

MITSUBISHI

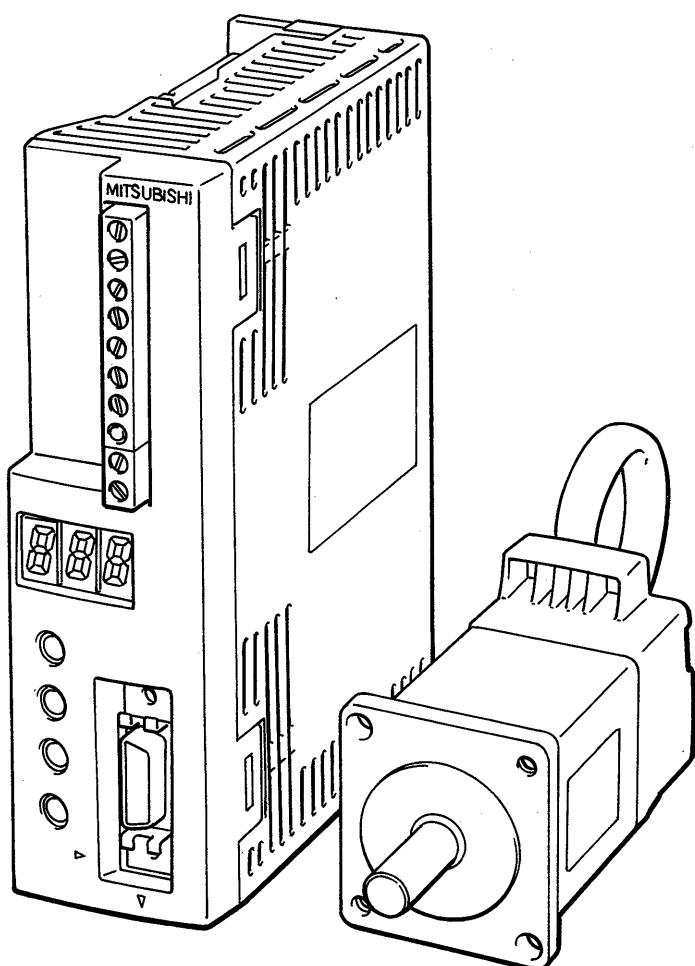
General Purpose AC Servo

MELSERVO-C Series

General Purpose Interface

MR-C□A

Instruction Manual



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:

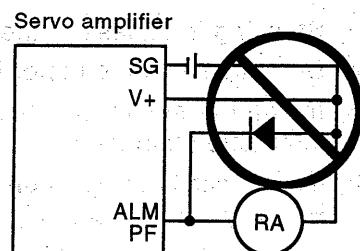
Environment		Conditions	
		Servo Amplifier	Servo Motor
Ambient temperature	[°C]	0 to +50 (non-freezing)	0 to +40 (non-freezing)
	[°F]	32 to 122 (non-freezing)	32 to 104 (non-freezing)
Ambient humidity		90%RH or less (non-condensing)	
Storage temperature	[°C]	-20 to +65 (non-freezing)	-15 to +70 (non-freezing)
	[°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 ²]	5.9 (0.6G) or less	X, Y: 19.6 (2G)
	[ft/s ²]	19.4 (0.6G) or less	X, Y: 64 (2G)

- ⚠ Securely mount the servo motor to the machine. If mount insecurely, the servo motor may come off during operation.
- ⚠ The servo motor with reduction gear must be installed in the specified direction to prevent oil leakage.
- ⚠ For safety of personnel, always cover rotating and moving parts.
- ⚠ Never hit the servo motor or shaft, especially when coupling the servo motor to the machine.
- ⚠ Do not load the servo motor shaft to more than the permissible load. Otherwise, the shaft may break.
- ⚠ When the equipment has been stored for an extended period of time, contact with Mitsubishi.

(2) Wiring

⚠ CAUTION

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



(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.

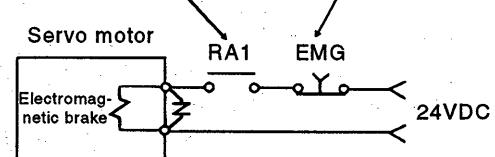
(5) Just in case

⚠ CAUTION

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

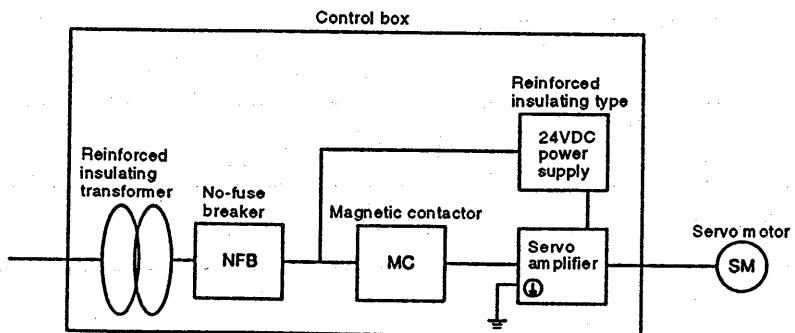
The servo do not function independently but are designed for use with machines and equipment. Therefore, the EMC Directive does not apply to the servo but applies to the machines and equipment into which the servo are installed.

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**

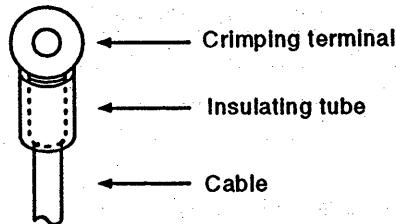
- 1) To prevent an electric shock, always connect the protective earth (PE) terminal (marked \ominus) of the servo amplifier to the protective earth (PE) of the control box.
- 2) Do not connect two ground cables to the same protective earth (PE) terminal. Always connect the cables to the terminals one-to-one.



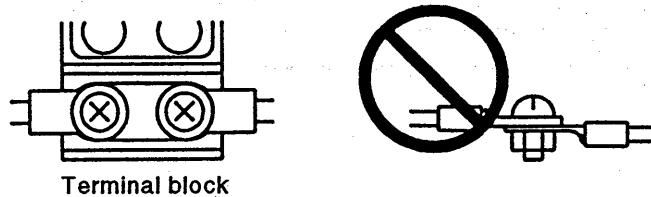
- 3) If a leakage current breaker is used to prevent an electric shock, the protective earth (PE) terminals of the servo amplifier must be connected to the corresponding earth terminals.

(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) **Auxiliary equipment and options**

- 1) The no-fuse breaker and magnetic contactor used should be the EN/IEC Standard-compliant products of the models described in Section 6-2-1.
- 2) The sizes of the cables described in Section 6-2-1 meet the following requirements. To meet the other requirements, follow Table 5 and Appendix C in EN60204.
 - Ambient temperature: 40 (104) [$^{\circ}$ C ($^{\circ}$ 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 x 150 x 6	033-053-13
250 x 250 x 6	23
250 x 250 x 12	43

(4) Discharge time of Capacitor

The discharge time of capacitor is shown as followings.

For safety please do not touch those charged area during 10 minutes after power off.

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

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REVISIONS

CHAPTER 1

INTRODUCTION

This chapter provides basic information needed to use this servo.

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SELECTION	CHAPTER 11
OPTIONAL PRODUCTS	CHAPTER 12

1. INTRODUCTION

1-1 Model Definition

(1) Servo amplifier

MR-C A

Series

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

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

Note: Unavailable for MR-C40A.

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

(2) Servo motor

HC-PQ 3

Series

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

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

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

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

Symbol	Electromagnetic brake
None	Without
B	With

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

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 XXXXXXXX	

Serial number
Rated output current
Applicable power supply
Capacity
Model

MITSUBISHI AC SERVO

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

Serial number
Rated output current
Applicable power supply
Capacity
Model

Date of manufacture

Serial number

Model

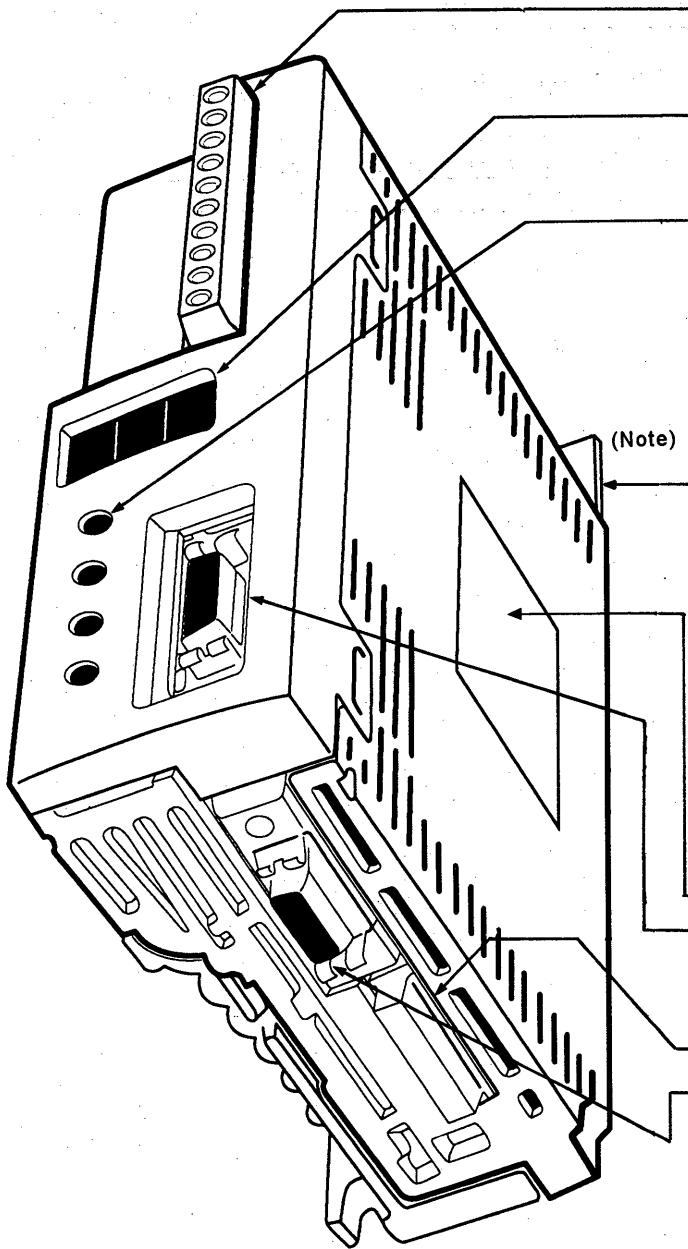
Name plate

MITSUBISHI AC SERVO MOTOR	
HC-PQ053	
SERIAL	
DATE	895505 01
MITSUBISHI ELECTRIC CORPORATION 895505 01	

1. INTRODUCTION

1-2 Parts Identification and Application

1-2-1 Servo amplifier

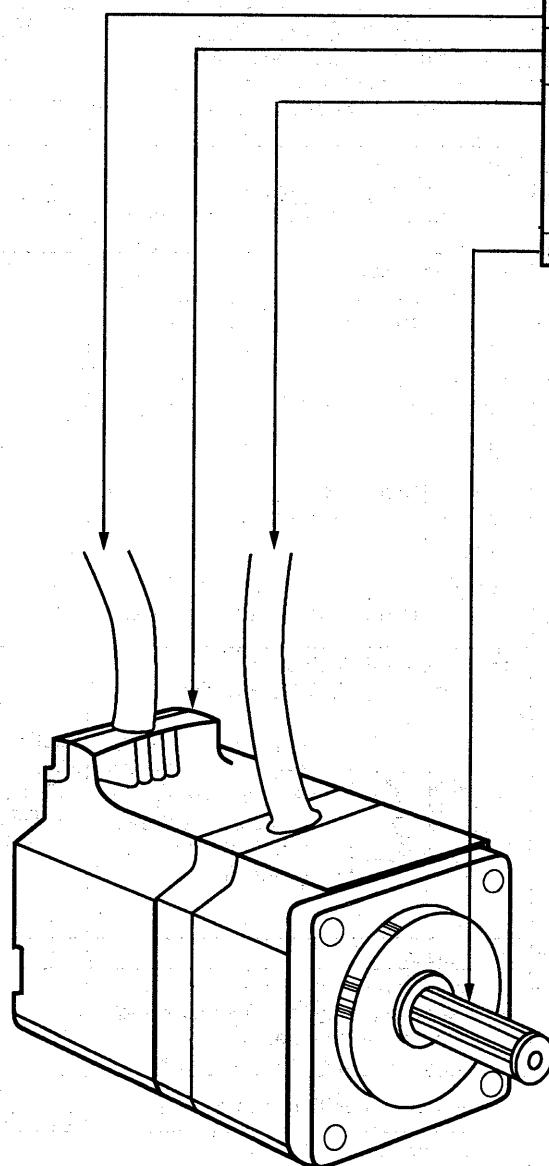


Name/Application	Refer To
Main circuit terminal block (TE) Used to connect the power supply, servo motor, regenerative brake option and ground.	Section 3-1-1
Display The three-digit, seven-segment LED shows the servo status and alarm number.	Section 2-3
Operation section Used to perform status display,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

