



# *GE Fanuc Automation*

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*Computer Numerical Control Products*

*Beta Series AC Servo Motor*

*Descriptions Manual*

GFZ-65232EN/02

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## *Warnings, Cautions, and Notes as Used in this Publication*

### **Warning**

Warning notices are used in this publication to emphasize that hazardous voltages, currents, temperatures, or other conditions that could cause personal injury exist in this equipment or may be associated with its use.

In situations where inattention could cause either personal injury or damage to equipment, a Warning notice is used.

### **Caution**

Caution notices are used where equipment might be damaged if care is not taken.

### **Note**

Notes merely call attention to information that is especially significant to understanding and operating the equipment.

This document is based on information available at the time of its publication. While efforts have been made to be accurate, the information contained herein does not purport to cover all details or variations in hardware or software, nor to provide for every possible contingency in connection with installation, operation, or maintenance. Features may be described herein which are not present in all hardware and software systems. GE Fanuc Automation assumes no obligation of notice to holders of this document with respect to changes subsequently made.

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# FANUC SERVO MOTOR series

# SAFETY PRECAUTIONS

This "Safety Precautions" section describes the precautions which must be observed to ensure safety when using FANUC servo motors (including spindle motors). Users of any servo motor model are requested to read this manual carefully before using the servo motor.

The users are also requested to read this manual carefully and understand each function of the motor for correct use.

The users are basically forbidden to do any behavior or action not mentioned in this manual. They are invited to ask FANUC previously about what behavior or action is prohibited.

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# 1

## DEFINITION OF WARNING, CAUTION, AND NOTE

This manual includes safety precautions for protecting the user and preventing damage to the machine. Precautions are classified into Warning and Caution according to their bearing on safety. Also, supplementary information is described as a Note. Read the Warning, Caution, and Note thoroughly before attempting to use the machine.

### WARNING

Applied when there is a danger of the user being injured or when there is a damage of both the user being injured and the equipment being damaged if the approved procedure is not observed.

### CAUTION

Applied when there is a danger of the equipment being damaged, if the approved procedure is not observed.

### NOTE

The Note is used to indicate supplementary information other than Warning and Caution.

- **Read this manual carefully, and store it in a safe place.**

# 2

## WARNING

### WARNING

- **Be safely dressed when handling a motor.**

Wear safety shoes or gloves when handling a motor as you may get hurt on any edge or protrusion on it or electric shocks.

- **Use a crane or lift to move a motor from one place to another.**

Motors are heavy. When moving them, use a crane or lift as required. (For the weight of motors, refer to their respective specification manuals.)

When moving a motor using a crane or lift, use a hanging bolt if the motor has a corresponding tapped hole, or textile rope if it has no tapped hole. If a motor is attached with a machine or any other heavy stuff, do not use a hanging bolt to move the motor as the hanging bolt and/or motor may get broken. When moving a motor, be careful not to apply excessive force to its windings as the windings may break and/or their insulation may deteriorate.

- **Do not touch a motor with a wet hand.**

A failure to observe this caution is vary dangerous because you may get electric shocks.

- **Before starting to connect a motor to electric wires, make sure they are isolated from an electric power source.**

A failure to observe this caution is vary dangerous because you may get electric shocks.

- **Do not bring any dangerous stuff near a motor.**

Motors are connected to a power line, and may get hot. If a flammable is placed near a motor, it may be ignited, catch fire, or explode.

- **Be sure to ground a motor frame.**

To avoid electric shocks, be sure to connect the grounding terminal in the terminal box to the grounding terminal of the machine.

- **Do not ground a motor power wire terminal or short-circuit it to another power wire terminal.**

A failure to observe this caution may cause electric shocks or a burned wiring.

\* Some motors require a special connection such as a winding changeover. Refer to their respective motor specification manuals for details.

**WARNING****● Connect power wires securely so that they will not get loose.**

A failure to observe this caution may cause a wire to be disconnected, resulting in a ground fault, short circuit, or electric shock.

**● Do not supply the power to the motor while any terminal is exposed.**

A failure to observe this caution is very dangerous because you may get electric shocks if your body or any conductive stuff touches an exposed terminal.

**● Do not get close to a rotary section of a motor when it is rotating.**

A rotating part may catch your cloths or fingers. Before starting a motor, ensure that there is no stuff that can fly away (such as a key) on the motor.

**● Before touching a motor, shut off the power to it.**

Even if a motor is not rotating, there may be a voltage across the terminals of the motor. Especially before touching a power supply connection, take sufficient precautions. Otherwise you may get electric shocks.

**● Do not touch any terminal of a motor for a while (at least 5 minutes) after the power to the motor is shut off.**

High voltage remains across power line terminals of a motor for a while after the power to the motor is shut off. So, do not touch any terminal or connect it to any other equipment. Otherwise, you may get electric shocks or the motor and/or equipment may get damaged.

**● To drive a motor, use a specified amplifier and parameters.**

An incorrect combination of a motor, amplifier, and parameters may cause the motor to behave unexpectedly. This is dangerous, and the motor may get damaged.

**● Do not touch a motor when it is running or immediately after it stops.**

A motor may get hot when it is running. Do not touch the motor before it gets cool enough. Otherwise, you may get burned.

**● Be careful not get your hair or cloths caught in a fan.**

Be careful especially for a fan used to generate an inward air flow.  
Be careful also for a fan even when the motor is stopped, because it continues to rotate while the amplifier is turned on.

**● Ensure that motors and related components are mounted securely.**

If a motor or its component slips out of place or comes off when the motor is running, it is very dangerous.

# 3 CAUTION

## CAUTION

- **FANUC motors are designed for use with machines. Do not use them for any other purpose.**

If a FANUC motor is used for an unintended purpose, it may cause an unexpected symptom or trouble. If you want to use a motor for an unintended purpose, previously consult with FANUC.

- **Ensure that a base or frame on which a motor is mounted is strong enough.**

Motors are heavy. If a base or frame on which a motor is mounted is not strong enough, it is impossible to achieve the required precision.

- **Be sure to connect motor cables correctly.**

An incorrect connection of a cable cause abnormal heat generation, equipment malfunction, or failure. Always use a cable with an appropriate current carrying capacity (or thickness). For how to connect cables to motors, refer to this manual.

- **Ensure that motors are cooled if they are those that require forcible cooling.**

If a motor that requires forcible cooling is not cooled normally, it may cause a failure or trouble. For a fan-cooled motor, ensure that it is not clogged or blocked with dust and dirt. For a liquid-cooled motor, ensure that the amount of the liquid is appropriate and that the liquid piping is not clogged. For both types, perform regular cleaning and inspection.

- **When attaching a component having inertia, such as a pulley, to a motor, ensure that any imbalance between the motor and component is minimized.**

If there is a large imbalance, the motor may vibrates abnormally, resulting in the motor being broken.

- **Be sure to attach a key to a motor with a keyed shaft.**

If a motor with a keyed shaft runs with no key attached, it may impair torque transmission or cause imbalance, resulting in the motor being broken.

# 4

## NOTE

### NOTE

- **Do not step or sit on a motor.**

If you step or sit on a motor, it may get deformed or broken. Do not put a motor on another unless they are in packages.

- **When storing a motor, put it in a dry (non-condensing) place at room temperature (0 to 40 °C).**

If a motor is stored in a humid or hot place, its components may get damaged or deteriorated. In addition, keep a motor in such a position that its shaft is held horizontal and its terminal box is at the top.

- **Do not remove a nameplate from a motor.**

If a nameplate comes off, be careful not to lose it. If the nameplate is lost, the motor becomes unidentifiable, resulting in maintenance becoming impossible. For a nameplate for a built-in spindle motor, keep the nameplate with the spindle.

- **Do not apply shocks to a motor or cause scratches to it.**

If a motor is subjected to shocks or is scratched, its components may be adversely affected, resulting in normal operation being impaired. Be very careful when handling plastic portions, sensors, and windings, because they are very liable to break. Especially, avoid lifting a motor by pulling its plastic portion, winding, or power cable.

- **Do not conduct dielectric strength or insulation test for a detector.**

Such a test can damage elements in the detector.

- **When testing the winding or insulation resistance of a motor, satisfy the conditions stipulated in IEC34.**

Testing a motor under a condition severer than those specified in IEC34 may damage the motor.

- **Do not disassemble a motor.**

Disassembling a motor may cause a failure or trouble in it.

If disassembly is in need because of maintenance or repair, please contact a service representative of FANUC.

- **Do not modify a motor.**

Do not modify a motor unless directed by FANUC. Modifying a motor may cause a failure or trouble in it.



## NOTE

- **Use a motor under an appropriate environmental condition.**

Using a motor in an adverse environment may cause a failure or trouble in it. Refer to this manual for details of the operating and environmental conditions for motors.

- **Do not apply a commercial power source voltage directly to a motor.**

Applying a commercial power source voltage directly to a motor may result in its windings being burned. Be sure to use a specified amplifier for supplying voltage to the motor.

- **For a motor with a terminal box, make a conduit hole for the terminal box in a specified position.**

When making a conduit hole, be careful not to break or damage unspecified portions. Refer to this manual.

- **Before using a motor, measure its winding and insulation resistances, and make sure they are normal.**

Especially for a motor that has been stored for a prolonged period of time, conduct these checks. A motor may deteriorate depending on the condition under which it is stored or the time during which it is stored. For the winding resistances of motors, refer to this manual, or ask FANUC. For insulation resistances, see the following table.

- **To use a motor as long as possible, perform periodic maintenance and inspection for it, and check its winding and insulation resistances.**

Note that extremely severe inspections (such as dielectric strength tests) of a motor may damage its windings. For the winding resistances of motors, refer to their respective specification manuals, or ask FANUC. For insulation resistances, see the following table.

**MOTOR INSULATION RESISTANCE MEASUREMENT**

Measure an insulation resistance between each winding and motor frame using an insulation resistance meter (500 VDC). Judge the measurements according to the following table.

<b>Insulation resistance</b>	<b>Judgment</b>
100 M $\Omega$ or higher	Acceptable
10 to 100 M $\Omega$	The winding has begun deteriorating. There is no problem with the performance at present. Be sure to perform periodic inspection.
1 to 10 M $\Omega$	The winding has considerably deteriorated. Special care is in need. Be sure to perform periodic inspection.
Lower than 1 M $\Omega$	Unacceptable. Replace the motor.

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**I. DESCRIPTIONS FOR  
FANUC AC SERVO MOTOR  $\beta$  series**



# 1

## OVERVIEW

The FANUC AC SERVO MOTOR  $\beta$  series is a range of cost-effective AC servo motors that are ideally suited to the positioning of the peripheral equipment used with machine tools. The series is notable for the following features.

**Compact**

By employing a larger frame, the length of the motors has been reduced.

**Detector**

An absolute pulse coder ( $\beta$ A32B) or incremental pulse coder ( $\beta$ I32B) is built into each model of the series. (Resolution: 32,768/rev)

**Drip-proof structure**

The series has a drip-proof structure complying with the IP55 standard.

**Optional built-in brake**

An optional built-in holding brake is available.

# 2

## NOTES ON USE



## 2.1 COMPATIBLE AMPLIFIERS

The FANUC AC SERVO MOTOR  $\beta$  series can be driven by the FANUC Power Mate—MODEL E, FANUC SERVO AMPLIFIER  $\alpha$  series or  $\beta$  series.

Motor model	Names and specifications of compatible amplifiers and Power Mate			Connection axis
$\beta 0.5/3000$	$\beta$ series servo amplifier unit (PWM interface)	SVU-12	A06B-6093-H101	
$\beta 1/3000$				
$\beta 2/3000$	$\beta$ series servo amplifier unit (I/O Link interface)	SVU-12	A06B-6093-H151	
	Power Mate—MODEL E (conforms to CE standard)		A02B-0168-B043 A02B-0168-B053	
	$\alpha$ series servo amplifier module	SVM1-12	A06B-6079-H101	
		SVM2-12/12 SVM2-12/20 SVM2-12/40	A06B-6079-H201 A06B-6079-H202 A06B-6079-H204	L-axis and M-axis L-axis L-axis
		SVM3-12/12/12 SVM3-12/12/20	A06B-6079-H301 A06B-6080-H301(Note 5) A06B-6079-H302	L-axis, M-axis, and N-axis L-axis and M-axis
		SVM3-12/20/20	A06B-6080-H302(Note 5) A06B-6079-H303	L-axis
		SVM3-12/12/40	A06B-6080-H303(Note 5) A06B-6079-H305	L-axis and M-axis
		SVM3-12/20/40	A06B-6080-H305(Note 5) A06B-6079-H306 A06B-6080-H306(Note 5)	L-axis
		$\alpha$ series servo amplifier unit	SVU1-12	A06B-6089-H101
	SVU2-12/12 SVU2-12/20 SVU2-12/40 SVU2-12/80		A06B-6089-H201 A06B-6089-H202 A06B-6089-H204 A06B-6089-H209	L-axis and M-axis L-axis L-axis L-axis
	SVU3-12/12/12 SVU3-12/12/20 SVU3-12/20/20		A06B-6089-H321 (Note 6) A06B-6089-H322 (Note 6) A06B-6089-H323 (Note 6)	L-, M-, and N-axis L-axis and M-axis L-axis

Motor model	Names and specifications of compatible amplifiers and Power Mate			Connection axis
$\beta$ 3/3000 $\beta$ 6/2000	$\beta$ series servo amplifier unit (PWM interface)	SVU-20	A06B-6093-H102	
	$\beta$ series servo amplifier unit (I/O Link interface)	SVU-20	A06B-6093-H152	
	Power Mate-MODEL E (conforms to CE standard)		A02B-0168-B042 A02B-0168-B052	
	$\alpha$ series servo amplifier module	SVM1-12	A06B-6079-H102	
		SVM2-12/20 SVM2-20/20 SVM2-20/40	A06B-6079-H202 A06B-6079-H203 A06B-6079-H205	M-axis L-axis and M-axis L-axis
		SVM3-12/12/20 SVM3-12/20/20	A06B-6079-H302 A06B-6080-H302(Note 5) A06B-6079-H303 A06B-6080-H303(Note 5)	N-axis M-axis, N-axis
		SVM3-20/20/20	A06B-6079-H304 A06B-6080-H304(Note 5)	L-axis, M-axis, and N-axis
		SVM3-12/20/40	A06B-6079-H306 A06B-6080-H306(Note 5)	M-axis
		SVM3-20/20/40	A06B-6079-H307 A06B-6080-H307(Note 5)	L-axis and M-axis
		$\alpha$ series servo amplifier unit	SVU1-20	A06B-6089-H102
	SVU2-12/20 SVU2-20/20 SVU2-20/40 SVU2-20/80		A06B-6089-H202 A06B-6089-H203 A06B-6089-H205 A06B-6089-H210	M-axis L-axis and M-axis L-axis L-axis
	SVU3-12/12/20 SVU3-12/20/20 SVU3-20/20/20		A06B-6089-H322 (Note 6) A06B-6089-H323 (Note 6) A06B-6089-H324 (Note 6)	N-axis M-axis and N-axis L-, M-, and N-axis

**WARNING**

Using a combination other than those listed above is likely to result in motor damage.

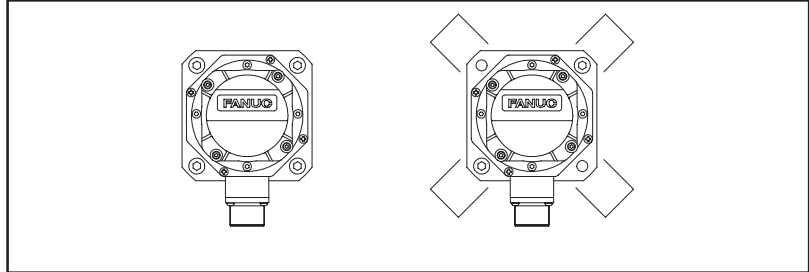
**NOTE**

- For information about the  $\beta$  series amplifier, refer to Part III of this manual.
- For information about the Power Mate-MODEL E, refer to the descriptions of the Power Mate-MODEL E (B-62112E).
- For information about the  $\alpha$  series servo amplifier modules, refer to the relevant Control Motor Amplifier  $\alpha$  series Descriptions (B-65162E).
- For information about the  $\alpha$  series servo amplifier units, refer to the CONTROL MOTOR AMPLIFIER  $\alpha$  series Descriptions (B-65192EN).
- When an  $\alpha$  series three-axis amplifier is used with type B interface-based CNCs, such as the series 20, series 21, and Power Mate-MODEL H, the amplifier specifications differ from those used with other CNCs.
- The three-axis amplifiers of the  $\alpha$  series servo amplifier units can be used only with the TYPE B interface.

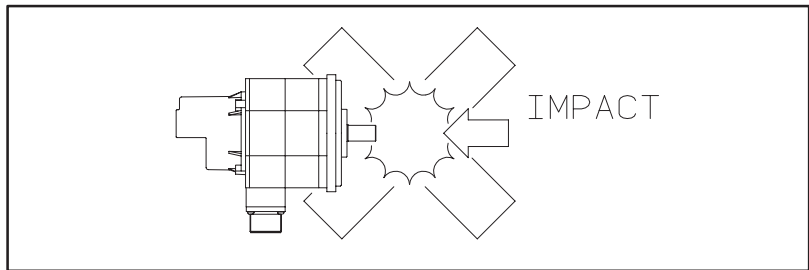
## 2.2 INSTALLATION

The servo motor contains a precision detector, and is carefully machined and assembled to provide the required precision. Pay attention to the following items to maintain the precision and prevent damage to the detector.

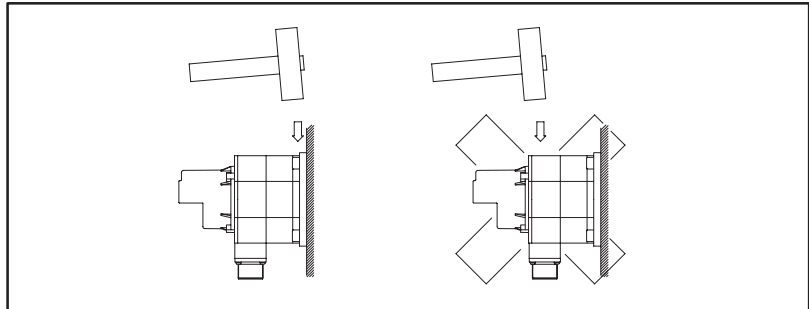
- Secure the servo motor uniformly using four bolt holes provided on the front flange.



- The machine surface on which the motor is mounted must be flat.
- When mounting on the machine, take care not to apply a shock to the motor.



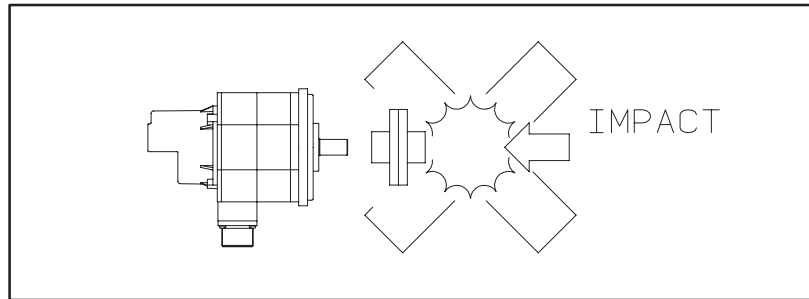
- When it is unavoidable to tap the motor for adjusting the position, etc., use a plastic hammer and tap only the front flange if possible.



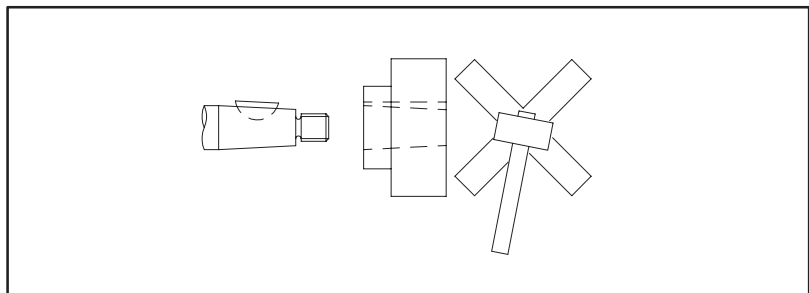
## 2.3 COUPLING

A precision detector is directly connected to the servo motor shaft.  
Pay attention to the following items to prevent damage to the detector.

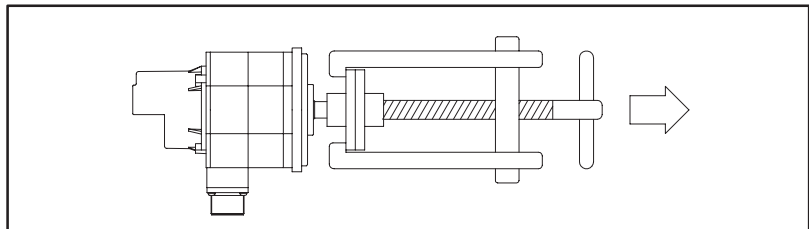
- When connecting the power transmission elements such as a gear, a pulley and a coupling to the shaft, take care not to apply a shock to the shaft.



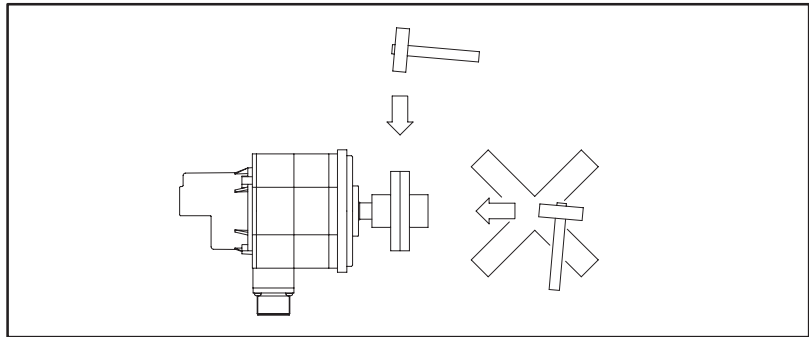
- Generally, in the case of straight shaft, use a span ring for connection with the shaft.
- In the case of tapered shaft, match the tapered surface with the power transmission element and fix by tightening the screw at the end. Even if the power transmission element cannot be mounted securely, for example, because of the woodruff key being tight, do not strike the shaft with a hammer or the like. The woodruff key mounted on the taper shaft is used mainly for positioning, while the tapered surface of the shaft is used for torque transmission. The tapered surface of the transmission element should be ground so that at least 70% of the tapered surface meets the shaft surface for efficient torque transmission.



- To remove the connected power transmission element, be sure to use a jig such as a gear puller.



- When tapping slightly to remove the tightly contacted tapered surface, tap in the radial direction to prevent a shock in the axial direction.



- Suppress the rotary unbalance of the connected power transmission element to the level as low as possible. It is usually believed that there is no problem in the symmetrical form. Be careful when rotating continuously the asymmetrical different form power transmission element. Even if the vibration caused by the unbalance is as small as 0.5G, it may damage the motor bearing or the detector.
- An exclusive large oil seal is used in the front flange of the models  $\beta 3/3000$  and  $\beta 6/2000$ . The oil seal surface is made of steel plate. Take care not to apply a force to the oil seal when installing the motor or connecting the power transmission elements.

## 2.4 AXIS LOAD

The allowable axis load of the motor shaft is as follows.

Motor model	Radial load	Axial load	Front bearing (reference)
$\beta$ 0.5/3000	20kg	5kg	6902
$\beta$ 1/3000 $\beta$ 2/3000	25kg	8kg	6003 (without brake) 6202 (with brake)
$\beta$ 3/3000 $\beta$ 6/2000	70kg	20kg	6205

- The allowable radial load is the value when a load is applied to the shaft end. It indicates the total continuous force applied to the shaft in some methods of mounting (e.g. belt tension) and the force by load torque (e.g., moment/pulley radius).
- The belt tension is critical particularly when a timing belt is used. Too tight belt causes breakage of the shaft or other fault. Belt tension must be controlled so as not to exceed the limits calculated from the permissible radial load indicated above.
- In some operation conditions, the pulley diameter and the gear size need to be checked. For example, when using the model  $\beta$ 6 with a pulley/gear with the radius of 2.5cm or less, the radial load at the occurrence of 180kg-cm torque will exceed 70kg. In the case of timing belt, as the belt tension is added to this value, it is thus necessary to support the shaft end.  
The timing belt is also subject to the belt tension restrictions. Therefore, some support is required; for example, the end of the motor shaft should be supported mechanically.
- Actually, when using a timing belt, a possible fault like a broken shaft can be prevented by positioning the pulley as close to the bearing as possible.
- When there is a possibility of a large load, the machine tool builder needs to examine the life by referring to the shaft diameter, bearing, etc.
- Since the standard single row deep groove ball bearing is used for the motor bearing, a very large axial load can not be used. Particularly, when using a worm gear and a helical gear, it is necessary to provide another bearing.
- The motor bearing is generally fixed with a C-snap ring, and there is a small play in the axial direction. When this play influences the positioning in the case of using a worm gear and a helical gear, for example, it is necessary to fix it with another bearing.



## 2.5 ENVIRONMENT

### Ambient temperature

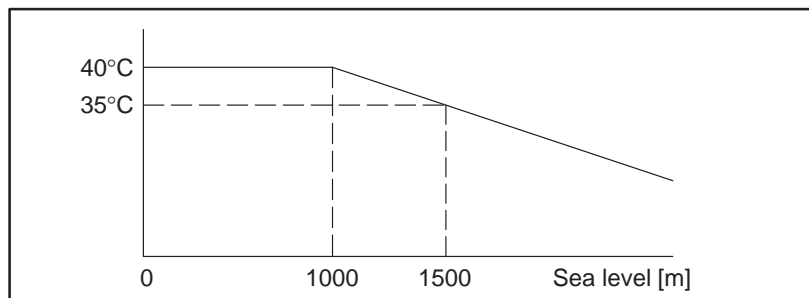
The ambient temperature should be  $-10$  to  $40^{\circ}\text{C}$ . When operating the machine at a higher temperature, it is necessary to lower the output power so that the motor temperature does not exceed the specified constant value. (The values in the data sheet are determined for an ambient temperature of  $20^{\circ}\text{C}$ .)

### Vibration

When installed in a machine, the vibration applied to the motor must not exceed 5G.

### Installation height

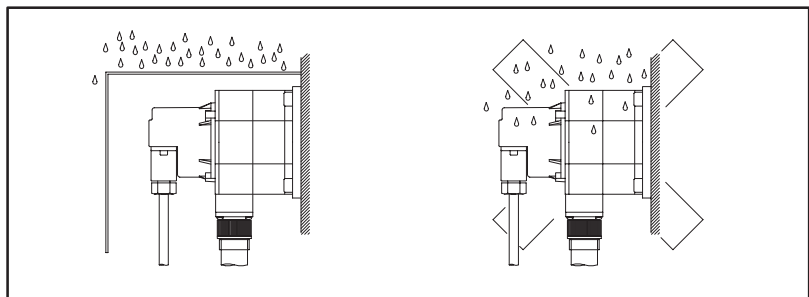
Up to 1,000 meters above the sea level requires, no particular provision for attitude. When operating the machine at a higher level, special care is unnecessary if the ambient temperature is lowered  $1^{\circ}\text{C}$  at every 100m higher than 1,000m. For example, when the machine is installed at a place of 1,500 meters above sea level, there is no problem if the ambient temperature is  $35^{\circ}\text{C}$  or less. For higher temperatures, it is necessary to limit the output power.



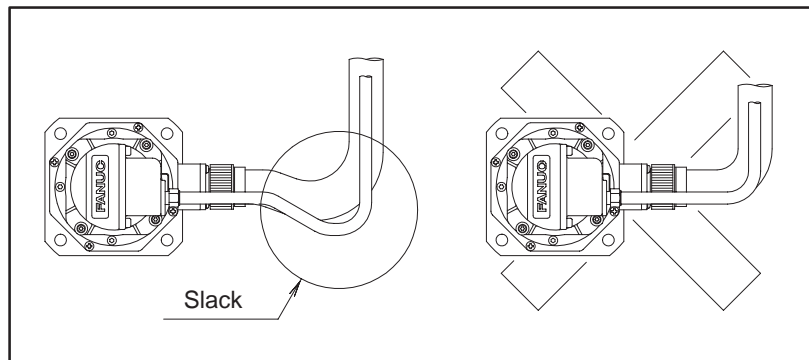
### Drip-proof environment

The protection form for a single motor unit satisfies IP55 of the IEC standards (equivalent to JP55, dust-proof and jet-proof type, of JIS C4004-1980, code for revolving electric machines) These standards, however, refer only to short-term performance. In actual operation, note also the following:

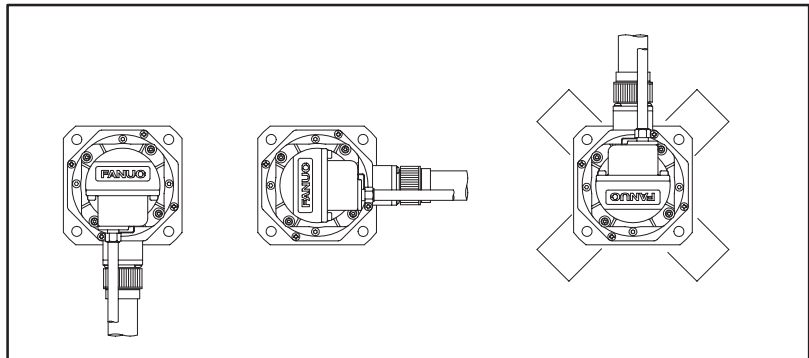
- Protect the motor surface from the cutting fluid or lubricant. Use a cover when there is a possibility of wetting the motor surface. Only the telescopic cover of the sliding part can not completely prevent leakage of the cutting fluid. Pay attention to the drop along the structure body, too.



- Prevent the cutting fluid from being led to the motor through the cable. When the motor connector is used in the up position, put a drip loop in the cable.



- When the motor connector is up, the cutting fluid is collected in the cable connector through the cable. Turn the motor connector sideways or downward as far as possible. Most of the defects caused by the cutting fluid have occurred in the cable connector. The standard receptacle on the motor side is waterproof. If the cable connector will be subjected to moisture, it is recommended that an R class or waterproof plug be used. Suitable plugs are listed in the cable plug combination recommendations in Chapter 8. (The standard MS plug is not waterproof; water is liable to enter the pin section.)



- AMP Dynamic Series connectors are used for the power and signal cables of the  $\beta$  0.5/3000. These connectors are neither drip-proof nor dust-proof. The machine tool builder is requested to take some measure to protect them from drips and dust.

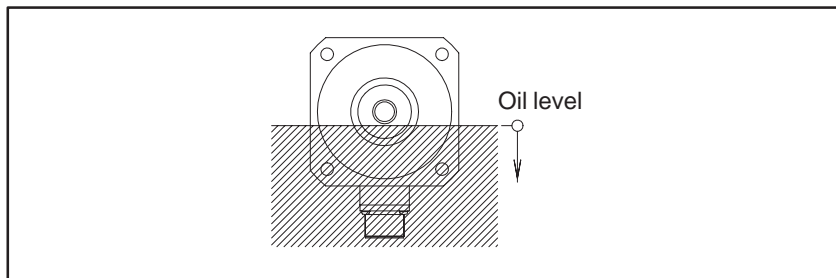
## Shaft attachment section requirements

The shaft of the motor has an oil seal to prevent foreign matter such as oil from entering the motor. Given that motors tend to be used in a wide range of environments, however, protection against oil penetration cannot always be perfect. Therefore, always observe the following precautions when using these motors.

When oil bath lubrication is provided for the gear engagement, for example, the oil level must be below the lip of the oil seal (where the shaft sticks to the oil seal). Set the oil level so that oil merely splashes the lip. Thus, as the shaft rotates, the oil seal can repel oil. If, however, pressure is applied continuously while the shaft is stopped, oil may penetrate the lip. When the shaft is always immersed in oil, for example, under the condition that the motor is to be used with the shaft oriented vertically a special design is required. For example, another oil seal could be installed on the machine side, and a drain provided so that oil penetrating that seal can drain off.

When grease is used for lubrication, the oil seal characteristics are usually lost.

In either case, ensure that no pressure is applied to the oil seal lip.



The motor shaft oil seal diameter and specification are as shown below.

Motor model	Oil seal diameter	Oil seal specification (manufactured by NOK) (FANUC specification)
$\beta$ 0.5/3000	$\phi$ 14mm	AE0526A9 (A98L-0001-0135/E0526A9)
$\beta$ 1/3000, $\beta$ 2/3000	$\phi$ 15mm	AC0616E2 (A98L-0001-0135/C0616E2)
$\beta$ 3/3000, $\beta$ 6/2000	$\phi$ 24mm	BC3554E1 (A98L-0004-0249/A1188RX)

## 2.6 ACCEPTANCE AND STORAGE

When the servo motor is delivered, check the following items.

- The motor meets the specifications.  
(Specifications of the model/shaft/detector)
- Damage caused by the transportation.
- The shaft is normal when rotated by hand.
- The brake works.
- Looseness or play in screws.

FANUC servo motors are completely checked before shipment, and the inspection at acceptance is normally unnecessary. When an inspection is required, check the specifications (wiring, current, voltage, etc.) of the motor and detector.

Store the motor indoors. However avoid storing in the following places.

- Place with high humidity so condensation will form.
- Place with extreme temperature changes.
- Place always exposed to vibration.  
(The bearing may be damaged.)
- Place with much dust.

The storage temperature is  $-20^{\circ}\text{C}$  to  $+60^{\circ}\text{C}$ .

# 3

## INSTRUCTIONS



### 3.1 DRIVE SHAFT COUPLING

#### Direct connection using a flexible coupling

There are four methods for connecting the motor shaft to the ball screw:

- Direct connection through a flexible coupling
- Direct connection through a rigid coupling
- Connection through gears
- Connection through timing belts

It is important to understand the advantages and disadvantages of each method, and select one that is most suitable for the machine.

Direct connection by a flexible coupling has the following advantages over connection using gears:

- Even if the angle of the motor shaft to the ball screw changes, it can be compensated to a certain extent.
- Because a flexible coupling connects elements with less backlash, driving noise from joints can be significantly suppressed.

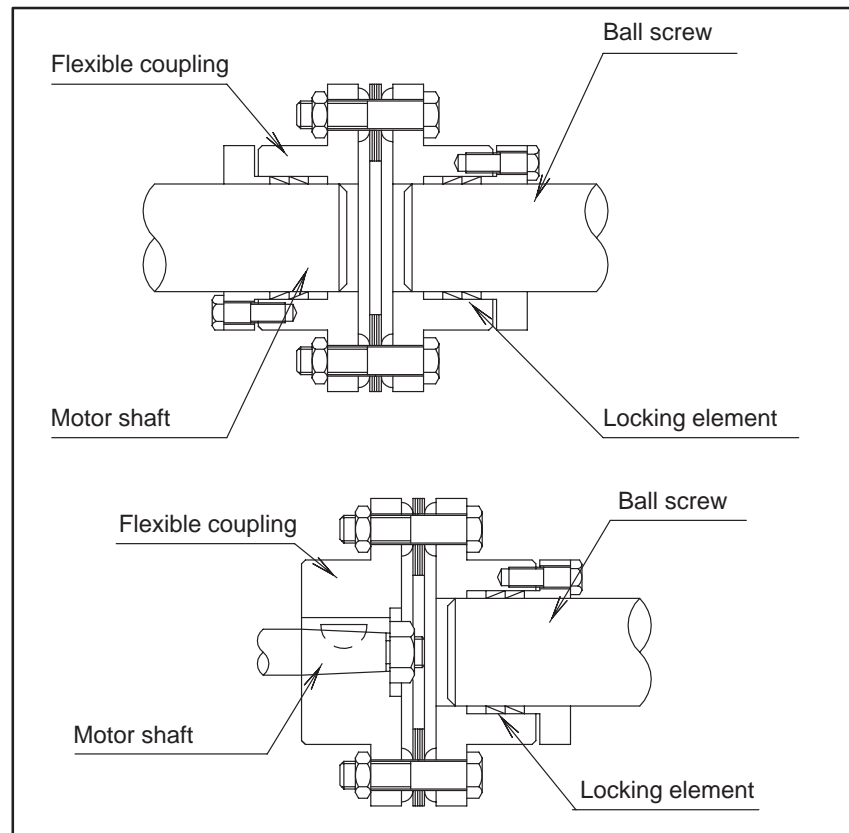
However, this method has the following disadvantages:

- The motor shaft and the ball screw must not slide from each other in the radial direction (for single coupling).
- Loose assembly may result in lower rigidity.

When the motor shaft needs to be connected directly to the ball screw, connecting them using a flexible coupling facilitates adjustment and installation of the motor.

To use a single coupling, the machine needs to be designed so that the centers of the motor shaft and the ball screw are aligned.

If it is difficult to align the centers, a double coupling needs to be employed.



### Direct connection using a rigid coupling

Direct connection using a rigid coupling has the following advantages over direct connection using a flexible coupling:

- More economical
- The coupling rigidity can be increased.
- If the rigidity is the same as with a flexible coupling, the inertia can be reduced.

However, this method has the following disadvantages:

- The motor shaft and the ball screw must not slide from each other in the radial direction, and the angle of the motor shaft to the ball screw must be fixed.

For this reason, a rigid coupling needs to be mounted very carefully. It is desirable that the run-out of the ball screw is 0.01 mm or less. When a rigid coupling is used on the motor shaft, the run-out of the hole for the ball screw must be set to 0.01 mm or less by adjusting the tightness of the span ring.

The run-out of the motor shaft and the ball screw in the radial direction can be adjusted or compensated to a certain extent by deflection. Note, however, that it is difficult to adjust or measure changes in the angle. Therefore, the structure of the machine should be such that precision can be fully guaranteed.

### Gears

This method is used when the motor cannot be put in line with the ball screw because of the mechanical interference problem or when the reduction gear is required in order to obtain large torque. The following attention should be paid to the gear coupling method:

- Grinding finish should be given to the gear, and eccentricity, pitch error, tooth-shape deviations etc. should be reduced as much as possible. Please use the JIS, First Class as a reference of precision.
- Adjustment of backlash should be carefully performed. Generally, if there is too little backlash, a high-pitched noise will occur during high-speed operation, and if the backlash is too big, a drumming sound of the tooth surfaces will occur during acceleration/deceleration. Since these noises are sensitive to the amount of backlash, the structure should be so that adjustment of backlash is possible at construction time.

### Timing belt

A timing belt is used in the same cases as gear connection, but in comparison, it has advantages such as low cost and reduced noise during operation, etc. However, it is necessary to correctly understand the characteristics of timing belts and use them appropriately to maintain high precision.

Generally, the rigidity of timing belt is sufficiently higher than that of other mechanical parts such as ball screw or bearing, so there is no danger of inferiority of performance of control caused by reduction of rigidity by using timing belt. When using a timing belt with a position detector on the motor shaft, there are cases where poor precision caused by backlash of the belt tooth and pulley tooth, or elongation of belt after a long time becomes problem, so consideration should be given to whether these errors significantly affect precision. In case the position detector is mounted behind the timing belt (for example, on the ball screw axis), a problem of precision does not occur.

Life of the timing belt largely varies according to mounting precision and tension adjustment. Please refer to the manufacturer's Instruction Manual for correct use.

### Connection between the straight shaft and a connecting element

To use a straight shaft that has no key groove, connect the shaft with a coupling using a span ring.

Because the span ring connects elements by the friction generated when the screw is tightened, it is free from backlash and the concentration of stress. For this reason, the span ring is highly reliable for connecting elements.

To assure sufficient transmission with the span ring, factors such as the tightening torque of the screw, the size of the screw, the number of screws, the clamping flange, and the rigidity of connecting elements are important. Refer to the manufacturer's specifications before using the span ring.

When a coupling or gear is mounted using the span ring, tighten the screws to remove a run-out of the coupling or gear including the shaft.



## 3.2 MACHINE MOVEMENT PER 1 REVOLUTION OF MOTOR SHAFT

The machine movement per 1 revolution of motor shaft must be determined at the first stage of machine design referring the load torque, load inertia, rapid traverse speed, and relation between minimum increment and resolution of the position sensor mounted on the motor shaft. To determine this amount, the following conditions should be taken into consideration.

- The machine movement per 1 revolution of motor shaft ("L") must be such that the desired rapid traverse speed can be obtained. For example, if the maximum motor speed is 1500 rpm and the rapid traverse speed must be 12 m/min., the amount of "L" must be 8 mm/rev. or higher.
- As the machine movement per 1 revolution of motor shaft is reduced, both the load torque and the load inertia reflected to motor shaft also decrease.  
Therefore, to obtain large thrust, the amount of "L" should be the lowest value at which the desired rapid traverse speed can be obtained.
- Assuming that the accuracy of the reduction gear is ideal, it is advantageous to make the machine movement per 1 rev. of motor shaft as low as possible to obtain the highest accuracy in mechanical servo operations. In addition, minimizing the machine movement per 1 rev. of motor shaft can increase the servo rigidity as seen from the machine's side, which can contribute to system accuracy and minimize the influence of external load changes.
- An optimum condition for the servo system is attained when the motor rotor inertia is equal to the load inertia reflected to the motor shaft. If the machine operation is characterized by repeated acceleration/deceleration (for example, in a machine such as a punch press or print board drill), a heating problem may occur due to the current caused by acceleration and deceleration. Should this occur, specify the amount of machine movement per motor rotation so as to satisfy the optimum condition as much as possible.

# 4

## SELECTING A MOTOR

When selecting an applicable motor, the load, feedrate, increment system, and other conditions must be considered. This section describes how to calculate the load and other conditions, showing an example of a table with a horizontal axis.

A motor is subjected to two types of load: load torque (including friction) and load inertia. Calculate the two loads accurately and select a motor that satisfies the following conditions:

### Condition 1

**When the machine is operating without any load, the torque is lower than or equal to the 70% continuous torque rating.**

If the rated torque is exceeded because of an increase in the friction coefficient when the machine tool is stopped or operated at an extremely low speed, the motor may be overheated by the current flowing when the machine tool is stopped. If the rated torque is exceeded due to viscosity when the machine tool is operated at a high speed, a sufficient acceleration torque may not be obtained, resulting in need for a considerable increase in the acceleration time constant. (It would appear that no current flows through the motor when the machine tool stops. Actually, however, a current continuously flows to balance the torque with the friction produced at a low speed.)

### Condition 2

**Acceleration can be made with a desired time constant.**

Generally, the load torque helps deceleration. If acceleration can be executed with a desired time constant, deceleration can be made with the same time constant. Calculate the acceleration torque and check that the torque required for acceleration is within the intermittent operating zone of the motor.

### Condition 3

**The frequency of positioning in rapid traverse is set to a desired value.** The greater the frequency of positioning in rapid traverse, the greater the ratio of acceleration time to the entire operation time. This may overheat the motor. When the acceleration time constant is increased according to the rapid traverse feedrate and positioning frequency constant, the amount of produced heat decreases in inverse proportion to the acceleration time constant.

### Condition 4

**If the load condition varies during a single cycle, the root-mean-square value of the torques is smaller than or equal to the rated torque.**

### Condition 5

**The time for which the table can be moved with the maximum load torque (percentage duty cycle and ON time) is within a desired range.**

## 4.1 MOTOR SELECTION

Select a suitable motor according to the load to be applied, rapid traverse feedrate, and increment system. To ensure satisfactory motor selection, the user should determine the conditions of use according to the servo motor selection data table (models for positioning) given at the end of this section. Enter the necessary machine data (up to the external detector item) in the servo motor selection data table (models for positioning). If the customer sends it to FANUC, we will provide the remaining items, and check the customer-provided data. For details of each item in the servo motor selection data table, see the descriptions below.

### 4.1.1 Blanks for Those Other than Data

<b>Kind of machine tool</b>	Fill in this blank with a general name of machine tools, such as lathe, milling machine, machining center, and others.
<b>Type of machine tool</b>	Fill in this blank with the type of machine tool decided by machine tool builder.
<b>CNC equipment</b>	Fill in this blank with the name of CNC (15-TB, 16-MC, etc.) employed.
<b>Names of axes</b>	Fill in this blank with names of axes practically employed in CNC command. If the number of axes exceeds 2 axes, enter them in the second sheet.
<b>Blanks of version number, date, name, and reference number.</b>	These blanks are left blank by the FANUC.

### 4.1.2 Data Items to be Entered

The machine tool builder is to provide the following data: direction of movement, feed mechanism, mechanical specifications, and external position detector. Enter either determined or desired values for these items. Leave blank any items for which a value cannot be determined. FANUC will enter an appropriate value, considering the overall specification. Each item is described in detail below.

#### **Specifications of moving object**

Data in this blank are used for determining approximate values of motor load conditions (inertia, torque). Fill in blanks of all items.

- **Axis movement direction**

Enter the movement directions of driven parts such as table, tool post, etc. Write the angle from the horizontal level, if their movement directions are slant (Example : Slant 60°)

Whether their movement directions are horizontal or vertical (or slant) is necessary for calculating the regenerative energy. Fill in this blank without fail.

- **Weight of driven parts**

Enter the weight of driven parts, such as table, tool post, etc. by the maximum value including the weight of workpiece, jig, and so on. Do not include the weight of the counter balance in the next item in this item.

- **Counter balance**

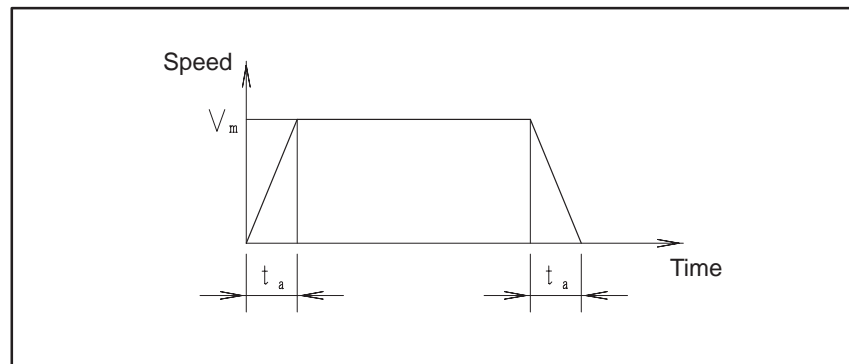
Enter the weight of the counter balance in the vertical axis, if provided. Write the force in case of hydraulic balance.

- **Table support** Enter the type of table slide as to rolling, sliding, or static pressure type. If a special slide way material like Turcite is used, note it.
  
- Feed mechanism** Enter values for whichever items are pertinent.

  - **Feed screw** Enter the diameter, pitch, and axial length of the lead screw in order.
  - **Rack and pinion** Enter the pinion diameter and amount of travel for the machine tool, per revolution of the pinion.
  - **Others** When using a feed mechanism other than the above, provide details of the mechanical section, and enter a travel amount for the machine tool.

- Mechanical specifications** Data in this blank serve as the basis for selecting the motor. Enter these data correctly.

  - **Movement per rotation of motor** Enter the movement of the machine tool when the motor rotates one turn.  
Example
    - When the pitch of ball screw is 12 mm and the gear ratio is  $2/3$ ,  
 $12 \times 2/3 = 8$  mm
    - When the gear ratio is  $1/72$  in rotary table ;  
 $360 \times 1/72 = 5$  deg
  - **Total gear ratio** Enter the gear ratio between the ball screw and the servo motor, gear ratio between the final stage pinion and the servo motor in case of the rack pinion drive, or gear ratio between the table and the motor in case of rotary table.
  - **Inertia** Enter a load inertia value reflected to the motor shaft.  
It is not always necessary to enter this inertia value in detail.  
Enter it as a 2-digit or 1-digit value. (Example : 0.2865→0.29 or 0.3)  
Do not include any inertia of the motor proper in this value.
  - **Least input increment CNC** Enter the least input increment of NC command. The least input increment is 0.01 mm in  $\beta$  series servo motor.
  - **Maximum rapid traverse feedrate** Enter a maximum rapid traverse feedrate according to the mechanical specifications.
  - **Motor speed during rapid traverse** FANUC will enter this value. The motor speed for the maximum rapid traverse feedrate is entered.
  - **Acceleration / deceleration time at rapid traverse** The acceleration/deceleration time is determined according to the load inertia, load torque, motor output torque, and working speed.  
The acceleration/deceleration mode at rapid traverse is generally linear acceleration/deceleration in FANUC's CNC.



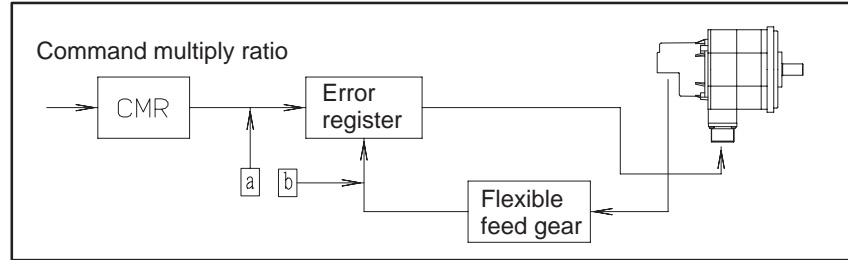
- **Distance covered when positioning during rapid traverse** Enter the amount of travel when positioning during rapid traverse.
  - **Rapid traverse positioning frequency** Enter the rapid traverse positioning frequency by the number of times per minute. This value is used to check if the motor is overheated or not by a flowing current during acceleration / deceleration or to check the regenerative capacity of the amplifier.
  - **Load torque**
    - **In low speed**  
Since the torque produced in low speed without cutting may be applied even during the stop of motor, a sufficient allowance is necessary as compared with the continuous rated torque of the motor. Suppress this load torque to be lower than 60% of the rated torque.
    - **In rapid traverse**  
For the torque during rapid traverse, enter the torque during traveling at rapid traverse steady-state speed.  
Keep this value within the continuous rating. Do not include any torque required for acceleration/deceleration in this item.
  - **Backlash amount** Enter the backlash amount between the motor and the final driven part like table by converting it into the move amount of the table.
- External detector**
- This item is required to determine the servo system stability under the influence of an external position detector, mounted on the motor. When configuring a servo system using a linear scale, always enter this data.
- **External position detector** If you want to mount an external position detector outside the motor, specify the name of the detector and its detection unit. If you want to use a rotary detector such as a resolver or rotary encoder, enter the following items in the "remarks" column.
    - Resolver  
Move amount of machine tool per revolution of resolver  
Number of wave lengths per revolution of resolver
    - Rotary encoder  
Move amount per revolution of pulse coder  
Number of pulses (per revolution)  
Gear diameter and reduction ratio
- Motor specifications**
- **Motor model Feedback (FB) type** Enter the model name of the motor employed and the specifications of the built-in feedback unit by using symbols.
  - **Option, special specifications** Enter special specifications, if any, in this blank.

