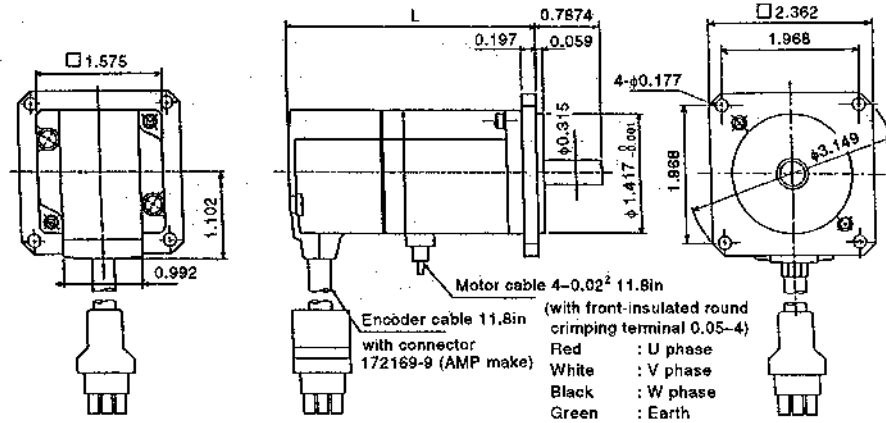
Model	Variable Dimension L	Brake Static Friction Torque [N.m]	Inertia Moment GD <sup>2</sup> [kgf·cm <sup>2</sup> ]	Weight [kg]
HC-PQ23B-S2/-S4	126	1.3	0.576	1.75
HC-PQ43B-S2/-S4	151	1.3	0.576	2.2
HC-PQ23B-S3	135	1.3	0.576	1.78
HC-PQ43B-S3	160	1.3	0.576	2.28

## 12. OPTIONAL PRODUCTS

### 12-1-5 Stepping motor intercompatibility series (in inches)

#### (1) Standard

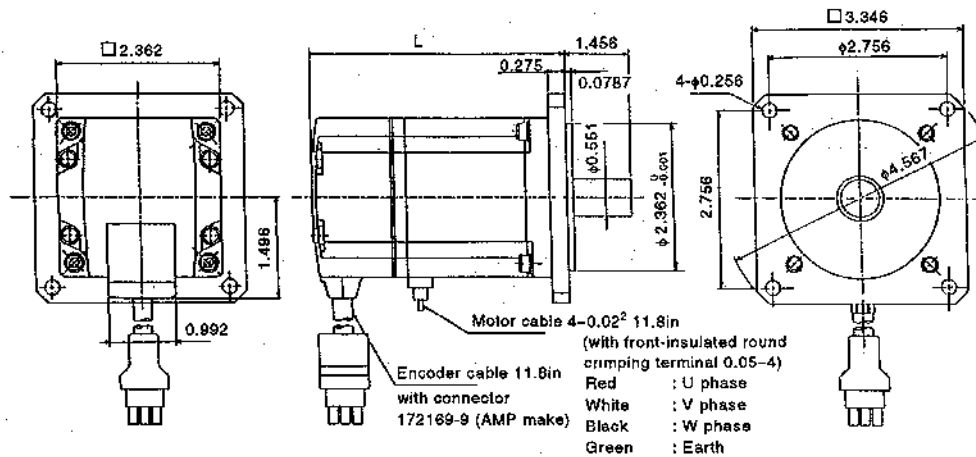
HC-PQ033-S2/-S3/-S4 to HC-PQ13-S2/-S3/-S4



[Unit: in]

Model	Variable Dimension L	Inertia Moment GD <sup>2</sup> [oz·in <sup>2</sup> ]	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]