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

1. INTRODUCTION

1-2-2 Servo motor



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

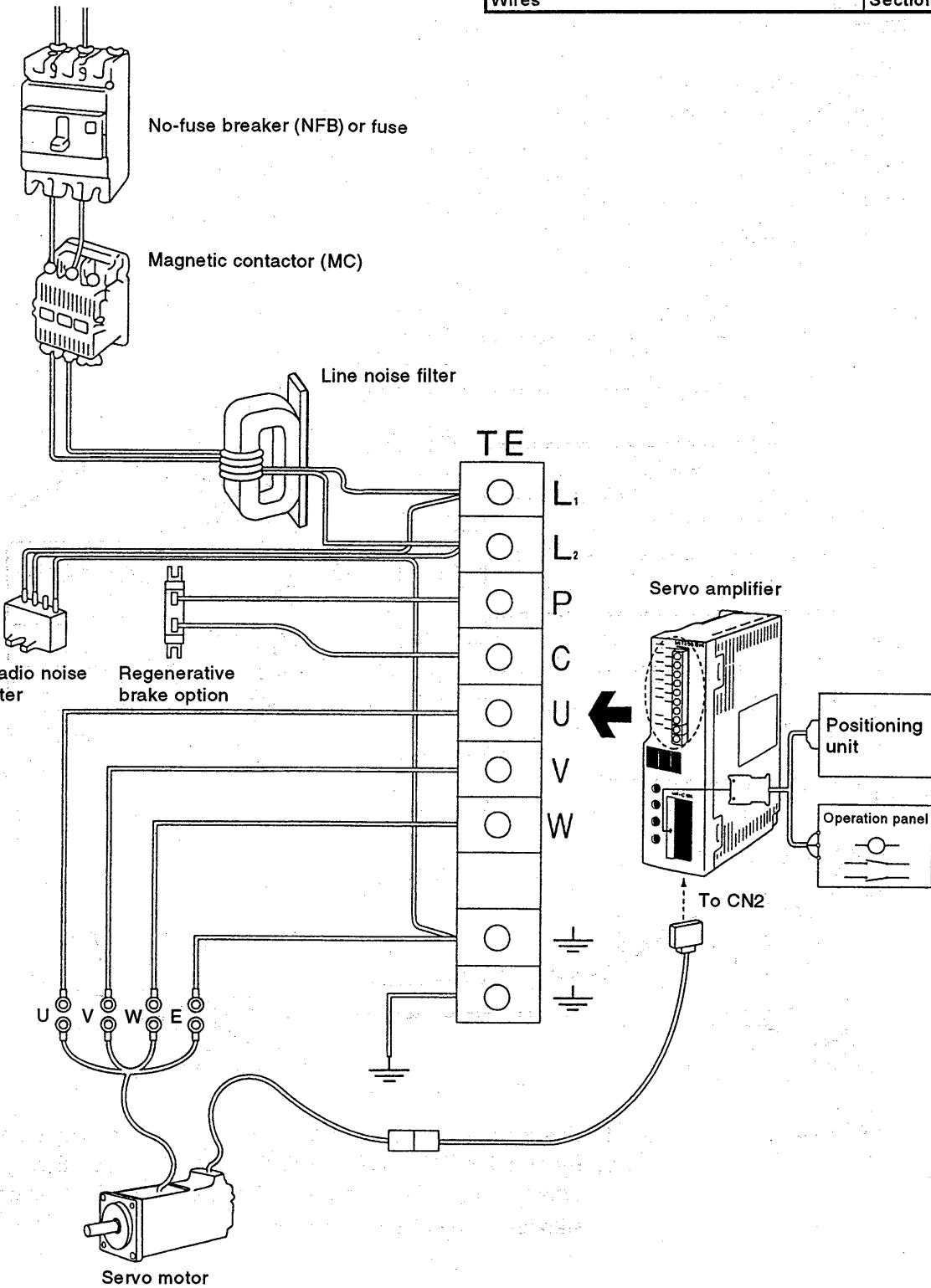
1. INTRODUCTION

1 – 3 Basic Configuration

1 – 3 – 1 Standard models

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

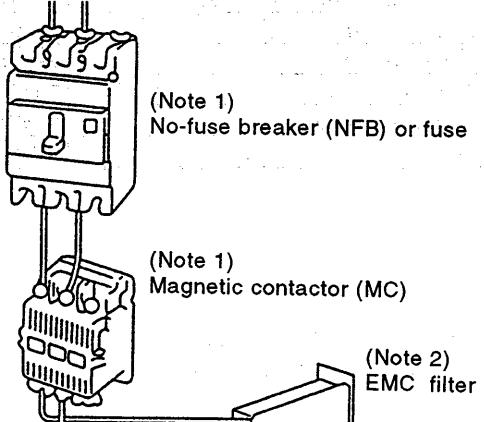
Options, Auxiliary Equipment	Refer To
No-fuse breaker	Section 6 – 2 – 1
Magnetic contactor	Section 6 – 2 – 1
Radio noise filter	Section 6 – 2 – 4
Regenerative brake option	Section 6 – 1 – 1
Wires	Section 6 – 2 – 1



1. INTRODUCTION

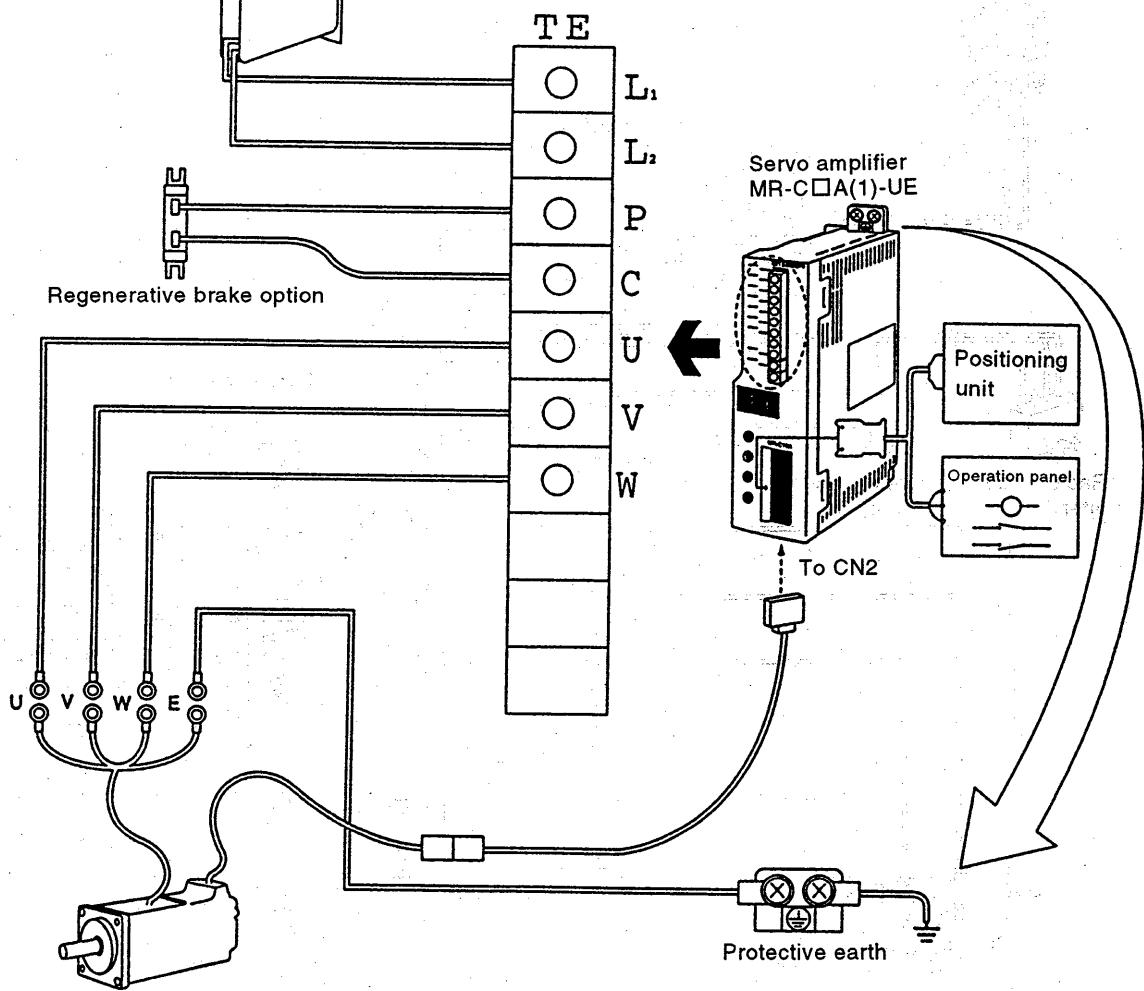
1 – 3 – 2 EN Standard-, UL/C-UL Standard-compliant models

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



MEMO-RANDOM

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

This chapter gives basic connection examples and operation procedure.

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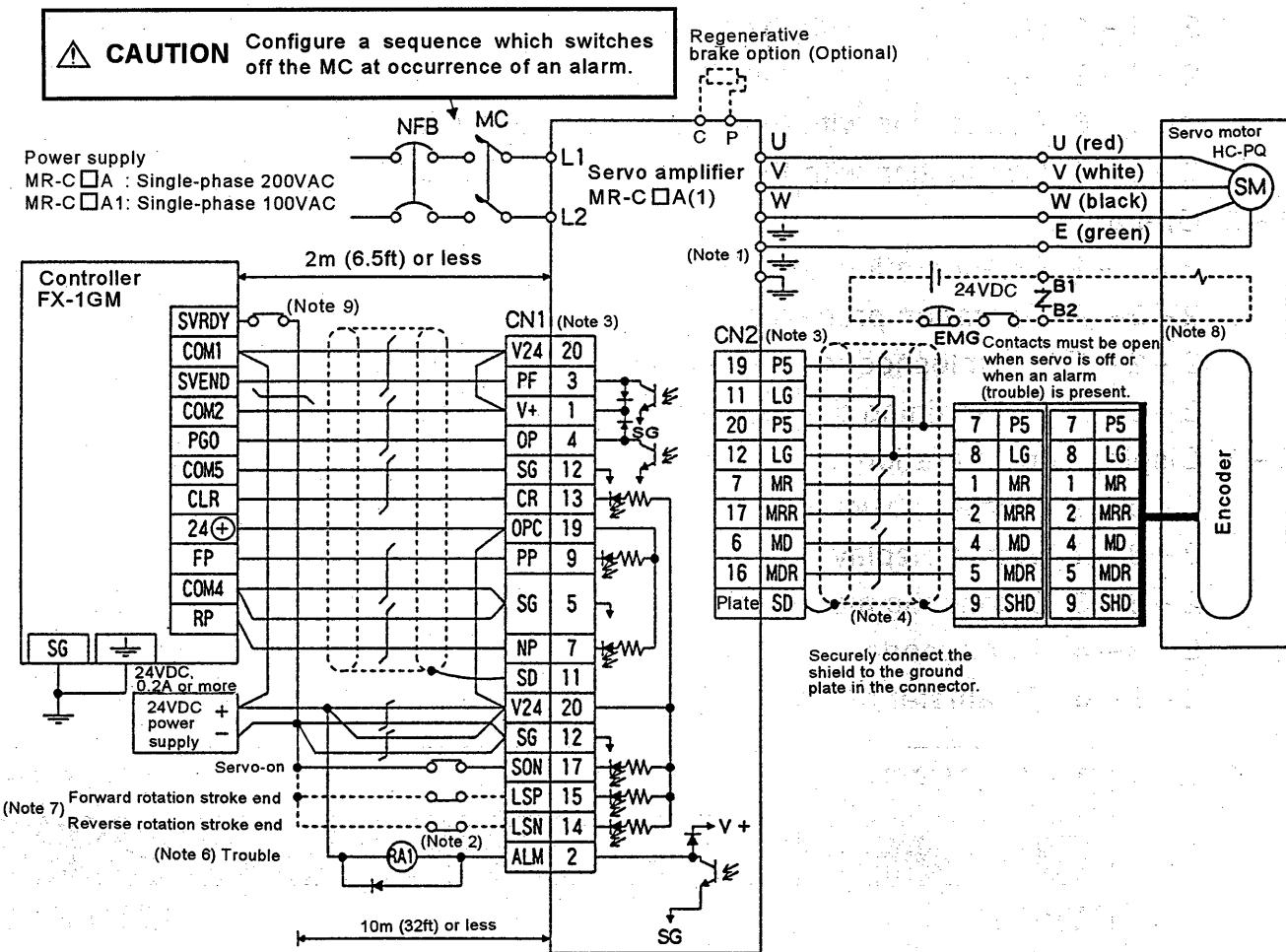
INTRODUCTION	CHAPTER 1
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2. OPERATION

2 – 1 Standard Connection Examples

⚠ CAUTION Always follow the wiring instructions in Chapter 3.