**Data to be provided by  
FANUC**

- **Input multiply ratio,  
command multiply ratio,  
and flexible feed gear  
ratio**

The NC set values required for moving the machine tool at the least input increment values are entered in these blanks.

The relation among these values as illustrated below.



In the above figure, each ratio is set so that the units of the two inputs (a and b) of the error register are the same. The β pulse coder uses a flexible feed gear as standard. So, CMR is normally set to 1. When other than 1 is to be set for CMR, contact FANUC for details.

For the flexible feed gear (F.FG), the ratio of the number of position pulses required per motor shaft revolution to the number of feedback pulses is set. The set value is obtained as follows:

$$F.FG = \frac{\text{Number of position pulses required per motor shaft revolution}}{1,000,000}$$

**NOTE**

The maximum permissible value for both the numerator and denominator is 32,767. So, the fraction should be reduced to its lowest terms, after which the resultant numerator and denominator should be set.

**Example)**

Suppose that the NC uses increments of 10μm, the machine travel distance per motor shaft revolution is 8 mm, and pulse coder αA32B is used.

$$F.FG = \frac{800}{1,000,000} = \frac{1}{1,250} \quad CMR = 1$$

- **Position loop gain**

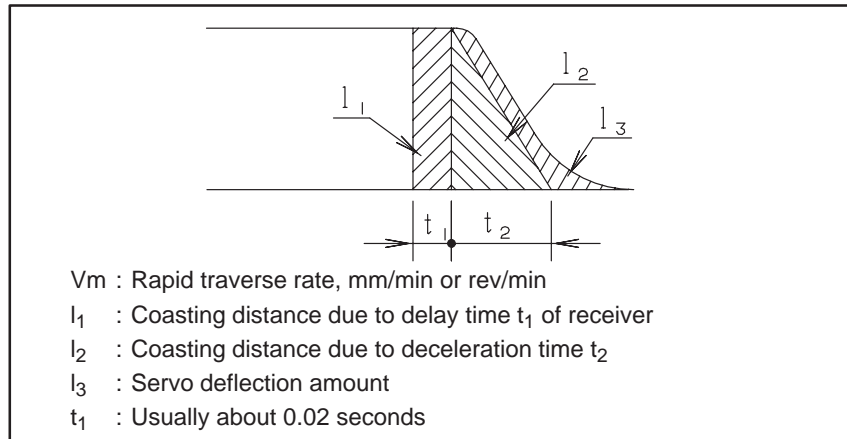
Fill in this blank with a value which is considered to be settable judging it from the inertia value based on experiences. Since this value is not always applicable due to rigidity, damping constant, and other factors of the machine tool, it is usually determined on the actual machine tool. If the position detector is mounted outside the motor, this value is affected by the machine tool rigidity, backlash amount, and friction torque value. Enter these values without fail.

- **Deceleration stopping distance and dynamic brake stopping distance**

In these items, the coasting distance of the machine tool at the machine tool stroke end is entered. Usually, a stroke end consists of two limit stages. The stage-1 limit triggers a deceleration stop, while the stage-2 limit triggers a dynamic brake stop. When the stage-1 limit is tripped, the displayed position exactly matches the stop position of the machine tool. When the stage-2 limit is tripped, the position data is lost. The stage-2 limit is designed to stop the machine tool if the machine tool becomes uncontrollable and runs away. Therefore, always install a stage-2 limit to protect the machine tool from damage.

- Deceleration stop distance

Enter the coasting distance when the machine tool is decelerated and stopped at the stroke end.

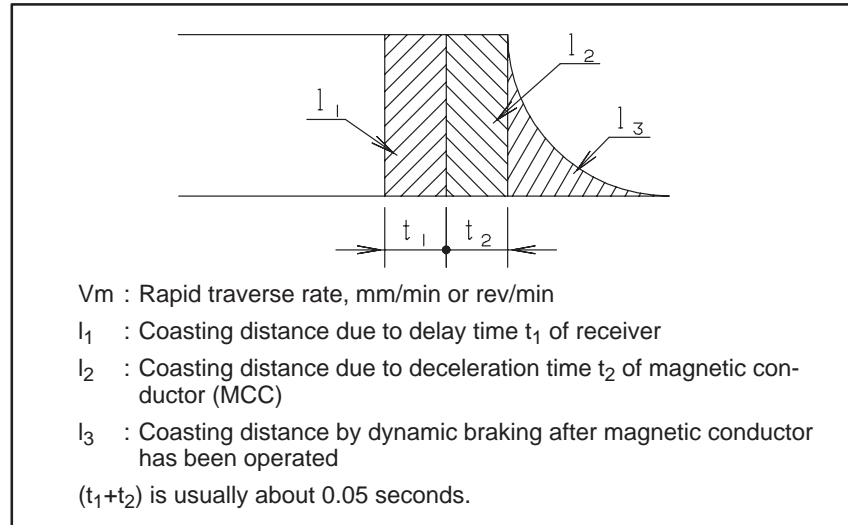


$$\text{Coasting distance} = \frac{V_m}{60} \times \left( t_1 + \frac{t_2}{2} + \frac{1}{k_s} \right) \text{ (mm or deg)}$$

$k_s$  : Position loop gain ( $\text{sec}^{-1}$ )

- Dynamic brake stop distance

This is coasting distance when the machine tool is stopped by dynamic braking with both ends of the motor power line shorted, if the machine tool is in trouble.



**Coasting distance(mm or deg)**

$$= \frac{V_m}{60} \times (t_1 + t_2) + (J_m + J_1) \times (A N_o + B N_o^3) \times L$$

$J_m$  : Motor inertia (kg-cm-s<sup>2</sup>)  
 $J$  : Load inertia (kg-cm-s<sup>2</sup>)  
 $N_o$  : Motor speed at rapid traverse (rpm)  
 $L$  : Machine movement on one-rotation of motor (mm or deg)  
 $N_o L = V_m$   
 A and B are constants that vary with the model of the motor being used. The values for each model are listed under "Coefficients for Calculating the Dynamic Brake Stopping Distance."

- Specifications of amplifier and transformer

For these items, the specifications of the servo amplifier and transformer to be used are entered. Enter a desired amplifier model, if any, as the remarks item.

**Coefficients for calculating the dynamic brake stopping distance**

Model	A	B	Jm (kgf-cm-s <sup>2</sup> )
β0.5/3000	$8.1 \times 10^{-2}$	$5.9 \times 10^{-8}$	0.00018
β1/3000	$4.8 \times 10^{-2}$	$5.7 \times 10^{-8}$	0.0034
β2/3000	$1.9 \times 10^{-2}$	$3.1 \times 10^{-8}$	0.0067
β3/3000	$9.7 \times 10^{-3}$	$2.4 \times 10^{-8}$	0.020
β6/2000	$3.9 \times 10^{-3}$	$1.2 \times 10^{-8}$	0.040

The values of A and B are calculated by assuming that the resistance of the power line is 0.05 Ω per phase. The values will vary slightly according to the resistance value of the power line.

Coefficient will vary depending on the servo amplifiers. The machine may stop by a less distance movement by the coefficient.



**MTB** Servo motor selection data table (models for positioning)

Machine		Model	
NC model	NC : FANUC	Name	
<b>Item</b>	<b>Axis name</b>		
Specifications of moving object			
	Direction of movement (horizontal, vertical, rotation)		
	Weight of the moving object (including the workpiece)	kg	
	Counterbalance	kg	
	Table support (sliding contact, rolling contact, static pressure) (*)		
Feed mechanism (Select one of the following and enter the corresponding data.)			
	1 Ball screw: Diameter $\times$ pitch $\times$ length		
	2 Rack and pinion: Diameter of pinion (traveling distance of the machine tool per revolution of the pinion: mm)		
	3 Others		
Mechanical specifications			
	Traveling distance of the machine tool per revolution of the motor	mm	
	Total gear reduction ratio		
	Inertia (Note "before deceleration" or "applied to the motor shaft.")	kgf $\cdot$ cm $\cdot$ s <sup>2</sup>	
	Least input increment of NC (resolution)	mm	
	Maximum rapid traverse feedrate	mm/min	
	Motor speed in rapid traverse	1/min	
	Acceleration/deceleration time in rapid traverse	m-sec	
	Frequency of positioning in rapid traverse	frequency/min	
	In the remarks section, note the operation cycle (speed pattern) if it is determined.		
	Steady-state load torque (such as frictional torque that occurs when the table moves)	kgf $\cdot$ cm	
	Backlash	mm	
Fill in these blanks when an external detector is used.(**)			
	Type of external position detector (detection unit, number of pulses, etc.)		
	Gear diameter and reduction ratio when a rotary encoder is used		
Motor specifications			
	Motor type (desired size and output, if any)		
	FB type (when an absolute position detector is required)		
	Option (when a brake, non-standard shaft, etc. is required)		
FANUC will fill in these blanks.			
	Command multiplier	CMR	
	Detection multiplier	DMR	
	Flexible feed gear	FFG	
	Position loop gain	sec <sup>-1</sup>	
	Deceleration stop distance	mm	
	Dynamic brake stop distance	mm	
	Specifications of amplifier		
	Regenerative discharge unit		
	Specifications of transformer		
Note	(*) Note the friction coefficient of the sliding surface if it is determined.		
	(**) An external position detector is required when: -The positions of the motor and machine may be mechanically displaced, for example, by slippage of a driving tire or an elongated driving chain. (Example:Slip by tire drive, expansion of chain when chain is driver, or etc.)		
Remarks			
	Version	Date	Name
	1		
	2		
	3		

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## 4.2 CHARACTERISTIC CURVE AND DATA SHEET

Performance of each motor model is represented by characteristic curves and data sheet shown below.

---

### 4.2.1 Performance Curves

The typical characteristic curves consist of the following.

#### Torque–speed characteristics

These are known as operating curves and describe the relationship between the output torque and speed of the motor. The motor can be operated continuously at any combination of speed and torque within the prescribed continuous operating zone. To use the motor outside this zone, obtain an operating condition from an overload duty curve, and use the motor intermittently. The limit of continuous operating zone is determined under the following conditions.

- The ambient temperature for the motor is 20°C.
- The drive current of the motor is pure sine wave.

The limit of the intermittent operating zone is determined by the motor input voltage and the limit of the servo axis current.

Due to the negative temperature coefficient of the magnetic material, continuous operating zone must be derated at the rate of 0.19% per degree centigrade rise of magnets. (i.e. for ambient temperature above 20°C derate 0.19% for each degree over)

#### Overload duty characteristic

This is known as a duty cycle curve and used to calculate the ON time (during which the motor can be powered) and OFF time (during which the motor must be kept at a rest to get cooled) for the motor to run intermittently without becoming overheated.

Basically, this curve is obtained from the maximum temperature that the motor can be heated to. Additional limits may be imposed, if the motor is powered with a driving circuit that has a thermal protection device such as a thermal relay or fuse.

See Section 4.2.3 for how to calculate the ON and OFF times.

---

### 4.2.2 Data Sheet

The data sheet gives the values of motor parameters relating to the performance.

The values of parameters are those under the following conditions.

- The ambient temperature for the motor is 20°C.
- The drive current of the motor is pure sine wave.

Important parameters on the data sheet are defined as follows :

#### **Continuous RMS current at stall TENV : Is (Arms)**

Up to 40°C ambient motor can be operated at this RMS current continuously at stall (or low speed) with TENV (Totally Enclosed Non Ventilation).

**Torque constant :  $K_t$  (kgf·cm/Arms)**

This is known as torque sensitivity and represents the torque developed per ampere of phase current. The torque constant is a function of the total flux and the total number of conductors in the armature.

The back EMF constant and the torque constant are inter-related as follows :

$$K_t(\text{kgf} \cdot \text{cm}/\text{Arms}) = 30.6K_v(\text{Volt} \cdot \text{sec}/\text{rad})$$

Thus if  $K_v$  is reduced due to demagnetization of the magnetic field,  $K_t$  is also reduced in the same proportion.

**Back EMF (electromotive force) constant:  $K_v$  (volt·sec/rad)**

A back EMF is a voltage that is generated by rotating a servo motor with external mechanical force. The back EMF constant of a motor represents the relationship between the number of conductors in the armature of the motor and the amount of flux in the field magnet. The back EMF constant is also a parameter representing the intensity of a permanent magnet. The relationship can be given as.

$$\frac{\text{Volt} \cdot \text{sec}}{\text{rad}} = \frac{\text{Volt}}{\text{rpm}} \times 9.55$$

Back EMF constant is indicated as the RMS voltage per phase, so multiply  $\sqrt{3}$  to get actual terminal voltage.

**Mechanical time constant :  $t_m$  (sec)**

This is a function of the initial rate of rise in velocity when a step voltage is applied. It is calculated from the following relationship.

$$t_m = \frac{J_m \cdot R_a}{K_t \cdot K_v}$$

$J_m$  : Rotor inertia (kgf·cm·s<sup>2</sup>)  
 $R_a$  : Resistance of the armature ( $\Omega$ )

**Thermal time constant :  $t_t$  (min)**

This is a function of the initial rate of rise of winding temperature at rated current. It is defined as the time required to attain 63.2 percent of the final temperature rise.

**Static friction :  $T_f$  (kg·cm)**

This is the no-load torque required just to rotate the rotor.

**Max. current before demagnetization :  $I_m$  (A)**

This value of current is the instantaneous (peak) current which can be applied to the motor without demagnetizing the permanent magnet field. The magnet can be demagnetized even on only one pulse of high current. Care should therefore be taken to limit peak currents to the stated value. Usually, this value is limited by the servo amplifier limiter.

### 4.2.3 How to Use Overload Duty Curves

The servo motor can be driven out of the continuous operating zone, but intermittently. Duty characteristics shows the Duty (%) and the "ON" time in which motor can be operated under the given overload conditions. The ON and OFF times of a motor are conditioned using the following procedure.

- 1 Calculate Torque percent by formula below.  
The ON time for a motor can be specified within the torque percent.

$$TMD = \frac{\text{Load torque}}{\text{Continuous rated torque}}$$

- 2 Calculate "OFF" time by formula.

$$t_F = t_R \times \left( \frac{100}{\text{Duty percent}} - 1 \right)$$

$t_F$  : "OFF" time

$t_R$  : "ON" time

#### Example)

If it is necessary to run the  $\beta$  2/3000 under a load of 30 kgfcm at very low speed:

Because the rated torque of the  $\beta$  2/3000 is 20 kgfcm:

Torque percent:  $TMD = 30/20 = 1.5$  (150%)

From the overload duty curve of the  $\beta$  2/3000:

Duty percent of the motor when it runs with  $TMD = 150\%$  for five minutes is: About 37%

OFF time:  $t_F = 5 \times (100/37 - 1) \doteq 8.5$  min

After the motor runs under the above conditions, therefore, it must be kept at a stop for at least 8.5 minutes.

The drive amplifier also incorporates a thermal protection device such as a circuit breaker or thermal circuit. The thermal protection device may additionally limit the operation of the motor. In addition, a software function protects the motor and amplifier from short-term overload. The function may limit the operation of the motor.

# 5

## IEC34 STANDARD



## 5.1 REQUIREMENTS FOR COMPLIANCE

This section describes the conformity of the FANUC AC SERVO MOTOR  $\beta$  series to the IEC34 standard. The IEC34 standard can be satisfied by using a motor having a nameplate bearing a TÜV mark and satisfying the conditions below.

### 5.1.1 Drive unit

The motor must be driven by the servo amplifier  $\beta$  series,  $\alpha$  series, or Power Mate-E.

### 5.1.2 Connector

Motor power lines and brake units must be connected using the connectors listed below.

Motor model	Plug connector FANUC specification [Manufacturer's specification]		Cable clamp specification Connector manufacturer	Manufacturer
$\beta$ 0.5/3000 Power cable	Housing : 3-178129-6 Contact : 1-175217-2 [A06B-6050-K119] (The contacts and housing are packaged together.)		_____	AMP JAPAN, LTD
$\beta$ 1/3000, $\beta$ 2/3000, $\beta$ 3/3000, $\beta$ 6/2000 Power cable	Straight type	H/MS3106A18-10S-D-T(10) [A63L-0001-0648/61810SH]	H/MS3057-10A(10) [A63L-0001-0592/10AK]	HIROSE ELECTRIC
	L type	H/MS3108B18-10S-D-T(10) [A63L-0001-0648/81810SH]		
$\beta$ 1/3000, $\beta$ 2/3000, $\beta$ 3/3000, $\beta$ 6/2000 Brake unit connection	Straight type	JL04V-6A10SL-3SE-EB [A63L-0001-0648/610SL3SJ]	JL-04-1012CK-(07) [A63L-0001-0653/04A]	Japan Aviation Electronics Industry
	L type	JL04V-8A10SL-3SE-EB [A63L-0001-0648/810SL3SJ]		

#### WARNING

- 1 The connectors for the  $\beta$ 0.5/3000 are not water-proof.
- 2 For grounding, a wire with a cross-sectional area equal to or greater than that of U, V, or W must be used.

#### NOTE

The plug connectors do not feature a cable clamp.

Dedicated tools are necessary to crimp and pull out contacts included in the connector kit for the  $\beta$ 0.5/3000. The machine tool builder is requested to prepare them.

- Specification of the dedicated crimping tool:  
914595-3 (AMP Japan specification)  
A97L-0200-0979/M (FANUC specification)
- Specification of the dedicated pull-out tool:  
914677-1 (AMP Japan specification)  
A97L-0200-0980/D3 (FANUC specification)

TUV has certified that the aforementioned plug and cable connectors for the  $\beta$ 1/3000 to  $\beta$ 6/2000 comply with safety standard VDE0627 when they are used in combination with the FANUC AC servo motor  $\beta$  series.

The following table lists plug connectors produced by other manufacturers. The customers are requested to determine whether these connectors comply with the safety standard when they are used in combination with the FANUC AC servo motor  $\beta$  series. For details of these connectors, ask the relevant manufacturers.

<b>Manufacturer</b>	<b>Product series name</b>
HIROSE ELECTRIC	H/MS310 TUV-compliant series
Japan Aviation Electronics Industry	JL04V series
DDK Ltd.	CE05 series

## 5.2 APPROVAL SPECIFICATIONS

### 5.2.1 Rotational Speed (IEC34-1)

Each model's maximum allowable speed is as shown below:

Motor model	Rated output speed (rpm)	Maximum allowable speed (rpm)	Output (kW)
$\beta$ 0.5/3000	3000	4000	0.2
$\beta$ 1/3000	3000	4000	0.3
$\beta$ 2/3000	3000	4000	0.5
$\beta$ 3/3000	3000	4000	0.5
$\beta$ 6/2000	2000	3000	0.9

\* The maximum allowable speed (rpm) is applicable only when the motors are driven under HRV control.

### 5.2.2 Output (IEC34-1)

The rated output is guaranteed as continuous output only at the rated output speed. Beyond the rated output speed, the rated output is defined based on the continuous operation torque. Output in an intermittent operating zone is not defined.

Each model's approved output is as listed in the table in Section 5.2.1.

### 5.2.3 Protection Mode (IEC34-5)

The protection mode defined by IEC34-5 is as follows:

Motor model	IP	Approval condition
$\beta$ 0.5/3000	55	Confined to the motor main body. The connectors are graded as IP00.
$\beta$ 1/3000, $\beta$ 2/3000, $\beta$ 3/3000, $\beta$ 6/2000	55	Only when a specified connector and water-proof cover are used

#### IP5x:Dust-proof machine tool

Dust protection need not be perfect, but any dust caught must not prevent the smooth operation of the machine tool.

#### IPx5:Machine tool protected against water spray

Water, sprayed randomly onto the machine tool through a nozzle, must not adversely affect the operation of the machine tool.

The IPx5 mode test conditions are as follows:

Inner nozzle diameter	:	6.3 mm
Volume of water	:	12.5 l/minute
Water pressure at nozzle	:	30 kPa
Injection time per unit surface area (1 m <sup>2</sup> )	:	1 minute
Minimum test time	:	3 minutes
Distance between nozzle and machine tool	:	About 3 m



**WARNING**

As described above, IPx5 evaluates a machine tool by means of a short-term test using water, assuming that the machine tool is dried after being sprayed with water. Note that the use of a liquid other than water or the continuous application of water, such that the machine tool is not allowed to dry, can adversely affect the machine tool even if the other aspects of the test are less severe.

### 5.2.4 Cooling Method (IEC34-6)

The following motor cooling method is to be used:

Motor model	IC code	Method
$\beta$ 0.5/3000, $\beta$ 1/3000, $\beta$ 2/3000, $\beta$ 3/3000, $\beta$ 6/2000	IC 410	Totally enclosed, natural air-cooling

### 5.2.5 Installation Method (IEC34-7)

A motor can be installed using any of the following methods:

- IMB5: The motor is installed by using a flange, with the shaft oriented horizontally (from the back).
- IMV1: The motor is installed by using a flange, with the shaft oriented upwards (from the back).
- IMV3: The motor is installed by using a flange, with the shaft oriented downwards (from the back).

### 5.2.6 Heat Protection (IEC34-11)

The heat protection mode defined in IEC 34-11 is as follows:

Motor model	Code	Method
$\beta$ 6/2000	TP112	Indirect protection of windings by means of a thermal cut-out

**TP112**

- 2: Temperature rise limit class 2 for heat protection
- 1: One-stage stop only (with no alarm information output)
- 1: Protection against less abrupt overload only

**NOTE**

- 1 Heat protection is not defined for  $\beta$ 0.5/3000,  $\beta$ 1/3000,  $\beta$ 2/3000, and  $\beta$ 3/3000.
- 2 Models  $\beta$ 0.5/3000,  $\beta$ 1/3000,  $\beta$ 2/3000,  $\beta$ 3/3000, and  $\beta$ 6/2000 are software-protected against an abrupt overload of 150% or more.

# 6


## EMC COMMAND



The  $\beta$  series servo motors comply with the EMC command.

To make the entire machine compliant to the EMC command, the necessary measures must be taken according to the guideline published by FANUC (document No.: A-72937E).

# 7 FEEDBACK DETECTOR



## 7.1 BUILT-IN DETECTOR

All servo motors feature a pulse coder (optical rotary encoder). The pulse coder outputs position information and an alarm signal. The  $\beta$  series motors incorporate pulse coders designed to the specifications listed below.

Pulse coder type	Resolution Division/rev	Absolute/incremental	Applicable motor
Pulse coder $\alpha$ A32B	32,768	Absolute	All models in $\beta$ series motor
Pulse coder $\alpha$ I32B	32,768	Incremental	

### NOTE

The  $\beta$  series pulse coders can be connected to an NC if the NC is fitted with the serial interface, and the digital servo software for the  $\alpha$  pulse coders is installed.

## 7.2 ABSOLUTE-TYPE PULSE CODER

When the NC is turned off, the pulse coder position detection function is backed up by battery. So, when the NC is next turned on, the operator does not have to perform reference position return.

For backup, a battery unit for back-up must be installed in the NC or servo amplifier.

If a low-battery indication appears on the NC, renew the battery as soon as possible.

Replace the battery while the NC is turned on.

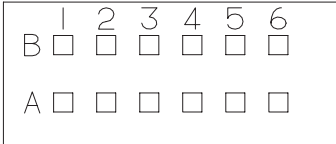
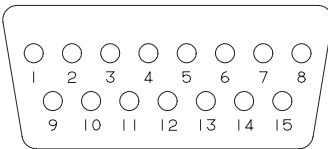
## 7.3 EXTERNAL POSITION DETECTOR

For detecting a position by attaching directly to a ball screw or a machine, use an external (separate type) position detector. Pay attention to the following items when using the external position detector.

- Increase the machine rigidity between the servo motor and the position detector to minimize mechanical vibration. If the machine rigidity is low or the structure vibrates, poor performance is likely to occur.
- Generally, when the separate type detector is used, the influence of gear, ball screw pitch error or table inclination is decreased and the positioning accuracy and geometrical accuracy (roundness, etc.) are increased, but the smoothness may deteriorate due to the elasticity in the machine between the servo motor and the position detector.
- Positioning precision is equivalent to the resolution of the built-in pulse coder, even if the resolution of the external position detector is higher than that of the built-in pulse coder.
- To connect the external position detector to the NC, connect only the signals described in the connecting manual. (Phase A, Phase B, Phase Z, 0V, 5V and REQ if necessary)
- The specifications of the FANUC external position detector are given in the descriptions (B-65142E) of the  $\alpha$  series servo motors.

## 7.4 DETECTOR SIGNAL OUTPUT

The following table lists the pin assignment of the β series servo motor output signals and the signals on each model's connectors.

Signal name	Pin number (β0.5/3000)		Pin number (β1 to β6)	
	βA32B	βI32B	βA32B	βI32B
SD	A4	A4	12	12
*SD	B4	B4	13	13
REQ	A3	A3	5	5
*REQ	B3	B3	6	6
+5V	A2, B2	A2, B2	8, 15	8, 15
0V	A1, B1	A1, B1	1, 2, 3	1, 2, 3
Shield	B6	B6	—	—
+6V	A5	—	14	—
0V	A6	—	10	—
	Connector pin assignment 		Connector pin assignment 	
	Dynamic : D3100D Free-hanging type (AMP JAPAN, LTD 178964-6)		D-SUB 15P	

# 8

## BUILT-IN BRAKE



Some of  $\beta$  series servo motors use motors that contain a holding brake to prevent falling along a vertical axis.

Motors with a built-in brake have different outlines and weight from other types of motors. For their outlines, refer to Section II-2.4.

The servo motor incorporates a brake which is applied to lock the shaft while the power is turned off, and which is released while the power is turned on.

## 8.1 BRAKE SPECIFICATIONS

The specifications of built-in brakes are listed below.

Motor model		Unit	$\beta 0.5/3000$	$\beta 1/3000$ $\beta 2/3000$	$\beta 3/3000$ $\beta 6/2000$
Brake torque		Nm kgf·cm	0.65 6.6	2 20	8 82
Response time	Release	msec	40	60	80
	Brake	msec	20	10	40
Supply voltage	VDC ( $\pm 10\%$ )		90	90	90
Current	A		0.1 or less	0.3 or less	0.4 or less
Weight increase	kg		Approx. 0.4kg	Approx. 1.5kg	Approx. 2.3kg
Inertia increase	kg·m <sup>2</sup>		$9 \times 10^{-6}$	$2 \times 10^{-5}$	$7 \times 10^{-5}$
	kgf·cm·s <sup>2</sup>		$9 \times 10^{-5}$	$2 \times 10^{-4}$	$7 \times 10^{-4}$

The time required before the brake is released is known as "release time," while the time required before the brake is applied is known as "brake time."

### Common notes to each series

When using a motor with a brake, observe the following:

- Use the full-wave rectified 100VAC or 90VDC as a power supply. **Don't use the half-wave rectified 200VAC.** Otherwise, a brake component, such as a surge absorber, may be damaged.
- Use a rectifier with dielectric strength of 400V or higher.
- Connect CR as shown in the drawing, to protect the contact of the switch.

#### WARNING

- 1 **This brake is used to hold the machine** when the servo motor control is turned off. It is possible to brake the machine by turning off the brake power at emergency stop such as at the stroke end, **but it is impossible to use this brake to reduce the stop distance.**

Do not use this brake to help an axis, such as an index table, to hold the same position for a long time.

- 2 Allow sufficient time to start the servo motor before releasing the brake. (with the servo motor deenergized) Turn the servo off when holding the axis by the built-in brake or another holding means. At this time, allow sufficient time to set the brake before turning off the servo.

## 8.2 BRAKE OPTIONS

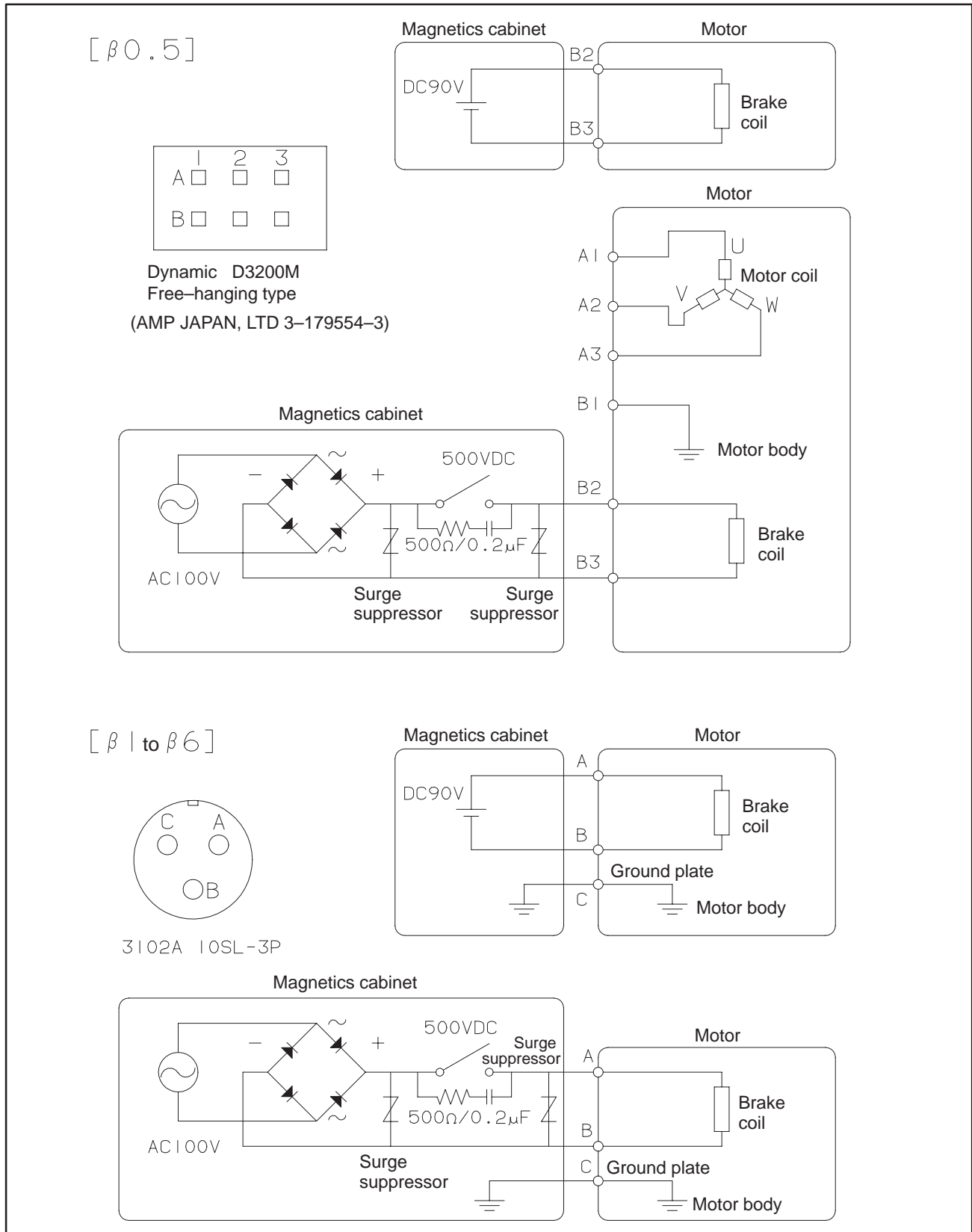
The following table lists the brake options and their specifications.

Item	Original manufacturer's specification (manufacturer name)	FANUC specification
Rectifier stack	S4VB60 (manufactured by Shindengen Electric Mfg.)	A06B-6050-K112 (single unit)
Surge absorber	ERZV20D221 (manufactured by Matsushita Electric Industrial)	A06B-6050-K113 (single unit)



### 8.3 CONNECTION OF THE BRAKES

The example of the connection of the brakes are as follows.



# 9

## CONNECTORS



## 9.1 SPECIFICATIONS OF MOTOR CONNECTORS

With the FANUC AC SERVO MOTOR  $\beta$  series, TÜV-approved connectors are used for power lines and brakes to ensure conformity with the IEC34 standard. For power lines and brakes in  $\beta$  series motors except model  $\beta$  0.5, receptacle connectors that are drip-proof when unmated (as single units) are used as standard.

### 9.1.1 $\beta$ 0.5 Motor-Side Connectors

The following table lists the connectors used on the  $\beta$ 0.5/3000 motor. Assigned to the power line connector pins.

For power lines	For signals	For brakes
3-179554-3 AMP JAPAN, LTD	178964-6 AMP JAPAN, LTD	See Section 8.3 for details of how to connect.

### 9.1.2 $\beta$ 1 to $\beta$ 6 Motor-Side Connectors

The standard receptacle connectors for models  $\beta$ 1 to  $\beta$ 6 do not exactly satisfy the MS standard in that the connectors are waterproof as single units, and their exterior color is black. However, their sizes and shapes are compatible with the conventional round-type connectors conforming to the MS standard. Accordingly, in addition to the products recommended below, plug connectors conforming to the MS standard can also be used. (When the water-resistance of the system is of prime importance, the waterproof plug connectors recommended in Subsection 9.3.1 and 9.3.2 should be used.)

The following table lists the connectors used on the  $\beta$ 1 to  $\beta$ 6 motors.

For power lines	For signals	For brakes
H/MS3102A18-10P-D-T(10) (HIROSE ELECTRIC)	SDAB-15P (HIROSE ELECTRIC)	JL04V-2A10SL-3P-B (Japan Aviation Electronics Industry)

#### WARNING

- 1 Direct motor connectors downwards whenever possible. When a motor connector must be directed horizontally or upwards, provide sufficient cable slack to prevent, for example, the connector from being wetted by liquid such as coolant. The connectors on the  $\beta$ 0.5 motor are not water-proof. The machine tool builder is requested to make some provision to protect the connectors from water and moisture. In any case, if a motor connector is exposed to liquid, protection by means of a cover, for example, must be provided.
- 2 If the motor is not grounded via the machine (cabinet) on which it is mounted, connect a wire between the terminal to which the motor ground cable is connected and that to which the amplifier ground cable is connected, to suppress noise. In such a case, use a wire of at least 1.25mm<sup>2</sup>, independently of the ground wire within the power cable, and route it as far away from the power cable as possible.

## 9.2 SPECIFICATIONS OF $\beta$ 0.5 MOTOR CABLE-END CONNECTORS

TÜV-certified dedicated plug connectors are available for use on the cable for the  $\beta$  0.5 motor. Note that the connectors on the  $\beta$  0.5 motor are not water-proof.

The following table lists the specifications of the connector kit.

Item	For power lines	For signals	
Connector specification (Manufacturer name) [FANUC specification]	Housing: 3-178129-6 Contact: 1-175217-2 (AMP Japan, Ltd.) [A06B-6050-K119] (The housing and contacts are packaged together.)	Housing: 178289-6 Contact: 1-175217-2 (AMP Japan, Ltd.) [A06B-6050-K120] (The housing and contacts are packaged together.)	
Number of required contacts	4 (or 6 if the motor incorporates a brake)	Motor with $\beta$ A32B : 11 Motor with $\beta$ I32B : 9	
Applicable wire size	AWG#20	AWG#24	AWG#22 AWG#20
Wire insulator outside diameter	$\phi$ 1.7 to 2.6	$\phi$ 1.2 to 1.6	$\phi$ 1.7 to 2.6

### WARNING

- Use wires with the following sizes so that the wires can convey the required current.  
Power line : AWG#20  
Signal line : AWG#20 for +5V, 0V, 6VA, and 0VA  
AWG#24 or thicker for other signals
- The contacts of the connectors are so structured that the wire and insulator are crimped together. So, be sure to observe the specified insulator diameter. Wires thinner than specified may be used depending on the wire type and the tool used. Consult with AMP Japan for details.

Dedicated tools are necessary to crimp and pull out the contacts. The machine tool builder is requested to prepare them as applicable.

Dedicated crimping tool : 914595-2 (AMP Japan specification)  
A97L-0200-0979/M (FANUC specification)

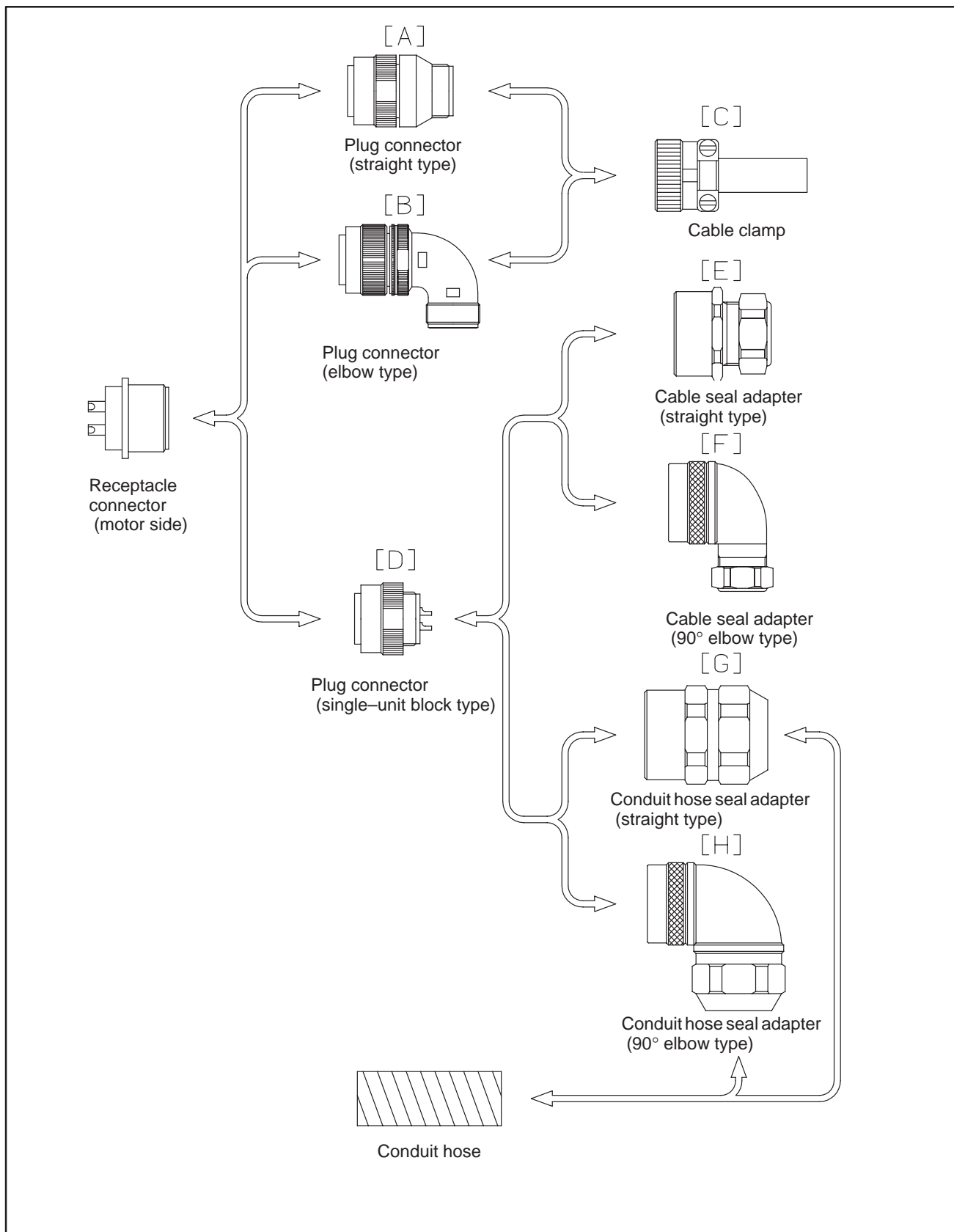
Dedicated pull-out tool : 914677-1 (AMP Japan specification)  
A97L-0200-0980/D3 (FANUC specification)

### 9.3 SPECIFICATIONS OF CABLE-SIDE PLUG CONNECTORS FOR POWER LINES IN MODELS $\beta$ 1 TO $\beta$ 6

To comply with the IEC34 standard, the plug connectors and cable clamp shown below must be used for the power line and brake unit connections. When the IEC34 standard can be satisfied only by using a cable seal adapter and conduit hose seal adapter, consult with the connector manufacturer. As the cable-side plug connectors for the models  $\beta$ 1 to  $\beta$ 6, TÜV-approved (waterproof), waterproof, and non-waterproof connectors are available (all in black). Because these connectors are compatible with the MS standard, conventional plug connectors can also be used.

An example of connector connections is shown below.  
The corresponding, connector specifications for this example are also provided.

### Example cable connections



### 9.3.1 Specifications of Cable Plug Connectors (TÜV-approved and Waterproof Type)

Connector type	For power lines	For brakes
[A]	H/MS3106A18-10S-D-T(10) (HIROSE ELECTRIC)	JL04V-6A10SL-3SE-EB (Japan Aviation Electronics Industry)
[B]	H/MS3108B18-10S-D-T(10) (HIROSE ELECTRIC)	JL04V-8A10SL-3SE-EB (Japan Aviation Electronics Industry)
[C]	H/MS3057-10A(10) (HIROSE ELECTRIC)	JL04-1012CK-(07) (Japan Aviation Electronics Industry)

For [A] to [C], see the cable connection examples.

Products of manufacturers not listed above may be used. Before selecting one, see Chapter 5.

### 9.3.2 Specifications of Cable Plug Connectors (Non-TÜV-approved and Waterproof Type)

Connector type	For power lines	For brakes
[A]	H/MS3106A18-10S(10) (HIROSE ELECTRIC) JA06A-18-10S-J1-EB (Japan Aviation Electronics Industry) MS3106A18-10S-B-BSS (DDK Ltd.)	H/MS3106A10SL-3S(10) (HIROSE ELECTRIC) JA06A-10SL-3S-J1-EB (Japan Aviation Electronics Industry) MS3106A10SL-3S-B-BSS (DDK Ltd.)
[B]	H/MS3108B18-10S(10) (HIROSE ELECTRIC) JA08A-18-10S-J1-EB (Japan Aviation Electronics Industry) MS3108A18-10S-B-BAS (DDK Ltd.)	H/MS3108B10SL-3S(10) (HIROSE ELECTRIC) JA08A-10SL-3S-J1-EB (Japan Aviation Electronics Industry) MS3108A10SL-3S-B-BAS (DDK Ltd.)
[C]	H/MS3057-10A(10) (HIROSE ELECTRIC) JL04-18CK(13) (Japan Aviation Electronics Industry) CE3057-10A-1(D265) (DDK Ltd.)	H/MS3057-4A(10) (HIROSE ELECTRIC) JL04-1012CK-(05) (Japan Aviation Electronics Industry) CE3057-4A-1(D265) (DDK Ltd.)
[D]	H/MS3106A18-10S(13) (HIROSE ELECTRIC) JA06A-18-10S-J1-(A72) (Japan Aviation Electronics Industry) MS3106A18-10S-B(D190) (DDK Ltd.)	H/MS3106A10SL-3S(13) (HIROSE ELECTRIC) JA06A-10SL-3S-J1-(A72) (Japan Aviation Electronics Industry) MS3106A10SL-3S-B(D190) (DDK Ltd.)
[E]	YSO 18-12-14 (Daiwa Dengyou) ACS-12RL-MS18F (Japan Flex)	YSO 10-5-8 (Daiwa Dengyou)
[F]	YLO 18-12-14 (Daiwa Dengyou) ACA-12RL-MS18F (Japan Flex)	YLO 10-5-8 (Daiwa Dengyou)
[G]	BOS 18-15 (Daiwa Dengyou) RCC-104RL-MS18F (Japan Flex)	BOS 9-10 (Daiwa Dengyou)
[H]	BOL 18-15 (Daiwa Dengyou) RCC-304RL-MS18F (Japan Flex)	BOL 9-10 (Daiwa Dengyou)

For [A] to [H], see the cable connection examples.

As described above, a combination of a plug connector (single-unit type) and an adapter (that is, a combination of [D] and one of [E] to [H] in the cable connection example) can enhance the water resistance around a cable/connector joint. Because these connectors and seal adaptors are compatible with those complying with the MS standard, MS standard compliant connectors and seal adaptors not listed above may also be used. Use the table above for reference only. For details, consult with the relevant manufacturer.

### 9.3.3 Specifications of Cable Plug Connectors (Non-TÜV-approved and Non-waterproof Type)

Connector type	For power lines	For brakes
[A]	H/MSA3106A18-10S(10) (HIROSE ELECTRIC) MS3106B18-10S-(A72) (Japan Aviation Electronics Industry) MS3106B18-10S-B (DDK Ltd.)	H/MSA3106A10SL-3S(10) (HIROSE ELECTRIC) MS3106B10SL-3S-(A72) (Japan Aviation Electronics Industry) MS3106A10SL-3S-B (DDK Ltd.)
[B]	H/MSA3108B18-10S(10) (HIROSE ELECTRIC) MS3108B18-10S-(A72) (Japan Aviation Electronics Industry) MS3108B18-10S-B (DDK Ltd.)	H/MSA3108B10SL-3S(10) (HIROSE ELECTRIC) MS3108B10SL-3S-(A72) (Japan Aviation Electronics Industry) MS3108A10SL-3S-B (DDK Ltd.)
[C]	H/MSA3057-10A(10) (HIROSE ELECTRIC) MS3057-10A-(A72) (Japan Aviation Electronics Industry) MS3057-16A(D265) (DDK Ltd.)	H/MSA3057-4A(10) (HIROSE ELECTRIC) MS3057-4A-(A72) (Japan Aviation Electronics Industry) MS3057-4A(D265) (DDK Ltd.)

For [A] to [C], see the connector connection examples.



## 9.4 SIGNAL LINE CONNECTORS OF MODELS $\beta$ 1 TO $\beta$ 6

D-sub connectors are used as standard for the signal lines of the models  $\beta$ 1 to  $\beta$ 6. The D-Sub connectors are not water-proof. To make the motor water-proof, it is necessary to use a dedicated connector cover. The specifications of the cable-side special connectors are given below.

Item	Manufacturer	FANUC specification
Connector kit (The D-Sub connector and water-proof cover are packaged together.)	—	A06B-6050-K115
D-Sub connector (female)	HDAB-15S (Solderling type) (HIROSE ELECTRIC)	A63L-0001-0434/AB15SNO
Waterproof cover	HDAW-15CV (HIROSE ELECTRIC)	A63L-0001-0496

## **II. FANUC AC SERVO MOTOR**

### **$\beta$ series**

# 1

## TYPES OF MOTORS AND DESIGNATION

The types and specifications of  $\beta$  series servo motors are described as follows.

### Model $\beta 0.5/3000$

**A06B-0113-B $\Delta$ ○○ #000 ☆**

$\Delta$

- 0 : Straight shaft (standard)
- 1 : Straight shaft with a brake (0.65Nm)

○○

- 75 : With the pulse coder  $\beta A32B$
- 77 : With the pulse coder  $\beta I32B$

☆

- 0 : Standard
- 8 : Straight shaft with a key

### Models $\beta 1/3000$ and $\beta 2/3000$

**A06B-00□□-B $\Delta$ ○○ # 000 ☆**

□

- 31 : Model  $\beta 1/3000$
- 32 : Model  $\beta 2/3000$

$\Delta$

- 0 : Straight shaft (standard)
- 1 : Straight shaft with a brake (2Nm)
- 5 : Taper shaft
- 6 : Taper shaft with a brake (2Nm)

○○

- 75 : With the pulse coder  $\alpha A32B$
- 77 : With the pulse coder  $\alpha I32B$

☆

- 0 : Standard
- 8 : Straight shaft with a key

**Models**  
**β3/3000 and β6/2000****A06B-00□□-B△○○ # 000 ☆**

□

**33** : Model β3/3000**34** : Model β6/2000

△

**0** : Straight shaft (standard)**1** : Straight shaft with a brake (8Nm)**5** : Taper shaft**6** : Taper shaft with a brake (8Nm)

○○


**75** : With the pulse coder βA32B**77** : With the pulse coder βI32B

☆

**0** : Standard**8** : Straight shaft with a key

- The resolution of the αA32B and αI32B serial pulse coders is 32,768/rev.
- The standard shafts used for β series motor are straight shafts. Use a straight shaft as far as circumstances, such as the delivery time and maintenance, permit.
- To specify a straight shaft with a key, suffix the motor specification with #0008. A woodruff key is attached to the tapered shaft as a standard. So, it is unnecessary to specify #0008.
- If the specification code is suffixed with #0000, the suffix need not be entered.

# 2 SPECIFICATIONS AND CHARACTERISTICS



## 2.1 TYPE OF MOTORS AND SPECIFICATIONS

Item	Unit	$\beta 0.5/3000$	$\beta 1/3000$	$\beta 2/3000$	$\beta 3/3000$	$\beta 6/2000$
Output	kw	0.2	0.3	0.5	0.5	0.9
	HP	0.3	0.4	0.67	0.67	1.2
Rated torque at stall	Nm	0.6	1.0	2.0	3.0	6.0
	kgf·cm	6.5	10	20	30	60
Rated output speed	1/min	3000	3000	3000	3000	2000
Maximum speed (*)	1/min	4000 (3000)	4000 (3000)	4000 (3000)	4000 (3000)	3000 (2000)
Maximum theoretical torque	Nm	3.4	5.6	11	17	32
	kgf·cm	35	58	112	171	321
Rotor inertia	kg·m <sup>2</sup>	$1.7 \times 10^{-5}$	0.00033	0.00065	0.0019	0.0039
	kgf·cm·s <sup>2</sup>	$1.8 \times 10^{-4}$	0.0034	0.0067	0.020	0.040
Maximum theoretical acceleration	rad/s <sup>2</sup>	190,000	17000	16500	8500	8000
Weight	kg	1.0	2.5	3.5	5.0	8.5

\* Maximum speed when HRV control is applied. When conventional control is applied, the maximum speed will be as indicated in the parentheses.