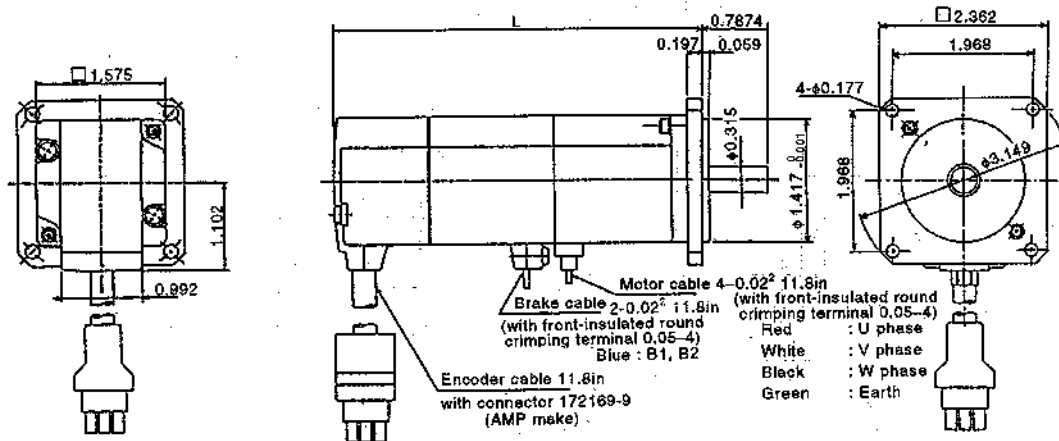
Model	Variable Dimension L	Inertia Moment GD <sup>2</sup> [oz·in <sup>2</sup> ]	Weight [lb]
HC-PQ23-S2/-S4	3.7	0.478	2.4
HC-PQ43-S2/-S4	4.685	0.478	3.4
HC-PQ23-S3	4.055	0.478	2.5
HC-PQ43-S3	5.039	0.478	3.5



## 12. OPTIONAL PRODUCTS

(2) With electromagnetic brake

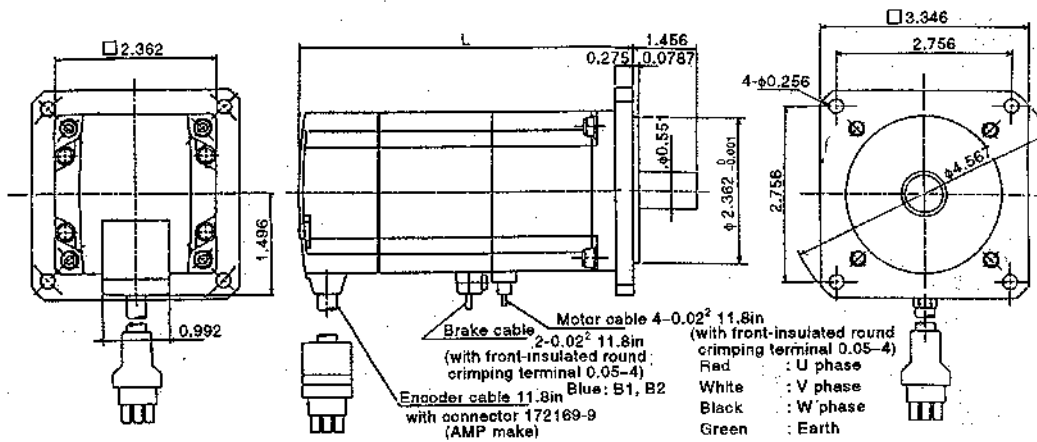
HC-PQ033B-S2/-S3/-S4 to HC-PQ13B-S2/-S3/-S4



[Unit: in]

Model	Variable Dimension L	Brake Static Friction Torque [oz·in]	Inertia Moment $GD^2$ [oz·in <sup>2</sup> ]	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



[Unit: in]

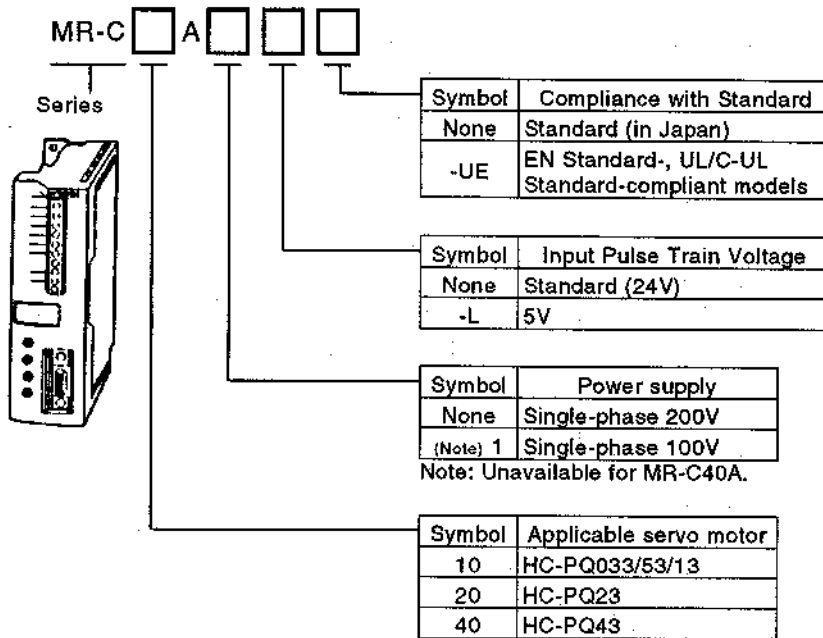
Model	Variable Dimension L	Brake Static Friction Torque [oz·in]	Inertia Moment $GD^2$ [oz·in <sup>2</sup> ]	Weight [lb]
HC-PQ23B-S2/-S4	5.039	184	0.790	3.9
HC-PQ43B-S2/-S4	5.945	184	0.790	4.9
HC-PQ23B-S3	5.315	184	0.790	4.0
HC-PQ43B-S3	6.299	184	0.790	4.9