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



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

! WARNING

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

! CAUTION

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

NOTICE

2. OPERATION

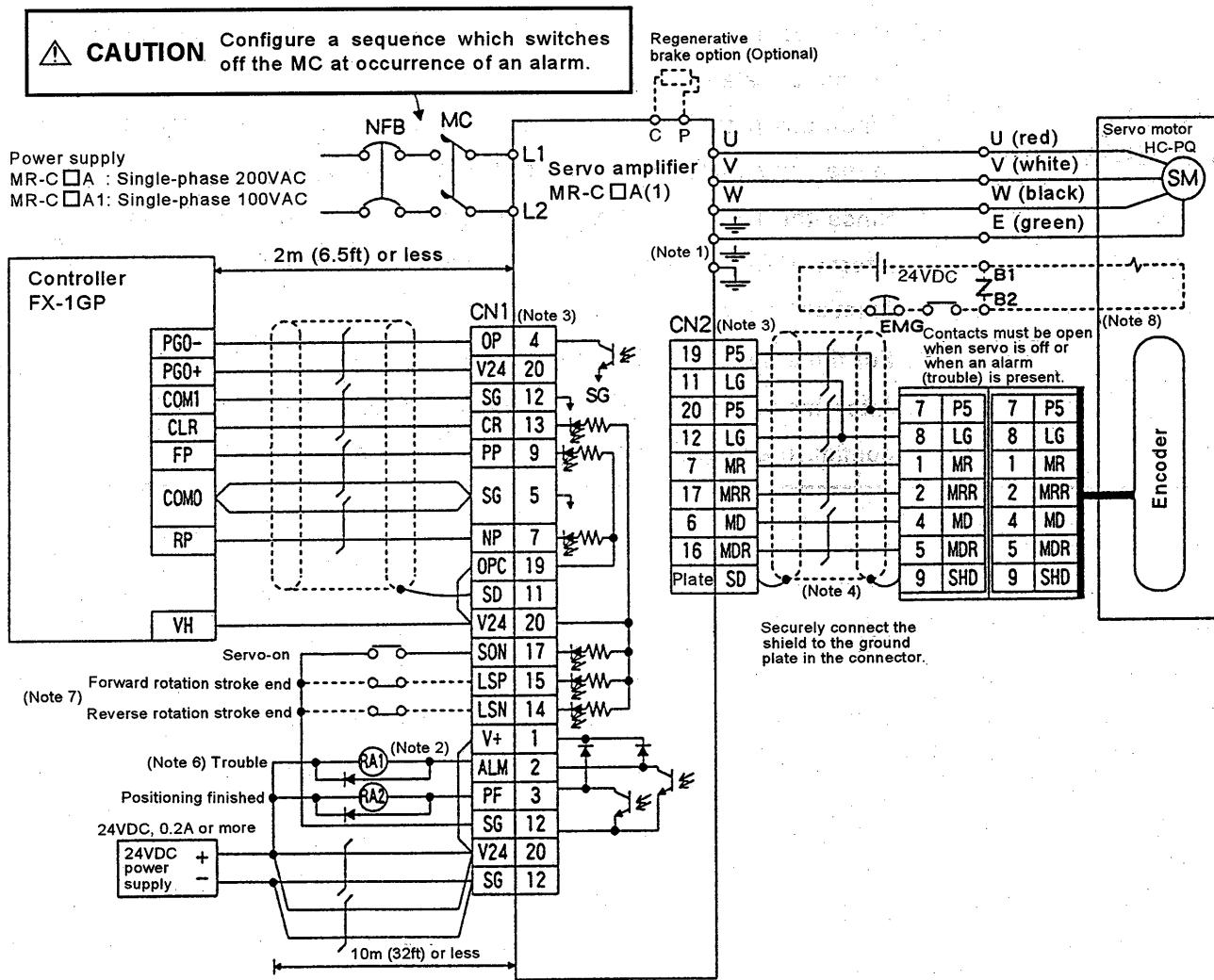
MEMO- RANDUM

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 – 2 Connection with the FX-1GP



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).

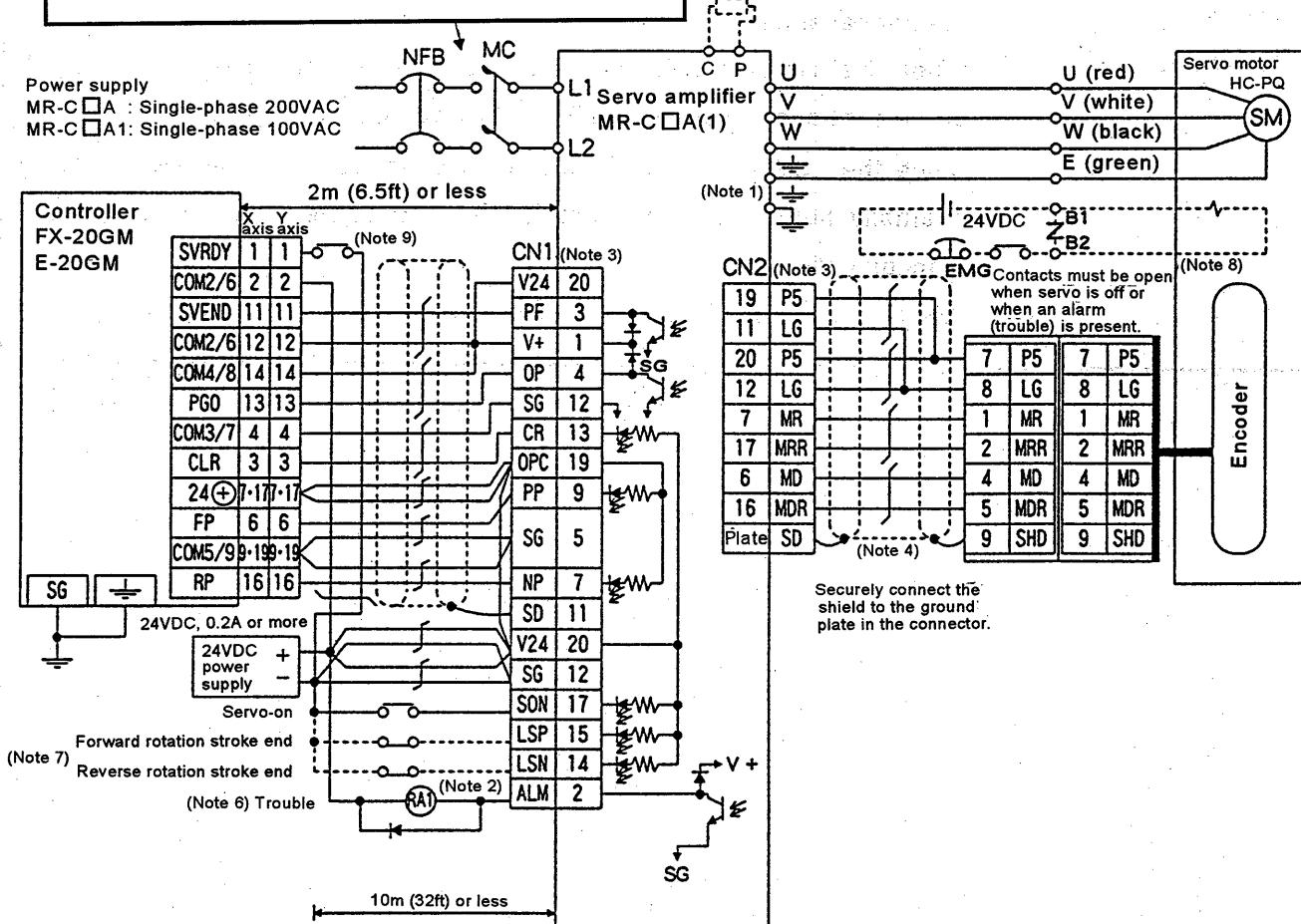
5. The pins with the same signal name are connected together in the servo amplifier.
6. The trouble (ALM) signal conducts current when there is no alarm, i.e. in the normal state.
When this signal is switched off (at occurrence of an alarm), the output of the controller must be stopped by the sequence 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.

2. OPERATION

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



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



WARNING Note 1. For the EN Standard model, always connect the protective earth (PE) terminal (marked \ominus) 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

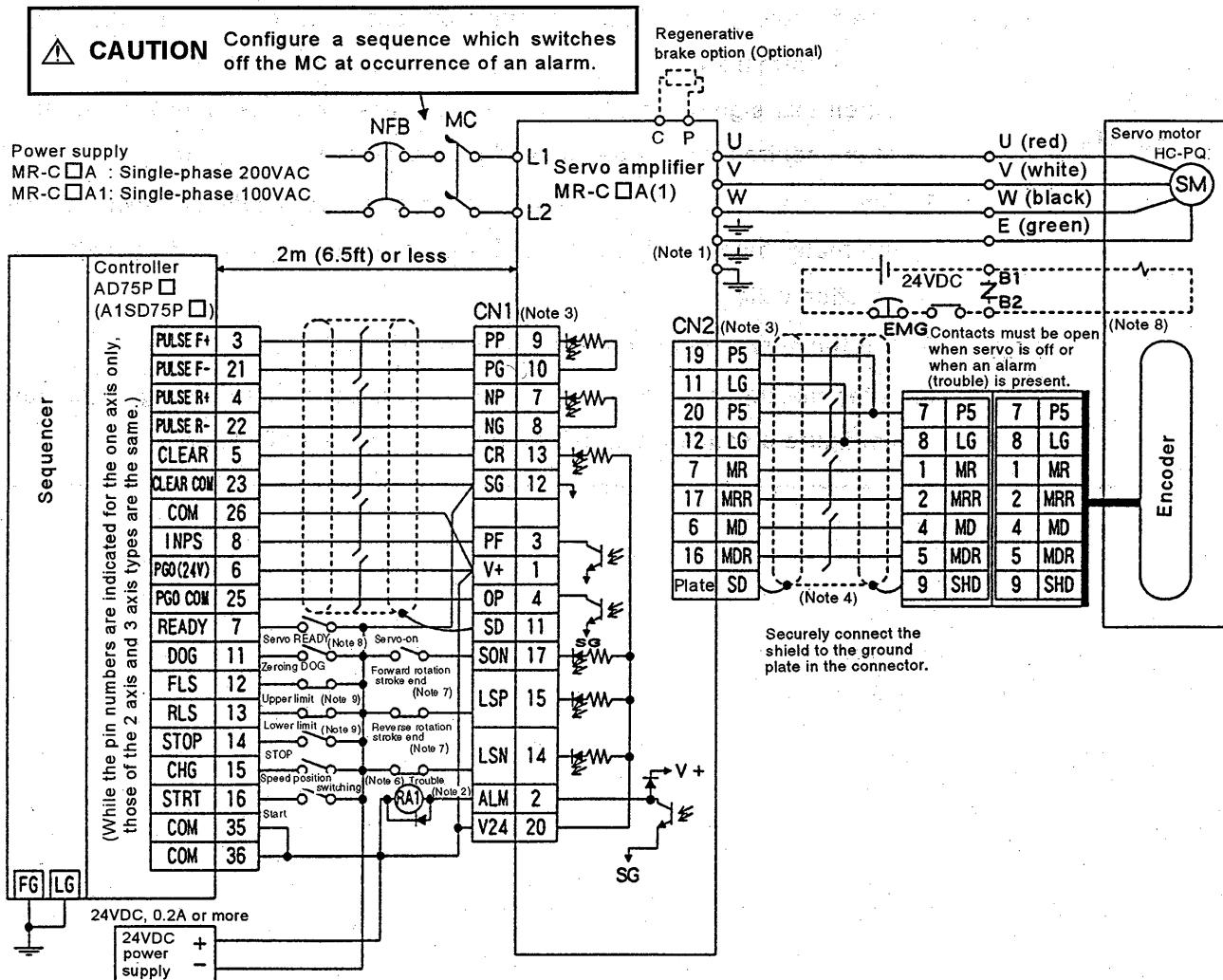
MEMO- RANDUM

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.

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



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

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

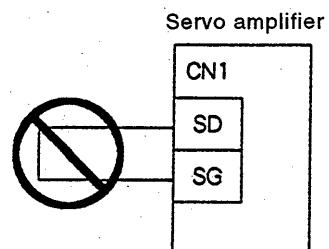
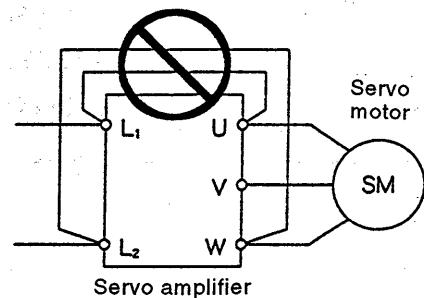
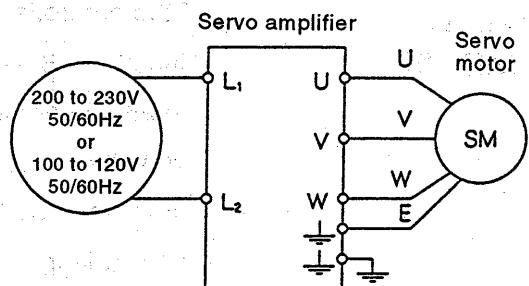
- 1) A correct power supply is connected to the power input terminals (L₁, L₂) of the servo amplifier.
- 2) The servo motor power supply terminals (U, V, W) of the servo amplifier match in phase with the power input terminals (U, V, W) of the servo motor.
- 3) The servo amplifier and servo motor are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



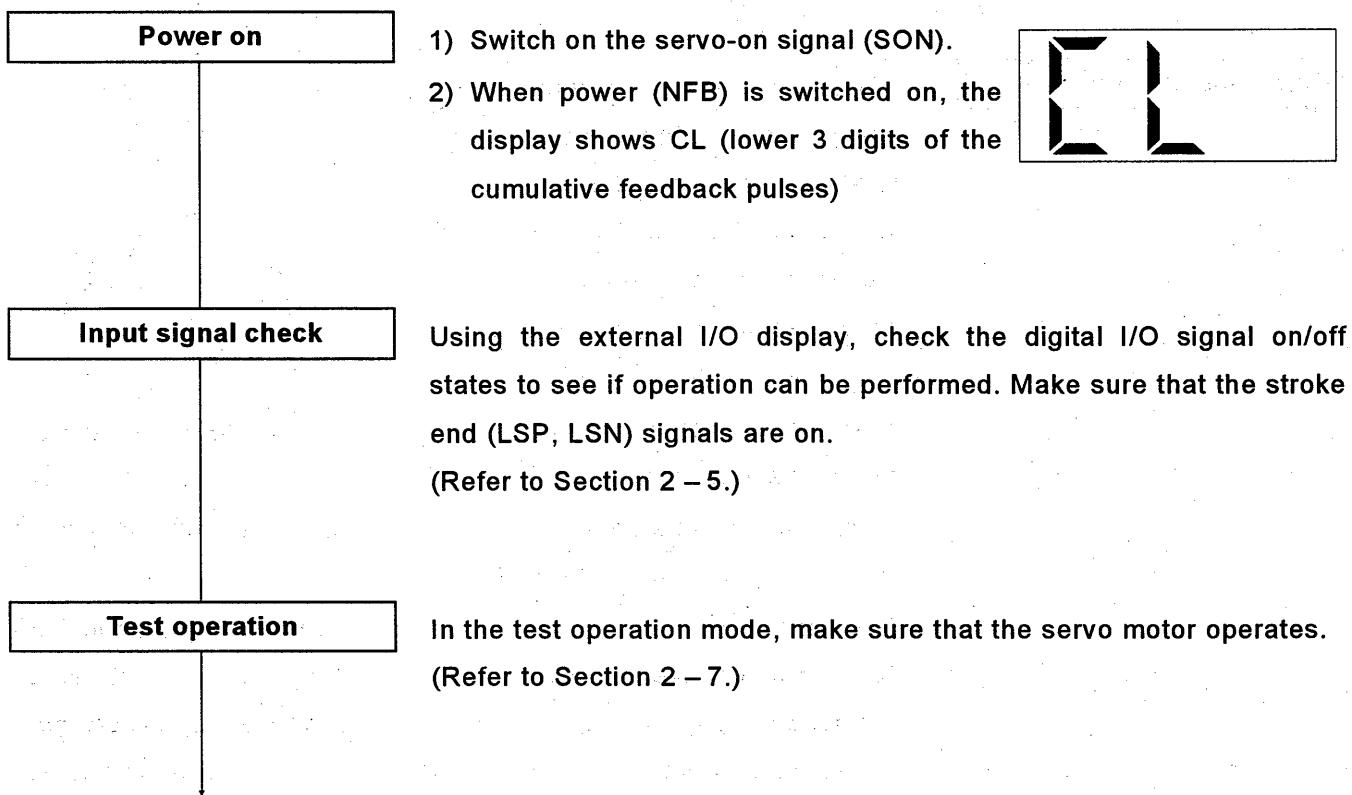
2. OPERATION

2-2-2 Operation procedure

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

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.