### NOTE

- 1 The above values are under the condition at 20°C.
- 2 The above values shown in the maximum theoretical torque are the theoretical values.  
The actual maximum torque is restricted by the current limit values of the drive amplifier.

## 2.2 CHARACTERISTIC CURVE AND DATA SHEET

See Section 4.2 of Chapter I of this manual for details of each item.

### Torque–speed characteristics

The torque–speed curve represents the relationships between the output torque of a motor and its speed. The data curve shown in this specification is for the rated input voltage (200V). Note, however, that the intermittent operating zone varies with the input voltage of the driving unit.

### Overload duty characteristic

The overload duty characteristic curves are determined based on the temperature restriction for the single motor unit (such as protection based on a thermal protector). The curves are determined by assuming that the temperature increases gradually under certain overload conditions. Therefore, the curves do not apply to the rapid temperature rise which occurs, for example, when an overcurrent flows in the motor windings until the thermal trip operates.

A thermal software function is provided to prevent an abrupt temperature rise in the motor by monitoring for abnormal current in the motor. This function may put a thermal limit to the operation of the motor when it is frequently accelerated and decelerated.

Driving units (such as amplifiers) contain their own overheating protection devices. Therefore, note that control may be imposed according to how the equipment is being used.

### Data sheet

The parameters given in the data sheet are representative values for an ambient temperature of 20°C. They are subject to an error of +10%.

The indicated logical values are threshold values for the single motor unit (when the motor is not restricted by the control system).

The maximum torque that can be produced during acceleration or deceleration in actual use is calculated as the approximate product of the motor torque constant and the current limit value of the amplifier.

Example :  $\beta 1/3000$

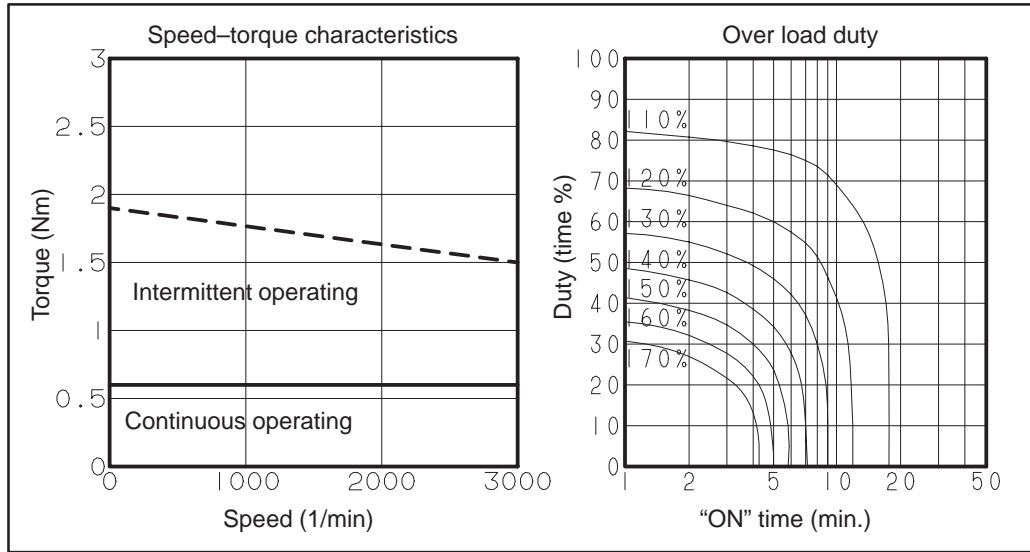
- Motor torque constant = 0.31 (Nm/Arms)
- Amplifier limit value = 12 Apeak
- Maximum torque value  
 $= 12 \times 0.707 \times 0.31$   
 (Converted to an effective value)  
 $= 2.6 \text{ Nm}$  (Converted to an effective value)

This value is for reference purposes only. The actual value will vary depending on changes in the power supply, as well as variations in motor parameters and amplifiers. If the maximum allowable current flows in the motor, the actual maximum torque may get lowered below the calculated value due to magnetic saturation.

The torque–speed curve is data designed in combination with amplifiers. So this data curve should be used for examination, instead of calculated values.

● Model β0.5/3000

Specification : A06B-0113-B□□□



Data sheet

Parameter	Symbol	Value		Unit
Rated output speed	Nmax	3000		min <sup>-1</sup>
Rated torque at stall (NOTE 1)	Ts	0.6 6.5		Nm kgfcm
Rotor inertia	Jm	1.7 × 10 <sup>-5</sup> 1.8 × 10 <sup>-4</sup>		kgm <sup>2</sup> kgfcms <sup>2</sup>
Continuous RMS current at stall	Is	2.8		Arms
Torque constant (NOTE 1)	Kt	0.23 2.3		Nm/Arms kgfcm/Arms
Back EMF constant(NOTE 1)	Ke Kv	7.9 0.08		V/1000min <sup>-1</sup> Vsec/rad
Armature resistance (NOTE 1)	Ra	0.93		Ω
Mechanical time constant (NOTE 1)	tm	7.0 × 10 <sup>-4</sup>		s
Thermal time constant	tt	10		min
Static friction	Tf	0.04 0.4		Nm kgfcm
Maximum allowable current	Im	19		Apeak
Maximum theoretical torque	Tm	3.4 35		Nm kgfcm
Maximum theoretical acceleration		190,000		rad/s <sup>2</sup>
Weight		1.0		kg

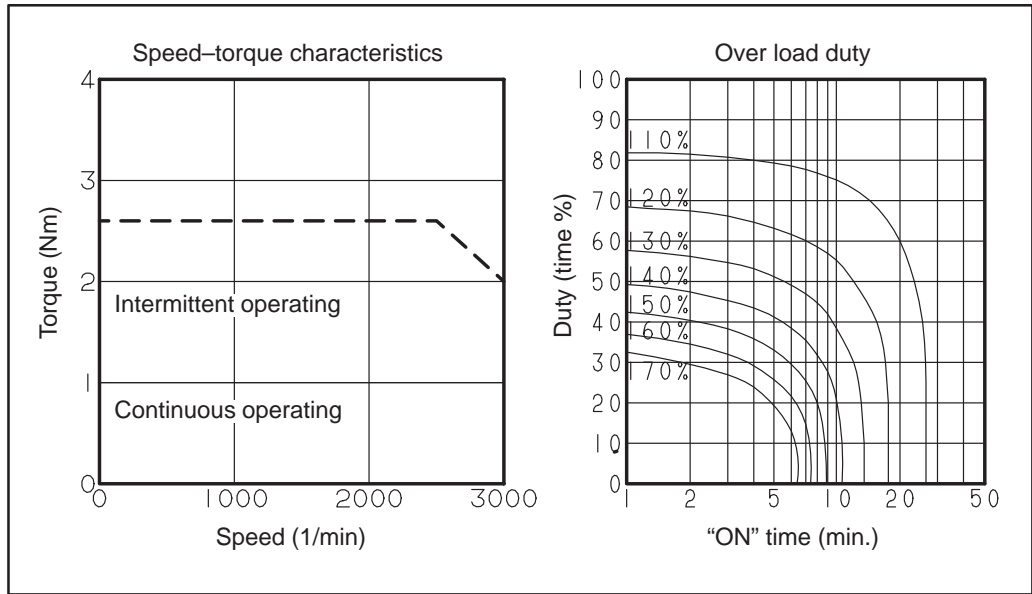
**NOTE**

- 1 The values are the standard values at 20°C and the tolerance is ± 10%.
- 2 The speed-torque characteristics vary depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.)



● Model β1/3000

Specification : A06B-0031-B□□□



Data sheet

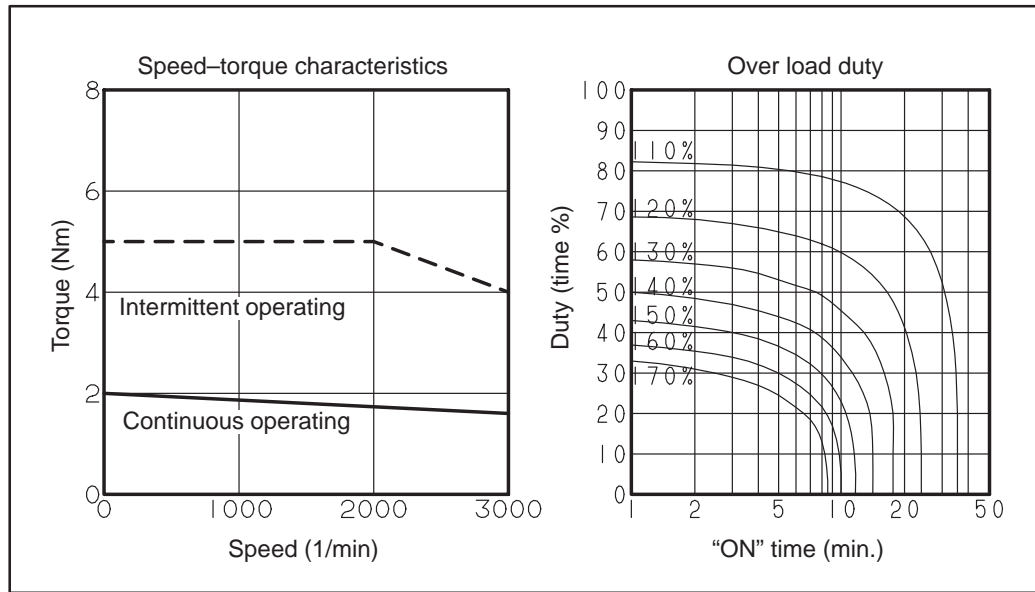
Parameter	Symbol	Value	Unit
Rated output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (NOTE 1)	Ts	1.0 10	Nm kgfcm
Rotor inertia	Jm	0.00033 0.0034	kgm <sup>2</sup> kgfcm <sup>2</sup>
Continuous RMS current at stall	Is	3.2	Arms
Torque constant (NOTE 1)	Kt	0.31 3.2	Nm/Arms kgfcm/Arms
Back EMF constant(NOTE 1)	Ke Kv	10.9 0.10	V/1000min <sup>-1</sup> Vsec/rad
Armature resistance (NOTE 1)	Ra	0.96	Ω
Mechanical time constant (NOTE 1)	tm	0.011	s
Thermal time constant	tt	15	min
Static friction	Tf	0.1 1	Nm kgfcm
Maximum allowable current	Im	18	Apeak
Maximum theoretical torque	Tm	5.6 58	Nm kgfcm
Maximum theoretical acceleration		17000	rad/s <sup>2</sup>
Weight		2.5	kg

NOTE

- 1 The values are the standard values at 20°C and the tolerance is ±10%.
- 2 The speed-torque characteristics vary depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.)

● Model  $\beta$ 2/3000

Specification : A06B-0032-B□□□



Data sheet

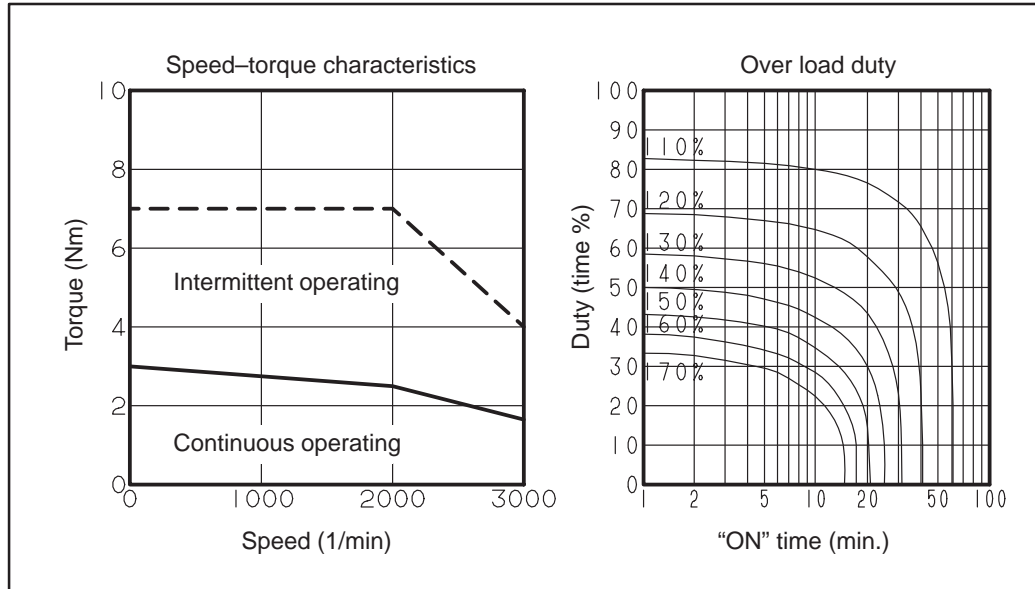
Parameter	Symbol	Value	Unit
Rated output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (NOTE 1)	Ts	2.0 20	Nm kgfcm
Rotor inertia	Jm	0.00065 0.0067	kgm <sup>2</sup> kgfcm <sup>2</sup>
Continuous RMS current at stall	Is	3.2	Arms
Torque constant (NOTE 1)	Kt	0.61 6.2	Nm/Arms kgfcm/Arms
Back EMF constant (NOTE 1)	Ke Kv	21.4 0.20	V/1000min <sup>-1</sup> Vsec/rad
Armature resistance (NOTE 1)	Ra	1.45	$\Omega$
Mechanical time constant (NOTE 1)	tm	0.008	s
Thermal time constant	tt	20	min
Static friction	Tf	0.1 1.5	Nm kgfcm
Maximum allowable current	Im	18	Apeak
Maximum theoretical torque	Tm	11 112	Nm kgfcm
Maximum theoretical acceleration		16500	rad/s <sup>2</sup>
Weight		3.5	kg

**NOTE**

- 1 The values are the standard values at 20°C and the tolerance is  $\pm 10\%$ .
- 2 The speed-torque characteristics vary depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.)

● Model β3/3000

Specification : A06B-0033-B□□□



Data sheet

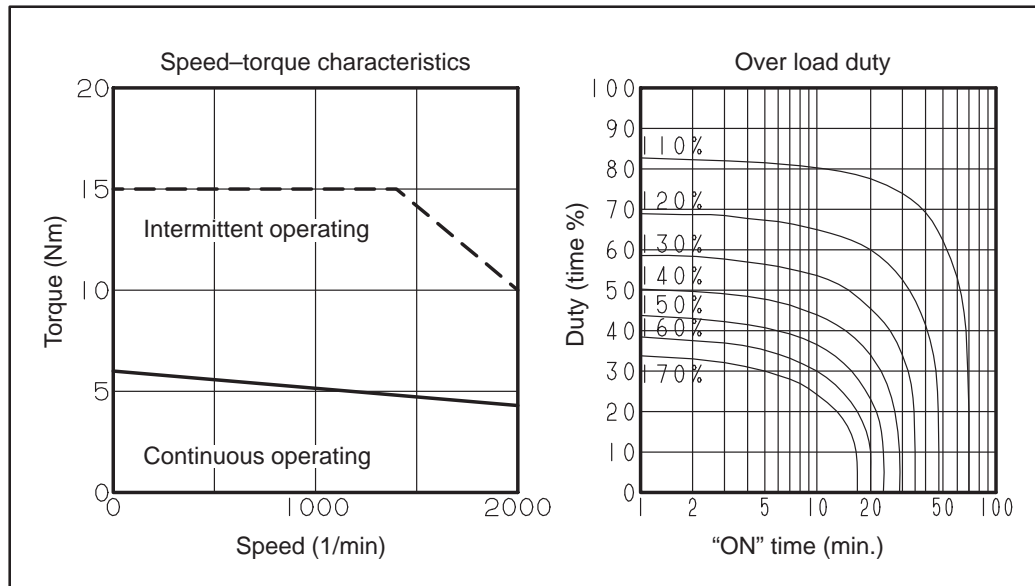
Parameter	Symbol	Value	Unit
Rated output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (NOTE 1)	Ts	3 30	Nm kgfcm
Rotor inertia	Jm	0.0019 0.020	kgm <sup>2</sup> kgfcm <sup>2</sup>
Continuous RMS current at stall	Is	5.3	Arms
Torque constant (NOTE 1)	Kt	0.56 5.7	Nm/Arms kgfcm/Arms
Back EMF constant (NOTE 1)	Ke Kv	19.4 0.18	V/1000min <sup>-1</sup> Vsec/rad
Armature resistance (NOTE 1)	Ra	0.57	Ω
Mechanical time constant (NOTE 1)	tm	0.009	s
Thermal time constant	tt	40	min
Static friction	Tf	0.3 3	Nm kgfcm
Maximum allowable current	Im	30	Apeak
Maximum theoretical torque	Tm	17 171	Nm kgfcm
Maximum theoretical acceleration		8500	rad/s <sup>2</sup>
Weight		5.0	kg

**NOTE**

- 1 The values are the standard values at 20°C and the tolerance is ± 10%.
- 2 The speed-torque characteristics vary depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.)

● Model β6/2000

Specification : A06B-0034-B□□□



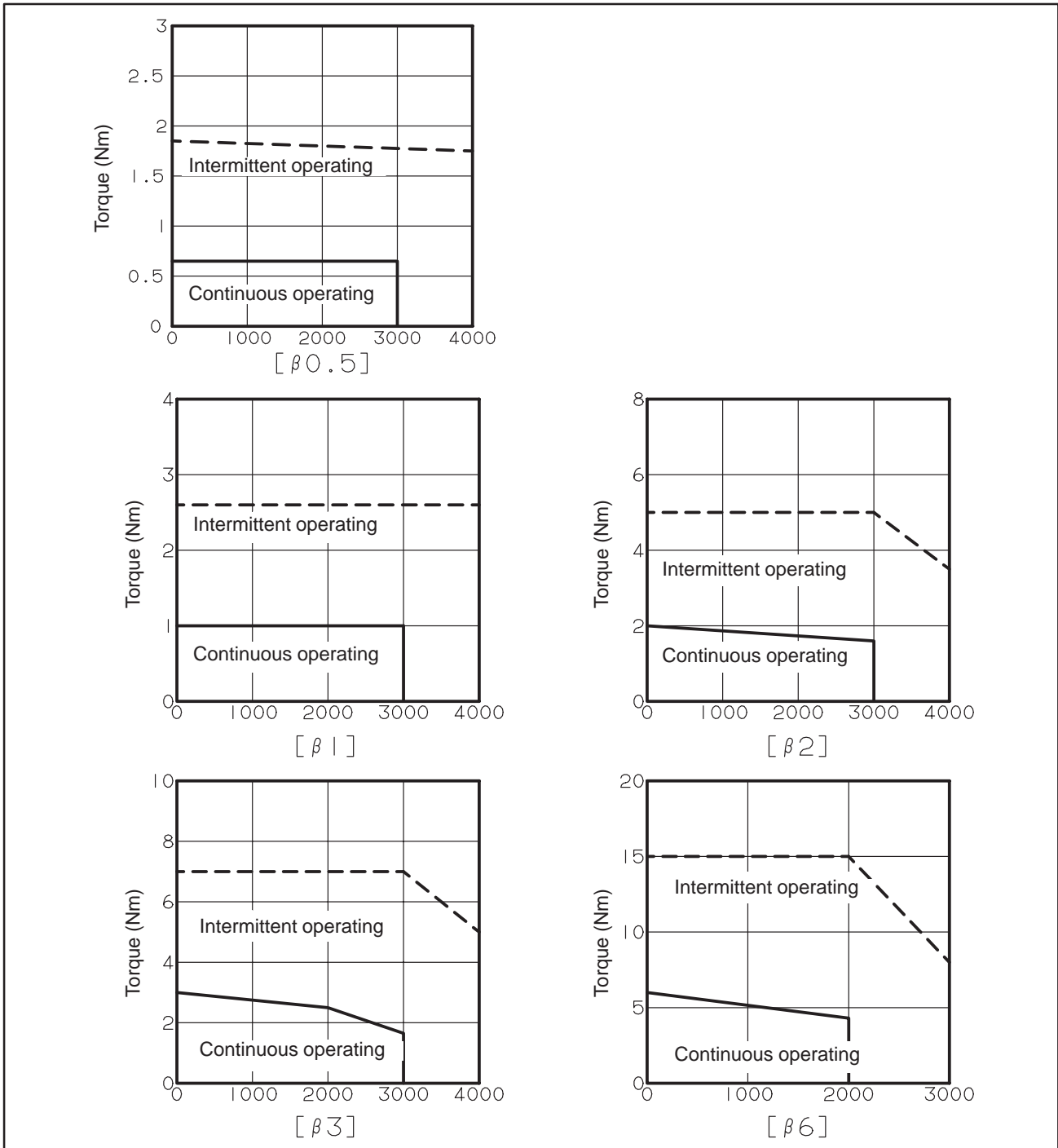
Data sheet

Parameter	Symbol	Value	Unit
Rated output speed	Nmax	2000	min <sup>-1</sup>
Rated torque at stall (NOTE 1)	Ts	6.0 60	Nm kgfcm
Rotor inertia	Jm	0.0039 0.040	kgm <sup>2</sup> kgfcm <sup>2</sup>
Continuous RMS current at stall	Is	5.6	Arms
Torque constant (NOTE 1)	Kt	1.05 10.7	Nm/Arms kgfcm/Arms
Back EMF constant (NOTE 1)	Ke Kv	37.0 0.35	V/1000min <sup>-1</sup> Vsec/rad
Armature resistance (NOTE 1)	Ra	0.87	Ω
Mechanical time constant (NOTE 1)	tm	0.009	s
Thermal time constant	tt	40	min
Static friction	Tf	0.3 3	Nm kgfcm
Maximum allowable current	Im	30	Apeak
Maximum theoretical torque	Tm	32 321	Nm kgfcm
Maximum theoretical acceleration		8000	rad/s <sup>2</sup>
Weight		8.5	kg

NOTE

- 1 The values are the standard values at 20°C and the tolerance is ± 10%.
- 2 The speed-torque characteristics vary depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.)

### 2.3 SPEED-TORQUE CHARACTERISTICS FOR HRV CONTROL



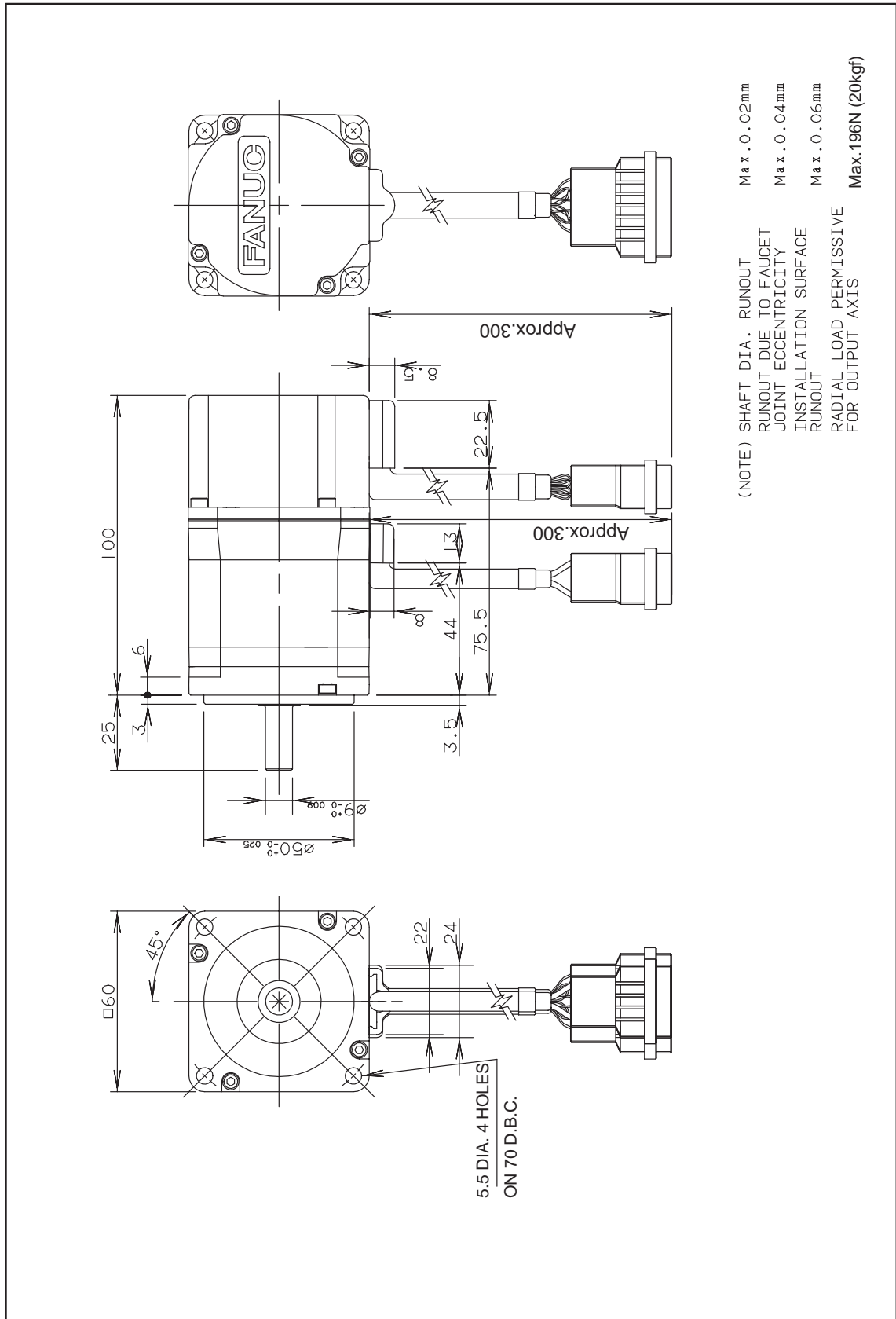
**NOTE**

Some CNC systems do not support HRV control. Applying HRV control causes the intermittent operating area to be expanded, at high speed. The continuous operating area is the same as that conventional control.

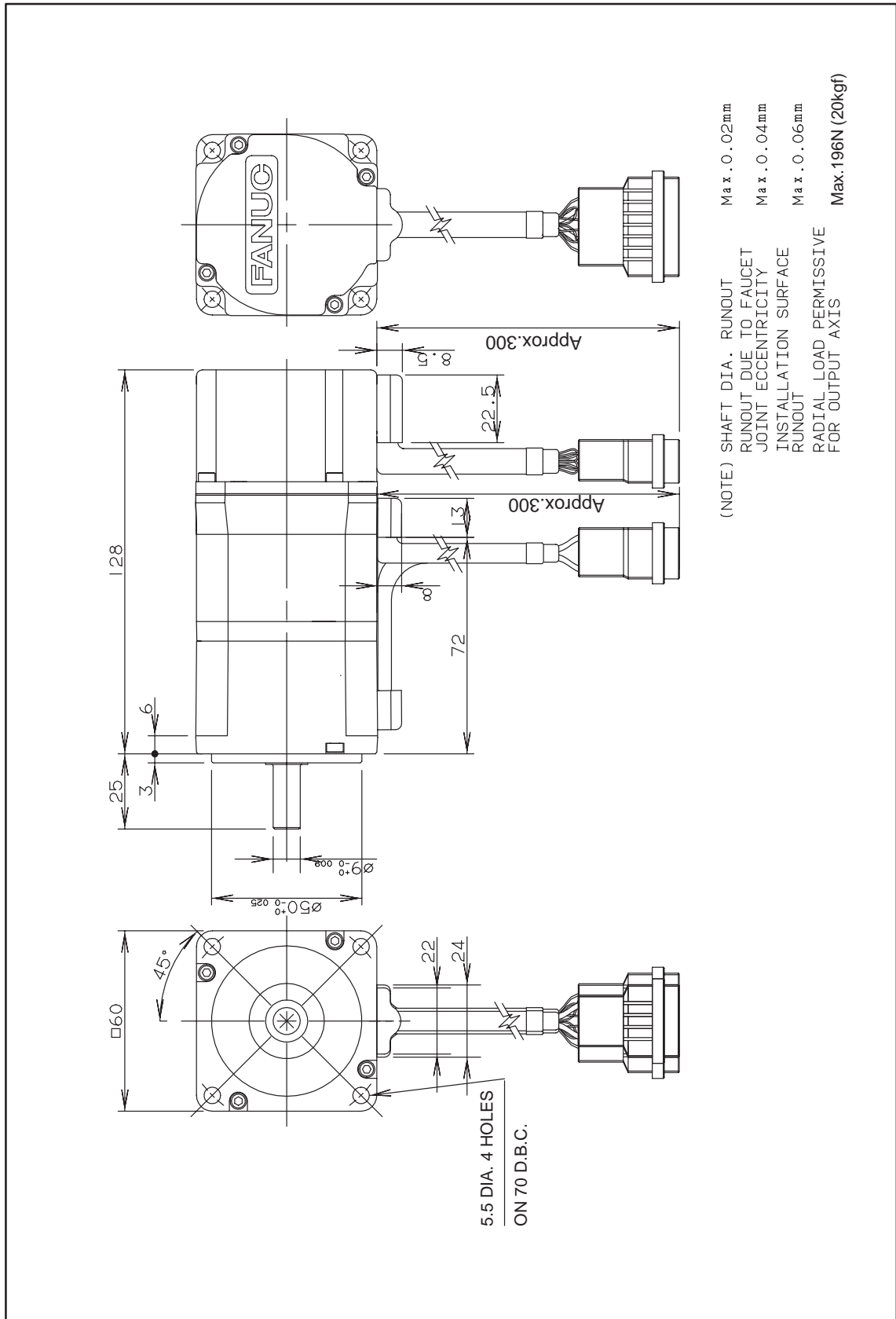
## 2.4 OUTLINE DRAWINGS

Model	Fig. No.
Models $\beta 0.5$	Fig.2.4 (a)
Models $\beta 0.5$ (with brake)	Fig.2.4 (b)
Models $\beta 0.5$ (shaft option)	Fig.2.4 (c)
Models $\beta 1$ and $\beta 2$	Fig.2.4 (d)
Models $\beta 1$ and $\beta 2$ (with brake)	Fig. 2.4 (e)
Models $\beta 1$ and $\beta 2$ (shaft option)	Fig. 2.4 (f)
Models $\beta 3$ and $\beta 6$	Fig. 2.4 (g)
Models $\beta 3$ and $\beta 6$ (with brake)	Fig. 2.4 (h)
Models $\beta 3$ and $\beta 6$ (shaft option)	Fig. 2.4 (i)

**Fig. 2.4 (a) Model  $\beta$ 0.5**

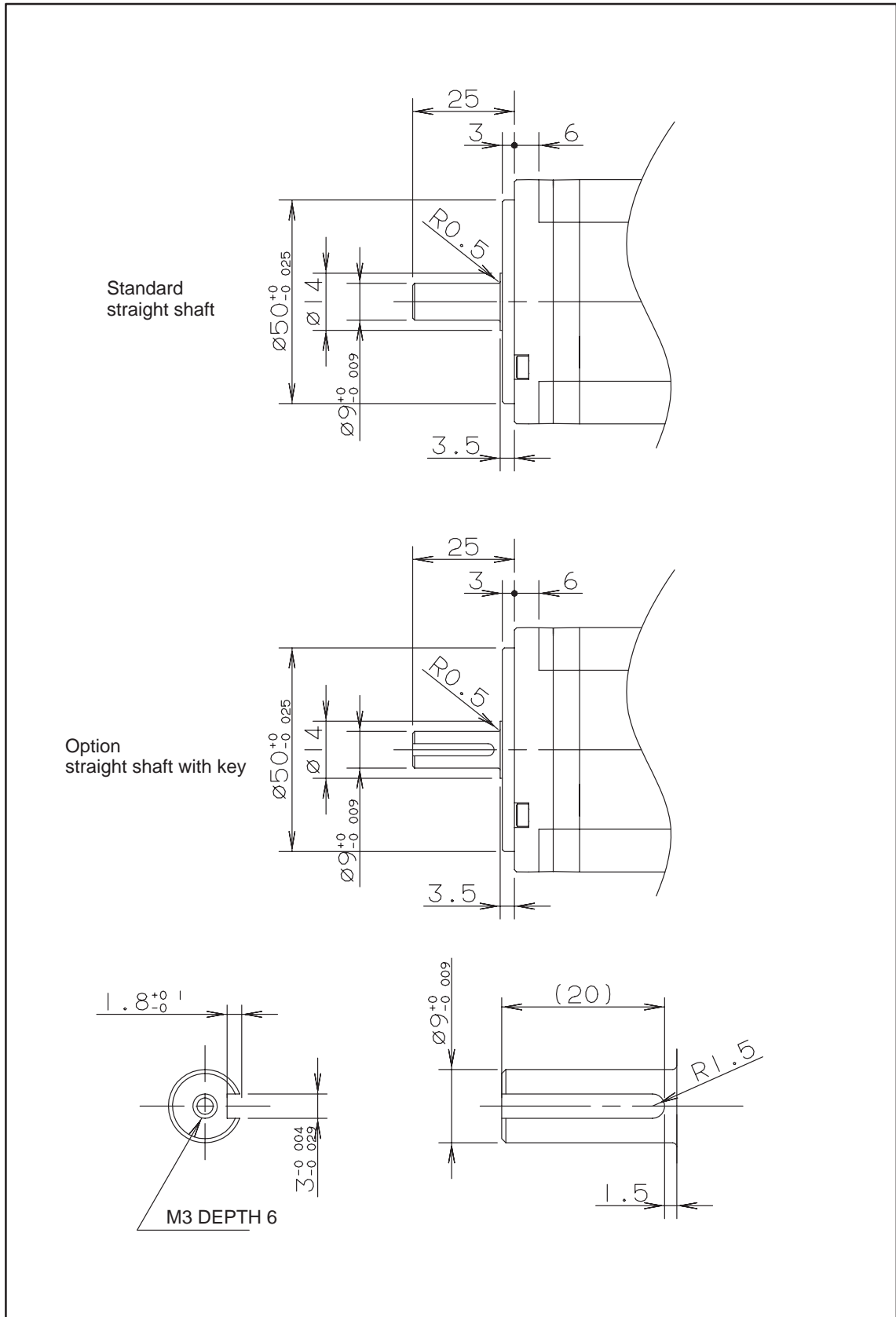


**Fig. 2.4 (b) Model  $\beta$ 0.5 (with brake)**

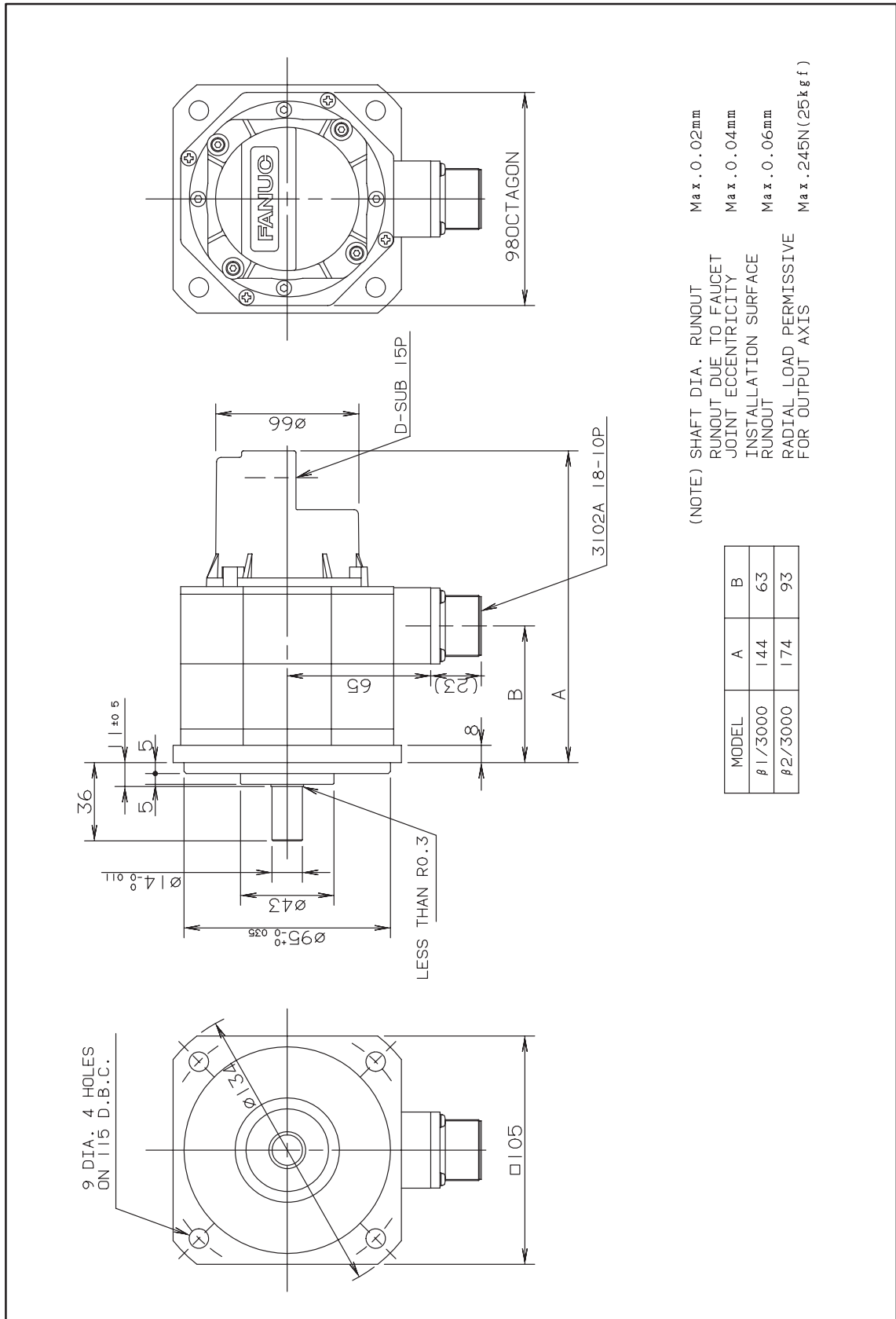




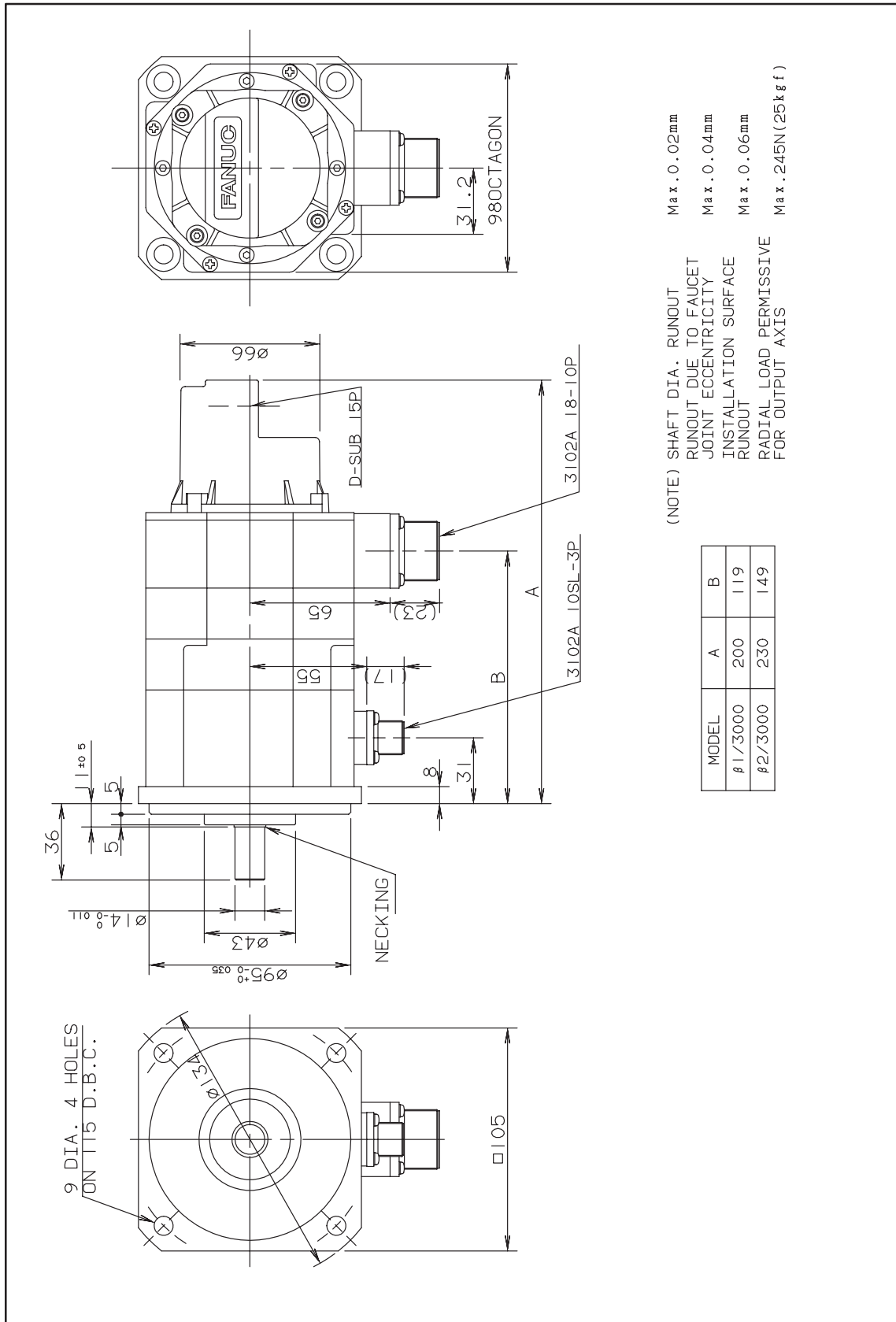
**Fig. 2.4 (c) Model  $\beta$ 0.5 (shaft option)**



**Fig. 2.4 (d) Models  $\beta$ 1 and  $\beta$ 2**



**Fig. 2.4 (e) Models β1 and β2 (with brake)**



**Fig. 2.4 (f) Models  $\beta$ 1 and  $\beta$ 2 (shaft option)**

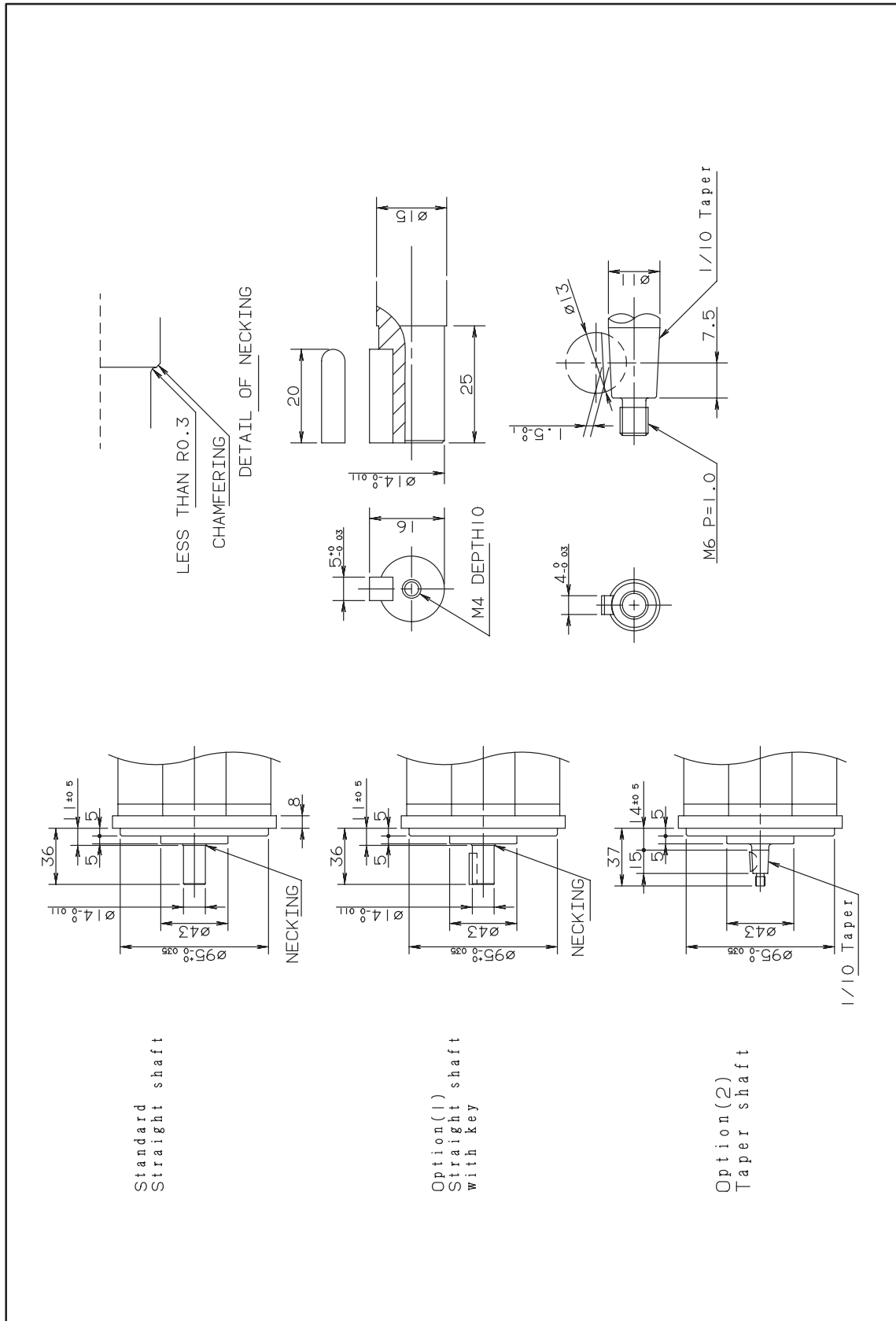
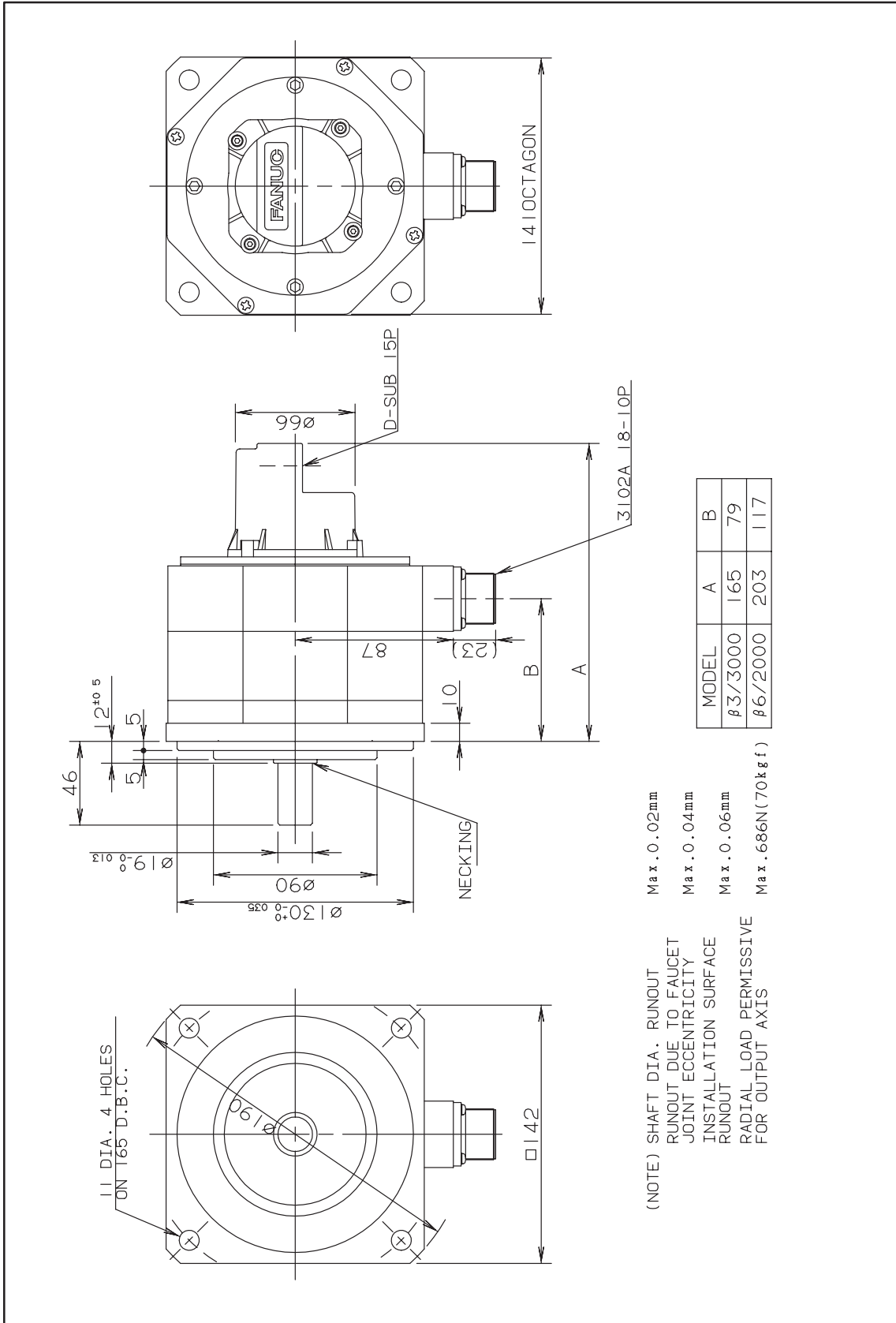
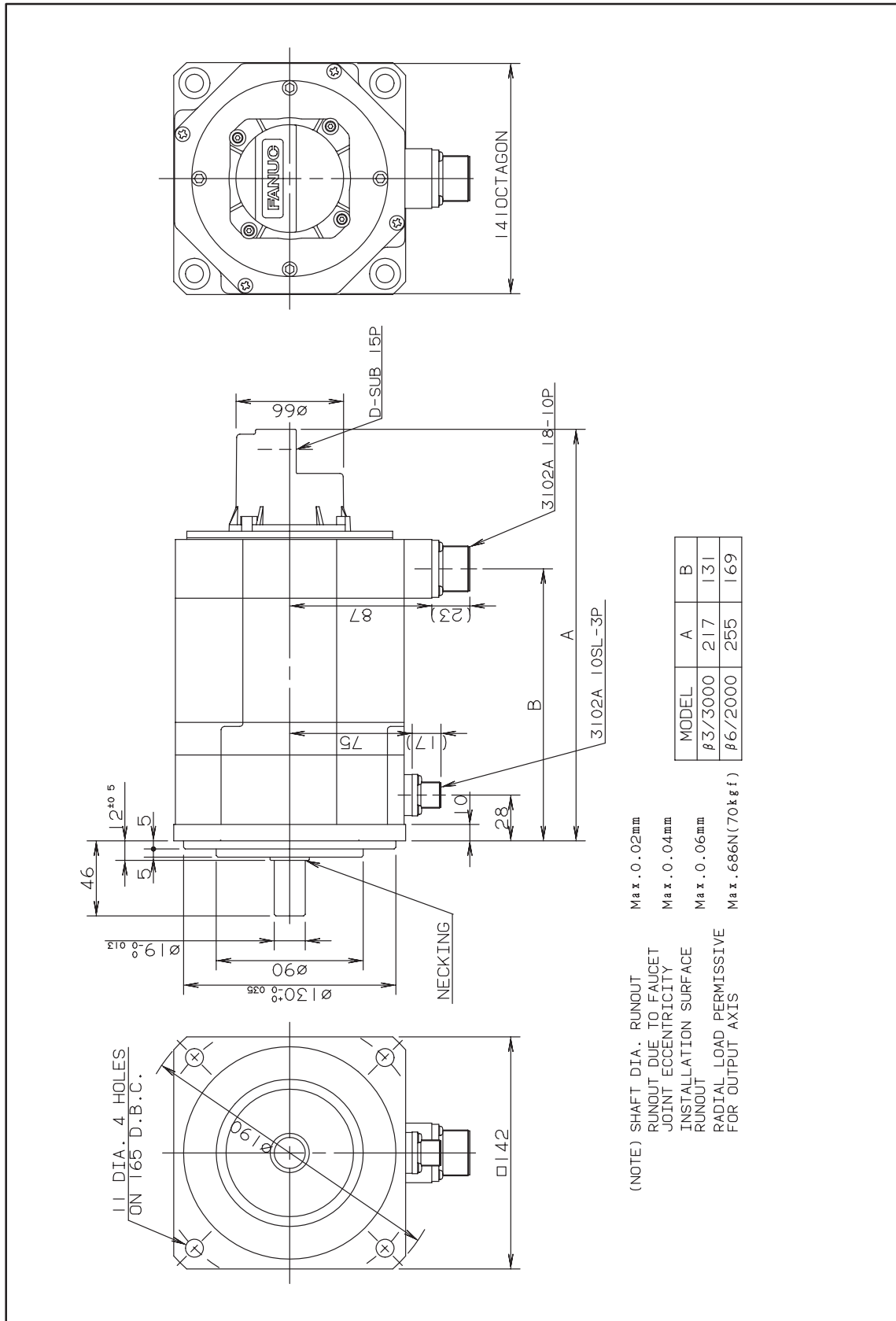


