



# *GE Fanuc Automation*

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*Computer Numerical Control Products*

*$\alpha$  Series AC Servo Motor*

*Descriptions Manual*

GFZ-65142E/02

March 1995

## *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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## PREFACE

This manual describes the specifications and characteristics of the  $\alpha$  series servo motors. The manual consists of the following chapters:

### **I. SPECIFICATIONS FOR THE $\alpha$ series**

This chapter provides general notes on the use of the  $\alpha$  series and explains how to select the optimum motor for a given application. This chapter also provides the specifications common to each model of the  $\alpha$  series, concerning the detectors, internal brakes, plug connectors, and so forth.

### **II. FANUC AC SERVO MOTOR $\alpha$ series**

This chapter explains how to specify a certain  $\alpha$  series servo motor and provides specifications, dimensions, and data sheets for the entire range of  $\alpha$  series servo motors.

### **III. FANUC AC SERVO MOTOR $\alpha$ (HV) series**

This chapter explains how to specify a certain  $\alpha$ (HV) series servo motor and provides specifications, dimensions, and data sheets for the entire range of  $\alpha$ (HV) series servo motors.

### **IV. FANUC AC SERVO MOTOR $\alpha$ C series**

This chapter explains how to specify a certain  $\alpha$ C series servo motor and provides specifications, dimensions, and data sheets for the entire range of  $\alpha$ C series servo motors.

### **V. FANUC AC SERVO MOTOR $\alpha$ M series**

This chapter explains how to specify a certain  $\alpha$ M series servo motor and provides specifications, dimensions, and data sheets for the entire range of  $\alpha$ M series servo motors.

### **VI. FANUC AC SERVO MOTOR $\alpha$ L series**

This chapter explains how to specify a certain  $\alpha$ L series servo motor and provides specifications, dimensions, and data sheets for the entire range of  $\alpha$ L series servo motors.

Although this manual provides information on detector signal outputs, it does not describe connection to a servo amplifier or NC. For details of these connections, refer to the "FANUC CONTROL MOTOR  $\alpha$  series Maintenance Manual" (B-65165E).

**Related manuals**

The following six kinds of manuals are available for FANUC CONTROL MOTOR  $\alpha$  series. In the table, this manual is marked with an asterisk (\*).

Document name	Document number	Major contents	Major usage	
FANUC AC SERVO MOTOR $\alpha$ series DESCRIPTIONS	B-65142E	<ul style="list-style-type: none"> <li>● Specification</li> <li>● Characteristics</li> <li>● External dimensions</li> <li>● Connections</li> </ul>	<ul style="list-style-type: none"> <li>● Selection of motor</li> <li>● Connection of motor</li> </ul>	*
FANUC AC SPINDLE MOTOR $\alpha$ series DESCRIPTIONS	B-65152E	<ul style="list-style-type: none"> <li>● Specification</li> <li>● Characteristics</li> <li>● External dimensions</li> <li>● Connections</li> </ul>		
FANUC CONTROL MOTOR AMPLIFIER $\alpha$ series DESCRIPTIONS	B-65162E	<ul style="list-style-type: none"> <li>● Specifications and functions</li> <li>● Installation</li> <li>● External dimensions and maintenance area</li> <li>● Connections</li> </ul>	<ul style="list-style-type: none"> <li>● Selection of amplifier</li> <li>● Connection of amplifier</li> </ul>	
FANUC CONTROL MOTOR $\alpha$ series MAINTENANCE MANUAL	B-65165E	<ul style="list-style-type: none"> <li>● Start up procedure</li> <li>● Troubleshooting</li> <li>● Maintenance of motor</li> </ul>	<ul style="list-style-type: none"> <li>● Start up the system (Hardware)</li> <li>● Troubleshooting</li> <li>● Maintenance of motor</li> </ul>	
FANUC AC SERVO MOTOR $\alpha$ series PARAMETER MANUAL	B-65150E	<ul style="list-style-type: none"> <li>● Initial setting</li> <li>● Setting parameters</li> <li>● Description of parameters</li> </ul>	<ul style="list-style-type: none"> <li>● Start up the system (Software)</li> <li>● Tuning the system (Parameters)</li> </ul>	
FANUC AC SPINDLE MOTOR $\alpha$ series PARAMETER MANUAL	B-65160E	<ul style="list-style-type: none"> <li>● Initial setting</li> <li>● Setting parameters</li> <li>● Description of parameters</li> </ul>		

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## **I. DESCRIPTIONS FOR THE $\alpha$ series**



# 1

## GENERAL

The FANUC AC servo motor  $\alpha$  series has been designed for machine tool feed axis applications. This servo motor  $\alpha$  series has the following features:

### Smooth rotation

The special magnetic pole shape minimizes torque ripples which, when combined with precise current control and accurate pulse coder feedback, enables extremely smooth motor rotation.

### Excellent acceleration

The use of a special rotor shape results in motors that are smaller and lighter than previous models, but which can develop a high level of torque. These motors, therefore, provide excellent acceleration characteristics.

### High reliability

A totally-enclosed, friction-free brushless design is used. This allows the servo motors to be used in demanding environments with no need for special checks or maintenance.

### Built-in, high-precision detector

A low-indexing-error optical encoder (pulse coder) is built into the motors. This pulse coder enables precise positioning.

Pulse coders that output 8,192, 65,536, or 1,000,000 pulses per rotation are available. As such, the  $\alpha$  series motors can be used for positioning applications ranging from simple positioning to those requiring a high degree of precision. (Available pulse coders vary with the series and model of the motor being used.)

The FANUC AC servo motor  $\alpha$  series consists of the  $\alpha$ ,  $\alpha C$ ,  $\alpha M$ , and  $\alpha(HV)$  series, all of which are suitable general machine tool, control applications, and the  $\alpha L$  series, designed for controlling machine tools that require frequent positioning operations, such as punch presses and PCB drilling machines.

Each of these series is further divided into the following models:

- **$\alpha$  series**  
 $\alpha 0.5/3000$ ,  $\alpha 1/3000$ ,  $\alpha 2/2000$ ,  $\alpha 2/3000$ ,  $\alpha 3/3000$ ,  $\alpha 6/2000$ ,  
 $\alpha 6/3000$ ,  $\alpha 12/2000$ ,  $\alpha 12/3000$ ,  $\alpha 22/1500$ ,  $\alpha 22/2000$ ,  $\alpha 22/3000$ ,  
 $\alpha 30/1200$ ,  $\alpha 30/2000$ ,  $\alpha 30/3000$ ,  $\alpha 40/2000$ ,  $\alpha 40/2000$  (with fan),  
 $\alpha 65/2000$ ,  $\alpha 100/2000$ ,  $\alpha 150/2000$
- **$\alpha(HV)$  series**  
 $\alpha 3/3000HV$ ,  $\alpha 6/3000HV$ ,  $\alpha 12/3000HV$ ,  $\alpha 22/3000HV$ ,  $\alpha 30/3000HV$
- **$\alpha C$  series**  
 $\alpha C3/2000$ ,  $\alpha C6/2000$ ,  $\alpha C12/2000$ ,  $\alpha C22/1500$
- **$\alpha M$  series**  
 $\alpha M3/3000$ ,  $\alpha M6/3000$ ,  $\alpha M9/3000$
- **$\alpha L$  series**  
 $\alpha L3/3000$ ,  $\alpha L6/3000$ ,  $\alpha L9/3000$ ,  $\alpha L25/3000$ ,  $\alpha L50/2000$

# 2 PRECAUTIONS ON USE



## 2.1 APPLICABLE AMPLIFIERS

The FANUC  $\alpha$  series AC servo motors can be driven using FANUC  $\alpha$  series controller amplifiers.

Motor model	Servo amplifier module (SVM)/ Servo amplifier unit (SVU)			
	Model name	Specification	Connection axis	
$\alpha$ 0.5/3000 $\alpha$ 1/3000 $\alpha$ 2/2000 $\alpha$ 2/3000	SVM1-12	A06-6079-H101		
	SVM2-12/12 SVM2-12/20 SVM2-12/40	A06B-6079-H201 A06B-6079-H202 A06B-6079-H204	L and M axes L axis L axis	
	SVM3-12/12/12 SVM3-12/12/20 SVM3-12/20/20 SVM3-12/12/40 SVM3-12/20/40	A06B-6079-H301 A06B-6080-H301 (Note 3) A06B-6079-H302 A06B-6080-H302 (Note 3) A06B-6079-H303 A06B-6080-H303 (Note 3) A06B-6079-H305 A06B-6080-H305 (Note 3) A06B-6079-H306 A06B-6080-H306 (Note 3)	L, M and N axes L and M axes L axis L and M axes L axis	
	SVU1-12	A06B-6089-H101		
	SVU2-12/12 SVU2-12/20 SVU2-12/40	A06B-6089-H201 A06B-6089-H202 A06B-6089-H204	L and M axes L axis L axis	
	$\alpha$ C3/2000 $\alpha$ C6/2000 $\alpha$ C12/2000	SVM1-20	A06B-6079-H102	
		SVM2-12/20 SVM2-20/20 SVM2-20/40	A06B-6079-H202 A06B-6079-H203 A06B-6079-H205	M axis L and M axes L axis
		SVM3-12/12/20 SVM3-12/20/20 SVM3-20/20/20 SVM3-12/20/40 SVM3-20/20/40	A06B-6079-H302 A06B-6080-H302 (Note 3) A06B-6079-H303 A06B-6080-H303 (Note 3) A06B-6079-H304 A06B-6080-H304 (Note 3) A06B-6079-H306 A06B-6080-H306 (Note 3) A06B-6079-H307 A06B-6080-H307 (Note 3)	N axis M and N axes L, M and N axes M axis L and M axes
		SVU1-20	A06B-6089-H102	
		SVU2-12/20 SVU2-20/20 SVU2-20/40	A06B-6089-H202 A06B-6089-H203 A06B-6089-H205	M axis L and M axes L axis

Motor model	Servo amplifier module (SVM)/ Servo amplifier unit (SVU)		
	Model name	Specification	Connection axis
$\alpha$ 3/3000 $\alpha$ 6/2000 $\alpha$ M3/3000 $\alpha$ L3/3000	SVM1-40S	A06B-6079-H103	
	SVM1-40L	A06B-6079-H104	
	SVM2-12/40	A06B-6079-H204	M axis
	SVM2-20/40	A06B-6079-H205	M axis
	SVM2-40/40	A06B-6079-H206	L and M axes
	SVM2-40/80	A06B-6079-H207	L axis
	SVM2-40L/40L	A06B-6079-H209	L and M axes
	SVM3-12/12/40	A06B-6079-H305	N axis
	SVM3-12/20/40	A06B-6080-H305 (Note 3) A06B-6079-H306	N axis
	SVM3-20/20/40	A06B-6080-H306 (Note 3) A06B-6079-H307 A06B-6080-H307 (Note 3)	N axis
	SVU1-40	A06B-6089-H104	
	SVU2-12/40 SVU2-20/40 SVU2-40/40 SVU2-40/80	A06B-6089-H204 A06B-6089-H205 A06B-6089-H206 A06B-6089-H207	M axis M axis L and M axes L axis
$\alpha$ 12/2000 $\alpha$ C22/1500 (The SVU2 is unapplicable to the $\alpha$ C22/1500.)	SVM1-40L	A06B-6079-H104	
	SVM2-12/40	A06B-6079-H204	M axis
	SVM2-20/40	A06B-6079-H205	M axis
	SVM2-40/40	A06B-6079-H206	L and M axes
	SVM2-40/80	A06B-6079-H207	L axis
	SVM2-40L/40L	A06B-6079-H209	L and M axes
	SVM3-12/12/40	A06B-6079-H305	N axis
	SVM3-12/20/40	A06B-6080-H305 (Note 3) A06B-6079-H306	N axis
	SVM3-20/20/40	A06B-6080-H306 (Note 3) A06B-6079-H307 A06B-6080-H307 (Note 3)	N axis
	SVU1-40	A06B-6089-H104	
	SVU2-12/40 SVU2-20/40 SVU2-40/40 SVU2-40/80	A06B-6089-H204 A06B-6089-H205 A06B-6089-H206 A06B-6089-H207	M axis M axis L and M axes L axis
	$\alpha$ 22/1500	SVM1-40L	A06B-6079-H104
SVM2-40/80 SVM2-40L/40L		A06B-6079-H207 A06B-6079-H209	L axis L and M axes
SVU1-40		A06B-6089-H104	

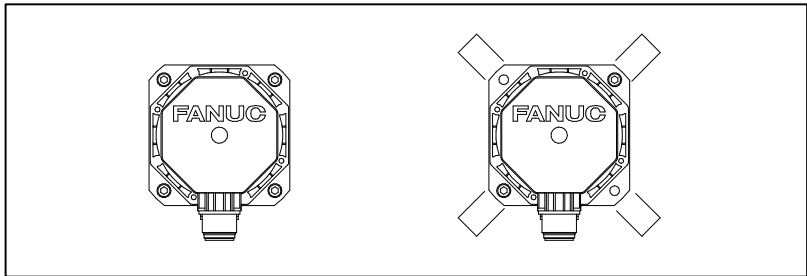
Motor model	Servo amplifier module (SVM)/ Servo amplifier unit (SVU)			
	Model name	Specification	Connection axis	
$\alpha$ 6/3000 $\alpha$ M6/3000 $\alpha$ L6/3000	SVM1-80	A06B-6079-H105		
	SVM2-40/80 SVM2-80/80	A06B-6079-H207 A06B-6079-H208	M axis L and M axes	
	SVU1-40	A06B-6089-H104		
	SVU2-40/80 SVU2-80/80 SVU2-12/80 SVU2-20/80	A06B-6089-H207 A06B-6089-H208 A06B-6089-H209 A06B-6089-H210	M axis L and M axes M axis M axis	
	$\alpha$ 12/3000 $\alpha$ 22/2000 $\alpha$ 30/1200 $\alpha$ M9/3000 $\alpha$ L9/3000	SVM1-80	A06B-6079-H105	
		SVM2-40/80 SVM2-80/80	A06B-6079-H207 A06B-6079-H208	M axis L and M axes
		SVU1-80	A06B-6089-H105	
$\alpha$ 30/2000 $\alpha$ 40/2000	SVM1-130	A06B-6079-H106		
	SVU1-130	A06B-6089-H106		
$\alpha$ 22/3000 $\alpha$ 30/3000 $\alpha$ 40/2000 (with FAN) $\alpha$ L25/3000 $\alpha$ L50/2000	SVM1-130	A06B-6079-H106 (Note 4)		
	SVU1-130	A06B-6089-H106 (Note 4)		

**Notes**

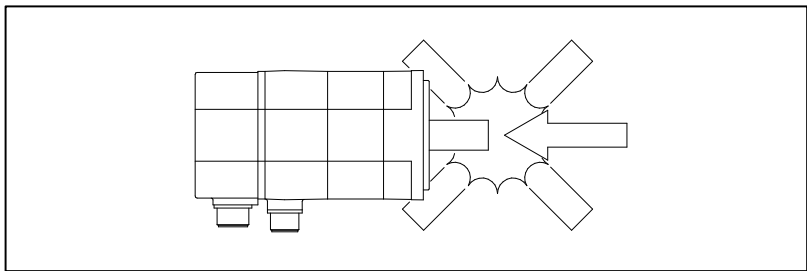
1. If a motor is used in a combination other than those listed above, it will be broken, except for the C series servo amplifier. Contact FANUC for more information.
2. For details of the  $\alpha$  series control motor amplifiers, refer to "FANUC Control Motor Amplifier  $\alpha$  series Descriptions" (B-65162E).
3. The specification of the  $\alpha$  series servo amplifier modules for three axes (SVM3) varies from one NC to another. Refer to "FANUC Control Motor Amplifier  $\alpha$  series Descriptions" (B-65162E).
4. When the SVM-130 is used to drive the  $\alpha$ 22/3000,  $\alpha$ 30/3000,  $\alpha$ 40/2000 (with fan),  $\alpha$ L25/3000, or  $\alpha$ L50/2000, it must be cooled by a forced air flow. For details, refer to "FANUC Control Motor Amplifier  $\alpha$  series Descriptions" (B-65162E).

## 2.2 INSTALLATION

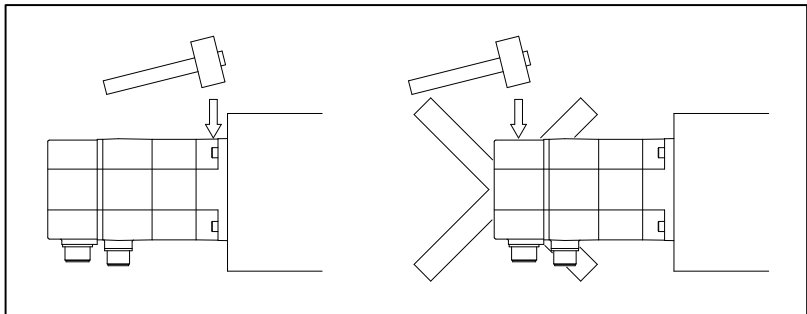
- The servo motor contains a precision detector, and is carefully machined and assembled to provide the required precision. Pay attention to the following items to maintain the precision and prevent damage to the detector.



- Secure the servo motor uniformly using four bolt holes provided on the front flange.
- When mounting on the machine, take care not to apply a shock to the motor.



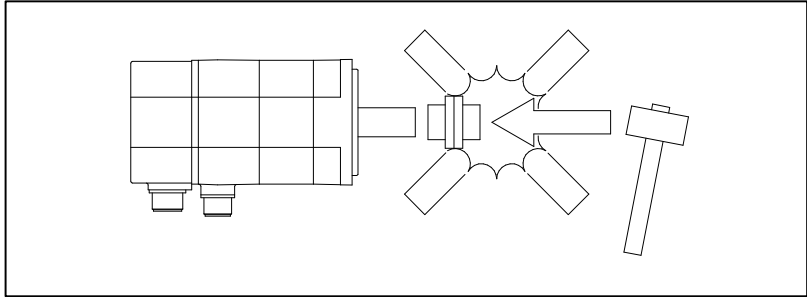
- When it is unavoidable to tap the motor for adjusting the position, etc., use a plastic hammer and tap only the front flange if possible.



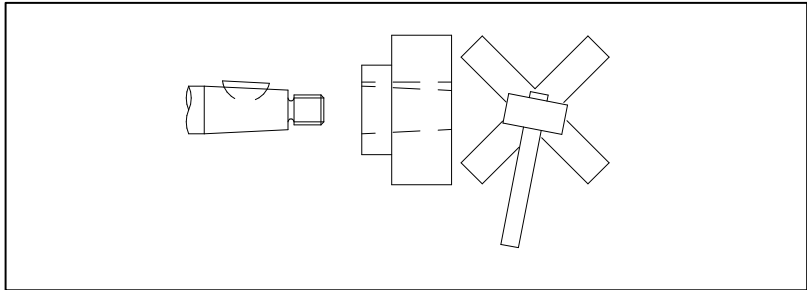
## 2.3 COUPLING

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

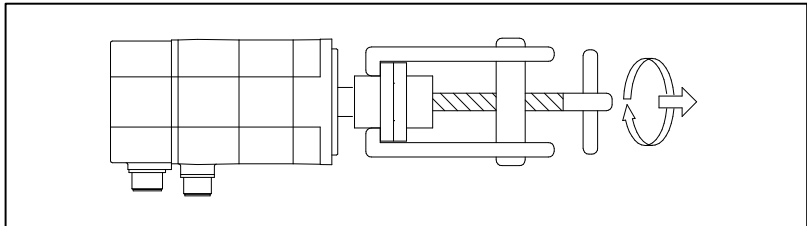
- When connecting the power transmission elements such as a gear, a pulley and a coupling to the shaft, take care not to apply a shock to the shaft.



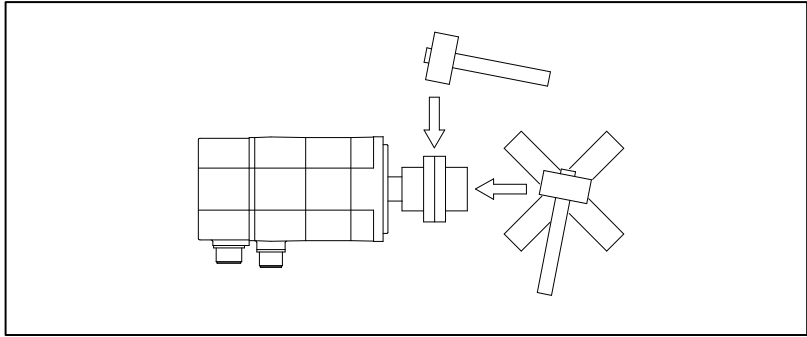
- Generally, in the case of straight shaft, use a span ring for connection with the shaft.
- In the case of tapered shaft, match the tapered surface with the power transmission element and fix by tightening the screw at the end. When the woodruff key is too tight, don't tap it with a hammer. Use the woodruff key mainly for positioning, and use the tapered surface for torque transmission. Machine the tapered surface of the power transmission element so that over 70% of the whole surface is contacted.



- 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  $\alpha 3/6/12/22/30/40$ ,  $\alpha 3/6/12/22/30HV$ ,  $\alpha C3/6/12/22$ ,  $\alpha M3/6/9$ , and  $\alpha L3/6/9$ .

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)
$\alpha$ 0.5	20kg	5kg	6902
$\alpha$ 1/2	25kg	8kg	6003
$\alpha$ 3/6 $\alpha$ 3/6HV $\alpha$ C3/6 $\alpha$ M3/6/9 $\alpha$ L3/6/9	70kg	20kg	6205
$\alpha$ 12/22/30/40 $\alpha$ 12/22/30HV $\alpha$ C12/22 $\alpha$ L25/50	450kg	135kg	6208
$\alpha$ 65/100/150	900kg	250kg	6312

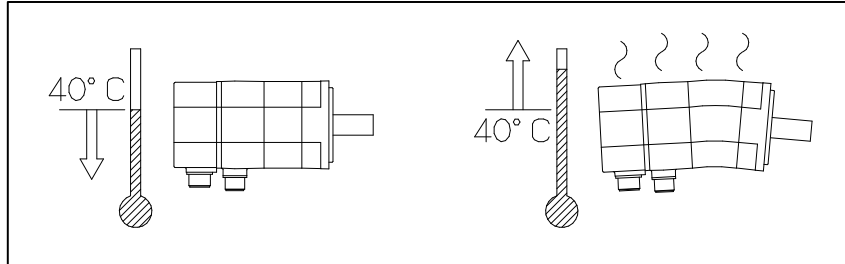
The above values are the reference assuming the use as a feed axis on the typical machine tool.

- 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  $\alpha$ 3 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 40°C or less. 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°C.)



### Vibration

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

### Installation height

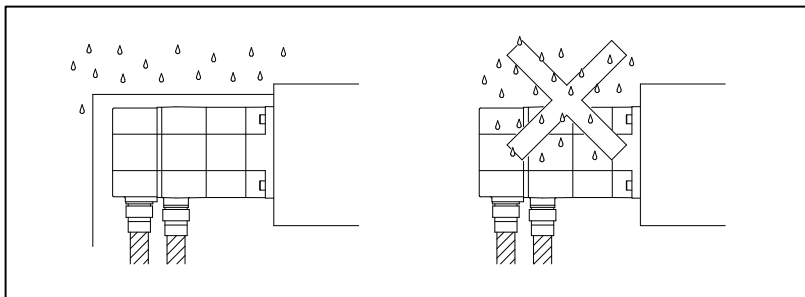
Up to 1,000 meters above the sea level requires, no particular provision for attitude. When operating the machine at a higher level, special care is unnecessary if the ambient temperature is lowered 1°C at every 100m higher than 1,000m. For example, when the machine is installed at a place of 1,500 meters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

If any one of the three environmental conditions specified above is not satisfied, the output must be restricted.

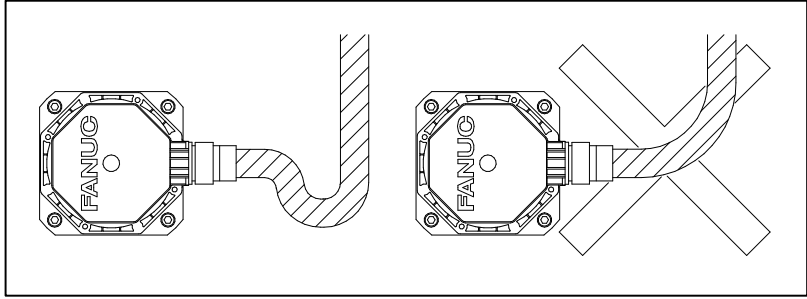
### Drip-proof environment

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)(except the connectors of the  $\alpha 0.5$ ). (The  $\alpha 65$  to  $\alpha 150$  use the terminal box specification, thus IP54 applies to these motors.) These standards, however, refer only to short-term performance. In actual operation, note also the following:

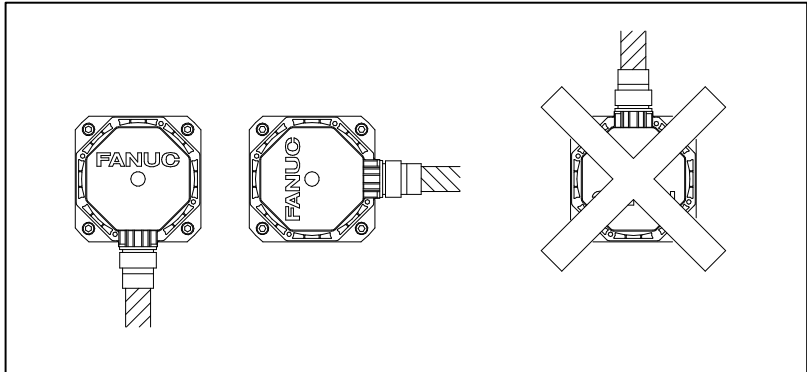
- Protect the motor surface from the cutting fluid or lubricant. Use a cover when there is a possibility of wetting the motor surface. Only the telescopic cover of the sliding part can not completely prevent leakage of the cutting fluid. Pay attention to the drop along the structure body, too.



- 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.)



### Shaft attachment section requirements

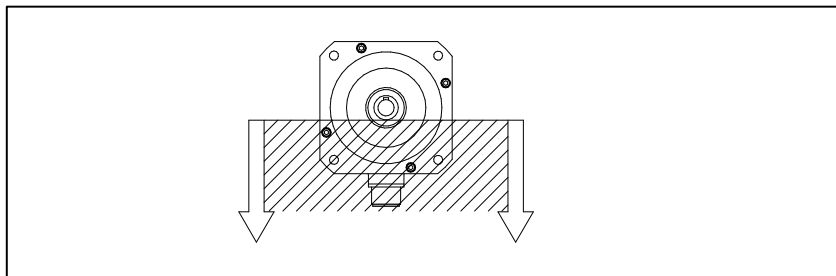
The motor shaft is sealed to prevent penetration of oil into the motor housing. However, sealing may not be perfect under severe working conditions. Observe the following points.

To maintain a constant sealing effect, it is necessary to replace the oil seal regularly before its lifetime expires. The lifetime of the oil seal greatly varies with its working environment and conditions.

When oil bath lubrication is provided for the gear engagement, for example, the oil level must be below the lip of the shaft's 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 is as shown below.

Motor mode	Oil seal diameter
$\alpha 0.5$	$\phi 9\text{mm}$
$\alpha 1/2$	$\phi 15\text{mm}$
$\alpha 3/6$ $\alpha 3/6\text{HV}$ $\alpha \text{C}3/6$ $\alpha \text{M}3/6/9$ $\alpha \text{L}3/6/9$	$\phi 24\text{mm}$
$\alpha 12/22/30/40$ $\alpha 12/22/30\text{HV}$ $\alpha \text{C}12/22$ $\alpha \text{L}25/50$	$\phi 35\text{mm}$
$\alpha 65/100/150$	$\phi 55\text{mm}$

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

# 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.

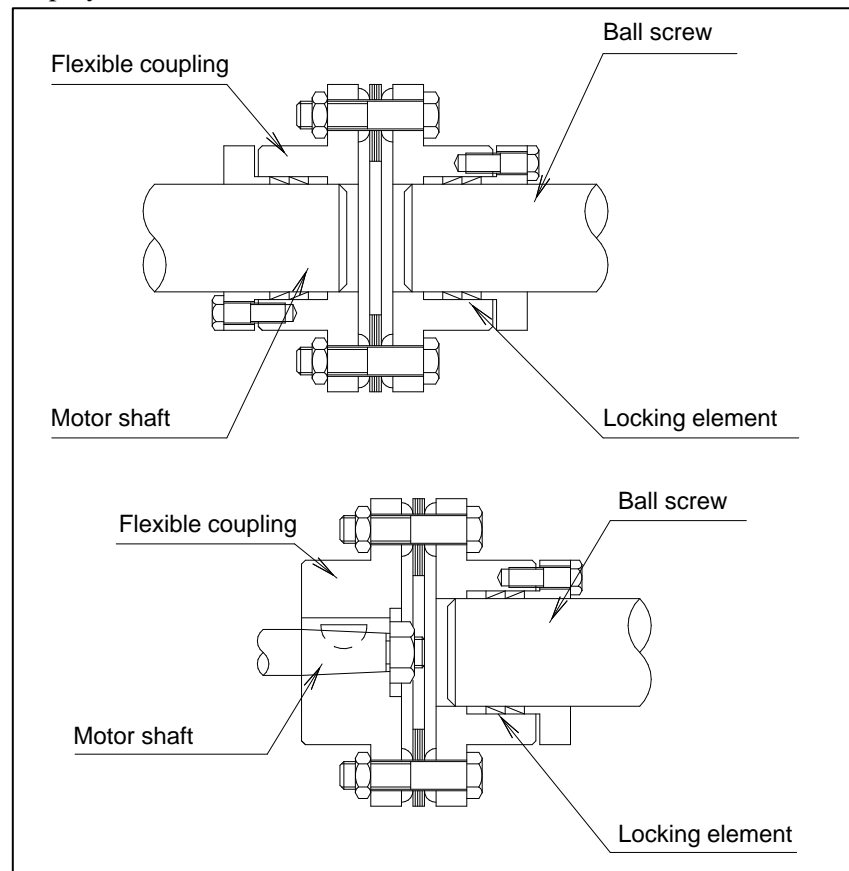
However, this method has the following disadvantages:

- 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.
- When the machine is operation is characterized by repeated acceleration/deceleration cycles, a heating problem may occur due to the current flow caused by the acceleration and deceleration. Should this occur, the machine travel distance per motor shaft revolution should be modified. Given optimum conditions, the machine travel distance per motor shaft revolution is set such that the motor's rotor inertia equals the load inertia based on motor shaft conversion. For machines such as punch presses and PCB drilling machines, the machine's travel distance per motor shaft revolution should be set so as to satisfy this optimum condition as far as possible, while also considering the rapid traverse rate and increment system.

# 4

## SELECTING A MOTOR

When selecting an applicable motor, the load, rapid traverse 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 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.**

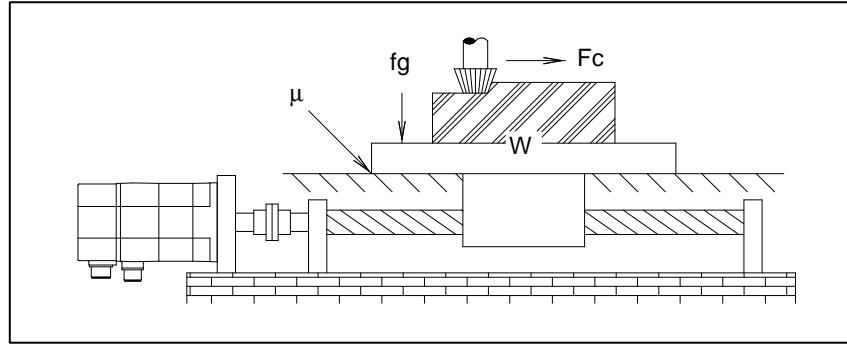
### Condition 5

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

The procedure for selecting a motor is described below:

## 4.1 CALCULATING CONDITIONS FOR SELECTING A MOTOR

This section describes the procedure for selecting a servo motor best suited for a table with a horizontal axis (figure below).



### Sample mechanical specifications of the table and workpiece

- $W$  : Weight of movable parts (table and workpiece) (kgf) = 1000 (kgf)  
 $\mu$  : Friction coefficient of the sliding surface = 0.05  
 $\pi$  : Efficiency of the driving system (including a ball screw) = 0.9  
 $fg$  : Gib fastening force (kgf) = 50 (kgf)  
 $F_c$  : Thrust counter force caused by the cutting force (kgf) = 100 (kgf)  
 $F_{cf}$  : Force by which the table is pressed against the sliding surface, caused by the moment of cutting force (kgf) = 30 (kgf)  
 $Z_1/Z_2$  : Gear reduction ratio = 1/1

### Sample specifications of the feed screw (ball screw)

- $D_b$  : Shaft diameter = 32 (mm)  
 $L_b$  : Shaft length = 1000 (mm)  
 $P$  : Pitch = 8 (mm)

### Sample specifications of the operation of the motor shaft

- $T_a$  : Acceleration torque (kgf·cm)  
 $V_m$  : Motor speed in rapid traverse ( $\text{min}^{-1}$ ) = 3000 ( $\text{min}^{-1}$ )  
 $t_a$  : Acceleration time (s) = 0.10 (s)  
 $J_M$  : Motor inertia ( $\text{kgf}\cdot\text{cm}\cdot\text{sec}^2$ )  
 $J_L$  : Load inertia ( $\text{kgf}\cdot\text{cm}\cdot\text{sec}^2$ )  
 $k_s$  : Servo position loop gain ( $\text{sec}^{-1}$ ) = 30 ( $\text{sec}^{-1}$ )

### 4.1.1 Calculating the Load Torque and Load Inertia

#### Calculating the load torque

The load torque applied to the motor shaft is generally given by the following equation:

$$T_m = \frac{F \times L}{2\pi\eta} + T_f$$

$T_m$  : Load torque applied to the motor shaft (Nm)

$F$  : Force required to move a movable part (table or tool post) along the axis (kgf)

$L$  : Traveling distance of the machine tool per revolution of the motor =  $P \times (Z1/Z2) = 8$  (mm)

$T_f$  : Friction torque of the nut of the ball screw or bearing applied to the motor shaft = 2 (Nm)

$F$  depends on the weight of the table, friction coefficient, whether cutting is in progress, and whether the axis is horizontal or vertical. If the axis is vertical,  $F$  also depends on the presence of a counterbalance. For a table with a horizontal axis,  $F$  is calculated as follows:

When cutting is not executed:

$$F = \mu (W + fg)$$

Example)

$$F = 0.05 \times (1000 + 50) = 52.5 \text{ (kgf)}$$

$$T_m = (52.5 \times 0.8)/(2 \times \mu \times 0.9) + 2 = 9.4 \text{ (kgf}\cdot\text{cm)} = 0.9 \text{ (Nm)}$$

When cutting is in progress:

$$F = F_c + \mu (W + fg + F_c f)$$

Example)

$$F = 100 + 0.05 \times (1000 + 50 + 30) = 154 \text{ (kgf)}$$

$$T_{mc} = (154 \times 0.8)/(2 \times \mu \times 0.9) + 2 = 21.8 \text{ (kgf}\cdot\text{cm)} = 2.1 \text{ (Nm)}$$

To satisfy condition 1, check the data sheet and select a motor whose load torque (rated torque at stall) when cutting is not executed is 0.9 (Nm) or higher and the maximum speed is 3000 ( $\text{min}^{-1}$ ) or higher. Considering the acceleration/deceleration conditions, provisionally select  $\alpha 2/3000$  (rated torque at stall is 2.0 (Nm)).

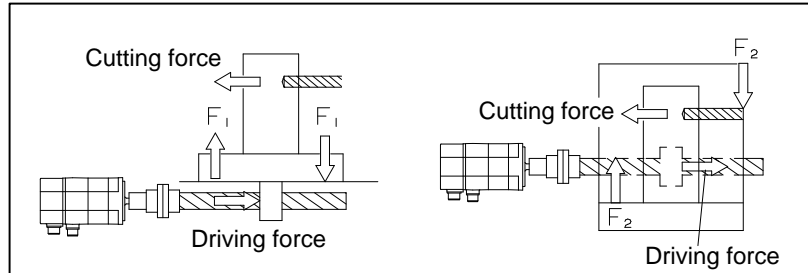
#### Notes

When calculating the torque, take the following precautions:

- Allow for the friction torque caused by the gib fastening force ( $fg$ ). The torque calculated only from the weight of a movable part and the friction coefficient is generally quite small. The gib fastening force and precision of the sliding surface may have a great effect on the torque.
- The pre-load of the bearing or nut of the ball screw, pre-tension of the screw, and other factors may make  $F_c$  of the rolling contact considerable. In a small, lightweight machine tool, the friction torque will greatly affect the entire torque.

- Allow for an increase in friction on the sliding surface ( $F_{cf}$ ) caused by the cutting resistance. The cutting resistance and the driving force generally do not act through a common point as illustrated below. When a large cutting resistance is applied, the moment increases the load on the sliding surface.

When calculating the torque during cutting, allow for the friction torque caused by the load.

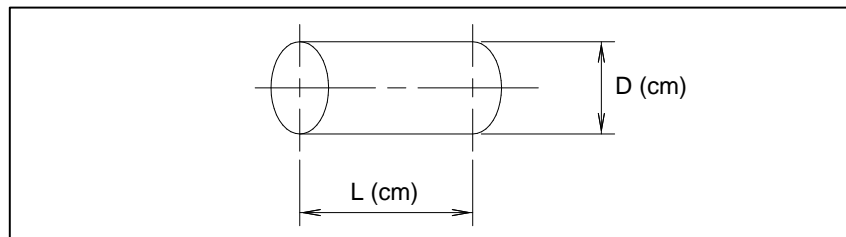


- The feedrate may cause the friction torque to vary greatly. Obtain an accurate value by closely examining variations in friction depending on variations in speed, the mechanism for supporting the table (sliding contact, rolling contact, static pressure, etc.), material of the sliding surface, lubricating system, and other factors.
- The friction torque of a single machine varies widely due to adjustment conditions, ambient temperature, and lubrication conditions. Collect a great amount of measurement data of identical models so that a correct load torque can be calculated. When adjusting the gib fastening force and backlash, monitor the friction torque. Avoid generating an unnecessarily great torque.

### Calculating the load inertia

Unlike the load torque, an accurate load inertia can be obtained just by calculation. The inertia of all objects moved by the revolution of a driving motor forms the load inertia of the motor. It does not matter whether the object is rotated or moved along a straight line. Calculate the inertia values of individual moving objects separately, then add the values together, according to a rule, to obtain the load inertia. The inertia of almost all objects can be calculated according to the following basic rules:

- Inertia of a cylindrical object (ball screw, gear, coupling, etc.)



The inertia of a cylindrical object rotating about its central axis is calculated as follows:

$$J = \frac{\pi\gamma}{32 \times 980} D_b^4 L_b \quad (\text{kgf}\cdot\text{cm}\cdot\text{s}^2)$$

J : Inertia (kgf·cm·s<sup>2</sup>)

$\gamma$  : Weight of the object per unit volume (kg/cm<sup>3</sup>)

$D_b$  : Diameter of the object (cm)

$L_b$  : Length of the object (cm)

If the object is made of steel ( $\gamma = 7.8 \times 10^{-3}$  kg/cm<sup>3</sup>), an approximation of the inertia is:

$$J = 0.78 \times 10^{-6} D_b^4 L_b \quad (\text{kgf}\cdot\text{cm}\cdot\text{s}^2)$$

Example)

When  $D_b$  is 32 (mm) and  $L_b$  is 1000 (mm), inertia  $J_b$  of the shaft of a ball screw is calculated as follows:

$$J_b = 0.78 \times 10^{-6} \times 3.2^4 \times 100 = 0.0082 \quad (\text{kg}\cdot\text{cm}\cdot\text{s}^2)$$

- Inertia of a heavy object moving along a straight line (table, workpiece, etc.)

$$J = \frac{W}{980} \times \left(\frac{L}{2\pi}\right)^2 \quad (\text{kgf}\cdot\text{cm}\cdot\text{s}^2)$$

W : Weight of the object moving along a straight line (kg)

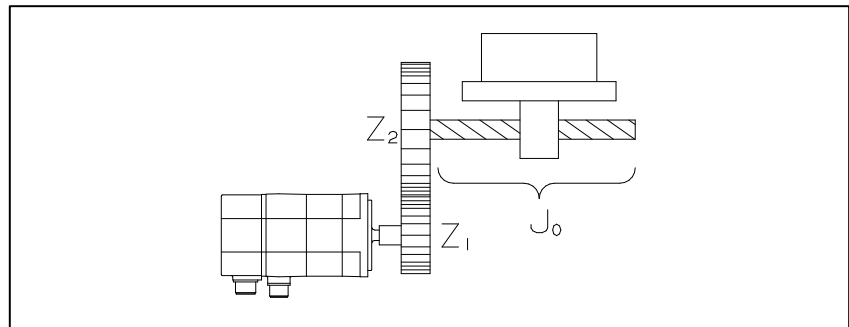
L : Traveling distance along a straight line per revolution of the motor (cm)

Example)

When W is 1000(kg) and L is 8(mm),  $J_w$  of a table and workpiece is calculated as follows:

$$J_w = 1000/980 \times (0.8/2/\pi)^2 = 0.0165(\text{kgf}\cdot\text{cm}\cdot\text{s}^2)$$

- Inertia of an object whose speed is increased above or decreased below the speed of the motor shaft

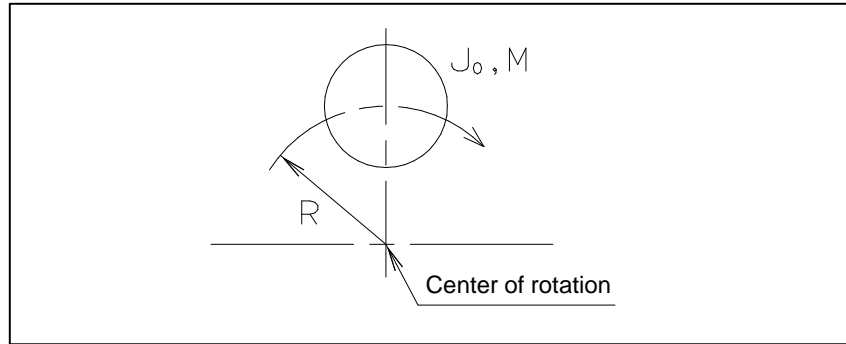


The inertia applied to the motor shaft by inertia  $J_0$  is calculated as follows:

$$J = \left(\frac{Z_1}{Z_2}\right)^2 \times J_0 \quad (\text{kgf}\cdot\text{cm}\cdot\text{s}^2)$$

$J_0$ : Inertia before the speed is changed (kgf·cm·s<sup>2</sup>)

- **Inertia of a cylindrical object in which the center of rotation is displaced**



$$J = J_0 + \frac{M}{980} R^2 \quad (\text{kgf}\cdot\text{cm}\cdot\text{s}^2)$$

$J_0$  : Inertia around the center of the object (kgf·cm·s<sup>2</sup>)

$M$  : Weight of the object (kg)

$R$  : Radius of rotation (cm)

The above equation is used to calculate the inertia of, for example, a large gear which is hollowed out in order to reduce the inertia and weight.