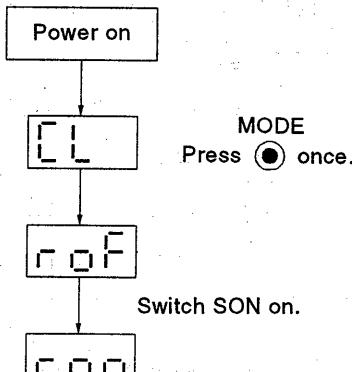
2. OPERATION

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.

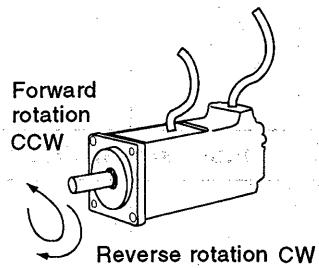
Confirmation method



When SON is switched on,
this display is shown.

Command pulse train input

- When a pulse train is input from the positioning unit, the servo motor starts rotating. First, run the motor at low speed and check the rotation direction, etc. If the motor does not run as expected, recheck the input signals.
- On the status display, check the servo motor speed, command pulse frequency, load factors, etc.
- 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

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

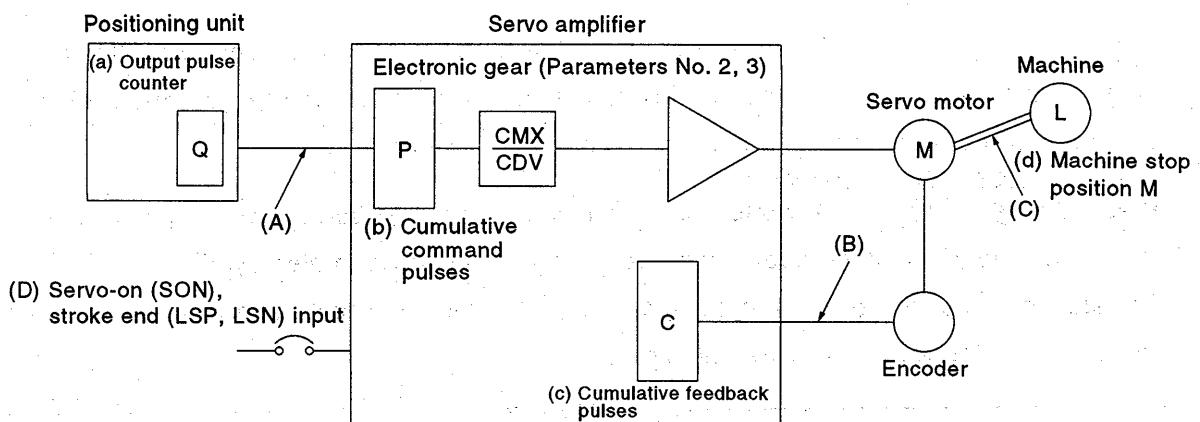
Never adjust and change the parameter settings extremely. Otherwise, operation will be instable.

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"> The LED is not lit. The LED flickers. 	Not improved when the connectors CN1 and CN2 are disconnected.	<ul style="list-style-type: none"> Power supply voltage faulty. Servo amplifier failure 	—
			Improved when the connector CN1 is disconnected.	Short circuit in the power supply of the CN1 cable wiring	
			Improved when the connector CN2 is disconnected.	<ol style="list-style-type: none"> Short circuit in the power supply of the encoder cable wiring 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	Chapter 8
		Servo is not locked. (The servo motor shaft is free.)	Confirm the external I/O signal display.	<ol style="list-style-type: none"> The servo ON signal is not input. (Wiring error) V24 or V5 is not supplied with DC power. 	
3	Position command is input (test run)	The servo motor does not rotate.	Confirm the cumulative command pulses.	<ol style="list-style-type: none"> Wiring error <ol style="list-style-type: none"> For the open collector pulse train input, OPC is not supplied with 24VDC. LSP or LSN and SG are not connected. 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: <ol style="list-style-type: none"> Increase the response setting of auto tuning. 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	
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

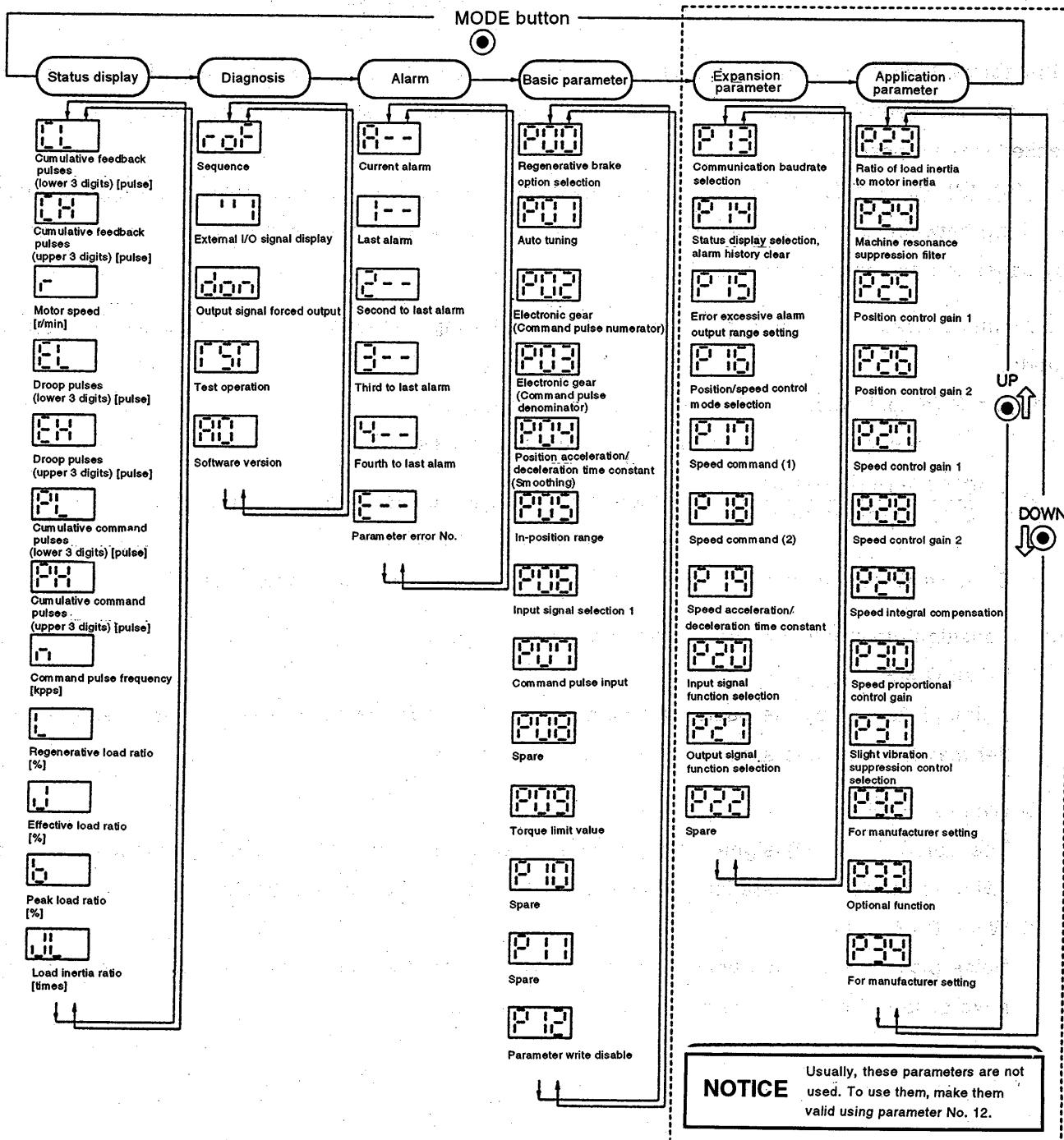
2-3-1 Display flowchart

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 **UP** or **DOWN** button to change display data as desired. When the required data is selected, the corresponding symbol is displayed. Press the **SET** button to display that data.

Name	Symbol	Display Range	Unit	Description
Cumulative feedback pulses (Lower 3 digits)	CL	-999999 to 999999	Pulse	After operation has been made ready, the travel distance of the servo motor is counted and displayed. When ± 999999 is exceeded, the value begins with zero.
Cumulative feedback pulses (Upper 3 digits)	CH	-999999 to 999999	Pulse	Press the SET button to reset the display value to zero. When the servo motor is rotating in the reverse direction, the decimal points in all digits are lit.
Servo motor speed	r	-540 to 540	$\times 10r/min$	The servo motor speed is displayed. When the servo motor is rotating in the reverse direction, the decimal points in all digits are lit. The r/min value rounded off is displayed. (The display data is updated every 0.3s.)
Droop pulses (Lower 3 digits)	EL	-999999 to 999999	Pulse	Press the SET button to display the value in r/min.
Droop pulses (Upper 3 digits)	EH	-999999 to 999999	Pulse	The number of droop pulses in the deviation counter is displayed. When ± 999999 is exceeded, the value begins with zero. When the servo motor is rotating in the reverse direction, the decimal points in all digits are lit.
Cumulative command pulses (Lower 3 digits)	PL	-999999 to 999999	Pulse	The position command input pulses are counted and displayed. As this value is displayed before it is multiplied by the electronic gear (CMX/CDV), it may not match the cumulative feedback pulses.
Cumulative command pulses (Upper 3 digits)	PH	-999999 to 999999	Pulse	Press the SET button to reset the display value to zero. When the servo motor is rotating in the reverse direction, the decimal points in all digits are lit.
Command pulse frequency	n	-200 to 200	kpps	The frequency of the position command input pulses is displayed in kpps which is represented by the decimal point. This value is displayed before it is multiplied by the electronic gear (CMX/CDV). When the servo motor is rotating in the reverse direction, the decimal points in all digits are lit.
Regenerative load ratio	L	0 to 100	%	Press the SET button to display the value in 0.1kpps.
Effective load ratio	J	0 to 300	%	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.
Peak load ratio	b	0 to 400	%	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.
Load inertia ratio	JL	0 to 100	Times	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.
				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.
External I/O signal display	 Input signals Output signals LSN LSP CR SON OP ALM PF	Indicates the on/off states of the external I/O signals. The upper segments correspond to the input signals and the lower segments to the output signals. Lit: ON Extinguished: OFF Refer to (1) in this section. The I/O signals can be changed using parameters No. 20 and 21. The ALM signal is ON when there is no alarm. Refer to Section 5-2-2.
Output signal forced output		The digital output signal can be forcibly switched on/off. For more information, refer to (2) in this section.
Test operation mode		The servo motor can be operated without pulse train input. During test operation, speed control servo is provided. The status display values of the droop pulses, cumulative command pulses and command pulse frequency do not change. For details, refer to (3) in this section.
Software version		Indicates the version of the software.

2. OPERATION

(1) External I/O signal display

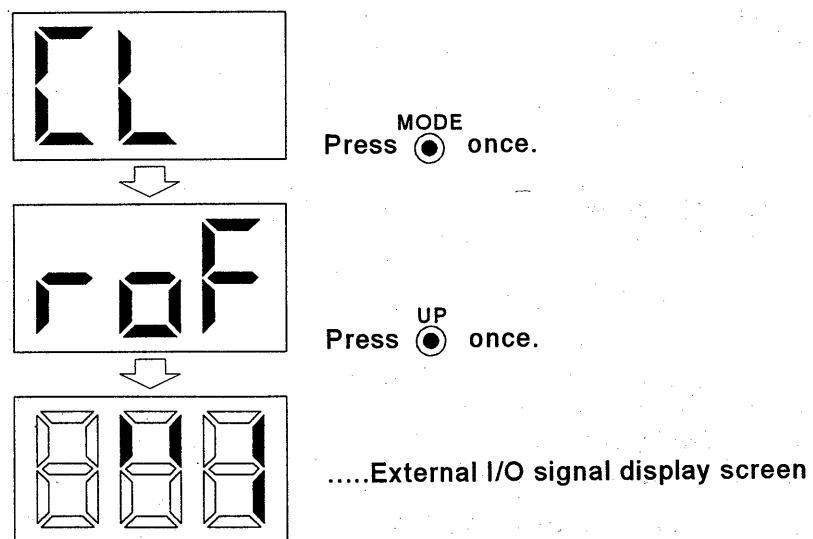
MEMO- RANDUM

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

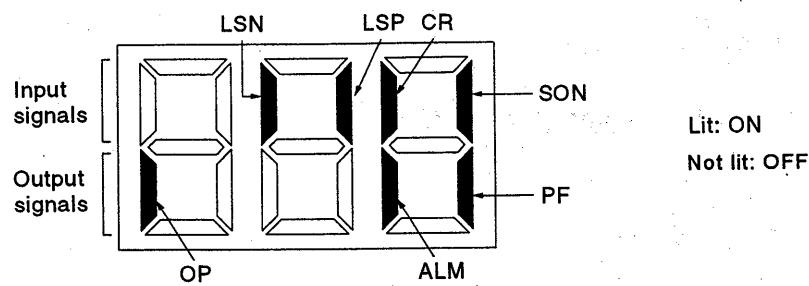
The on/off states of the digital I/O signals connected to the servo amplifier can be confirmed. In addition, the I/O signals displayed for parameters No. 20 and 21 can be changed. Refer to Section 5-2-2.