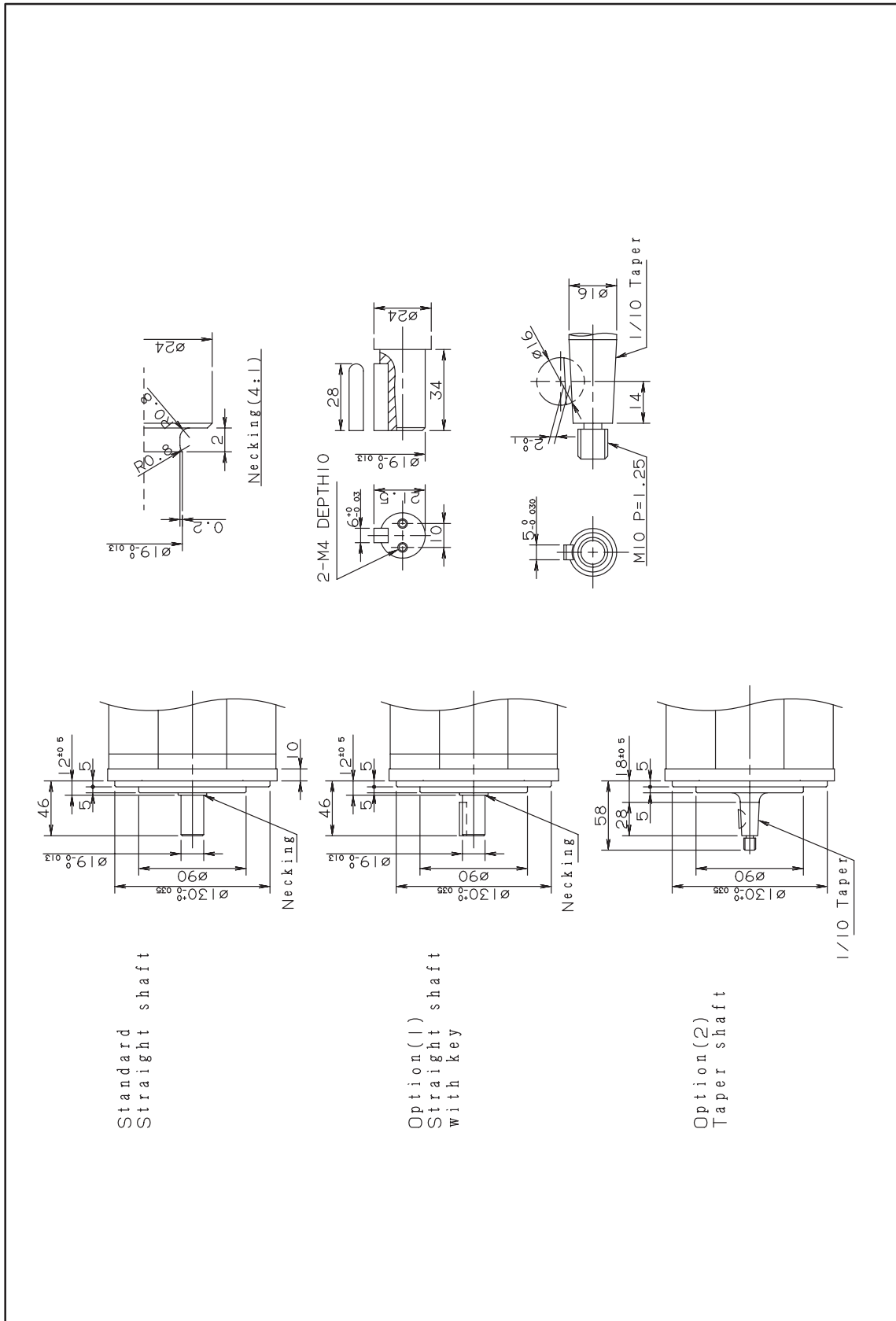
Fig. 2.4 (g) Models β3 and β6



**Fig. 2.4 (h) Models  $\beta$ 3 and  $\beta$ 6 (with brake)**

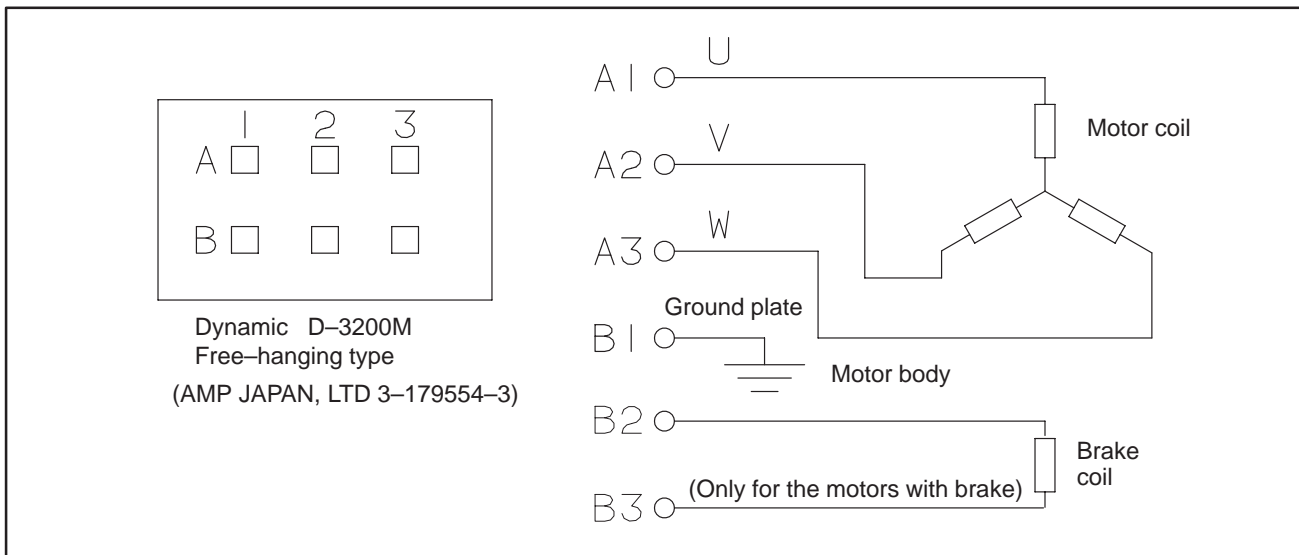


**Fig. 2.4 (i) Models  $\beta$ 3 and  $\beta$ 6 (shaft option)**

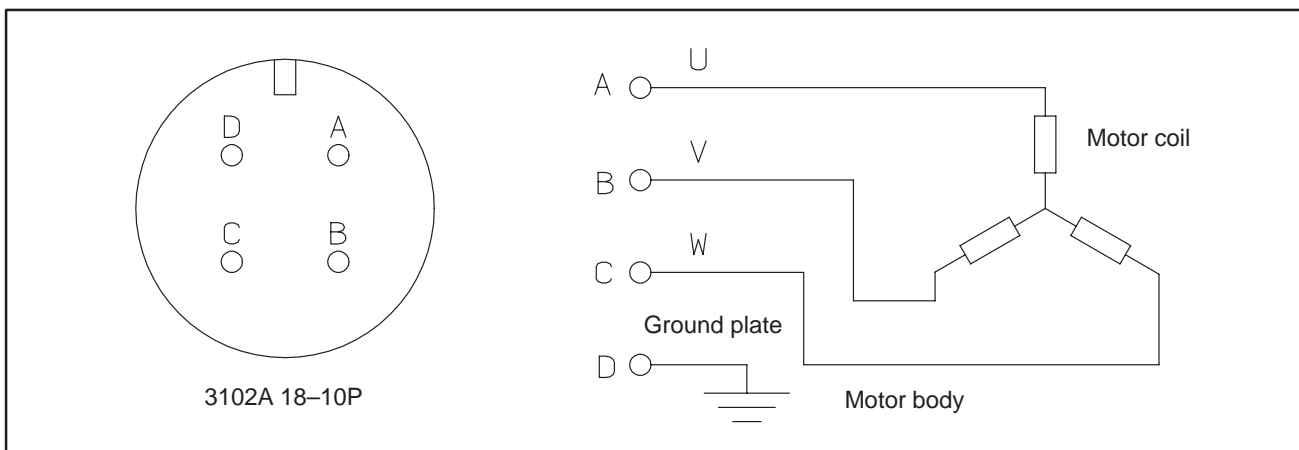


## 2.5 CONNECTION OF POWER LINE

### • Models $\beta$ 0.5/3000



### • Models $\beta$ 1/3000, $\beta$ 2/3000, $\beta$ 3/3000, and $\beta$ 6/2000



#### WARNING

If a motor is not connected to ground through the machine (housing) on which it is mounted, connect, for noise suppression, the ground plate of the motor, through a cable, to the point where the ground plate of the amplifier is connected.

In this case, do not use the GND wire of the power line. Instead, use a separate cable having a cross-sectional area of 1.25 mm<sup>2</sup> or more. Route the cable as far as possible from the power line.



# **III. FANUC SERVO AMPLIFIER $\beta$ series**

# 1 OVERVIEW

This servo amplifier  $\beta$  series is a single-axis control motor amplifier, suitable for positioning, and specifically designed to drive the FANUC AC servo motor  $\beta$  series.

The main features of servo amplifier  $\beta$  series are as follows:

- (1) The servo amplifier  $\beta$  series is a low-cost, single-axis amplifier that is intended for positioning tasks.
- (2) Some models support the PWM interface (type B), that is, FANUC's standard amplifier interface, as well as the I/O interface incorporated in the CNC, Power Mate, and PLC.
- (3) The amplifier unit features a footprint and volume that have been reduced by 60%, relative to the previous model.
- (4) The amplifier unit has been designed to conform to the European VDE0160 safety standard, American UL standards, and Canadian CSA standards.

The  $\beta$  series servo amplifiers supporting the I/O link interface have the following features:

- (1) Have a position control function as well as a set to facilitate control over peripheral devices such as turrets and ATCs.
- (2) Can be connected to the Series 16/18/21, Power Mate PMC, and PLC via the I/O link, thereby facilitating positioning axis expansion.
- (3) Have the same dimensions as those of the  $\beta$  series servo amplifiers supporting the PWM interface, despite the fact that they have a position control function.
- (4) Enable the master CNC to set and display parameters, the current position, and diagnosis data.
- (5) Support move commands that make movement synchronize with a train of external pulses, thereby enabling diverse use.

# 2

## CONFIGURATION



Following contents shows an example system configuration having two controlled axes. A separate regenerative discharge unit may be required to handle large amounts of regenerative energy if the load is particularly heavy.

## 2.1 PWM INTERFACE

### (1) Three-phase power input

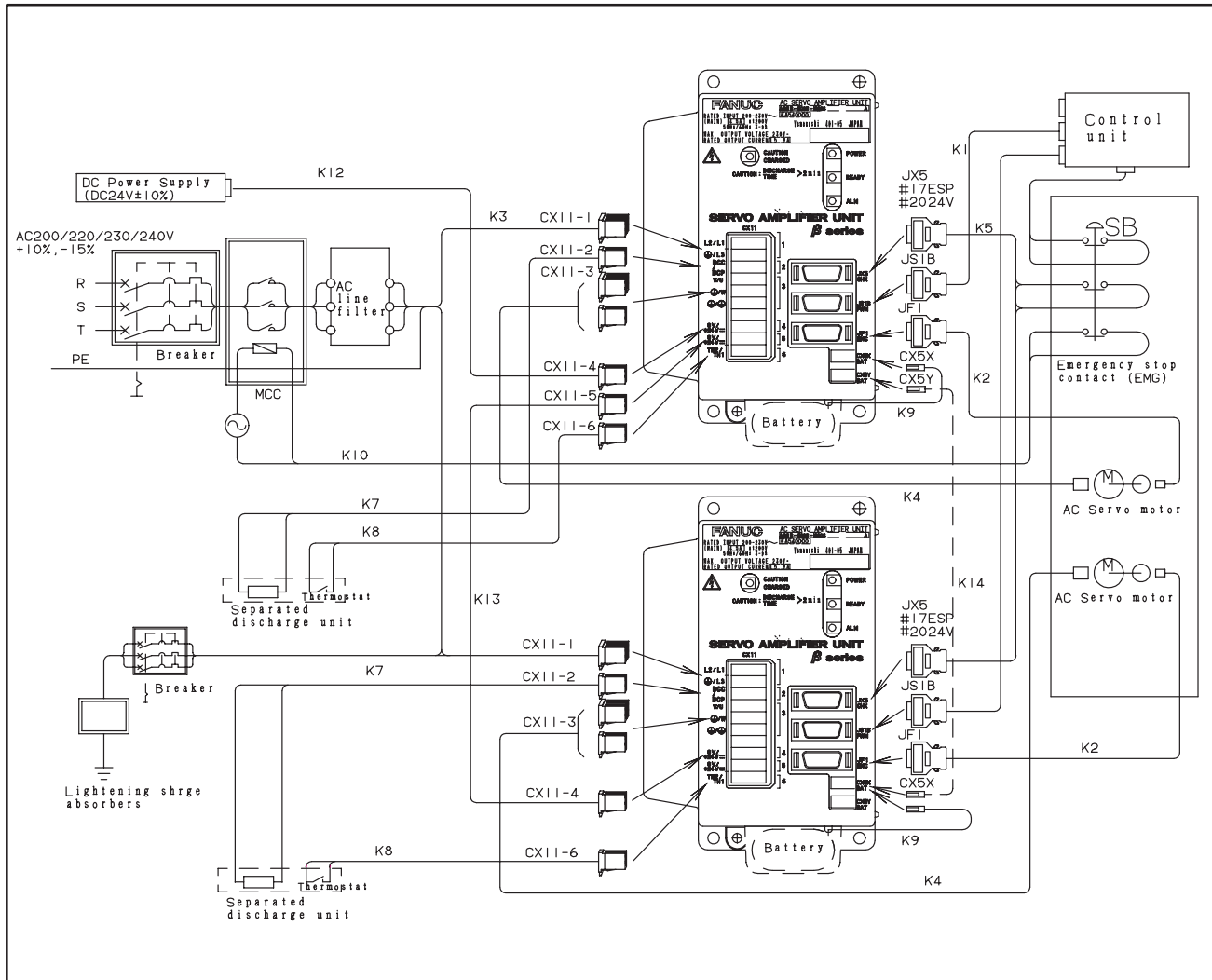


Fig.2.1(a) Example of System Configuration

#### WARNING

A circuit breaker, electromagnetic contractor, and AC line filter must be installed.

(2) Single-phase power input

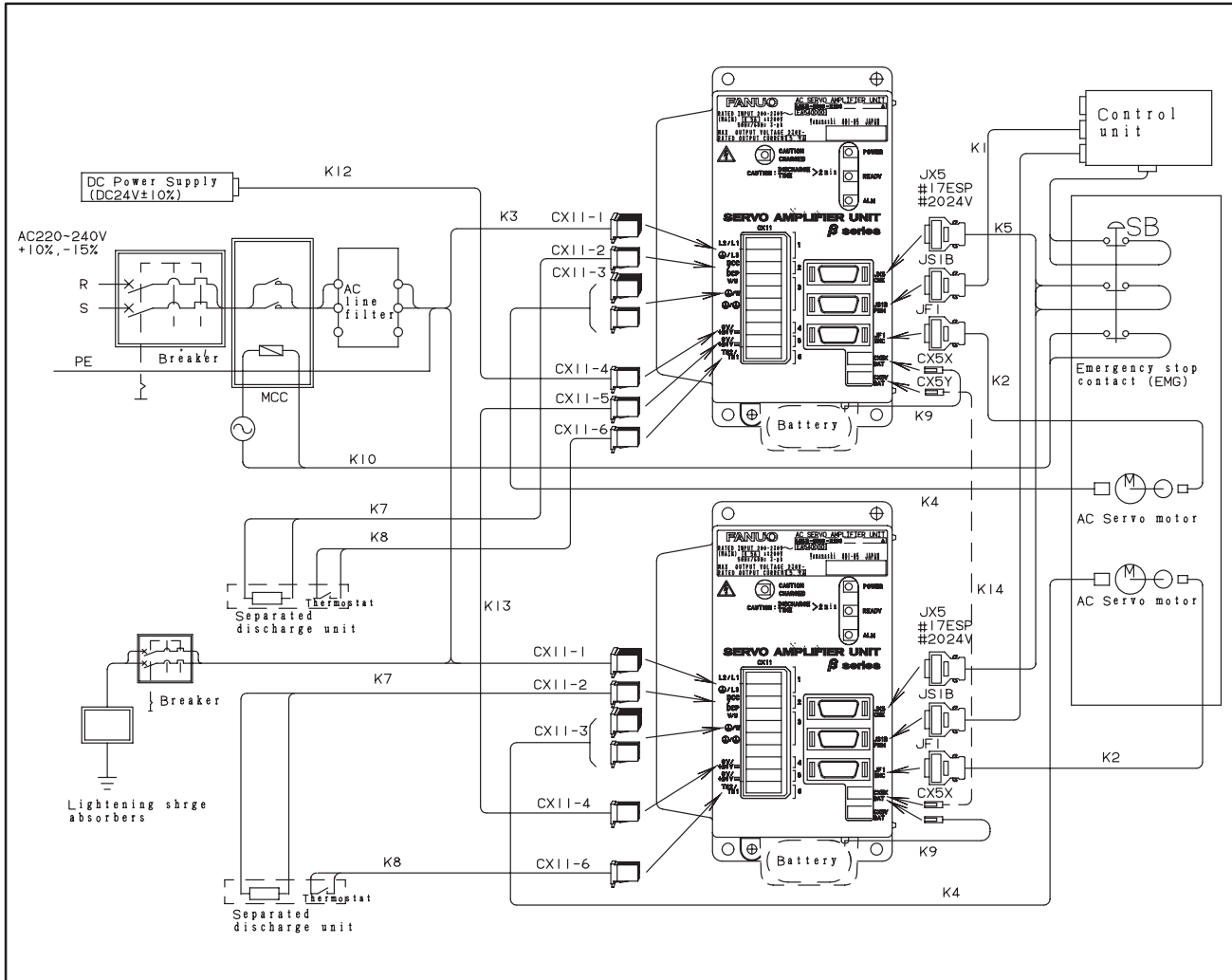


Fig.2.1(b) Example of System Configuration

**WARNING**

A circuit breaker, electromagnetic contractor, and AC line filter must be installed.

## 2.2 I/O LINK INTERFACE

### (1) Three-phase power input

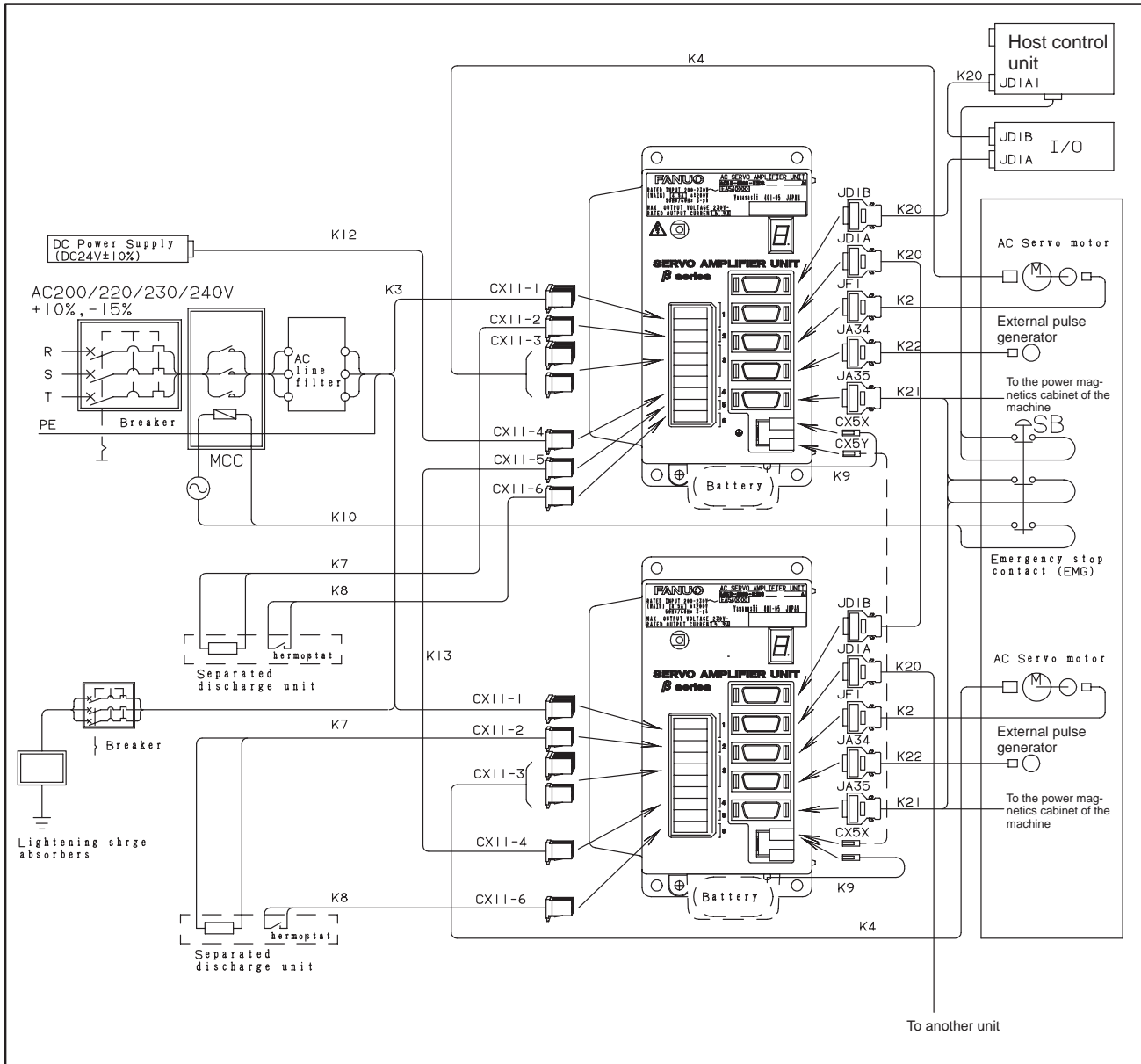


Fig.2.2(a) Example of System Configuration

#### WARNING

A circuit breaker, electromagnetic contractor, and AC line filter must be installed.

(2) Single-phase power input

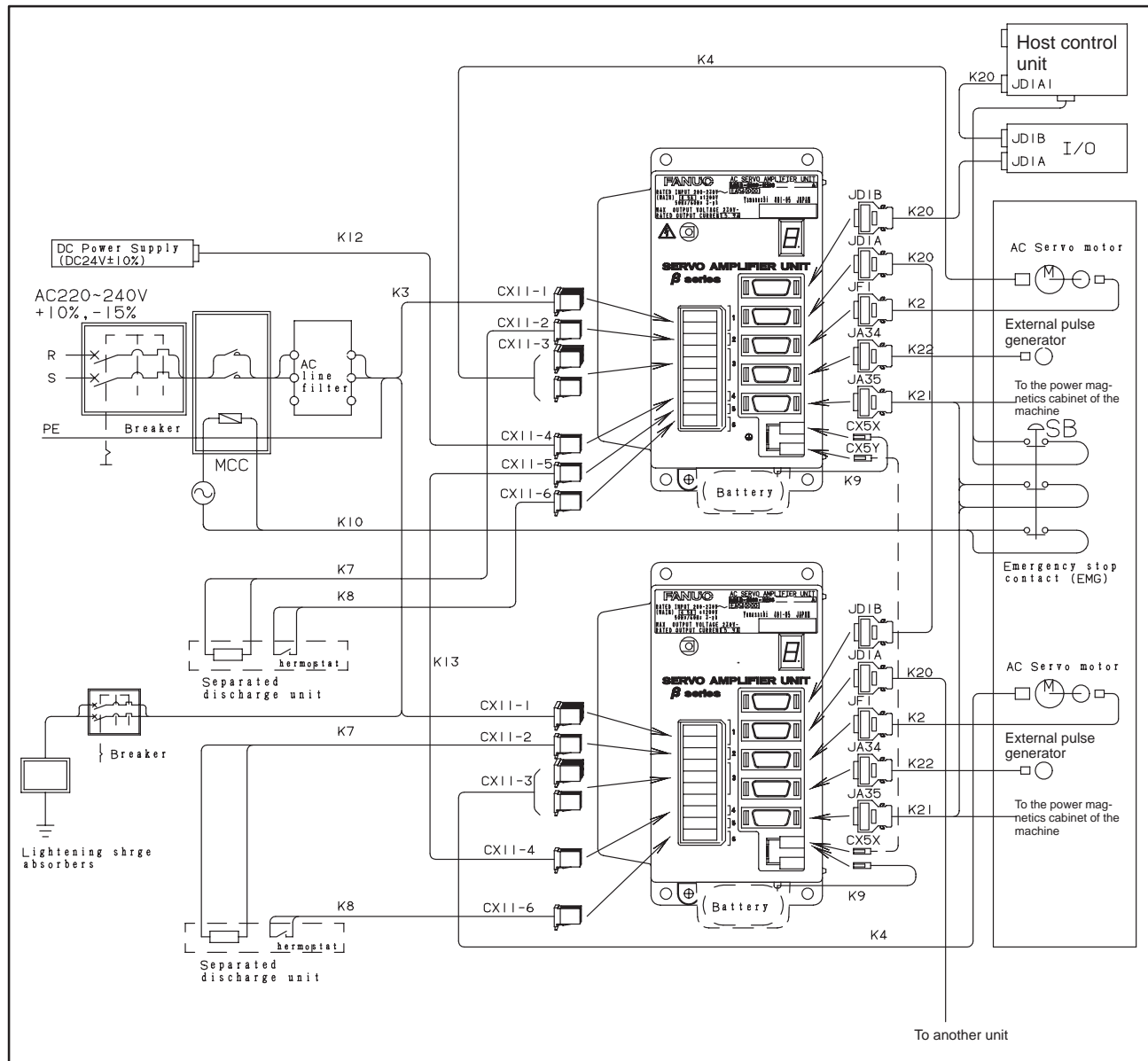


Fig.2.2(b) Example of System Configuration

**WARNING**

A circuit breaker, electromagnetic contractor, and AC line filter must be installed.

## 2.3 UNIT TYPES AND SPECIFICATIONS

**Table 2.3(a) Unit Types and Specifications (1)**

Classification	Name		Specification	Applicable motor
Basic	SVU-12	PWM Interface	A06B-6093-H101 (Limit current : 12A)	$\beta$ 0.5/3000, $\beta$ 1/3000, $\beta$ 2/3000 $\alpha$ 1/3000(NOTE), $\alpha$ 2/2000(NOTE), $\alpha$ 2/3000(NOTE)
		I/O link Interface	A06B-6093-H151 (Limit current : 12A)	
	SVU-20	PWM Interface	A06B-6093-H102 (Limit current : 20A)	$\beta$ 3/3000, $\beta$ 6/2000 $\alpha$ C3/2000 (NOTE), $\alpha$ C6/2000(NOTE), $\alpha$ C12/2000(NOTE)
		I/O link Interface	A06B-6093-H152 (Limit current : 20A)	

### NOTE

These motors can be driven, but the feed fluctuation and stability at stopping are better when  $\alpha$  series servo amplifier is included in the configuration.

**Table 2.3(b) Unit Types and Specifications (2)**

Classification	Name	Application	Specification
Basic	AC line filter (WARNING)	Type A: For applications where the sum of the rated motor powers does not exceed 5.4 kW	A81L-0001-0083#3C
Option	Separate regenerative discharge unit (CAUTION)	30 ohms/20W, at natural cooling	A06B-6093-H401
		30 ohms/100W, at natural cooling	A06B-6093-H402 (NOTE)

### WARNING

An AC line filter must be used to suppress the influences of high-frequency noise on the power supply.

For details, see Section 2.4.3. When a power transformer (insulation type) is used because a power supply voltage within the specified range is not available, this AC line filter is not necessary. If the use of this AC line filter fails to fully satisfy EMC requirements the use of a commercially available noise filter is recommended.

### CAUTION

A separate regenerative discharge unit must be used when the amount of regenerative energy produced by the motor exceeds a specified value because of a high load inertia of frequent acceleration/deceleration. If excessive heat dissipation is anticipated, contact FANUC as detailed in the servo motor selection document.

Refer to Chapter 4 "Separated regenerative discharge unit" for details of regenerative discharge unit.

### NOTE

A06B-6093-H402 contains a connector kit for connection with a  $\beta$  series amplifier as a standard accessory.



Table 2.3(c) Unit Types and Specifications (3)

Classification	Name	Application	Specification	
Basic	Connector (PWM)	JX5 : For ESP signal	Solder type	A06B-6073-K212
			Crimp type	A06B-6073-K213
	Connector (PWM)	JS1B : NC-SVU command cable	Solder type	A06B-6073-K212
			Crimp type	A06B-6073-K213
	Connector (I/O Link)	JD1A : For I/O Link	Solder type	A06B-6073-K212
			Crimp type	A06B-6073-K213
	Connector (I/O Link)	JD1B : For I/O Link	Solder type	A06B-6073-K212
			Crimp type	A06B-6073-K213
	Connector (I/O Link)	JA35 : For built-in DI input cable	Solder type	A06B-6073-K212
			Crimp type	A06B-6073-K213
	Connector (Common)	JF1 : For pulse coder F/B cables		A06B-6073-K214
	Connector (Common)	JA34 : For external pulse input cable		A06B-6073-K214
	Connector (Common)	CX11-1, 3, 4, 5 and dummy plug for 6: When a regenerative discharge unit is not used		A06B-6093-K301
Connector (Common)	CX11-1, 3, 4, 5: When a regenerative discharge unit is used		A06B-6093-K302	
Connector (Common) (Caution)	CX11-4, 5: When the cross-sectional area of wire exceeds 0.5 mm <sup>2</sup>		A06B-6093-K304	
Fuse (Common)	For protecting control power 24 VDC from a short-circuit		A06B-6073-K250	
Option	Connector	CX5X, Y: For battery cable	A06B-6093-K303	
	Battery case	For absolute pulse coders. Connection method 1 (NOTE)	A06B-6093-K002	
	Battery	For absolute pulse coders. Connection method 1 (NOTE)	A06B-6093-K001	
	Battery case	For absolute pulse coders. Connection method 2 (NOTE)	A06B-6050-K060	
	Battery	For absolute pulse coders. Connection method 2 (NOTE)	A06B-6050-K061	
	Battery cable	For absolute pulse coders (Cable length: 5m). Connection method 2 (NOTE)	A06B-6093-K810	
	Lightning surge absorber	Not complying with the standard (WARNING)		A06B-6077-K141
Complying with the standard (WARNING)			A06B-6077-K142	

The terms “PWM,” “I/O link,” and “common” used in the Name column indicate what interface to be used.

PWM : The PWM interface is used.

I/O link : The I/O link interface is used.

Common : Both PWM and I/O link interfaces can be used.

**WARNING**

At the power input of the power magnetics cabinet, install a surge absorber between the power lines and between each power line and a ground to protect the unit from a voltage surge caused by lightning.  
See Section 7.5 for details of the lightning surge absorber.

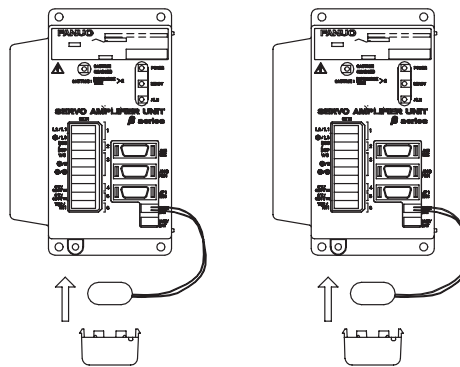
**CAUTION**

When using some amplifiers and more than wire 0.53 mm, this connector is used. The power supply current is 0.4A (for PWM interface) or 0.9A (for I/O Link Interface) per an amplifier, so the wire is depended on this condition.

**NOTE**

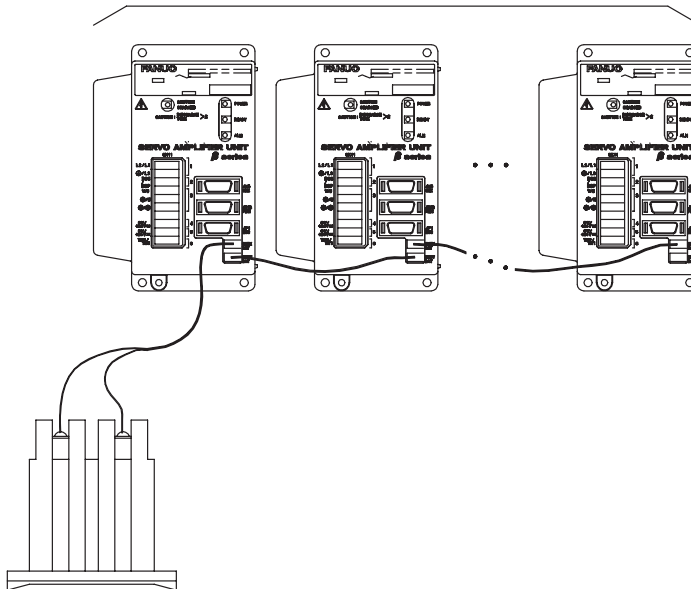
There are two methods of connecting the batteries for the absolute pulse coder. Specify an appropriate battery case and battery according to the connection method selected.

1. Connection method 1

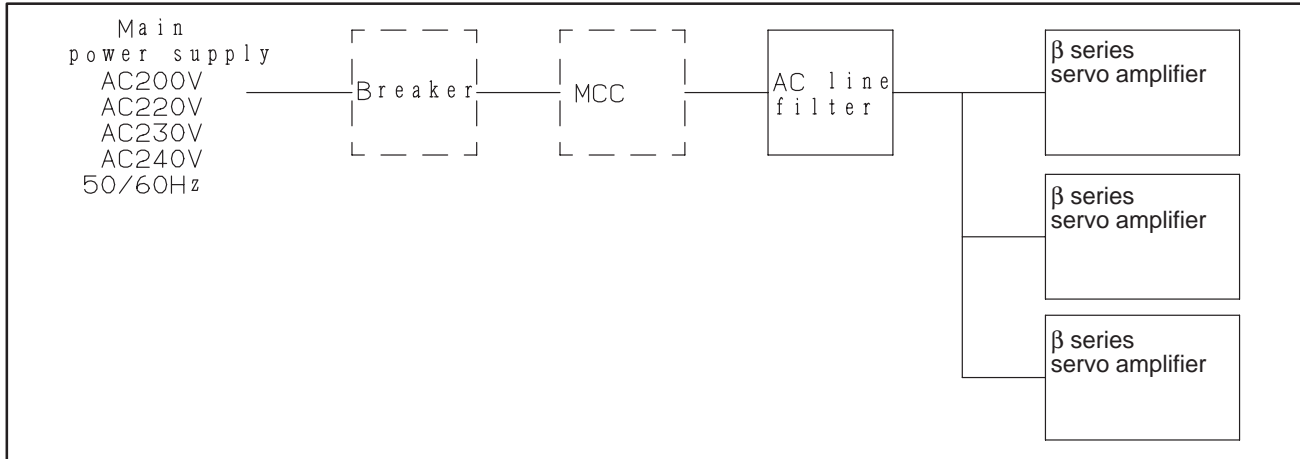


2. Connection method 2

Maximum 4 per .



## 2.4 CIRCUIT BREAKER, ELECTROMAGNETIC CONTACTOR, AND AC LINE FILTER



### 2.4.1 Circuit Breaker Rating

Select an appropriate circuit breaker based on Table 2.4.1. When multiple amplifiers are to be connected to a single circuit breaker, select a breaker based on the sum of the currents on this table.

Note that, during rapid motor acceleration, a current that is roughly triple the continuous rating flows. Therefore, select a circuit breaker that does not trip when a current that is triple the continuous rating flows for 2 seconds.

To conform to the European Standard (CE marking), it is necessary to use a circuit breaker rated at 10A or lower for a reason of protection harmony for the power input cord and the related circuits.

To use one circuit breaker for more than one amplifier, obtain the current rating for the circuit breaker by multiplying a sum of the input currents of all motors operating at their continuous-duty output rating by 0.6.

Example selection: EA33 Series manufactured by Fuji Electric Co., Ltd.

**Table 2.4.1 Currents Drawn by Motors Operating at Continuous Rated Output**

Motor	Input current (three-phase input)	Input current (single-phase input)
β 0.5/3000, β 1/3000, α C3/2000	1.9 Arms	3.2 Arms
β 2/3000, β 3/3000, α 1/3000, α 2/2000, α 2/3000	3.2 Arms	5.1 Arms
β 6/2000, α C6/2000, α C12/2000	6.3 Arms	10.1 Arms

#### Example)

Connecting two β6/2000 units operating on three-phase power  
Because one β6/2000 unit requires an input current of 6.3 Arms:

$$(6.3 + 6.3) \times 0.6 \doteq 7.6 \text{ Arms}$$

So, a 10A circuit breaker can be used.

#### WARNING

Be sure to install a circuit breaker for circuit protection.

## 2.4.2 Electromagnetic Contactor Rating

Select an appropriate electromagnetic contactor based on Table 2.4.2. When multiple amplifiers are to be connected to a single Electromagnetic contactor (MCC), select an MCC based on the sum of the currents on Table 2.4.1.

Example selection:

**Table 2.4.2 Electromagnetic contactor specifications**

Manufactured by Fuji Electric Co., Ltd.	Rated current
SC-03	11 Apeak
SC-4-1	18 Apeak
SC-1N	26 Apeak

## 2.4.3 AC Line Filter

An AC line filter or an EMC noise filter must be used to suppress the influence of high-frequency noise on the power supply unit. When multiple amplifiers are connected to a single AC line filter, select a line filter based on the sum of the currents on Table 2.4.1.

**Table 2.4.3 (a) AC Line Filter Specifications**

AC line filter	Continuous rated current	Continuous rated power	Heat dissipation
Type A: A81L-0001-0083#3C	24A	5.4 kW or less	20W

Example selection:

**Table 2.4.3 (b) EMC Noise Filters**

Manufactured by Tokin Corp.	Rated current
LF-305	5 Apeak
LF-310	10 Apeak
LF-315	15 Apeak
LF-320	20 Apeak

## 2.5 MAKING CONNECTIONS

For making connections, dedicated tools are available from each manufacturer.

**Table 2.5 (a) Connectors Manufactured by AMP**

Name	Part No.
Contact crimp tool	914596-3
Contact extractor	914677-1

**Table 2.5 (b) Connectors (Crimp Types)  
Manufactured by Honda Tsushin**

Name	Part No.
Wire laying cassette	JGPS-015-1/1-20
Wire laying cassette mounting table	JGPS-014
Press-mount locator	PCS-K1
Handpress	MFC-K1

# 3

## SPECIFICATIONS



## 3.1 SPECIFICATIONS

**Table 3.1 (a) Specifications (Common)**

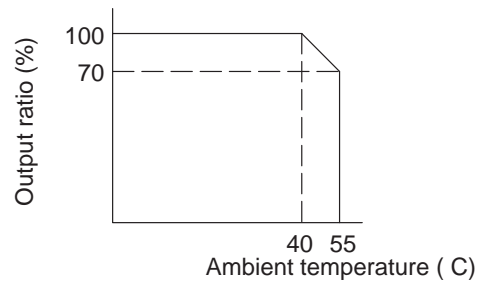
	Item	Specifications
Power supply	Three-phase input power supply for motor power	Voltage: 200 VAC to 240 VAC Allowable voltage fluctuation: +10%, -15% (NOTE 1) Frequency: 50 Hz, 60 Hz Allowable frequency fluctuation: $\pm 2$ Hz Voltage fluctuation during acceleration/deceleration: 7% or less
	Single-phase power supply for motor power (CAUTION)	Voltage: 220 VAC to 240 VAC Allowable voltage fluctuation: +10%, -15% (NOTE 1) Frequency: 50 Hz, 60 Hz Allowable frequency fluctuation: $\pm 2$ Hz Voltage fluctuation during acceleration/deceleration: 7% or less
	Single-phase input power supply for control power	Voltage: 24 VDC Allowable voltage fluctuation: $\pm 10\%$
Main circuit control system		Sinusoidal PWM control based on transistor (IGBT) bridge
Alarm protection function		Overvoltage alarm DC link undervoltage alarm Regenerative overheat alarm Overcurrent alarm Amplifier overheat alarm Fan failure alarm

Table 3.1 (b) Specifications (Individual)

Name		Specification	Rated output current (RMS value)	Nominal current limiting (peak value)
SVU-12	PWM Interface	A06B-6093-H101	3.2 Arms	12 Apeak
	I/O Link Interface	A06B-6093-H151		
SVU-20	PWM Interface	A06B-6093-H102	5.9Arms	20 Apeak
	I/O Link Interface	A06B-6093-H152		

**CAUTION**

Driving the  $\beta$ 6/2000,  $\alpha$ C6/2000, and  $\alpha$ C12/2000 motors with a single-phase voltage requires temperature derating.



When a motor is powered with a single-phase voltage, the lifetime of the related servo amplifier is decreased due to repeated acceleration/deceleration, because the current that flows at acceleration/deceleration increases, as compared with when it is powered with a three-phase voltage.

If the  $\beta$ 6/2000,  $\alpha$ C6/2000, or  $\alpha$ C12/2000 motor is used for applications in which frequent acceleration/deceleration (20 s/cycle or more often) occurs, it should be powered with a three-phase voltage.

**NOTE**

- 1 The allowable voltage fluctuation is a change observed for several minutes. It is not a continuous change.
- 2 The rated output is guaranteed provided the rated input voltage is applied. If the input voltage fluctuates, however, the rated output may not be obtained even if the fluctuation falls within the allowable fluctuation range.
- 3 The nominal current limiting peak values are standard setting values. The operation fluctuation due to a circuit constant is about  $\pm 10\%$ .



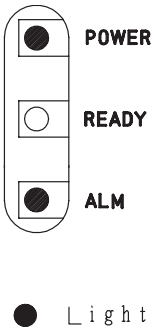


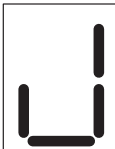



## 3.2 PROTECTION AND ABNORMALITY DETECTION FUNCTIONS

The servo amplifier is provided with the protection and abnormality detection functions indicated below.

Determine any alarm status from the diagnostic data displayed by the controller.

If an alarm condition occurs, the "ALM" LED or the 7-segment indicator lights on the PWM interface or the I/O link interface, respectively. At this time, the motor is stopped by the dynamic brake.

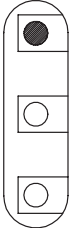
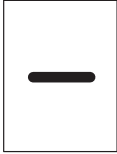

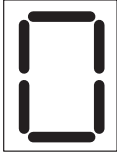
Table 3.2 Protection and Abnormality Detection Function

LED display for PWM	LED display for I/O Link	Type	Description
		Overvoltage alarm (HV)	This alarm is issued if the DC voltage in the main circuit power supply is abnormally high.
		DC link undervoltage alarm (LVDC)	This alarm is issued if the DC voltage in the main circuit power supply is abnormally low. This alarm is also issued if the circuit breaker has tripped.
		Regenerative overheat alarm (DCOH)	This alarm is issued if the average regenerative discharge energy is excessively high (such as when acceleration/deceleration is performed too frequently).
		Overheat alarm (OH)	This alarm is issued if the temperature inside the amplifier becomes so high that the thermostat trips.
		Fan failure alarm (FAL)	This alarm is issued if the fan unit, built into the servo amplifier, fails.
		Overcurrent alarm (HC)	This alarm is issued if an abnormally high current is detected in the main circuit.

### 3.3 NORMAL OPERATING MODE

In normal operating mode, the LEDs located on the front of the servo amplifier light as indicated below.

Table 3.3 Normal Operating Mode

LED display for PWM ● : Light	LED display for I/O Link	State	Description
 <p>POWER READY ALM</p>		Amplifier not ready	Indicates that the control power supply voltage (+24 VDC) is applied.
 <p>POWER READY ALM</p>		Amplifier ready	Indicates that the motor has been activated, and that the servo amplifier is ready to accept commands.

# 4

## SEPARATED REGENERATIVE DISCHARGE UNIT



## 4.1 CASES WHERE A SEPARATE REGENERATIVE DISCHARGE UNIT IS NOT REQUIRED

When the amount of regenerative energy produced [J] never exceeds the amounts indicated in Table 4.1, a separate regenerative discharge unit is not required.

**Table 4.1 Maximum allowable regenerative energy for amplifiers**

Name	Maximum allowable regenerative energy
SVU-12	13 (J)
SVU-20	16 (J)

### 4.1.1 Calculating the Amount of Regenerative Energy Produced

For horizontal operation :

$$P = 5.37 \times 10^{-4} J V_m^2 - 5.13 \times 10^{-3} t_a V_m T_L \text{ (J) } \dots\dots \text{ (Expression 1)}$$

where, (Expression 1)

$$J = J_M + J_L$$

$J_M$  : Motor rotor inertia (kgf · cm · sec<sup>2</sup>)

$J_L$  : Load inertia converted to motor shaft inertia (kgf · cm · sec<sup>2</sup>)

$V_m$  : Motor speed during rapid traverse (1/min)

$t_a$  : Acceleration/deceleration duration during rapid traverse (sec)

$T_L$  : Machine tool friction torque (converted to motor shaft torque)  
(kgf · cm)

For vertical operation :

$$Q = 1.026 \times 10^{-2} T_H V_m t_a \text{ (J) } \dots\dots \text{ (Expression 2)}$$

$T_H$  : Upward supporting torque applied by the motor during downward rapid traverse (kgf · cm)

$V_m$  : Motor speed during rapid traverse (rpm)

$t_a$  : Acceleration/deceleration duration during rapid traverse (sec)

If the operation is vertical, the regenerative energy per operation is a sum of the values of Expressions 1 and 2.

$$R = P + Q \text{ (J) } \dots \text{ (Expression 3)}$$

## 4.2 CASES WHERE A SEPARATE REGENERATIVE DISCHARGE UNIT IS REQUIRED

When the amount of regenerative energy produced [J] exceeds the amounts indicated in Table 4.1, the DC link overvoltage alarm is issued. To prevent this, a separate regenerative discharge unit is required. For details of connecting the discharge unit, see Chapter. V.

### 4.2.1 Selecting Regenerative Discharge Unit

(1) First, calculate the regenerative energy.

For horizontal operation :

Suppose that acceleration/deceleration is performed once every F (sec) during rapid traverse. Then,

$$P' = (5.37 \times 10^{-4} J V_m^2 - 5.13 \times 10^{-3} t_a V_m T_L) / F \text{ [W]} \dots\dots \text{(Expression 4)}$$

where,  $J = J_m + J_L$

F: Frequency of acceleration/deceleration during rapid traverse (sec/occurrence) (When FANUC selects a regenerative discharge unit, we assume  $F = 5$  (s/cycle).)