The sum of the inertia values calculated above is  $J$  (load inertia) for accelerating the motor.

In this example, the sum of  $J_b$  and  $J_w$  obtained in above is load inertia  $J_L$ .  
 $J_L = 0.0082 + 0.0165 = 0.0247$  (kgf·cm·s<sup>2</sup>)

- **Note Limitations on load inertia**

The load inertia has a great effect on the controllability of the motor as well as the time for acceleration/deceleration in rapid traverse. When the load inertia is increased, the following two problems may occur: When a command is changed, it takes more time for the motor to reach the speed specified by the new command. When a machine tool is moved along two axes at a high speed to cut an arc or curve, a larger error occurs.

When the load inertia is smaller than or equal to the rotor inertia of the motor, those problems will not occur. When the load inertia is up to three times the rotor inertia, the controllability may have to be lowered a little. Actually, this will not adversely affect the operation of an ordinary metal cutting machine. If a router for woodworking or a machine to cut a curve at a high speed is used, it is recommended that the load inertia be smaller than or equal to the rotor inertia.

If the load inertia much larger than three times the rotor inertia, the controllability will be lowered significantly. If the load inertia much larger than three times the rotor inertia, an adjustment in the normal range may be insufficient. Avoid using a machine with such a great load inertia. If the machine design does not allow a smaller load inertia, contact a FANUC engineer.



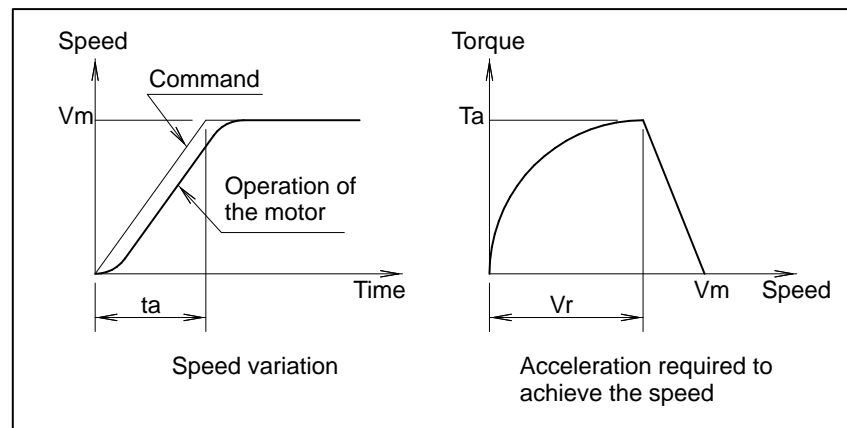
## 4.1.2 Calculating the Acceleration Torque

### Calculating acceleration torque : Procedure 1

Following the procedure described below, calculate the torque required for acceleration:

Assuming that the motor shaft operates ideally in the acceleration/deceleration mode determined by the NC, calculate the acceleration. Multiply the acceleration by the entire inertia (motor inertia + load inertia). The product is the acceleration torque. The equation is given below.

- In linear acceleration/deceleration



$$T_a = \frac{V_m}{60} \times 2\pi \times \frac{1}{t_a} \times J_M \times (1 - e^{-k_s \cdot t_a}) + \frac{V_m}{60} \times 2\pi \times \frac{1}{t_a} \times J_L \times (1 - e^{-k_s \cdot t_a}) \div \eta$$

$$V_r = V_m \times \left\{ 1 - \frac{1}{t_a \cdot k_s} (1 - e^{-k_s \cdot t_a}) \right\}$$

$T_a$  : Acceleration torque (kgf·cm)

$V_m$  : Motor speed in rapid traverse ( $\text{min}^{-1}$ )

$t_a$  : Acceleration time (sec)

$J_M$  : Motor inertia ( $\text{kgf}\cdot\text{cm}\cdot\text{sec}^2$ )

$J_L$  : Load inertia ( $\text{kgf}\cdot\text{cm}\cdot\text{sec}^2$ )

$V_r$  : Point from which the acceleration torque starts to decrease (difference from  $V_m$ ) ( $\text{min}^{-1}$ )

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

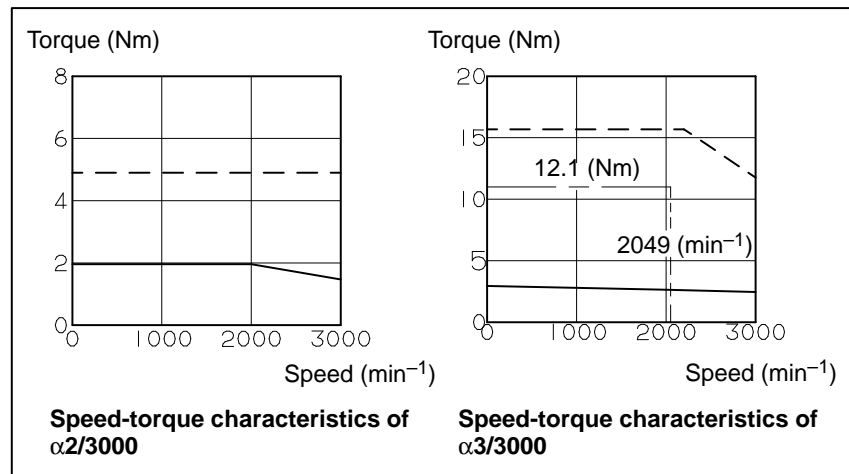
$\eta$  : Machine tool efficiency

## Example)

Try to perform linear acceleration/deceleration under the following condition.

When  $\alpha 2/3000$  is used, the load inertia is calculated as follows. First select the  $\alpha 2/3000$  and calculate its acceleration torque.  $J_M$  motor inertia is  $0.0061$  ( $\text{kgf}\cdot\text{cm}\cdot\text{s}^2$ ),  $V_m$  is  $3000$  ( $\text{min}^{-1}$ ),  $t_a$  is  $0.1$  (s),  $k_s$  is  $30$  ( $\text{sec}^{-1}$ ), and  $J_L = 0.0247$  ( $\text{kgf}\cdot\text{cm}\cdot\text{s}^2$ ).

$$\begin{aligned} T_a &= \frac{3000}{60} \times 2\pi \times \frac{1}{0.1} \times 0.0061 \times (1 - e^{-30 \times 0.1}) \\ &\quad + \frac{3000}{60} \times 2\pi \times \frac{1}{0.1} \times 0.0247 \times (1 - e^{-30 \times 0.1}) \div 0.9 \\ &= 100.1(\text{kgf}\cdot\text{cm}) = 9.81(\text{Nm}) \end{aligned}$$



The speed-torque characteristics of  $\alpha 2/3000$  show that the acceleration torque of  $9.81$  (Nm) is beyond the intermittent operating zone of  $\alpha 2/3000$  (see the characteristic curve above and data sheet). (The torque is insufficient for  $\alpha 2/3000$ .)

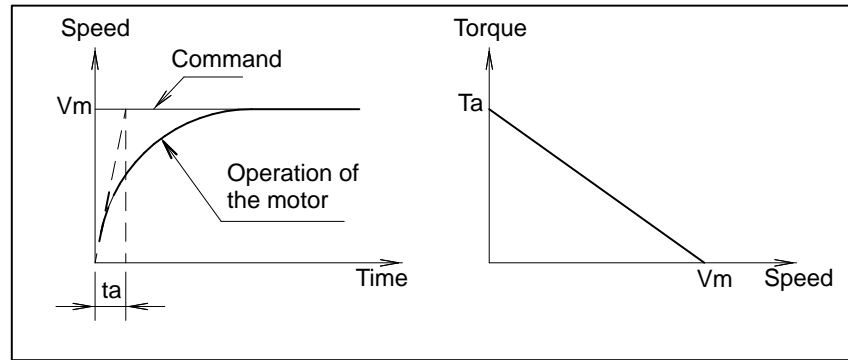
If the operation specifications of the shaft (for instance, the acceleration time) cannot be changed, a larger motor must be selected. Select an  $\alpha 3/3000$  ( $J_M$  is  $0.02$  ( $\text{kgf}\cdot\text{cm}\cdot\text{s}^2$ )) and calculate the acceleration torque again.

$$\begin{aligned} T_a &= 123.7(\text{kg}\cdot\text{cm}) = 12.1(\text{Nm}) \\ V_r &= 2049(\text{min}^{-1}) \end{aligned}$$

In acceleration, an acceleration torque of  $12.1$  (Nm) is required at  $2049$  ( $\text{min}^{-1}$ ). The speed-torque characteristic curve shown above shows that the acceleration is possible with  $\alpha 3/3000$ .

As  $\alpha 2/3000$  is changed to  $\alpha 3/3000$ , the size of the attachment flange is increased from  $90$  mm x  $90$  mm to  $130$  mm x  $130$  mm. If the machine tool does not allow a larger motor, the specifications must be changed. For example, the acceleration time must lengthen.

- When acceleration/ deceleration is not controlled



Assume these equations.

$$T_a = \frac{V_m}{60} \times 2\pi \times \frac{1}{t_a} \times (J_M + J_L), \quad t_a = \frac{1}{k_s}$$

### Calculating acceleration torque : Procedure 2

To obtain T (torque) required by the motor shaft, add  $T_m$  (friction torque) to  $T_a$  acceleration torque.

$$T = T_a + T_m$$

$$T = 12.1(\text{Nm}) + 0.9(\text{Nm}) = 13.0(\text{Nm})$$

### Calculating acceleration torque : Procedure 3

Check that T obtained in Procedure 2 above is smaller than or equal to the torque limit determined by the amplifier. Using the speed-torque characteristic curve on the data sheet of the corresponding motor, check that T obtained in Procedure 1 above is within the intermittent operating zone at  $V_r$ .

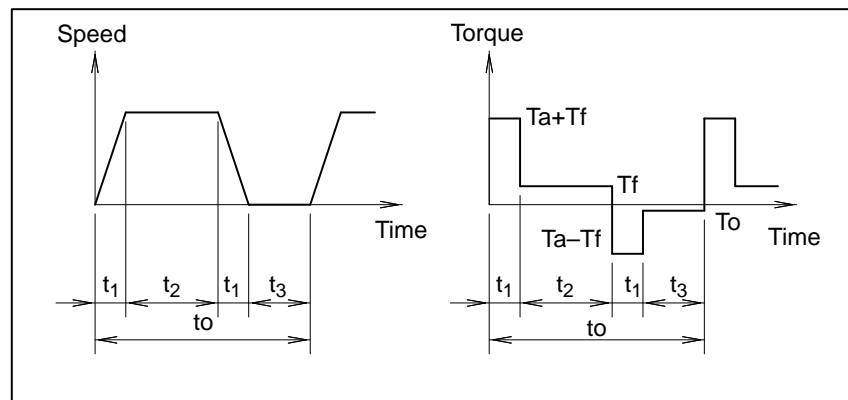
As  $V_r$  is  $2049 \text{ (min}^{-1}\text{)}$  and T is  $13.0 \text{ (Nm)}$ , the acceleration is possible with the specified time constant (condition 2).

### 4.1.3 Calculating the Root-mean-square Value of the Torques

#### Calculating the frequency of positioning in rapid traverse

Generate an operation cycle which includes rapid traverse. Write the time-speed graph and time-torque graph as shown below.

In a common cutting machine, the frequency of positioning in rapid traverse will cause no problems. In a special machine tool which frequently executes rapid traverse, however, the motor must be checked to see whether it is overheated by the current required for acceleration or deceleration.



From the time-torque graph, obtain the root-mean-square value of torques applied to the motor during the single operation cycle. Check whether the value is smaller than or equal to the rated torque (condition 3).

$$Trms = \sqrt{\frac{(Ta + Tm)^2 t_1 + Tm^2 t_2 + (Ta - Tm)^2 t_1 + To^2 t_3}{t_0}}$$

Ta : Acceleration torque

Tm : Friction torque

To : Torque when stopped

If Trms is smaller than or equal to the rated torque at stall ( $T_s$ ), the motor can be used.

(Set a value equal to 90% of the static rated torque, considering the total thermal efficiency.)

Example)

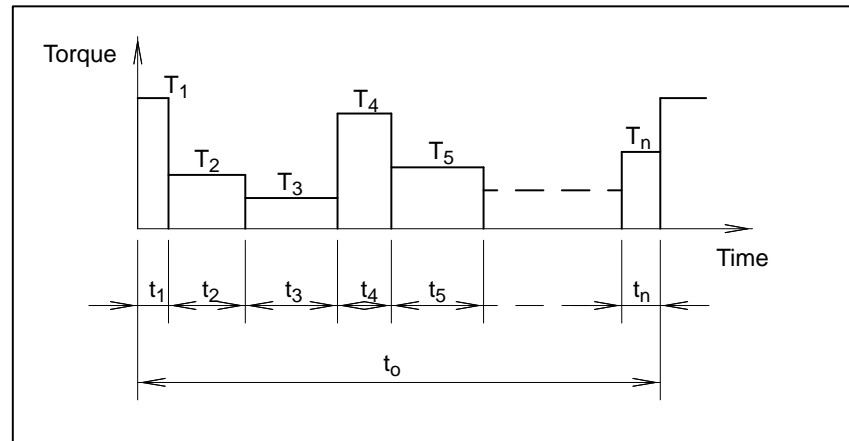
When an  $\alpha 3/3000$  ( $T_s = 31$  (kgf-cm) = 3.0 (Nm)) is used under the following conditions:  $T_a = 12.1$  (Nm),  $T_m = T_o = 0.9$  (Nm),  $t_1 = 0.1$  (s),  $t_2 = 1.8$  (s),  $t_3 = 7.0$  (s)

$$\begin{aligned} Trms &= \sqrt{\frac{(12.1 + 0.9)^2 \times 0.1 + 0.9^2 \times 1.8 + (12.1 - 0.9)^2 \times 0.1 + 0.9^2 \times 7}{0.1 + 1.8 + 0.1 + 7}} \\ &= 20.2(Nm) < T_s \times 0.9 = 2.9 \times 0.9 = 2.61(Nm) \end{aligned}$$

The  $\alpha 3/3000$  can be used for operation. (Condition 3)

### Calculating the torque in a cycle in which the load varies

If the load conditions (cutting load, acceleration/deceleration conditions, etc.) vary widely in a single cycle, write a time–torque graph according to the operation cycle, as in above item. Obtain the root-mean-square value of the torques and check that the value is smaller than or equal to the rated torque (condition 4).



$$T_{rms} = \sqrt{\frac{T_1^2 t_1 + T_2^2 t_2 + T_3^2 t_3 + \dots + T_n^2 t_n}{t_o}}$$

$$t_o = t_1 + t_2 + \dots + t_n$$

#### 4.1.4 Calculating the Percentage Duty Cycle with the Maximum Cutting Torque

Check that the time for which the table can be moved with the maximum cutting torque,  $T_{mc}$ , (percentage duty cycle and ON time) is within a desired range of cutting time. (Condition 5)

If  $T_{mc}$  (maximum load torque) applied to the motor shaft during cutting, which is obtained in Subsec. 4.1.1, is smaller than the product of rated torque at stall of the motor ( $T_c$ ) and  $\alpha$  (thermal efficiency), the motor can be used in continuous cutting. If  $T_{mc}$  is greater than the product ( $T_{mc} > T_c \cdot \alpha$ ), follow the procedure below to calculate the percentage ratio of time ( $t_{ON}$ )  $T_{mc}$  can be applied to the motor to total time ( $t$ ) of a single cutting cycle. ( $\alpha$  is assumed to be 0.9. Calculate the percentage considering the specifications of the machine.)

**$T_{mc} < T_c \times \alpha$  ...** Operation can be continued with the maximum cutting torque. (The percentage duty cycle with the maximum cutting torque is 100%.)

**$T_{mc} > T_c \times \alpha$  ...** Calculate the percentage duty cycle, according to the following figure and expressions.

Example)

As calculated in Subsec. 4.1.1,

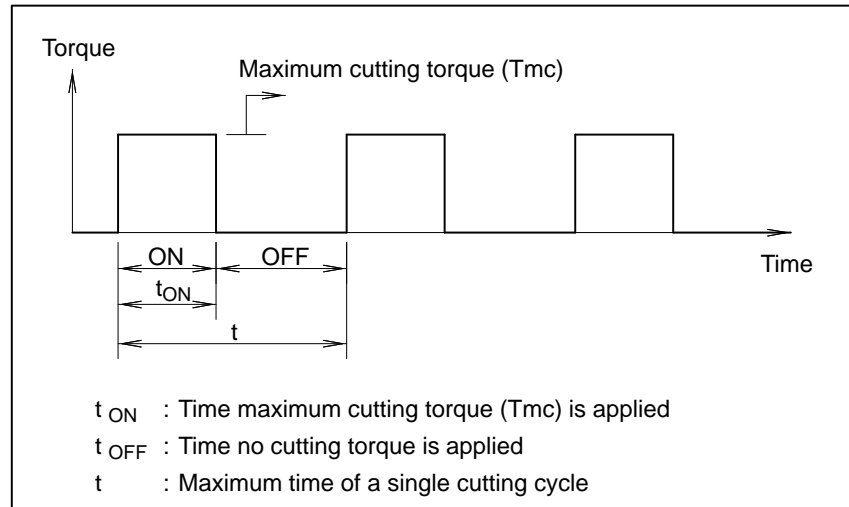
$T_{mc} = 21.8 \text{ (kgf-cm)} = 2.1 \text{ (Nm)}$

OS:  $T_c = 30 \text{ (kgf-cm)} = 2.9 \text{ (Nm)}$

$2.9 \cdot 0.9 = 2.6 \text{ (Nm)} > 2.1 \text{ (Nm)} = T_{mc}$

No problems will occur in continuous cutting.

### Calculating the percentage duty cycle with the maximum cutting torque



Calculate the root-mean-square value of torques applied in a single cutting cycle as described in Subsec 4.1.3. Specify  $t_{ON}$  and  $t_{OFF}$  so that the value does not exceed the product of rated torque at stall of the motor ( $T_c$ ) and thermal efficiency ( $\alpha$ ). Then, calculate the percentage duty cycle with the maximum cutting torque as shown below.

$$\text{Percentage duty cycle with the maximum cutting torque (} T_{mc} \text{)} = \frac{t_{ON}}{t} \times 100(\%)$$

Example)

Assume that  $T_{mc}$  is 4.0(Nm) ( $T_m = 0.9(\text{Nm})$ ).

$$\sqrt{\frac{4.0^2 \times t_{ON} + 0.9^2 \times t_{OFF}}{t_{ON} + t_{OFF}}} < 2.6(\text{Nm})$$

Therefore,

$$\frac{t_{ON}}{t_{OFF}} < \frac{1}{1.6}$$

The ratio of non-cutting time to cutting time must be 1.6 or greater.

The percentage duty cycle is calculated as follows:

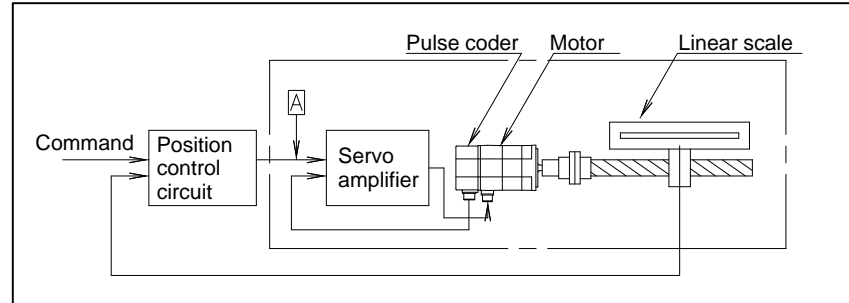
$$\frac{t_{ON}}{2.6t_{ON}} \times 100 = 38.5\%$$

Finally, the  $\alpha 3/3000$  that satisfies conditions 1 to 5 is selected.

## 4.2 PRECAUTIONS FOR USING LINEAR SCALE

### Machine system natural frequency

In the case where the machine moves in a linear direction and movement is directly detected by linear scale such as inductosyn, magne-scale etc., special considerations are necessary in comparison with the method where feedback is produced by detecting the motor shaft rotation. This is because the machine movement now directly influences the characteristics of the control system.



This method is shown in the figure above by block diagram. The response of this control system is determined by the adjustment value (position loop gain) of the position control circuit. In other words, the position loop gain is determined by the specified response time of the control system. In the diagram above, the section enclosed by the broken line is called the velocity loop. Unless the response time of this section where position signal is detected is sufficiently shorter than the response time determined by the position loop gain, the system does not operate properly. In other words, when a command signal is put into point A, response time of the machine where position signals are detected must be sufficiently shorter than the response time defined by the position loop gain.

When the response of the detector section is slow, the position loop gain must be reduced to have the system operate normally, and as a result, the response of the whole system is slow. The same problem is caused when inertia is great (see section 4.1, item 1)).

The main causes for slow response are the mass of the machine and the elastic deformation of the machine system. The larger the volume, and the greater the elastic deformation, the slower the response becomes.

As an index for estimating the response of this machine system, the natural frequency of the machine is used, and this is briefly calculated by the following equation.

$$W_m = \frac{1}{2\pi} \times \frac{K_m}{JL}$$

$W_m$ : Natural frequency

$JL$  : Load inertia reflected to motor shaft (kgf·cm·s<sup>2</sup>)

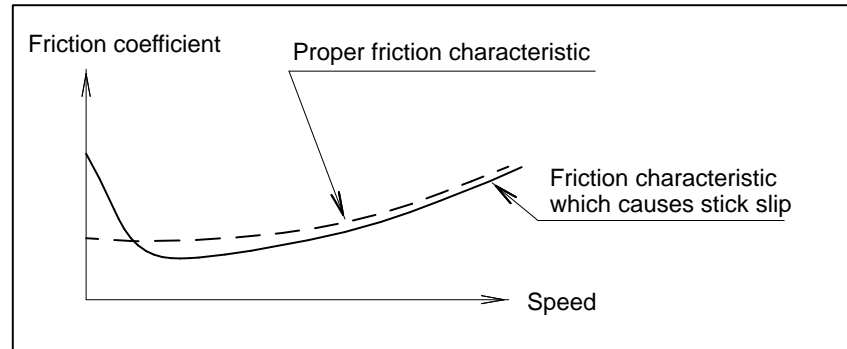
$K_m$  : Rigidity of machine system (kgf·cm/rad)  
=Torque necessary to elastically deform 1 rad at the motor shaft when the machine table is clamped.

The above values can be obtained by calculating the elastic deformation for each section of the driving system. If the value of this natural frequency (Hz) is more than the value of position loop gain (see<sup>-1</sup>), it operates normally in most cases. That is to say, when setting 20 sec<sup>-1</sup> as the value of position loop gain, natural frequency of machine system must be more than 20 Hz. In this case, attention must be paid to the fact that

response becomes a problem for extremely small amounts of movement. Consequently, the natural frequency should be calculated from the rigidity at extremely small displacement such as less than 10  $\mu\text{m}$ .

### Stick slip

If machine movement causes a stick slip, the control system does not operate normally. That is, it does not stop where it is supposed to, but a phenomenon occurs where it goes beyond and then back within an extremely small range (hunting). To avoid stick slip, the machine rigidity should be increased, or friction characteristics of the sliding surface should be improved. When the sliding surface friction characteristic is as in the figure below, stick slip occurs easily.



### Value of machine overrun (Damping coefficient of machine system)

When the machine is floated by static pressure, etc., there are cases where the machine keeps on moving within the range of backlash although the motor shaft has stopped. If this amount is large, hunting will also occur. To avoid this, backlash should be reduced (especially the backlash of the last mass where position detector is mounted) and the appropriate damping should be considered.



## 4.3 MOTOR SELECTION

Select a suitable motor according to the load condition, rapid traverse rate, increment system, and so on. To aid in selecting the correct motor, fill out the "servo motor selection data table" at the end of this section.

Fill in blanks of machine tool data items (No. 1, 2 and 3) of this table with necessary data, and send this table to our representative.

The representative will fill in blanks of item No. 4 to 8 with suitable data of motor and send this table back.

Details of each item in this selection data table are as described in Subsec. 4.3.1 and 4.3.2.

### 4.3.1 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 (15T, 16M, 0MC, etc.) employed.
<b>Spindle motor output</b>	Fill in this blank for reference when examining the servo motor output.
<b>Names of axes</b>	Fill in this blank with names of axes practically employed in CNC command. If the number of axes exceeds 4 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.

### 4.3.2 Data

Machine tool builders are requested to fill in data blanks No. 1, 2, 3. Fill in No. 4 items and higher blanks with decided values or desired values, if any, from the viewpoints of specifications.

If these values are unknown or undecided, the representative will decide these values according to the contents in item No. 1, 2, and 3. So leave them blank. See the following for details of the contents of filling in.

#### No. 1 blank

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.

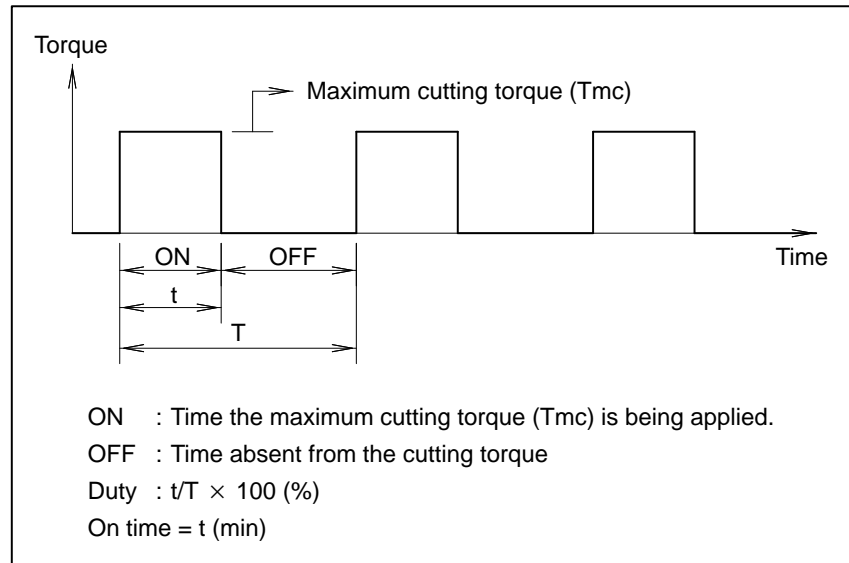
- **weight of driven parts**

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 screw** Enter the diameter, pitch, and axial length of the lead screw in order.
  - **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.
- No. 2 blank** Data in this blank serve as the basis for selecting the motor. Enter these data correctly. For details of calculating methods of respective items, refer to sec. 4.1 and 4.2.
- **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
  - **Least input increment CNC** Enter the least input increment of NC command. The standard value is 0.001 mm in Series 0, 15, 16, and 18 CNCs.
  - **Rapid traverse rate and cutting feedrate** Enter the rapid traverse rate and cutting feedrate required for machine tool specifications.
  - **Inertia** Enter a load inertia value reflected to the motor shaft. For details of this calculation, see Subsec. 4.1.1.  
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.
  - **Load torque**
    - 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 70% of the rated torque.
    - 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.
    - For the cutting torque, enter the maximum value of the force being applied during cutting by the force in the feed axis direction.
    - For the maximum cutting torque, enter the torque value on the motor shaft corresponding to the maximum value of the above cutting thrust. Since the torque transfer efficiency may substantially deteriorate to a large extent due to the reaction from the slide way, etc. produced by the cutting thrust, obtain an accurate value by taking measured values in similar machine tools and other data into due account.
    - If the load torque values differ during lifting and lowering in the vertical axis, enter both values.

- **Maximum cutting duty / ON time**

Enter the duty time and ON time with the maximum cutting torque in item “Load torque” applied. These values mean as follows.



- **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.

**No. 3 blank**

Data in this blank are necessary for examining the stability of the servo system when the position detector is attached outside the motor. Enter these data without fail when the servo system is constructed using a linear scale.

- **Separate type position detector**

If the position detector is mounted outside the motor, enter the name of the detector. Enter the following items in the “remarks” column, if a rotary detector such as resolver, pulse coder, or the like is used.

- **Resolver**

Move amount of machine tool per revolution of resolver  
 Number of wave lengths per revolution of resolver

- **Pulse coder**

Move amount per revolution of pulse coder  
 Number of pulses of pulse coder

- **Rigidity of feed system machine tool**

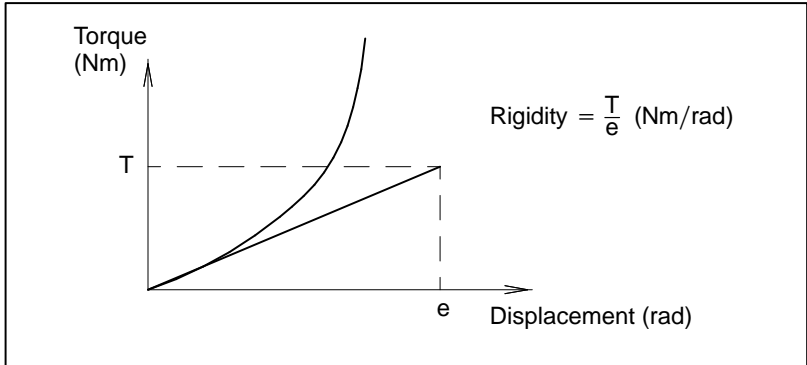
Enter the relation between the torque and the displacement when the torque is applied to the motor shaft, assuming that the final driven part like the table has been fully locked. Fill in this value as a torque value required for the angular displacement of 1 radian.

Example)

If displacement of 5 deg. at 500 kgf·cm torque as a calculation results,

$$\text{Rigidity} = \frac{500}{5} \times \frac{180}{\pi} = 5730 \text{kgf} \cdot \text{cm/rad}$$

If the relation between the displacement and the torque is nonlinear, calculate the rigidity by the gradient in the vicinity of origin.



● 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.

No. 4 blank

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.

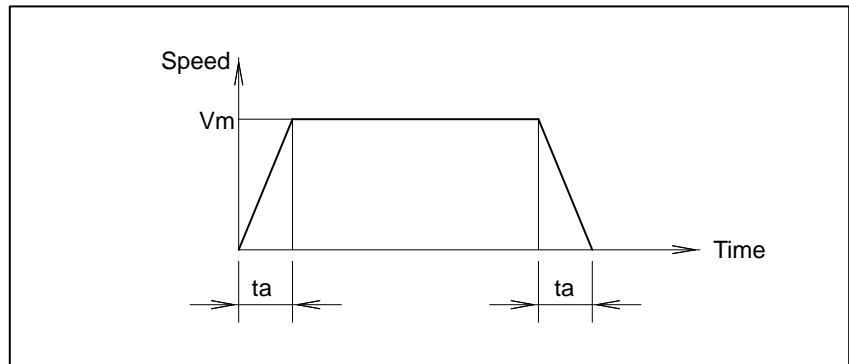
No. 5 blank

The acceleration / deceleration time in this item is a commanded value. It does not mean any actual completion time of positioning.

● Acceleration / deceleration time at rapid traverse

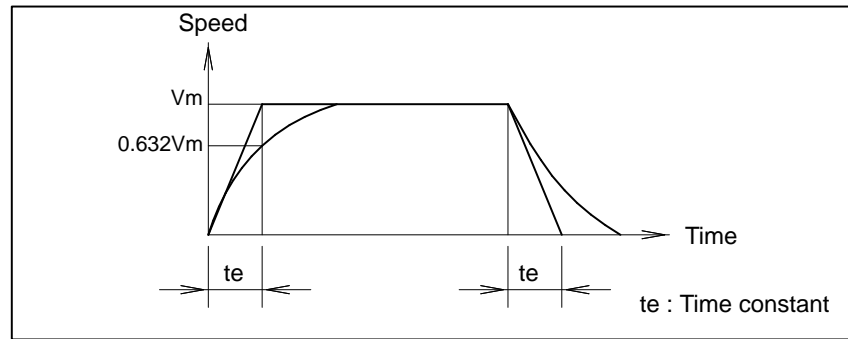
The acceleration/deceleration time is determined according to the load inertia, load torque, motor output torque, and working speed. For details of calculations, refer to Subsec. 4.1.2 and 4.1.3.

The acceleration/deceleration mode at rapid traverse is generally linear acceleration/deceleration in FANUC's CNC.



● **Acceleration/ deceleration time at cutting feed**

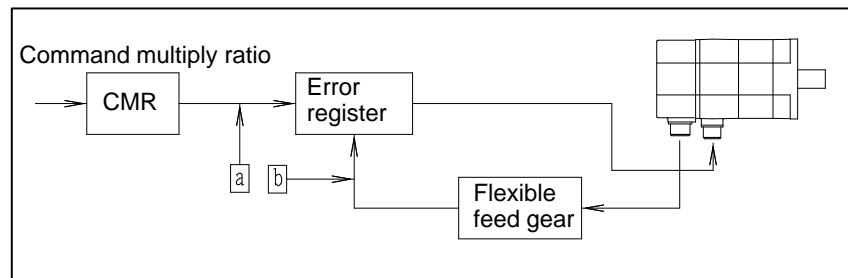
The acceleration/deceleration at cutting feed is exponential acceleration /deceleration in general. This blank is filled in with its time constant



**No. 6 blank**

● **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 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**

For calculation, the number of feedback pulses for the α pulse coder must always be set to 1,000,000. 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 1 μm, the machine travel distance per motor shaft revolution is 8 mm, and pulse coder A64 is used.

$$F.FG = \frac{8,000}{1,000,000} = \frac{1}{125}, \quad CMR = 1$$

Setting F.FG when 1 μm detection is performed using the semi-closed loop

Machine travel distance per motor shaft revolution (mm/rev)	Number of required position pulses (pulses/rev)	F.FG value
10	10000	1/100
20	20000	2/100 or 1/50
30	30000	3/100

● 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.

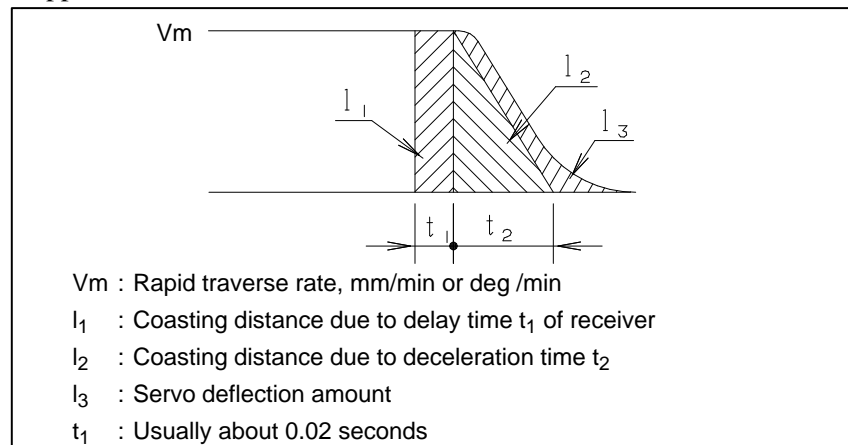
No. 7 blank

The coasting distance of the machine tool at the machine tool stroke end is entered in this blank. The stroke end is usually limited in 2 steps consisting of the deceleration stop in the first step and dynamic brake stop in the second step.

The position display accurately coincides with the stop position of the machine tool when the first step limit switch is depressed. However, this position is lost when the second step limit switch is depressed. Mount this second limit switch without fail for preventing the machine tool from being damaged, because it is only one means of stopping the machine tool, if the machine tool should run away due to a control failure.

● Deceleration stop distance

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

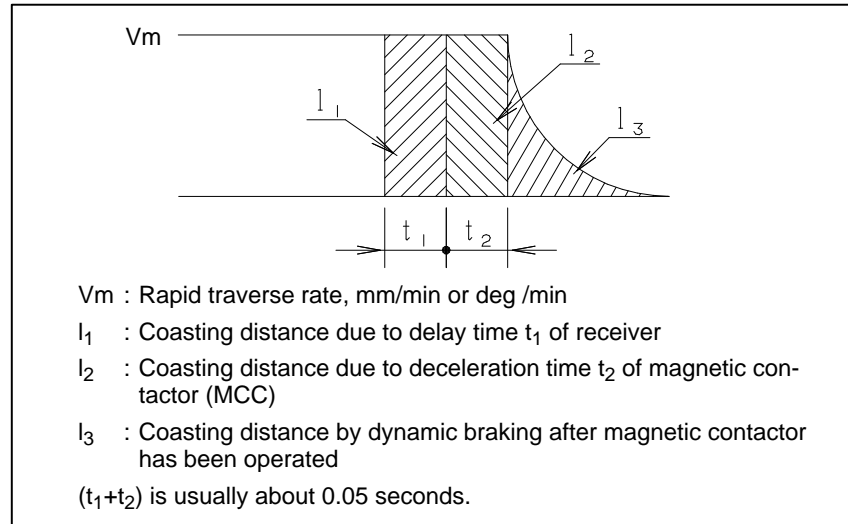


$$Coasting\ distance = \frac{Vm}{60} \times \left( t_1 + \frac{t_2}{2} + \frac{1}{k_s} \right)$$

k<sub>s</sub> : Position loop gain (sec<sup>-1</sup>)

• **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."

**No. 8 blank**

- Type of amplifier
- Transformer
- Specifications

Servo amplifier specification

Designate AC servo.

Fill the transformer specification.

Enter the servo amplifier module specifications.