1) Operation

Display screen after power-on is shown.



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

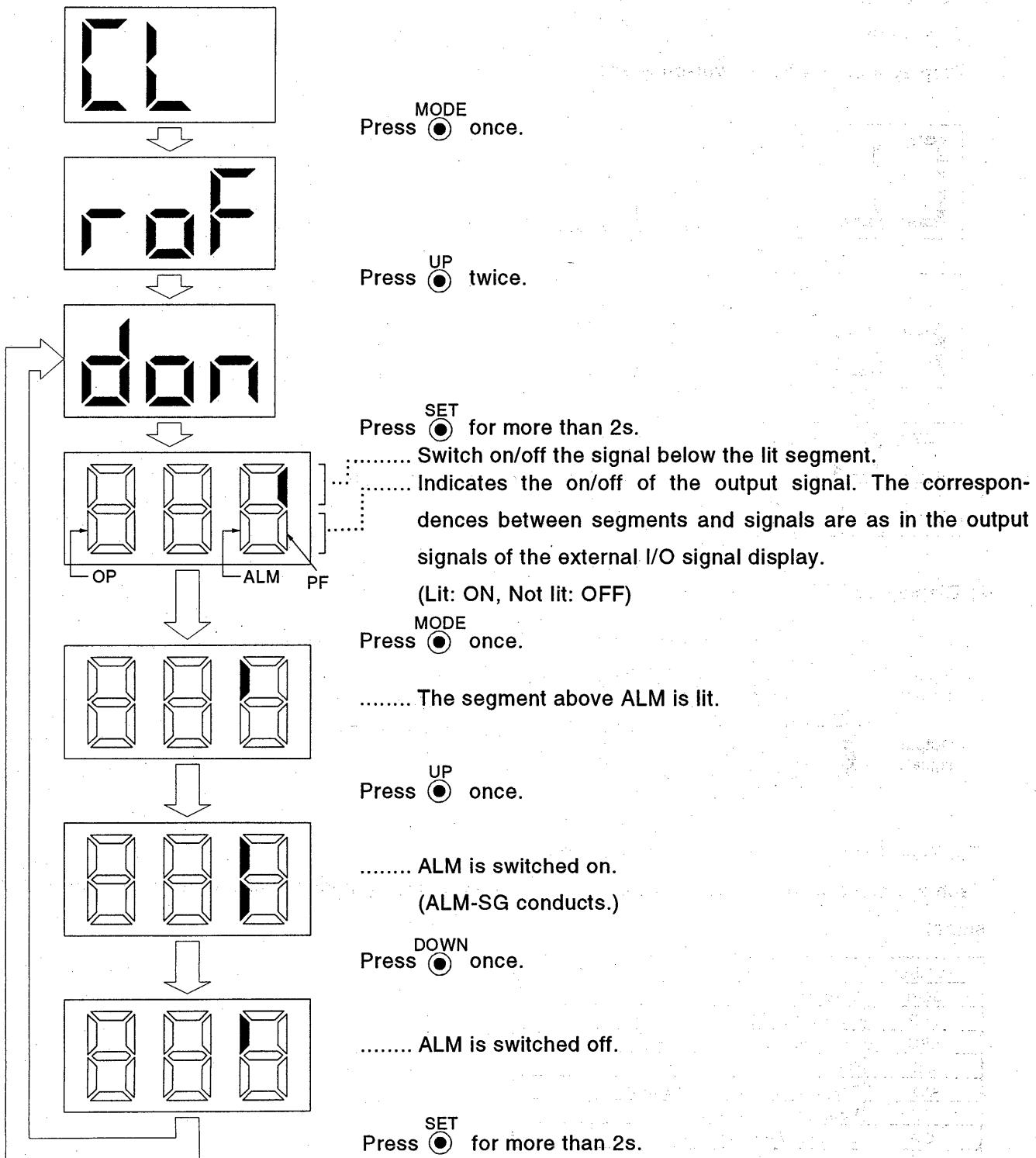
(2) Output signal forced output

MEMO- RANDOM

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.



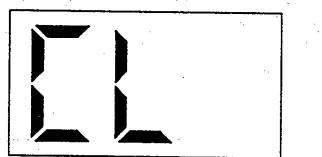
2. OPERATION

(3) Test operation mode

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

1) Mode switching

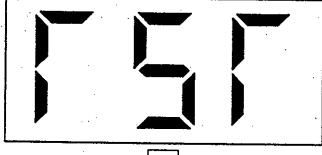
Display screen after power-on is shown.



MODE
Press  once.

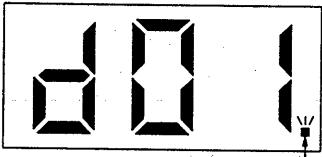


UP
Press  three times.



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  to shift to the status display screen. The display data is the same as in the status display in Section 2-3-2.

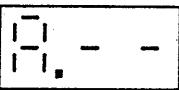
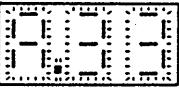
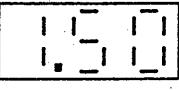
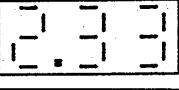
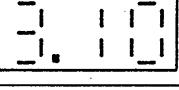
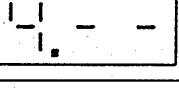
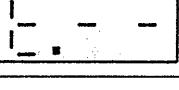
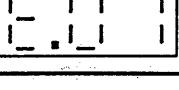
4) Termination of test operation

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

2. OPERATION

2-3-4 Alarm mode

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

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

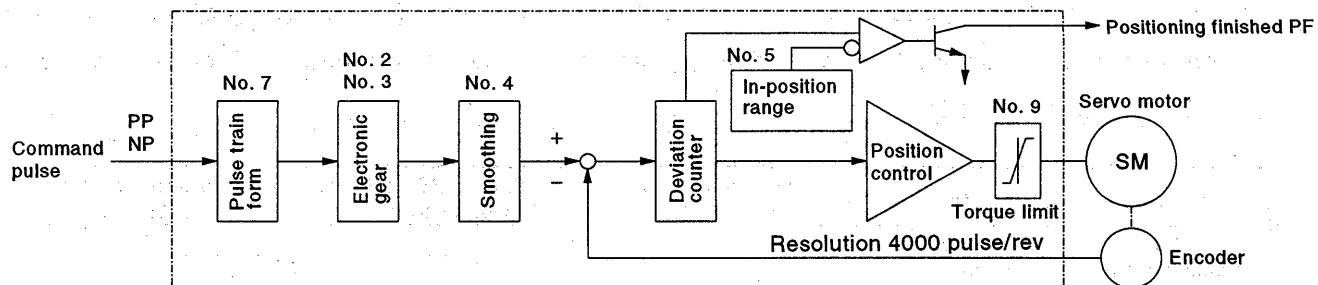
Functions at occurrence of an alarm

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

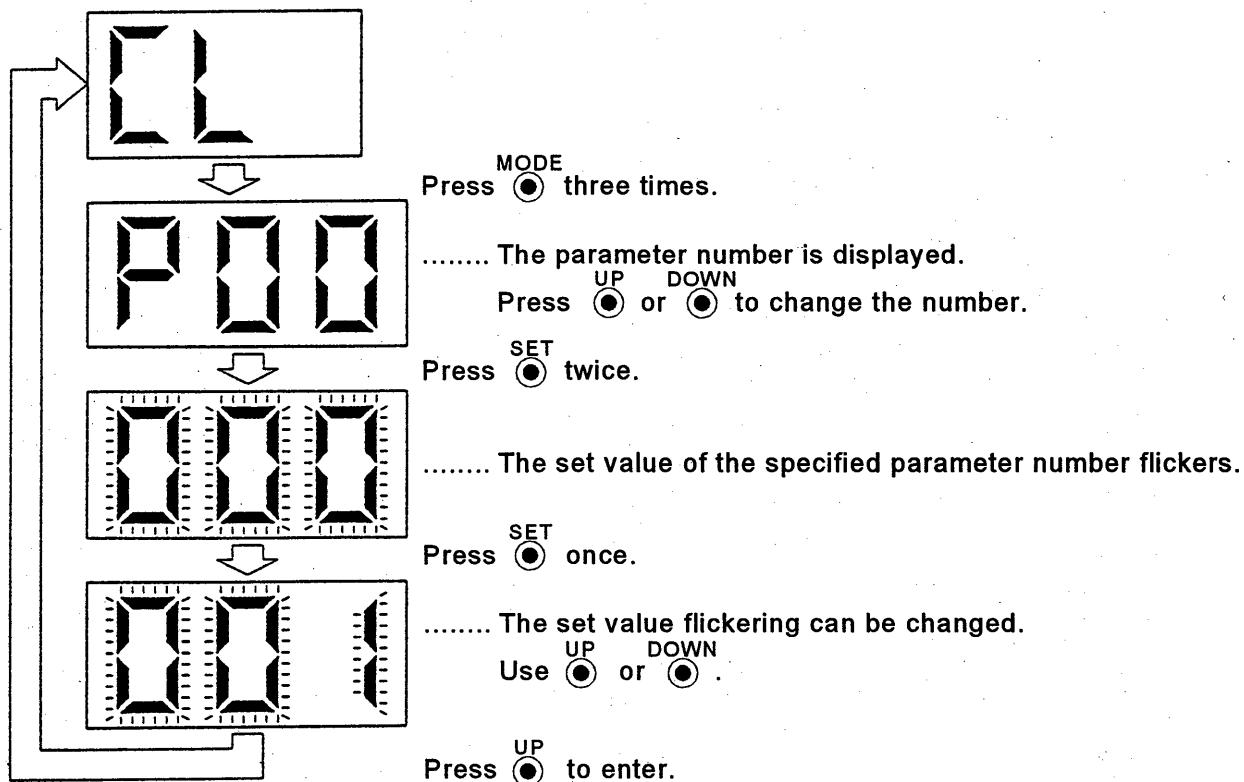


The parameter settings need not be changed to operate this servo. Note that the parameter settings should be changed when:

- 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	× 10rad/s	
	28	VG2	Speed control gain 2 (actual position gain)	60	× 10rad/s	
	29	VIC	Speed integral compensation	20	ms	
	30	VDC	Speed proportional control gain	980		
	31	MVC	Slight vibration suppression control selection	000		
	32	MVP	For manufacturer setting	412		
	33	*OP2	Optional function	A00		
	34	VPI	For manufacturer setting	0	pulse	

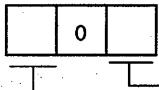
NOTICE

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

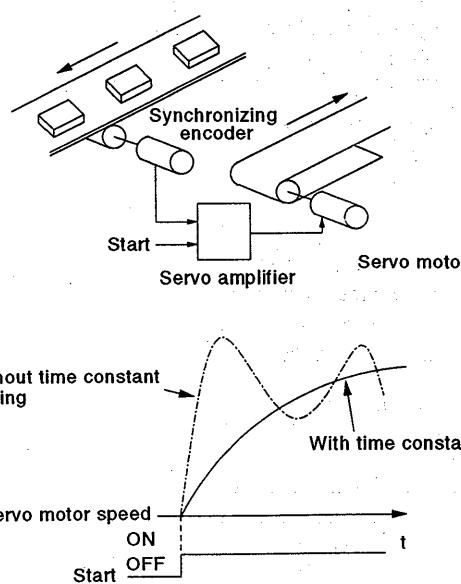
2. OPERATION

(4) Detailed explanation of the parameters

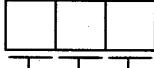
Note: To make the parameter marked * valid, set the parameter, switch power off once, then switch power on again.