$J_M$ : Motor rotor inertia (kgf · cm · sec<sup>2</sup>)

$J_L$ : Load inertia converted to motor shaft inertia (kgf · cm · sec<sup>2</sup>)

$V_m$ : Motor speed during rapid traverse (rpm)

$t_a$ : Acceleration/deceleration duration during rapid traverse (sec)

$T_L$ : Machine tool friction torque (converted to motor shaft torque) (kgf · cm)

For vertical operation :

Let D (%) be the duty cycle of downward vertical operation during rapid traverse. Then,

$$Q' = (1.026 \times 10^{-2} T_H V_m D) / 100 \text{ [W]} \dots\dots \text{(Expression 5)}$$

where,

$T_H$ : Upward supporting torque applied by the motor during downward rapid traverse (kgf · cm)

$V_m$ : Motor speed during rapid traverse (rpm)

D: Duty cycle of downward vertical operation during rapid traverse (%)

If the operation is vertical, the regenerative energy per operation is a sum of the values of Expressions 4 and 5.

$$R' = P' + Q' \text{ [W]} \dots\dots \text{(Expression 6)}$$

- (2) From Table 4.2, select a separate regenerative discharge unit having a regenerative discharge rating greater than the value determined in (1).

**Table 4.2 Regenerative Discharge Ratings of Separate Regenerative Discharge Units**

Separate regenerative discharge unit	Regerative discharge rating	Candition
A06B-6093-H401 (30 $\Omega$ )	20W	Air flow=0 m/sec
A06B-6093-H402 (30 $\Omega$ )	100W	

**NOTE**

If the separate regenerative discharge unit overheats, its built-in thermostat will trip; the external overheat alarm is issued.

# 5

## POWER SUPPLY



## 5.1 INPUT POWER SUPPLY

### 5.1.1 Three-Phase Input Power Supply for Motor Power

- Nominal rated voltage: 200 to 240 VAC
- Allowable voltage fluctuation:  $-15\%$  to  $+10\%$
- Frequency: 50/60 Hz
- Allowable frequency fluctuation:  $\pm 2$  Hz
- Power supply impedance: Voltage fluctuation caused by load (at maximum output) not to exceed 7%
- Power supply unbalance: Within  $\pm 5\%$  of the rated voltage

#### NOTE

The allowable voltage fluctuation is a change observed for several minutes. It is not a continuous change.

### 5.1.2 Single-Phase Input Power Supply for Motor Power

In European countries, power sources are 380 to 400 VAC and neutral-grounded. To use the  $\beta$  series amplifiers in these European countries, it is necessary to install a power transformer at the input or supply single-phase power.

To use the motors with single-phase power, observe the following:

#### (1) Power source specification

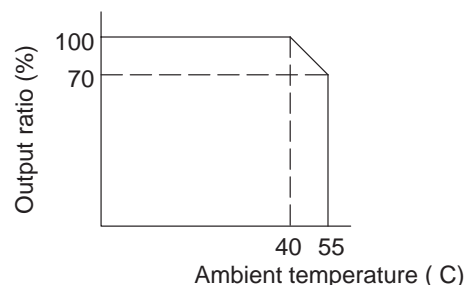
- Nominal voltage rating: 220 to 240 VAC
- Allowable voltage fluctuation:  $-15\%$  to  $+10\%$
- Frequency: 50/60 Hz
- Allowable frequency fluctuation:  $\pm 2$  Hz
- Voltage fluctuation at acceleration/deceleration: 7% or less

#### NOTE

The allowable voltage fluctuation is a change observed for several minutes. It is not a continuous change.

#### (2) Temperature derating

Driving the following motors requires temperature derating:  
 $\beta 6/2000$ ,  $\alpha C 6/2000$ , and  $\alpha C 12/2000$





**CAUTION**

When a motor is powered with a single-phase voltage, the lifetime of the related servo amplifier is decreased due to repeated acceleration/deceleration, because the current that flows at acceleration/deceleration increases, as compared with when it is powered with a three-phase voltage.

If the  $\beta 6/2000$ ,  $\alpha C6/2000$ , or  $\alpha C12/2000$  motor is used for applications in which frequent acceleration/deceleration (20 s/cycle or more often) occurs, it should be powered with a three-phase voltage.

---

**5.1.3  
Single-Phase Input for  
Control Power**

- Nominal rated voltage: 24VDC
- Allowable voltage fluctuation:  $\pm 10\%$

## 5.2 POWER SUPPLY RATINGS

### 5.2.1 Power Supply Ratings for Motor Power

- (1) The power supply rating necessary when using multiple servo motors can be determined by summing the rating of the power supplies required by the individual motors.
- (2) The power supply ratings listed in Table 5.2.1 are sufficient as continuous ratings. Note, however, that servo motor acceleration causes a current that is roughly triple the continuous rating to flow momentarily.
- (3) When the power is turned on, a surge current of about 37 A (when 264 VAC is applied) flows the 20 msec.

Table 5.2.1 Three-Phase Power Supply Ratings

Motor	Power supply rating per motor	Motor	Power supply rating per motor	Motor	Power supply rating per motor
$\beta$ 0.5/3000	0.31kVA	$\beta$ 6/2000	1.4kVA	$\alpha$ C3/2000	0.46kVA
$\beta$ 1/3000	0.46kVA	$\alpha$ 1/3000	0.46kVA	$\alpha$ C6/2000	0.93kVA
$\beta$ 2/3000	0.77kVA	$\alpha$ 2/2000	0.62kVA	$\alpha$ C12/2000	1.6kVA
$\beta$ 3/3000	0.77kVA	$\alpha$ 2/3000	0.77kVA		

### 5.2.2 Power Supply Rating for Control Power

Table 5.2.2 DC Power Supply Rating for Control Power

	Power supply rating per amplifier
PWM Interface	0.4A
I/O Link Interface	0.9A

# 6 HEAT DISSIPATION

The heat dissipation values for the  $\beta$  series servo amplifier are listed in Table 6.1.

**Table 6.1  $\beta$  series Servo Amplifier Heat Dissipation**

Unit	Total heat dissipation (W)
SVU-12 (PWM Interface)	18 W
SVU-12 (I/O Link Interface)	20 W
SVU-20 (PWM Interface)	33 W
SVU-20 (I/O Link Interface)	35 W

# 7

## INSTALLATION CONDITIONS AND NOTES



## 7.1 ENVIRONMENTAL CONDITIONS

Install the  $\beta$  series servo amplifier in a location satisfying the following environmental conditions

- (1) Ambient Temperature  
Ambient temperature: 0°C to 55°C (operating)  
-20°C to 60°C (storage and transportation)
- (2) Humidity  
Humidity: 30% to 95% RH (no condensation)
- (3) Altitude  
No more than 1,000m above sea level
- (4) Vibration  
No more than 0.5G during operation
- (5) Atmosphere  
The circuitry and cooling fins must not be exposed to any corrosive and conductive vapor or liquid.

## 7.2 INSTALLATION CONDITION

- (1) The amplifier unit must be installed in a cabinet to protect the unit from contaminants (such as dust, coolant, organic solvents, acid, corrosive gas, and salt). When the amplifier unit is used in an environment where it could be exposed to radiation (microwave, ultraviolet, laser light, or X rays), provide adequate protection.
- (2) Ensure that contaminants such as dust and coolant cannot enter through the air outlet. Moreover, ensure that the flow of cooling air is not obstructed.
- (3) Ensure that the amplifier unit can be easily inspected, unmounted, and reinstalled for maintenance.
- (4) Ensure that the power lines are sufficiently separated from the signal lines, and that noise protection is provided. For details, see Section 7.4. Also, refer to the CNC connection manual.

### 7.3 SELECTING A GROUND FAULT INTERRUPTER

The  $\beta$  series servo amplifier drives a motor by means of the transistor-based PWM inverter method, in which a high-frequency leakage current flows to ground through the stray capacitance of the motor windings, power cable and amplifier. The ground fault interrupter or leakage-protection relay, installed on the power supply side, can malfunction if such a leakage current should flow. So, select an inverter-compatible ground fault interrupter to protect against the occurrence of this malfunction.

(a) Servo motor

Motor	Commercial frequency component
$\beta$ 0.5/3000, $\beta$ 1/3000, $\beta$ 2/3000, $\beta$ 3/3000, $\beta$ 6/2000 $\alpha$ 1/3000, $\alpha$ 2/2000, $\alpha$ 2/3000, $\alpha$ C3/2000, $\alpha$ C6/2000	1.8mA
$\alpha$ C12/2000	2.0mA

## 7.4 NOISE PROTECTION

### 7.4.1 Separation of Signal Lines

When routing the signal lines, amplifier input power line and motor power line, the signal lines must be separated from the power lines. The following table lists how to separate the cables.

Group	Signal	Action
A	Amplifier input power line Motor power line MCC drive coil	Separate these cables from those of group B by bundling them separately (NOTE 1) or by means of electromagnetic shielding (NOTE 2). Attach a noise preventer, such as a spark killer, to the MCC drive coil.
B	Cable connecting the control unit and servo amplifier Pulse coder feedback cable	Separate these cables from those of group A by bundling them separately or by means of electromagnetic shielding. In addition, shielding must be provided.

#### NOTE

- 1 The bundle of group A cables must be separated from the bundle of group B cables by at least 10 cm.
- 2 Electromagnetic shielding involves shielding groups from each other by means of a grounded metal (steel) plate.



## 7.4.2 Grounding

A CNC machine tool has three separate ground systems:

(a) Signal ground (SG) system

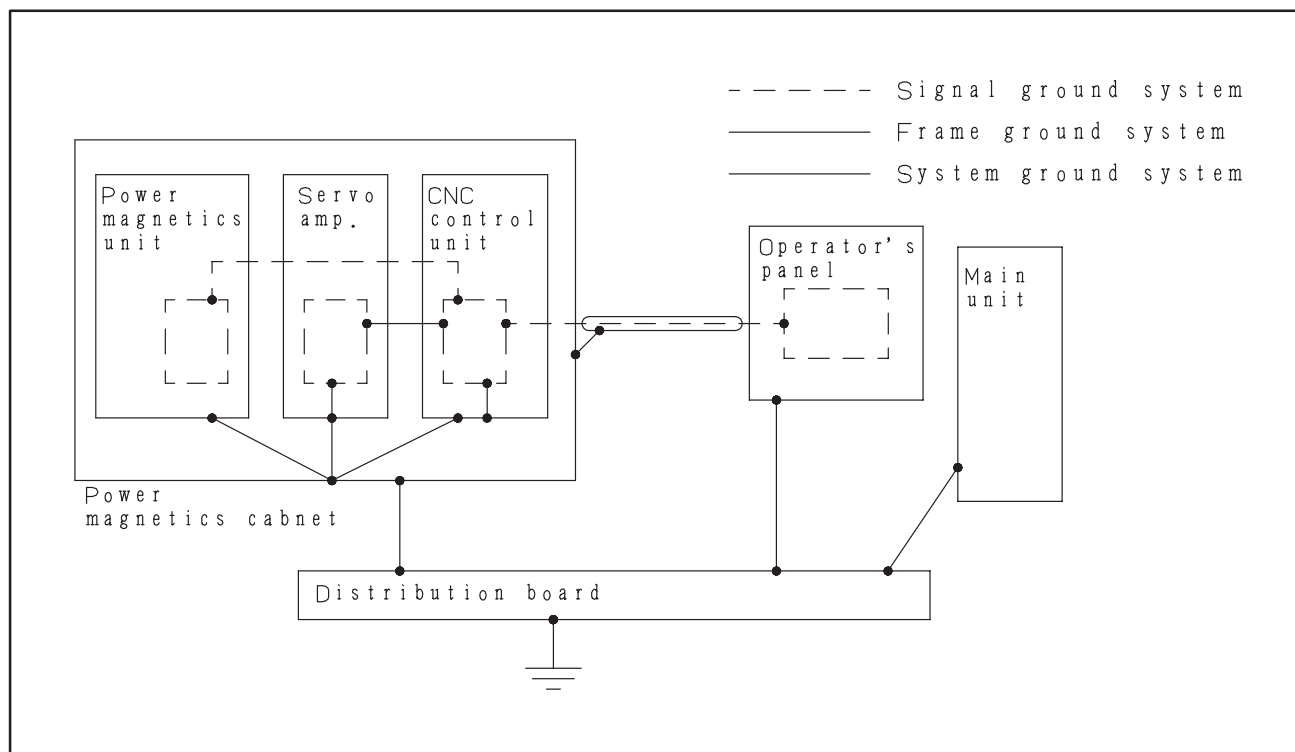
The signal ground (SG) system provides the reference potential (0 V) for the electrical signal system.

(b) Frame ground (FG) system

The frame ground (FG) system is provided to ensure safety and to shield external and internal noise. For example, the equipment frames, unit cases, panels, and interface cables connecting devices are all shielded.

(c) System ground system

The system ground system is designed to connect each unit and the inter-unit frame ground system to ground.



### WARNING

[Warning on ground system wiring]

- 1 The ground resistance of the system ground must not exceed 100 ohms (class-3 ground).
- 2 System ground connection cables must have a sufficiently large cross-sectional area to enable them to safely carry the current that will arise in the event of a mishap such as a short-circuit. (In general, a cross-sectional area no less than that of the AC power line must be provided.)
- 3 The system ground connection cable shall be integrated with the AC power line, such that power cannot be supplied if the ground wire is disconnected.

### 7.4.3 Noise Suppressor

The AC/DC solenoid and relay are used in the power magnetics cabinet. A high pulse voltage is caused by coil inductance when these devices are turned on or off.

This pulse voltage induced through the cable causes the electronic circuits to be disturbed. In general, to reduce this pulse voltage, a spark killer is used in AC circuits, while a diode is used in DC circuits.

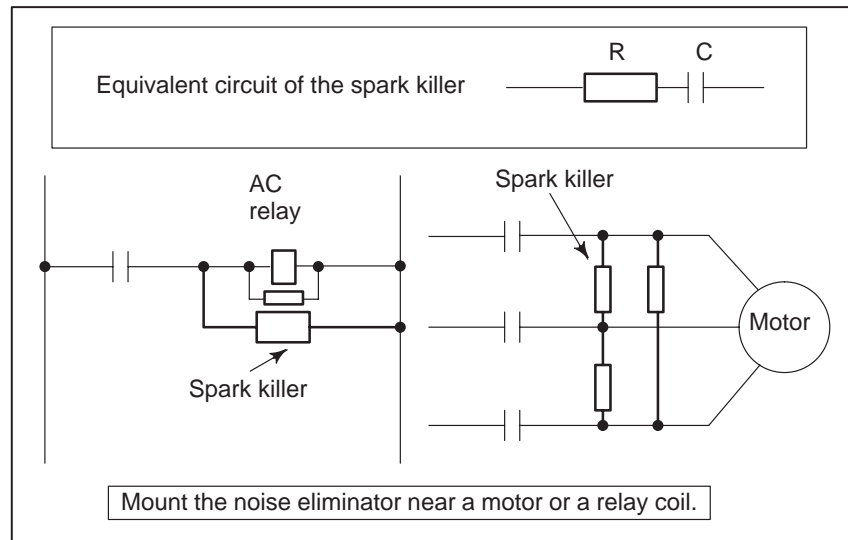
#### Spark killer

- Use a spark killer consisting of a resistor and capacitor in series. This type of spark killer is called a CR spark killer.(Use it under AC)  
(A varistor is useful in clamping the peak voltage of the pulse voltage, but cannot suppress the sudden rise of the pulse voltage. FANUC therefore recommends a CR spark killer.)
- The reference capacitance and resistance of the spark killer shall conform to the following based on the current (I(A)) and DC resistance of the stationary coil:

1) Resistance (R) : Equivalent DC resistance of the coil

2) Capacitance (C):  $\frac{I^2}{10}$  to  $\frac{I^2}{20}$  (μF)

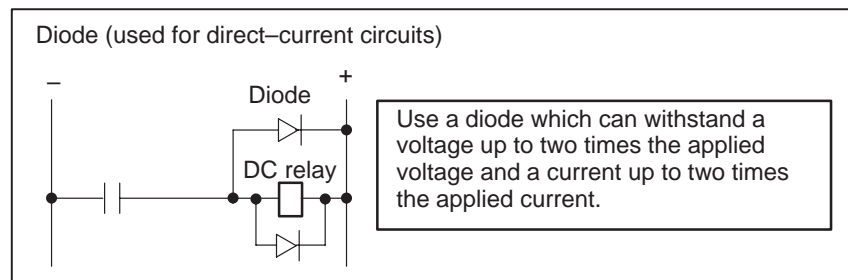
I : Current at stationary state of the coil (A)



#### CAUTION

Use a CR-type noise eliminator. Varistor-type noise eliminators clamp the peak pulse voltage but cannot suppress a sharp rising edge.

#### Diode



### 7.4.4 Cable Clamp and Shield Processing

The power motion controller cables that require shielding should be clamped by the method shown below. This cable clamp treatment is for both cable support and proper grounding of the shield. To insure stable CNC system operation, follow this cable clamp method.

Partially peel out the sheath and expose the shield. Push and clamp by the plate metal fittings for clamp at the part. The ground plate must be made by the machine tool builder, and set as follows :

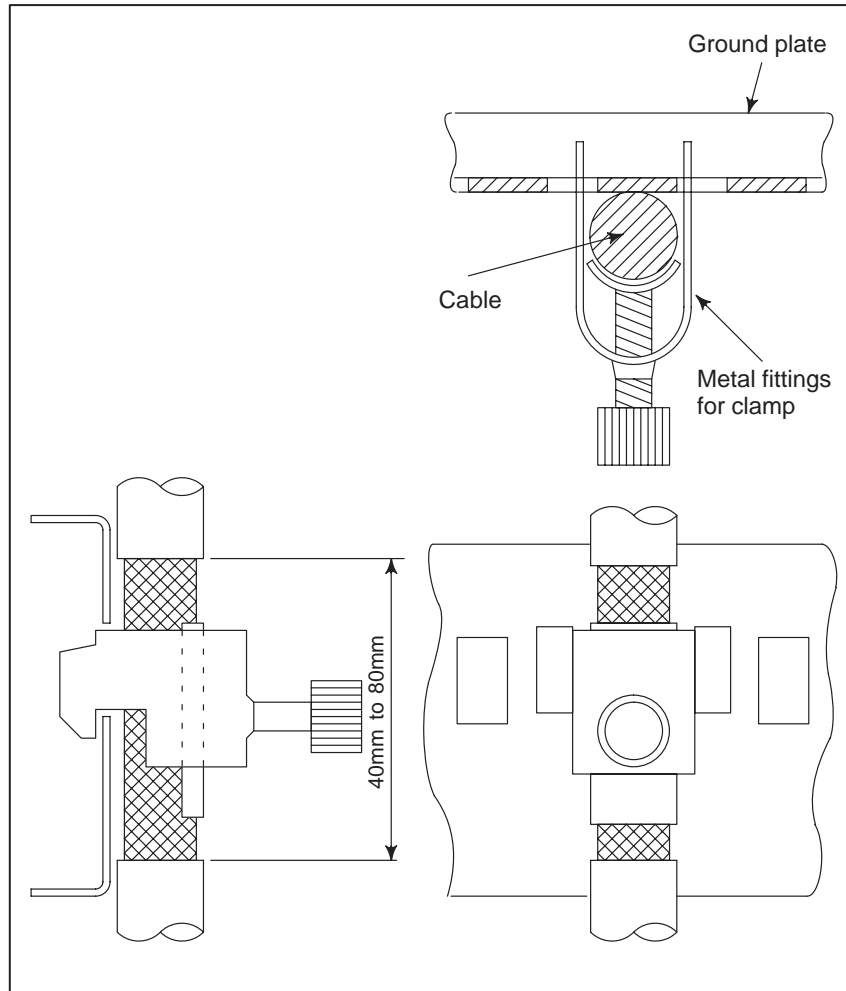
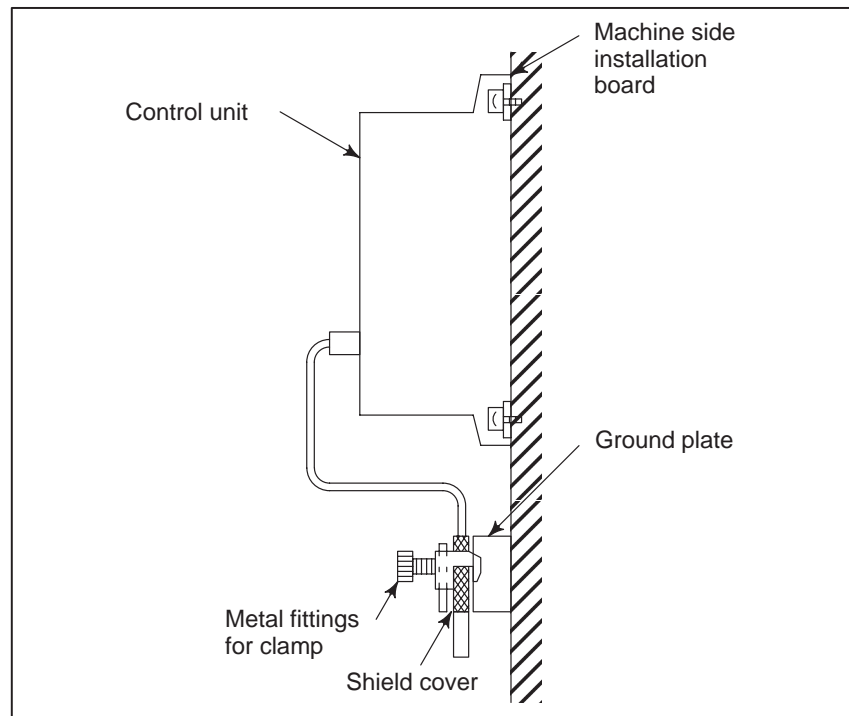
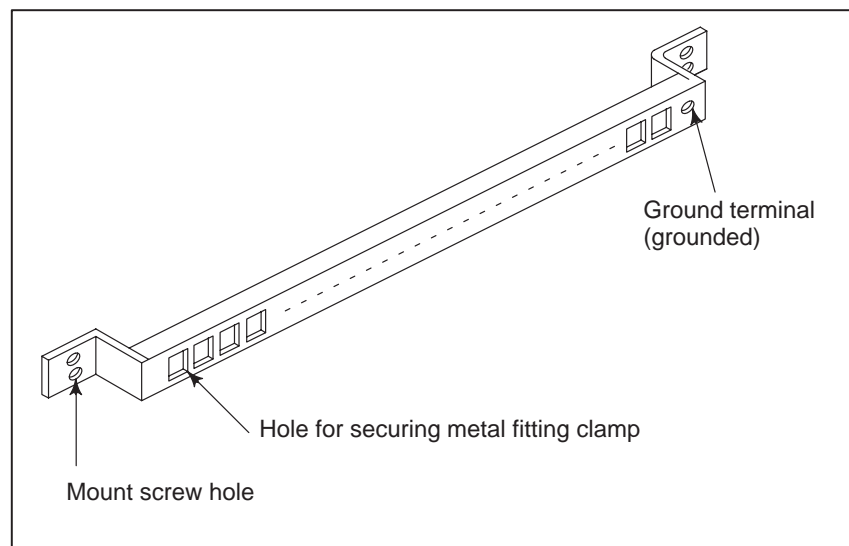


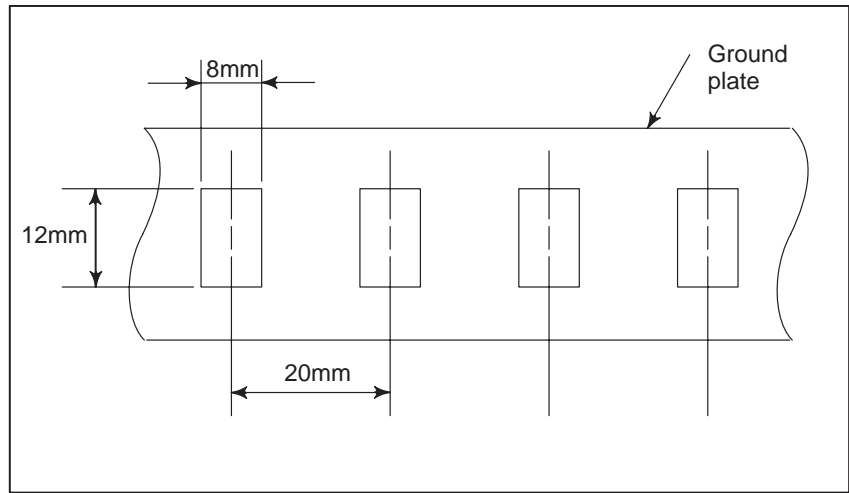
Fig.7.4.4(a) Cable clamp (1)

**Fig.7.4.4(b) Cable clamp (2)**

Prepare ground plate like the following figure.

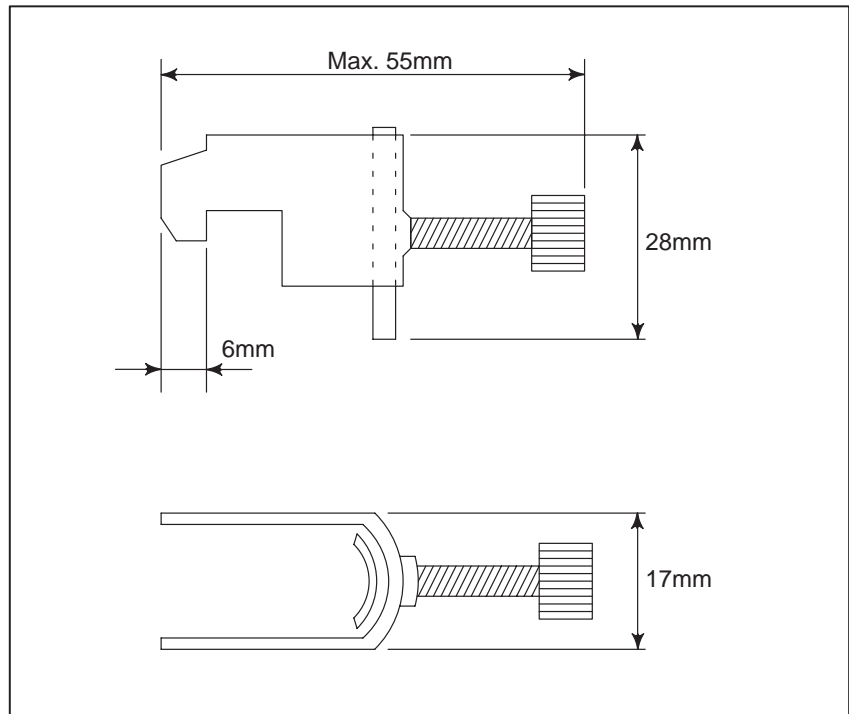
**Fig.7.4.4(c) Ground plate**

For the ground plate, use a metal plate of 2 mm or thicker, which surface is plated with nickel.



**Fig.7.4.4(d) Ground plate holes**

(Reference) Outer drawings of metal fittings for clamp.



**Fig.7.4.4(e) Outer drawings of metal fittings for clamp**

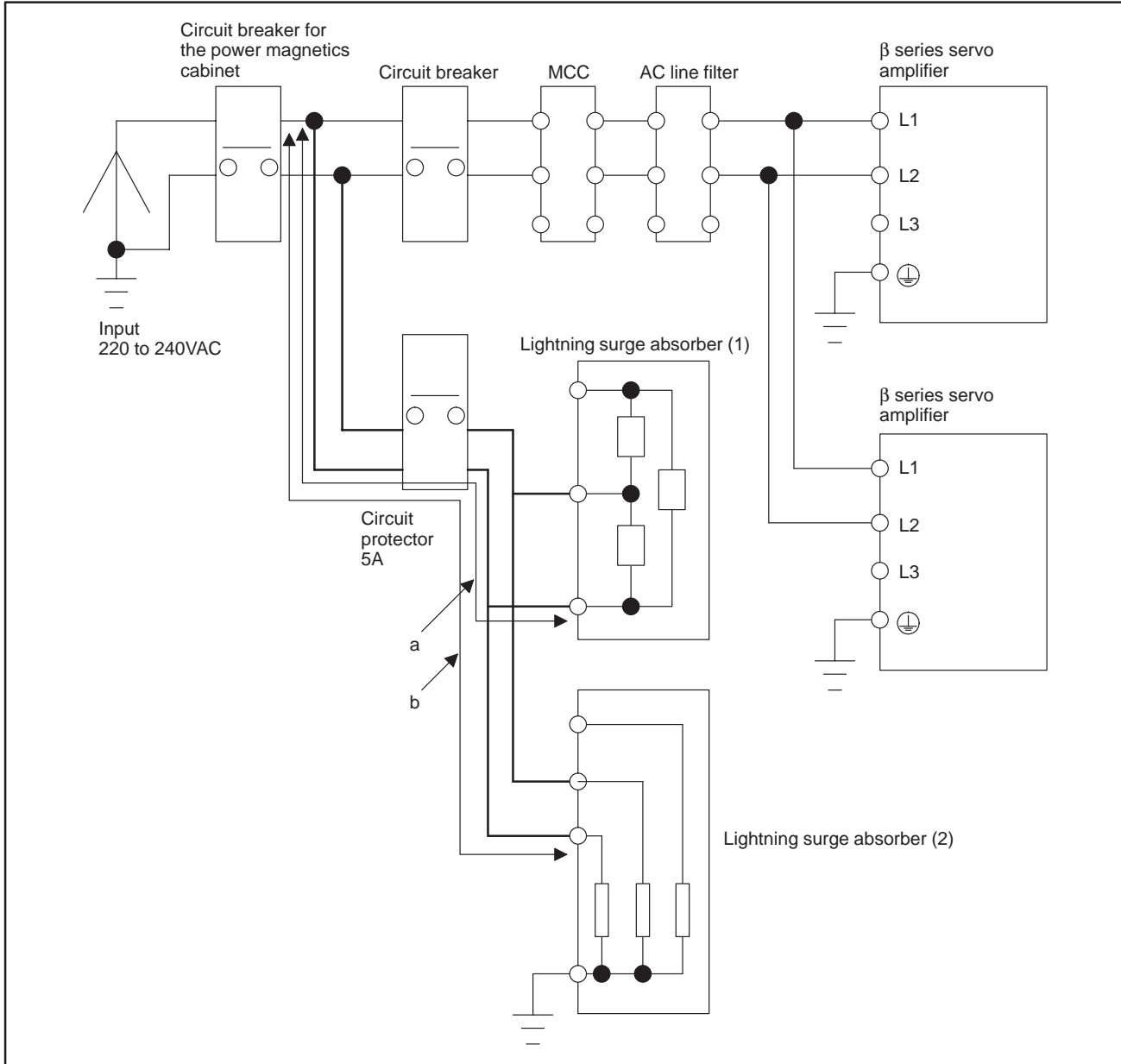
Ordering specification for metal fittings for clamp  
A02B-0214-K001 (2 pieces)

# 7.5 INSTALLING LIGHTNING SURGE ABSORBERS

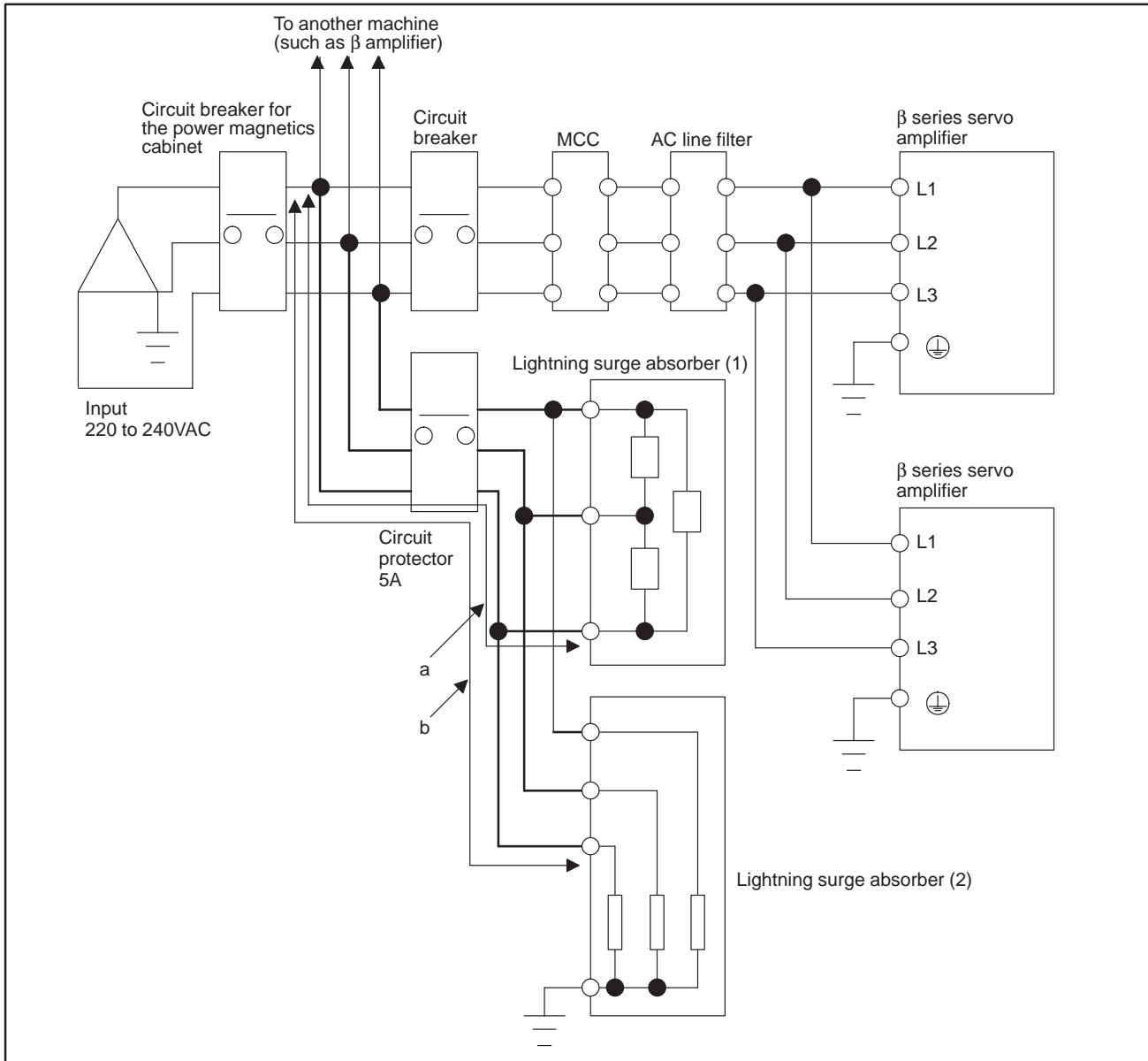
At the power input of the power magnetics cabinet, install a surge absorber between the power lines and between each power line and a ground to protect the unit from a voltage surge caused by lightning.

How to install the surge absorber is shown below.

(1) Surge absorber for single-phase input



(2) Surge absorber for three-phase input



**WARNING**

- 1 Make the wires shown with thick line in the above diagram as short as possible in order to increase the effect of the lightning surge absorber.  
 Wire Cross section : At least 2mm<sup>2</sup>  
 Length : Keep the total wire length (a+b) to within 2m,  
 where a = length of wire used to connect lightning surge absorber (1)  
 b = length of wire used to connect lightning surge absorber (2)
- 2 When performing a dielectric strength test by applying an overvoltage (such as 1000 or 1500 VAC) to a power line, remove lightning surge absorber (2) so that it will not operate.
- 3 The circuit protector (5A) is intended to protect the lines if a lightning surge absorber is damaged due to a surge that is higher than the maximum allowable voltage of the surge absorber.
- 4 Usually, no current flows through the lightning surge absorbers. So the circuit protector (5A) may be used also for other sections (such as power supply module control power and spindle motor fan power).

The following table lists commercially available lightning surge absorbers.

**Table 7.5(a) Lightning surge absorbers (not complying with the relevant standards)**

Lightning surge absorber	Manufacturer's specification Okaya Electric Industries	Clamp voltage [V] $\pm 10\%$	Maximum allowable surge current 8/20 $\mu$ sec [A]	Maximum allowable surge voltage 1.2/50 $\mu$ sec [V]	Maximum allowable circuit voltage [V rms]
(1)	R•A•V-781BYZ-2	783	1000	12000	300
(2)	R•A•V-781BXZ-2A	783	1000	12000	300

**Table 7.5(b) Lightning surge absorbers (complying with the relevant standards)**

Lightning surge absorber	Manufacturer's specification Okaya Electric Industries	Clamp voltage [V] $\pm 10\%$	Maximum allowable surge current 8/20 $\mu$ sec [A]	Maximum allowable surge voltage 1.2/50 $\mu$ sec [V]	Maximum allowable circuit voltage [V rms]
(1)	R•A•V-781BYZ-2	783	1000	12000	300
(2)	R•A•V-781BXZ-4	783	1000	12000	300



# 8

## CAUTIONS FOR SAFETY STANDARDS RELATED TO AMPLIFIER INSTALLATION



## 8.1 OVERVIEW

The  $\beta$  series control motor amplifiers are designed to the following European safety standard.

DIN VDE 0160 : 1988/A1 : 1989

(Electronics devices to be used in power equipment and their installation in it)

This chapter supplements conditions for installation of the  $\beta$  series servo amplifiers, focusing on safety standard-related topics. If you want to acquire a CE mark for your power magnetics cabinet based on the EC machine commands (based on 89/392/EEC), be sure to satisfy this requirement in designing the power magnetics cabinet.

### Remark

To acquire a CE mark for equipment, it is necessary to make the equipment comply with the related EN standard, EN60204-1 (general requirements for electric equipment for industrial machines).

If there is an EN standard (or IEC standard if there is no EN standard) that applies to machine components, the components used in your machine must conform to the standard.

Because there is no EN standard (IEC standard) for amplifiers at present, FANUC is using amplifiers that comply with the VDE standard according to the result of investigation made by TÜV Rheinland, which is a qualified certifying agency.

Therefore, the  $\beta$  series servo amplifiers satisfy the requirements to acquire a CE mark. So you can use them without anxiety.

## 8.2 STANDARD CATEGORIES RELATED TO INSULATION DESIGN

### (1) Insulation between circuits and protective grounding

The amplifiers are designed to the DIN VDE 0160 standard, so they conform to Part 1 of DIN VDE 0110 and related standards.

- The primary side (power source and main circuit side) is separated from the secondary side (control circuit side) for safety with reinforced insulation.
- The circuits are isolated from the protective grounding with fundamental insulation.

The power supply main circuit and heat sinks are isolated from one another with fundamental insulation. So, the grounding terminal of a heat sink should be connected to the protective grounding line as shown in Figs. 8.6 (a) and 8.6 (b).

### (2) Installation category (overvoltage category)

DIN VDE 0110 (electric device insulation harmony) classifies power supply equipment by the amplitude of an impulse voltage contained in the power supply for the amplifier in reference to a ground potential.

The  $\beta$  series servo amplifiers are classified in installation category (overvoltage category) II.

This category requires that the rated impulse dielectric strength (measured in reference to a ground potential) in a power supply connected to the amplifiers be not higher than 2.5 kV. Any impulse voltage higher than 2.5 kV in reference to a ground potential must be eliminated from the power supply.

Generally, an isolation transformer at the input section of the power supply of a machine would make the machine satisfy that requirement. If the power supply does not use an isolation transformer, a lightning surge absorber should be installed between the power and ground lines to suppress an impulse voltage higher than 2.5 kV in reference to a ground potential.

### (3) Installation environment contamination level and power magnetics cabinet protection grade

EN60204-1 (Section 13.3) states that machines to be installed in an ordinary factory environment satisfy protection grade IP54 or higher against dust debris, cutting fluid, and cutting chips. The  $\beta$  series servo amplifiers do not satisfy IP54 unless an additional measure is taken. So they should be installed within a power magnetics cabinet that satisfies IP54.

The IP grade to be satisfied varies with the environment (atmosphere) in which the machine is installed. So, it is necessary to select the protection grade for the power magnetics cabinet according to the environment in which it is installed.

The series amplifiers are designed on the assumption that they are installed in an environment with a contamination level of 2. So, the contamination level for the power magnetics cabinet must be 2 or below.

## 8.3 PROTECTION AGAINST SHOCK HAZARDS

### (1) Preventing direct contact with live parts

The  $\beta$  series servo amplifiers, after installed, satisfy a protection grade of IP1X (hand protection), which prevents unconscious or inadvertent contact.

The  $\beta$  series servo amplifiers shall be installed within a power magnetics cabinet. When they are powered, the power magnetics cabinet shall be locked according to EN60204-1 so that any person other than specialist service personnel (including those sufficiently trained in avoiding shock hazards and qualified for maintenance) cannot open it.

Should if a machine operator must open the power magnetics cabinet and act on it, the operator shall be sufficiently trained for safety beforehand, or a provision, such as a protection cover, to keep the operator from touching the amplifiers shall be installed in advance.

### (2) Confirming electrolytic capacitor discharge

The  $\beta$  series amplifiers contain electrolytic capacitors with a high capacitance in their smoothing circuits. These capacitors remain charged for a while after the power input is shut off. If you need to touch an amplifier, for example, for maintenance purposes, wait for at least two minutes after the power is switched off, or confirm safety by measuring the remaining voltage in the DC link section and making sure that the red LED to indicate "charge" is off.

DC voltages higher than 60V are assumed to be dangerous, according to the relevant standards.

### (3) Current leakage to a protective grounding wire

Servo motors are controlled by changing the average amplitude and frequency of a voltage applied to their armature (winding) using pulse width modulation. A chopper voltage with a carrier frequency of several kHz is applied to the motor power lines for pulse width modulation.

The motor current partly leaks to the protective grounding wire of the motor power cord and a ground through stray capacitances mainly between the motor armature winding and casing and between the motor power line and a protective ground. Part of the leakage current flows through the protective grounding wire of the machine. This leakage current is about 0.4 to 0.5mA per motor, measured at the commercial frequency (50/60Hz). It is increased to 2.0mA when measured with an EN60950 compliant measurement circuit, because the measurement circuit has a relatively high sensitivity to higher frequency components.

If the machine is not grounded to a substantial earth ground, you may get shocked when touching the machine. To avoid shock hazards:

- Use wire whose cross section is 10mm<sup>2</sup> or larger for protective grounding.
- Install a ground-fault circuit interrupter to shut off the power instantly on a ground fault.
- Install an additional protective grounding terminal to the cabinet for duplicated protective grounding connection.

The ground-fault circuit interrupter used for the machine should be an electromagnetic type with a low sensitivity to high frequency components or an electronics type usable together with an inverter, so that a malfunction will not occur.

## **8.4 PROTECTIVE GROUNDING**

The  $\beta$  series servo amplifiers have more than one protective grounding terminal (marked according to 417-IEC-5019). These terminals are used to prevent shock hazards should a dielectric breakdown occur, and to prevent a malfunction due to noise.

All protective grounding terminals shall be connected to the protective grounding connection terminal (PE) in the power magnetics cabinet.

The protective grounding connections you installed should be checked according to the indicated connection instruction (shown in Figs. 8.6 (a) and 8.6 (b)). Moreover, it is necessary to make sure that the cross section of the protective grounding wires is larger than that of the power wire.

Do not attach more than one wire to a single protective grounding terminal. So prepare protective grounding terminals for the number of protective grounding wires to be attached.

## **8.5 CAUTIONS FOR CONFIGURING AN EMERGENCY STOP CIRCUIT**

The power shut-off method used in the  $\beta$  series servo amplifiers is based on an IGBT (transistor) rather than an electromechanical device. The emergency stop circuit must be so configured that operating the emergency stop switch can turn off directly a line connector installed on the power input line of the servo amplifiers.

## 8.6 SUPPRESSING ELECTROMAGNETIC INTERFERENCE

The  $\beta$  series amplifiers conform to EN55011 group 1/class A for interference noise due to radiation or conduction.

To make a machine using the  $\beta$  series amplifiers conform to the EMC command, take necessary measures according to the guideline published by FANUC (document No.: A-72937E).

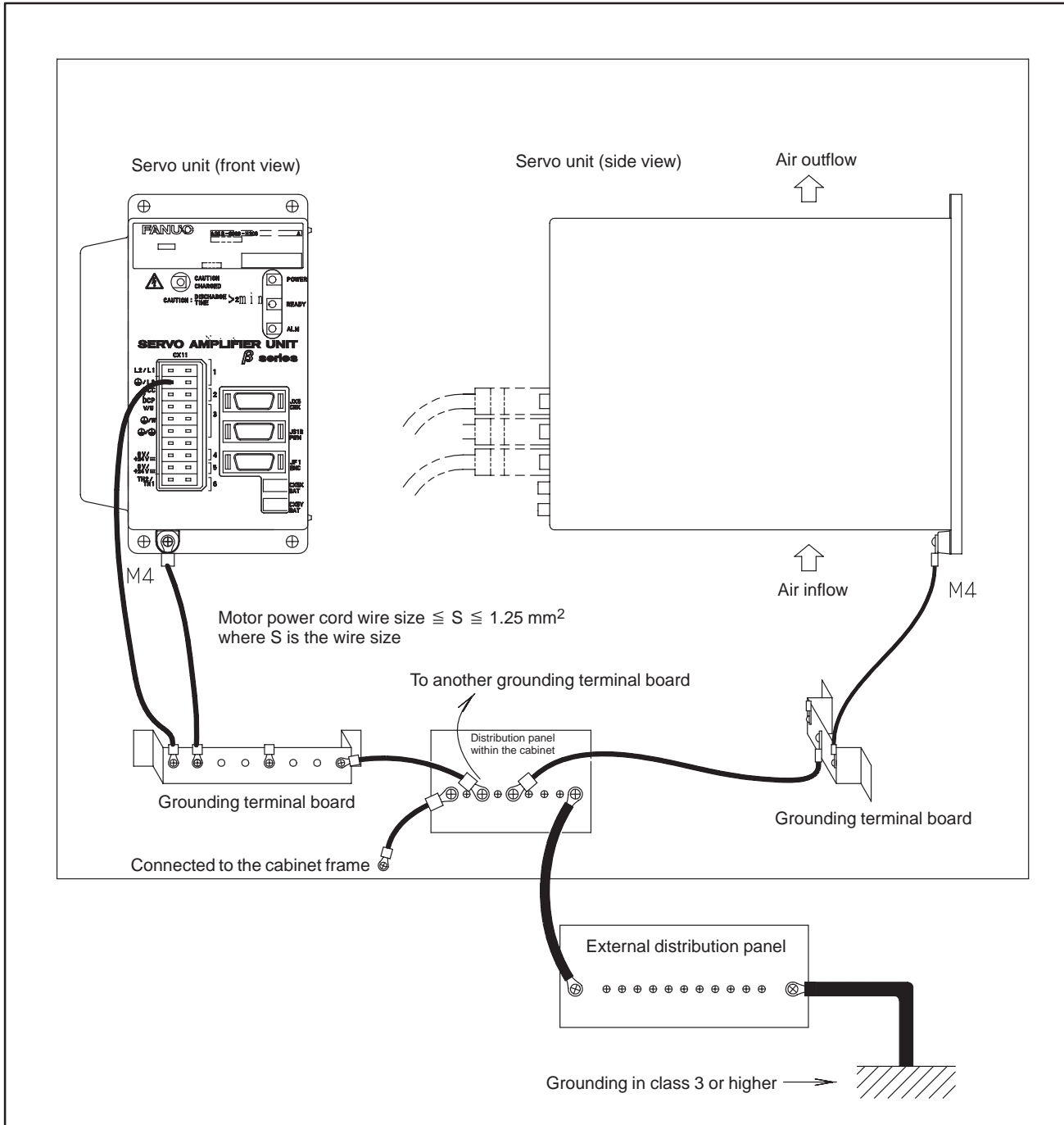


Fig.8.6(a) Protective ground wiring (PWM interface version)

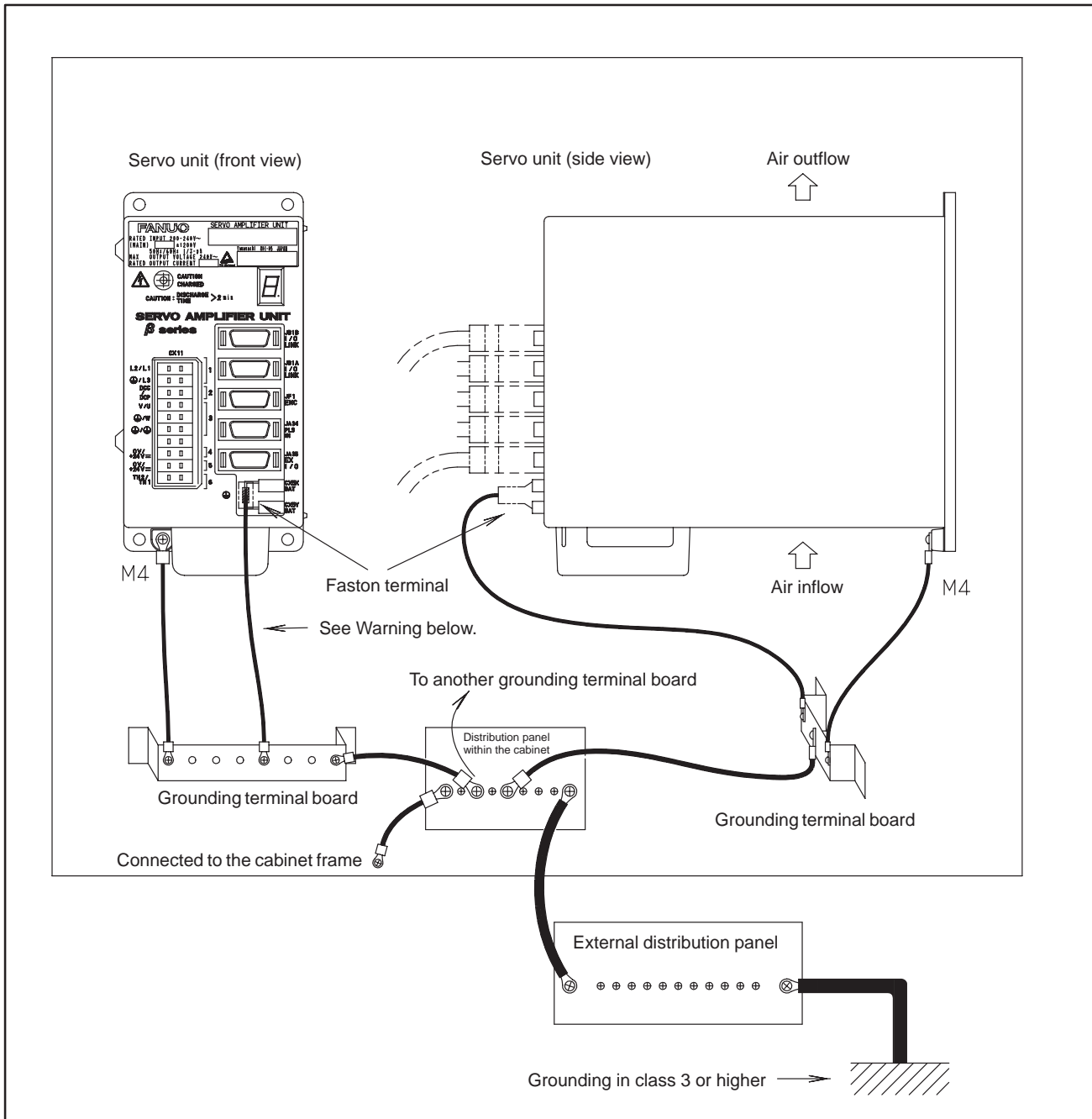


Fig.8.6(b) Protective ground wiring (I/O link interface version)

**WARNING**

Ground the servo unit, using Faston terminals (A65L-0001-0148/2) in the servo unit and 2mm<sup>2</sup> or larger twisted wires 100 to 300 mm long. Otherwise, the servo unit becomes less immune to noise.