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

Model	A	B	$J_m$ (kgf·cm·s <sup>2</sup> )
<b>α series</b>			
α0.5/3000	$8.1 \times 10^{-2}$	$5.9 \times 10^{-8}$	0.00018
α1/3000	$5.9 \times 10^{-2}$	$1.3 \times 10^{-8}$	0.0037
α2/2000	$1.9 \times 10^{-2}$	$5.3 \times 10^{-9}$	0.0061
α2/3000	$2.2 \times 10^{-2}$	$4.6 \times 10^{-9}$	0.0061
α3/3000	$1.4 \times 10^{-2}$	$7.3 \times 10^{-9}$	0.014
α6/2000	$5.5 \times 10^{-3}$	$4.4 \times 10^{-9}$	0.027
α6/3000	$1.1 \times 10^{-2}$	$2.1 \times 10^{-9}$	0.027
α12/2000	$3.0 \times 10^{-3}$	$6.8 \times 10^{-9}$	0.064

Model	A	B	Jm (kgf-cm-s <sup>2</sup> )
$\alpha$ 12/3000	$6.7 \times 10^{-3}$	$3.1 \times 10^{-9}$	0.064
$\alpha$ 22/1500	$1.5 \times 10^{-3}$	$3.3 \times 10^{-9}$	0.12
$\alpha$ 22/2000	$2.8 \times 10^{-3}$	$1.8 \times 10^{-9}$	0.12
$\alpha$ 22/3000	$4.2 \times 10^{-3}$	$1.2 \times 10^{-9}$	0.12
$\alpha$ 30/1200	$8.6 \times 10^{-4}$	$2.5 \times 10^{-9}$	0.17
$\alpha$ 30/2000	$1.1 \times 10^{-3}$	$2.0 \times 10^{-9}$	0.17
$\alpha$ 30/3000	$2.5 \times 10^{-3}$	$8.6 \times 10^{-10}$	0.17
$\alpha$ 40/2000	$1.1 \times 10^{-3}$	$1.1 \times 10^{-9}$	0.23
$\alpha$ 65/2000	$1.7 \times 10^{-3}$	$4.2 \times 10^{-10}$	0.19
$\alpha$ 100/2000	$1.3 \times 10^{-3}$	$2.4 \times 10^{-10}$	0.27
$\alpha$ 150/2000	$1.0 \times 10^{-3}$	$1.7 \times 10^{-10}$	0.35
<b><math>\alpha</math>(HV) series</b>			
$\alpha$ 3/3000HV	$3.4 \times 10^{-2}$	$3.0 \times 10^{-9}$	0.014
$\alpha$ 6/3000HV	$1.3 \times 10^{-2}$	$1.8 \times 10^{-9}$	0.027
$\alpha$ 12/3000HV	$1.4 \times 10^{-2}$	$1.5 \times 10^{-9}$	0.064
$\alpha$ 22/3000HV	$7.8 \times 10^{-3}$	$6.4 \times 10^{-10}$	0.12
$\alpha$ 30/3000HV	$4.3 \times 10^{-3}$	$5.0 \times 10^{-10}$	0.17
<b><math>\alpha</math>C series</b>			
$\alpha$ C3/2000	$8.3 \times 10^{-3}$	$1.3 \times 10^{-8}$	0.014
$\alpha$ C6/2000	$2.7 \times 10^{-3}$	$8.8 \times 10^{-9}$	0.027
$\alpha$ C12/2000	$1.4 \times 10^{-3}$	$1.5 \times 10^{-8}$	0.064
$\alpha$ C22/1500	$1.5 \times 10^{-3}$	$3.3 \times 10^{-9}$	0.12
<b><math>\alpha</math>M series</b>			
$\alpha$ M3/3000	$2.0 \times 10^{-2}$	$7.1 \times 10^{-9}$	0.008
$\alpha$ M6/3000	$9.7 \times 10^{-3}$	$2.7 \times 10^{-9}$	0.014
$\alpha$ M9/3000	$5.5 \times 10^{-3}$	$1.0 \times 10^{-9}$	0.026
<b><math>\alpha</math>L series</b>			
$\alpha$ L3/3000	$2.3 \times 10^{-2}$	$3.0 \times 10^{-8}$	0.0025
$\alpha$ L6/3000	$1.4 \times 10^{-2}$	$1.1 \times 10^{-8}$	0.0050
$\alpha$ L9/3000	$1.1 \times 10^{-2}$	$1.9 \times 10^{-9}$	0.010
$\alpha$ L25/3000	$3.6 \times 10^{-3}$	$1.6 \times 10^{-9}$	0.055
$\alpha$ L50/2000	$1.7 \times 10^{-3}$	$1.1 \times 10^{-9}$	0.10

The values of A and B are calculated by assuming that the resistance of the power line is 0.05  $\Omega$  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 AC servo motor selection data table**

Machine	Kind	Type
NC, spindle motor	NC ; FANUC ( )	Spindle motor kW

No.	Item	Axis					
1	Axis movement direction (horizontal, vertical rotation)						
	Weight of moving component parts (including workpiece, etc.)		kgf				
	Counter balance		kgf				
	Table support (sliding, rolling, static pressure)						
	Feed screw	Diameter					
		Pitch					
		Axial length					
Total gear ratio							
2	Movement of machine tool per revolution of motor		mm				
	Least input increment of NC		mm				
	Rapid traverse feedrate		mm/min				
	Cutting traverse feedrate		mm/min				
	Inertia		kgf-cm-sec <sup>2</sup>				
	Load torque	Low feed without cutting		kgf-cm			
		Rapid traverse		kgf-cm			
		Cutting thrust		kg			
		Maximum cutting torque		kgf-cm			
	Maximum cutting duty/ON time		%/min				
Rapid traverse positioning frequency		times/min					
3	Separate type position detector						
	Feed system machine tool rigidity		kgf-cm/rad				
	Backlash amount		mm				
4	Motor type						
	FB type						
	Number of rotation at rapid traverse		rpm				
	Option / Special specifications						
5	Acceleration/deceleration time at rapid traverse		msec				
	Acceleration/deceleration time at cutting feed		msec				
6	Command multiply ratio		CMR				
	Detection multiply ratio		DMR				
	Flexible feed gear		FFG				
	Position loop gain		sec <sup>-1</sup>				
7	Deceleration stop distance		mm				
	Dynamic brake stop distance		mm				
8	Amplifier type						
	Transformer						
	Specifications	Amplifier					
Remarks							
			Version	Date	Name		
			1				
			2				
		3					

**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)	kgf	
	Counterbalance	kgf	
	Table support (sliding contact, rolling contact, static pressure) (*)		
Feed mechanism (Select one of the following and enter the corresponding data.)			
	1 Ball screw: Diameter _ pitch _ 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·cm·sec <sup>2</sup>	
	Least input increment of NC (resolution)	mm	
	Maximum rapid traverse feedrate	mm/min	
	Motor speed in rapid traverse	rpm	
	Acceleration/deceleration time in rapid traverse	msec	
	Distance of positioning in rapid traverse	mm	
	Frequency of positioning in rapid traverse	times/min	
	In the remarks section, note the operation cycle (speed pattern) if it is determined.		
	Load torque		
	Low feed without cutting	kgf·cm	
	Rapid traverse	kgf·cm	
	Backlash	mm	
Fill in these blanks when an separate type position detector is used.(**)			
	Type of separate type 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		
	Specifications of regenerative discharge unit		
	Specifications of transformer		
Note	(*) Note the friction coefficient of the sliding surface if it is determined. (**) A separate type 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.		
Remarks			
	Version	Date	Name
	1		
	2		
	3		

## 4.4 CHARACTERISTIC CURVE AND DATA SHEET

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

### 4.4.1 Performance Curves

The typical characteristic curves consist of the following.

#### Speed-torque 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. Outside of this zone, the motor must be operated on an intermittent basis using the duty cycle curves. The limit of continuous operating zone is determined under the following conditions. And this zone may be limited by the thermal protection of mounted precision instrument. (pulse coder)

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

The limit of intermittent operating zone is determined by input voltage to the motor.

Actual operation is limited by the current limit of servo unit.

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° derate 0.19% for each degree over)

#### Overload duty characteristic

These curves are known as duty cycle curves and provided very important information on how to determine the "ON" time for intermittent overload torque without overheating the motor. The curves shown in the following figures are ones determined by the limit of the temperature of the motors. When the motor is driven by some driving circuit having thermal protect devices such as thermal relay or fuse, the "ON" time may be limited by the characteristics of those elements.

### 4.4.2 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)**

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. This value can usually be obtained by measuring the torque developed by rated 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)**

The back EMF constant is the indication of the permanent magnet field strength. It is the value of the generated voltage at a specified speed when magnetic field is rotated mechanically, and is the function of total number of conductors in the armature and total flux of the field. The back EMF constant has the dimensions of volt-second per radian or volts per rpm. 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

**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. Repeated pulses at rated peak or less will not affect demagnetization.

### 4.4.3 How to Use Duty Cycle Curves

Servo motors can be operated in the range exceeding continuous rated torque depending on thermal time constant. Duty characteristics shows the Duty (%) and the "ON" time in which motor can be operated under the given overload conditions. Calculation procedure is as follows.

- 1 Calculate Torque percent by formula (b) below.
- 2 Motor can be operated at any point on and inside the curve corresponding to the given over load conditions obtained from 1.
- 3 Calculate  $t_F$  by formula (a)

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

$$TMD = \frac{\text{Load torque}}{\text{Continuous rated torque}} \quad \dots\dots\dots (b)$$

$t_F$  : "OFF" time

$t_R$  : "ON" time

The values of  $t_R$  and  $t_F$  obtained from the above mentioned procedure shows the ones limited by motor thermal conditions. Other circuit protectors such a thermal relay or fuse also limit the operating zone of the motor. To determine  $t_R$  and  $t_F$  for actual use, characteristics of those protectors must be considered.

In the case of digital servo, the software protection is available to protect against a shorter time overload. This also limits the motor operating conditions.

# 5

## CONDITIONS FOR APPROVAL RELATED TO THE IEC34 STANDARD



## 5.1 APPLICABLE MOTORS

This chapter describes the conditions the following FANUC  $\alpha$ ,  $\alpha$ (HV),  $\alpha$ C,  $\alpha$ M, and  $\alpha$ L series AC servo motors must clear before they can be approved for the IEC34 standard.

### 5.1.1 200 VAC Input Types

From the FANUC  $\alpha$ ,  $\alpha$ C,  $\alpha$ M, and  $\alpha$ L series AC servo motors listed below, select the motors that meet any combination in “Motor Types and Specifications” (sections II.2, IV.2, V.2, and VI.2) and either of the following conditions: Designated as #Txxx or #Uxxx (where xxx is any code) at the end of their specification code indicated on the nameplates, or manufactured in March 1995 or later. The selected motors will meet the IEC34 standard if they are used under the conditions described in this chapter.

#### $\alpha$ series

Model name	Motor specification number
$\alpha$ 0.5/3000	A06B-0113-Bxxx
$\alpha$ 1/3000	A06B-0371-Bxxx
$\alpha$ 2/2000	A06B-0372-Bxxx
$\alpha$ 2/3000	A06B-0373-Bxxx
$\alpha$ 3/3000	A06B-0123-Bxxx
$\alpha$ 6/2000	A06B-0127-Bxxx
$\alpha$ 6/3000	A06B-0128-Bxxx
$\alpha$ 12/2000	A06B-0142-Bxxx
$\alpha$ 12/3000	A06B-0143-Bxxx
$\alpha$ 22/1500	A06B-0146-Bxxx
$\alpha$ 22/2000	A06B-0147-Bxxx
$\alpha$ 22/3000	A06B-0148-Bxxx
$\alpha$ 30/1200	A06B-0151-Bxxx
$\alpha$ 30/2000	A06B-0152-Bxxx
$\alpha$ 30/3000	A06B-0153-Bxxx
$\alpha$ 40/2000	A06B-0157-Bxxx
$\alpha$ 40/2000 Motor with fan	A06B-0158-Bxxx
$\alpha$ 65/2000	A06B-0331-Bxxx
$\alpha$ 100/2000	A06B-0332-Bxxx
$\alpha$ 150/2000	A06B-0333-Bxxx

#### $\alpha$ C series

Mode name	Motor specification number
$\alpha$ C3/2000	A06B-0121-Bxxx
$\alpha$ C6/2000	A06B-0126-Bxxx
$\alpha$ C12/2000	A06B-0141-Bxxx
$\alpha$ C22/1500	A06B-0145-Bxxx

#### $\alpha$ M series

Model name	Motor specification number
$\alpha$ M3/3000	A06B-0161-Bxxx
$\alpha$ M6/3000	A06B-0162-Bxxx
$\alpha$ M9/3000	A06B-0163-Bxxx

#### $\alpha$ L series

Model name	Motor specification number
$\alpha$ L3/3000	A06B-0561-Bxxx
$\alpha$ L6/3000	A06B-0562-Bxxx
$\alpha$ L9/3000	A06B-0564-Bxxx
$\alpha$ L25/3000	A06B-0571-Bxxx
$\alpha$ L50/3000	A06B-0572-Bxxx

## 5.1.2 400 VAC Input Types

From the FANUC  $\alpha$  (HV) series AC servo motors listed below, select the motors that meet any combination in III.2 “Motor Types and Specifications” (described later). The selected motors will meet the IEC34 standard if they are used under the conditions described in this chapter.

### $\alpha$ (HV) series

Model name	Motor specification number	Model name	Motor specification number
$\alpha$ 3/3000HV	A06B-0171-Bxxx	$\alpha$ 12/3000HV	A06B-0176-Bxxx
$\alpha$ 6/3000HV	A06B-0172-Bxxx	$\alpha$ 22/3000HV	A06B-0177-Bxxx
		$\alpha$ 30/3000HV	A06B-0178-Bxxx



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## 5.2 DRIVES

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### 5.2.1 200 VAC Input Types

The FANUC  $\alpha$ ,  $\alpha$ C,  $\alpha$ M, and  $\alpha$ L series AC servo motors can be driven only by the FANUC control motor amplifiers for 200 to 230 VAC.

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### 5.2.2 400 VAC Input Types

The FANUC  $\alpha$  (HV) series AC servo motors can be driven only by the FANUC control motor amplifiers for 400 to 460 VAC.

## 5.3 POWER CABLE CONNECTORS

### 5.3.1 Model $\alpha$ 0.5

The connector kit or cable assembly specified below must be used to connect a power cable to the model  $\alpha$  0.5. This connector is not waterproof.

- Connector kit

Housing: 3-178129-6 [AMP Japan specification]  
A06B-6050-K119 [FANUC specification]  
(This specification includes the contacts.)

Contact: 1-175217-2 [AMP Japan specification]

The contacts of the  $\alpha$  0.5 connector are one-piece crimp type. The size of the applicable wire is AWG#20, and the outside diameter of the insulation is 1.7 to 2.6 mm.

The following dedicated tools are required to mount and remove the contacts. They should be prepared separately from the connector kit.

Crimping tool specification: 914595-3 [AMP Japan]  
A97L-0200-0979 M [FANUC]

Extractor specification: 914677-1 [AMP Japan]  
A97L-0200-0980/D3 [FANUC]

The following FANUC power cables use the wires that meet the VDE.

- Cable assembly (14 m as standard)

Model with no brake:  
A06B-6050-K822 [FANUC specification]

Model with a built-in brake:  
A06B-6050-K823 [FANUC specification]

### 5.3.2 Models $\alpha$ 1 and $\alpha$ 2

Section 8.2.3 of IEC204-1 (EN60204-1), which must be met to acquire CE marking approval, stipulates that all exposed live conductors of electric equipment and machines be connected to a protection link circuit.

If the connector portion of a motor is exposed to the outside, its metal portion should be covered with a non-moving insulation, or the metal shell should be connected to a protection link circuit using the following connector kit.

- Connector kit: A06B-6050-K121 [FANUC specification]

The contacts of the  $\alpha$ 1 and  $\alpha$ 2 connectors are one-piece crimp type. The sizes of the applicable wires are AWG#18 and AWG#16 respectively, and the outside diameters of the insulations are 1.8 to 2.8 mm (for #18) and 2.2 to 2.8 mm (for #16).

The following dedicated tools are required to insert and remove the contacts. They should be prepared separately from the connector kit.

Crimping tool specification: 914596-3 (AMP Japan)  
A97L-0200-0979/L [FANUC]

Extractor specification: 914677-1 (AMP Japan)  
A97L-0200-0980/D3 [FANUC]

- Cables with an external size of 9.9 to 10.9 mm<sup>2</sup> should be used to provide a sufficient waterproof performance related to cable clamps.

The number of cable conductors is 1 greater than the conventional U/V/W/G/(B1)/(B2) to provide for the connector shell protection link circuit, that is 5 or 7 conductors.

The following FANUC power cables use the wires that meet the VDE.

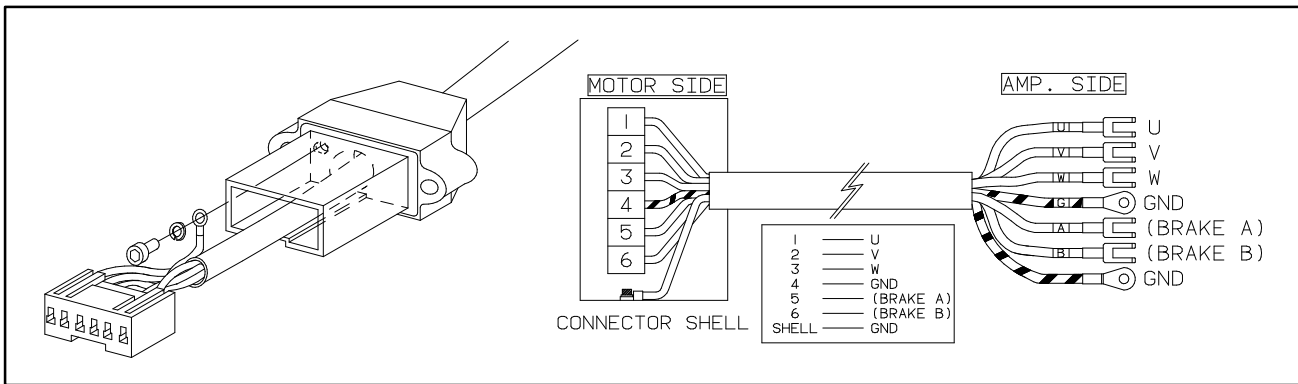
- Cable assembly (14 m as standard)

Model with no brake: A06B-6050-K824 [FANUC specification]

Model with a built-in brake:

A06B-6050-K825 [FANUC specification]

- The motor grounding wire (at terminal 4) and connector shell grounding wire should be bundled with one crimping terminal and connected to the grounding terminal of the amplifier. The grounding lines must be indicated in yellow/green.



### 5.3.3 Models α3 and Higher

The motor power cable and brake fan unit must be connected using the connectors and cable clamps specified below.

Motor model name	Plug connector maker specification [FANUC specification]		Cable clamp specification and connector maker name
α3/3000, α6/2000, α6/3000, α3/3000HV, α6/3000HV, αC3/2000, αC6/2000, αM3/3000, αM6/3000, αM9/3000 αL3/3000, αL6/3000, αL9/3000	Straight type	H/MS3106A18-10S-D-T (10) [A63L-0001-0648/61810SH]	H/MS3057-10A (10) [A63L-0001-0592/10AK]  Hirose Electric
	L-shape type	H/MS3108B18-10S-D-T (10) [A63L-0001-0648/81810SH]	
α12/2000, α12/3000, α12/3000HV, α22/3000HV, α30/3000HV, α22/1500, α22/2000, α30/1200, αC12/2000, αC22/1500	Straight type	JL04V-6A22-22SE-EB [A63L-0001-0648/62222SJ]	JL04-2022CK-(14) [A63L-0001-0653/12A]  Japan Aviation Electronics Industry
	L-shape type	JL04V-8A22-22SE-EB [A63L-0001-0648/82222SJ]	
α22/3000, α30/2000, α30/3000, α40/2000, α40/2000 (with fan) αL25/3000, αL50/2000	Straight type	JL04V-6A24-10SE (G)-EB [A63L-0001-0648/62410SJ]	JL04-2428CK-(17) [A63L-0001-0653/16A]  Japan Aviation Electronics Industry
	L-shape type	JL04V-8A24-10SE (G)-EB [A63L-0001-0648/82410SJ]	
Brake and fan unit connection	Straight type	JL04V-6A10SL-3SE-EB [A63L-0001-0648/610SL3SJ]	JL04-1012CK-(05) [A63L-0001-0653/04A]  Japan Aviation Electronics Industry
	L-shape type	JL04V-8A10SL-3SE-EB [A63L-0001-0648/810SL3SJ]	

- Also see Section 8.
- The power cable for the α22/3000, α30/2000, α30/3000, α40/2000, αL25/3000, and αL50/2000 has 7 conductors. Its grounding wire (one conductor) must have a cross section not less than that for the U, V, or W line (two conductors). For the grounding wire for the other connectors, its cross section must not be less than that for the U, V, or W line.
- If a cable or conduit hose seal adapter is used, consult an appropriate connector maker.

## 5.4 APPROVED SPECIFICATIONS

The following specifications are approved for the IEC34 standard.

### 5.4.1 Motor Speed (IEC34–1)

The allowable maximum speeds of motors are as listed below.

Motor model	Rated-output speed [1/min]	Allowable maximum speed [1/min]
$\alpha$ 1/3000, $\alpha$ 2/3000, $\alpha$ 3/3000, $\alpha$ 6/3000, $\alpha$ 12/3000, $\alpha$ 22/3000, $\alpha$ 30/3000, $\alpha$ 3/3000HV, $\alpha$ 6/3000HV, $\alpha$ 12/3000HV, $\alpha$ 22/3000HV, $\alpha$ 30/3000HV, $\alpha$ M3/3000, $\alpha$ M6/3000, $\alpha$ M9/3000, $\alpha$ L3/3000, $\alpha$ L6/3000, $\alpha$ L9/3000, $\alpha$ L25/3000	3000	3000
$\alpha$ 2/2000, $\alpha$ 6/2000, $\alpha$ 12/2000, $\alpha$ 22/2000, $\alpha$ 30/2000, $\alpha$ C3/2000, $\alpha$ C6/2000, $\alpha$ 40/2000, $\alpha$ C12/2000, $\alpha$ L50/2000	2000	2500
$\alpha$ 22/1500, $\alpha$ C22/1500	1500	2000
$\alpha$ 30/1200	1200	1500
$\alpha$ 65/2000, $\alpha$ 100/2000, $\alpha$ 150/2000	2000	2000

Motors must not be used at a speed higher than the allowable maximum speed. Motors cannot be used continuously at the allowable maximum speed. The output is not specified for the allowable maximum speed. The allowable maximum speed applies only to motors. Separate limits are laid on the drive units.

### 5.4.2 Output (IEC34–1)

The rated output is guaranteed as continuous output only for the rated-output speed. At a speed other than the rate-output speed, the output is specified in terms of a continuous operation torque. The output in an intermittent operation range is not specified. The approved output of each model is as listed in II to VI.3, “Specifications and Characteristics” (described later) for the  $\alpha$ ,  $\alpha$ (HV),  $\alpha$ C,  $\alpha$ M, and  $\alpha$ L series.

### 5.4.3 Protection Type (IEC34–5)

The protection types are as listed below.

Motor model	IP	Approval conditions
$\alpha$ 0.5/3000	55	Applies only to the motor section; for connectors, IP00 applies.
$\alpha$ 65/2000, $\alpha$ 100/2000, $\alpha$ 150/2000	55	Only when a conduit meeting IP55 is used.
Models other than those listed above.	55	Only when a specified connector is used.

**IP5x: Dustproof machines**

A dust-proof machine shall be protected from dust to an extent that dust does not impede the normal operation of the motor if the motor is not protected from dust completely.

**IPx5: Sprinkle-proof machines**

A sprinkle-proof machine shall not suffer inadvertent influence when they are exposed to water sprinkled from nozzles at any angle to the machine.

The conditions of the IPx5 type test are as follows:

- Nozzle inside diameter: 6.3 mm
- Amount of sprinkled water: 12.5 liters/minute
- Water pressure at the nozzle: 30 kPa
- Sprinkle time per a surface of 1 m<sup>2</sup>: 1 minute
- Minimum required time: 3 minutes
- Distance between the nozzle and machine: Approximately 3 m

**Note**

IPx5 evaluates machines for waterproofness in a short-term test as described above, allowing chances that the machines may get dry after the test. If a machine is exposed to liquids other than water or so continuously to water that it cannot get dry, it may suffer inadvertent influence even if the degree of exposure is low.

**5.4.4  
Cooling Method  
(IEC34-6)**

The motor cooling methods are as listed below.

Motor model	IC code	Method
α40/2000 with fan	IC 416	Fully closed; cooled by an external independent fan
Other models	IC 410	Fully closed; cooled by a natural air flow

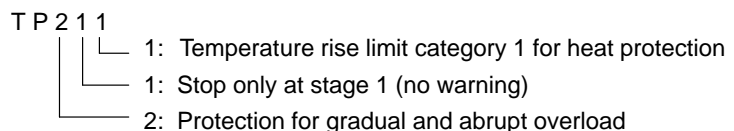
**5.4.5  
Mounting Method  
(IEC34-7)**

The motors can be mounted by the following methods.

- IMB5: Flange mounting with the shaft facing sideways (from the rear)
- IMV1: Flange mounting with the shaft facing upward (from the rear)
- IMV3: Flange mounting with the shaft facing downward (from the rear)

**5.4.6  
Heat Protection  
(IEC34-11)**

The heat protection type is as listed below:



# 6

## FEEDBACK DETECTOR



## 6.1 BUILT-IN DETECTOR

All AC servo motors feature a pulse coder (optical encoder). The pulse coder outputs position information and an alarm signal. The following lists the available pulse coders, together with their specifications and the motors with which they are compatible.

Pulse coder type	Resolution Division/rev	Absolute/ incremental	Applicable motor
Pulse coder $\alpha$ A64	65,536	Absolute	$\alpha$ (HV), $\alpha$ C, $\alpha$ M, $\alpha$ L, and $\alpha$ series except $\alpha$ 0.5
Pulse coder $\alpha$ A8B	8,192	Absolute	$\alpha$ 0.5 (Pulse coder is built into the motor.)
Pulse coder $\alpha$ I64	65,536	Incremental	$\alpha$ (HV), $\alpha$ C, $\alpha$ M, $\alpha$ L, and $\alpha$ series except $\alpha$ 0.5
Pulse coder $\alpha$ I8B	8,192	Incremental	$\alpha$ 0.5 (Pulse coder is built into the motor.)
Pulse coder A	1,000,000	Absolute	$\alpha$ (HV), $\alpha$ M, $\alpha$ L, and $\alpha$ series except $\alpha$ 0.5

### Note

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



## 6.2 PULSE CODER RESOLUTION AND CONTROL RESOLUTION

### **65,536 divisions/revolution**

With the NC's flexible feed gear function, 1- $\mu$ m control can be performed for feed pitches of up to 30 mm per motor revolution.

Note that, however, that this function is subject to a rounding error of 1/65,536 revolution exists.

### **8,192 divisions/revolution**

This pulse coder is suitable for applications that require a precision of about 2  $\mu$ m, which tend to correspond to feed pitches up to about 12 mm per motor revolution.

Although 1- $\mu$ m control can be set, note that this is subject to a rounding error of 1/8,192 revolution. If 1- $\mu$ m control is performed with a feed pitch exceeding 8 mm per motor revolution, the motor may not be stable when stopped. In such a case, it is recommended that CMR be set to 1/2, and the detection unit to 2  $\mu$ m.

### **1,000,000 divisions/revolution**

With the NC's flexible feed gear function 0.1- $\mu$ m control (up to 100 mm/revolution) and 0.01- $\mu$ m control (up to 10 mm/revolution) can be performed.

### **6.3 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 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.

## 6.4 SEPARATE TYPE POSITION DETECTOR

For detecting a position by attaching directly to a ball screw or a machine, use a separate type position detector. Pay attention to the following items when using the separate type 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.
- It is necessary to use the built-in pulse coder with a resolution equal to or finer than that of the separate type position detector.

To connect the separate type position detector to the NC, connect only the signals described in the connecting manual. (A, B, Z, 0V, 5V and REQ if necessary)

When the other signal is connected, the unit may malfunction.

Do not connect the C1, C2, C4, and C8 signals output from the separate type pulse coder unit.

FANUC provides the following external position (rotary) detector.

### Pulse coder unit

Available in the following specifications. The feature and restrictions on the feed rate, etc. are the same those of the built-in pulse coder.

- Incremental pulse coder unit

#### A860-0301-T0□□

□□

**01** : 2000P/rev (Up to 3000min<sup>-1</sup>)

**02** : 2500P/rev (Up to 2400min<sup>-1</sup>)

**03** : 3000P/rev (Up to 2000min<sup>-1</sup>)

**04** : 4000P/rev (Up to 1500min<sup>-1</sup>)

The dimensions are given in “Pulse Coder Unit Outside Dimensions” in this section.

- Absolute pulse coder unit

#### A860-0324-T1□□

□□

**01** : 2000P/rev (Up to 3000min<sup>-1</sup>)

**02** : 2500P/rev (Up to 2400min<sup>-1</sup>)

**03** : 3000P/rev (Up to 2000min<sup>-1</sup>)

**04** : 4000P/rev (Up to 1500min<sup>-1</sup>)

The dimensions are given in “Pulse Coder Unit Outside Dimensions” in this section.

- High-speed high resolution pulse coder unit

### A860-0314-T1 □□



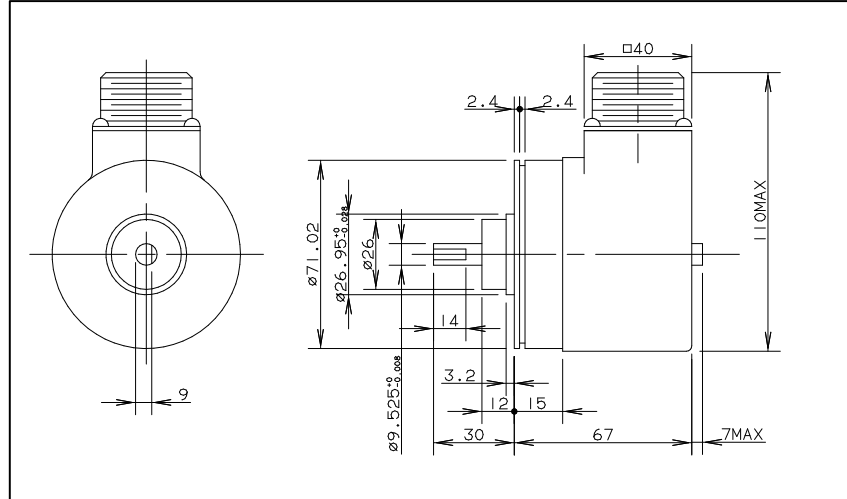
11 : 20000/rev (Up to 3000min<sup>-1</sup>)

12 : 25000/rev (Up to 2400min<sup>-1</sup>)

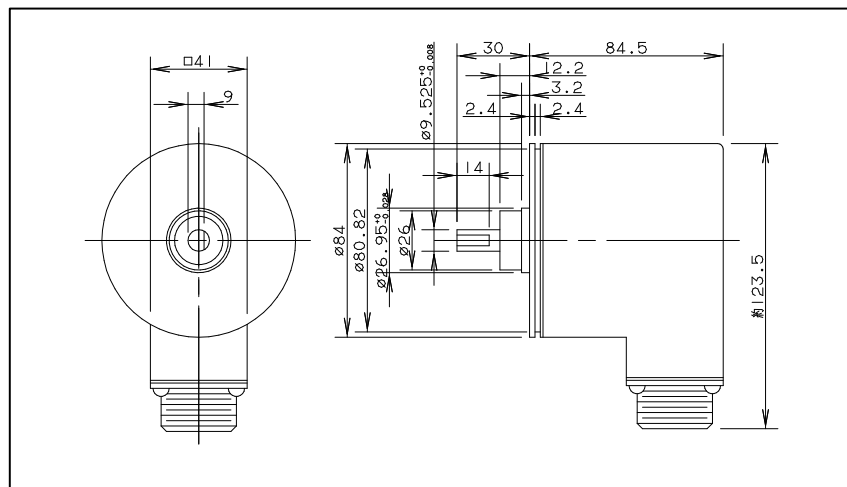
13 : 30000/rev (Up to 2000min<sup>-1</sup>)

### Pulse coder unit outside dimensions

- Incremental pulse coder unit



- Absolute pulse coder unit
- High-speed high resolution pulse coder unit



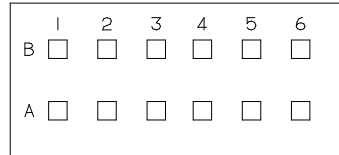
**Pulse coder unit specifications**

Power supply	5V $\pm$ 5%, 0.35A or less
Maximum pulse rate	100KHz
Working temperature range	0°C to 60 °C
Rated loads	Radial 2.0kg, Axial 1.0kg
Shaft diameter runout	0.02mm
Weight	2.0kg
Rotor inertia	Max. 0.057g·cm·sec <sup>2</sup>
Friction torque	Max. 0.8kg·cm

## 6.5 DETECTOR INPUT/OUTPUT SIGNALS

The  $\alpha$ -type pulse coders signals are inputted or outputted as shown below. The pin assignments of the signals for the connector used for each model are also shown. (The output signals and pin assignments for serial pulse coder A are the same as those for the  $\alpha$ -type pulse coder.)

### Model $\alpha 0.5/3000$

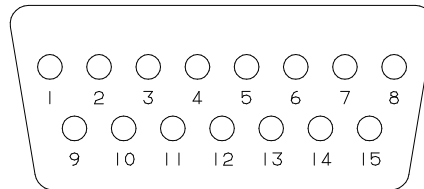


Dynamic D-3100D  
Free hanging type  
(Manufactured by AMP Japan;  
178964-6)

Mating cable connector housing  
specifications  
(Manufactured by AMP Japan;  
178289-6)

Signal name	Pin No.	
	$\alpha A8B$	$\alpha I8B$
SD	A4	A4
*SD	B4	B4
REQ	A3	A3
*REQ	B3	B3
+5V	A2, B2	A2, B2
0V	A1, B1	A1, B1
Shield	B6	B6
+6VA	A5	-
0VA	A6	-

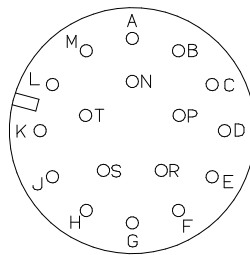
### Models $\alpha 1/3000$ , $\alpha 2/2000$ , $\alpha 2/3000$



D-SUB 15P

Signal name	Pin No.	
	$\alpha A64$	$\alpha I64$
SD	12	12
*SD	13	13
REQ	5	5
*REQ	6	6
+5V	8, 15	8, 15
0V	1, 2, 3	1, 2, 3
Shield	4	4
+6VA	14	-
0VA	10	-

### Models $\alpha 3/3000$ to $\alpha 150/2000$ $\alpha 3/3000HV$ to $\alpha 30/3000HV$ $\alpha C3/2000$ to $\alpha C22/1500$ $\alpha M3/3000$ to $\alpha M9/3000$ $\alpha L3/3000$ to $\alpha L50/3000$



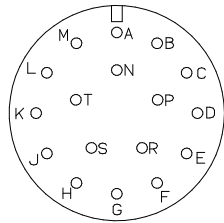
3102A 20-29PW

Signal name	Pin No.	
	$\alpha A64$ $\alpha A8$ SerialA	$\alpha I64$ $\alpha I8$
SD	A	A
*SD	D	D
REQ	F	F
*REQ	G	G
+5V	J, K	J, K
0V	N, T	N, T
Shield	H	H
+6VA	R	-
0VA	S	-

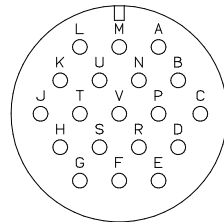
# 6.6 SIGNALS INPUT/OUTPUT FROM SEPARATE-TYPE DETECTOR

The separate-type detector signals are inputted or outputted as follows:

Separate type incremental absolute pulse coder unit



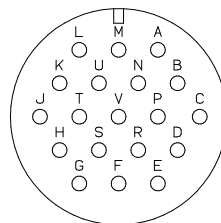
3102A20-29P



3102A22-14P

Signal names of the pulse coder	Pin names of the connector	
	Incremental 310A20-29P	Absolute 3102A22-14P
A	A	A
*A	D	B
B	B	C
*B	E	D
Z	F	E
*Z	G	F
C1	—	G
C2	—	H
C4	—	J
C8	—	K
+5V	C, J, K	L
0V	N, P, T	M
shield	H	N
OH1	—	—
OH2	—	—
REQ	—	S
+6VA	—	T
0VA	—	U

Separate type high-speed and high-resolution pulse coder unit



3102A22-14P

Signal names of the pulse coder	Pin names of the connector
	High-speed and high-resolution 3102A22-14P
A	A
AR	B
B	C
BR	D
Z	E
*Z	F
C1	G
C2	H
C4	J
C8	K
+5V	L, T
0V	M, U
Shield	N
OH1	—
OH2	—

# 7

## BUILT-IN BRAKE



Some of the  $\alpha$ ,  $\alpha$ (HV),  $\alpha$ C,  $\alpha$ M, and  $\alpha$ L series Models 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 appropriate outline drawings.



## 7.1 BRAKE SPECIFICATIONS

The specifications of built-in brakes are listed below.

Motor model	Unit	$\alpha 0.5$	$\alpha 1$ $\alpha 2$	$\alpha 3$ $\alpha 6$ $\alpha 3HV$ $\alpha 6HV$ $\alpha C3$ $\alpha C6$ $\alpha M3$ $\alpha M6$ $\alpha M9$	$\alpha 12$ $\alpha 22$ $\alpha 30$ $\alpha 12HV$ $\alpha 22HV$ $\alpha 30HV$ $\alpha C12$ $\alpha C22$	$\alpha 40$	$\alpha 65$ $\alpha 100$ $\alpha 150$
Brake torque	Nm kgf-cm	0.65 6.6	2 20	8 82	35 357	35 357	100 1020
Response time	Release	msec	40	60	80	150	150
	Brake	msec	20	10	40	20	20
Supply voltage	VDC ( $\pm 10\%$ )	90	90	90	90	90	90
Current	A	0.1 or less	0.3 or less	0.4 or less	0.6 or less	0.6 or less	0.9 or less
Weight increase	kg	Approx. 0.4kg	Approx. 1.3kg	Approx. 2.3kg	Approx. 6.3kg	Approx. 10kg	Approx. 15kg
Inertia increase	kg·m <sup>2</sup> kgf·cm·s <sup>2</sup>	0.000009 0.00009	0.00002 0.0002	0.00007 0.0007	0.0006 0.006	0.0010 0.010	0.0010 0.010

Motor model	Unit	$\alpha L3$ $\alpha L6$ $\alpha L9$	$\alpha L25$ $\alpha L50$	$\alpha L25$ $\alpha L50$
Brake torque	Nm kgf-cm	8 82	18 184	40 408
Response time	Release	msec	80	100
	Brake	msec	40	60
Supply voltage	VDC ( $\pm 10\%$ )	90	90	90
Current	A	0.4 or less	0.6 or less	0.8 or less
Weight increase	kg	Approx. 2.3kg	Approx. 6.0kg	Approx. 7.0kg
Inertia increase	kg·m <sup>2</sup> kgf·cm·s <sup>2</sup>	0.00007 0.0007	0.0006 0.006	0.0006 0.006

## Common notes to each series

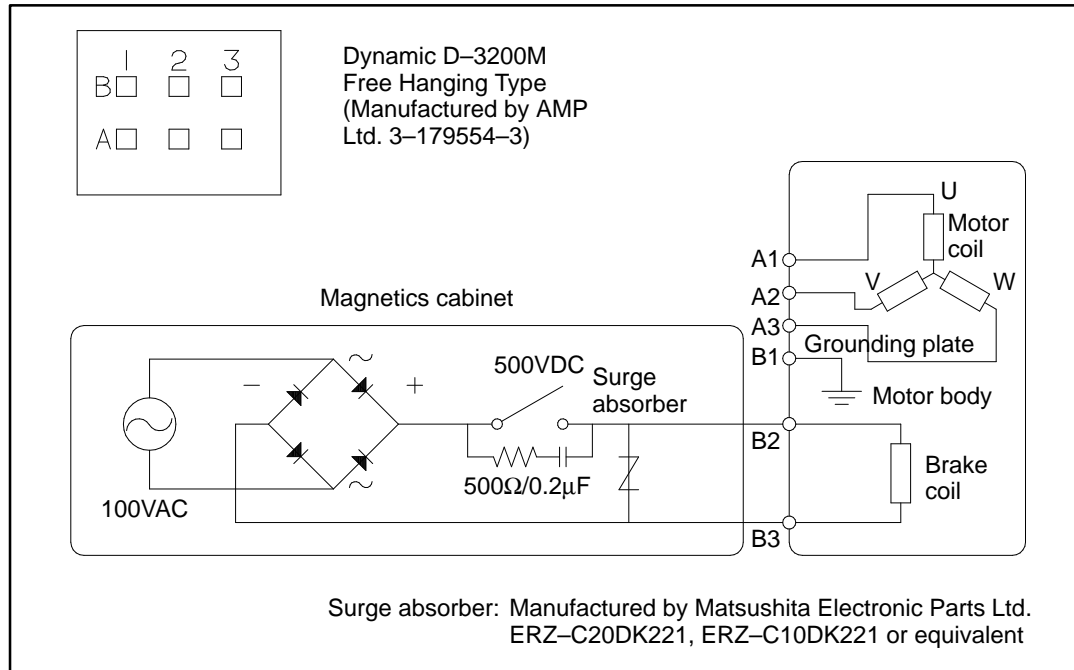
### Notes

1. Use the full-wave rectified 100VAC or 90VDC as a power supply. Don't use the half-wave rectified 200VAC. The surge suppressor 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.
2. 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 in normal operation.
3. Allow sufficient time to start the servo motor before releasing the brake. Don't use the brake as an aid for the axis to stop at the same position for a long time, such as an index table. 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.
4. Models  $\alpha$ 40/2000 are longer because they contain a brake. If an excessive load is applied to the opposite side of the flange, the flange may be damaged. Do not apply any load to the opposite side of the flange, and do not subject the motor to excessive force.

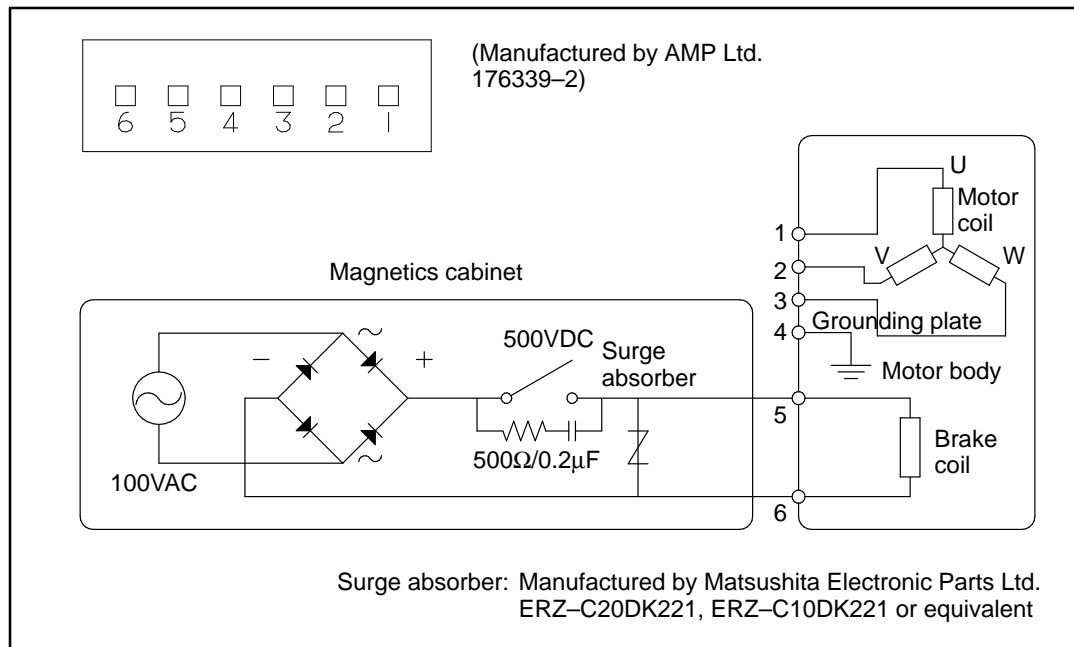
## 7.2 CONNECTION OF THE BRAKES

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

### Model α0.5

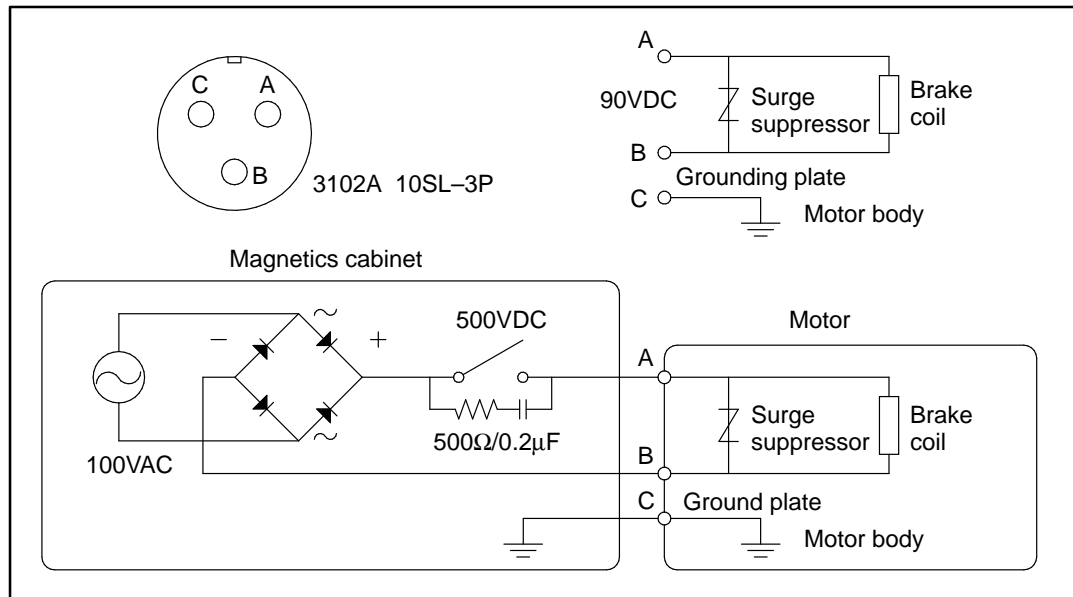


### Models α1 and α2



**Models**

$\alpha 3$  to  $\alpha 150$ ,  $\alpha C$ ,  $\alpha M$ , and  $\alpha L$



# 8

## CONNECTORS



## 8.1 CONNECTOR ON THE MOTOR SIDE

The FANUC  $\alpha$  series AC servo motors use TÜV-approved connectors on the power cable and brake/fan unit in order to comply with the IEC34 standard. Drip-proof receptacle connectors are used as standard for all cables including those for signals (except for the  $\alpha 0.5$ ,  $\alpha 1$ , and  $\alpha 2$  series). These connectors are drip-proof even when not engaged.