## 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

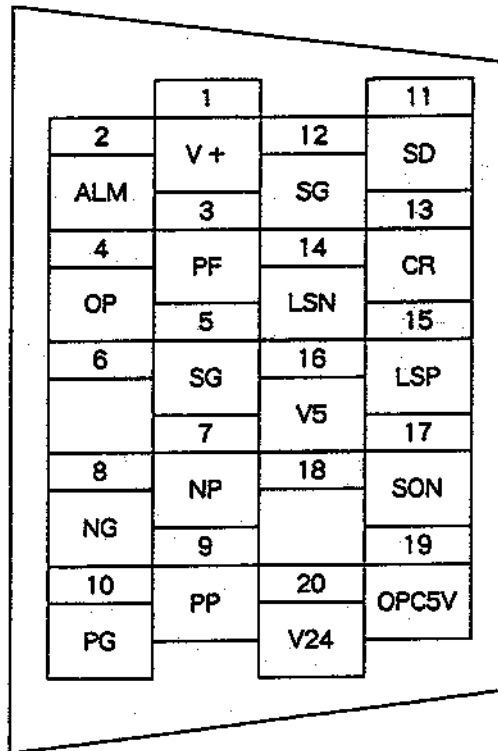


## 12. OPTIONAL PRODUCTS

### 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.

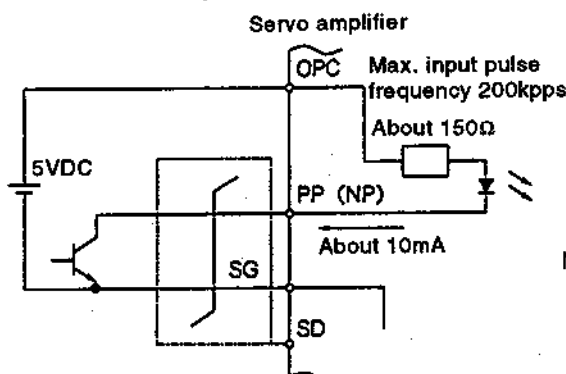
#### (2) Explanation of the connector pins (CN1A)

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.	