Be sure to connect the frame ground terminal of the servo unit to a grounding terminal in the cabinet.

# 9

## OUTLINE DRAWINGS AND MAINTENANCE CLEARANCES

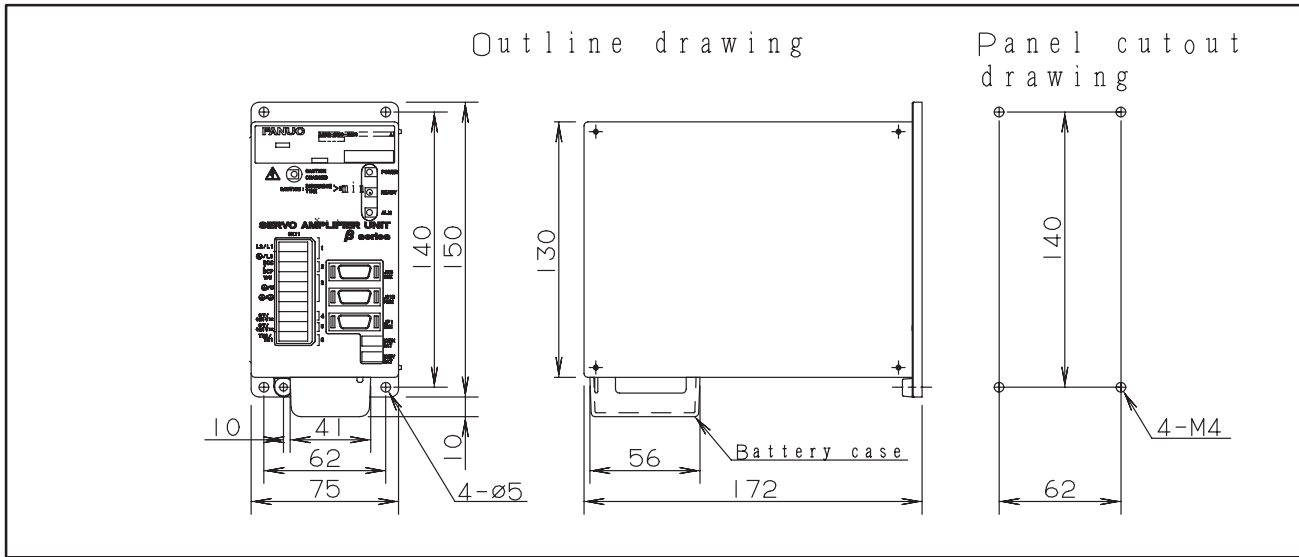




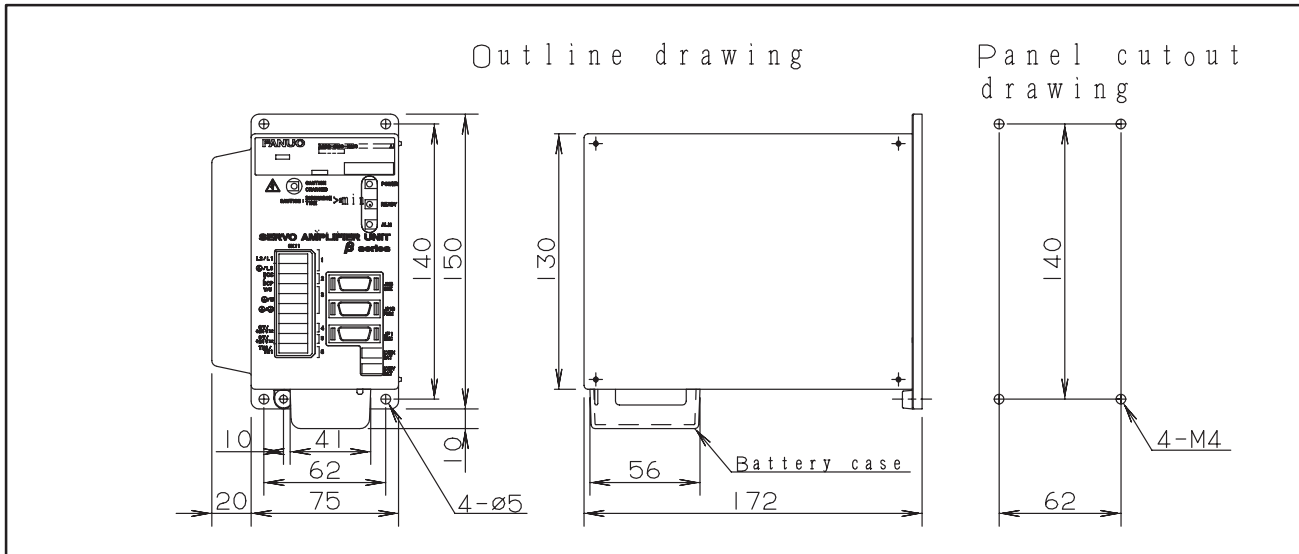
# 9.1 OUTLINE DRAWINGS AND PANEL CUT-OUT DRAWINGS

## 9.1.1 Servo Amplifier Unit (for PWM Interface)

(a) SVU-12



(b) SVU-20

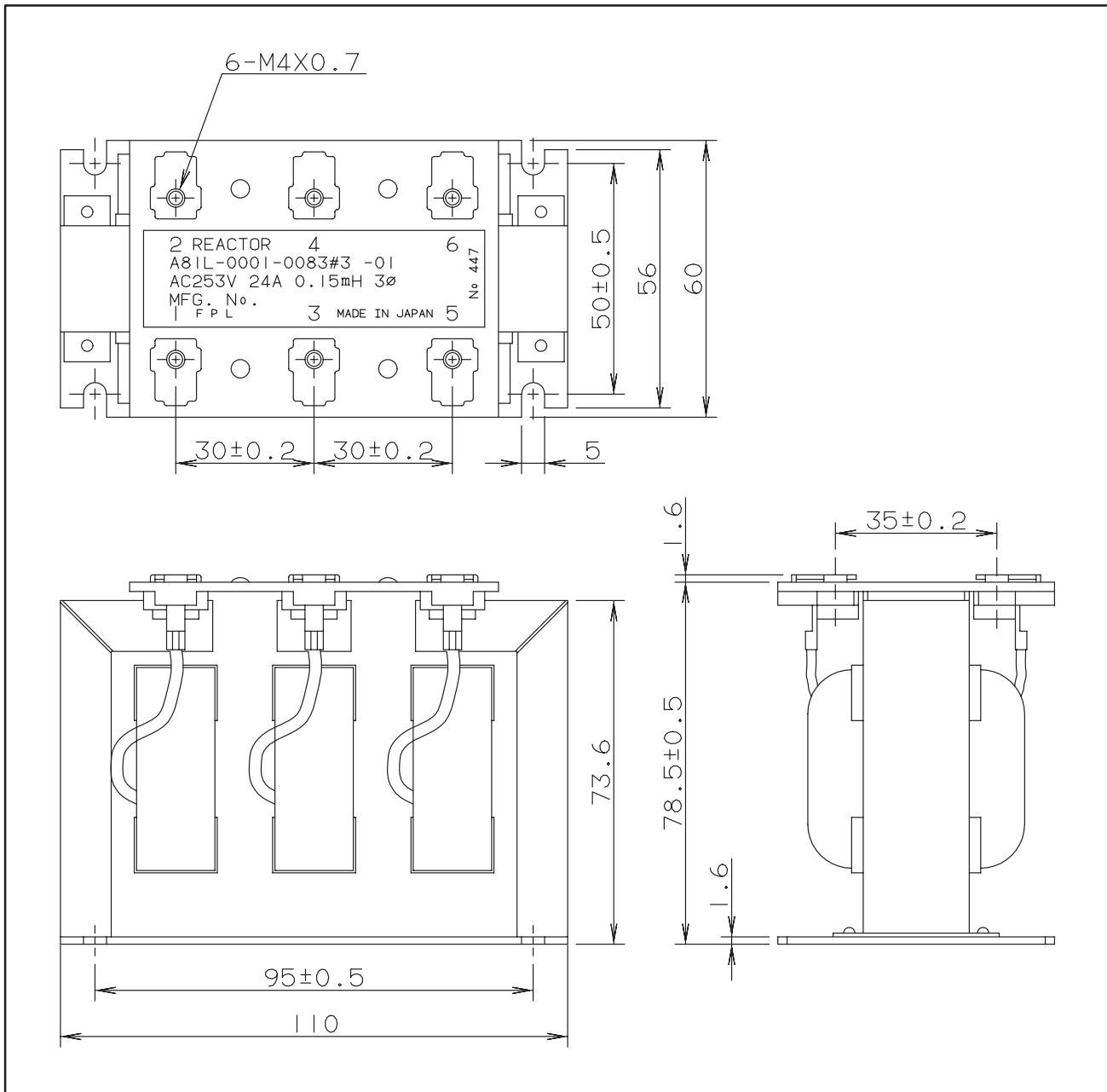


**NOTE**

- 1 The PWM interface versions of servo amplifiers have the same external dimensions as for the I/O link interface versions. Shown above are the PWM interface versions.
- 2 The battery case is required only when an absolute pulse coder is used.

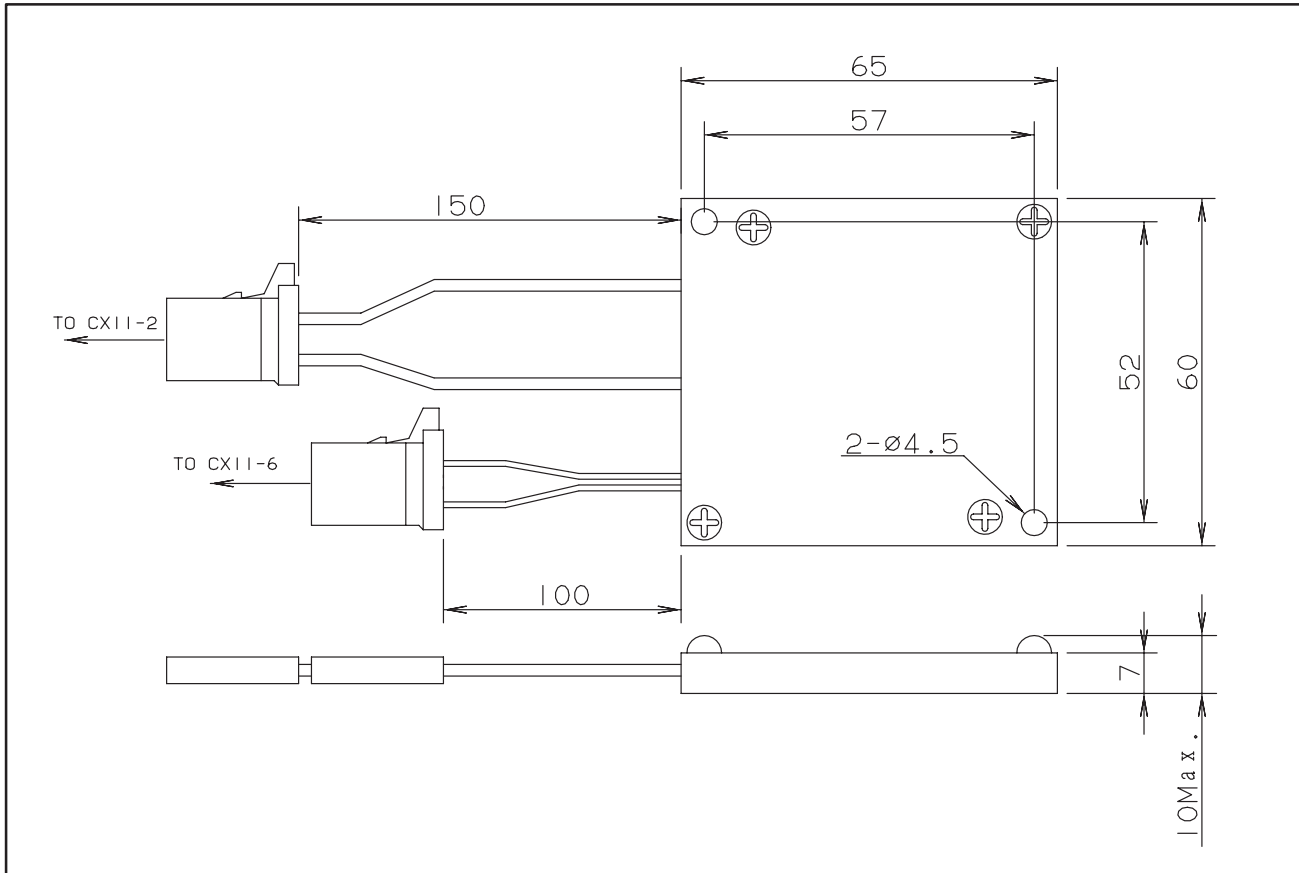
### 9.1.2 AC Line Filter

(a) A98L-0001-0083#3C

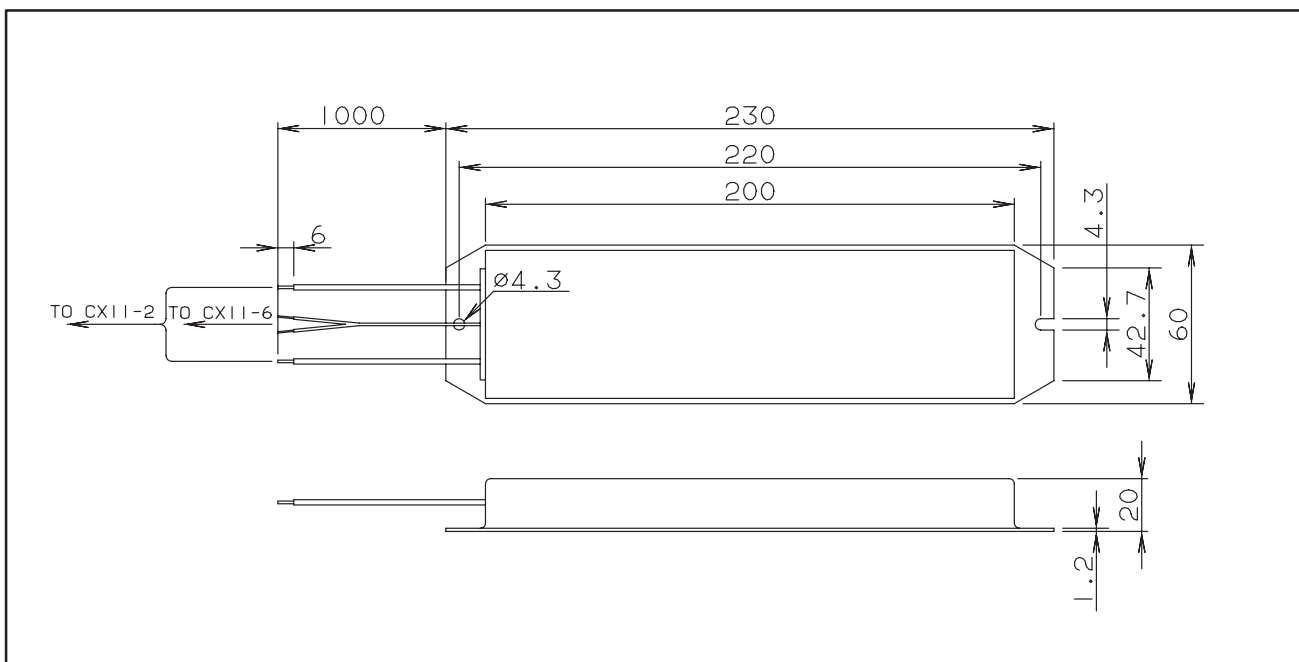


### 9.1.3 Regenerative Discharge Unit

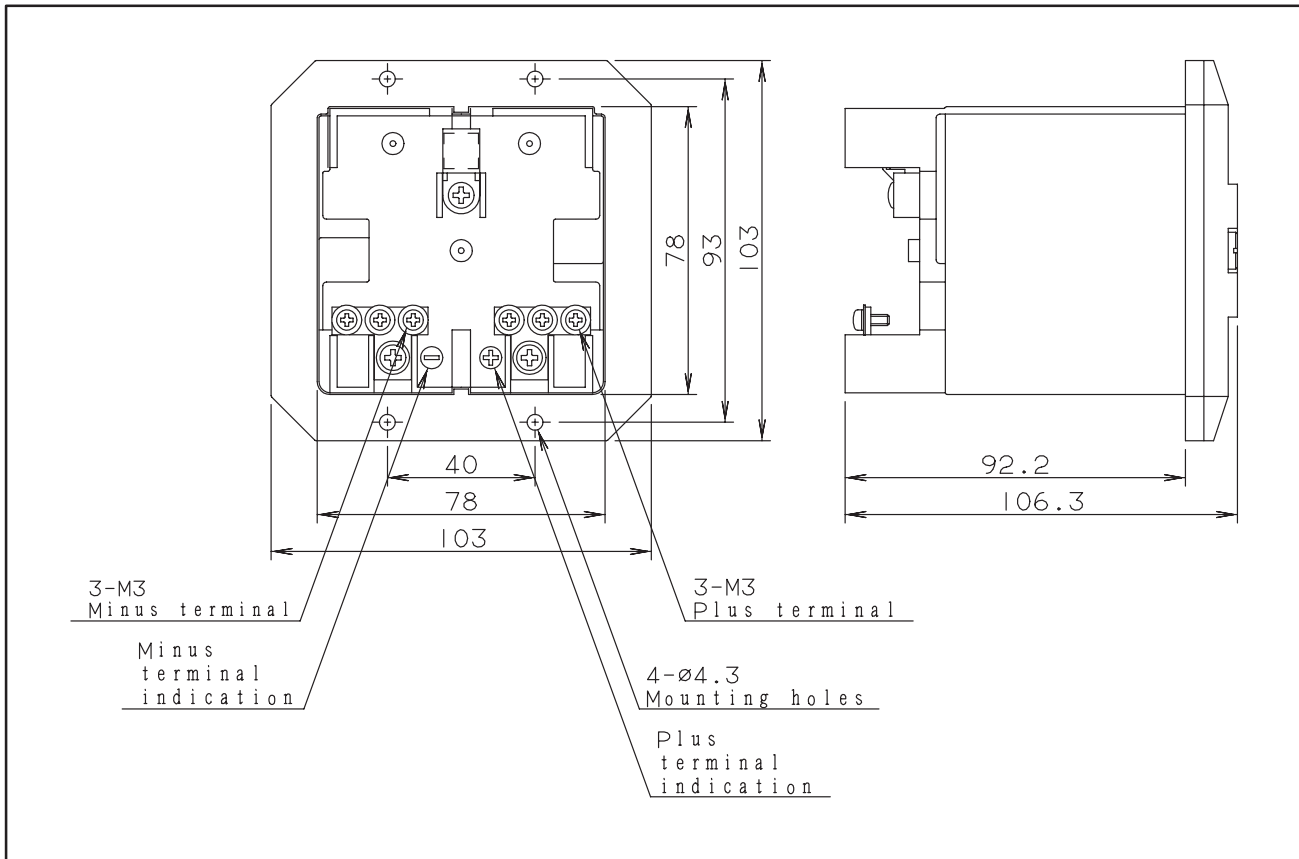
(a) A06B-6093-H401



(b) A06B-6093-H402



### 9.1.4 Battery Case

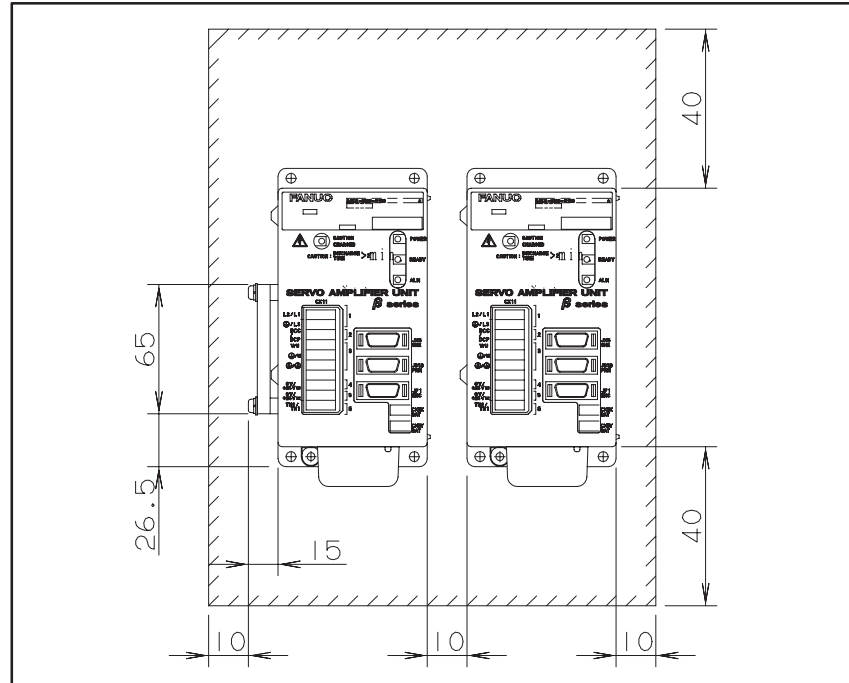


## 9.2 MAINTENANCE CLEARANCES

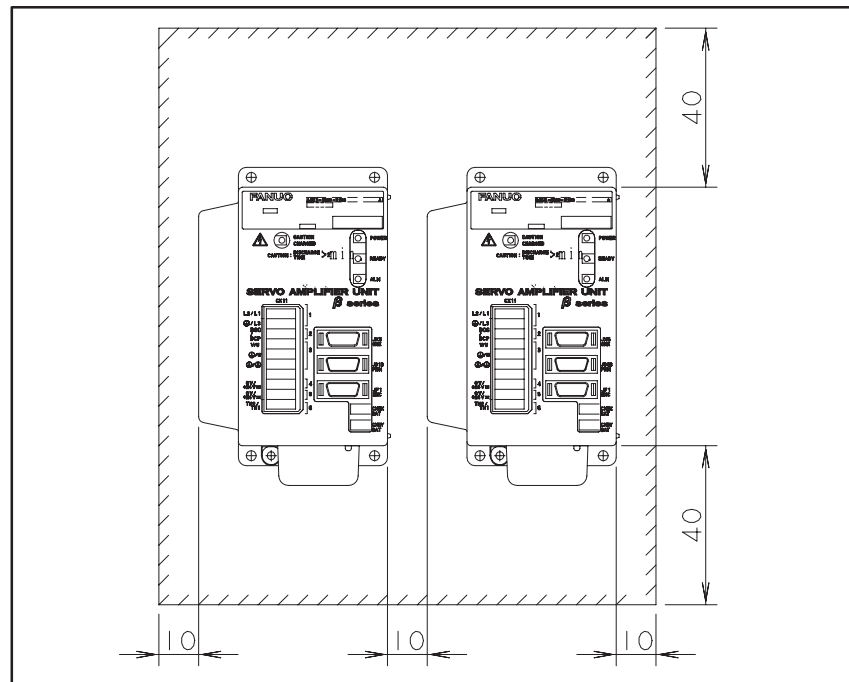
The amplifier unit contains a cooling fan which forces air through the unit. To prevent obstruction of the air flow, provide a clearance of about 40 mm both above and below the unit.

When multiple amplifier units are installed side by side, provide at least 10 mm clearance between the units to allow heat to escape from the cooling fins.

(a) SVU-12 (PWM interface and I/O Link interface)



(b) SVU-20 (PWM interface and I/O Link interface)



## **IV. CONNECTIONS**

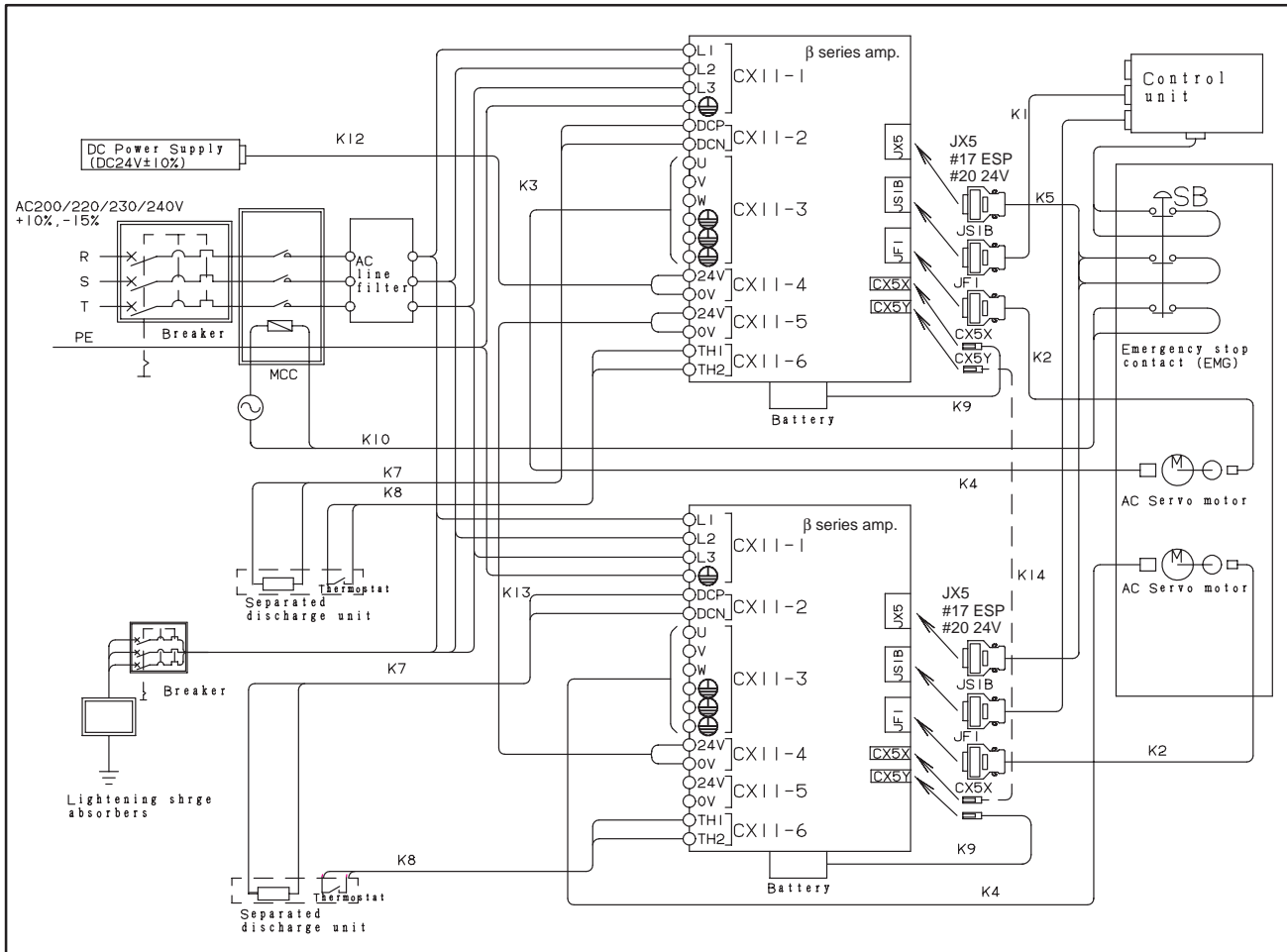
# 1

## OVERALL CONNECTION DIAGRAM



# 1.1 PWM INTERFACE

(1) Three-phase input

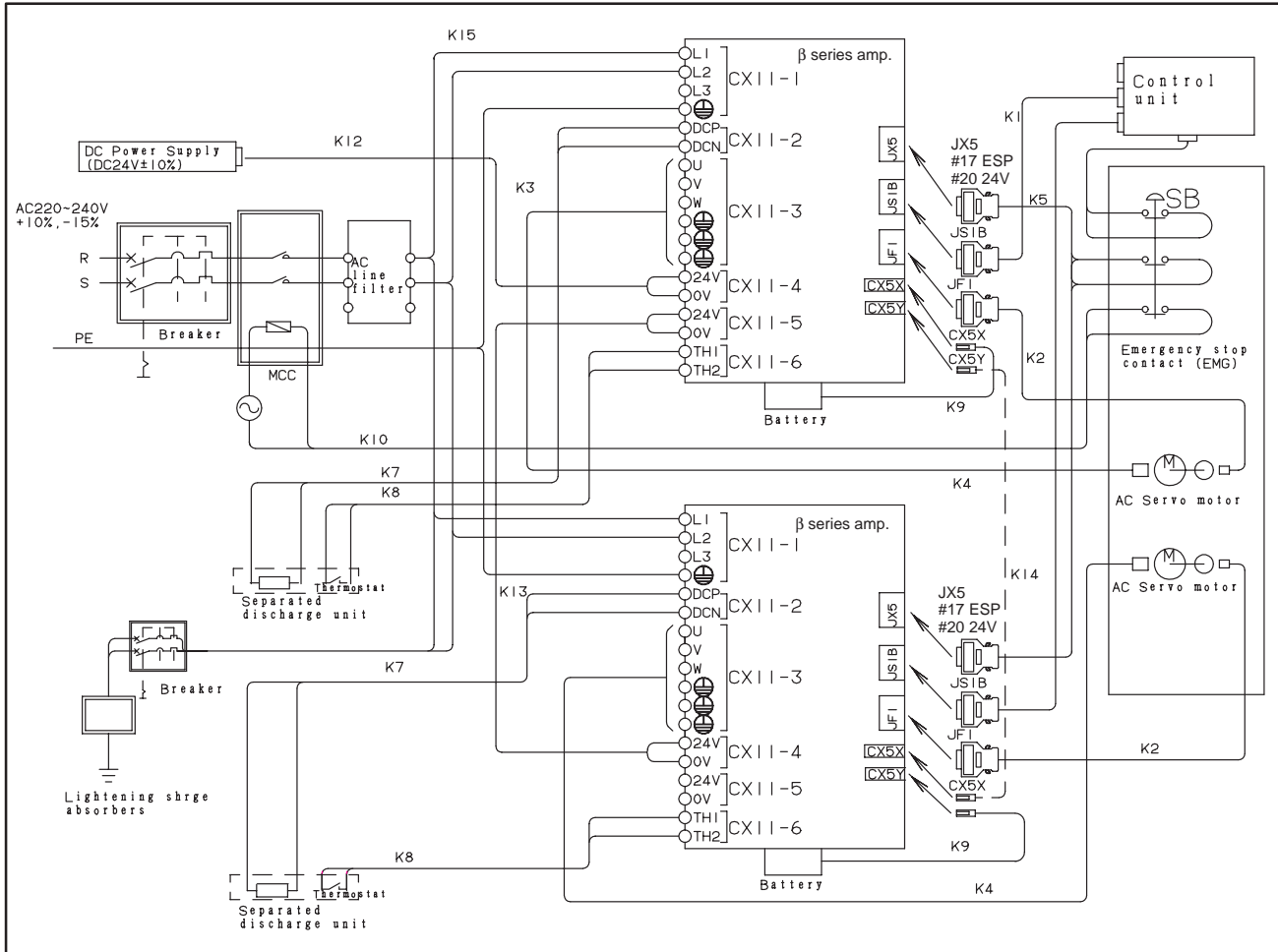


## WARNING

- 1 An AC line filter must be used to suppress the influence of high-frequency noise on the power supply unit.
- 2 Multiple amplifiers can be connected to a single AC line filter provided the rating of the AC line filter is not exceeded.
- 3 Be sure to install a circuit breaker for circuit protection. Restrict the number of motors connected to one circuit breaker so that its current rating will not be higher than 10A. See Subsection III-2.4.1 for the current carrying capacity of circuit breakers.



(2) Single-phase input

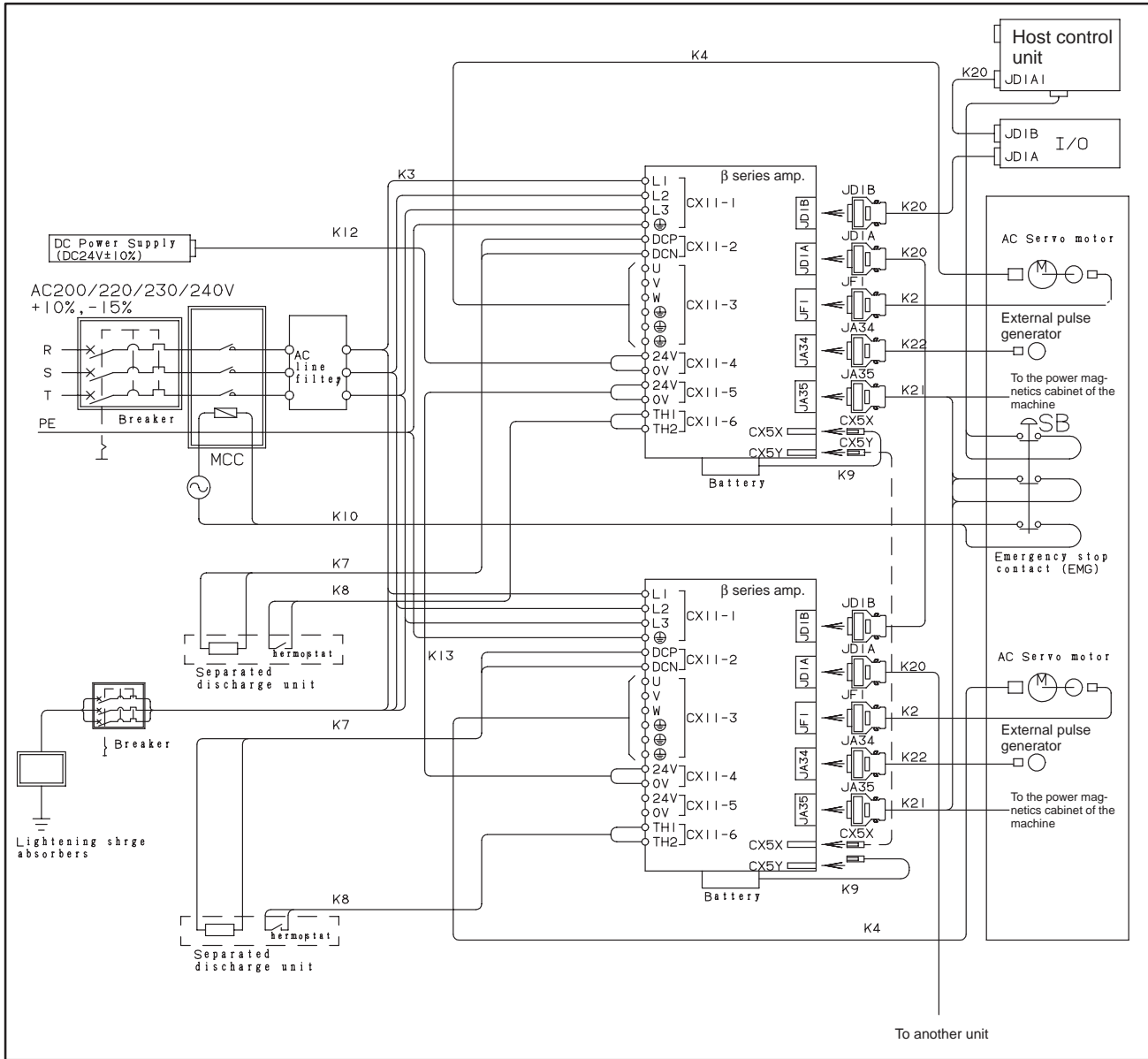


**WARNING**

- 1 An AC line filter must be used to suppress the influence of high-frequency noise on the power supply unit.
- 2 Multiple amplifiers can be connected to a single AC line filter provided the rating of the AC line filter is not exceeded.
- 3 Be sure to install a circuit breaker for circuit protection. Restrict the number of motors connected to one circuit breaker so that its current rating will not be higher than 10A. See Subsection III-2.4.1 for the current carrying capacity of circuit breakers.

# 1.2 I/O LINK INTERFACE

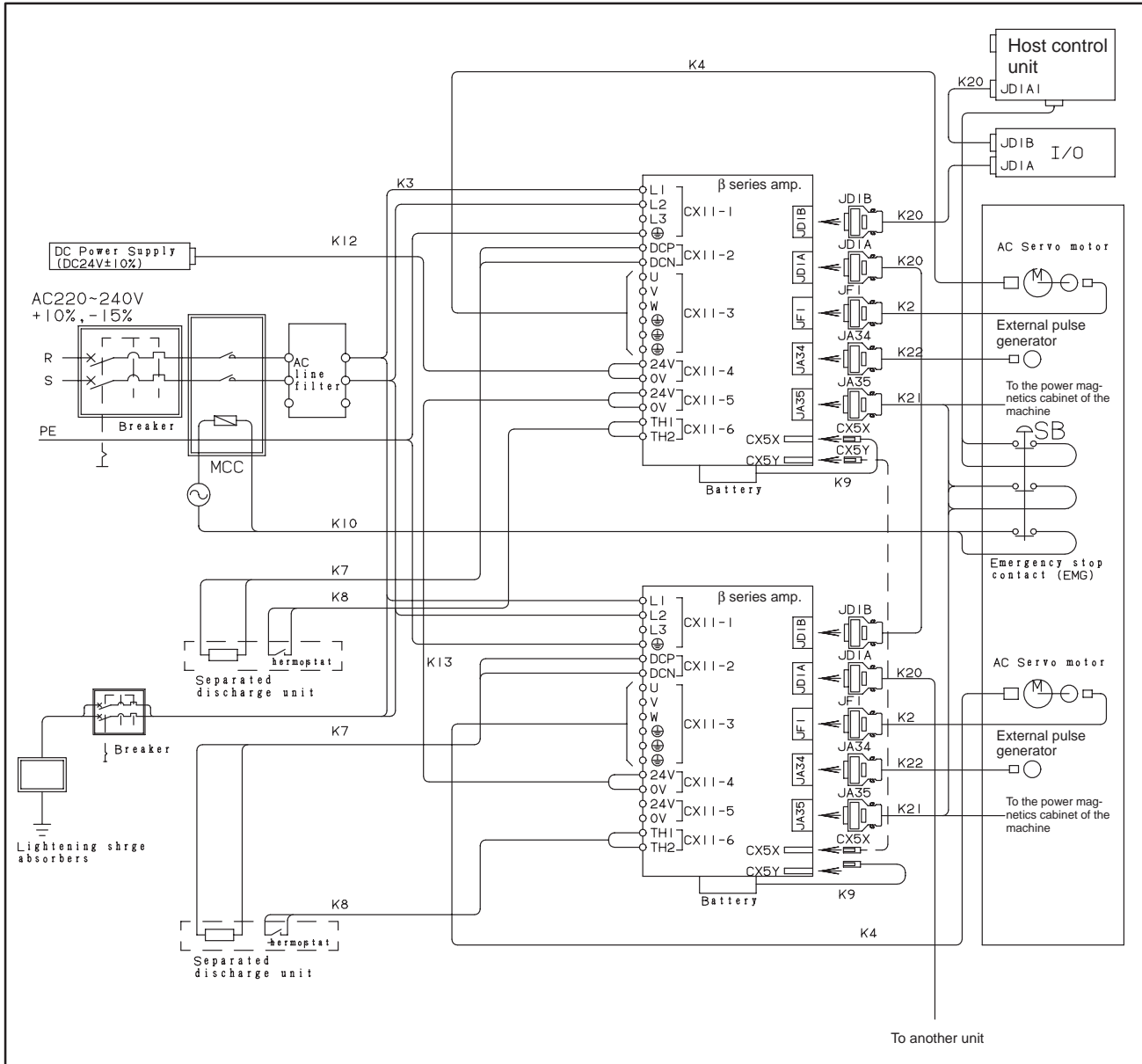
(1) Three-phase input



## WARNING

- 1 An AC line filter must be used to suppress the influence of high-frequency noise on the power supply unit.
- 2 Multiple amplifiers can be connected to a single AC line filter provided the rating of the AC line filter is not exceeded.
- 3 Be sure to install a circuit breaker for circuit protection. Restrict the number of motors connected to one circuit breaker so that its current rating will not be higher than 10A. See Subsection III-2.4.1 for the current carrying capacity of circuit breakers.

(2) Single-phase input



**WARNING**

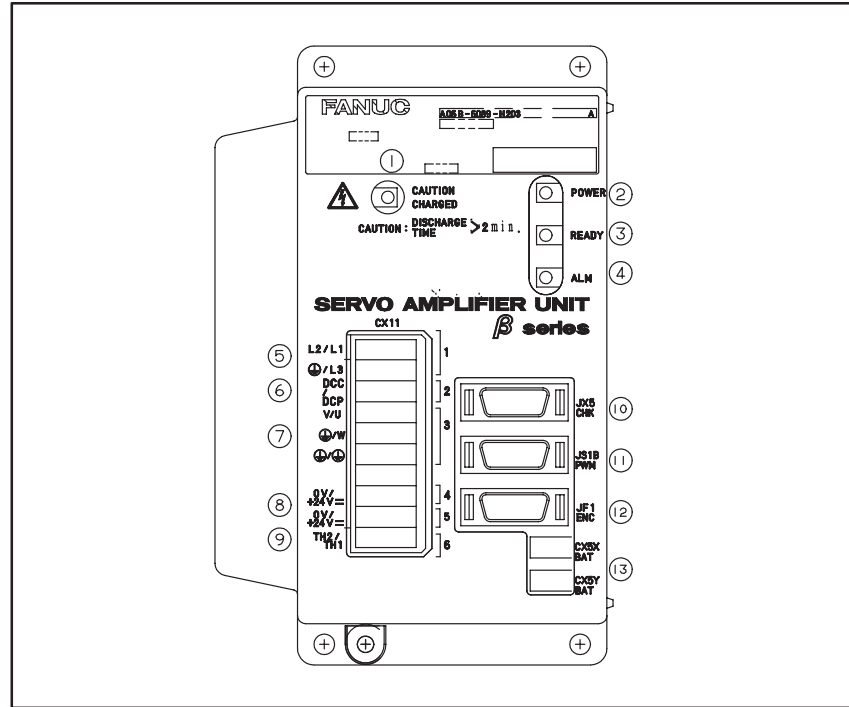
- 1 An AC line filter must be used to suppress the influence of high-frequency noise on the power supply unit.
- 2 Multiple amplifiers can be connected to a single AC line filter provided that the rating of the AC line filter is not exceeded.
- 3 Be sure to install a circuit breaker for circuit protection. Restrict the number of motors connected to one circuit breaker so that its current rating will not be higher than 10A. See Subsection III-2.4.1 for the current carrying capacity of circuit breakers.

# 2

## CONNECTOR LOCATIONS FOR β SERIES AMPLIFIER



## 2.1 PWM INTERFACE

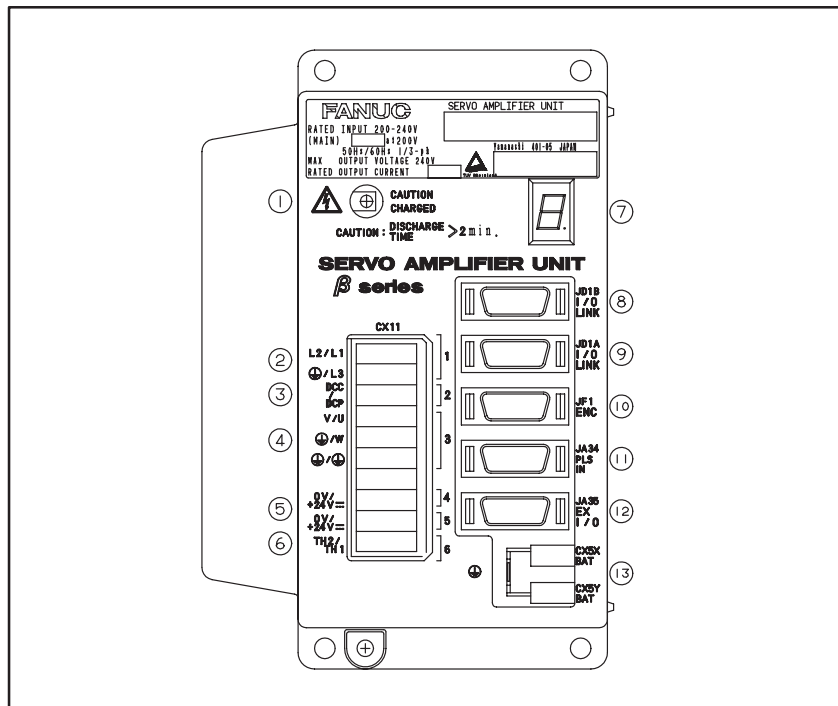


	Name	Description	Remarks
(1)		DC link charge indicator LED	(WARNING 1)
(2)	POWER	Control power status indicator LED	
(3)	READY	Activation status indicator LED	
(4)	ALM	Alarm status indicator LED	
(5)	CX11-1	Main power input connector	
(6)	CX11-2	Connector for regenerative resistor (DC link)	
(7)	CX11-3	Motor power line connector	
(8)	CX11-4, 5	24V power input/output connector	Both connectors have the same function.
(9)	CX11-6	Connector for regenerative resistor (for over heat)	(WARNING 2)
(10)	JX5/CHK	ESP connector & Signal check connector	For the servo check pin board
(11)	JS1B/PWM	NC interface connector Type B interface	
(12)	JF1/ENC	Connector for PULSECODER connection	
(13)	CX5X, CX5Y	Connector for ABS PULSECODER battery	

### WARNING

- 1 It is dangerous to touch any cables and components inside the module while this LED is lit. Never touch components or cables while this LED is lit.
- 2 Use a dummy connector if no regenerative discharge unit is used.

## 2.2 I/O LINK INTERFACE



	Name	Description	Remarks
(1)		LED for indicating that the DC link is charged.	(WARNING 1)
(2)	CX11-1	Main power input connector	
(3)	CX11-2	Regenerative resistor connector (DC link)	
(4)	CX11-3	Motor power line connector	
(5)	CX11-4, 5	24V power input/output connector	Both connectors have the same function.
(6)	CX11-6	Regenerative resistor connector (for overheat protection)	(WARNING 2)
(7)		Status indicator LED	
(8)	JD1B/I/O LINK	FANUC I/O Link connector	From a unit at the previous stage
(9)	JD1A/I/O LINK	FANUC I/O Link connector	To a unit at the next stage
(10)	JF1/ENC	Pulse coder connector	
(11)	JA34/Pulse In	External pulse input connector	
(12)	JA35/EX I/O	Built-in DI connector	
(13)	CX5X, CX5Y	Battery connector for ABS pulse coder	Both connectors have the same function.

### WARNING

- 1 It is dangerous to touch any cables and components inside the module while this LED is lit. Never touch components or cables while this LED is lit.
- 2 Use a dummy connector if no regenerative discharge unit is used.

## 2.3 CONNECTOR PIN ASSIGNMENT

The following tables list the pin assignment of connectors CX11-1 to CX11-6.

**Table 2.3(a) Three-phase power input version**

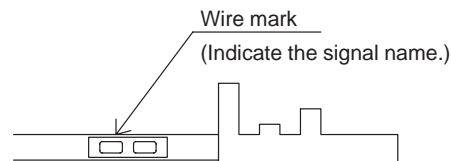
Connector arrangement and name		Description	Signals and corresponding connector pins
L2	L1	Three-phase 200V power connection CX11-1 (L1 = R phase; L2 = S phase; L3 = T phase)	L1 : B1, L2 : A1 L3 : B2, $\oplus$ : A2
$\oplus$	L3		
DCC	DCP	Regenerative discharge resistor connection CX11-2	DCP : B1, DCC : A1
V	U	Motor power line CX11-3 (U = U phase; V = V phase; W = W phase)	U : B1, V : A1 W : B2, $\oplus$ : A2
$\oplus$	W		
$\oplus$	$\oplus$	CX11-3 To be connected only for $\alpha$ 1/2	
Not connected	Not connected		
0V	+24V	DC power input/output CX11-4, CX11-5	+24V : B1, 0V : A1
0V	+24V	DC power input/output CX11-4, CX11-5	+24V : B1, 0V : A1
TH2	TH1	Regenerative discharge resistor thermostat connection CX11-6	TH1 : B1, TH2 : A1

**Table 2.3(B) Single-phase power input version**

Connector arrangement and name		Description	Signals and corresponding connector pins
L2	L1	Single-phase 200V power connection CX11-1 (L1 = R phase; L2 = S phase)	L1 : B1, L2 : A1 $\oplus$ : A2
$\oplus$	Not connected		
DCC	DCP	Regenerative discharge resistor connection CX11-2	DCP : B1, DCC : A1
V	U	Motor power line CX11-3 (U = U phase; V = V phase; W = W phase)	U : B1, V : A1 W : B2, $\oplus$ : A2
$\oplus$	W		
$\oplus$	$\oplus$	CX11-3 To be connected only for $\alpha$ 1/2	
Not connected	Not connected		
0V	+24V	DC power input/output CX11-4, CX11-5	+24V : B1, 0V : A1
0V	+24V	DC power input/output CX11-4, CX11-5	+24V : B1, 0V : A1
TH2	TH1	Regenerative discharge resistor thermostat connection CX11-6	TH1 : B1, TH2 : A1

### NOTE

Mark cables with signal names using wire labels or the like to prevent incorrect insertion.  
[Example of marking]



DCP and DCC can be in either polarity.  
TH1 and TH2 can be in either polarity.