Strictly speaking, the IEC34 for connectors is different from the MS standard with respect to the connector disengaged-state waterproof function and appearance (black in color). However, the TÜV-approved connectors are compatible with the MS-standard round connectors in size and shape. So, MS-standard plug connectors other than those recommended below are also usable. (The waterproof plug connectors recommended in Sections 8.3.1 and 8.3.2 should be used if it is necessary to keep the whole system waterproof.)

### 8.1.1 Specifications of Connectors on the Motor Side

$\alpha 0.5$  to  $\alpha 2$

Motor model	Power cable	Signal cable	Brake circuit cable
$\alpha 0.5/3000$	3-179554-3 (AMP Japan)	178964-6 (AMP Japan)	The brake circuit cable should be accommodated in the power cable connector. See Section 6.2 for detailed connection diagrams.
$\alpha 1/3000$ $\alpha 2/2000$ , $\alpha 2/3000$	176339-2 (AMP Japan)	SDAB-15P (Hirose Electric)	

#### Note

The specification of the AMP Japan connector for the model  $\alpha 0.5$  does not include a contact; it only includes a connector housing.

$\alpha 3$  to  $\alpha 40$ ,  $\alpha(HV)$ ,  $\alpha C$ ,  $\alpha M$ ,  $\alpha L$

Power cable			Signal cable	Brake/fan cable
$\alpha 3/3000$ , $\alpha 6/2000$ $\alpha 6/3000$ $\alpha 3/3000HV$ , $\alpha 6/3000HV$ $\alpha C3/2000$ , $\alpha C6/2000$ $\alpha M3/3000$ , $\alpha M6/3000$ $\alpha M9/3000$ , $\alpha L3/3000$ $\alpha L6/3000$ , $\alpha L9/3000$	$\alpha 12/2000$ , $\alpha 12/3000$ $\alpha 22/1500$ , $\alpha 22/2000$ $\alpha 30/1200$ $\alpha 12/3000HV$ $\alpha 22/3000HV$ $\alpha 30/3000HV$ $\alpha C12/2000$ , $\alpha C22/1500$	$\alpha 22/3000$ , $\alpha 30/2000$ $\alpha 30/3000$ , $\alpha 40/2000$ $\alpha 40/2000fan$ $\alpha L25/3000$ $\alpha L50/2000$	(Common to all models)	(Common to all models)
H/MS3102A18-10P-D-T(10) (Hirose electric)	JL04HV-2E22-22PE-B (Japan Aviation Electronics Industry)	JL04V-2E24-10PE(G)B (Japan Aviation Electronics Industry)	H/MS3102A20-29PCW4(10) (Hirose electric)	JL04V-2E10SL-3PE-B (Japan Aviation Electronics Industry)

**Notes**

1. The motors should be installed with their connector facing downward as long as possible. When it is impossible to install a motor in this position, allow slack in the cable to keep liquids such as a dielectric fluid from going along the cable into the cable or motor. If there is a possibility that the motors and connectors get wet, provide a cover to protect them.
2. If a motor is not connected to the earth ground through the machine (frame), connect the motor grounding point and the amplifier grounding point to absorb noise using a 1.25 mm<sup>2</sup> or larger conductor other than the grounding conductor in the power cable. Keep the grounding conductor as far from the power cable as possible.

## 8.2 CONNECTORS ON THE CABLE SIDE (MODELS $\alpha 0.5$ , $\alpha 1$ AND $\alpha 2$ )

FANUC can provide TÜV-approved connectors for models  $\alpha 0.5$ ,  $\alpha 1$ , and  $\alpha 2$ . The table below lists the specifications of connector kits. The connectors used in models  $\alpha 1$  and  $\alpha 2$  are dripproof in an engaged position.

### 8.2.1 Connector Kit Specifications

Motor model	Power cable		Signal cable (straight type)	
	$\alpha 0.5/3000$	3-178129-6 [housing] 1-175217-2 [contact] (AMP Japan) A06B-6050-K119 (FANUC specification)		178289-6 [housing] 1-175217-2 [contact] (AMP Japan) A06B-6050-K120 (FANUC specification)
Necessary number of contacts	4 (or 6 for model with a brake)		11 (for absolute) or 9 (for incremental)	
Applicable wire size (Note 1)	AWG#20		AWG#24	AWG#22 AWG#20
Insulation external diameter (Note 2)	$\phi 1.7\text{--}2.6$		$\phi 1.2\text{--}1.6$	$\phi 1.7\text{--}2.6$
$\alpha 1/3000$ $\alpha 2/2000$ , $\alpha 2/3000$	176346-6 (AMP Japan) A06B-6050-K121 (FANUC specification)		HDAB-15S [contact] HDAW-15-CV [waterproof cover] (Hirose Electric) A06B-6050-K115 (FANUC specification)	
Contact	Contacts are included.		One-piece soldering type	
Applicable wire size (Note1)	AWG#18	AWG#16	AWG#20 (maximum)	
Insulation external diameter (Note 2)	$\phi 1.8\text{--}2.8$	$\phi 2.2\text{--}2.8$		



**Notes**

1. AMP Japan connector contacts used in the power cable for the  $\alpha 0.5$  and signal cable for the  $\alpha 1$  and  $\alpha 2$  are crimp type. Be careful about the applicable wire and necessary number of contacts ( $\alpha 0.5$  only). Each FANUC specification includes the contacts and housing. The size of conductors used must meet the following requirements so that they carry the required current.

$\alpha 0.5$  power cable: AWG#20

$\alpha 1$  and 2 power cables: AWG#18 to 16

$\alpha 0.5$ ,  $\alpha 1$  and  $\alpha 2$  signal cables: AWG#20 for +5V, 0V, 6VA, and 0VA, and AWG#24 or greater for the others

2. For crimp contacts, insulations as well as wires are crimped. So, they must meet the size requirements listed above. An insulation smaller than those listed here may also be used depending on the wire and tool used. Contact AMP Japan for details. For  $\alpha 1$  and  $\alpha 2$  power cables, select the external diameter that matches the cable clamp applicable range (9.9 to 10.9 mm<sup>2</sup>) in order to secure TUV approval and waterproof performance.

The following dedicated tools are required to insert and remove the contacts. They should be prepared separately from the connector kit.

Crimping tool specification ( $\alpha 1$  and  $\alpha 2$ ): 914596-3 (AMP Japan)  
A97L-0200-0979/L  
(FANUC)

Crimping tool specification ( $\alpha 0.5$ ): 914595-2 (AMP Japan)  
A97L-0200-0979/M (FANUC)

Extractor specification (common to  $\alpha 0.5$ ,  $\alpha 1$ , and  $\alpha 2$ ):  
914677-1 (AMP Japan)  
A97L-0200-0980/D3 (FANUC)

**8.2.2****Cable Assembly Specifications (14m standard)**

Motor model	Power cable	Power cable (for model with brake)	Signal cable (straight type)
$\alpha 0.5/3000$	A06B-6050-K822 (FANUC specification)	A06B-6050-K823 (FANUC specification)	A02B-0200-K802 (FANUC specification)
$\alpha 1/3000$ $\alpha 2/2000$ $\alpha 2/3000$	A06B-6050-K824 (FANUC specification)	A06B-6050-K825 (FANUC specification)	A06B-6050-K853 (FANUC specification)

**Note**

The signal cable assembly is applicable when the NC is Series16, Series18-A, Series15-B, Series21-TA, Power Mate MODEL D or F (type A interface), Series16-B, Series18-B, Series20, Series21-GA, Series21-TB, or Power Mate MODEL H (type B interface).

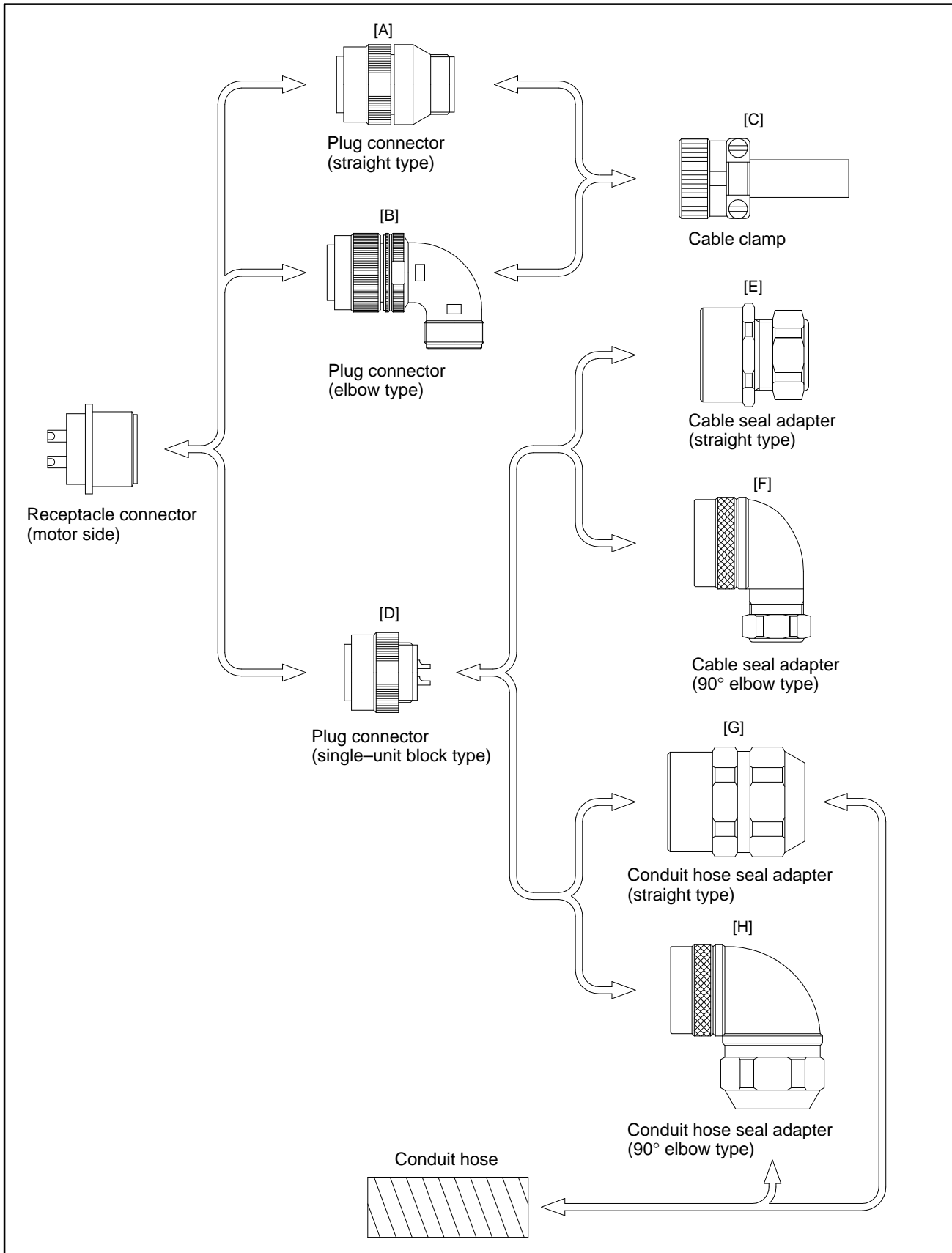
### **8.3 SPECIFICATIONS OF THE CONNECTORS ON THE CABLE SIDE (MODELS $\alpha$ 3 AND HIGHER)**

To meet the IEC34 standard, TÜV-approved plug connectors and cable clamps should be used in connecting the power cable and brake/fan unit. To meet the IEC34 standard by using a cable or conduit hose seal adaptor, contact the manufacturer for details.

FANUC can provide TÜV-approved types (waterproof), waterproof types, and non-waterproof types as plug connectors on the cable side for the FANUC  $\alpha$  series AC servo motors; all these connectors are black. Of course, conventional plug connectors may be used, because they are MS-compatible.

The specifications of each connector are explained based on the examples shown below.

### Example of connector connection



### 8.3.1 Specifications of Plug Connectors on the Cable Side (Waterproof TÜV-Approved Type)

Con- nec- tor type	Power cable				Signal cable (Common to all models)	Brake/fan cable (Common to all models)
	$\alpha$ 3/3000, $\alpha$ 6/3000 $\alpha$ 3/3000HV, $\alpha$ 6/3000HV $\alpha$ C3/2000, $\alpha$ M3/3000, $\alpha$ M9/3000, $\alpha$ L6/3000,	$\alpha$ 6/2000 $\alpha$ 6/3000HV $\alpha$ C6/2000 $\alpha$ M6/3000 $\alpha$ L3/3000 $\alpha$ L9/3000	$\alpha$ 12/2000, $\alpha$ 12/3000 $\alpha$ 22/1500, $\alpha$ 22/2000 $\alpha$ 30/1200 $\alpha$ 12/3000HV $\alpha$ 22/3000HV $\alpha$ 30/3000HV $\alpha$ C12/2000 $\alpha$ C22/1500	$\alpha$ 12/3000 $\alpha$ 22/2000		
[A]	H/MS3106A18-10S-D-T(10) (Hirose Electric)	JL04V-6A22-22SE-EB (Japan Aviation Electronics Industry)	JL04V-6A24-10SE(G)-EB (Japan Aviation Electronics Industry)	The IEC34 standard does not apply to signal cable connectors.	JL04V-6A10SL-3SE-EB (Japan Aviation Electronics Industry)	
[B]	H/MS3108B18-10S-D-T(10) (Hirose Electric)	JL04V-8A22-22SE-EB (Japan Aviation Electronics Industry)	JL04V-8A24-10SE(G)-EB (Japan Aviation Electronics Industry)		JL04V-8A10SL-3SE-EB (Japan Aviation Electronics Industry)	
[C]	H/MS3057-10A(10) (Hirose Electric)	JL04-2022CK-(14) (Japan Aviation Electronics Industry)	JL04-2428CK-(17) (Japan Aviation Electronics Industry)		JL04-1012CK-(05) (Japan Aviation Electronics Industry)	
[D]	H/MS3106A18-10S-D-T(13) (Hirose Electric)	JL04V-6A22-22SE (Japan Aviation Electronics Industry)	JL04V-6A24-10SE(G) (Japan Aviation Electronics Industry)		JL04V-6A10SL-3SE (Japan Aviation Electronics Industry)	

See the examples of connector connection for [A] to [D].

#### Note

If connector type [D] is used in conjunction with a cable or conduit seal adapter to meet the IEC34 standard, contact an appropriate maker for details.

### 8.3.2 Specifications of Plug Connectors on the Cable Side (Waterproof Type)

Con- nec- tor type	Power cable			Signal cable (Common to all models)	Brake/fan cable (Common to all models)
	$\alpha$ 3/3000, $\alpha$ 6/3000, $\alpha$ 6/3000HV $\alpha$ C3/2000, $\alpha$ M3/3000, $\alpha$ M9/3000, $\alpha$ L6/3000	$\alpha$ 6/2000 $\alpha$ 3/3000HV $\alpha$ C6/2000 $\alpha$ M6/3000 $\alpha$ L3/3000 $\alpha$ L9/3000	$\alpha$ 12/2000, $\alpha$ 12/3000 $\alpha$ 22/1500, $\alpha$ 22/2000 $\alpha$ 30/1200 $\alpha$ 12/3000HV $\alpha$ 22/3000HV $\alpha$ 30/3000HV $\alpha$ C12/2000 $\alpha$ C22/1500		
[A]	H/MS3106A18-10S(10) (Hirose Electric) JA06A-18-10S-J1-EB (Japan Aviation Electronics Industry)	H/MS3106A22-22S(10) (Hirose Electric) JA06A-22-22S-J1-EB (Japan Aviation Electronics Industry)	H/MS3106A24-10S(10) (Hirose Electric) JA06A-24-10S-J1-EB (Japan Aviation Electronics Industry)	H/MS3106A20-29SW(11) (Hirose Electric) JA06A-20-29SW-J1-EB (Japan Aviation Electronics Industry)	H/MS3106A10SL-3S(10) (Hirose Electric) JA06A-10SL-3S-J1-EB (Japan Aviation Electronics Industry)
[B]	H/MS3108B18-10S(10) (Hirose Electric) JA08A-18-10S-J1-EB (Japan Aviation Electronics Industry)	H/MS3108B22-22S(10) (Hirose Electric) JA08A-22-22S-J1-EB (Japan Aviation Electronics Industry)	H/MS3108B24-10S(10) (Hirose Electric) JA08A-24-10S-J1-EB (Japan Aviation Electronics Industry)	H/MS3108B20-29SW(11) (Hirose Electric) JA08A-20-29SW-J1-EB (Japan Aviation Electronics Industry)	H/MS3108B10SL-3S(10) (Hirose Electric) JA08A-10SL-3S-J1-EB (Japan Aviation Electronics Industry)
[C]	H/MS3057-10A(10) (Hirose Electric) JL04-18CK-(13) (Japan Aviation Electronics Industry)	H/MS3057-12A(10) (Hirose Electric) JL04-2022CK-(14) (Japan Aviation Electronics Industry)	H/MS3057-16A(10) (Hirose Electric) JL04-2428CK-(17) (Japan Aviation Electronics Industry)	H/MS3057-12A(10) (Hirose Electric) JL04-2022CK-(14) (Japan Aviation Electronics Industry)	H/MS3057-4A(10) (Hirose Electric) JL04-1012CK-(05) (Japan Aviation Electronics Industry)
[D]	JA06A-18-10S-J1-(A72) (Japan Aviation Electronics Industry) H/MS3106A18-10S-(13) (Hirose Electric)	JA06A-22-22S-J1-(A72) (Japan Aviation Electronics Industry) H/MS3106A22-22S(13) (Hirose Electric)	JA06A-24-10S-J1-(A72) (Japan Aviation Electronics Industry) H/MS3106A24-10S(13) (Hirose Electric)	JA06A-20-29SW-J1-(A72) (Japan Aviation Electronics Industry) H/MS3106A20-29SW(14) (Hirose Electric)	JA06A-10SL-3S-J1-(A72) (Japan Aviation Electronics Industry) H/MS3106A10SL-3S(13) (Hirose Electric)
[E]	YSO 18-12-14 (Daiwa Dengyo) ACS-12RL-MS18F (Nippon Flex)	YSO 22-12-14 (Daiwa Dengyo) ACS-16RL-MS22F (Nippon Flex)	YSO 24-15-17 (Daiwa Dengyo) ACS-20RL-MS24F (Nippon Flex)	YSO 20-9-11 (Daiwa Dengyo) ACS-12RL-MS20F (Nippon Flex)	YSO 10-5-8 (Daiwa Dengyo)
[F]	YLO 18-12-14 (Daiwa Dengyo) ACA-12RL-MS18F (Nippon Flex)	YLO 22-12-14 (Daiwa Dengyo) ACA-16RL-MS22F (Nippon Flex)	YLO 24-15-17 (Daiwa Dengyo) ACA-20RL-MS24F (Nippon Flex)	YLO 20-9-11 (Daiwa Dengyo) ACA-12RL-MS20F (Nippon Flex)	YLO 10-5-8 (Daiwa Dengyo)
[G]	BOS 18-15 (Daiwa Dengyo) RCC-104RL-MS18F (Nippon Flex)	BOS 22-19 (Daiwa Dengyo) RCC-106RL-MS22F (Nippon Flex)	BOS 24-19 (Daiwa Dengyo) RCC-106RL-MS24F (Nippon Flex)	BOS 20-15 (Daiwa Dengyo) RCC-104RL-MS20F (Nippon Flex)	BOS 10-9 (Daiwa Dengyo)
[H]	BOL 18-15 (Daiwa Dengyo) RCC-304RL-MS18F (Nippon Flex)	BOL 22-19 (Daiwa Dengyo) RCC-306RL-MS22F (Nippon Flex)	BOL 24-19 (Daiwa Dengyo) RCC-306RL-MS24F (Nippon Flex)	BOL 20-15 (Daiwa Dengyo) RCC-304RL-MS20F (Nippon Flex)	BOL 10-9 (Daiwa Dengyo)

See the examples of connector connection for [A] to [H].

Combining a plug connector (one-piece block type) and an adapter (combination of [D] with [E] to [H] in “Example of connector connection”) can enhance waterproofness for cables and connector contacts. (Specification numbers of two manufacturers are listed for reference.) Of course, conventional waterproof plug connectors may be used, because they are MS-compatible. This table is only a guideline. Contact an appropriate maker for details. Do not connect the 0V pulse corder signal line to the connector shell.

### 8.3.3 Specifications of Plug Connectors on the Cable Side (Non-waterproof Type)

Con- nec- tor type	Power cable						Signal cable (Common to all models)	Brake/fan cable (Common to all models)
	$\alpha$ 3/3000, $\alpha$ 6/3000, $\alpha$ 6/3000HV $\alpha$ C3/2000, $\alpha$ M3/3000, $\alpha$ M9/3000, $\alpha$ L6/3000,	$\alpha$ 6/2000 $\alpha$ 3/3000HV $\alpha$ C6/2000 $\alpha$ M6/3000 $\alpha$ L3/3000 $\alpha$ L9/3000	$\alpha$ 12/2000, $\alpha$ 22/1500, $\alpha$ 30/1200 $\alpha$ 12/3000HV $\alpha$ 22/3000HV $\alpha$ 30/3000HV $\alpha$ C12/2000 $\alpha$ C22/1500	$\alpha$ 12/3000 $\alpha$ 22/2000	$\alpha$ 22/3000, $\alpha$ 30/3000, $\alpha$ 40/2000 $\alpha$ 40/2000fan $\alpha$ L25/3000 $\alpha$ L50/2000			
[A]	MS3106B18-10S-(A72) (Japan Aviation Electronics Industry) H/MSA3106A18-10S(10) (Hirose Electric)	MS3106B22-22S-(A72) (Japan Aviation Electronics Industry) H/MSA3106A22-22S(10) (Hirose Electric)	MS3106B24-10S-(A72) (Japan Aviation Electronics Industry) H/MSA3106A24-10S(10) (Hirose Electric)	MS3106B20-29SW-(A72) (Japan Aviation Electronics Industry) H/MSA3106A20-29SW(11) (Hirose Electric)	MS3106B10SL-3S-(A72) (Japan Aviation Electronics Industry) H/MSA3106A10SL-3S(10) (Hirose Electric)			
[B]	MS3108B18-10S-(A72) (Japan Aviation Electronics Industry) H/MSA3108B18-10S(10) (Hirose Electric)	MS3108B22-22S-(A72) (Japan Aviation Electronics Industry) H/MSA3108B22-22S(10) (Hirose Electric)	MS3108B24-10S-(A72) (Japan Aviation Electronics Industry) H/MSA3108B24-10S(10) (Hirose Electric)	MS3108B20-29SW-(A72) (Japan Aviation Electronics Industry) H/MSA3108B20-29SW(11) (Hirose Electric)	MS3108B10SL-3S-(A72) (Japan Aviation Electronics Industry) H/MSA3108B10SL-3S(10) (Hirose Electric)			
[C]	MS3057-10A-(A72) (Japan Aviation Electronics Industry) H/MSA3057-10A(10) (Hirose Electric)	MS3057-12A-(A72) (Japan Aviation Electronics Industry) H/MSA3057-12A(10) (Hirose Electric)	MS3057-16A-(A72) (Japan Aviation Electronics Industry) H/MSA3057-16A(10) (Hirose Electric)	MS3057-16A-(A72) (Japan Aviation Electronics Industry) H/MSA3057-12A(10) (Hirose Electric)	MS3057-4A-(A72) (Japan Aviation Electronics Industry) H/MSA3057-4A(10) (Hirose Electric)			

See the examples of connector connection for [A] to [C].

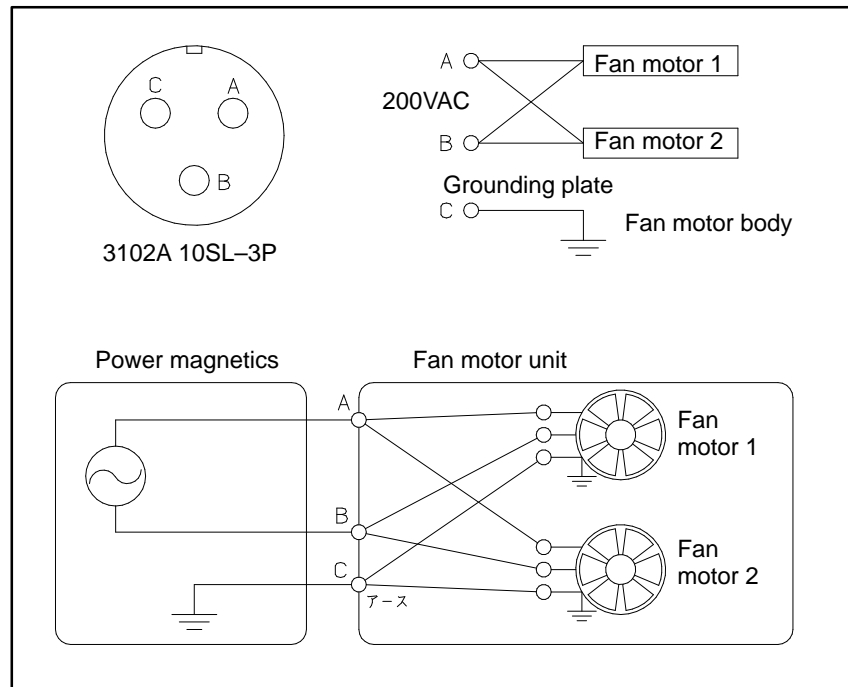
This table lists only examples. Contact each manufacturer for details.

# 9 COOLING FAN FOR MODEL α40

Model α40 can be fitted with an optional cooling fan. The cooling fan requires a single-phase 200 VAC power supply. The connection and operating current are given below. Use fuses or a circuit breaker in the power magnetics cabinet.

Input voltage	Steady-state current	Surge current
200V	Approx. 0.85Arms	Approx. 1.60Arms
230V	Approx. 0.98Arms	Approx. 1.84Arms

## Connection diagram



## **II. FANUC AC SERVO MOTOR $\alpha$ series**



# 1

## GENERAL



## 1.1 FEATURES OF COMPACT-TYPE $\alpha$ SERVO MOTOR ( $\alpha$ 0.5)

The FANUC AC servo motor  $\alpha$ 0.5 is a compact servo motor suitable for peripheral machine tool equipment. It has the following features:

### **Excellent acceleration characteristics**

A high maximum output torque and intermediate rotor inertia result in excellent acceleration characteristics.

### **Compact**

The use of the latest neodymium ferrite magnet, combined with a redesigned stator, results in servo motor that is both smaller and lighter than previous models.

### **Extended continuous-operation**

The use of the latest servo software minimizes the heat generated by high-speed rotation, allowing continuous operation over a wide range.

### **Controllability**

The use of the latest servo software maintains controllability even when a disturbance occurs.

### **High-performance detector**

The AC servo motor  $\alpha$ 0.5 is fitted with incremental pulse coder  $\alpha$ I8B or absolute pulse coder  $\alpha$ A8B as its standard pulse coder.

### **Powerful brake**

A powerful brake with an increased holding torque is available as an option. The brake uses an asbestos-free design.

## 1.2 FEATURES OF SERVO MOTOR $\alpha$ series ( $\alpha 1$ to $\alpha 150$ )

The FANUC AC servo motor  $\alpha$  series consists of a range of servo motors that are suitable for the feed axes of machine tools. They have the following features:

### Excellent acceleration characteristics

The rotor inertia has been reduced without sacrificing maximum output torque. As a result, the motors offer excellent acceleration characteristics.

### Compact

The use of the latest ferrite magnet, combined with an optimized mechanical design, reduces both the overall length and weight. The result is compact, lightweight servo motors.

### Excellent waterproofing

The use of waterproof connectors and FANUC's unique stator seal provide excellent waterproofing, ensuring that no liquid, such as coolant, can enter the motor.

### Extended continuous-operation

The use of the latest servo software minimizes the heat generated by high-speed rotation, allowing continuous operation over a wide range.

### Smooth rotation

Further improvements have been made to the unique magnetic pole shape to minimize torque ripple. The result is extremely smooth rotation.

### Controllability

The use of the latest servo software maintains controllability even when a disturbance occurs.

### High-performance detector

The high-resolution pulse coder model  $\alpha A64$  or  $\alpha I64$  is provided as standard. This pulse coder allows precise positioning.

### Powerful brake

A powerful brake with an increased holding torque is available as an option. The brake uses an asbestos-free design.

# 2 TYPES OF MOTORS AND DESIGNATION

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

## Model $\alpha 0.5/3000$

**A06B-01**□□-**B**☆○○

□□

**13** : Model  $\alpha 0.5/3000$

☆

**0** : Straight shaft (standard)

**1** : Straight shaft with the brake (0.65Nm)

○○

**78** : With the pulse coder  $\alpha A8B$

**80** : With the pulse coder  $\alpha I8B$

## Models $\alpha 1/3000$ , $\alpha 2/2000$ , and $\alpha 2/3000$

**A06B-03**□□-**B**☆○○

□□

**71** : Model  $\alpha 1/3000$

**72** : Model  $\alpha 2/2000$

**73** : Model  $\alpha 2/3000$

☆

**0** : Taper shaft (standard)

**1** : Taper shaft with the brake (2Nm)

**5** : Straight shaft

**6** : Straight shaft with the brake (2Nm)

○○

**75** : With the pulse coder  $\alpha A64$

**77** : With the pulse coder  $\alpha I64$

**84** : With the serial pulse coder A

The standard shafts used for models  $\alpha 1/3000$ ,  $\alpha 2/2000$ , and  $\alpha 2/3000$  are taper shafts. Use a taper shaft as far as circumstances, such as the delivery time and maintenance, permit.

**Models** **$\alpha$ 3/3000,  $\alpha$ 6/2000,  
and  $\alpha$ 6/3000****A06B-01□□-B☆○○**

□□

**23** : Model  $\alpha$ 3/3000**27** : Model  $\alpha$ 6/2000**28** : Model  $\alpha$ 6/3000

☆

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

○○

**75** : With the pulse coder  $\alpha$ A64**77** : With the pulse coder  $\alpha$ I64**84** : With the serial pulse coder A

The standard shafts used for models  $\alpha$ 3/3000,  $\alpha$ 6/2000, and  $\alpha$ 6/3000 are taper shafts. Use a taper shaft as far as circumstances, such as the delivery time and maintenance, permit.

**Models** **$\alpha$ 12/2000,  $\alpha$ 12/3000,  
 $\alpha$ 22/1500,  $\alpha$ 22/2000,  
 $\alpha$ 22/3000,  $\alpha$ 30/1200,  
 $\alpha$ 30/2000,  $\alpha$ 30/3000,  
 $\alpha$ 40/2000, and  
 $\alpha$ 40/2000 (with fan)****A06B-01□□-B☆○○**

□□

**42** : Model  $\alpha$ 12/2000**43** : Model  $\alpha$ 12/3000**46** : Model  $\alpha$ 22/1500**47** : Model  $\alpha$ 22/2000**48** : Model  $\alpha$ 22/3000**51** : Model  $\alpha$ 30/1200**52** : Model  $\alpha$ 30/2000**53** : Model  $\alpha$ 30/3000**57** : Model  $\alpha$ 40/2000**58** : Model  $\alpha$ 40/2000 (with fan)

☆

**0** : Straight shaft (standard)**1** : Straight shaft with the brake (35Nm)**5** : Taper shaft**6** : Taper shaft with the brake (35Nm)

○○

**75** : With the pulse coder  $\alpha$ A64**77** : With the pulse coder  $\alpha$ I64**84** : With the serial pulse coder A

A straight shaft is fitted as the standard shaft for models  $\alpha$ 12 to  $\alpha$ 40. When early delivery and ease-of-maintenance are important, a straight shaft should be used. For model  $\alpha$ 40, a tapered shaft is not available.

**Models**

$\alpha$ 65/2000,  $\alpha$ 100/2000,  
and  $\alpha$ 150/2000

**A06B-03**□□-**B**☆○○

□□

**31** : Model  $\alpha$ 65/2000

**32** : Model  $\alpha$ 100/2000

**33** ; Model  $\alpha$ 150/2000

☆

**0** : Taper shaft (standard)

**2** : Taper shaft with the brake (100Nm)

○○

**75** ; With the pulse coder  $\alpha$ A64

**77** : With the pulse coder  $\alpha$ I64

**84** : With the serial pulse coder A

# 3

## SPECIFICATIONS AND CHARACTERISTICS



### 3.1 TYPE OF MOTORS AND SPECIFICATIONS

Item	Unit	$\alpha 0.5/3000$	$\alpha 1/3000$	$\alpha 2/2000$ $\alpha 2/3000$
Output	kw	0.2	0.3	0.4 0.5
	HP	0.3	0.4	0.5 0.6
Rated torque at stall	Nm	0.6	1.0	2.0
	kgf·cm	6.5	10	20
Rating output speed	1/min	3000	3000	2000 3000
Maximum theoretical torque	Nm	3.4	8	16
	kgf·cm	35	80	160
Rotor inertia	kg·m <sup>2</sup>	0.000017	0.00036	0.00060
	kgf·cm·s <sup>2</sup>	0.00018	0.0037	0.0061
Maximum theoretical acceleration	rad/s <sup>2</sup>	190000	22000	26000
Weight	kg	1	3	4

The above values are under the condition at 20°C.

#### Note

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.



Item	Unit	$\alpha 3/3000$	$\alpha 6/2000$ $\alpha 6/3000$
Output	kw	0.9	1.0 1.4
	HP	1.3	1.4 1.9
Rated torque at stall	Nm	3.0	6.0
	kgf·cm	31	61
Rating output speed	1/min	3000	2000 3000
Maximum theoretical torque	Nm	27	56
	kgf·cm	280	571
Rotor inertia	kg·m <sup>2</sup>	0.0014	0.0026
	kgf·cm·s <sup>2</sup>	0.014	0.027
Maximum theoretical acceleration	rad/s <sup>2</sup>	20000	21000
Weight	kg	8	13

The above values are under the condition at 20°C.

**Note**

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.

Item	Unit	$\alpha$ 12/2000 $\alpha$ 12/3000	$\alpha$ 22/1500 $\alpha$ 22/2000 $\alpha$ 22/3000	$\alpha$ 30/1200 $\alpha$ 30/2000 $\alpha$ 30/3000	$\alpha$ 40/2000	$\alpha$ 40/2000 (with fan)
Output	kw	2.1 2.8	3.0 3.8 4.4	3.3 4.5 4.8	5.9	7.3
	HP	2.8 3.8	4.0 5.0 5.9	4.4 6.7 7.1	7.8	9.8
Rated torque at stall	Nm	12	22	30	38	56
	kgf-cm	122	225	306	387	571
Rating output speed	1/min	2000 3000	1500 2000 3000	1200 2000 3000	2000	2000
Maximum theoretical torque	Nm	66	130	200	270	270
	kgf-cm	670	1400	2100	2800	2800
Rotor inertia	kg-m <sup>2</sup>	0.0062	0.012	0.017	0.022	0.022
	kgf-cm-s <sup>2</sup>	0.064	0.12	0.17	0.23	0.23
Maximum theoretical acceleration	rad/s <sup>2</sup>	11000	11000	12000	12000	12000
Weight	kg	18	29	41	52	55

The above values are under the condition at 20°C.

**Note**

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.

Item	Unit	$\alpha 65/2000$	$\alpha 100/2000$	$\alpha 150/2000$
Output	kw	8.2	10	12
	HP	11	14	16
Rated torque at stall	Nm	65	100	150
	kgf·cm	663	1019	1529
Rating output speed	1/min	2000	2000	2000
Maximum theoretical torque	Nm	290	440	590
	kgf·cm	3000	4500	6000
Rotor inertia	kg·m <sup>2</sup>	0.019	0.026	0.034
	kgf·cm·s <sup>2</sup>	0.19	0.27	0.35
Maximum theoretical acceleration	rad/s <sup>2</sup>	16000	17000	17000
Weight	kg	80	100	120

The above values are under the condition at 20°C.

**Note**

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.

## 3.2 CHARACTERISTIC CURVE AND DATA SHEET

### Speed-torque characteristics

The intermittent operation zone is determined by the input voltage applied to the drive amplifier. The curve shown is the value for the rated input voltage (200V).

### Overload duty characteristic

The overload duty characteristic curves are determined based on the temperature restriction for the single motor unit (the temperature is restricted by means of a thermal trip built into the motor). 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 the motor shaft is locked. (An overcurrent flows in the motor windings until the thermal trip operates. The temperature rises momentarily.)

To detect such an abrupt temperature rise, the FANUC digital servo system provides a software thermal function that uses servo software to observe the current. During operation that is characterized by frequent acceleration/deceleration cycles, control is imposed by the software thermal function.

Driving units (such as amplifiers) and built-in detectors 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 :  $\alpha 3/3000$

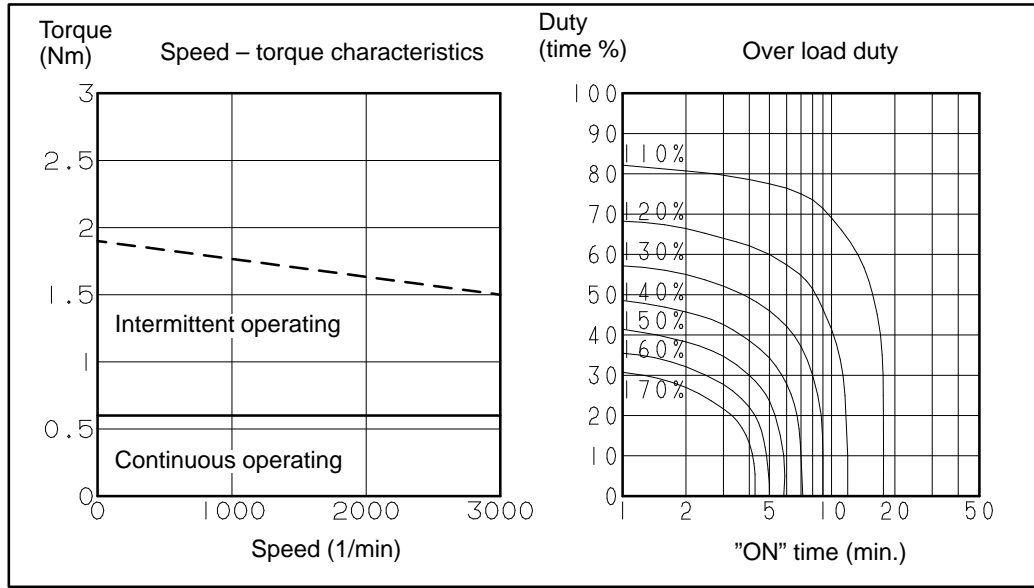
- Motor torque constant = 0.65 (Nm/Arms)
- Amplifier limit value = 40 A<sub>peak</sub>
- Maximum torque value  
 $= 40 \times 0.707 \times 0.65$   
 (Converted to an effective value)  
 $= 18.4 \text{ Nm}$  (Converted to an effective value)

This value is for reference only. The actual value will vary depending on changes in the power supply, as well as variations in motor parameters and amplifier limit values.

In some models, if the maximum current flows in the motor, the actual maximum torque is affected by, for example, magnetic saturation. As a result, the actual maximum torque will be lower than the calculated value. The intermittent operation area (maximum torque value) indicated in the speed to torque characteristics is the effective value, determined according to the combination with the amplifier.