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>  <p>Select the regenerative brake option.</p> <p>0: Not used 1: MR-RB013 2: MR-RB033</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> NOTICE If wrong setting is made, the regenerative brake option may overheat! </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>	000		000 to 102h																						
	1	ATU	<p>Auto tuning: Used to set response for execution of auto tuning.</p>  <p>Auto tuning response setting</p> <table border="1" style="margin-left: 10px;"> <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"> • If the machine hunts or generates large gear sound, decrease the set value. • To improve performance, e.g. shorten the set- <p>Machine selection Used to adjust the position setting characteristic according to the machine status.</p> <table border="1" style="margin-left: 10px;"> <thead> <tr> <th rowspan="2"></th> <th colspan="2">Position Setting Characteristic</th> </tr> <tr> <th>Ordinary</th> <th>Better (Note)</th> </tr> </thead> <tbody> <tr> <td>Machine friction</td> <td>Small</td> <td>0 2</td> </tr> <tr> <td></td> <td>Large</td> <td>1 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</p> <p>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	
Set Value	Response																											
1	Slow response																											
2	to																											
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	Position Setting Characteristic																											
	Ordinary	Better (Note)																										
Machine friction	Small	0 2																										
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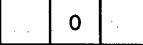
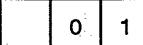
2. OPERATION

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>Command pulse input f_1 $\xrightarrow{\text{CMX}} \text{Position command}$ $f_2 = f_1 \cdot \frac{\text{CMX}}{\text{CDV}}$</p> <p>Note: Set in the range of $\frac{1}{50} < \frac{\text{CMX}}{\text{CDV}} < 20$.</p> <p>The setting of the number of input pulses per servo motor revolution can be changed by the following formula: $4000 \cdot \frac{\text{CDV}}{\text{CMX}}$ (pulse/rev)</p> <p>CAUTION If a wrong setting is made, the servo motor may rotate at unexpectedly high speed, causing injury.</p>	1		1 to 999
	3	CDV	<p>Electronic gear (Command pulse multiplying factor, denominator): Used to set the divisor of the command pulse input.</p>	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

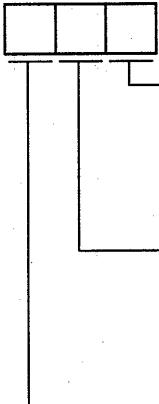
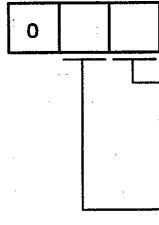
2. OPERATION

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-top: 10px;"> <p>MEMO-RANDOM</p> <p>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		Spare:																				
	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	
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	Communication baudrate selection: Used to select the serial interface when the RS-232C option unit is fitted to use the communication function.  Selection of baud rate when RS-232C is selected 0: 9600 (bps) 1: 19200 (bps) 2: 4800 (bps)	000		000 to 020h
	14	*DMD	Status display selection, alarm history clear: Used to select the status display shown at power-on.  Status display at power-on 0: Cumulative feedback pulses (lower 3 digits) 1: Cumulative feedback pulses (upper 3 digits) 2: Servo motor speed 3: Droop pulses (lower 3 digits) 4: Droop pulses (upper 3 digits) 5: Cumulative command pulses (lower 3 digits) 6: Cumulative command pulses (upper 3 digits) 7: Command pulse frequency 8: Regenerative load factor 9: Effective torque A: Peak torque B: Load inertia Alarm history clear 0: Invalid 1: Valid When alarm history clear is selected, this function is made valid at next power-on. After the alarm history is cleared, the setting is automatically reset to zero.	000		000 to 10Ah
	15	ERZ	Excessive error output range setting: Used to set the range in which the excessive error alarm (A52) is output.	50	kpulse	1 to 999
	16	*OP1	Position/speed control mode selection: Used to select the optional function.  Control mode selection 0: Position control 1: Speed control	001		001 to 101h
	17	SC1	Speed command (1): Used to set speed 1 of the internal speed command.	10	10r/min	0 to 450
	18	SC2	Speed command (2): Used to set speed 2 of the internal speed command.	100	10r/min	0 to 450

2. OPERATION

Class	No.	Symbol	Name	Initial Value	Unit	Setting Range
Expansion parameters	19	STC	Speed acceleration/deceleration time constant: Used to set the acceleration/deceleration time required to reach the rated speed in response to the speed command.	0	10ms	0 to 500
	20	*DIF	Input signal function selection: Used to select the input signal functions of pins No. 13, 14 and 15 on connector CN1.	210		000 to 888h
			 <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> <p>MEMO- RANDUM</p> <p>1. Selection of the same function will result in a parameter error. 2. When automatic on of LSP/LSN is selected in parameter No. 6, LSP/LSN is always on independently of the function selected in parameter No. 20.</p>			
	21	*DOF	Output signal function selection: Used to select the output signal functions of pins No. 3 and 4 on connector CN1.	010		000 to 055h
			 <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> <p>MEMO- RANDUM</p> <p>Selection of the same function will result in a parameter error.</p>			
	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.	0		0 to 7																	
			<table border="1"> <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		
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.	000		000 to 001h																		
32	MVP	For manufacturer setting:	412																				
33	*OP2	Optional function: Used to select the optional function.	A00		A00 to A01h																		
		<table border="1"> <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																			
A	0																						
34	VPI	For manufacturer setting:	0																				

CHAPTER 3

WIRING

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

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

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.

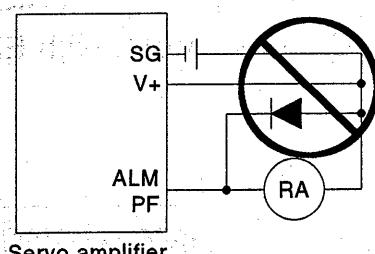
1. Wire the equipment correctly and securely. Otherwise, the servo motor may misoperate, resulting in injury.

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.

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

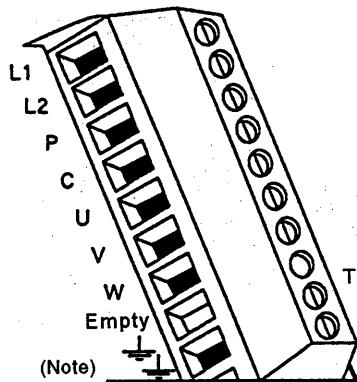
⚠ CAUTION

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

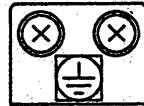
(1) Signal arrangement

1) Main circuit terminal block (TE)



Tightening torque: 5 to 8 [kgf·cm]
(4 to 7 [lb-in])

2) Protective earth (PE) terminals



Terminal screw: M4
Tightening torque: 13 [kgf·cm]
(11 [lb-in])

Note: Unavailable for the EN Standard- and UL/C-UL Standard-compliant models.

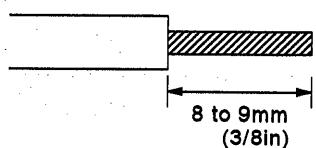
(2) Signals

Signal	Symbol	Description
Main circuit power supply	L ₁ , L ₂	Power input terminals. MR-C □A: Single-phase 200 to 230VAC, 50/60Hz MR-C □A1: Single-phase 100 to 120VAC, 50/60Hz When the servo amplifier is connected near a large-capacity power transformer (500kVA or more in the 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.

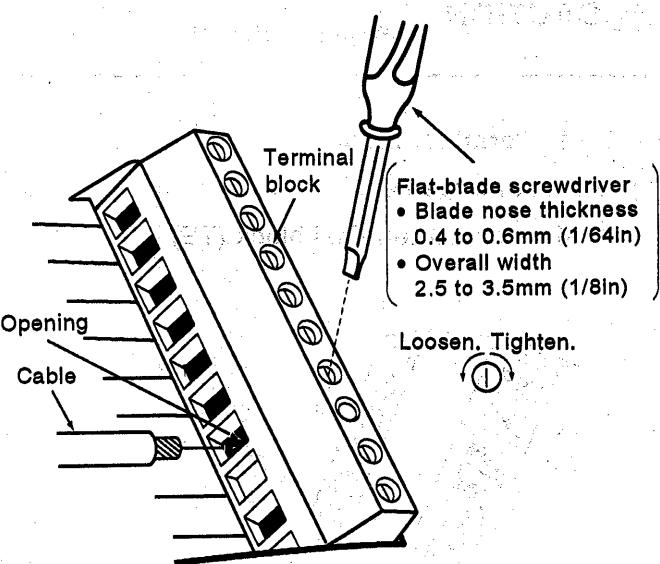


2) Insert the wire into the opening and tighten the corresponding screw with a flat-blade screwdriver so that the cable is not disconnected.

(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 1.25mm² (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 4.0mm² (24-11 AWG))

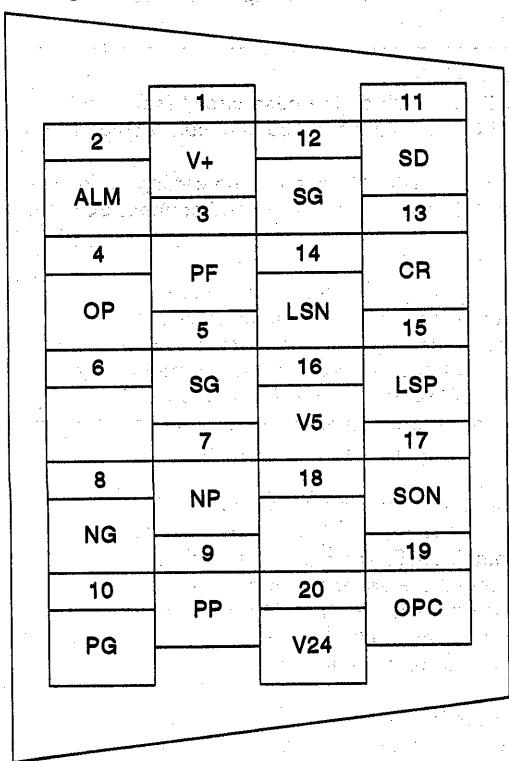
2) Twisted wire ... Use the cable after stripping the insulation and twisting the wire. At this time, note the short-circuit with the adjoining terminal by loose wires. Do not solder the core as it may cause a contact fault. (Wire size: 0.25 to 2.5mm² (23 to 13 AWG))

3. WIRING

3-1-2 Signal connectors

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

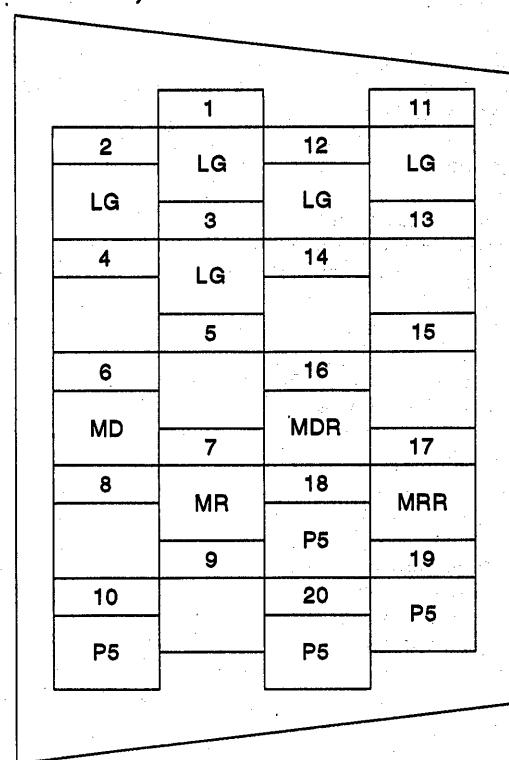
1) CN1 (I/O signal connector)



		1		11	
2		V+	12	SD	
ALM			SG	13	
	3				
4		PF	14	CR	
OP			LSN	15	
	5				
6		SG	16	LSP	
			V5	17	
7					
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			LG	13	
	3				
4		LG	14		
5				15	
6			16		
MD			MDR	17	
	7				
8		MR	18	MRR	
			P5	19	
9					
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 <input type="checkbox"/> 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 <input type="checkbox"/> 0 <input type="checkbox"/> 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 <input type="checkbox"/> 0 <input type="checkbox"/> in parameter No. 6. In this case, when LSN-SG are disconnected, the servo motor cannot be run in the CW direction. The servo motor can be run in the CCW direction. When LSN-SG are disconnected, an alarm does not occur but the home position is lost and zeroing is required again.	DI-1
Clear	CR	13	Clear signal input terminal. Connect CR-SG to clear the position control counter on the leading edge of the signal. Using parameter No. 6, the setting can be changed to always clear the position counter during connection of CR-SG. The pulse width should be 10ms or more.	DI-1
Trouble	ALM	2	Trouble signal output terminal. ALM-SG are disconnected when power is switched off or the protective circuit is activated to shut off the base circuit. Normally, ALM-SG are connected within 1.5s after power on. Connect the regenerative brake option or the like with a temperature detector to make up a protective circuit.	DO-1
Positioning finished	PF	3	Positioning finished signal output terminal. PF-SG are connected when the number of droop pulses is in the preset in-position range. The in-position range can be changed with parameter No. 5.	DO-1
Encoder Z-phase pulse	OP	4	Outputs the zero-point signal of a encoder. One pulse is output per servo motor revolution. The minimum pulse width is about 800μs. For zeroing using this pulse, set the creep speed to 100r/min or less.	DO-1
Forward rotation pulse train Reverse rotation pulse train	PP PG NP NG	9 10 7 8	Command pulse train input terminals. Input command pulse trains. In the open collector system: Forward pulse train across PP-SG Reverse pulse train across NP-SG In the differential receiver system: Forward pulse train across PP-NG Reverse pulse train across NP-NG	DI-2

3. WIRING

Signal	Symbol	Connector Pin No.	Functions/Applications	I/O Division (Note)
Open collector power input	OPC	19	When inputting a pulse train in the open collector system, supply this terminal with (+) 24VDC.	
Interface power input	V24 V5	20 16	Interface power input terminals. 24VDC or 5VDC can be used as an external power supply for interface in the digital input section. Connect the positive (+) terminal of the external supply to V24 when using 24VDC or to V5 when using 5VDC. Supply either of 24VDC and 5VDC to the power supply. Do not supply both at the same time. 24VDC, 24VDC $\pm 10\%$, 200mA or more 5VDC, 5VDC $\pm 5\%$, 100mA or more	
			NOTICE If power is supplied to both terminals V5 and V24, the servo amplifier will be faulty.	
Digital output power input	V+	1	Digital output power input terminal. Supply power for driving the digital output section.	
Power supply common	SG	5 12	Common terminals. Common terminals for OPC, V24, V5 and V+. Connect the negative (-) terminal of the external power supply.	
Shield	SD	11	Shield terminal. Connect one end of the shield cable.	

Note: Refer to Section 3 – 1 – 4.

2) CN2, CN3

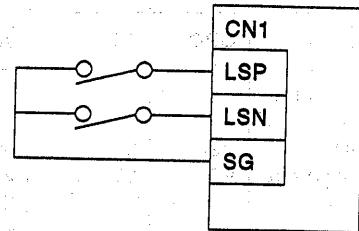
Connector	Function/Application
CN2	Connect with the servo motor encoder. CN1 and CN2 have the same shape. Wrong connection to the connectors may cause a failure.
CN3	Connect the RS-232C option unit (MR-C-T01).

3. WIRING

3-1-3 Control I/O signals

(1) Forward, reverse rotation stroke ends (LSP, LSN)

To use these signals, set $\square 0 \square$ 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.