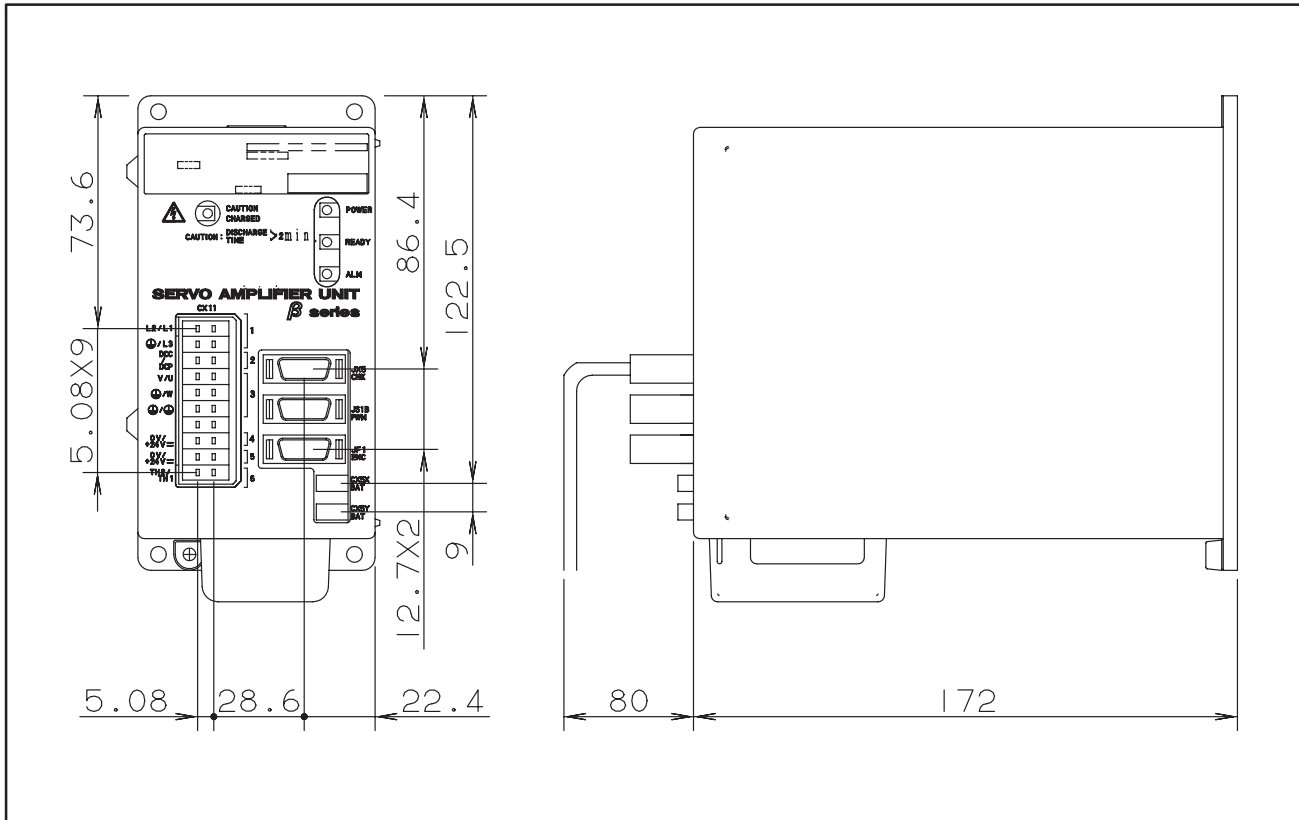
# 3

## DIMENSIONS INCLUDING CABLES

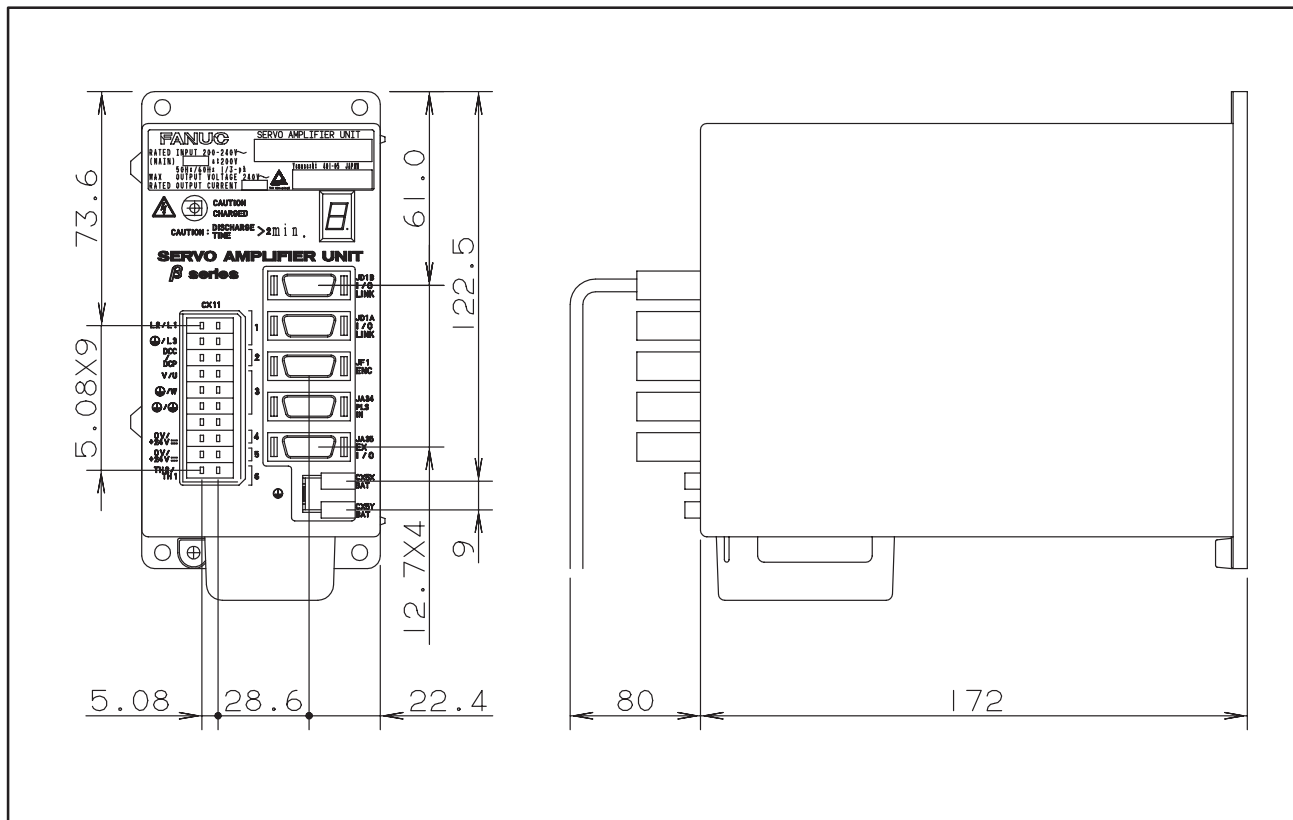




### 3.1 PWM INTERFACE (COMMON TO SVU-12 AND SVU-20)



### 3.2 I/O LINK INTERFACE (COMMON TO SVU-12 AND SVU-20)



# 4

## CONNECTION TO THE CONTROL UNIT



## **4.1 FOR PWM INTERFACE**

The  $\beta$  series servo amplifier is connected to the control unit via a TYPE B interface. Ensure, therefore, that the control unit to be used supports the TYPE B interface.

The  $\beta$  series servo motor can also be connected to servo amplifiers and control units other than the  $\beta$  series servo amplifie. For details, refer to the manuals provided with the servo amplifier and control unit to be used.

## **4.2 FOR I/O LINK INTERFACE**

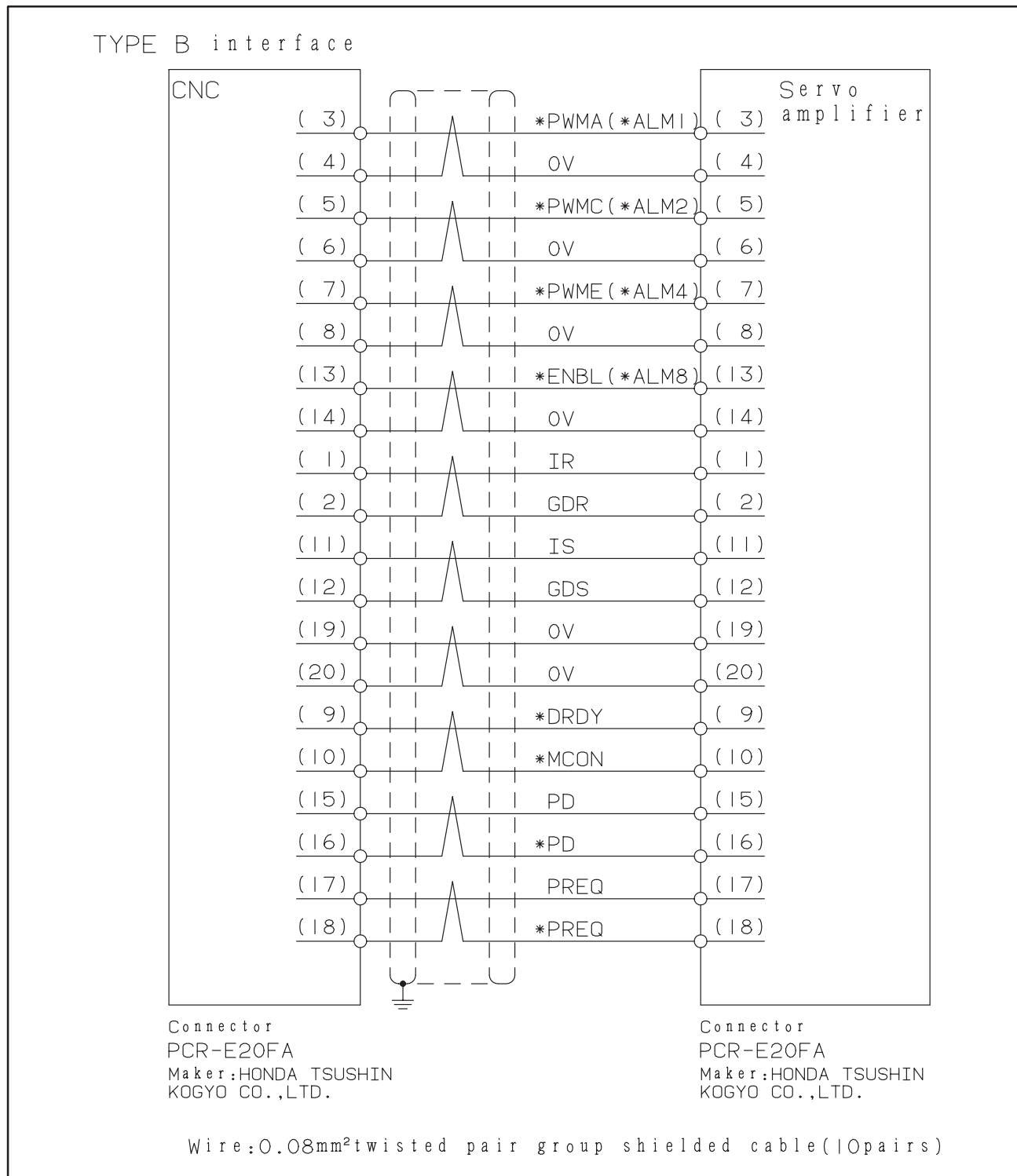
The FANUC I/O link is used to connect the  $\beta$  series servo amplifiers to a host control unit. See Section 6 for how to connect. Also refer to the manual for the host control unit.

# 5

## DETAILS OF CABLE CONNECTIONS



# 5.1 K1 CABLE CONNECTION (ONLY FOR PWM INTERFACE)



**Reference**

● **Wire for K1 cable**

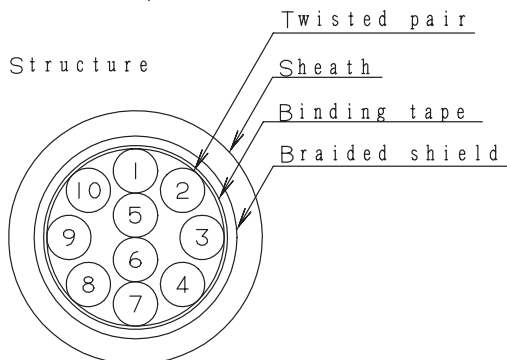
The following wire is recommended for the K1 cable:  
 FANUC specification: A66L-0001-0284/10P

Name: 10-pair cable

Wire: #28AWG × 10 pairs (20 conductors), standard length 200 m

Manufacturer: Hitach Cable, Ltd., Oki Electric Cable Co., Ltd.

(a) Cable manufactured by HITACHI CABLE, LTD.

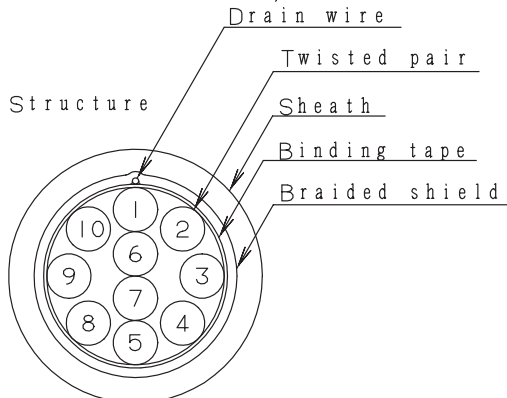


\*The circled numbers correspond to the twisted pair numbers in the table shown on the right.

Twisted pair conductor identification (HITACHI)

Twisted pair number	Insulator color	
	First conductor	Second conductor
1	Blue	White
2	Yellow	White
3	Green	White
4	Red	White
5	Purple	White
6	Blue	Brown
7	Yellow	Brown
8	Green	Brown
9	Red	Brown
10	Purple	Brown

(b) Cable manufactured by OKIELECTRIC CABLE CO., LTD.



\*The circled numbers correspond to the twisted pair numbers in the table shown on the right.

Twisted pair conductor identification (OKI)

Twisted pair number	Insulator color	Dot mark (1 pitch)	Dot mark color	
			First conductor	Second conductor
1	Orange	-	Red	Black
2	Gray	-	Red	Black
3	White	-	Red	Black
4	Yellow	-	Red	Black
5	Pink	-	Red	Black
6	Orange	--	Red	Black
7	Gray	--	Red	Black
8	White	--	Red	Black
9	Yellow	--	Red	Black
10	Pink	--	Red	Black

**WARNING**

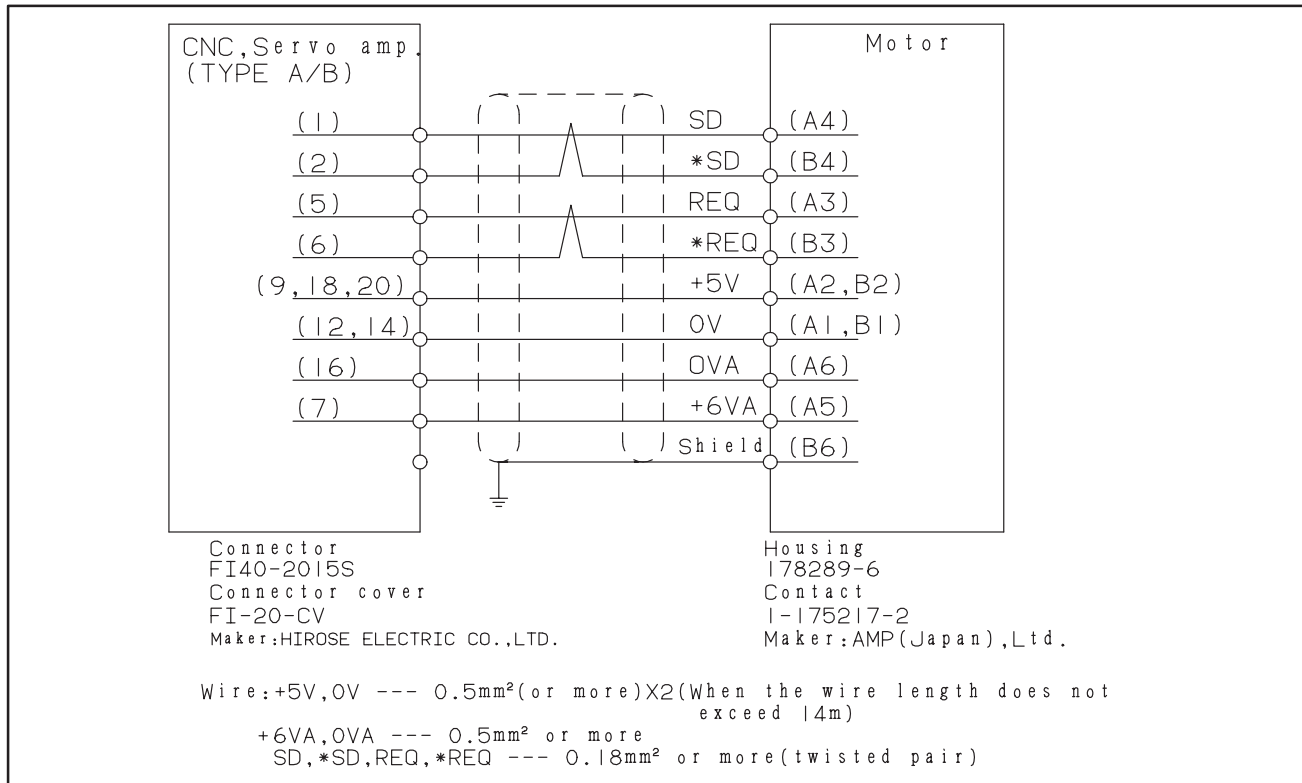
- 1 For the pairs (1-2, 11-12) used for the current feedback signals (IRn, ISn), use the central pairs of the cable to minimize the effect of external influences. (For IRn and ISn, use pairs 5 and 6 when using the Hitachi cable. Use pairs 6 and 7 when using the Oki cable.) The use of other cables may cause uneven feed or abnormal noise.
- 2 These cables feature group shielding. Connect the shielding to ground on the NC side.

### ● Specifications

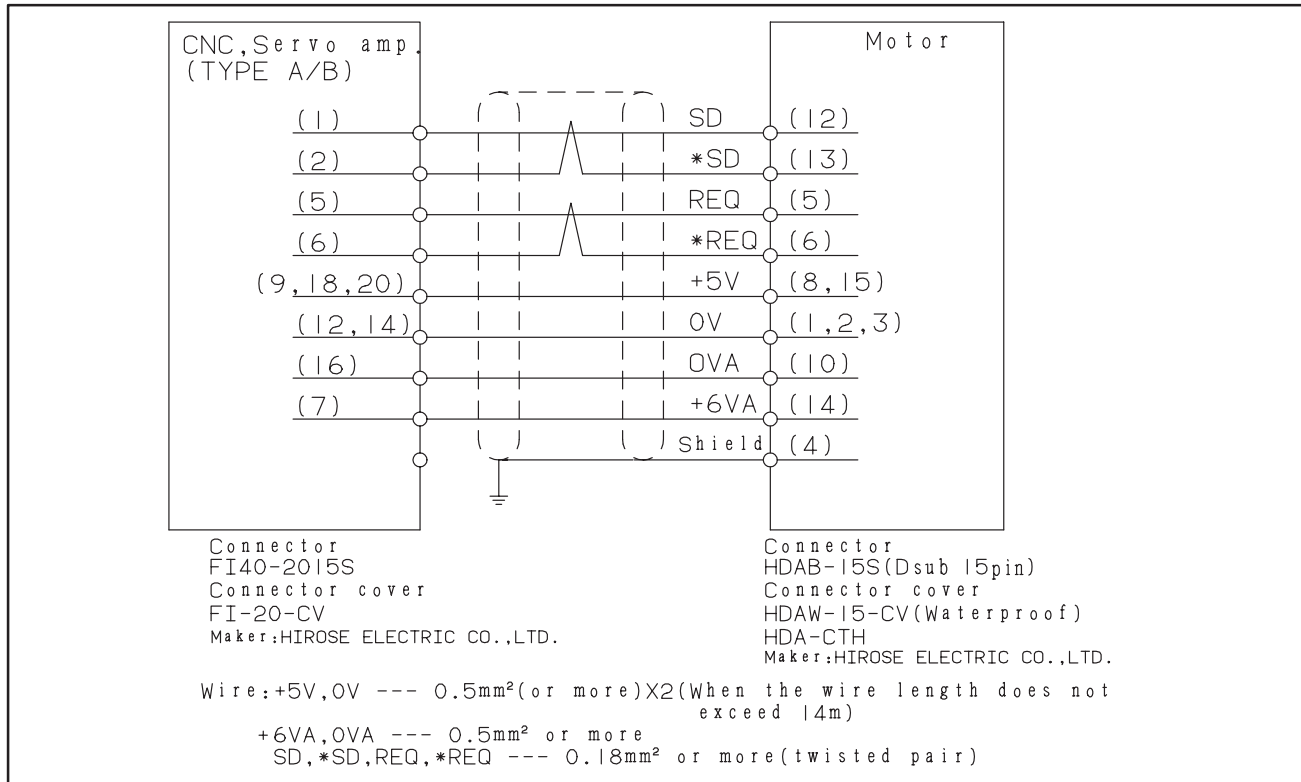
Item		Unit	Specifications
Part No.			A66L-0001-0284/10P
Manufacturer			Hitachi Cable, Ltd. Oki Electric Cable Co., Ltd.
Rating			60°C 30V : UL2789 80°C 30V : UL80276
Material	Conductor		Tinned soft steel wire (ASIM B-286)
	Insulator		Cross-linked vinyl
	Braided shield		Tinned soft steel wire
	Sheath		Heat-resistant, oil-resistant vinyl
Number of pairs		Pair	10
Conductor	Size	AWG	28
	Structure	Conductors/mm	7/0.127
	Outside diameter	mm	0.38
Insulator	Thickness	mm	0.1 Minimum thickness: 0.38 (3.1 mils)
	Outside diameter (approximate value)	mm	0.58
	Core style (rating)		UL1571 (80°C, 30V)
Twisted pair	Outside diameter (approximate value)	mm	1.16
	Twisting pitch	mm	20 or less
Twisted pair binding			A required number of twisted pairs are bundled using binding tape. To form a round cable, an interstitial wire can be used as required.
Outside diameter of bundled twisted pairs		mm	3.5
Drain wire		Wires/mm	Hitach Cable, Ltd.: No drain wire is provided. Oki Electric Cable Co., Ltd.: A drain wire is provided. 10/0.12
Braided shield	Strand diameter	mm	0.12
	Braiding density	%	85 or more
Sheath	Color		Black
	Thickness	mm	1.0
	Outside diameter (approximate value)	mm	6.2
Standard length		m	200
Packing			Bundle
Electrical characteristics	Electric resistance (20°C)	Ω/km	233 or less
	Insulation resistance (20°C)	MΩ-km	10 or more
	Dielectric strength (A.C.)	V/min.	300
Flame resistance			The UL standard flame resistance test (VW-ISC) must be satisfied.



## 5.2 K2 CABLE CONNECTION

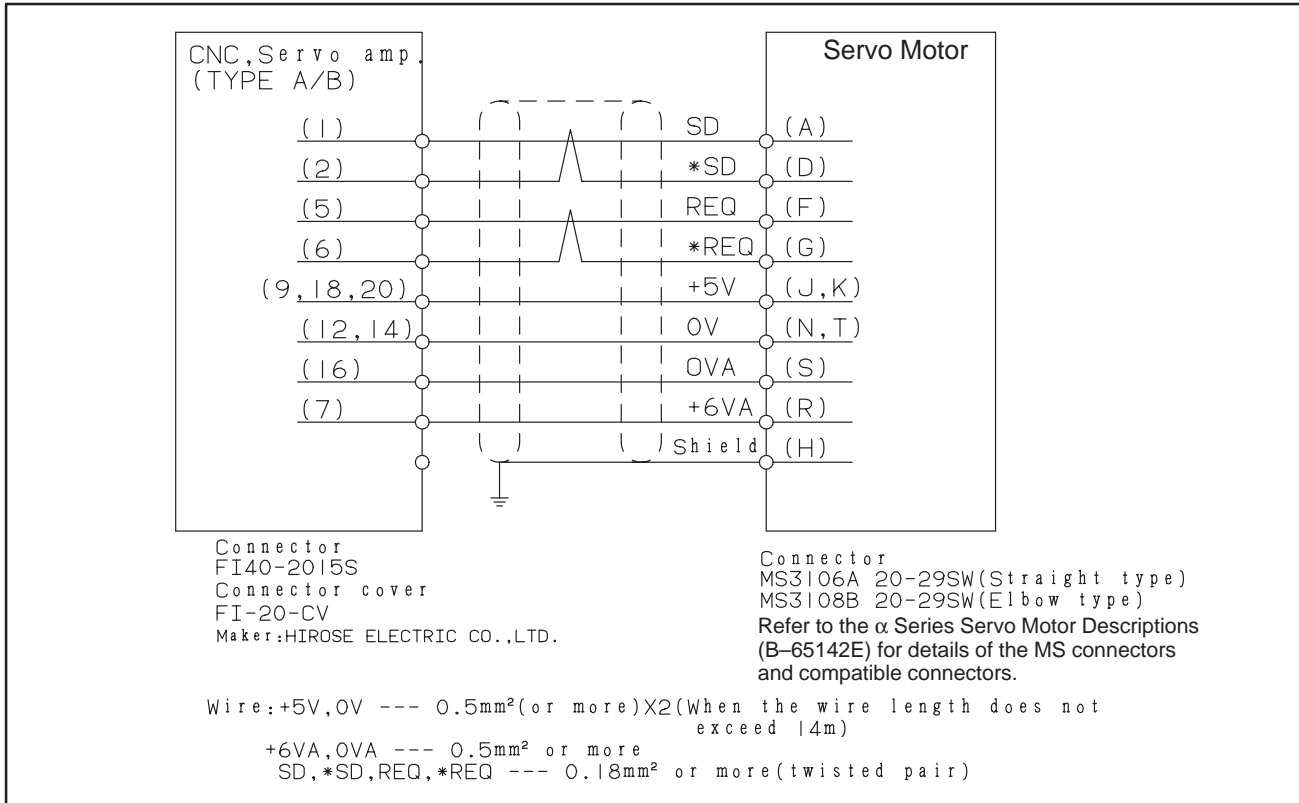
(a) In case of  $\beta 0.5/3000$ **NOTE**

- 1 When the wire length exceeds 14m, make whatever adjustment is necessary to ensure that the sum of the electrical resistances of 0V and 5V does not exceed 0.5 ohms.
- 2 Leave the 6V and 0V pins open when using an incremental pulse coder.

(b) In case of  $\alpha 1/3000$  to  $\alpha 2/3000$ ,  $\beta 1/3000$  to  $\beta 6/2000$ **NOTE**

- 1 When the wire length exceeds 14m, make whatever adjustment is necessary to ensure that the sum of the electrical resistances of 0V and 5V does not exceed 0.5 ohms.
- 2 Leave the 6V and 0V pins open when using an incremental pulse coder.

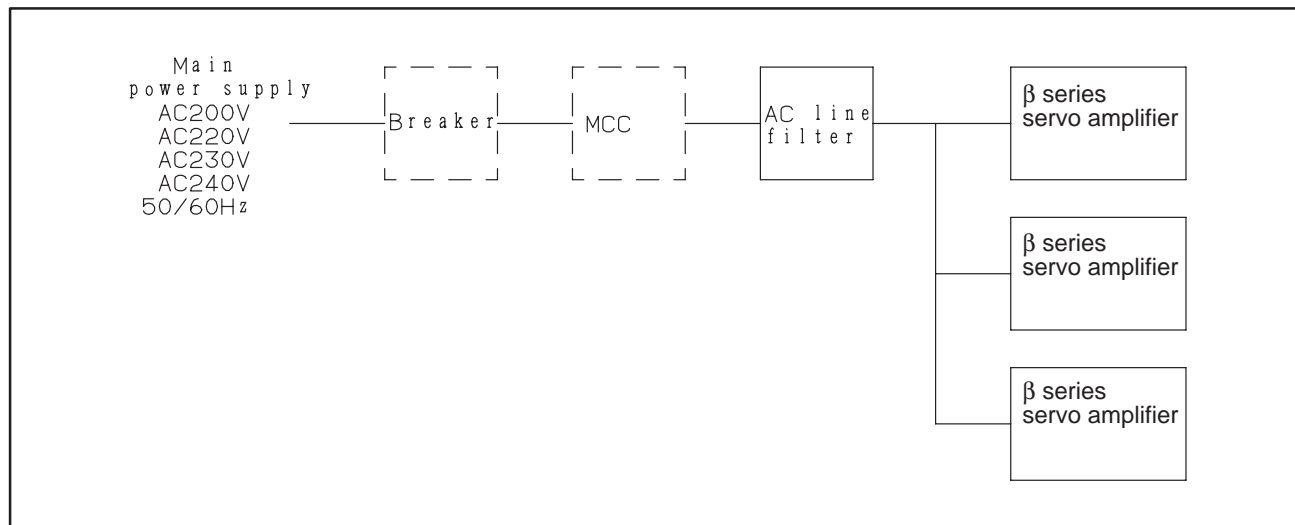
(c) In case of  $\alpha$ C3/2000 to  $\alpha$ C12/2000



**NOTE**

- 1 When the wire length exceeds 14m, make whatever adjustment is necessary to ensure that the sum of the electrical resistances of 0V and 5V does not exceed 0.5 ohms.
- 2 Leave the +6V and 0V pins open when using an incremental pulse coder.

## 5.3 K3 CABLE CONNECTION



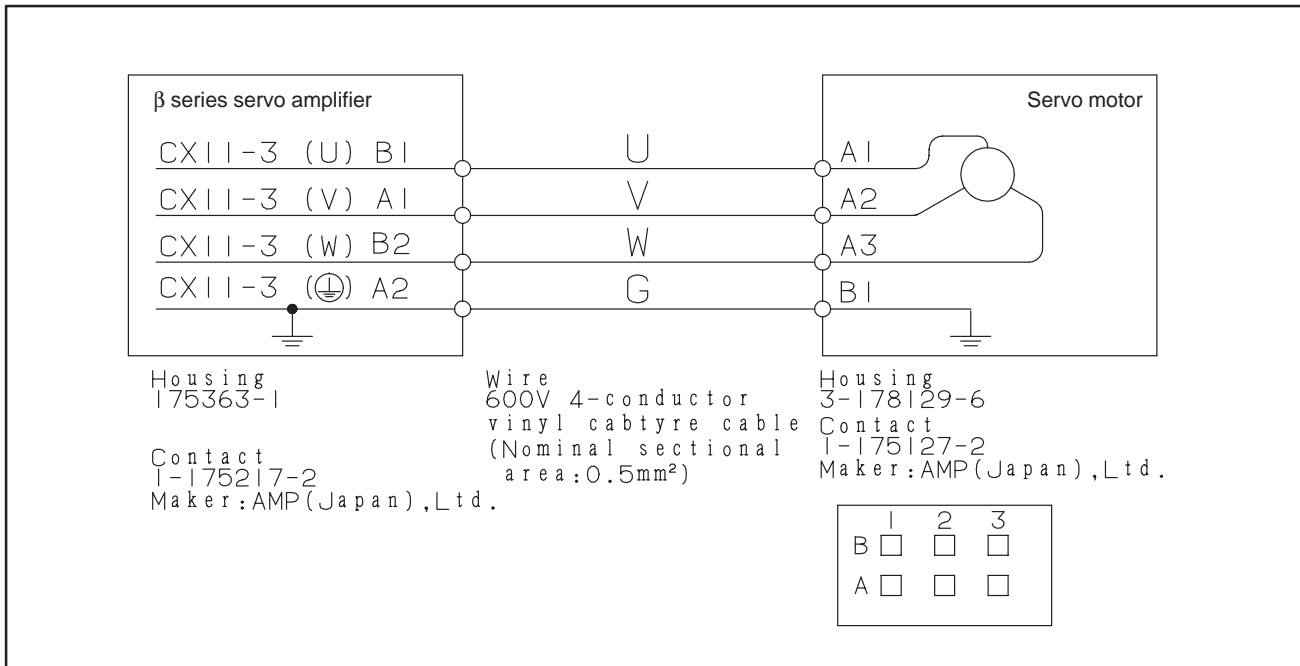
Model	Applicable cable	
	Captyre cable (WARNING 1)	Heat-resistant vinyl cable (WARNING 2)
SVU-12	0.5mm <sup>2</sup> or more	0.5mm <sup>2</sup> or more
SVU-20	1.0mm <sup>2</sup> or more	1.0mm <sup>2</sup> or more

### WARNING

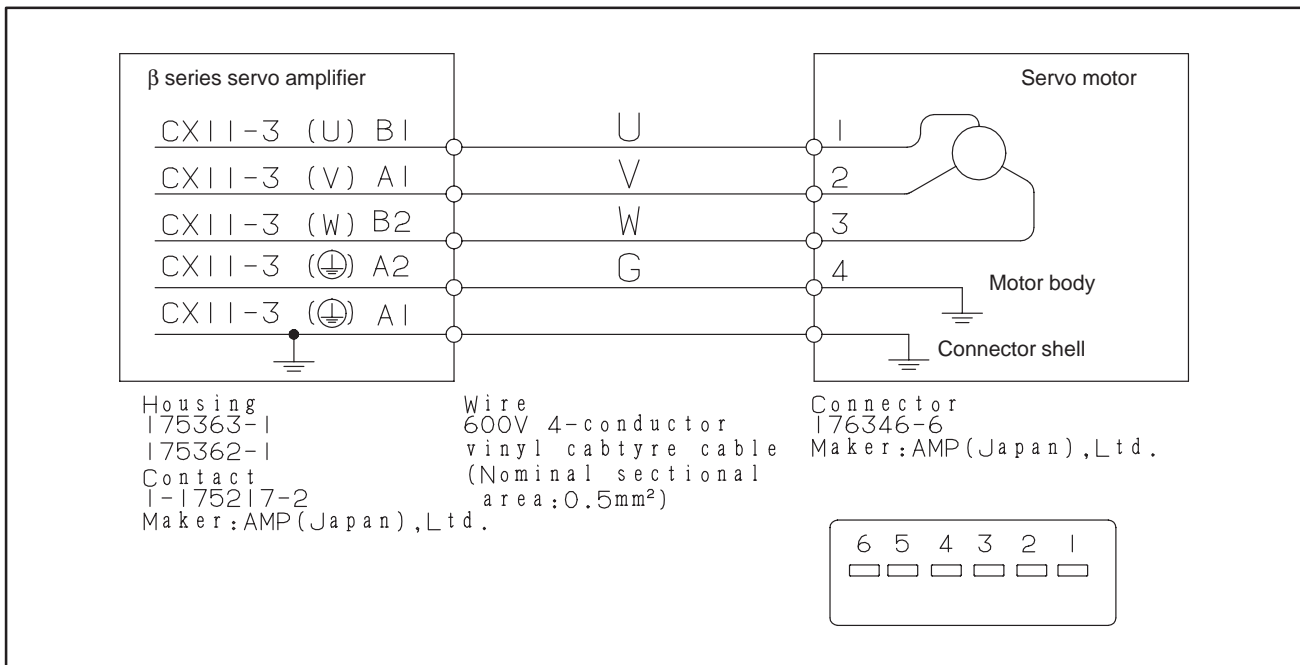
- 1 600V vinyl captyre cable, JIS C 3312, 4 conductors
- 2 Heat-resistant vinyl cable  
(maximum conductor temperature: 105°C)  
(equivalent to the LMFC, manufactured by FURUKAWA  
ELECTRIC CO., LTD.)

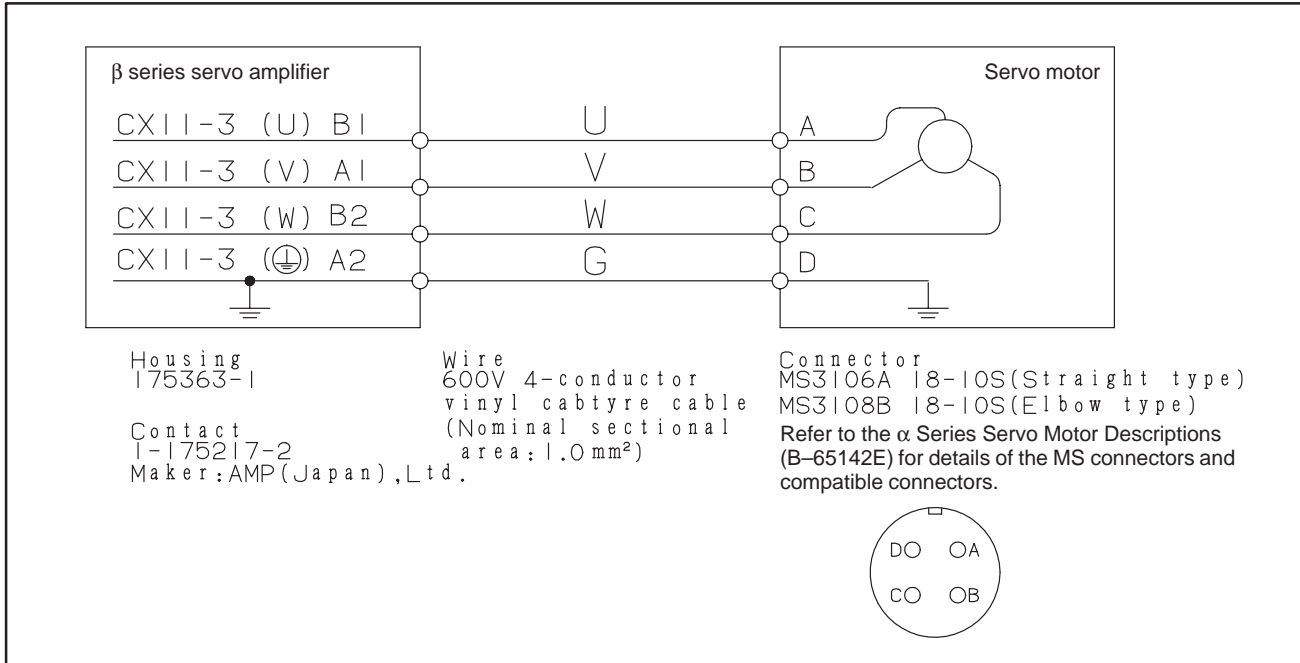
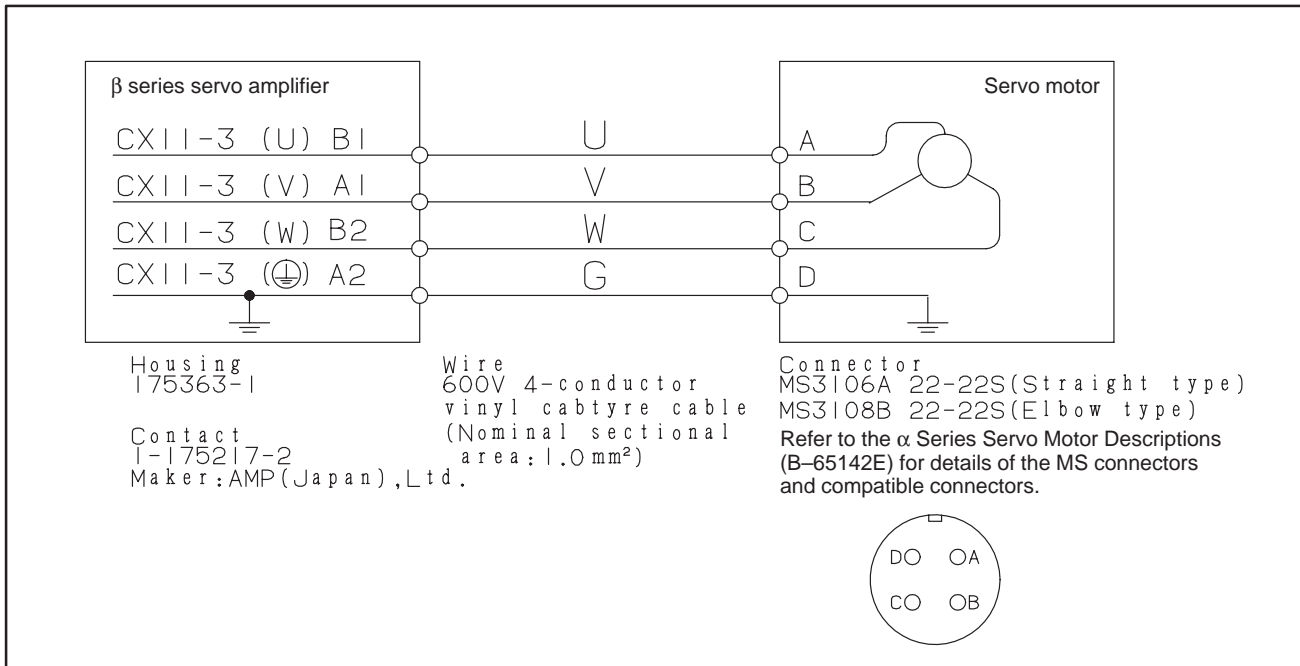
# 5.4 K4 CABLE CONNECTION

(a) In case of  $\beta 0.5/3000$



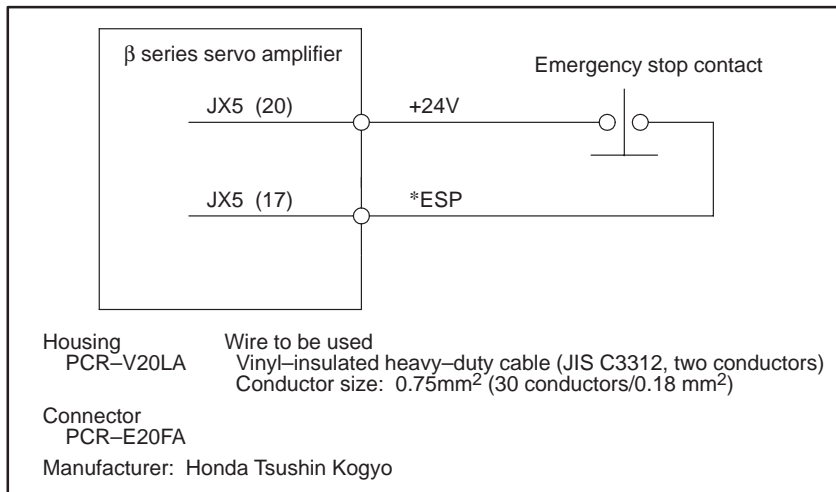
(b) In case of  $\alpha 1/3000$  to  $\alpha 2/3000$



(c) In case of  $\alpha$ C3/2000 to  $\alpha$ C6/2000,  $\beta$ 1/3000 to  $\beta$ 6/2000(d) In case of  $\alpha$ C12/2000**WARNING**

If a motor installed in a machine (cabinet) is not connected to ground via the machine, run a wire between the motor's ground terminal and the location to which amplifier's ground terminal is connected. Use a wire that is additional to the GND wire (shown above) in the power line, and which has a cross-sectional area of at least 1.25mm<sup>2</sup>. When routing the wire, keep it as far as possible from the power line. This connection minimizes the influence of switching noise.

## 5.5 DETAILED DESCRIPTIONS ABOUT HOW TO CONNECT CABLE K5 (PWM INTERFACE ONLY)

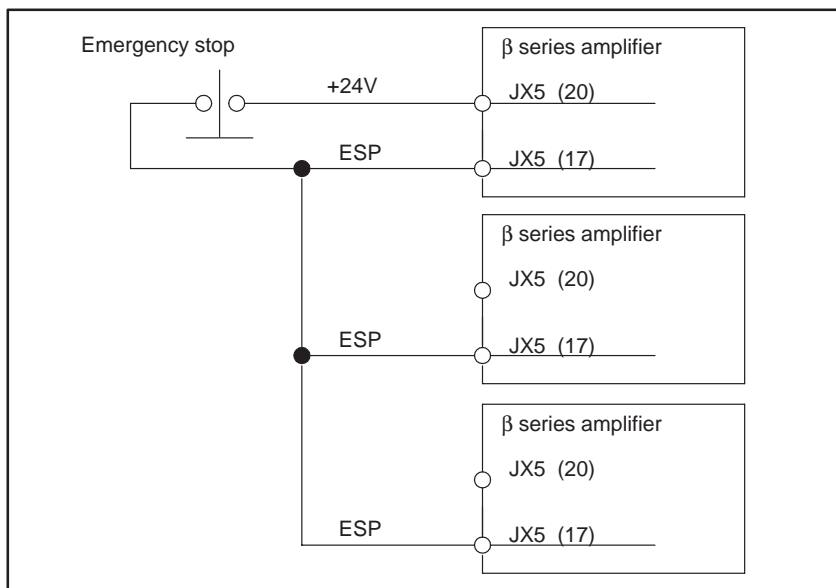


### NOTE

Contact input signals must satisfy the following requirements:

- 1 The external contact is rated at 30VDC, 100mA or higher.
- 2 The significant levels for no-contact inputs (if used) are:
  - Low level (ESP state) = not higher than 2V  
(as measured between the input terminals)
  - High level (normal state) = not lower than 20V  
(as measured between the input terminals)

### 5.5.1 ESP Signal Using More Than One β amplifier



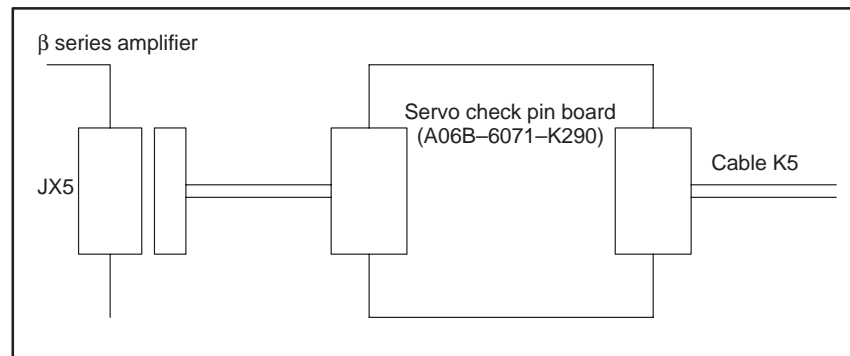
### WARNING

- 1 Up to six β series amplifiers can be connected to the emergency stop switch.
- 2 If you want to connect more than six β series amplifiers, contact FANUC.

### 5.5.2 ESP Signal in Using a Servo Check Pin Board

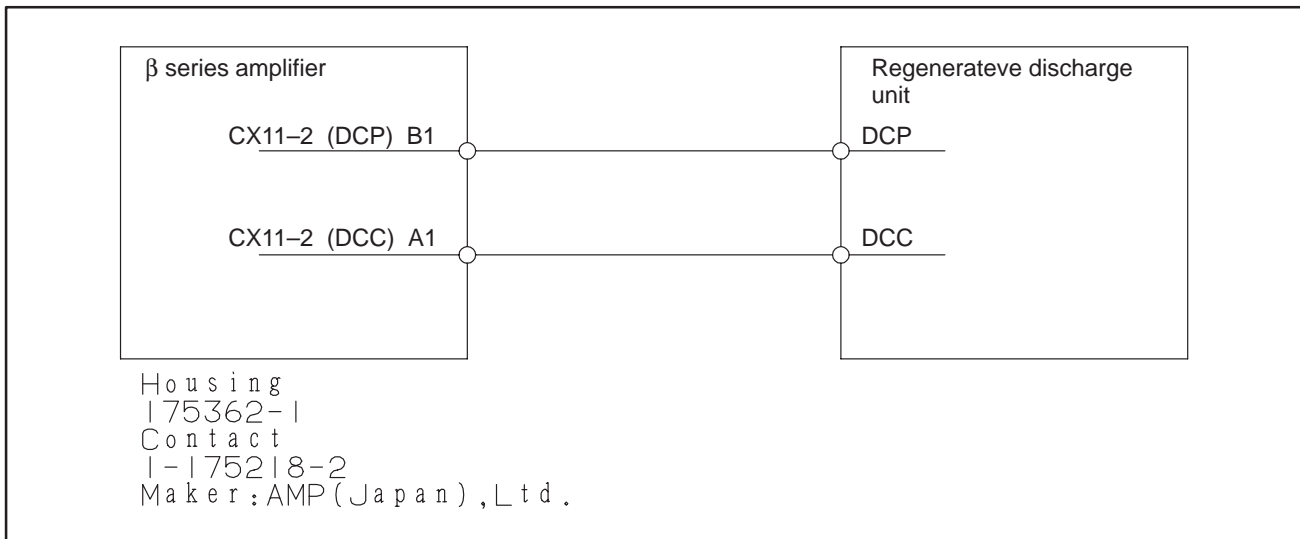
To use a servo check pin board (A06B-6071-K290), remove cable K5 from connector JX5 and attach the servo check pin board. The pin board has two connectors that are arranged back-to-back with their pins connected on a one-to-one basis. Attach the cable K5 to the remaining connector.

For details, refer to the maintenance manual (B-65235EN) for the  $\beta$  series amplifiers.