**Model α0.5/3000**

Specification : A06B-0113-B□□□



**Data sheet**

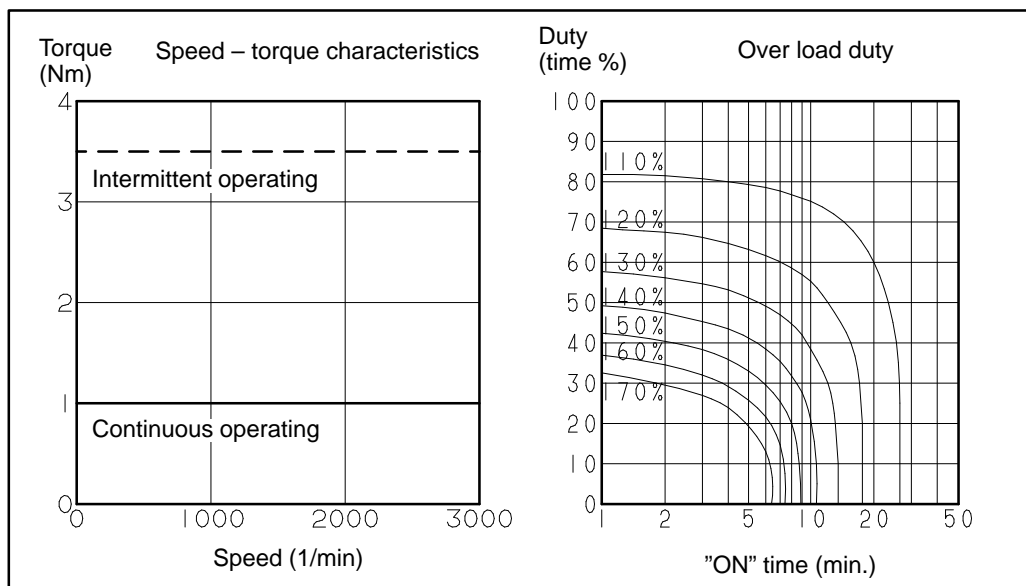
Parameter	Symbol	Value	Unit
Rating output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	0.6	Nm
		6.5	kgfcm
Rotor inertia	Jm	0.000017	kgm <sup>2</sup>
		0.00018	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	2.8	A (rms)
Torque constant (*)	Kt	0.23	Nm/A (rms)
		2.3	kgfcm/A (rms)
Back EMF constant (*)	Ke	7.9	V/1000min <sup>-1</sup>
		0.08	Vsec/rad
Armature resistance (*)	Ra	0.80	Ω
Mechanical time constant (*)	tm	0.0007	s
Thermal time constant	tt	10	min
Static friction	Tf	0.04	Nm
		0.4	kgfcm
Maximum allowable current	Im	19	A (peak)
Maximum theoretical torque	Tm	3.4	Nm
		35	kgfcm
Maximum theoretical acceleration		190000	rad/s <sup>2</sup>
Weight		1.0	kg

(\*) The values are the standard values at 20°C and the tolerance is ± 10%.

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.) These values may be changed without prior notice.

**Model α1/3000**

Specification : A06B-0371-B□□□



**Data sheet**

Parameter	Symbol	Value	Unit
Rating output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	1.0	Nm
		10	kgfcm
Rotor inertia	Jm	0.00036	kgm <sup>2</sup>
		0.0037	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	2.2	A (rms)
Torque constant (*)	Kt	0.44	Nm/A (rms)
		4.5	kgfcm/A (rms)
Back EMF constant (*)	Ke	15.5	V/1000min <sup>-1</sup>
		0.15	Vsec/rad
Armature resistance (*)	Ra	1.73	Ω
Mechanical time constant (*)	tm	0.010	s
Thermal time constant	tt	15	min
Static friction	Tf	0.10	Nm
		1	kgfcm
Maximum allowable current	Im	24	A (peak)
Maximum theoretical torque	Tm	8	Nm
		80	kgfcm
Maximum theoretical acceleration		22000	rad/s <sup>2</sup>
Weight		2.8	kg

(\*)The values are the standard values at 20°C and the tolerance is ± 10%.

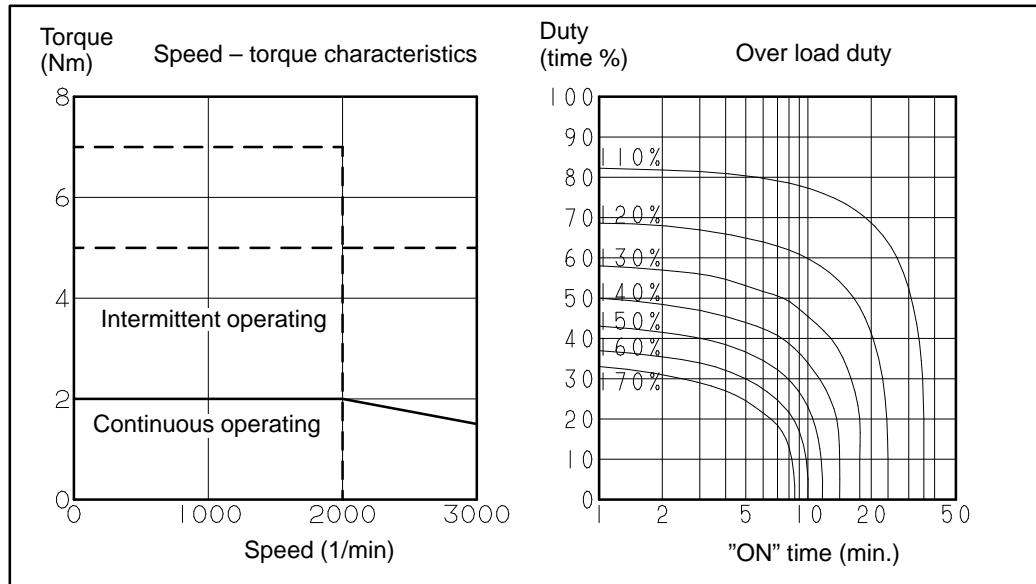
The speed–torque characteristics vary depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.

**Model  $\alpha 2/2000$** 

Specification : A06B-0372-B□□□

**Model  $\alpha 2/3000$** 

Specification : A06B-0373-B□□□

**Data sheet**

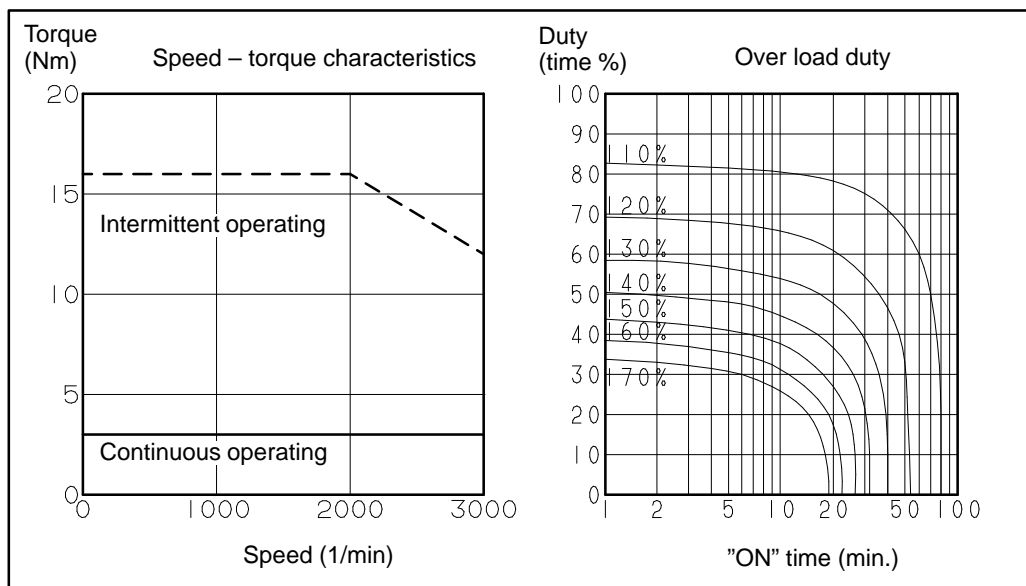
Parameter	Symbol	Value		Unit
Rating output speed	Nmax	2000	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	2.0	2.0	Nm kgfcm
Rotor inertia	Jm	0.00060	0.00060	kgm <sup>2</sup> kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	2.2	2.9	A (rms)
Torque constant (*)	Kt	0.90	0.67	Nm/A (rms) kgfcm/A (rms)
Back EMF constant (*)	Ke	31.3	23.5	V/1000min <sup>-1</sup>
	Kv	0.30	0.22	Vsec/rad
Armature resistance (*)	Ra	2.44	1.38	$\Omega$
Mechanical time constant (*)	tm	0.005	0.005	s
Thermal time constant	tt	20	20	min
Static friction	Tf	0.15	0.15	Nm kgfcm
Maximum allowable current	Im	24	32	A (peak)
Maximum theoretical torque	Tm	16	16	Nm kgfcm
Maximum theoretical acceleration		26000	26000	rad/s <sup>2</sup>
Weight		4.3	4.3	kg

(\*) The values are the standard values at 20°C and the tolerance is  $\pm 10\%$ .

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.) These values may be changed without prior notice.

**Model α3/3000**

Specification : A06B-0123-B□□□



**Data sheet**

Parameter	Symbol	Value	Unit
Rating output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	3.0	Nm
		31	kgfcm
Rotor inertia	Jm	0.0014	kgm <sup>2</sup>
		0.014	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	4.6	A (rms)
Torque constant (*)	Kt	0.65	Nm/A (rms)
		6.6	kgfcm/A (rms)
Back EMF constant (*)	Ke	23	V/1000min <sup>-1</sup>
		0.22	Vsec/rad
Armature resistance (*)	Ra	0.57	Ω
Mechanical time constant (*)	tm	0.006	s
Thermal time constant	tt	45	min
Static friction	Tf	0.3	Nm
		3	kgfcm
Maximum allowable current	Im	60	A (peak)
Maximum theoretical torque	Tm	27	Nm
		280	kgfcm
Maximum theoretical acceleration		20000	rad/s <sup>2</sup>
Weight		8	kg

(\*)The values are the standard values at 20°C and the tolerance is ± 10%.

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.) These values may be changed without prior notice.

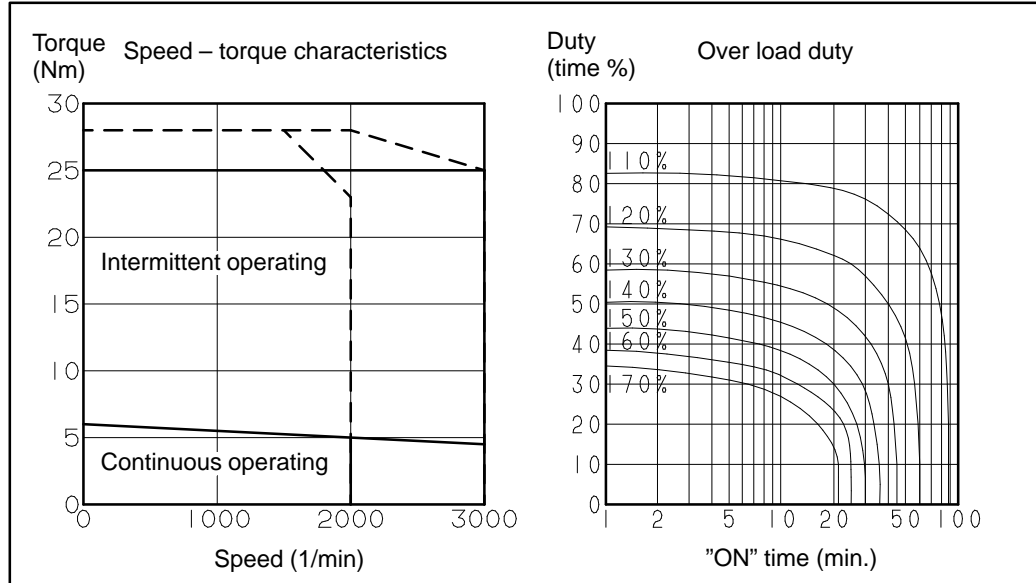


**Model  $\alpha$ 6/2000**

Specification : A06B-0127-B□□□

**Model  $\alpha$ 6/3000**

Specification : A06B-0128-B□□□

**Data sheet**

Parameter	Symbol	Value		Unit
Rating output speed	Nmax	2000	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	6.0	6.0	Nm
		61	61	
Rotor inertia	Jm	0.0026	0.0026	kgm <sup>2</sup>
		0.027	0.027	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	5.6	10.0	A (rms)
Torque constant (*)	Kt	1.08	0.60	Nm/A (rms)
		11.0	6.1	kgfcm/A (rms)
Back EMF constant (*)	Ke	38	21	V/1000min <sup>-1</sup>
		0.36	0.20	Vsec/rad
Armature resistance (*)	Ra	0.65	0.18	$\Omega$
Mechanical time constant (*)	tm	0.004	0.004	s
Thermal time constant	tt	50	50	min
Static friction	Tf	0.3	0.3	Nm
		3	3	kgfcm
Maximum allowable current	Im	73	132	A (peak)
Maximum theoretical torque	Tm	56	56	Nm
		570	570	kgfcm
Maximum theoretical acceleration		21000	21000	rad/s <sup>2</sup>
Weight		13	13	kg

(\*) The values are the standard values at 20°C and the tolerance is  $\pm 10\%$ .

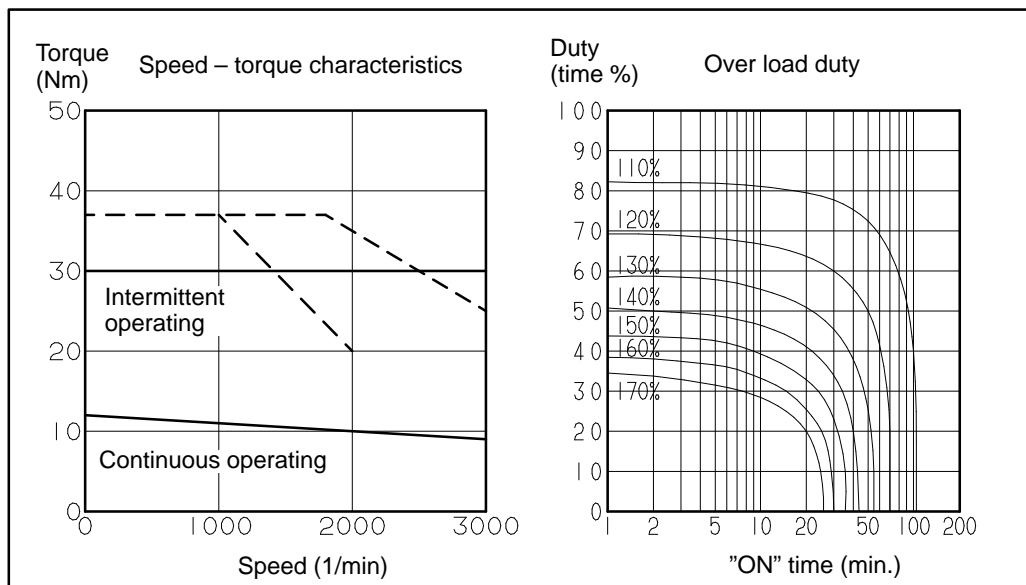
The speed–torque characteristics vary depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.

**Model α12/2000**

Specification : A06B-0142-B□□□

**Model α12/3000**

Specification : A06B-0143-B□□□



**Data sheet**

Parameter	Symbol	Value		Unit
Rating output speed	Nmax	2000	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	12	12	Nm
		122	122	
Rotor inertia	Jm	0.0062	0.0062	kgm <sup>2</sup>
		0.064	0.064	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	8.8	15.5	A (rms)
Torque constant (*)	Kt	1.36	0.77	Nm/A (rms)
		13.8	7.9	kgfcm/A (rms)
Back EMF constant (*)	Ke	47	27	V/1000min <sup>-1</sup>
	Kv	0.45	0.26	Vsec/rad
Armature resistance (*)	Ra	0.49	0.17	Ω
Mechanical time constant (*)	tm	0.005	0.005	s
Thermal time constant	tt	60	60	min
Static friction	Tf	0.8	0.8	Nm
		8	8	kgfcm
Maximum allowable current	Im	70	120	A (peak)
Maximum theoretical torque	Tm	66	66	Nm
		670	670	kgfcm
Maximum theoretical acceleration		11000	11000	rad/s <sup>2</sup>
Weight		18	18	kg

(\*) The values are the standard values at 20°C and the tolerance is ± 10%.

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.) These values may be changed without prior notice.

**Model  $\alpha$ 22/1500**

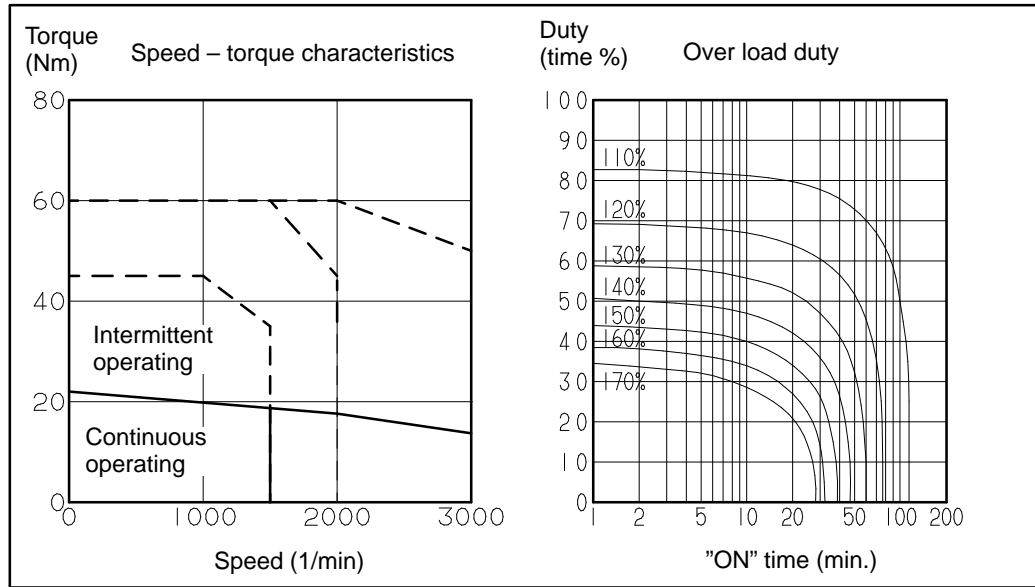
Specification : A06B-0146-B□□□

**Model  $\alpha$ 22/2000**

Specification : A06B-0147-B□□□

**Model  $\alpha$ 22/3000**

Specification : A06B-0148-B□□□

**Data sheet**

Parameter	Symbol	Value			Unit
		1500	2000	3000	
Rating output speed	Nmax	1500	2000	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	22	22	22	Nm
		224	224	224	kgfcm
Rotor inertia	Jm	0.012	0.012	0.012	kgm <sup>2</sup>
		0.12	0.12	0.12	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	12.5	18.7	32.1	A (rms)
Torque constant (*)	Kt	1.76	1.17	0.68	Nm/A (rms)
		18.0	12.0	7.0	kgfcm/A (rms)
Back EMF constant (*)	Ke	62	41	24	V/1000min <sup>-1</sup>
	Kv	0.59	0.39	0.23	Vsec/rad
Armature resistance (*)	Ra	0.315	0.140	0.049	$\Omega$
Mechanical time constant (*)	tm	0.004	0.004	0.004	s
Thermal time constant	tt	65	65	65	min
Static friction	Tf	1.2	1.2	1.2	Nm
		12	12	12	kgfcm
Maximum allowable current	Im	105	160	275	A (peak)
Maximum theoretical torque	Tm	130	130	130	Nm
		1400	1400	1400	kgfcm
Maximum theoretical acceleration		11000	11000	11000	rad/s <sup>2</sup>
Weight		29	29	29	kg

(\*) The values are the standard values at 20°C and the tolerance is  $\pm 10\%$ .

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.) These values may be changed without prior notice.

**Model α30/1200**

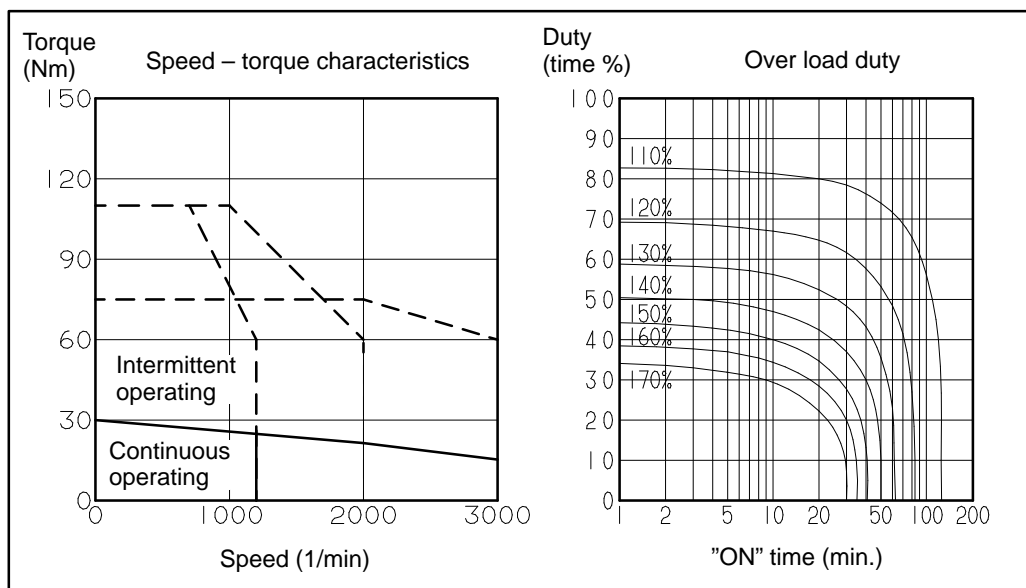
Specification : A06B-0151-B□□□

**Model α30/2000**

Specification : A06B-0152-B□□□

**Model α30/3000**

Specification : A06B-0153-B□□□



**Data sheet**

Parameter	Symbol	Value			Unit
		1200	2000	3000	
Rating output speed	Nmax	1200	2000	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	30	30	30	Nm
		306	306	306	kgfcm
Rotor inertia	Jm	0.017	0.017	0.017	kgm <sup>2</sup>
		0.17	0.17	0.17	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	12.6	20.2	33.7	A (rms)
Torque constant (*)	Kt	2.37	1.48	0.89	Nm/A (rms)
		24.2	15.1	9.1	kgfcm/A (rms)
Back EMF constant (*)	Ke	83	52	31	V/1000min <sup>-1</sup>
	Kv	0.79	0.49	0.30	Vsec/rad
Armature resistance (*)	Ra	0.34	0.13	0.046	Ω
Mechanical time constant (*)	tm	0.003	0.003	0.003	s
Thermal time constant	tt	70	70	70	min
Static friction	Tf	1.8	1.8	1.8	Nm
		18	18	18	kgfcm
Maximum allowable current	Im	120	190	320	A (peak)
Maximum theoretical torque	Tm	200	200	200	Nm
		2100	2100	2100	kgfcm
Maximum theoretical acceleration		12000	12000	12000	rad/s <sup>2</sup>
Weight		41	41	41	kg

(\*) The values are the standard values at 20°C and the tolerance is ± 10%.

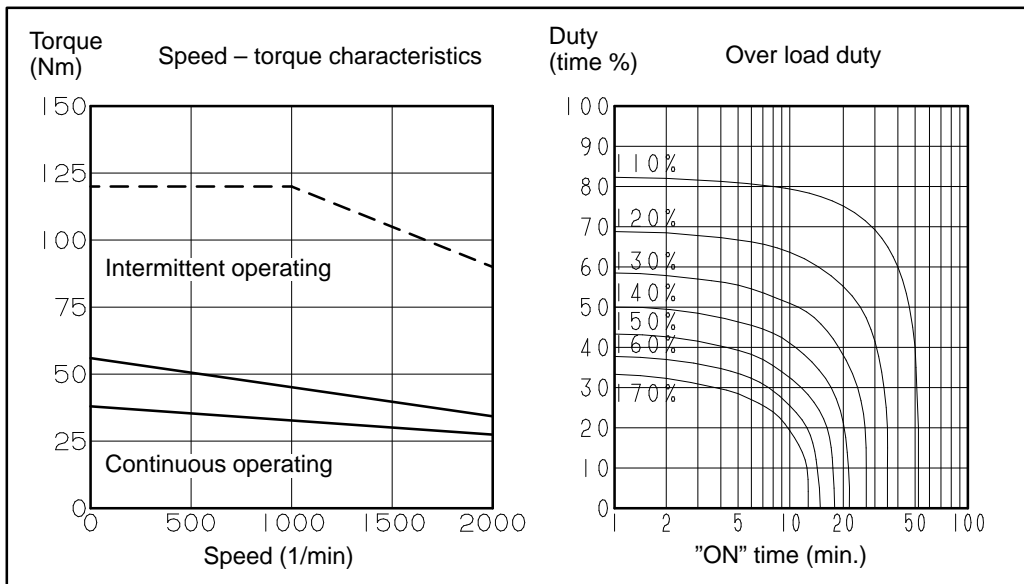
The speed-torque characteristics vary depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.

**Model α40/2000**

Specification : A06B-0157-B0□□

**Model α40/2000(with fan)**

Specification : A06B-0158-B0□□



**Data sheet**

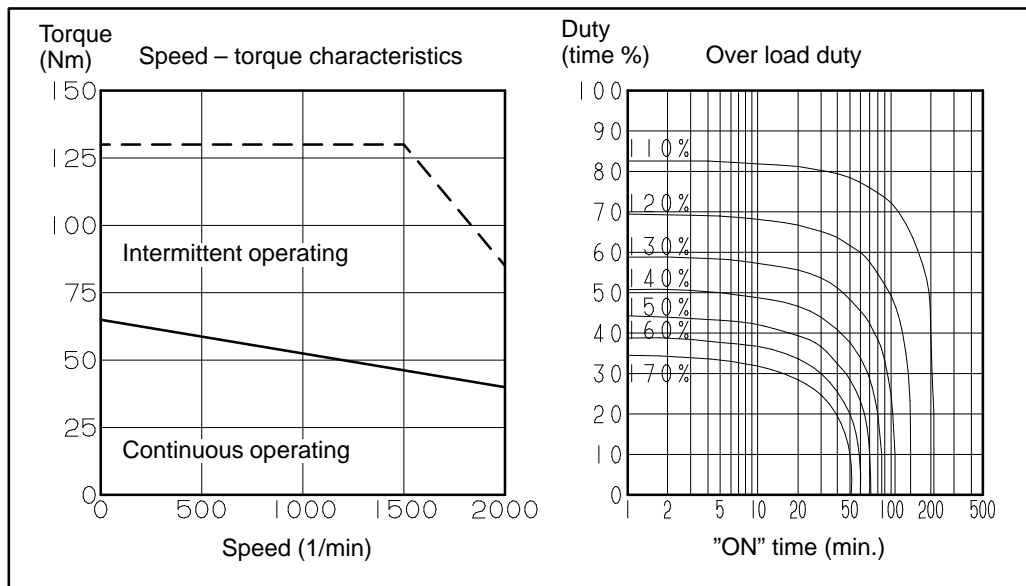
Parameter	Symbol	Value		Unit
Rating output speed	Nmax	2000	2000 (with fan)	min <sup>-1</sup>
Rated torque at stall (*)	Ts	38	56	Nm
		390	570	kgfcm
Rotor inertia	Jm	0.022	0.022	kgm <sup>2</sup>
		0.23	0.23	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	27.0	40.1	A (rms)
Torque constant (*)	Kt	1.40	1.40	Nm/A (rms)
		14.3	14.3	kgfcm/A (rms)
Back EMF constant (*)	Ke	49	49	V/1000min <sup>-1</sup>
		0.47	0.47	Vsec/rad
Armature resistance (*)	Ra	0.080	0.080	Ω
Mechanical time constant (*)	tm	0.003	0.003	s
Thermal time constant	tt	30	30	min
Static friction	Tf	1.8	1.8	Nm
		18	18	kgfcm
Maximum allowable current	Im	270	270	A (peak)
Maximum theoretical torque	Tm	270	270	Nm
		2800	2800	kgfcm
Maximum theoretical acceleration		12000	12000	rad/s <sup>2</sup>
Weight		52	55	kg

(\*) The values are the standard values at 20°C and the tolerance is ±10%.

The speed–torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.

**Model α65/2000**

Specification : A06B-0331-B□□□



**Data sheet**

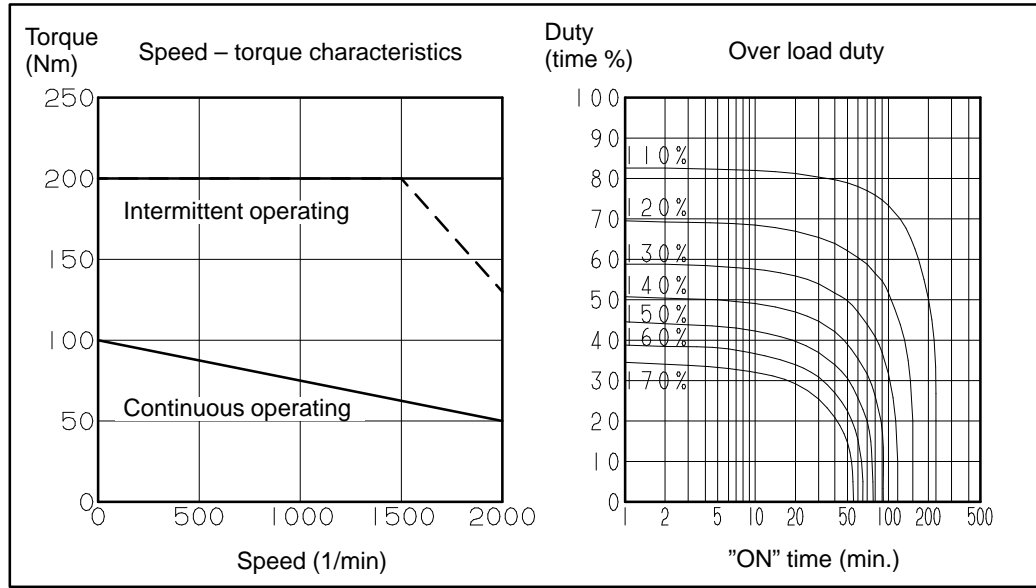
Parameter	Symbol	Value	Unit
Rating output speed	Nmax	2000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	65	Nm
		660	kgfcm
Rotor inertia	Jm	0.019	kgm <sup>2</sup>
		0.19	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	62	A (rms)
Torque constant (*)	Kt	1.04	Nm/A (rms)
		10.6	kgfcm/A (rms)
Back EMF constant (*)	Ke	36	V/1000min <sup>-1</sup>
		0.35	Vsec/rad
Armature resistance (*)	Ra	0.020	Ω
Mechanical time constant (*)	tm	0.001	s
Thermal time constant	tt	120	min
Static friction	Tf	3.7	Nm
		38	kgfcm
Maximum allowable current	Im	420	A (peak)
Maximum theoretical torque	Tm	290	Nm
		3000	kgfcm
Maximum theoretical acceleration		16000	rad/s <sup>2</sup>
Weight		80	kg

(\*)The values are the standard values at 20°C and the tolerance is ± 10%.

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.) These values may be changed without prior notice.

Model  $\alpha 100/2000$ 

Specification : A06B-0332-B□□□



## Data sheet

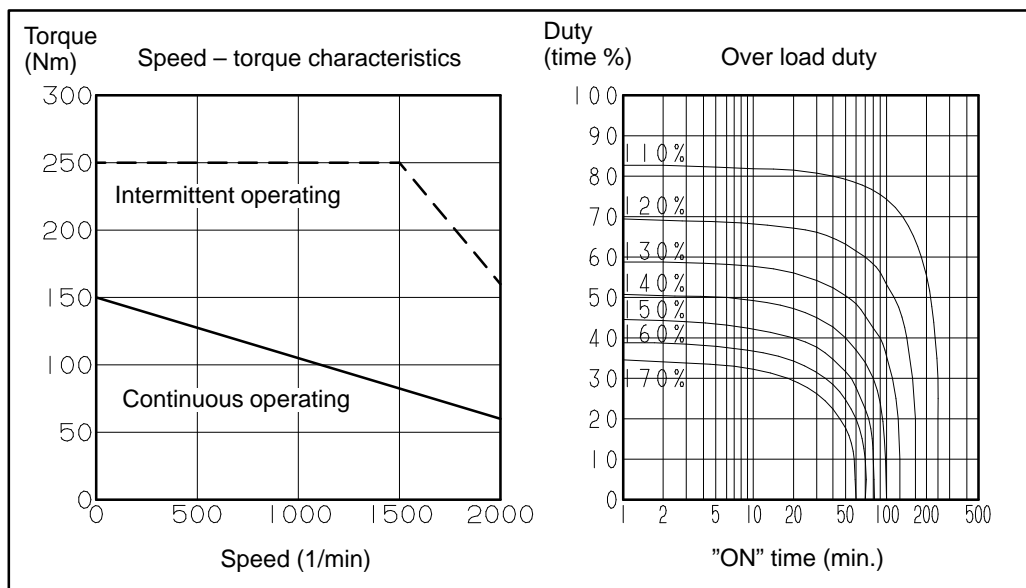
Parameter	Symbol	Value	Unit
Rating output speed	Nmax	2000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	100	Nm
		1020	kgfcm
Rotor inertia	Jm	0.026	kgm <sup>2</sup>
		0.27	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	85	A (rms)
Torque constant (*)	Kt	1.17	Nm/A (rms)
		12.0	kgfcm/A (rms)
Back EMF constant (*)	Ke	41	V/1000min <sup>-1</sup>
		0.39	Vsec/rad
Armature resistance (*)	Ra	0.014	$\Omega$
Mechanical time constant (*)	tm	0.001	s
Thermal time constant	tt	130	min
Static friction	Tf	5.5	Nm
		56	kgfcm
Maximum allowable current	Im	580	A (peak)
Maximum theoretical torque	Tm	440	Nm
		4500	kgfcm
Maximum theoretical acceleration		17000	rad/s <sup>2</sup>
Weight		100	kg

(\*) The values are the standard values at 20°C and the tolerance is  $\pm 10\%$ .

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.) These values may be changed without prior notice.

**Model  $\alpha$ 150/2000**

Specification : A06B-0333-B□□□



**Data sheet**

Parameter	Symbol	Value	Unit
Rating output speed	Nmax	2000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	150	Nm
		1530	kgfcm
Rotor inertia	Jm	0.034	kgm <sup>2</sup>
		0.35	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	113	A (rms)
Torque constant (*)	Kt	1.31	Nm/A (rms)
		13.3	kgfcm/A (rms)
Back EMF constant (*)	Ke	46	V/1000min <sup>-1</sup>
		0.44	Vsec/rad
Armature resistance (*)	Ra	0.011	$\Omega$
Mechanical time constant (*)	tm	0.001	s
Thermal time constant	tt	140	min
Static friction	Tf	7.4	Nm
		75	kgfcm
Maximum allowable current	Im	690	A (peak)
Maximum theoretical torque	Tm	590	Nm
		6000	kgfcm
Maximum theoretical acceleration		17000	rad/s <sup>2</sup>
Weight		120	kg

(\*)The values are the standard values at 20°C and the tolerance is  $\pm 10\%$ .

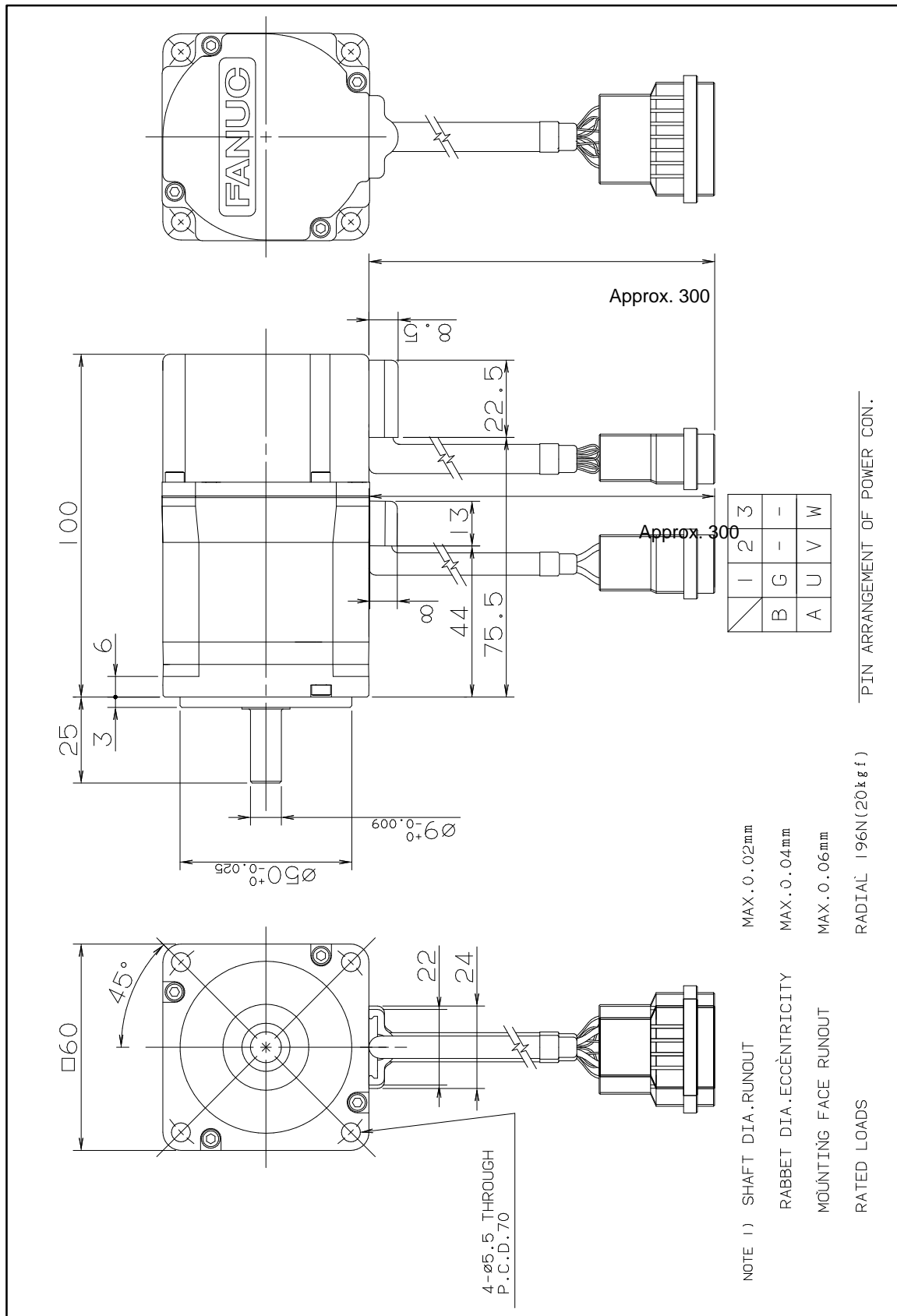
The speed-torque characteristics vary depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.