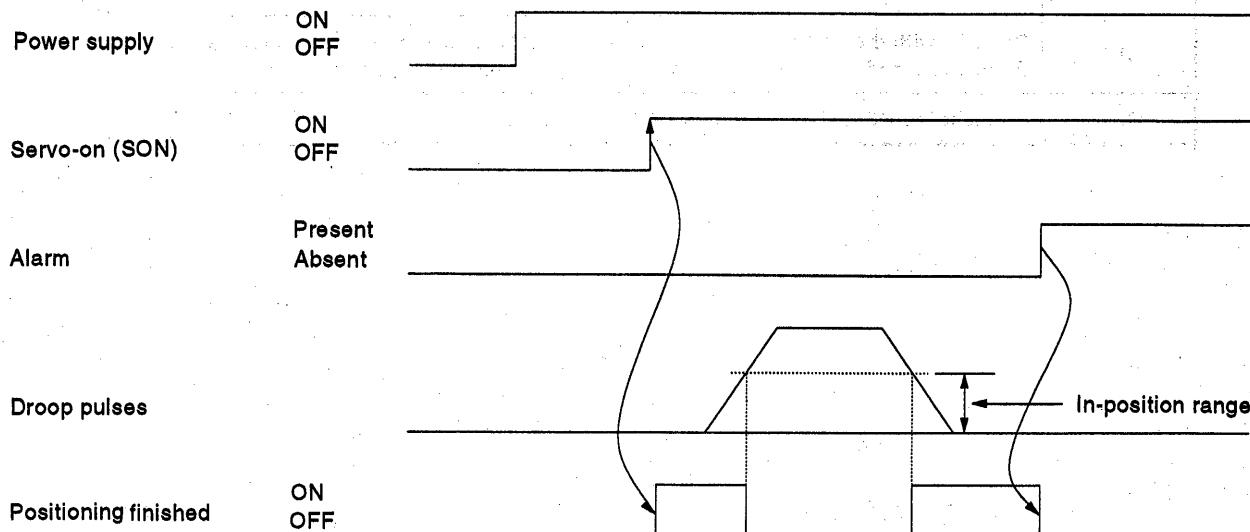


(2) Clear (CR)

When CR-SG are connected, the deviation counter is cleared on the leading edge of its signal. By setting $1\square\square$ 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

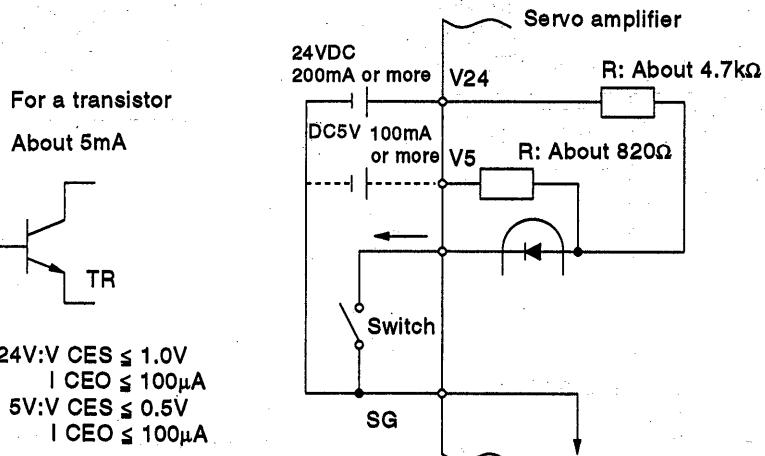
3-1-4 Interfaces

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.



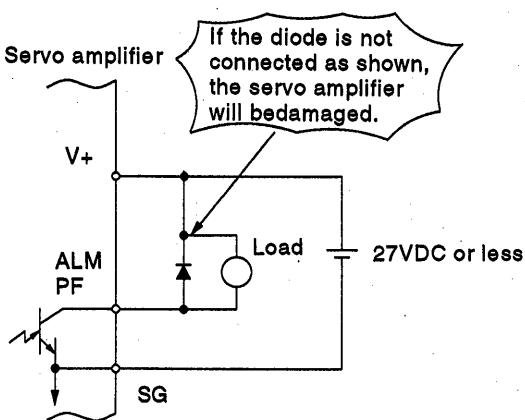
NOTICE

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

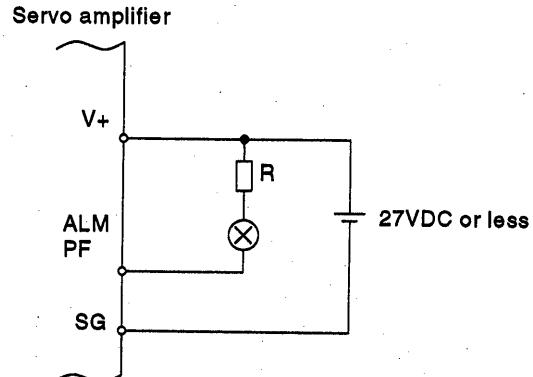
(2) Digital output interface DO-1

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

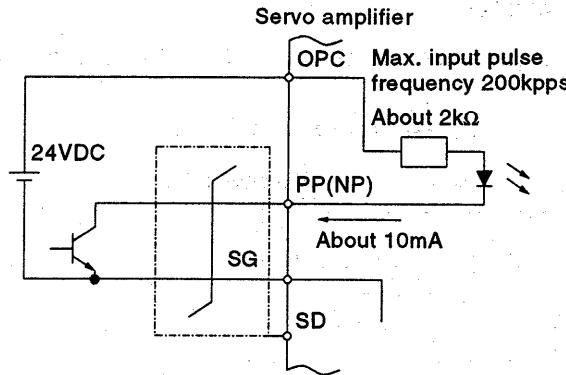


3. WIRING

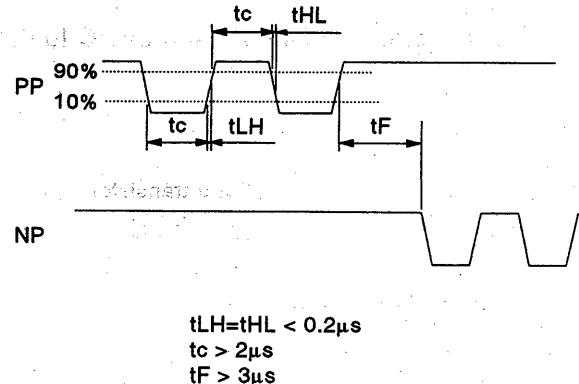
(3) Pulse train input interface DI-2

1) Open collector system

- Interface example



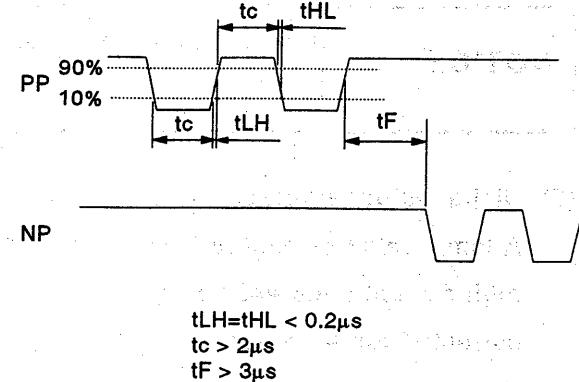
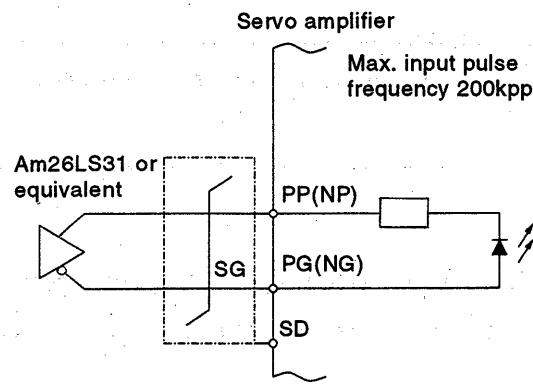
- Input pulse specification



2) Differential line driver system

- Interface example

- Input pulse specification



3. WIRING

3-2 Servo Motor

3-2-1 Connection instructions

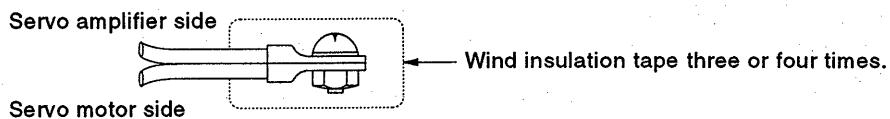
⚠ WARNING Insulate the power connection terminals to prevent an electric shock.

⚠ CAUTION

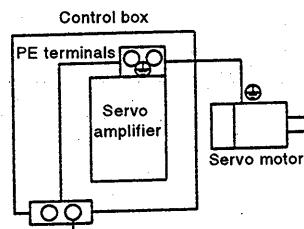
1. Connect the output terminals (U, V, W) correctly. Otherwise, the servo motor will not operate correctly.
2. Do not connect AC power supply directly to the servo motor. Otherwise, a fault may occur.

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

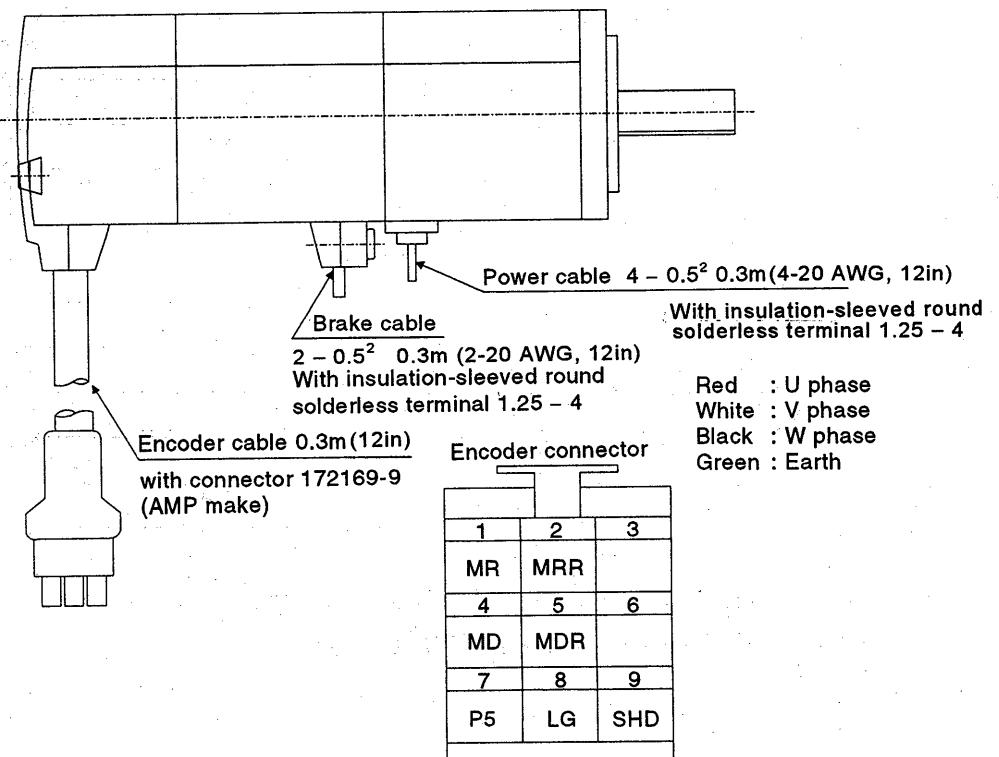
- 1) Wind insulation tape around the connection three or four times to ensure insulation. For the EN Standard-compliant models, make connection via a fixed terminal block.



- 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.