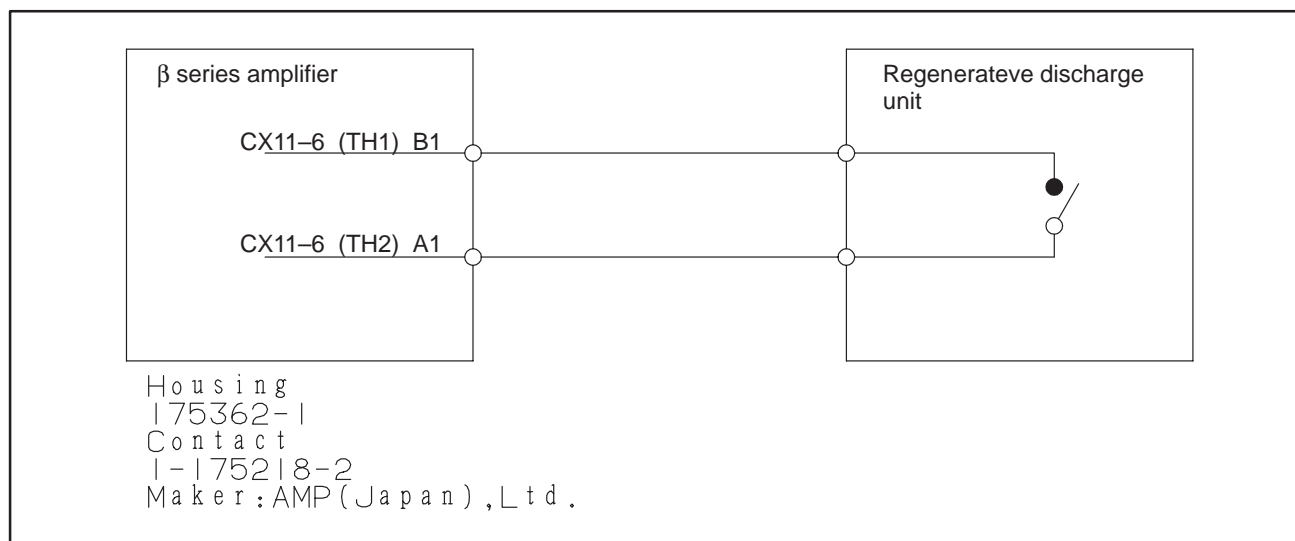


## 5.6 K7 CABLE CONNECTION



## 5.7 K8 CABLE CONNECTION

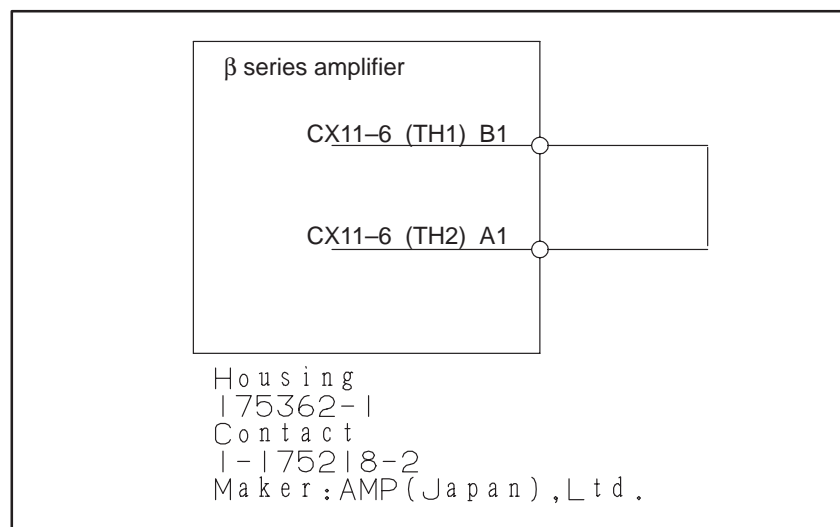
### 5.7.1 When Regenerative Discharge Unit is Used



### 5.7.2 When Regenerative Discharge Unit is not Used

If no regenerative discharge unit is used, jumper the CX11-6 pins.

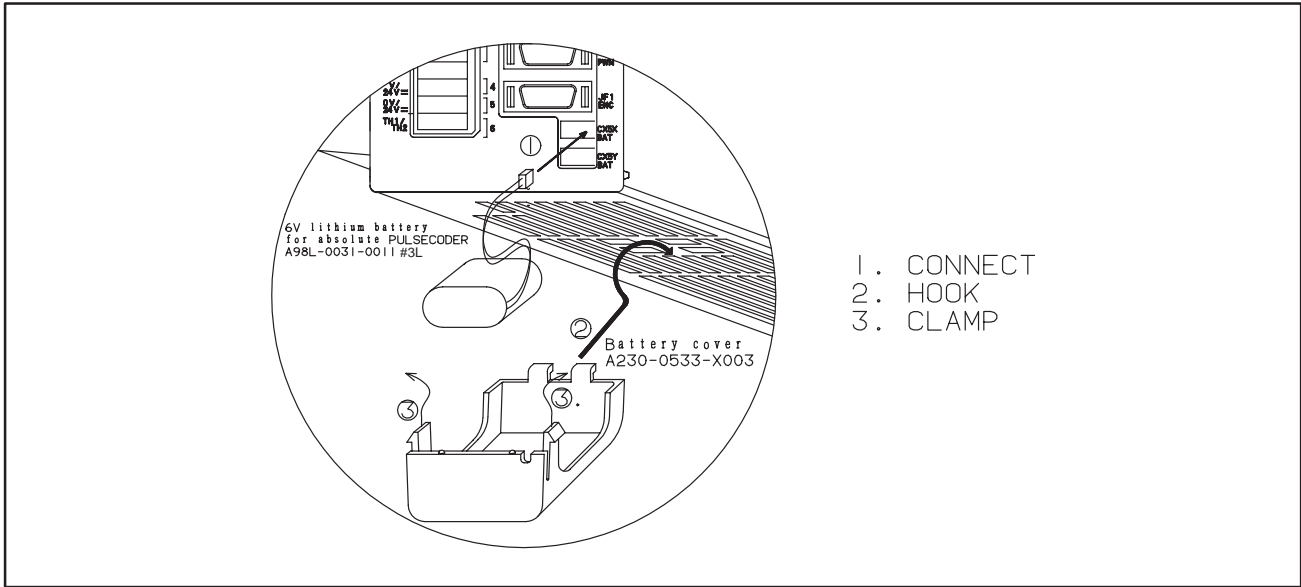
The connector kit (A06B-6093-K301) comes with a standard dummy connector that jumpers the CX11-6 pins.



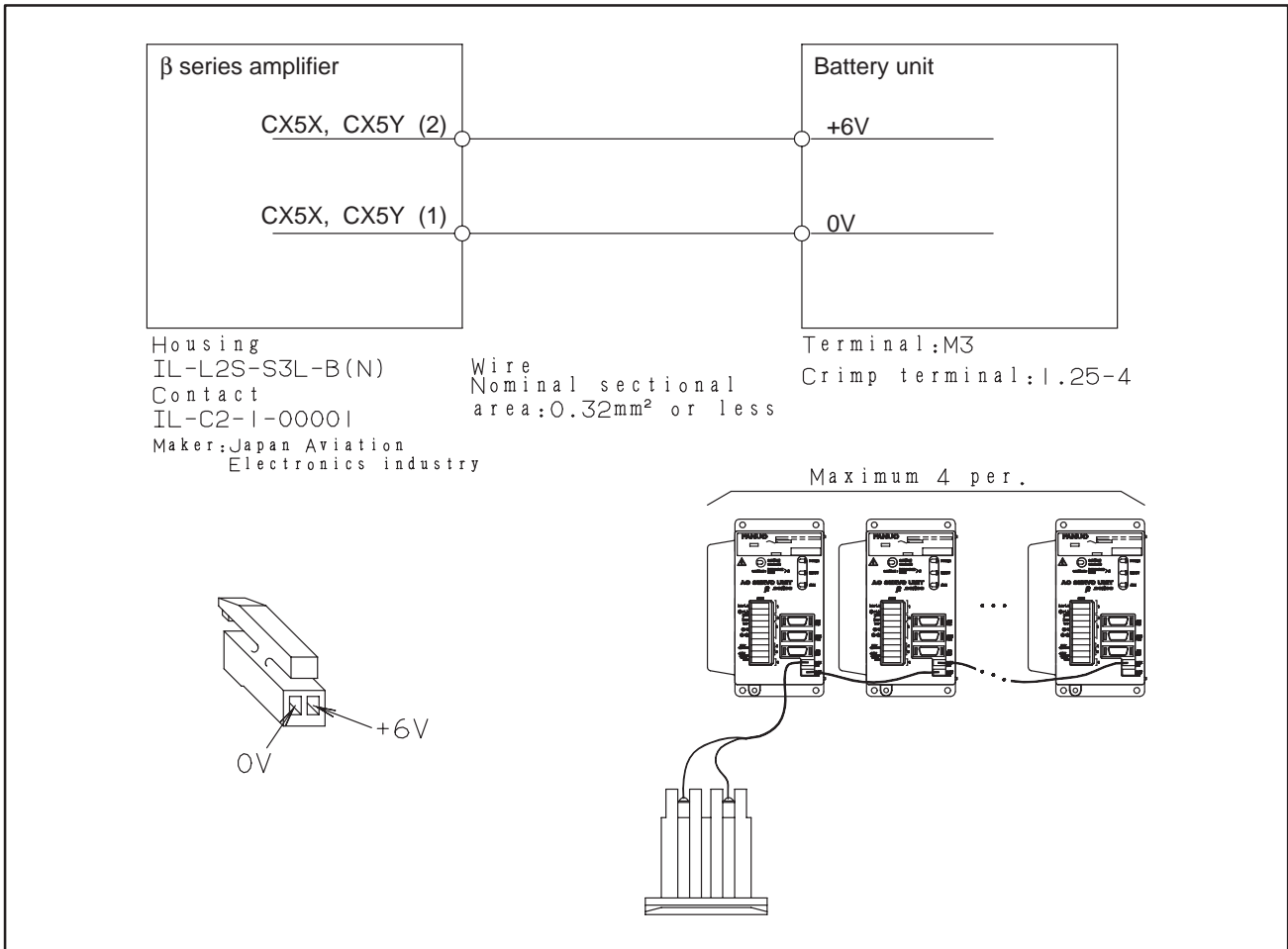
# 5.8 K9 CABLE CONNECTION

(a) Connection method 1

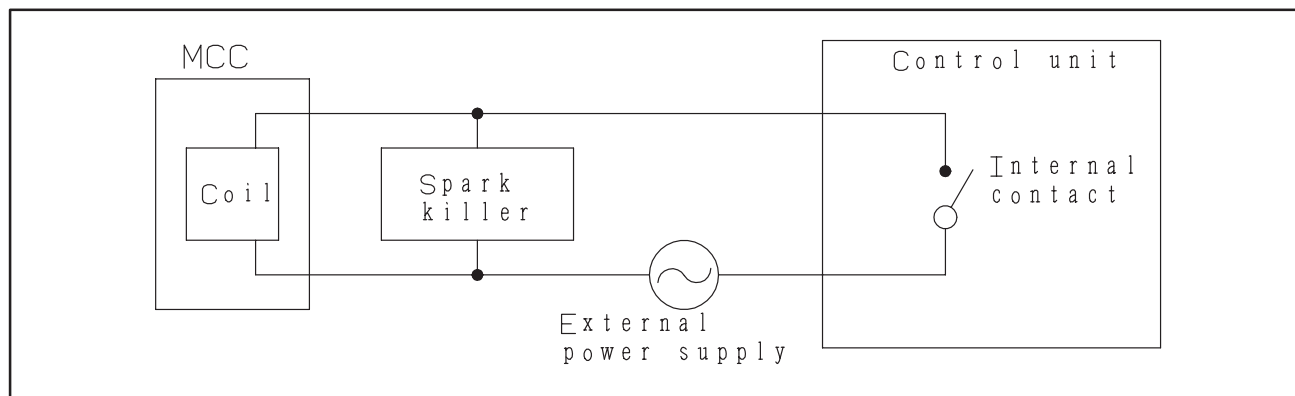
The lithium battery has its own connecting cables. Mount the lithium battery in the amplifier, as shown below.



(b) Connection method 2



## 5.9 K10 CABLE CONNECTION

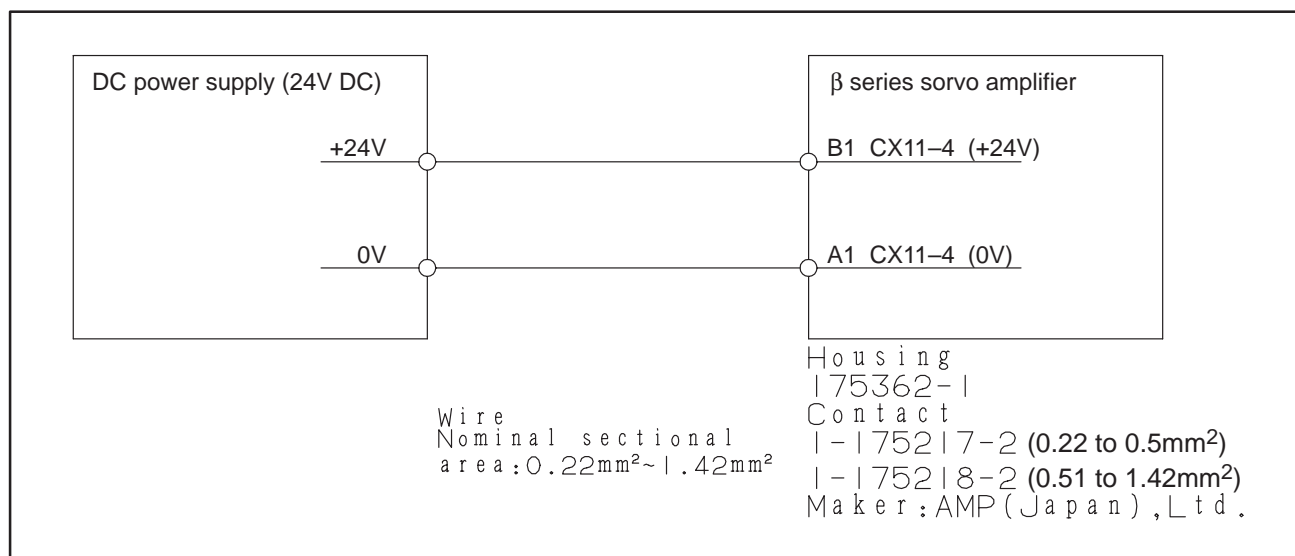


Cable specification : Heavy-duty vinyl power cord (JIS C 3312, 2 conductors)

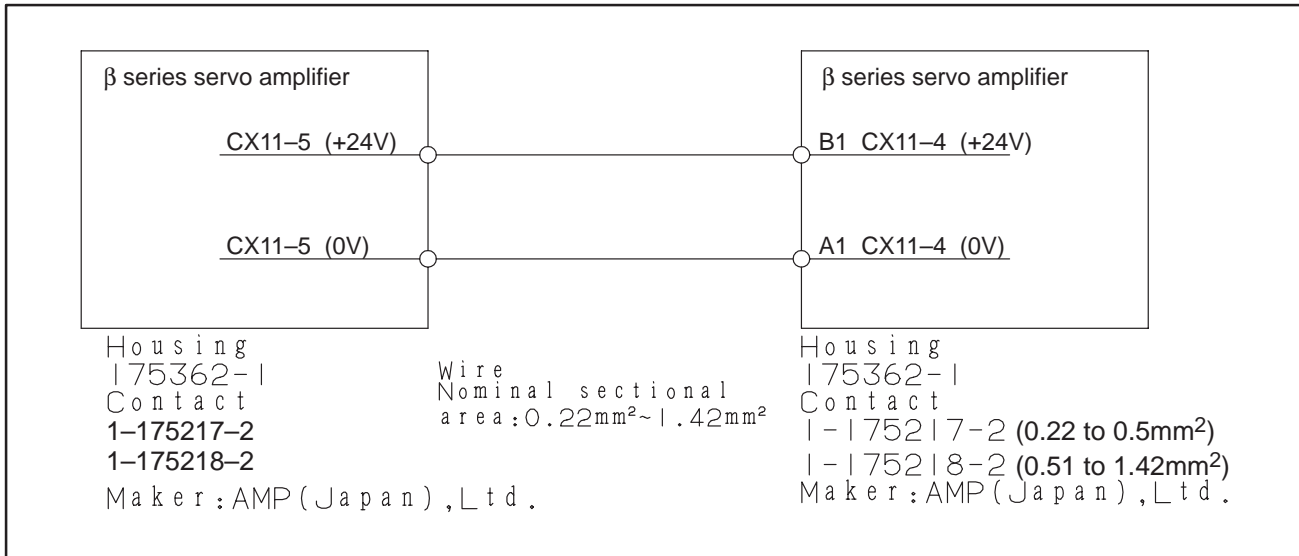
Conductor : 0.5 mm<sup>2</sup> Sheath : PCV 9.6 φ

Spark killer : To protect the internal contacts, always use a spark killer appropriate for the MMC being used.

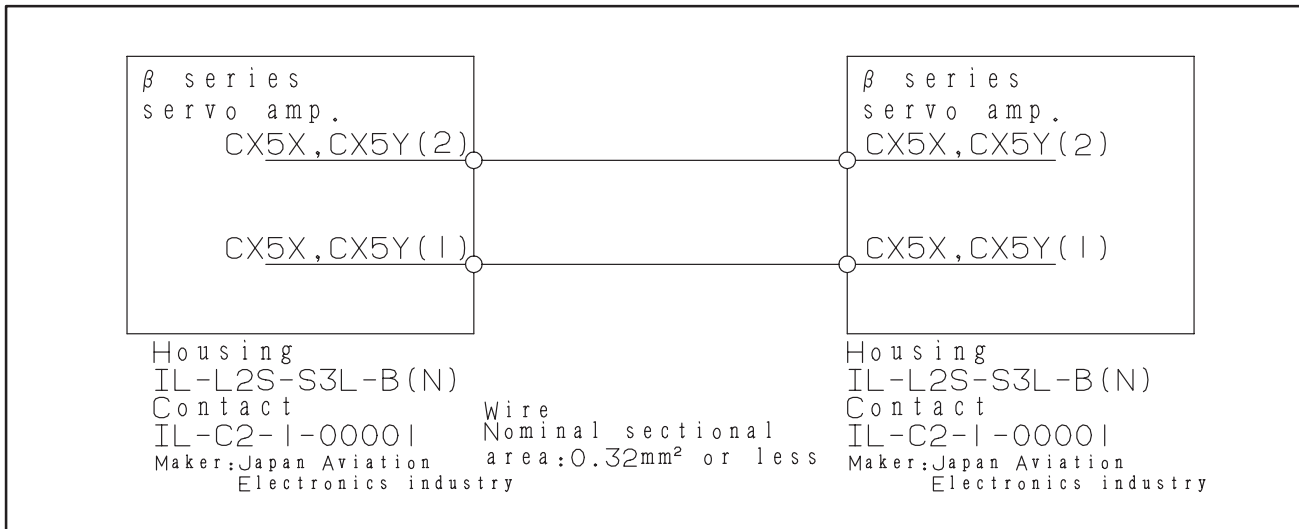
## 5.10 K12 CABLE CONNECTION



### 5.11 K13 CABLE CONNECTION



### 5.12 K14 CABLE CONNECTION

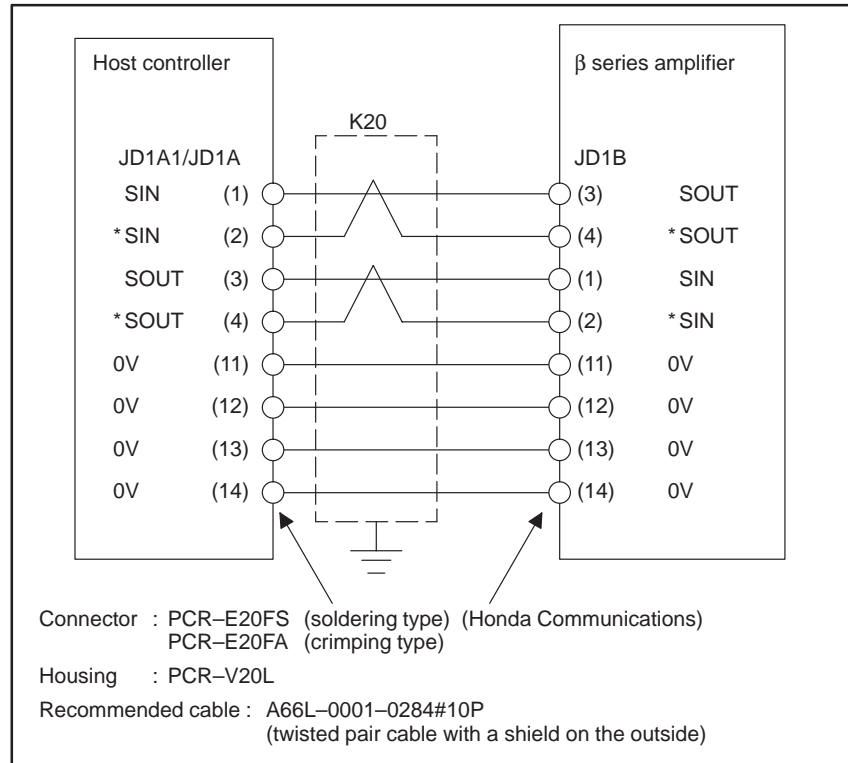


# 6

## FANUC I/O LINK CONNECTION (FOR I/O LINK INTERFACE ONLY)

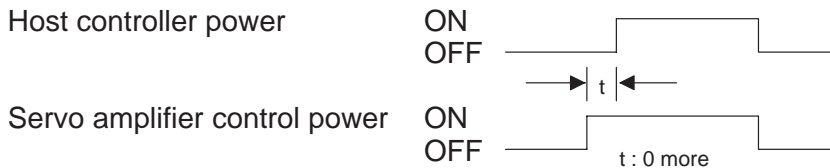


# 6.1 DETAILED DESCRIPTIONS ABOUT CABLE K20 CONNECTION



### NOTE

- 1 Maximum cable length: 10 m (when the above recommended wire is used)
- 2 Use the same twisted wire pair for the SIN and \*SIN signals. Also use the same twisted wire pair for the SOUT and \*SOUT signals.
- 3 Keep open all pins that are not shown above.
- 4 Ground the cable by fastening its shield with a metal cable clamp to a terminal on the cabinet grounding board on the JD1A1 side.
- 5 Switch on the control power for the servo amplifier at the same time with or before the host controller connected to the servo amplifier through the I/O link. When switching off the host controller power, also switch off the servo amplifier control power.



# 7 CONNECTION OF BUILT-IN DI (FOR I/O LINK INTERFACE ONLY)





## 7.1 INPUT SIGNAL SPECIFICATION

The DC input signals are those sent from the machine to the servo unit.

They are transferred via a noninsulated interface that can be switched between sink type (0V common) and source type (24V common) except for an emergency stop input, which is fixed at a sink type (0V common).

The relevant safety standards require that the interface be used as sink type.

The contacts on the machine side must satisfy the following requirements:

Contact capacity :

30VDC, 16mA or higher

Closed-state contact-to-contact leakage current:

1 mA or lower (at 26.4V)

Closed-state contact-to-contact voltage drop:

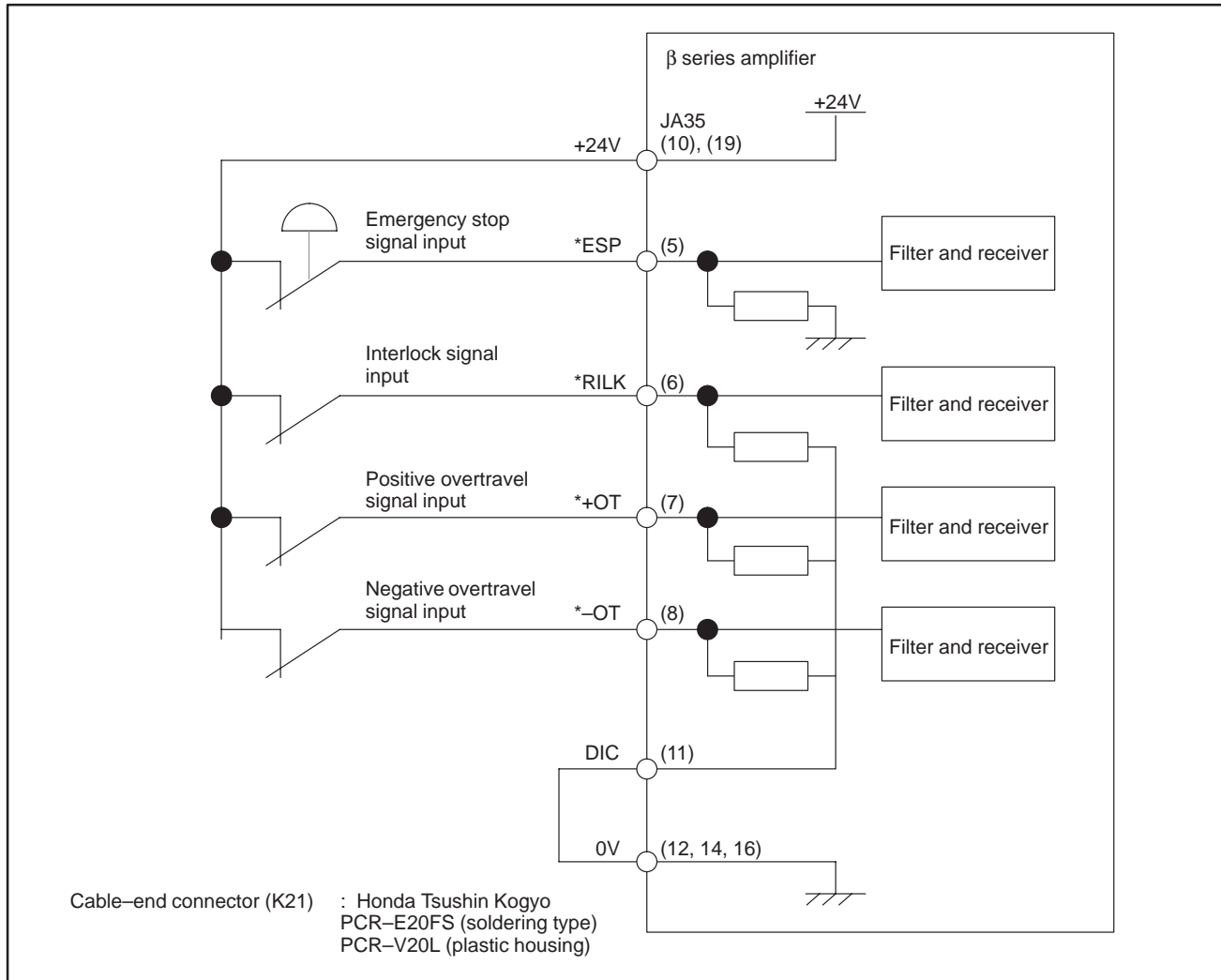
2V or lower (including voltage drop across cable, with 8.5mA)

For information about the specifications of the high-speed skip signal, see Section 7.4.

## 7.2 SIGNALS

- (1) \*ESP: Opening the contact for the emergency stop signal input (\*ESP) resets the servo unit and brings it to an emergency stop. Generally, this signal is issued using the B contact of a pushbutton switch.
- (2) \*+OT: Setting the positive overtravel signal input (\*+OT) to logical 0 disables forward movement. This signal can be made unusable by parameter setting.
- (3) \*-OT: Setting the negative overtravel signal input (\*-OT) to logical 0 disables reverse movement. This signal can be made unusable by parameter setting.
- (4) \*RILK: Setting the interlock signal input (\*RILK) to logical 0 decelerates movement along an axis to a stop. Setting this signal to logical 1 restarts movement along the axis.
- (5) HDI: The rising or falling edge of the high-speed skip signal input (HDI) can be used to cause the current block to be skipped. The signal can also be used to cause a movement specified in the current block to stop after a specified amount of movement is executed since the detection of the signal.

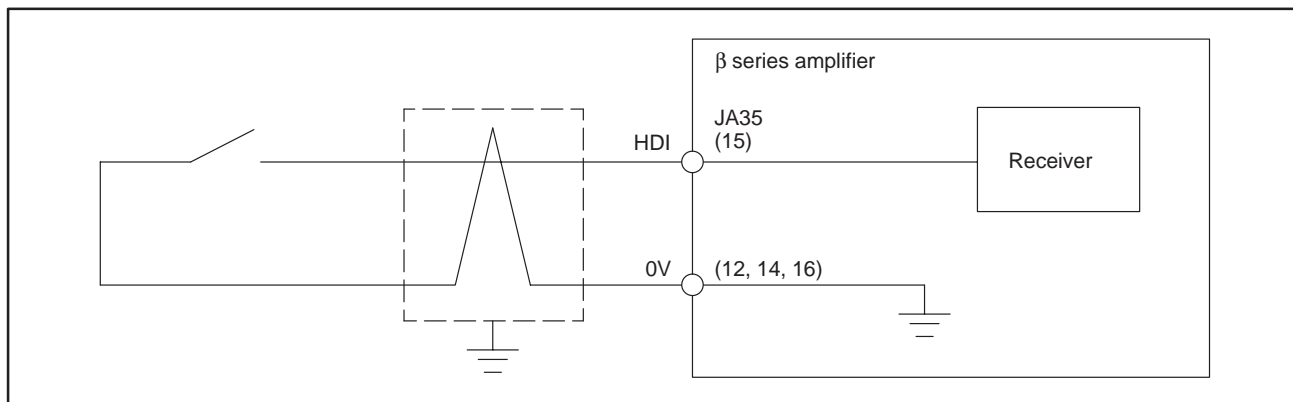
## 7.3 SIGNAL CONNECTION WITH THE POWER MAGNETICS CABINET



### NOTE

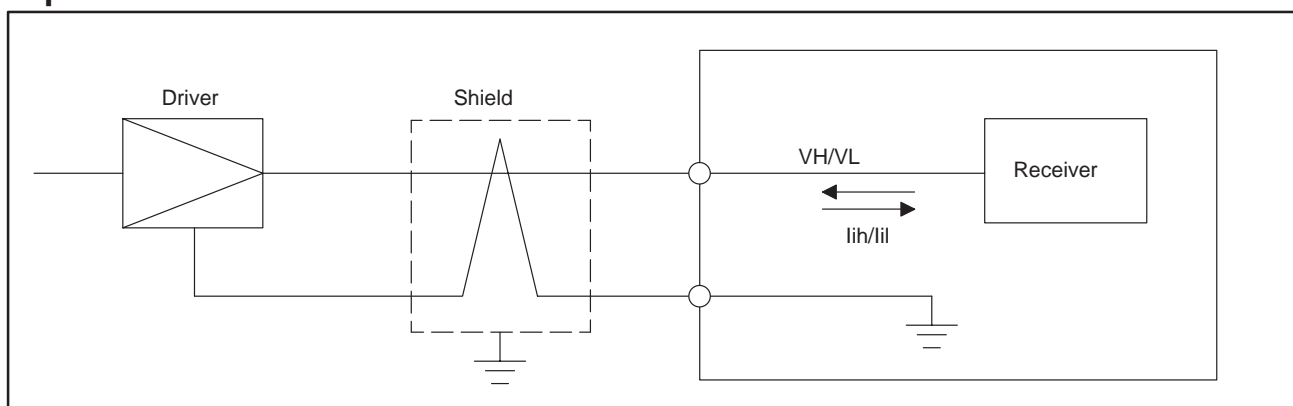
- 1 Use cable 2 (with a shield on the outside) for Cable K21.
- 2 Use wire having a size of 7/0.18 (0.18mm<sup>2</sup>) for 0V, +24V, and DIC.
- 3 Keep open all pins not shown above.
- 4 The above diagram is an example of a configuration with 0V common. For a configuration with 24V common, connect DIC (JA35-11) to +24V (JA35-10, 19), and the stage ahead of each switch to 0V (JA35-12, 14, 16). Note that only the 0V common configuration can be used for the emergency stop signal (JA35-5, \*ESP).

## 7.4 HIGH-SPEED SKIP SIGNAL INTERFACE



### 7.4.1 High-Speed Skip Signal Input Specification

(1) Circuit configuration



(2) Absolute maximum rating

Input voltage range  $V_{in}$ :  $-3.6V$  to  $+13.6V$

(3) Input characteristics

Item	Symbol	Rating	Unit	Remark
High-level input voltage	VH	3.6 to 11.6	V	
Low-level input voltage	VL	0 to 1.0	V	
High-level input current	lih	0.5 max	mA	$V_{in}=5V$
		9.3 max	mA	$V_{in}=10V$
Low-level input current	lil	-8.0 max	mA	$V_{in}=0V$

#### NOTE

- For lih and lil, the plus algebraic sign indicates the current that flows into the receiver, while the minus algebraic sign indicates the current that flows out from the receiver.
- If the input voltage of the high-speed skip signal is at a low level, the signal is logical 1, while the voltage is at a high, the signal is logical 0.

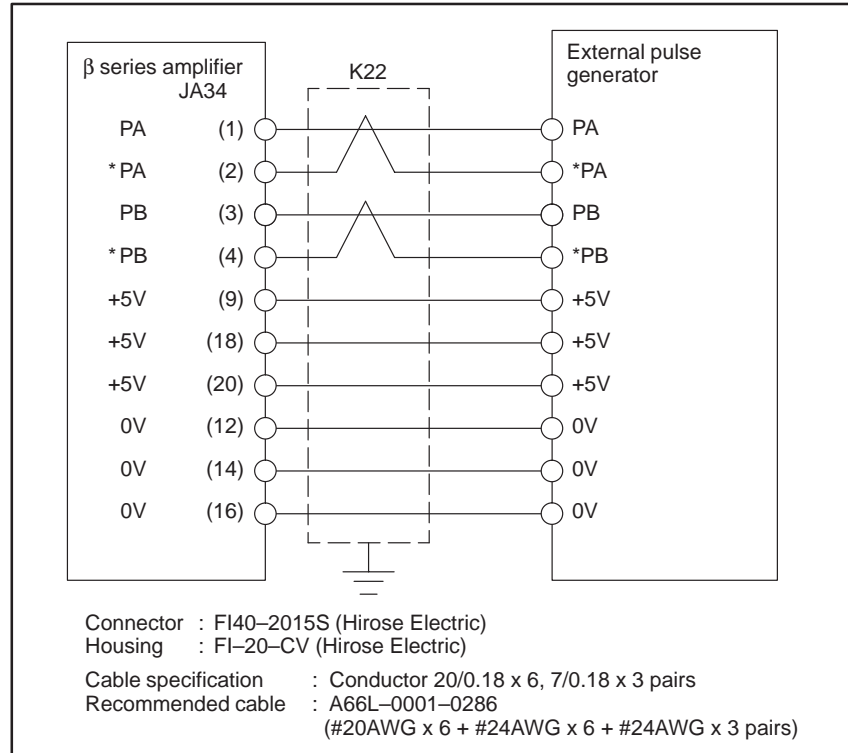
# 8

## EXTERNAL PULSE INPUT (ONLY FOR I/O LINK INTERFACE)



## 8.1 EXTERNAL PULSE INPUT INTERFACE

### 8.1.1 Detailed Descriptions about Cable K22 Connection



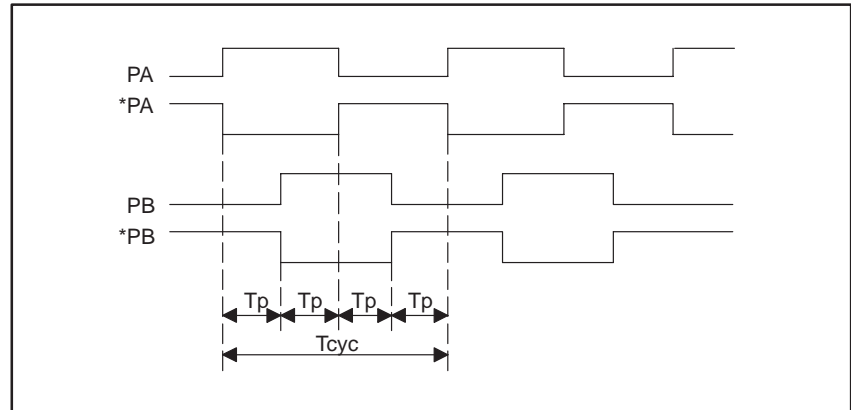
#### NOTE

- 1 The servo unit can supply power to a unit requiring up to +5V, 0.35A. In this case, consider the power supply voltage drop across the cable resistance.
- 2 Use the same twisted wire pair for the PA and \*PA signals. Also use the same twisted wire pair for the PB and \*PB signals.
- 3 Keep open all pins not shown above.
- 4 Maximum wire length: 50m

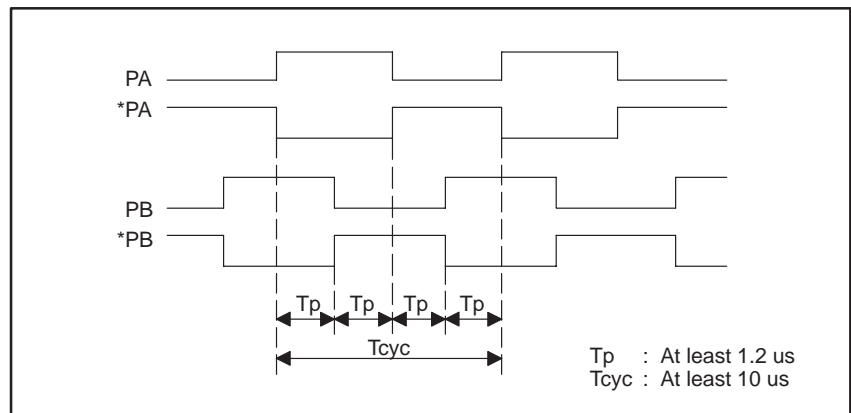
(a) Operating conditions

The maximum allowable frequency for the input signals is 100 kHz.

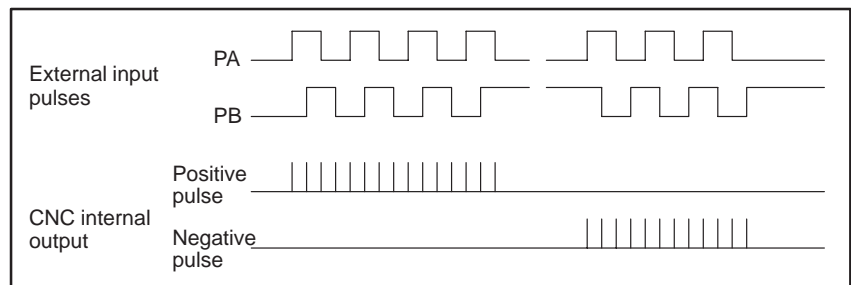
1) Positive movement command pulse



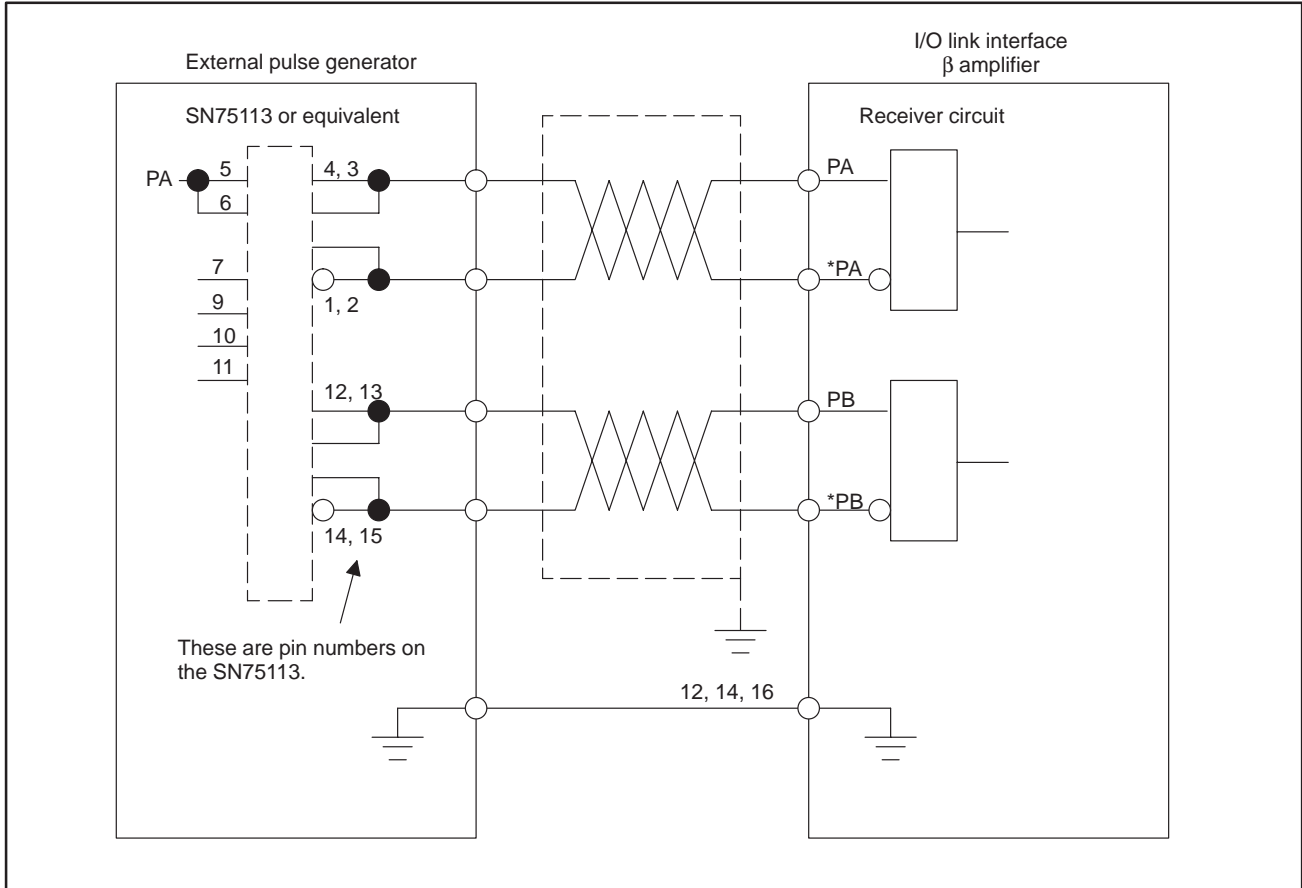
2) Negative movement command pulse



3) Sequence



(b) Example of a recommended circuit

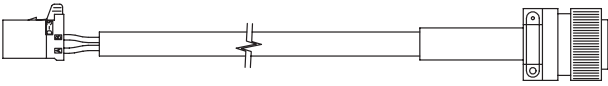
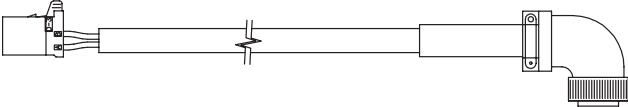
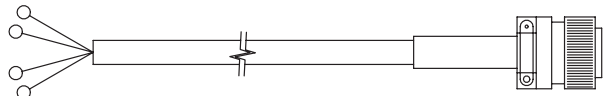
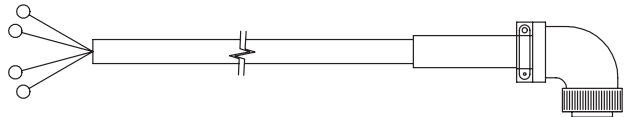
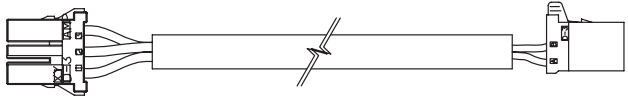
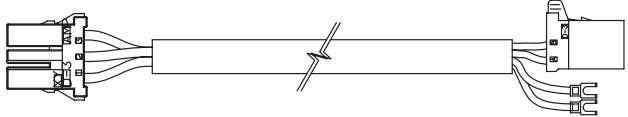
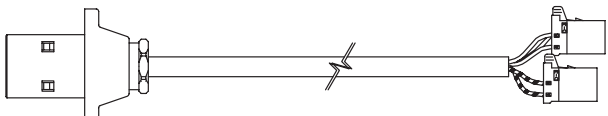


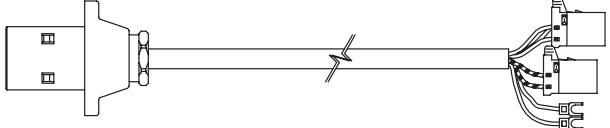

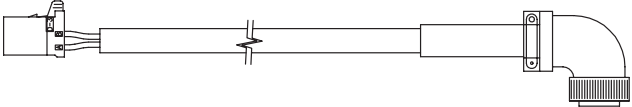
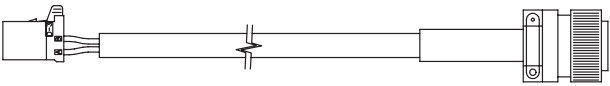

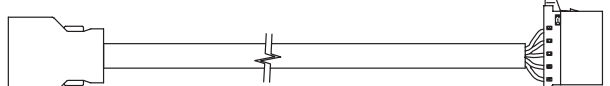
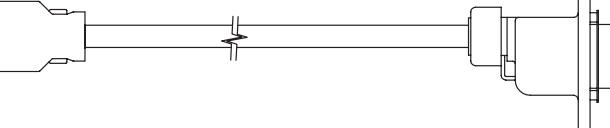
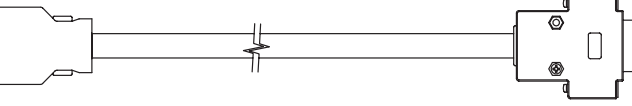
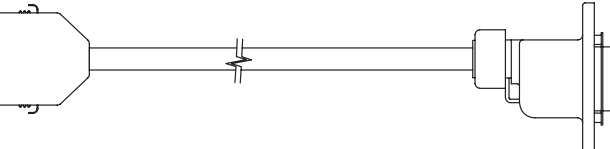


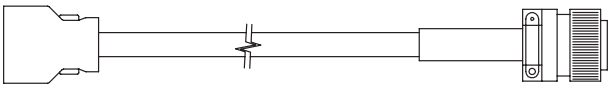
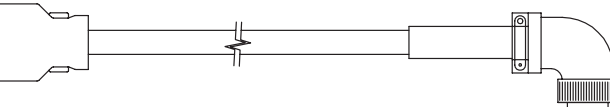


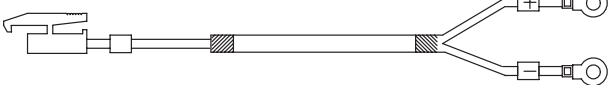
# 9 CABLE SPECIFICATIONS

The cables used with the FANUC AC servo motor  $\beta$  series and FANUC control motor amplifier  $\beta$  series are listed on the subsequent pages.

See Chapter 1 of this Part for the cable numbers at the left end.

Cable Number	Use	Specification	Designation (Length)
K3	$\beta$ series amp./ $\beta$ 1 to $\beta$ 6 Power line cable Straight type TUV approval connector VDE conformity cable		A06B-6093-K802 (Length 14m)
K3	$\beta$ series amp./ $\beta$ 1 to $\beta$ 6 Power line cable Elbow type TUV approval connector VDE conformity cable		A06B-6093-K801 (Length 14m)
	Servo amp./ $\beta$ 1 to $\beta$ 6 Power line cable Straight type TUV approval connector VDE conformity cable		A06B-6079-K800 (Length 14m)
	Servo amp./ $\beta$ 1 to $\beta$ 6 Power line cable Elbow type TUV approval connector VDE conformity cable		A06B-6079-K801 (Length 14m)
K3	$\beta$ series amp./ $\beta$ 0.5/3000 Power line cable TUV approval connector VDE conformity cable		A06B-6093-K803 (Length 14m)
K3	$\beta$ series amp./ $\beta$ 0.5/3000 Power line cable With brake TUV approval connector VDE conformity cable		A06B-6093-K804 (Length 14m)
K3	$\beta$ series amp./ $\alpha$ 1 to $\alpha$ 2.5 Power line cable TUV approval connector VDE conformity cable		A06B-6093-K805 (Length 14m)

Cable Number	Use	Specification	Designation (Length)
K3	$\beta$ series amp./ $\alpha 1$ to $\alpha 2.5$ Power line cable With brake TUV approval connector VDE conformity cable		A06B-6093-K806 (Length 14m)
K3	$\beta$ series amp./ $\alpha C3$ to $\alpha C6$ Power line cable Straight type TUV approval connector VDE conformity cable		A06B-6093-K802 (Length 14m)
K3	$\beta$ series amp./ $\alpha C3$ to $\alpha C6$ Power line cable Elbow type TUV approval connector VDE conformity cable		A06B-6093-K801 (Length 14m)
K3	$\beta$ series amp./ $\alpha C12$ Power line cable Straight type TUV approval connector VDE conformity cable		A06B-6093-K808 (Length 14m)
K3	$\beta$ series amp./ $\alpha C12$ Power line cable Elbow type TUV approval connector VDE conformity cable		A06B-6093-K807 (Length 14m)
K12	For $\beta 0.5$ Signal line cable TYPE A/B interface		A02B-0200-K802 (Length 14m)
K12	For $\alpha 1$ to $\alpha 2.5$ , $\beta 1$ to $\beta 6$ Signal line cable Waterproof TYPE A/B interface		A06B-6050-K853 (Length 14m)
K12	For $\alpha 1$ to $\alpha 2.5$ , $\beta 1$ to $\beta 6$ Signal line cable Non-waterproof TYPE A/B interface		A06B-6050-K856 (Length 14m)
K12	For $\alpha 1$ to $\alpha 2.5$ , $\beta 1$ to $\beta 6$ Signal line cable Waterproof Connect FS-0C, FS-15A		A06B-6050-K854 (Length 14m)

Cable Number	Use	Specification	Designation (Length)
K12	For $\alpha$ C3 to $\alpha$ C12 Signal line cable Straight type TYPE A/B interface		A02B-0200-K800 (Length 14m)
K12	For $\alpha$ C3 to $\alpha$ C12 Signal line cable Elbow type TYPE A/B interface		A02B-0200-K801 (Length 14m)
K1	CNC/ $\beta$ series amp. Command signal line cable TYPE B interface		A02B-0120-K800 (Length 5m)
K20	CNC/ $\beta$ series amp. Interface Connector line cable I/O Link interface		A02B-0124-K820 (Length 1m) A03B-0807-K801 (Length 5m) A03B-0807-K802 (Length 10m)
	BATTERY/ $\beta$ series amp. Battery cable		A06B-6093-K810 (Length 5m)

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Revision Record

FANUC SERVO MOTOR  $\beta$  series DESCRIPTIONS (B-65232EN)

Edition	Date	Contents	Edition	Date	Contents	
02	Aug., '97	<ul style="list-style-type: none"><li>• Addition of model <math>\beta</math>0.5</li><li>• Addition of <math>\beta</math> series amplifier for I/O Link option</li></ul>				
01	Mar., '96	_____				

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