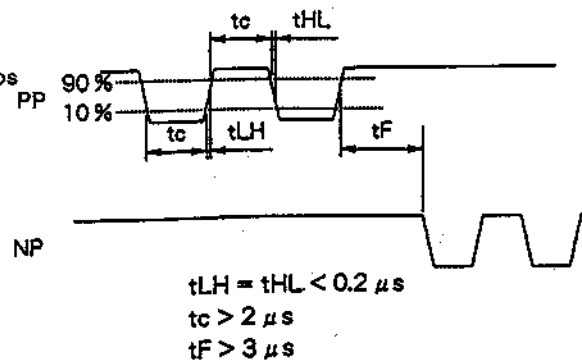
### 12-2-3 Inter faces

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

#### • Interface example



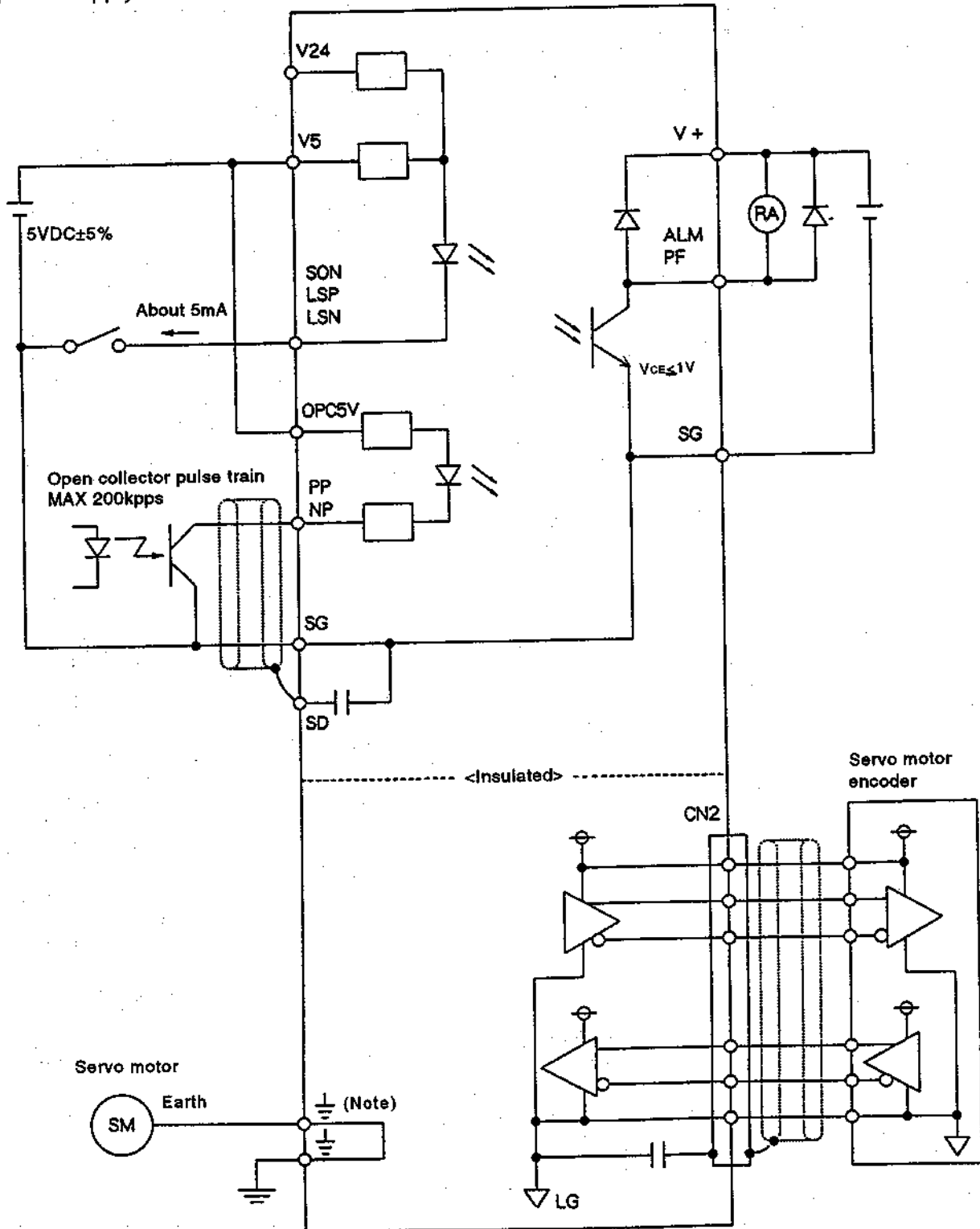
#### • Input pulse specification



## 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

\* The manual number is given on the bottom left of the back cover.

Print Date	*Manual Number	Revision
Dec., 1996	SH (NA) 3167-A	First edition
Aug., 1997	SH (NA) 3167-B	<p>Addition of instructions for conformance with the UL/C-UL Standard            Specification value of single-phase 100V changed to 100-120VAC</p> <p>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</p>
Feb., 1999	SH(NA)3167-C	<p>Conformity with the EC Directives: Chapter 1, (8) changed            Conformity with the UL/C-UL Standard: (2) changed.</p> <p>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</p> <p>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</p>

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	Mitsubishi Electric Europe B.V. Westgate Business Park, Ballymount <b>IRL-Dublin 24</b> Telefon +353 (0) 1 / 419 88 00 Fax: +353 (0) 1 / 419 88 90	<b>IRELAND</b>	
<b>USA</b>	SHERF Motion Techn. LTD Rehov Hamerkava 19 <b>IL-58851 Holon</b> Telefon +972 (0) 3 / 559 54 62 Fax: +972 (0) 3 / 556 01 82	<b>ISRAEL</b>	
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	GEVA Wiener Straße 89 <b>A-2500 Baden</b> Telefon +43 (0) 2252 / 85 55 20 Fax: +43 (0) 2252 / 488 60	<b>AUSTRIA</b>	
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