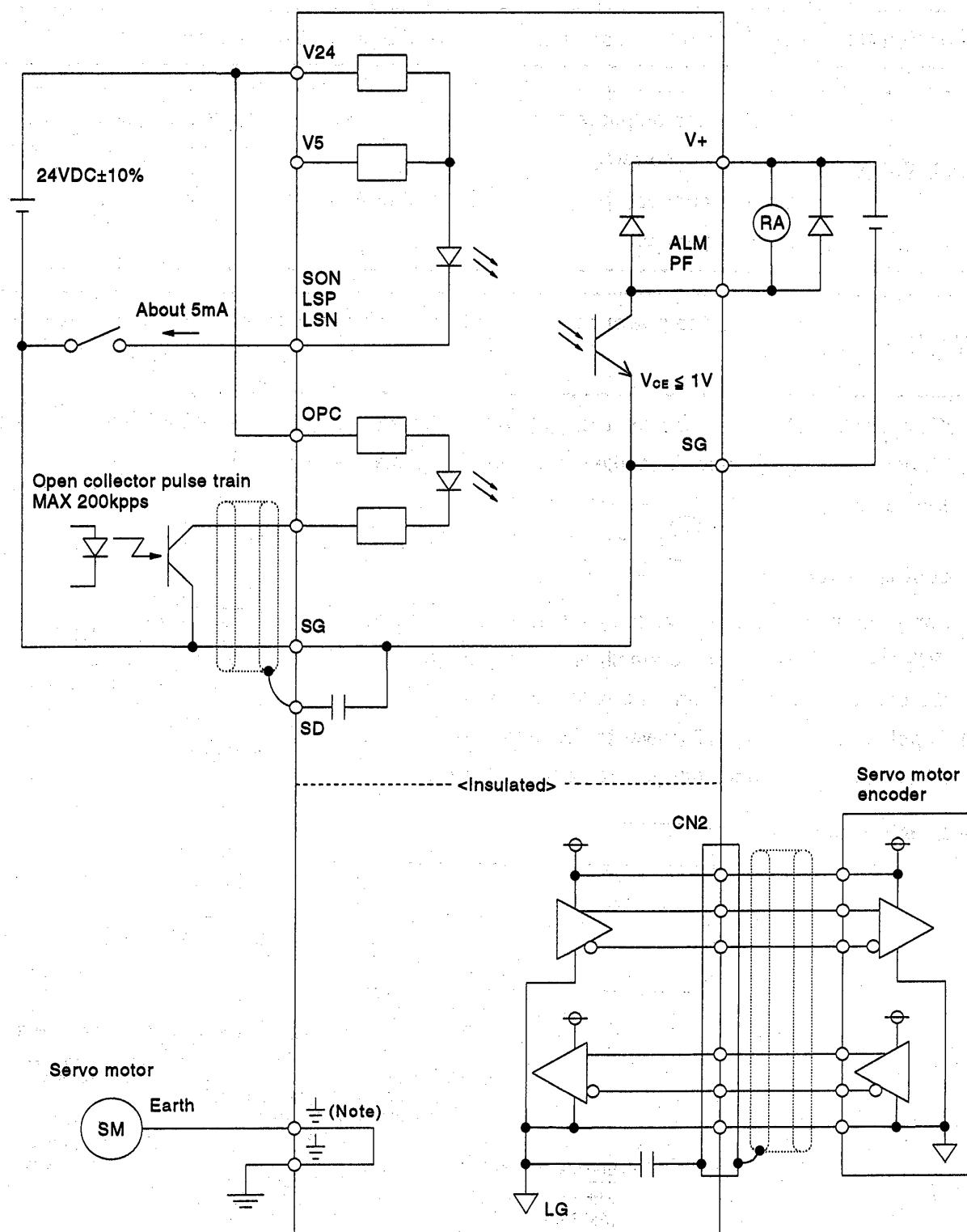
3-2-2 I/O terminals



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

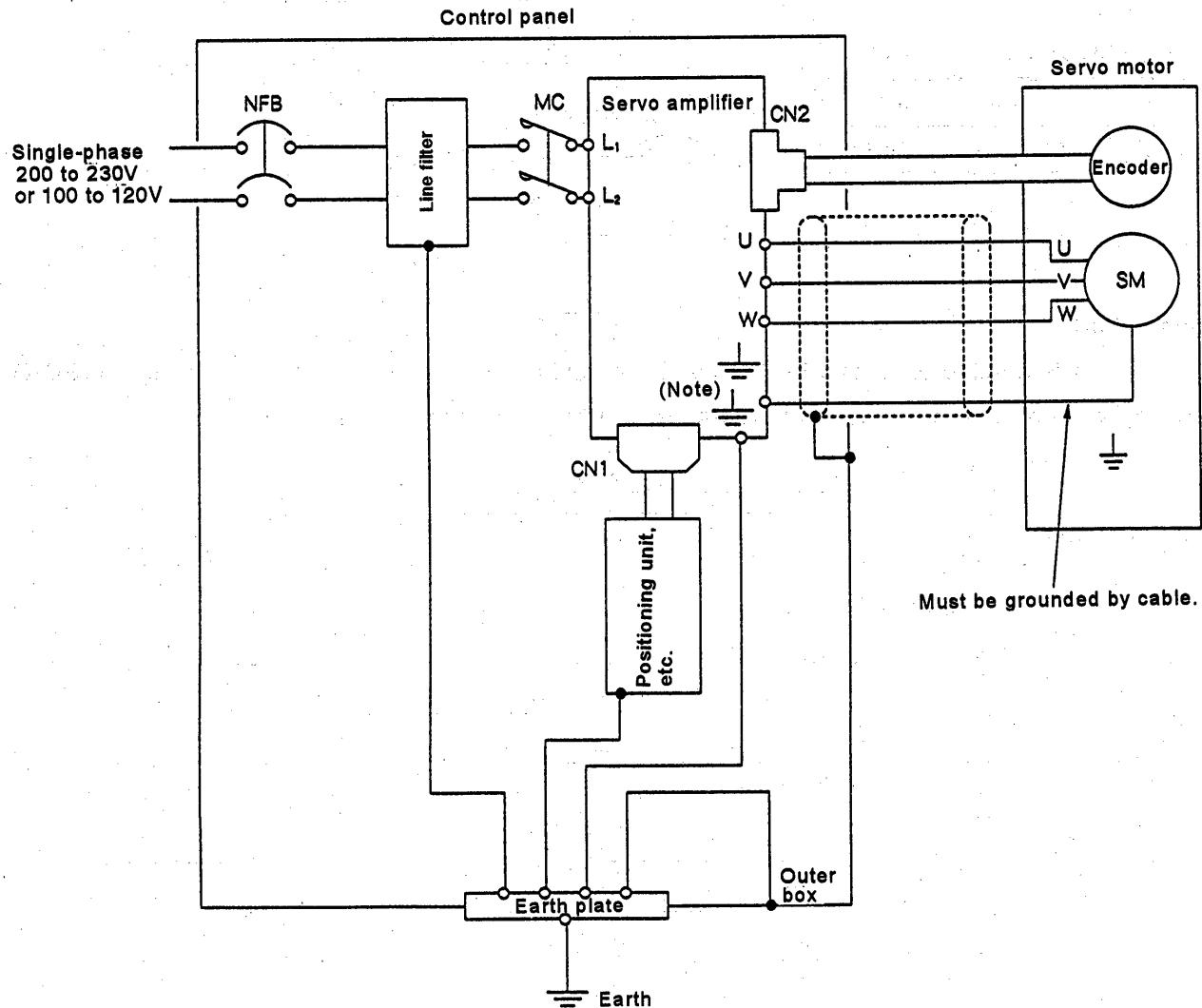
1. Connect the servo amplifier and servo motor to ground.
2. For the EN Standard-compliant model, always connect the protective earth (PE) terminal (marked \ominus) of the servo amplifier to the protective earth (PE) of the control box to prevent an electric shock.

WARNING

The servo amplifier switches the power transistor on-off to supply power to the servo motor. Depending on the wiring and ground cable routing, the servo amplifier may be affected by the switching noise (due to di/dt and dv/dt) of the transistor. To prevent a fault, always follow the grounding and wiring instructions.

Refer to the following diagram and run the ground cable, such as a flat mesh copper cable, as large as possible (3.5mm^2 (12 AWG) or more is desirable).

To conform to the EMC Directive, refer to the EMC INSTALLATION GUIDELINES (IB(NA)67310).



Note: When using the EN Standard-, UL/C-UL Standard-compliant model, use the protective earth (PE) terminals.

3. WIRING

3-5 Power Supply Circuit

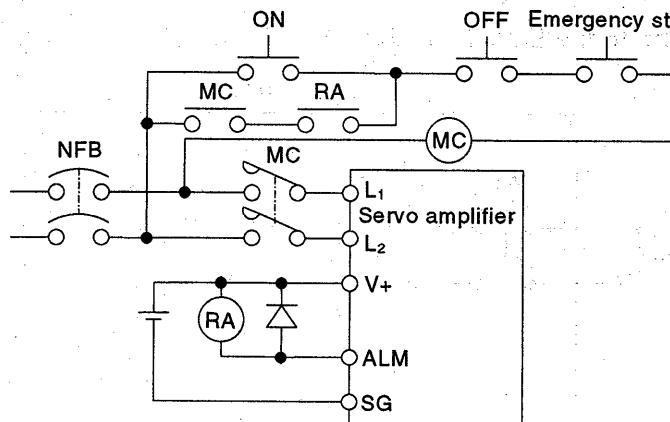
1. If you suspect faulty operation, immediately switch the power off. Continuous flow of a large current may cause a fire.
2. When a regenerative brake resistor is used, use an alarm signal to switch power off. Otherwise, a regenerative brake transistor fault may overheat the regenerative brake resistor 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.

CAUTION

(1) Connection example

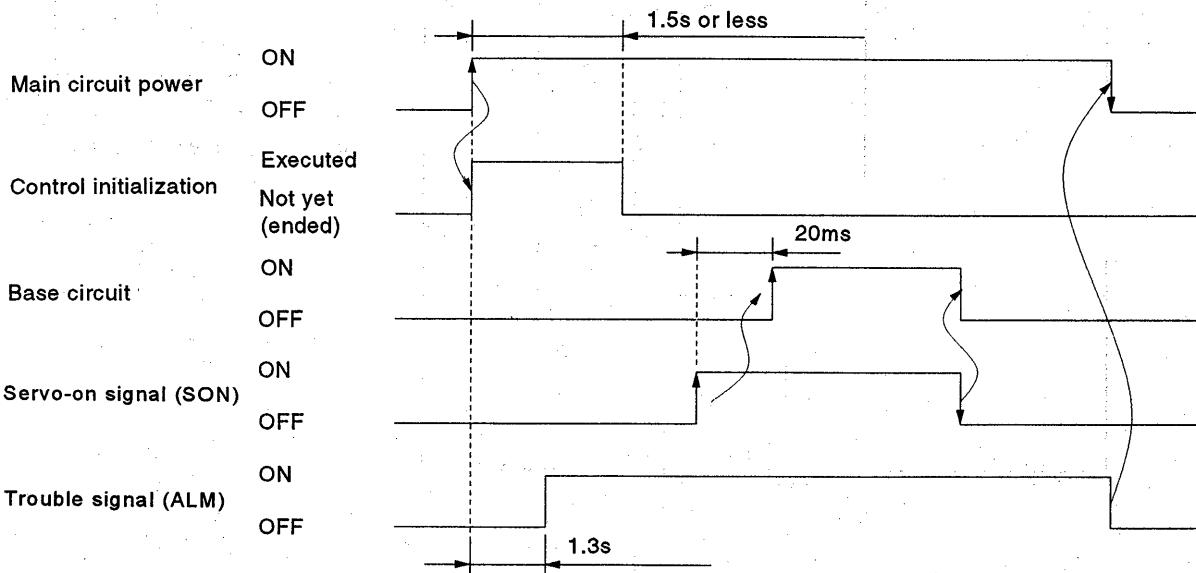
Wire the power and main circuits as shown below. A no-fuse breaker (NFB) must be used with the input cables of the power supply.

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



(2) Timing chart

When power is applied to L₁ and L₂, the control circuit is switched on. The servo-on signal (SON) is switched on after about 1.5s, then operation can be performed.



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Switching power on within 5s after power-off will cause the undervoltage alarm (A10).

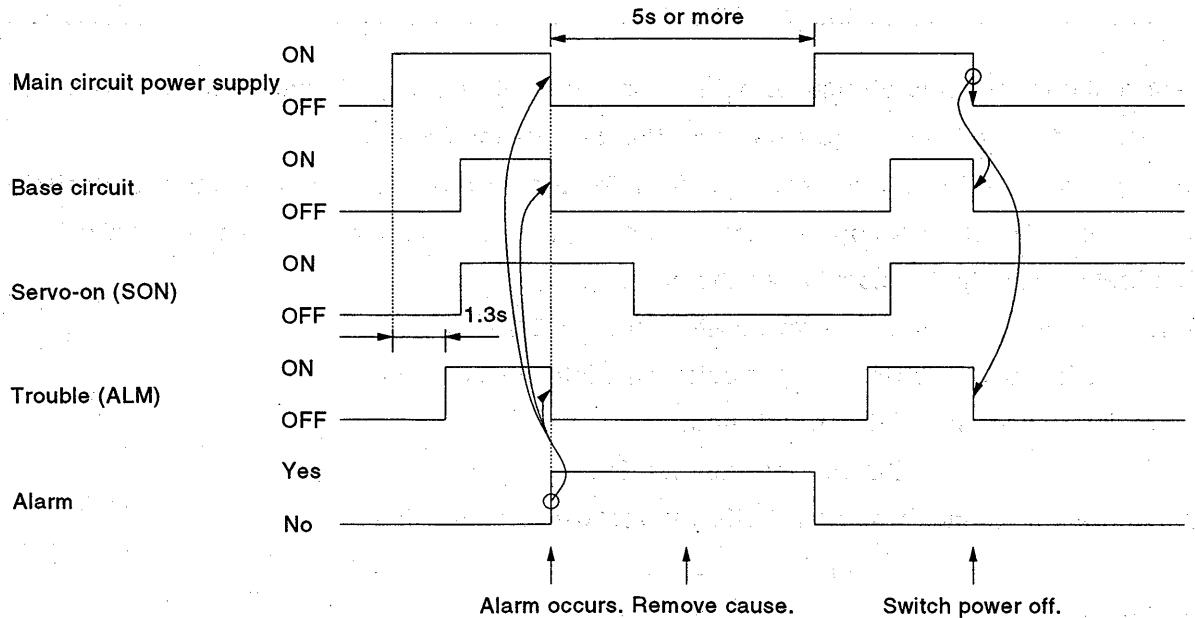
3. WIRING

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.

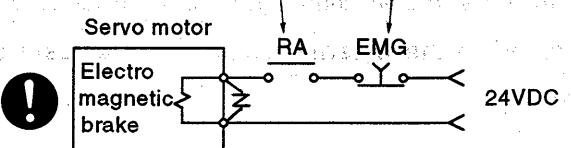
3. WIRING

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.



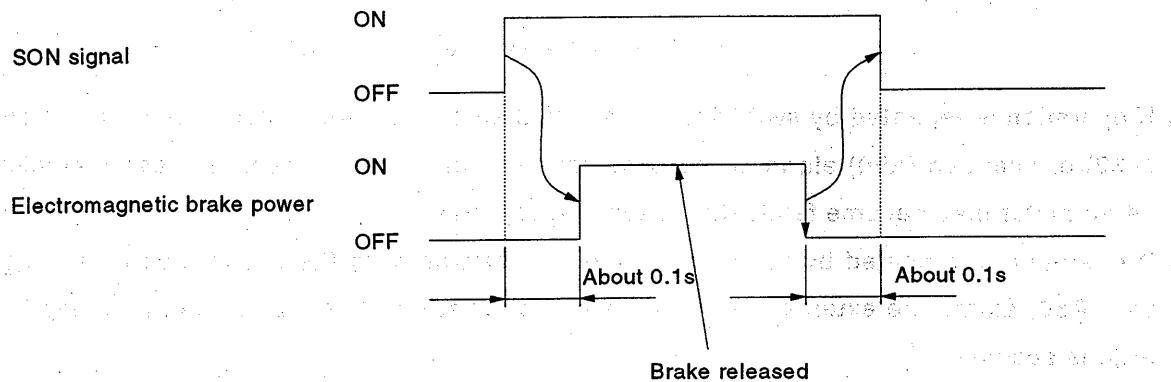
For applications requiring a brake to hold the motor shaft (vertical lift applications), a servo motor with electromagnetic brake should be used. Please note the following:

- 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.