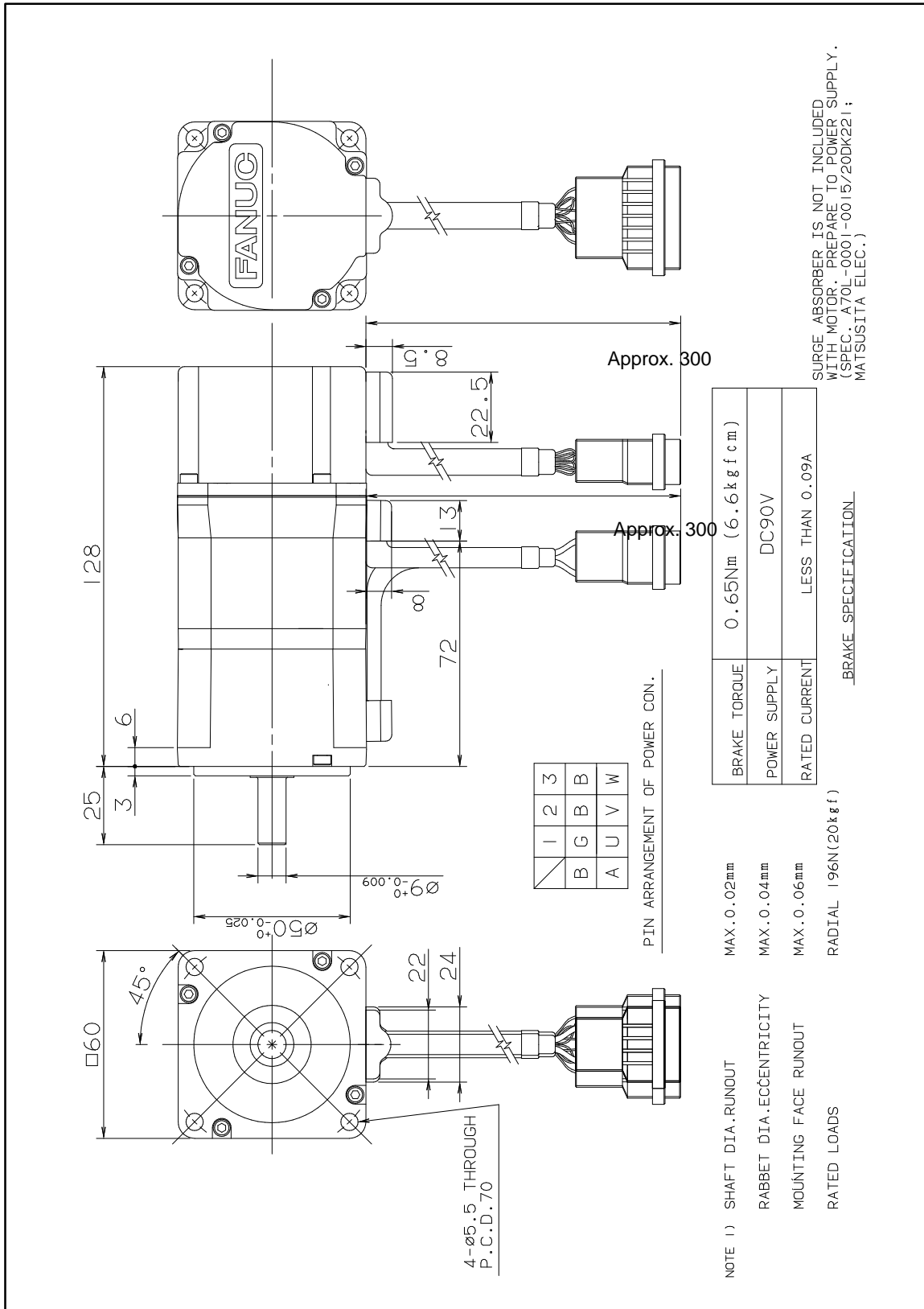
### 3.3 OUTLINE DRAWINGS

Model	Fig. No.
Model $\alpha$ 0.5	Fig. 3.3(a)
Model $\alpha$ 0.5 (with the brake)	Fig. 3.3(b)
Models $\alpha$ 0.5 (shaft option)	Fig. 3.3(c)
Models $\alpha$ 1 and $\alpha$ 2	Fig. 3.3(d)
Models $\alpha$ 1 and $\alpha$ 2 (with the brake)	Fig. 3.3(e)
Models $\alpha$ 1 and $\alpha$ 2 (shaft option)	Fig. 3.3(f)
Models $\alpha$ 3 and $\alpha$ 6	Fig. 3.3(g)
Models $\alpha$ 3 and $\alpha$ 6 (with the brake)	Fig. 3.3(h)
Models $\alpha$ 3 and $\alpha$ 6 (shaft option)	Fig. 3.3(i)
Models $\alpha$ 12, $\alpha$ 22, $\alpha$ 30 and $\alpha$ 40	Fig. 3.3(j)
Models $\alpha$ 12, $\alpha$ 22, $\alpha$ 30 and $\alpha$ 40 (with the brake)	Fig. 3.3(k)
Models $\alpha$ 12, $\alpha$ 22, $\alpha$ 30 and $\alpha$ 40 (shaft option)	Fig. 3.3(l)
Model $\alpha$ 40 (with fan)	Fig. 3.3(m)
Model $\alpha$ 40 (with fan) (with the brake)	Fig. 3.3(n)
Models $\alpha$ 65, $\alpha$ 100 and $\alpha$ 150	Fig. 3.3(o)
Models $\alpha$ 65, $\alpha$ 100 and $\alpha$ 150 (with the brake)	Fig. 3.3(p)

**Fig. 3.3 (a) Model α0.5**



**Fig. 3.3 (b) Model α0.5 (with the brake)**



**Fig. 3.3 (c) Model α0.5 (shaft option)**

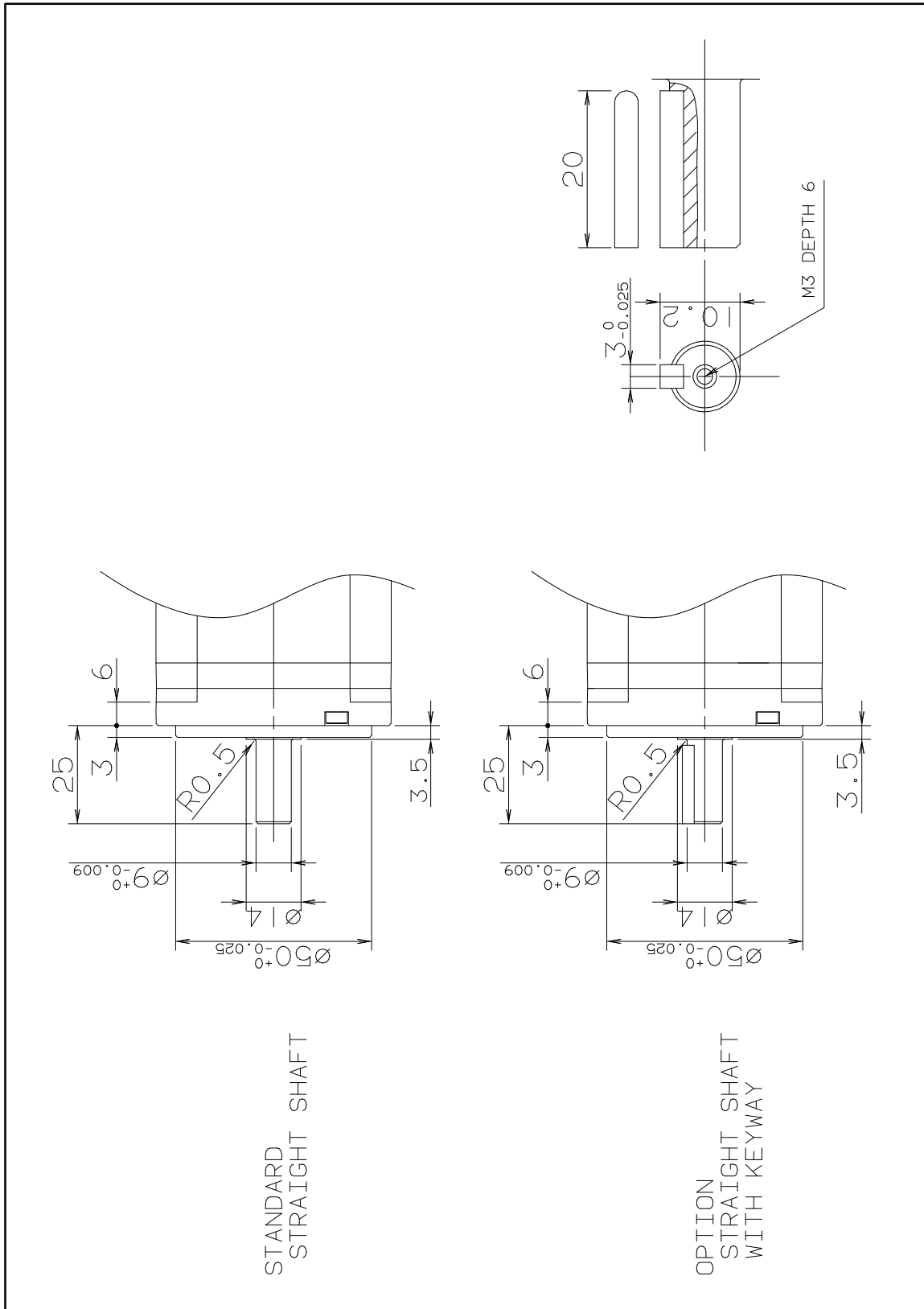
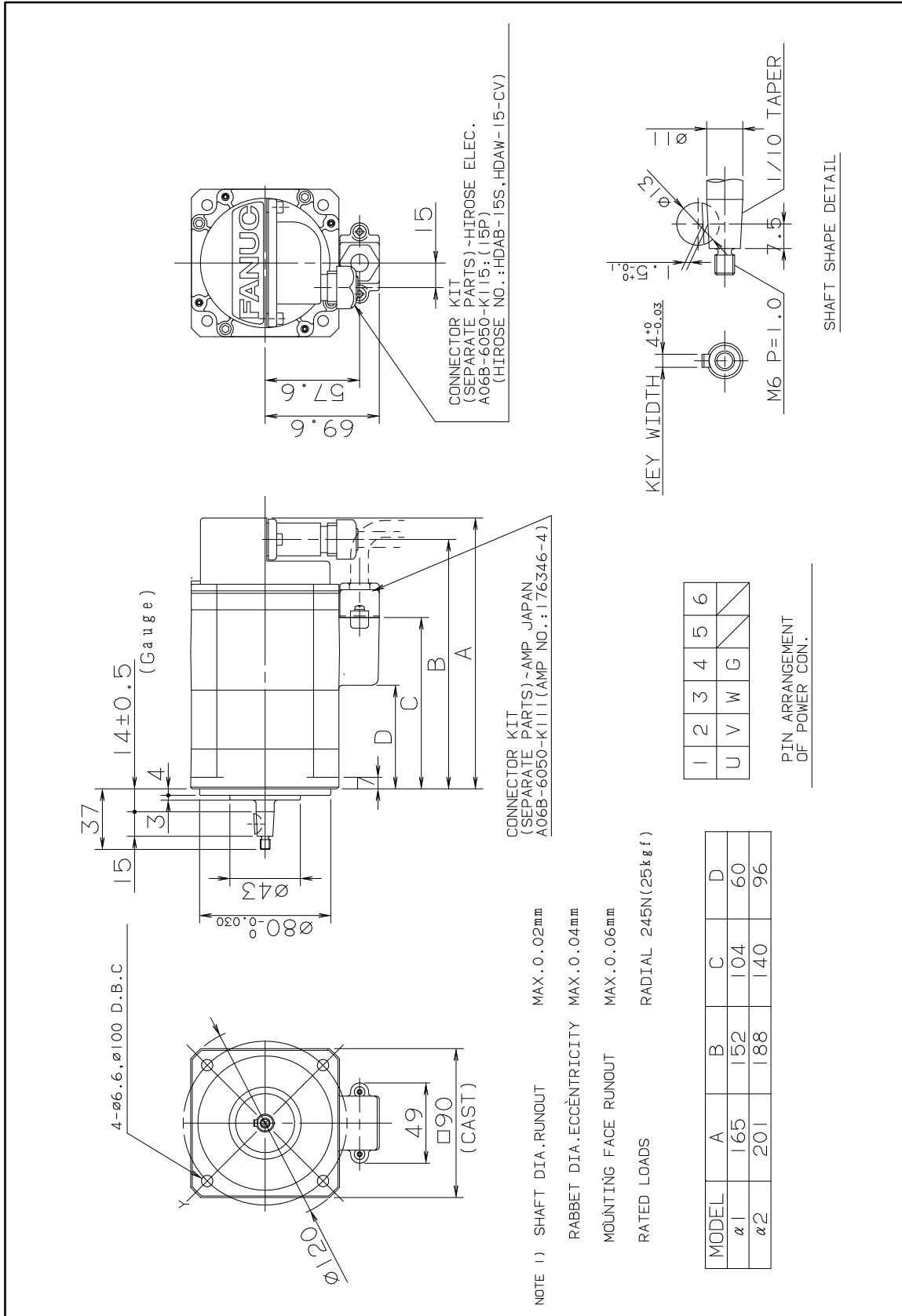
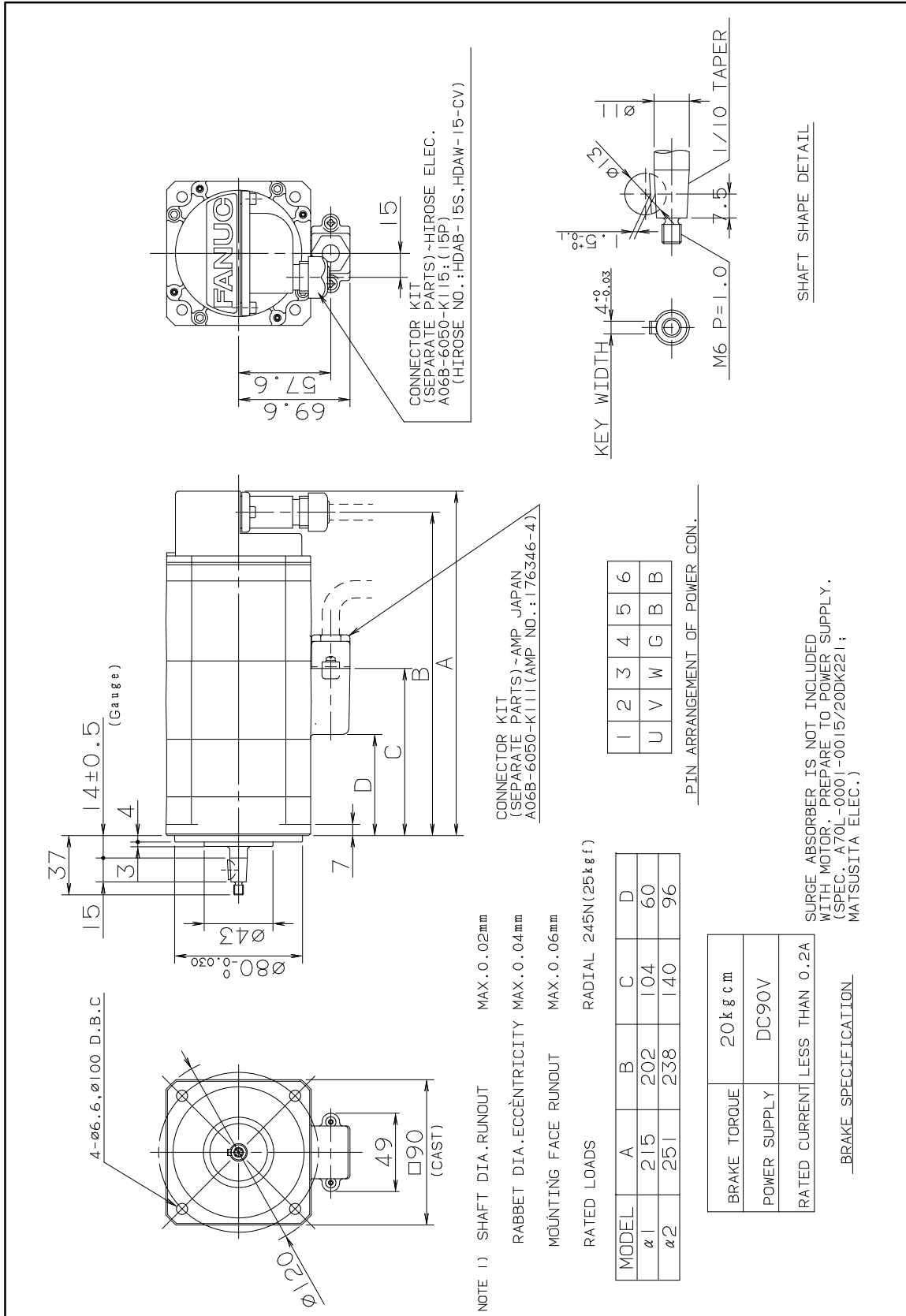


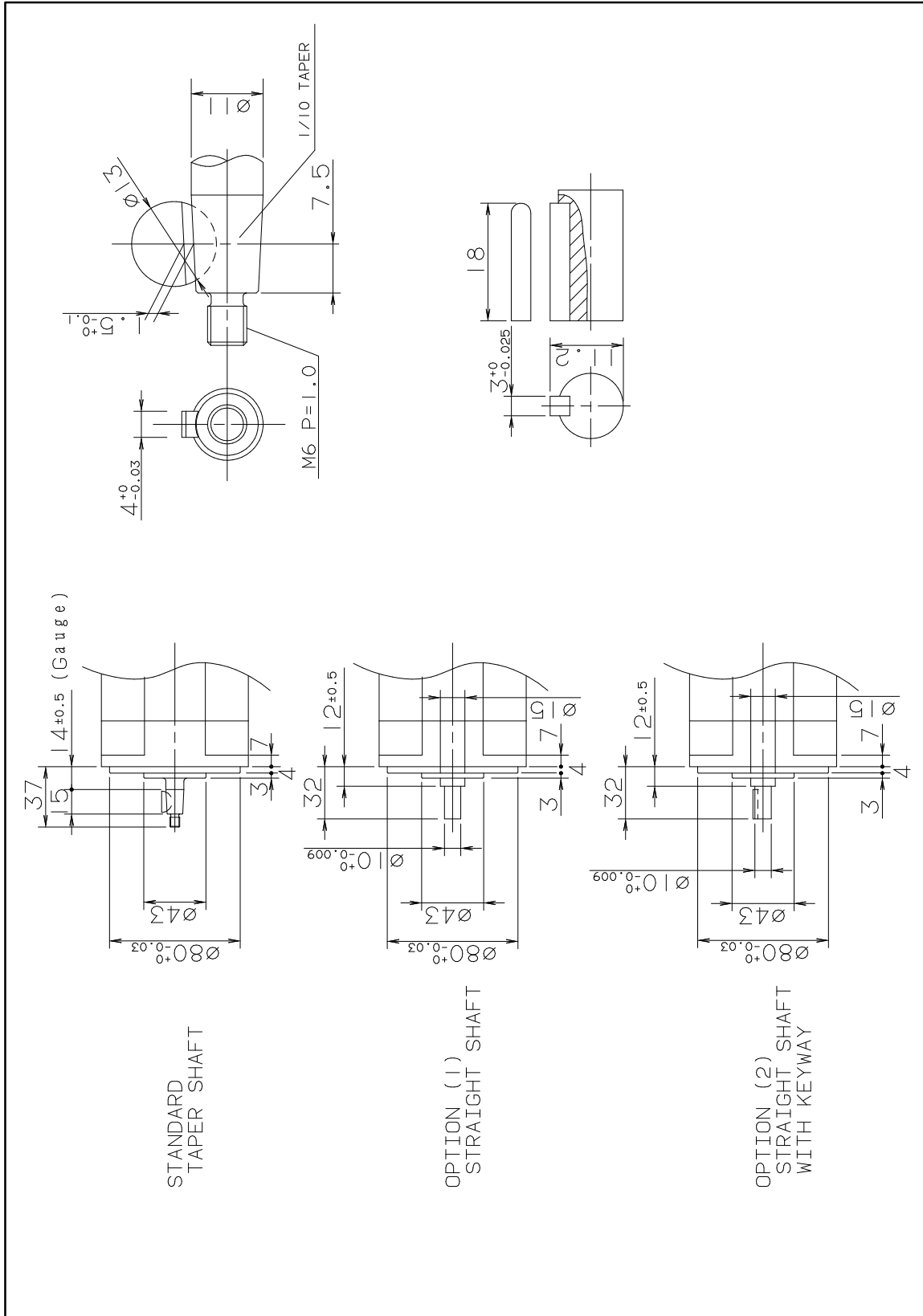
Fig. 3.3 (d) Models α1 and α2



**Fig. 3.3 (e) Models α1 and α2 (with the brake)**



**Fig. 3.3 (f) Models  $\alpha 1$  and  $\alpha 2$  (shaft option)**



**Fig. 3.3 (g) Models α3 and α6**

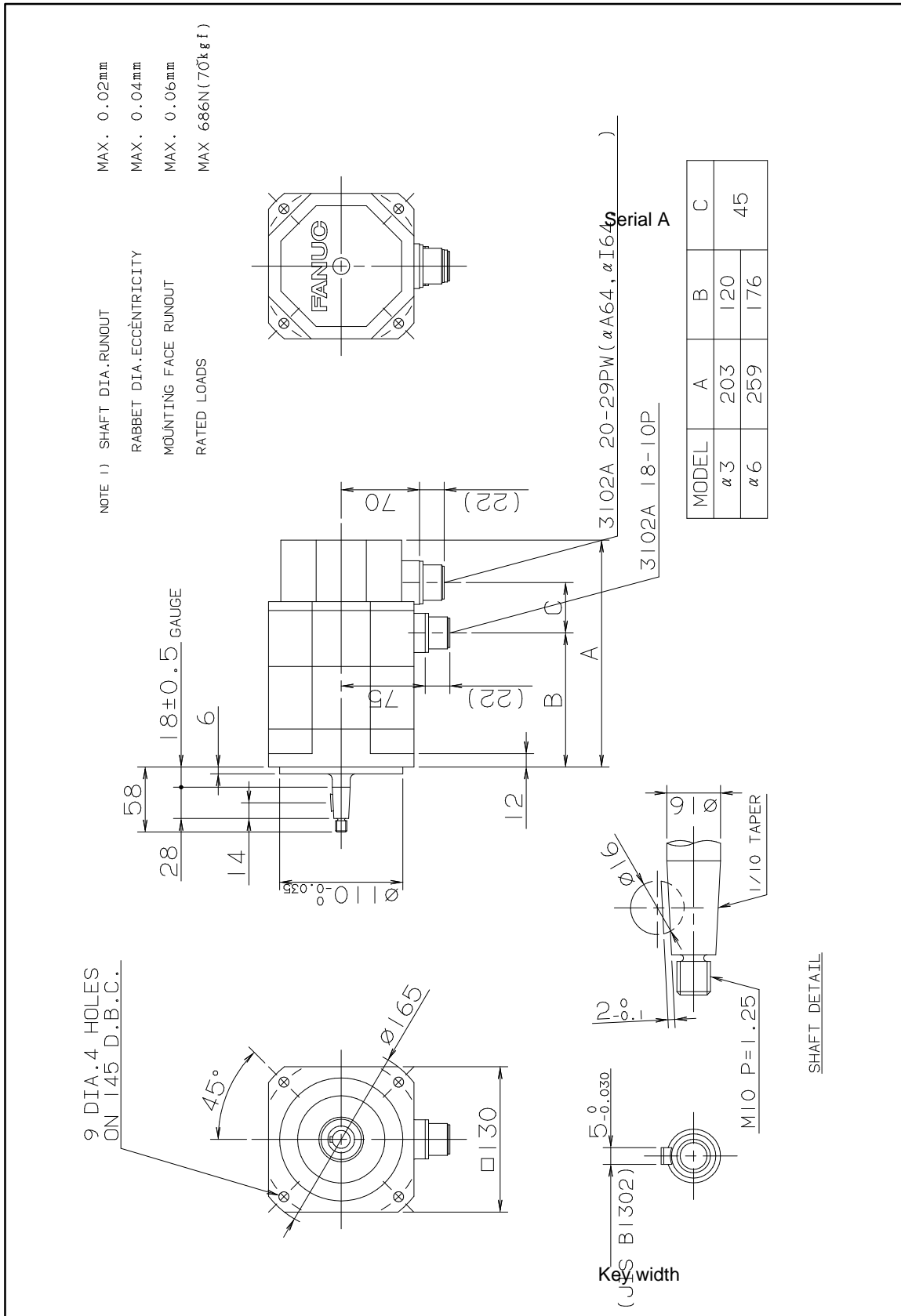
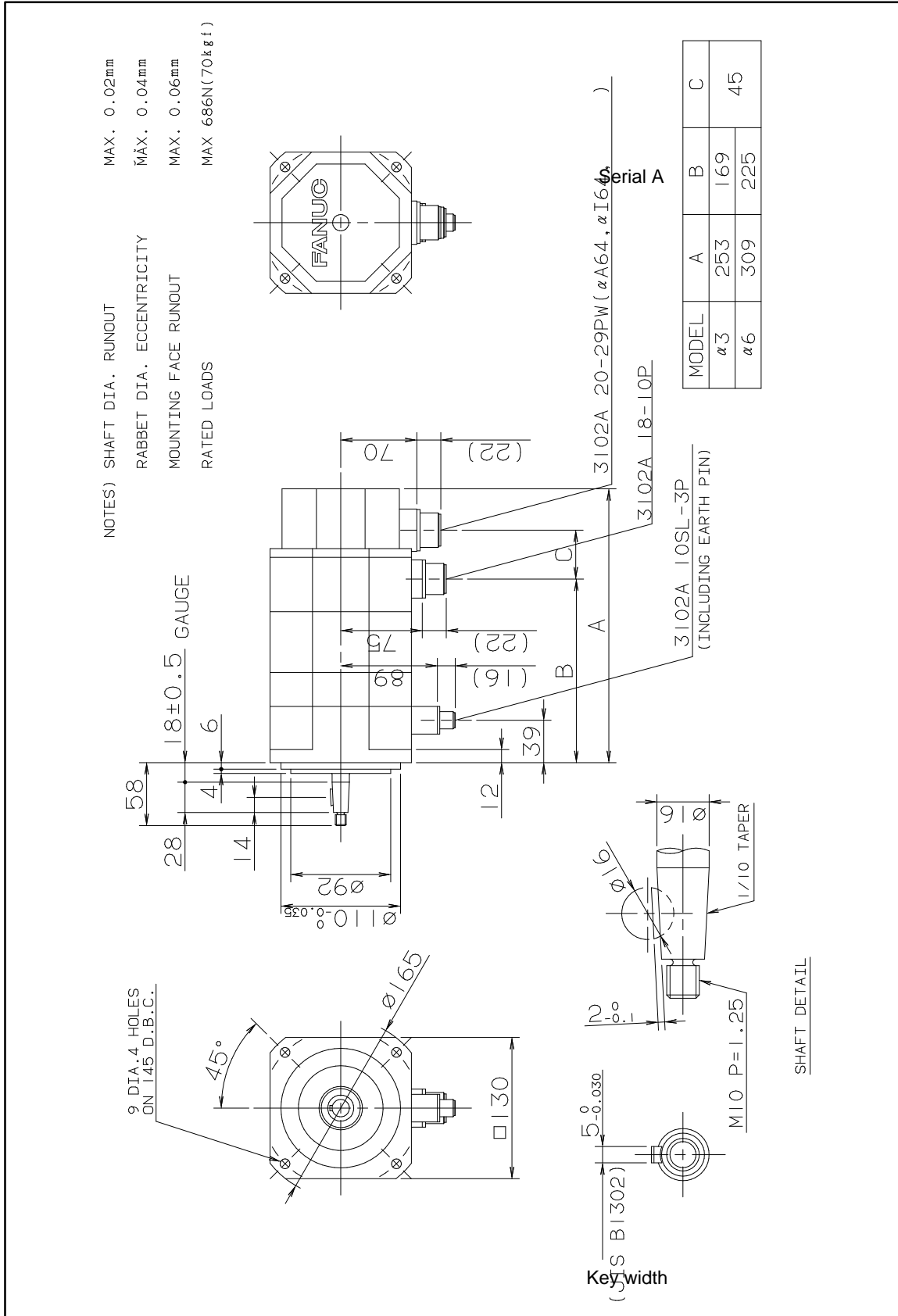
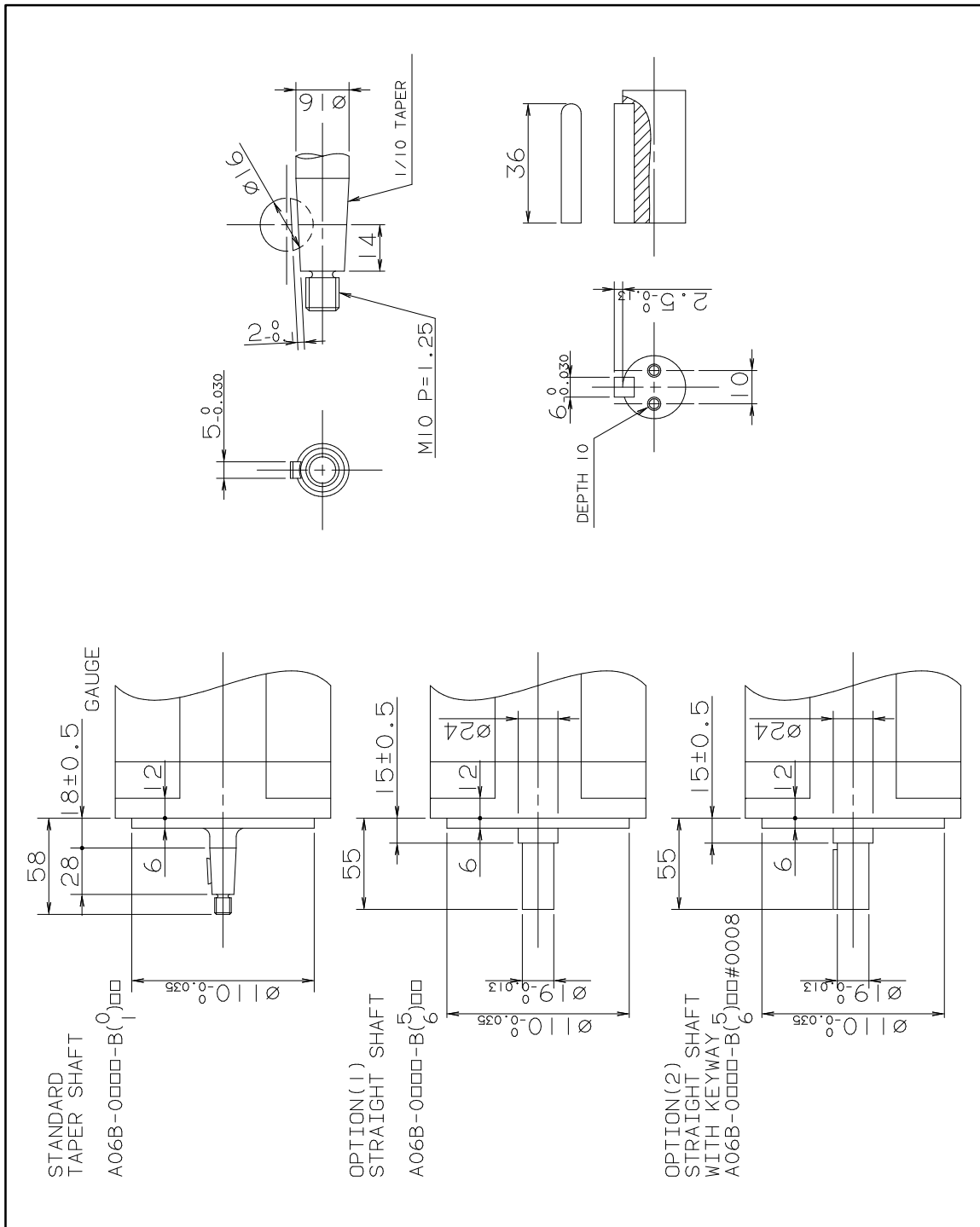




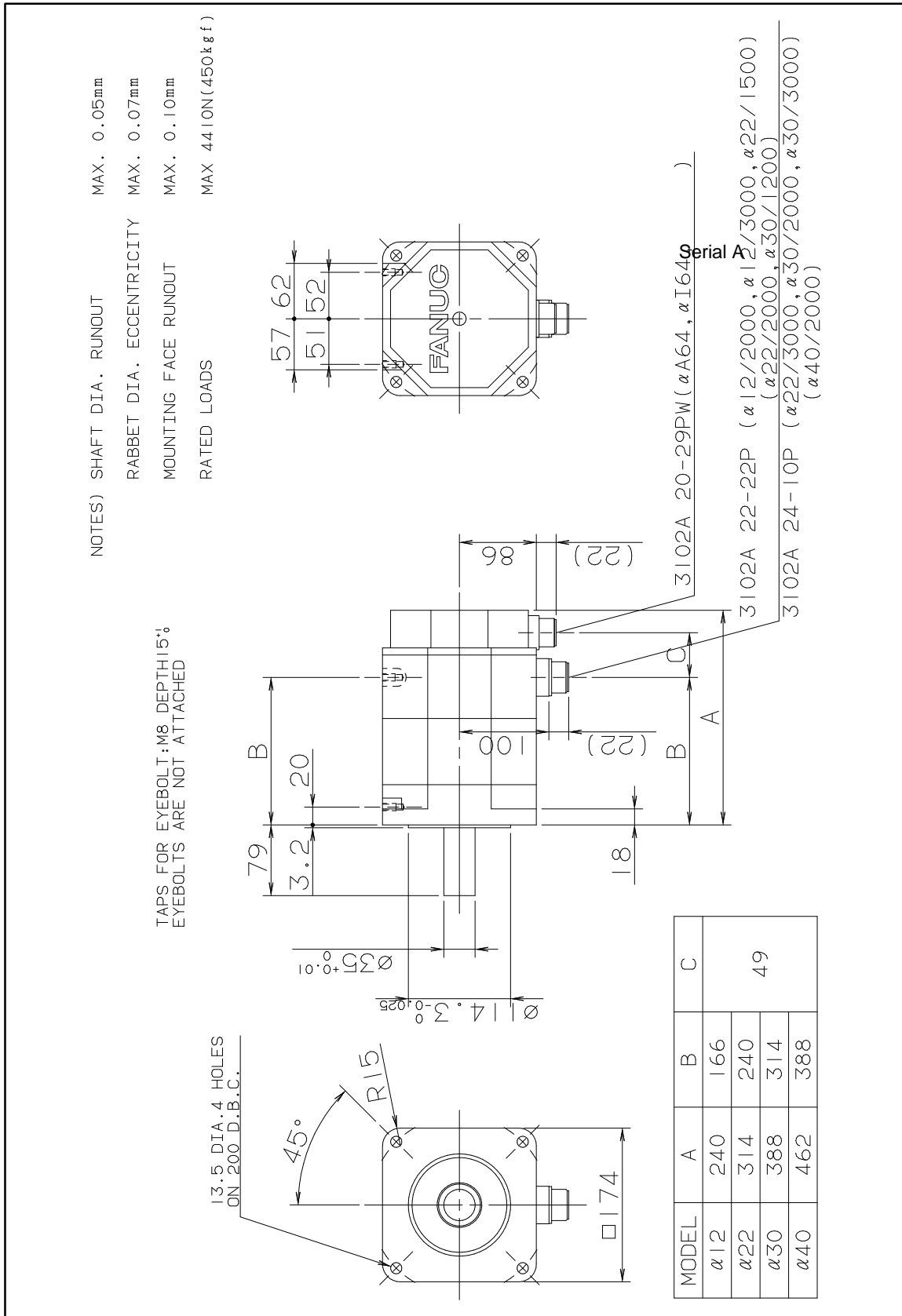
Fig. 3.3 (h) Models α3 and α6 (with the brake)



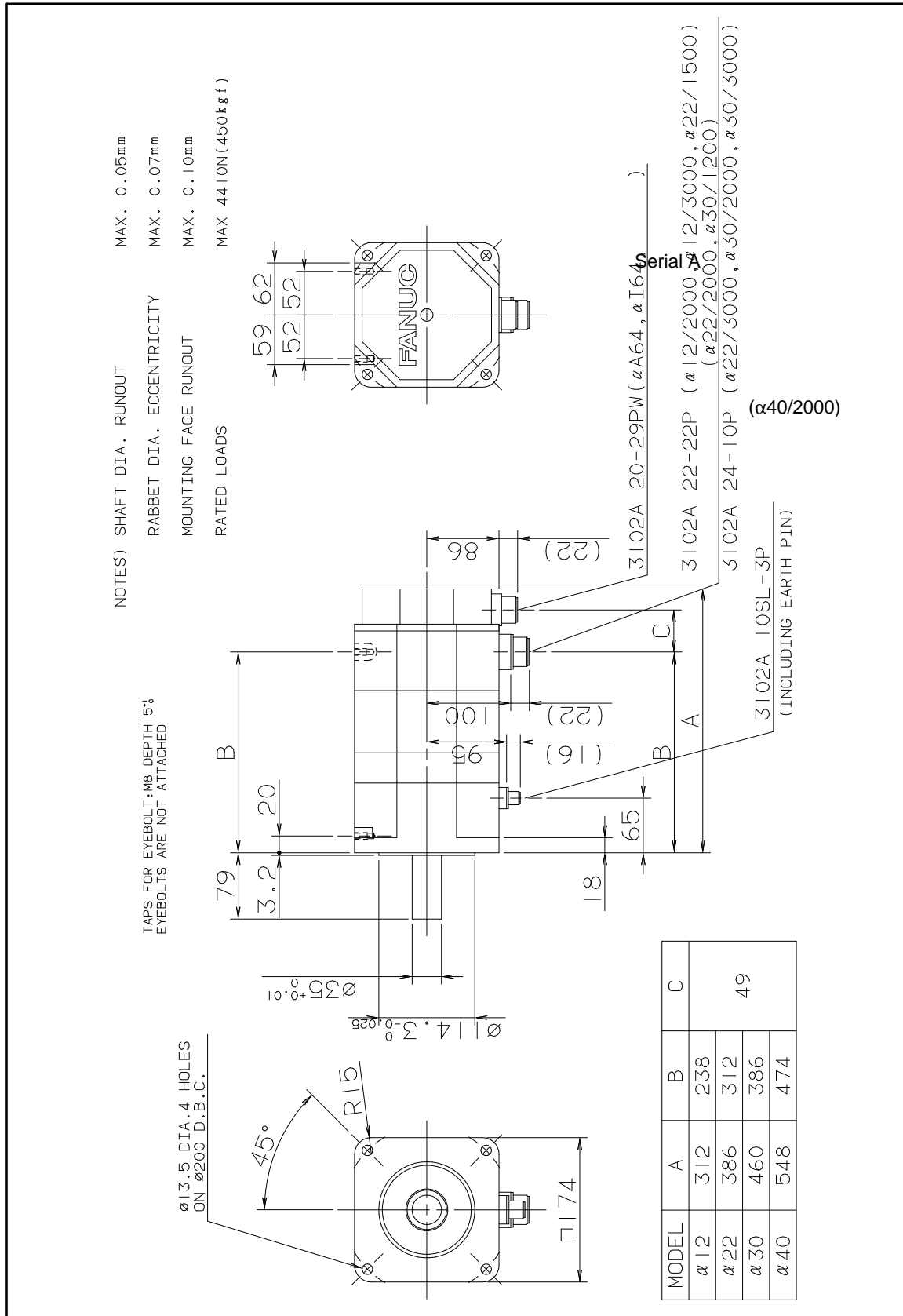
**Fig. 3.3 (j) Models α3 and α6 (shaft option)**



**Fig. 3.3 (j) Models α12, α22, α30, and α40**



**Fig. 3.3 (k) Models  $\alpha$ 12,  $\alpha$ 22,  $\alpha$ 30, and  $\alpha$ 40 (with the brake)**



**Fig. 3.3 (I) Models  $\alpha$ 12,  $\alpha$ 22,  $\alpha$ 30, and  $\alpha$ 40 (shaft option)**

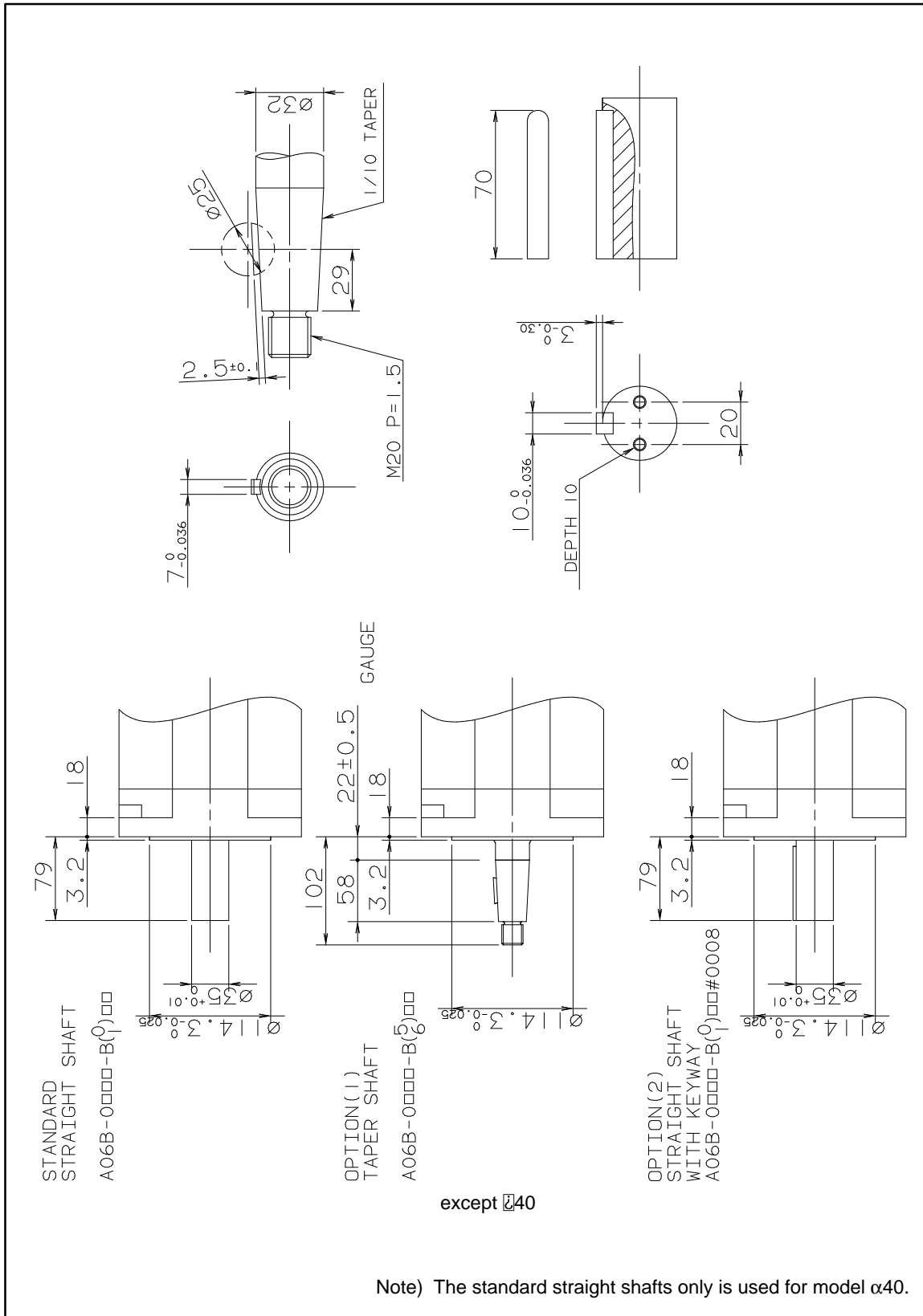


Fig. 3.3 (m) Model α40 (with fan)

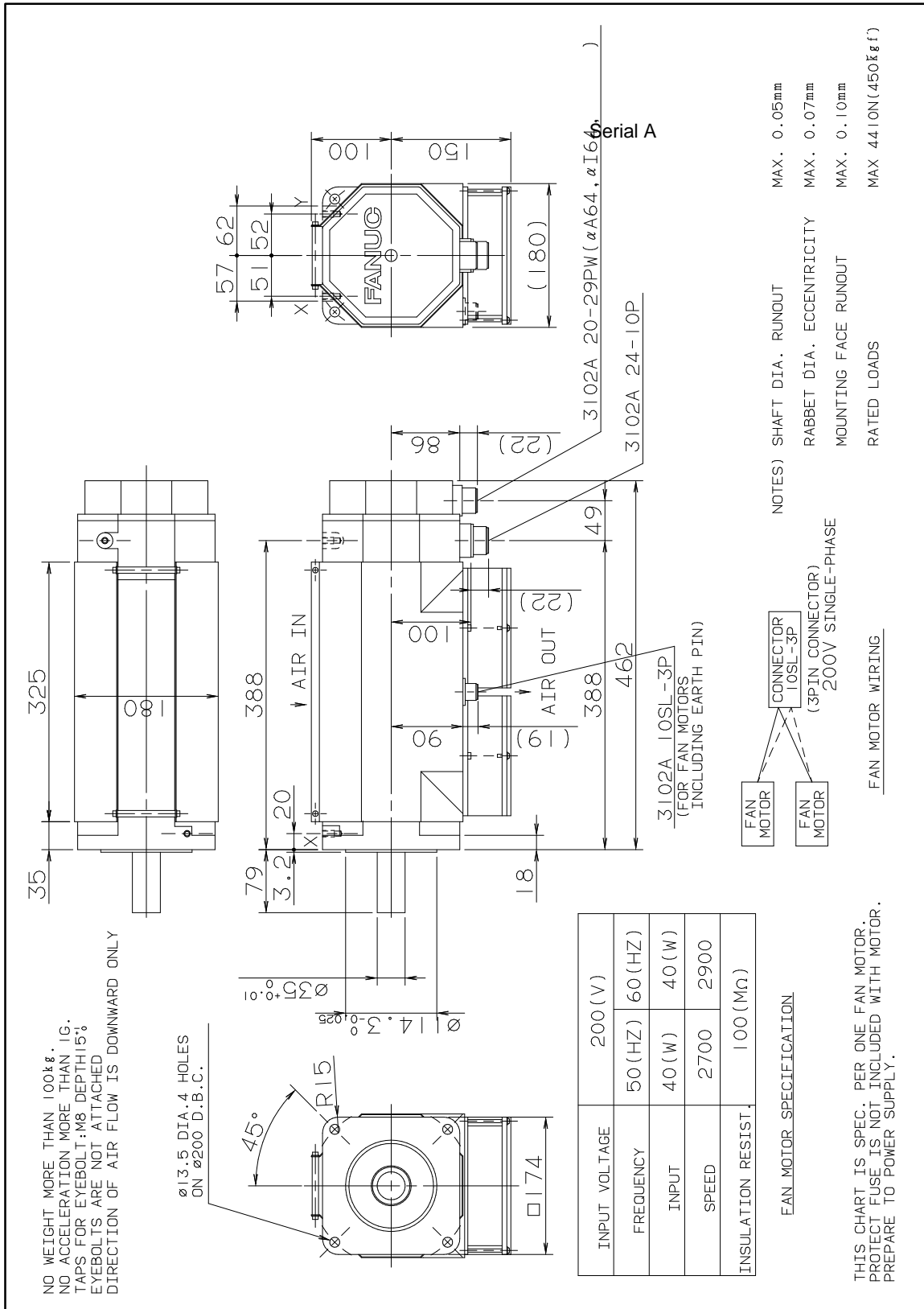
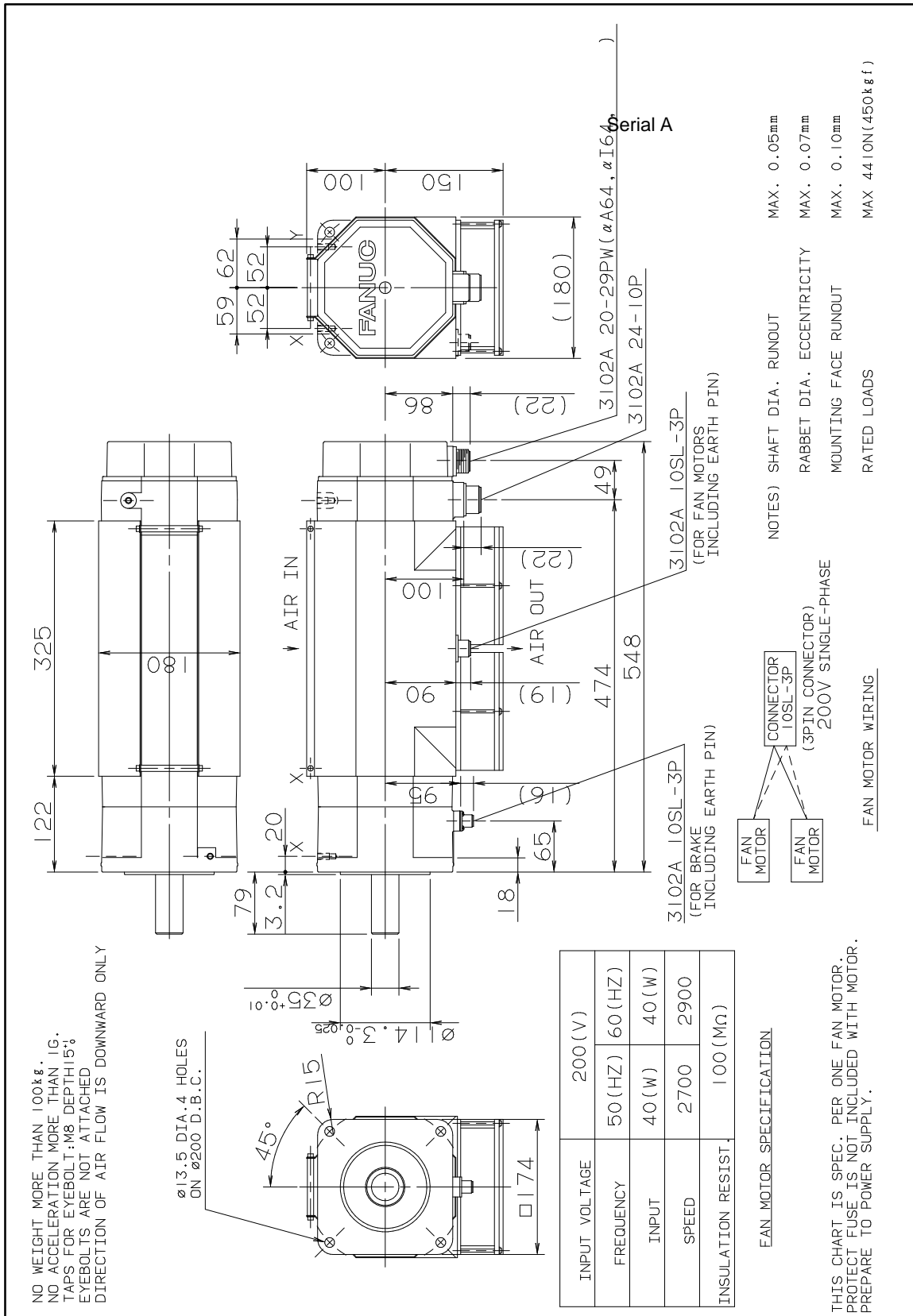
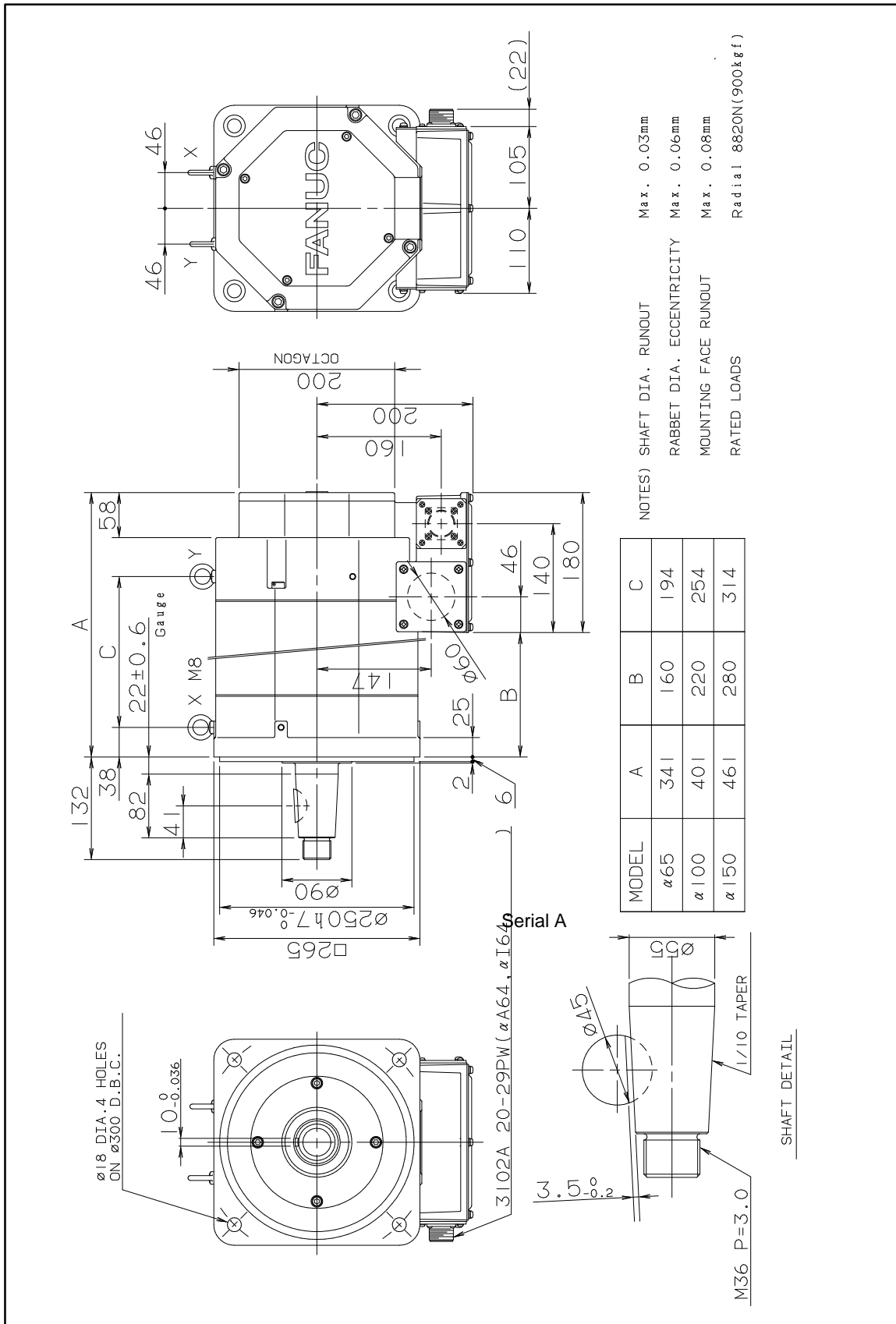


Fig. 3.3 (n) Model α40 (with fan) (with the brake)

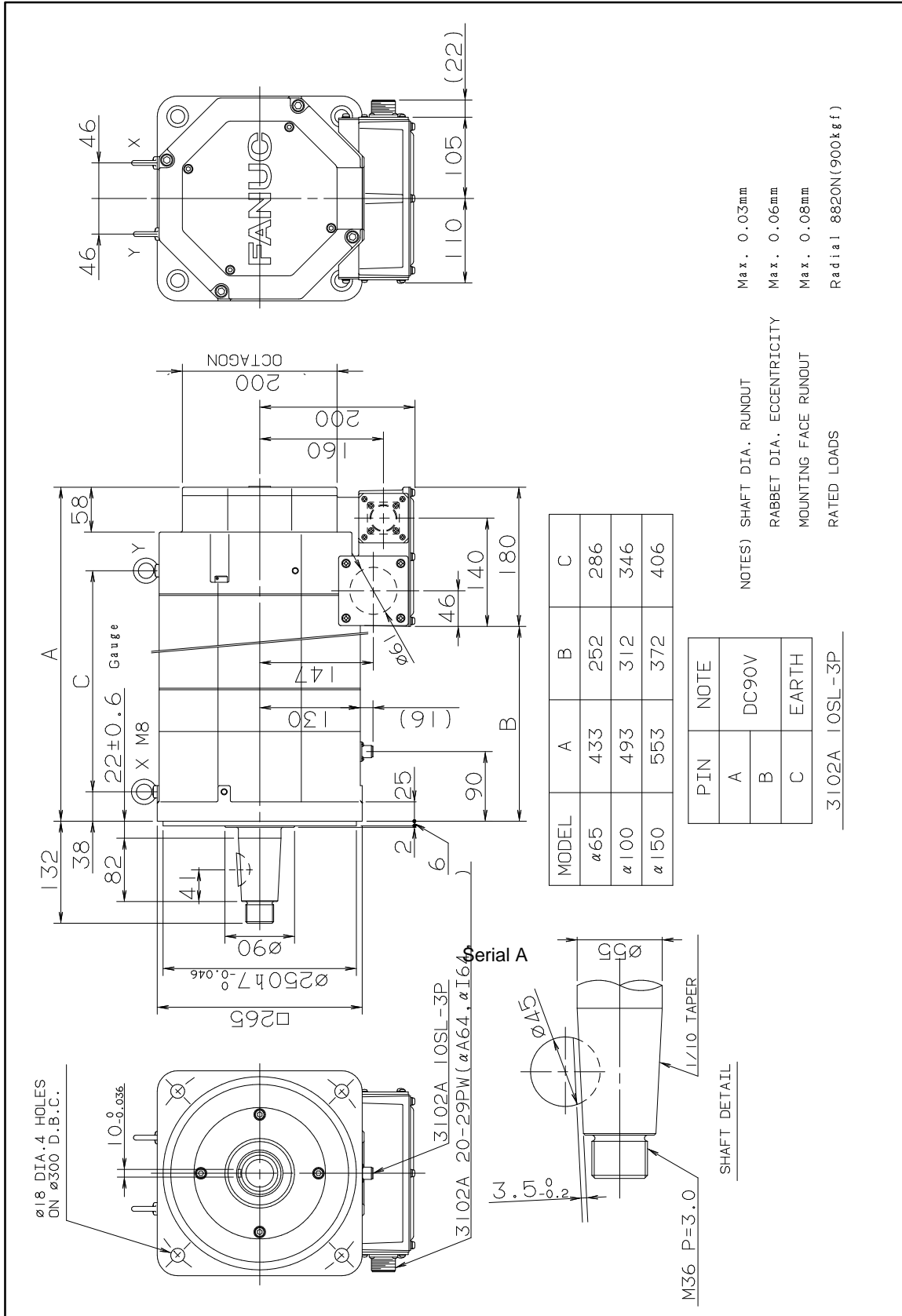


**Fig. 3.3 (o) Models  $\alpha$ 65,  $\alpha$ 100, and  $\alpha$ 150**



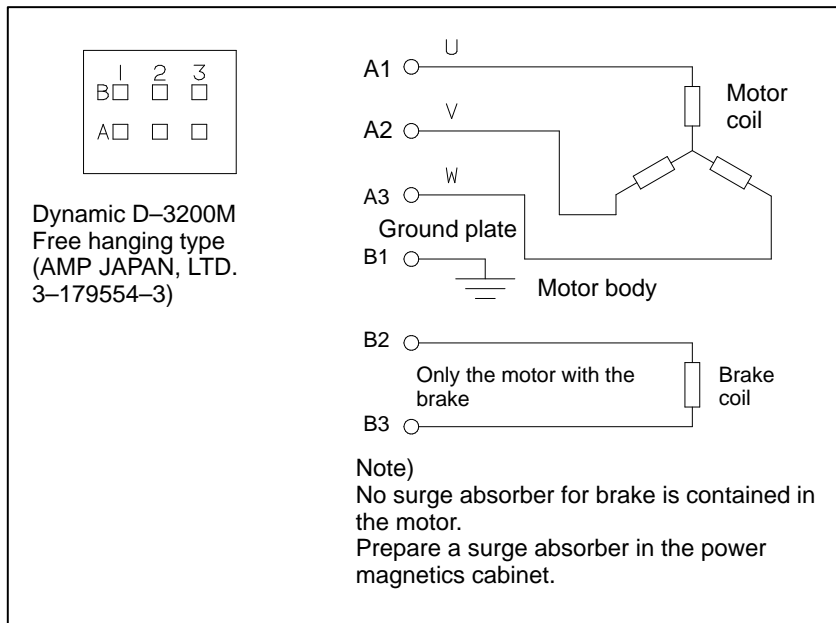


**Fig. 3.3 (p) Models  $\alpha 65$ ,  $\alpha 100$ , and  $\alpha 150$  (with the brake)**

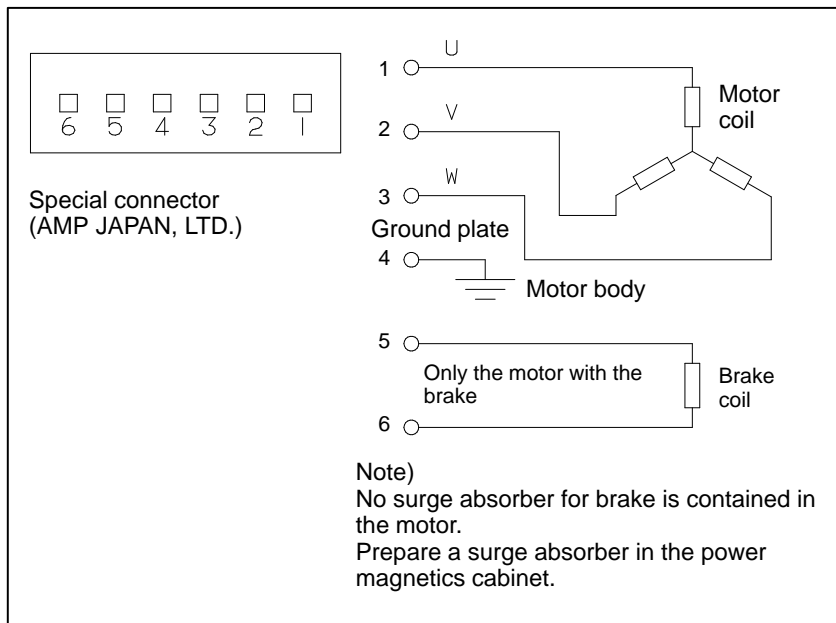


### 3.4 CONNECTION OF POWER LINE

**Model**  
 **$\alpha$ 0.5/3000**

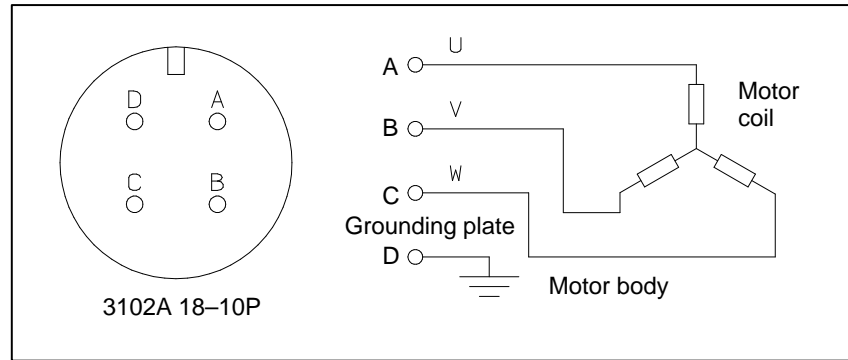


**Models**  
 **$\alpha$ 1/3000,  $\alpha$ 2/2000, and  $\alpha$ 2/3000**



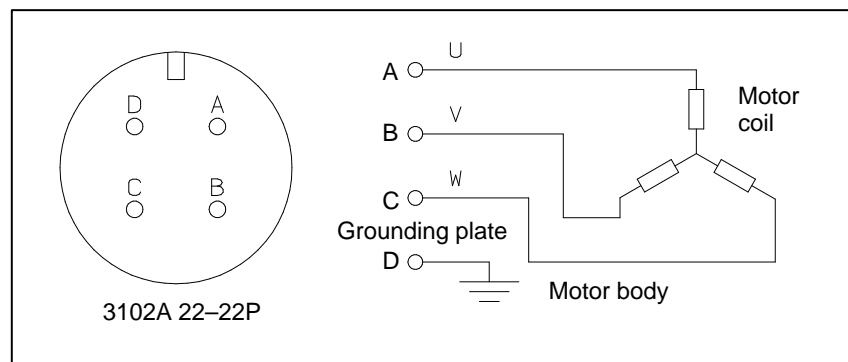
**Models**

$\alpha$ 3/3000,  $\alpha$ 6/2000, and  $\alpha$ 6/3000



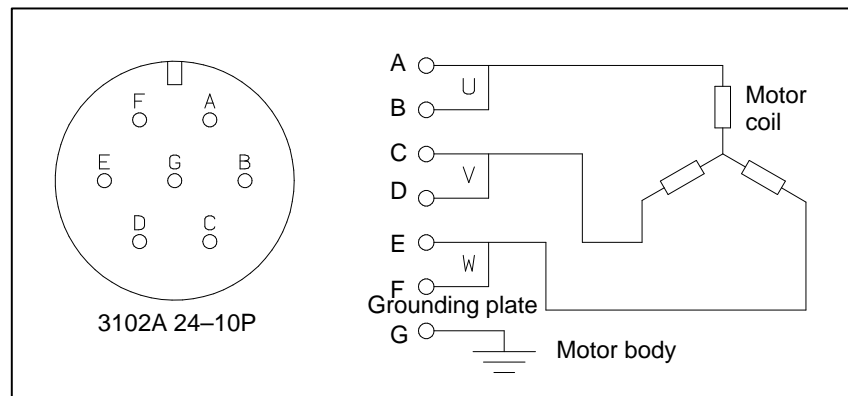
**Models**

$\alpha$ 12/2000,  $\alpha$ 12/3000,  $\alpha$ 22/1500,  $\alpha$ 22/2000, and  $\alpha$ 30/1200



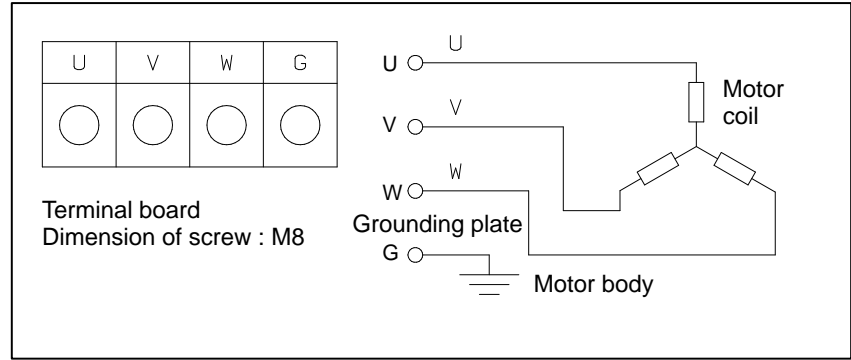
**Models**

$\alpha$ 22/3000,  $\alpha$ 30/2000,  $\alpha$ 30/3000, and  $\alpha$ 40/2000



**Models**

**$\alpha 65/2000$ ,  $\alpha 100/2000$ ,  
and  $\alpha 150/2000$**



### **III. FANUC AC SERVO MOTOR $\alpha$ (HV) series**

# 1

## GENERAL

The FANUC AC servo motor  $\alpha$ (HV) series is suitable for application to the feed axes of machine tools. These motors have the following features:

### **Direct connection to a 400V power source**

A 400V power source can be connected directly without using a transformer.

### **Compact**

The use of the latest ferrite magnet, combined with an optimized mechanical design, reduces both the overall length and weight. The result is compact, lightweight servo motors.

### **Excellent waterproofing**

The use of waterproof connectors and FANUC's unique stator seal provide excellent waterproofing, ensuring that no liquid, such as coolant, can enter the motor.

### **Smooth rotation**

Further improvements have been made to the unique magnetic pole shape to minimize torque ripple. The result is extremely smooth rotation.

### **Controllability**

The use of the latest servo software maintains controllability even when a disturbance occurs.

### **Built-in high-performance detector**

A high-resolution pulse coder  $\alpha$ A64 or  $\alpha$ 164 is provided as standard, assuring accurate positioning.

### **Powerful brake**

A powerful brake with an increased holding torque is available as an option. The brake uses an asbestos-free design.

The  $\alpha$ (HV) series includes models  $\alpha$ 3HV and  $\alpha$ 6HV, both of which are compatible with  $\alpha$  series models  $\alpha$ 3 and  $\alpha$ 6 in their installation size, and models  $\alpha$ 12HV,  $\alpha$ 22HV and  $\alpha$ 30HV, which are compatible with series models  $\alpha$ 12,  $\alpha$ 22,  $\alpha$ 30 in their installation size.

# 2 TYPES OF MOTORS AND DESIGNATION

The types and specifications of  $\alpha$ (HV) series servo motors are described as follows.

## Models $\alpha$ 3/3000HV and $\alpha$ 6/3000HV

**A06B-01**□□-**B**☆○○

□□

**71** : Model  $\alpha$ 3/3000HV

**72** : Model  $\alpha$ 6/3000HV

☆

**0** : Taper shaft (standard)

**1** : Taper shaft with the brake (8Nm)

**5** : Straight shaft

**6** : Straight shaft with the brake (8Nm)

○○

**75** : With the pulse coder  $\alpha$ A64

**77** : With the pulse coder  $\alpha$ I64

**84** : With the serial pulse coder A

The standard shafts used for models  $\alpha$ 3/3000HV and  $\alpha$ 6/3000HV are taper shafts. Use a taper shaft as far as circumstances, such as the delivery time and maintenance, permit.

## Models $\alpha$ 12/3000HV, $\alpha$ 22/3000HV and $\alpha$ 30/3000HV

**A06B-01**□□-**B**☆○○

□□

**76** : Model  $\alpha$ 12/3000HV

**77** : Model  $\alpha$ 22/3000HV

**78** : Model  $\alpha$ 30/3000HV

☆

**0** : Straight shaft (standard)

**1** : Straight shaft with the brake (35Nm)

**5** : Taper shaft

**6** : Taper shaft with the brake (35Nm)

○○

**75** : With the pulse coder  $\alpha$ A64

**77** : With the pulse coder  $\alpha$ I64

**84** : With the serial pulse coder A

A straight shaft is fitted as the standard shaft for models  $\alpha$ 12/3000HV,  $\alpha$ 22/3000HV and  $\alpha$ 30/3000HV. When early delivery and ease-of-maintenance are important, a straight shaft should be used.

# 3

## SPECIFICATIONS AND CHARACTERISTICS





### 3.1 TYPES OF MOTORS AND SPECIFICATIONS

Item	Unit	$\alpha$ 3/3000HV	$\alpha$ 6/3000HV
Output	kw	0.9	1.4
	HP	1.3	1.9
Rated torque at stall	Nm	3.0	6.0
	kgf·cm	31	61
Rating output speed	1/min	3000	3000
Maximum theoretical torque	Nm	27	56
	kgf·cm	280	570
Rotor inertia	kg·m <sup>2</sup>	0.0014	0.0026
	kgf·cm·s <sup>2</sup>	0.014	0.027
Maximum theoretical acceleration	rad/s <sup>2</sup>	20000	21000
Weight	kg	8	13

The above values are under the condition at 20°C.

#### Note

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.

Item	Unit	$\alpha$ 12/3000HV	$\alpha$ 22/3000HV	$\alpha$ 30/3000HV
Output	kw	2.8	4.0	4.0
	HP	3.8	5.4	5.4
Rated torque at stall	Nm	12	22	30
	kgf-cm	122	224	306
Rating output speed	1/min	3000	3000	3000
Maximum theoretical torque	Nm	66	130	200
	kgf-cm	670	1400	2100
Rotor inertia	kg·m <sup>2</sup>	0.0062	0.012	0.017
	kgf-cm·s <sup>2</sup>	0.064	0.12	0.17
Maximum theoretical acceleration	rad/s <sup>2</sup>	11000	11000	12000
Weight	kg	18	29	41

The above values are under the condition at 20°C.

**Note**

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.

## 3.2 CHARACTERISTIC CURVE AND DATA SHEET

### Speed-torque characteristics

The intermittent operation zone is determined by the input voltage applied to the drive amplifier. The curve shown is the value for the rated input voltage (400V).

### Overload duty characteristic

The overload duty characteristic curves are determined based on the temperature restriction for the single motor unit (the temperature is restricted by means of a thermal trip built into the motor). 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 the motor shaft is locked. (An overcurrent flows in the motor windings until the thermal trip operates. The temperature rises momentarily.)

To detect such an abrupt temperature rise, the FANUC digital servo system provides a software thermal function that uses servo software to observe the current. During operation that is characterized by frequent acceleration/deceleration cycles, control is imposed by the software thermal function.

Driving units (such as amplifiers) and built-in detectors 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 :  $\alpha$ 3/3000HV

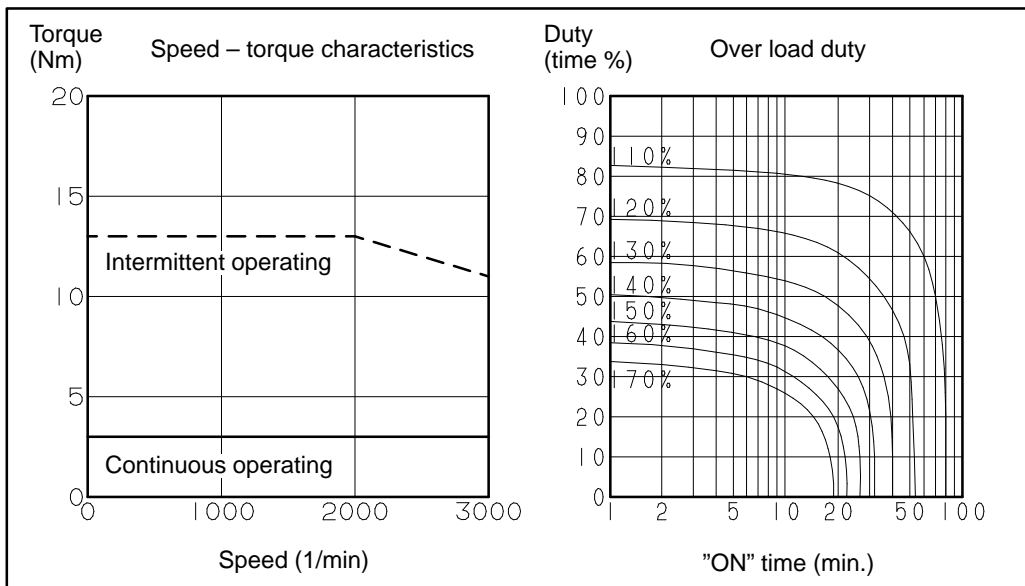
- Motor torque constant = 1.06 (Nm/Arms)
- Amplifier limit value = 20 A<sub>peak</sub>
- Maximum torque value  
=  $20 \times 0.707 \times 1.06$   
(Converted to an effective value)  
= 14.9 Nm

This value is for reference only. The actual value will vary depending on changes in the power supply, as well as variations in motor parameters and amplifier limit values.

In some models, if the maximum current flows in the motor, the actual maximum torque is affected by, for example, magnetic saturation. As a result, the actual maximum torque will be lower than the calculated value. The intermittent operation area (maximum torque value) indicated in the speed to torque characteristics is the effective value, determined according to the combination with the amplifier.

**Model α3/3000HV**

Specification : A06B-0171-B□□□



**Data sheet**

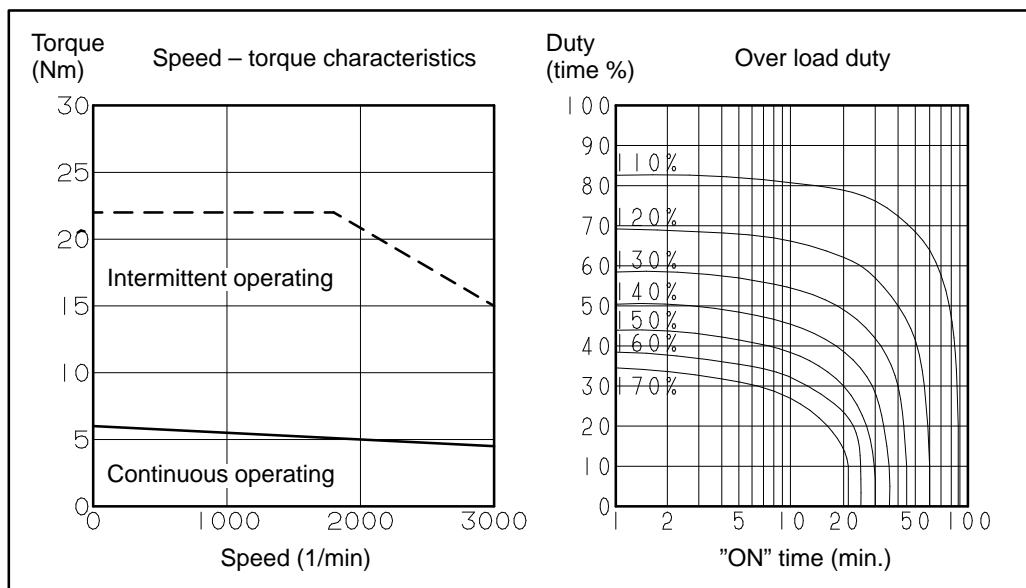
Parameter	Symbol	Value		Unit
Rating output speed	Nmax	3000		min <sup>-1</sup>
Rated torque at stall (*)	Ts	3.0		Nm
		31		kgfcm
Rotor inertia	Jm	0.0014		kgm <sup>2</sup>
		0.014		kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	2.8		A (rms)
Torque constant (*)	Kt	1.06		Nm/A (rms)
		10.8		kgfcm/A (rms)
Back EMF constant (*)	Ke	37		V/1000min <sup>-1</sup>
		0.35		Vsec/rad
Armature resistance (*)	Ra	1.85		Ω
Mechanical time constant (*)	tm	0.006		s
Thermal time constant	tt	45		min
Static friction	Tf	0.3		Nm
		3		kgfcm
Maximum allowable current	Im	37		A (peak)
Maximum theoretical torque	Tm	27		Nm
		280		kgfcm
Maximum theoretical acceleration		20000		rad/s <sup>2</sup>
Weight		8		kg

(\*) The values are the standard values at 20°C and the tolerance is ± 10%.

The speed–torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.

**Model α6/3000HV**

Specification : A06B-0172-B□□□



**Data sheet**

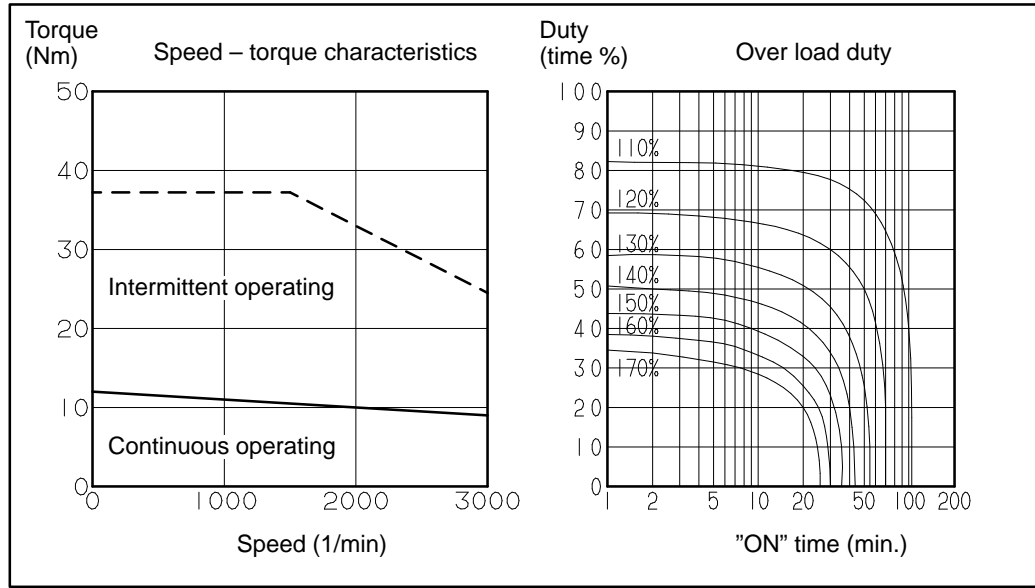
Parameter	Symbol	Value	Unit
Rating output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	6.0	Nm
		61	kgfcm
Rotor inertia	Jm	0.0026	kgm <sup>2</sup>
		0.027	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	3.6	A (rms)
Torque constant (*)	Kt	1.68	Nm/A (rms)
		17.1	kgfcm/A (rms)
Back EMF constant (*)	Ke	59	V/1000min <sup>-1</sup>
		0.56	Vsec/rad
Armature resistance (*)	Ra	1.52	Ω
Mechanical time constant (*)	tm	0.004	s
Thermal time constant	tt	45	min
Static friction	Tf	0.3	Nm
		3	kgfcm
Maximum allowable current	Im	47	A (peak)
Maximum theoretical torque	Tm	56	Nm
		570	kgfcm
Maximum theoretical acceleration		21000	rad/s <sup>2</sup>
Weight		13	kg

(\*)The values are the standard values at 20°C and the tolerance is ± 10%.

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.) These values may be changed without prior notice.

Model  $\alpha$ 12/3000HV

Specification : A06B-0176-B□□□



## Data sheet

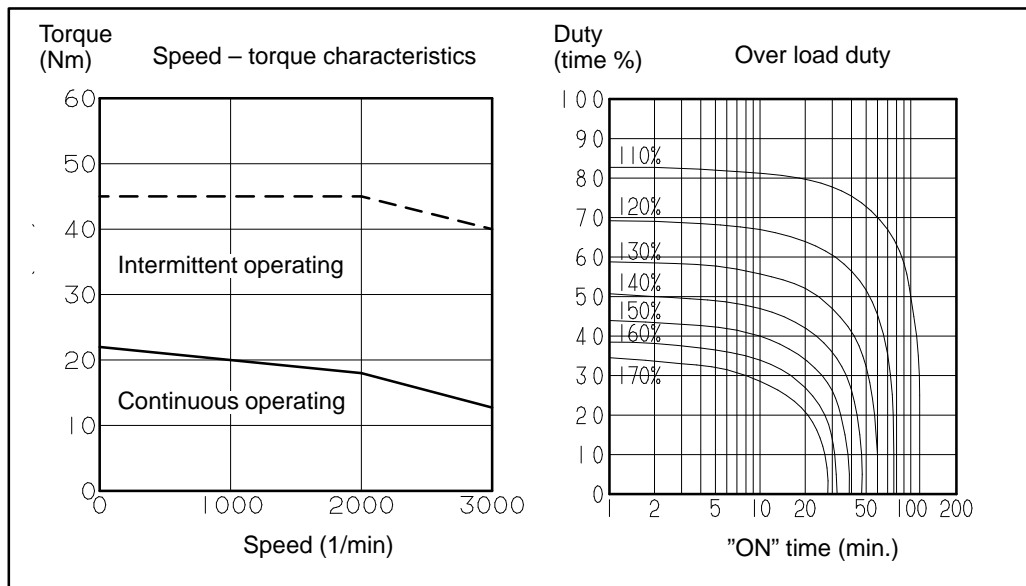
Parameter	Symbol	Value	Unit
Rating output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	12	Nm
		122	kgfcm
Rotor inertia	Jm	0.0062	kgm <sup>2</sup>
		0.064	kgfcm <sup>2</sup>
Continuous RMS current at stall (*)	Is	8.8	A (rms)
Torque constant (*)	Kt	1.36	Nm/A (rms)
		13.8	kgfcm/A (rms)
Back EMF constant (*)	Ke	47	V/1000min <sup>-1</sup>
	Kv	0.45	Vsec/rad
Armature resistance (*)	Ra	0.49	$\Omega$
Mechanical time constant (*)	tm	0.005	s
Thermal time constant	tt	60	min
Static friction	Tf	0.8	Nm
		8	kgfcm
Maximum allowable current	Im	70	A (peak)
Maximum theoretical torque	Tm	66	Nm
		670	kgfcm
Maximum theoretical acceleration		11000	rad/s <sup>2</sup>
Weight		18	kg

(\*) The values are the standard values at 20°C and the tolerance is  $\pm 10\%$ .

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.) These values may be changed without prior notice.

**Model α22/3000HV**

Specification : A06B-0177-B□□□



**Data sheet**

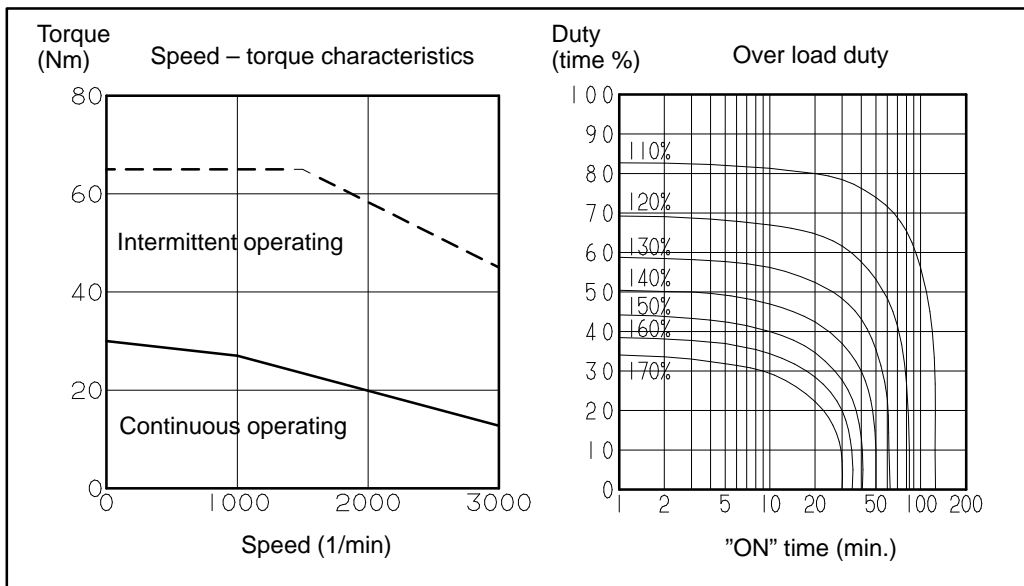
Parameter	Symbol	Value	Unit
Rating output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	22	Nm
		224	kgfcm
Rotor inertia	Jm	0.012	kgm <sup>2</sup>
		0.12	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	12.5	A (rms)
Torque constant (*)	Kt	1.76	Nm/A (rms)
		18.0	kgfcm/A (rms)
Back EMF constant (*)	Ke	62	V/1000min <sup>-1</sup>
		0.59	Vsec/rad
Armature resistance (*)	Ra	0.32	Ω
Mechanical time constant (*)	tm	0.003	s
Thermal time constant	tt	65	min
Static friction	Tf	1.2	Nm
		12	kgfcm
Maximum allowable current	Im	105	A (peak)
Maximum theoretical torque	Tm	130	Nm
		1400	kgfcm
Maximum theoretical acceleration		11000	rad/s <sup>2</sup>
Weight		29	kg

(\*)The values are the standard values at 20°C and the tolerance is ± 10%.

The speed–torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.

**Model α30/3000HV**

Specification : A06B-0178-B□□□



**Data sheet**

Parameter	Symbol	Value	Unit
Rating output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	30	Nm
		306	kgfcm
Rotor inertia	Jm	0.017	kgm <sup>2</sup>
		0.17	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	12.6	A (rms)
Torque constant (*)	Kt	2.37	Nm/A (rms)
		24.2	kgfcm/A (rms)
Back EMF constant (*)	Ke	83	V/1000min <sup>-1</sup>
		0.79	Vsec/rad
Armature resistance (*)	Ra	0.34	Ω
Mechanical time constant (*)	tm	0.003	s
Thermal time constant	tt	70	min
Static friction	Tf	1.8	Nm
		18	kgfcm
Maximum allowable current	Im	120	A (peak)
Maximum theoretical torque	Tm	200	Nm
		2100	kgfcm
Maximum theoretical acceleration		12000	rad/s <sup>2</sup>
Weight		41	kg

(\*)The values are the standard values at 20°C and the tolerance is ± 10%.

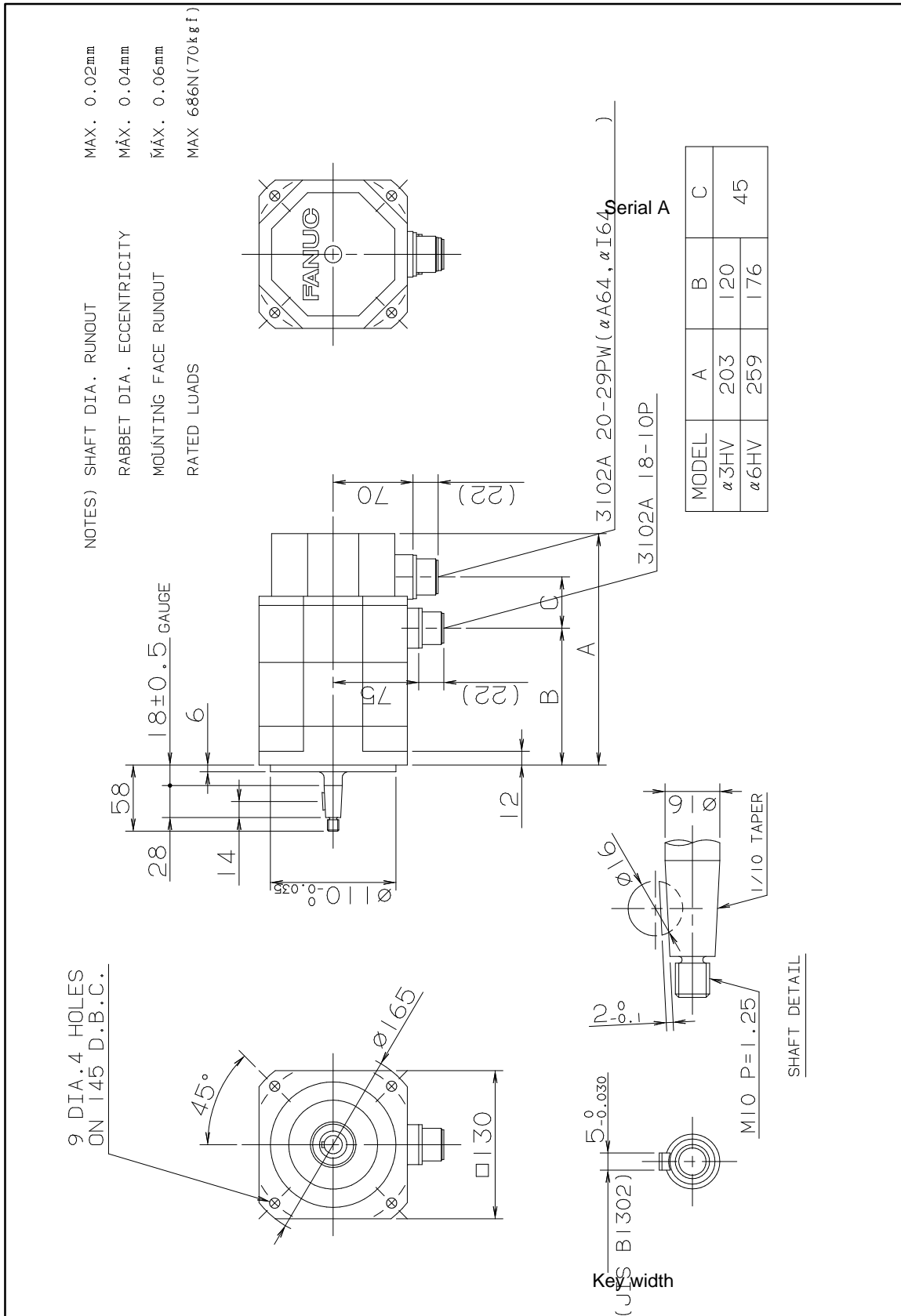
The speed–torque characteristics vary depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.



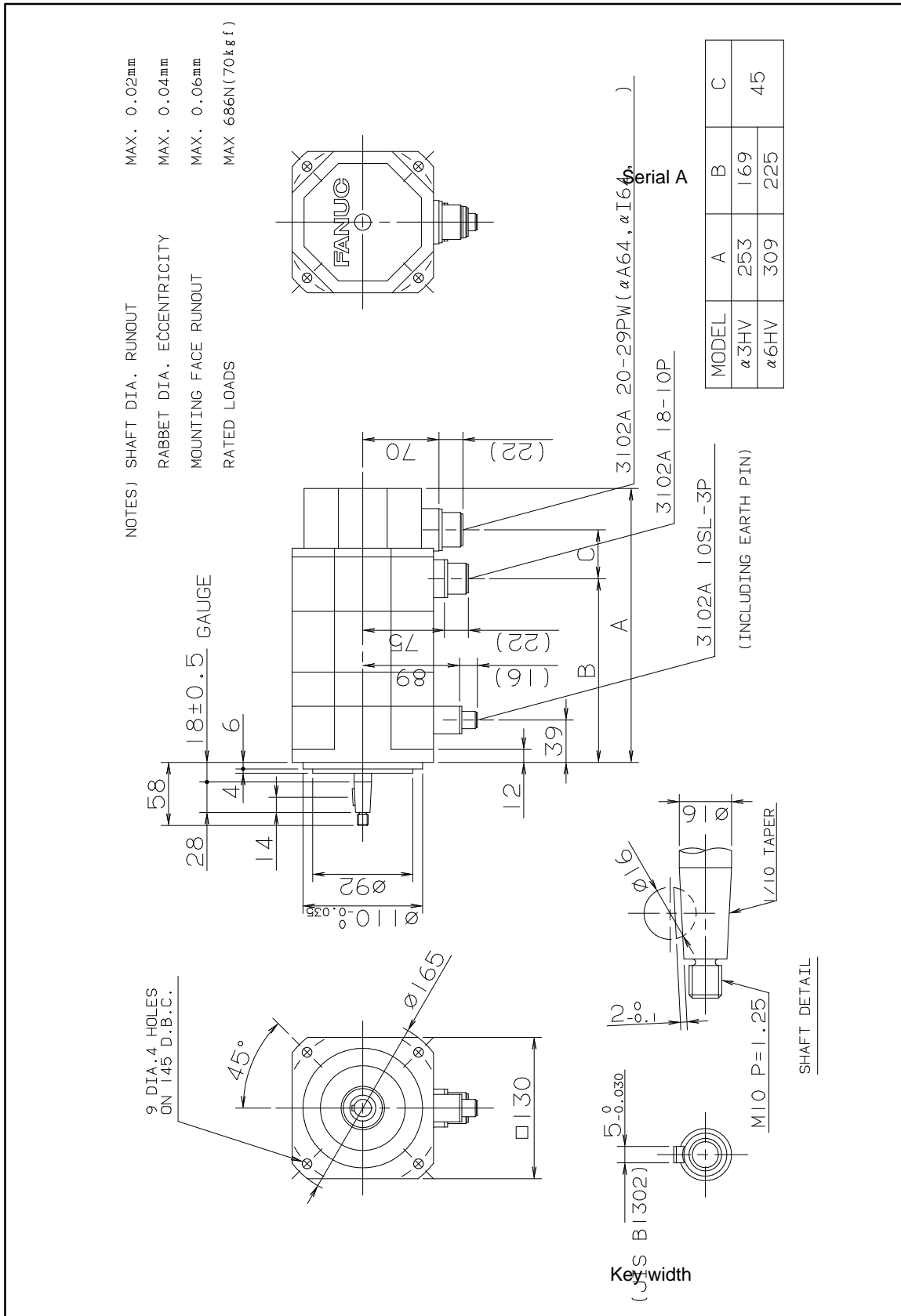
### 3.3 OUTLINE DRAWINGS

Model	Fig. No.
Models $\alpha$ 3/3000HV and $\alpha$ 6/3000HV	Fig. 3.3(a)
Models $\alpha$ 3/3000HV and $\alpha$ 6/3000HV (with the brake)	Fig. 3.3(b)
Models $\alpha$ 3/3000HV and $\alpha$ 6/3000HV (shaft option)	Fig. 3.3(c)
Models $\alpha$ 12/3000HV, $\alpha$ 22/3000HV, and $\alpha$ 30/3000HV	Fig. 3.3(d)
Models $\alpha$ 12/3000HV, $\alpha$ 22/3000HV, and $\alpha$ 30/3000HV (with the brake)	Fig. 3.3(e)
Models $\alpha$ 12/3000HV, $\alpha$ 22/3000HV, and $\alpha$ 30/3000HV (shaft option)	Fig. 3.3(f)

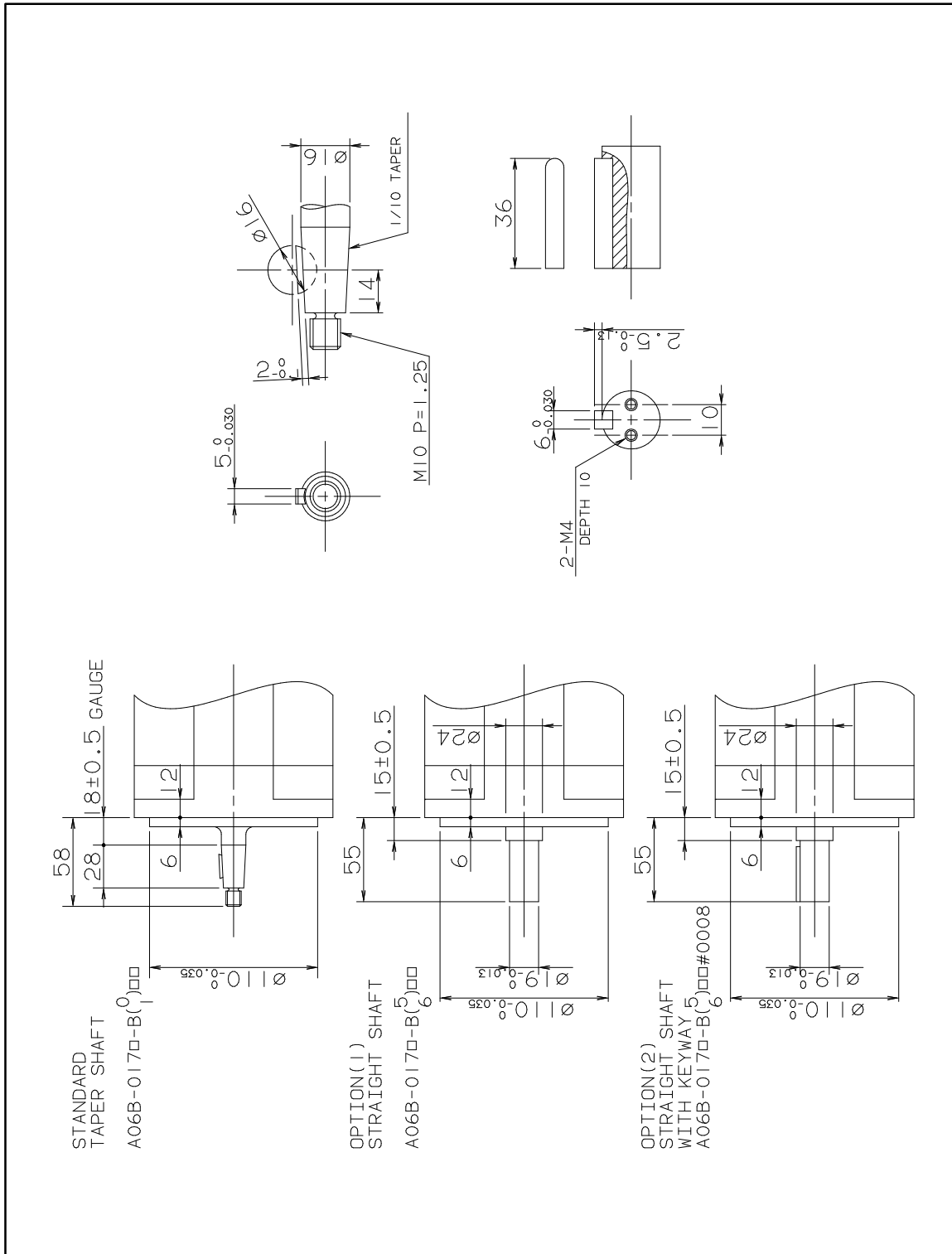
**Fig. 3.3 (a) Models α3/3000HV and α6/3000HV**



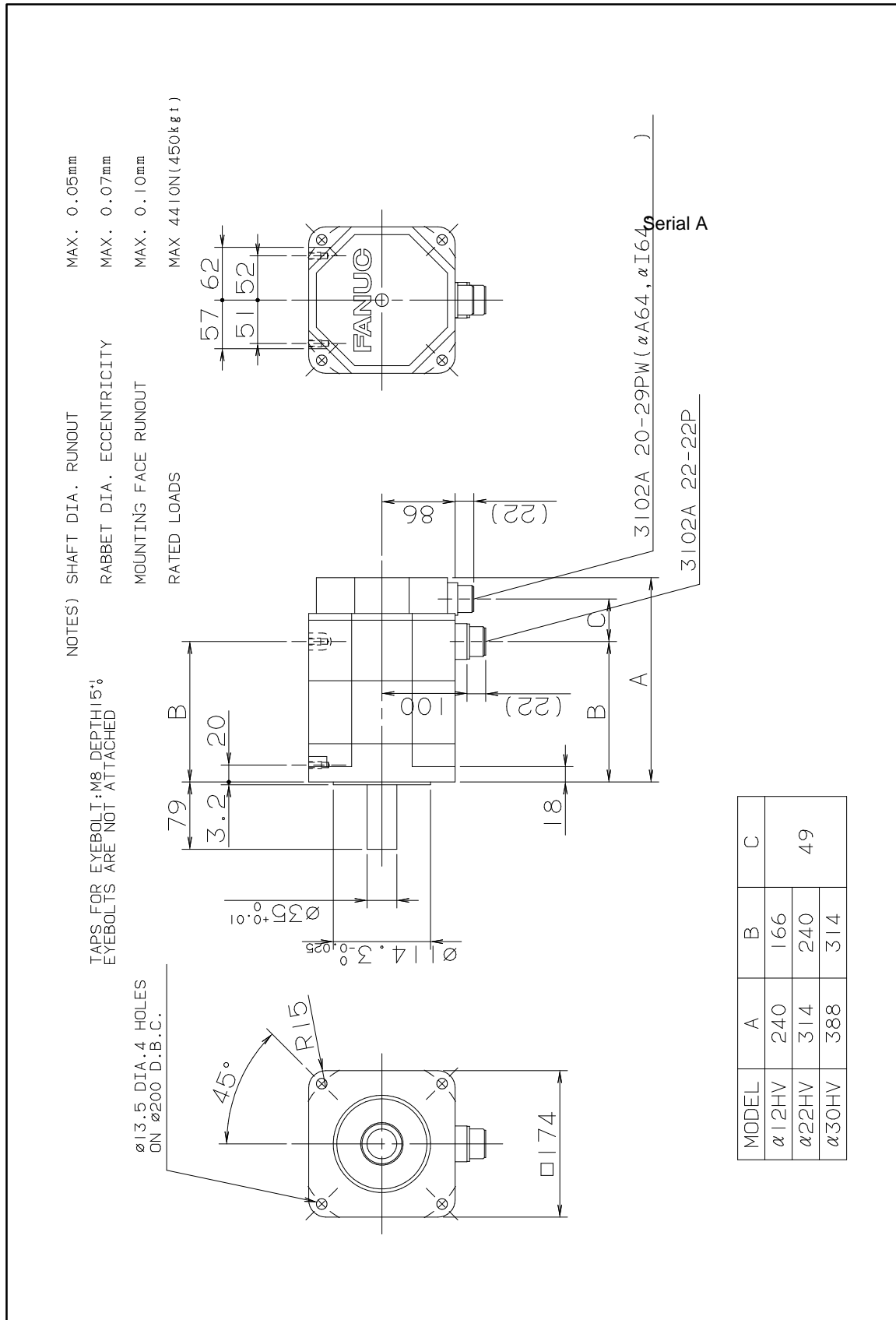
**Fig. 3.3 (b) Models  $\alpha$ 3/3000HV and  $\alpha$ 6/3000HV (with the brake)**



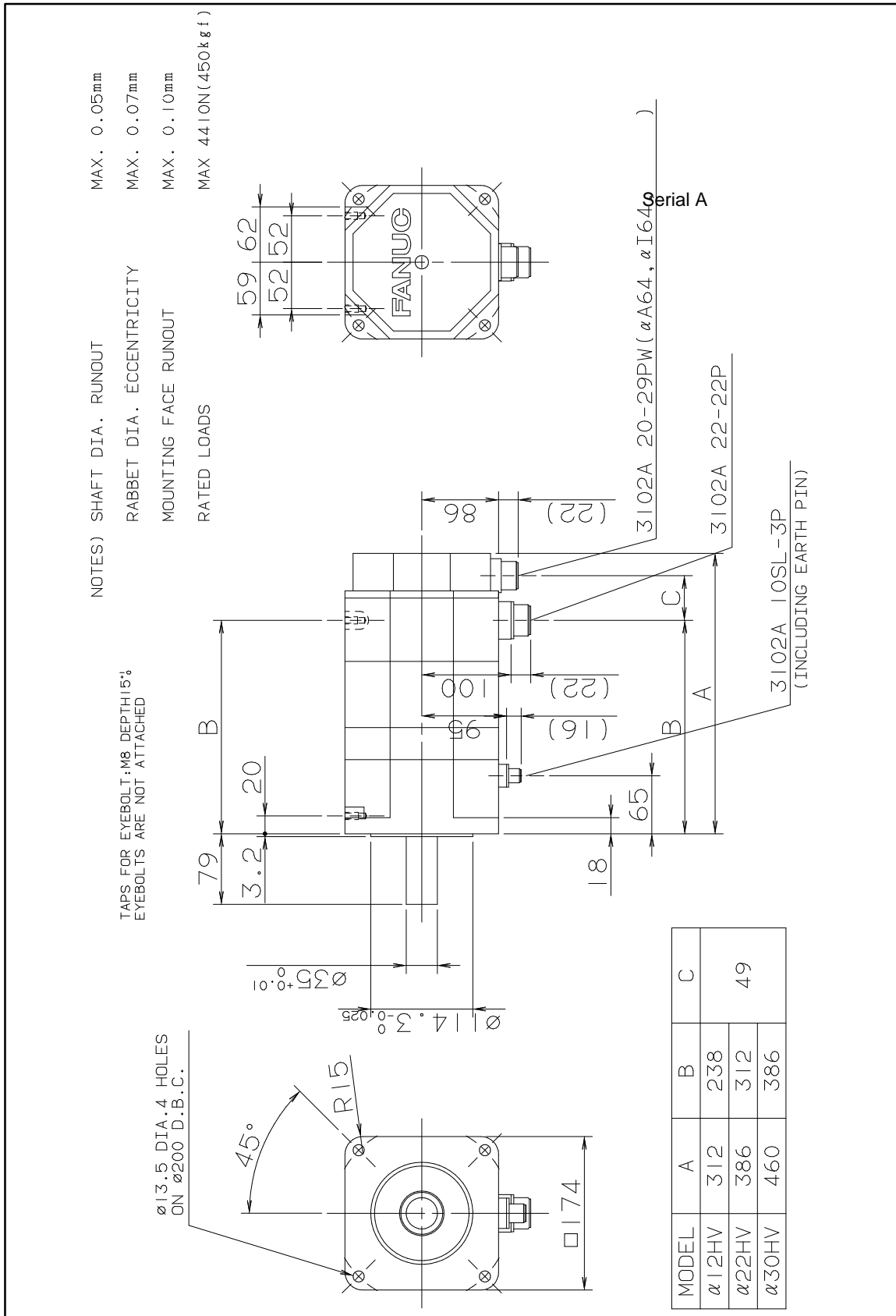
**Fig. 3.3 (c) Models α3/3000HV and α6/3000HV (shaft option)**



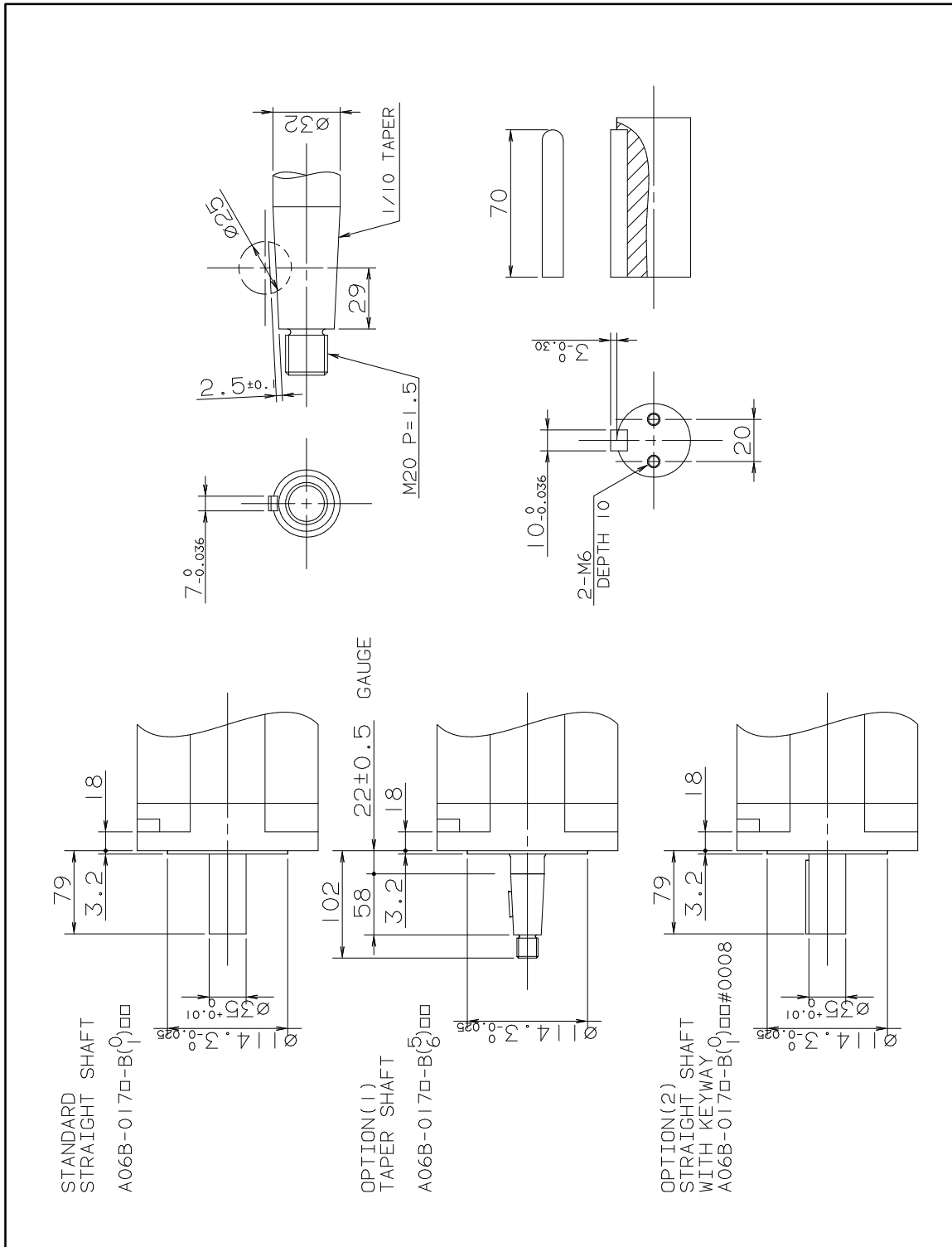
**Fig. 3.3 (d) Models α12/3000HV, α22/3000HV and α30/3000HV**



**Fig. 3.3 (e) Models  $\alpha$ 12/3000,  $\alpha$ 22/3000 and  $\alpha$ 30/3000HV (with the brake)**

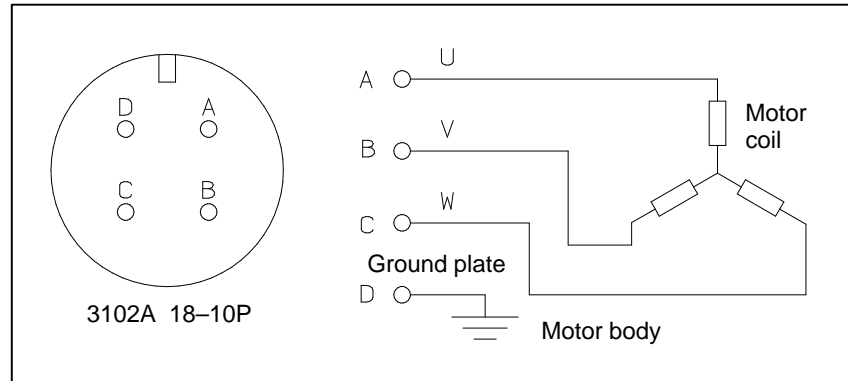


**Fig. 3.3 (f) Models α12/3000HV, α22/3000HV and α30/3000HV (shaft option)**

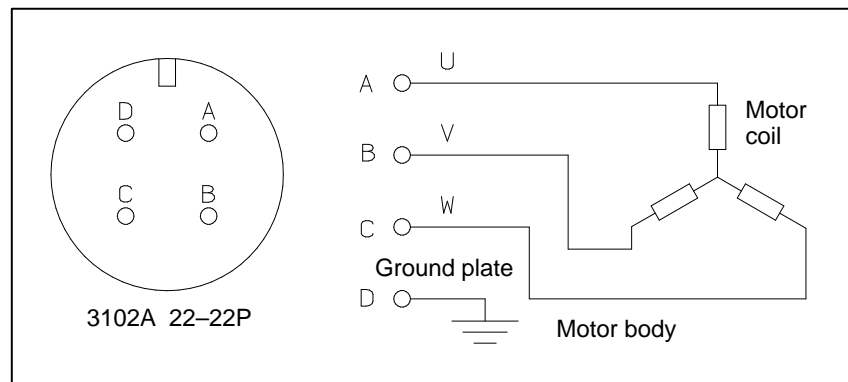


### 3.4 CONNECTION OF POWER LINE

**Models**  
 $\alpha$ 3/3000HV and  
 $\alpha$ 6/3000HV



**Models**  
 $\alpha$ 12/3000HV,  $\alpha$ 22/3000HV  
and  $\alpha$ 30/3000HV





## **IV. FANUC AC SERVO MOTOR $\alpha$ C series**

# 1

## GENERAL

The FANUC AC servo motor  $\alpha$ C series is suitable for application to the feed axes of machine tools. These motors have the following features:

### High cost-effectiveness

High cost-effectiveness has been achieved. Although a low-power amplifier is used, high acceleration is offered.

### Compact

The use of the latest ferrite magnet, combined with an optimized mechanical design, reduces both the overall length and weight. The result is compact, lightweight servo motors.

### Excellent waterproofing

The use of waterproof connectors and FANUC's unique stator seal provide excellent waterproofing, ensuring that no liquid, such as coolant, can enter the motor.

### Smooth rotation

Further improvements have been made to the unique magnetic pole shape to minimize torque ripple. The result is extremely smooth rotation.

### Controllability

The use of the latest servo software maintains controllability even when a disturbance occurs.

### High-performance detector

High-resolution pulse coder  $\alpha$ A64 or  $\alpha$ I64 is used in the standard configuration, enabling precise positioning.

### Powerful brake

A powerful brake with an increased holding torque is available as an option. The brake uses an asbestos-free design.

The  $\alpha$ C series includes models  $\alpha$ C3 and  $\alpha$ C6, both of which are compatible with  $\alpha$  series models  $\alpha$ 3 and  $\alpha$ 6 in their installation size, and models  $\alpha$ C12 and  $\alpha$ C22, which are compatible with  $\alpha$  series models  $\alpha$ 12 and  $\alpha$ 22 in their installation size.

# 2 TYPES OF MOTORS AND DESIGNATION

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

## Models $\alpha$ C3/2000 and $\alpha$ C6/2000

**A06B-01**□□-**B**☆○○

□□

**21** : Model  $\alpha$ C3/2000

**26** : Model  $\alpha$ C6/2000

☆

**0** : Taper shaft (standard)

**1** : Taper shaft with the brake (8Nm)

**5** : Straight shaft

**6** : Straight shaft with the brake (8Nm)

○○

**75** : With the pulse coder  $\alpha$ A64

**77** : With the pulse coder  $\alpha$ I64

The standard shafts used for models  $\alpha$ C3/2000 and  $\alpha$ C6/2000 are taper shafts. Use a taper shaft as far as circumstances, such as the delivery time and maintenance, permit.

## Models $\alpha$ C12/2000 and $\alpha$ C22/1500

**A06B-01**□□-**B**☆○○

□□

**41** : Model  $\alpha$ C12/2000

**45** : Model  $\alpha$ C22/1500

☆

**0** : Straight shaft (standard)

**1** : Straight shaft with the brake (35Nm)

**5** : Taper shaft

**6** : Taper shaft with the brake (35Nm)

○○

**75** : With the pulse coder  $\alpha$ A64

**77** : With the pulse coder  $\alpha$ I64

A straight shaft is fitted as the standard shaft for models  $\alpha$ C12/2000 and  $\alpha$ C22/1500. When early delivery and ease-of-maintenance are important, a straight shaft should be used.

### Note

For the  $\alpha$ C series, serial pulse coder A cannot be used.

# 3

## SPECIFICATIONS AND CHARACTERISTICS



### 3.1 TYPES OF MOTORS AND SPECIFICATIONS

Item	Unit	$\alpha$ C3/2000	$\alpha$ C6/2000	$\alpha$ C12/2000	$\alpha$ C22/1500
Output	kw	0.3	0.6	1.0	1.5
	HP	0.4	0.8	1.4	2.1
Rated torque at stall	Nm	3.0	6.0	12	22
	kgf·cm	31	61	122	224
Rating output speed	1/min	2000	2000	2000	1500
Maximum theoretical torque	Nm	27	56	66	130
	kgf·cm	280	570	670	1400
Rotor inertia	kg·m <sup>2</sup>	0.0014	0.0026	0.0062	0.012
	kgf·cm·s <sup>2</sup>	0.014	0.027	0.064	0.12
Maximum theoretical acceleration	rad/s <sup>2</sup>	20000	21000	11000	11000
Weight	kg	8	13	18	29

The above values are under the condition at 20°C.

#### Note

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.

## 3.2 CHARACTERISTIC CURVE AND DATA SHEET

### Speed–torque characteristics

The intermittent operation zone is determined by the input voltage applied to the drive amplifier. The curve shown is the value for the rated input voltage (200V).

### Overload duty characteristic

The overload duty characteristic curves are determined based on the temperature restriction for the single motor unit (the temperature is restricted by means of a thermal trip built into the motor). 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 the motor shaft is locked. (An overcurrent flows in the motor windings until the thermal trip operates. The temperature rises momentarily.)

To detect such an abrupt temperature rise, the FANUC digital servo system provides a software thermal function that uses servo software to observe the current. During operation that is characterized by frequent acceleration/deceleration cycles, control is imposed by the software thermal function.

Driving units (such as amplifiers) and built-in detectors 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 :  $\alpha$ C3/2000

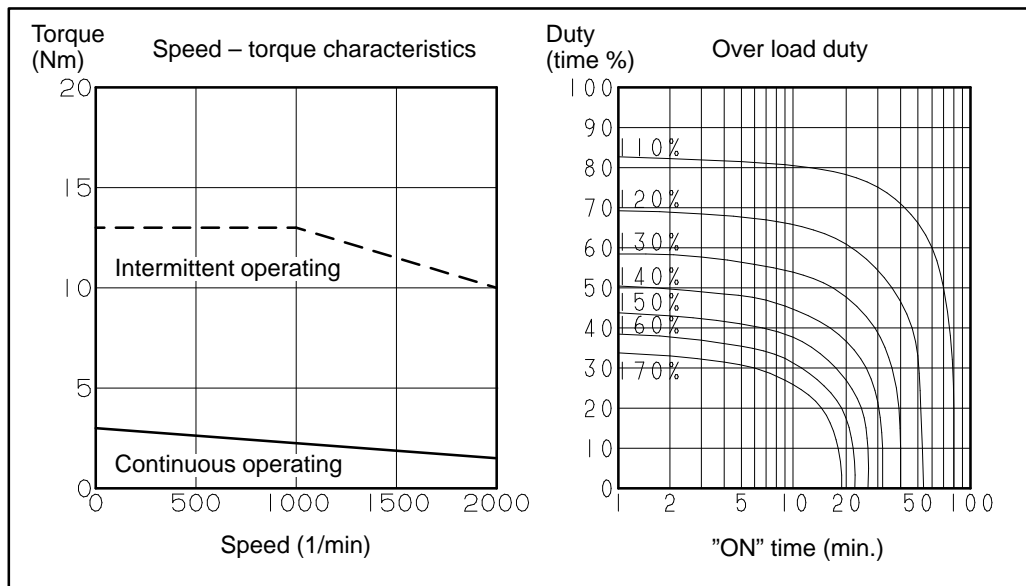
- Motor torque constant = 1.06 (Nm/Arms)
- Amplifier limit value = 20 A<sub>peak</sub>
- Maximum torque value  
 $= 20 \times 0.707 \times 1.06$   
 (Converted to an effective value)  
 $= 14.9 \text{ Nm}$  (Converted to an effective value)

This value is for reference only. The actual value will vary depending on changes in the power supply, as well as variations in motor parameters and amplifier limit values.

In some models, if the maximum current flows in the motor, the actual maximum torque is affected by, for example, magnetic saturation. As a result, the actual maximum torque will be lower than the calculated value. The intermittent operation area (maximum torque value) indicated in the speed to torque characteristics is the effective value, determined according to the combination with the amplifier.

**Model αC3/2000**

Specification : A06B-0121-B□□□



**Data sheet**

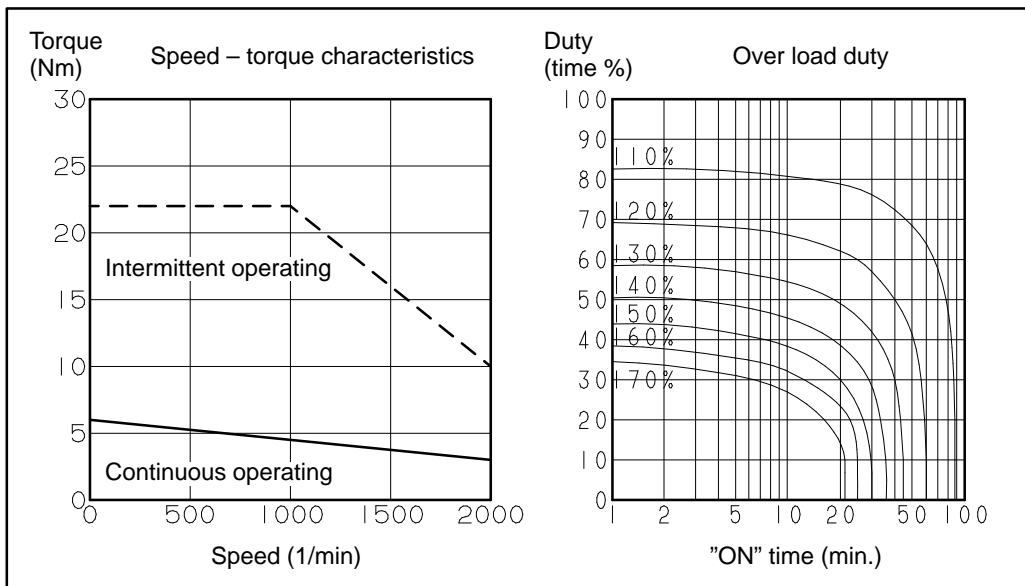
Parameter	Symbol	Value		Unit
Rating output speed	Nmax	2000		min <sup>-1</sup>
Rated torque at stall (*)	Ts	3.0		Nm
		31		kgfcm
Rotor inertia	Jm	0.0014		kgm <sup>2</sup>
		0.014		kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	2.8		A (rms)
Torque constant (*)	Kt	1.06		Nm/A (rms)
		10.8		kgfcm/A (rms)
Back EMF constant (*)	Ke	37		V/1000min <sup>-1</sup>
		0.35		Vsec/rad
Armature resistance (*)	Ra	1.85		Ω
Mechanical time constant (*)	tm	0.006		s
Thermal time constant	tt	45		min
Static friction	Tf	0.3		Nm
		3		kgfcm
Maximum allowable current	Im	37		A (peak)
Maximum theoretical torque	Tm	27		Nm
		280		kgfcm
Maximum theoretical acceleration		20000		rad/s <sup>2</sup>
Weight		8		kg

(\*) The values are the standard values at 20°C and the tolerance is ± 10%.

The speed–torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.

**Model αC6/2000**

Specification : A06B-0126-B□□□



**Data sheet**

Parameter	Symbol	Value	Unit
Rating output speed	Nmax	2000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	6.0	Nm
		61	kgfcm
Rotor inertia	Jm	0.0026	kgm <sup>2</sup>
		0.027	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	3.6	A (rms)
Torque constant (*)	Kt	1.68	Nm/A (rms)
		17.1	kgfcm/A (rms)
Back EMF constant (*)	Ke	59	V/1000min <sup>-1</sup>
		0.56	Vsec/rad
Armature resistance (*)	Ra	1.52	Ω
Mechanical time constant (*)	tm	0.004	s
Thermal time constant	tt	50	min
Static friction	Tf	0.3	Nm
		3	kgfcm
Maximum allowable current	Im	47	A (peak)
Maximum theoretical torque	Tm	56	Nm
		570	kgfcm
Maximum theoretical acceleration		21000	rad/s <sup>2</sup>
Weight		13	kg

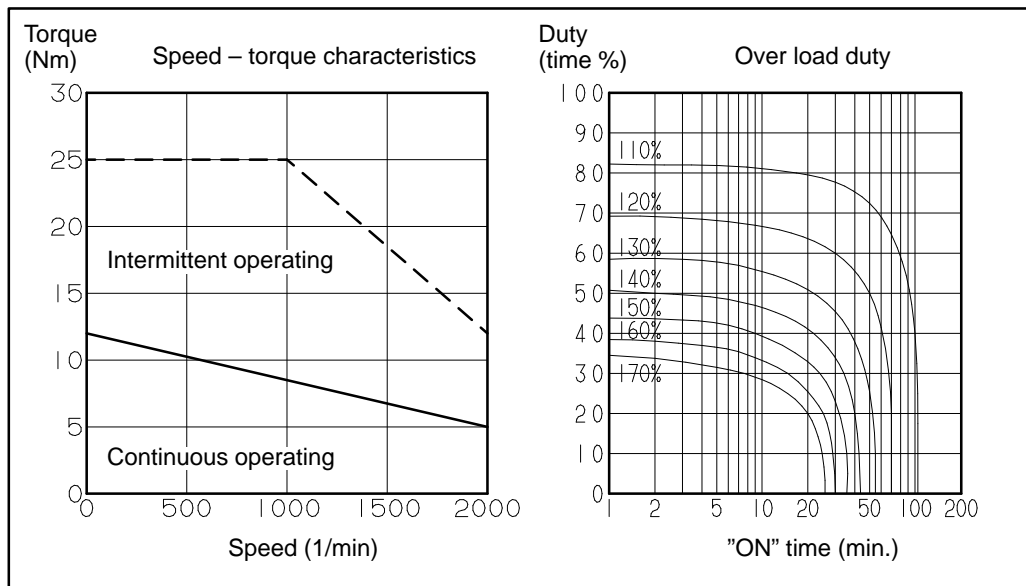
(\*)The values are the standard values at 20°C and the tolerance is ± 10%.

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.) These values may be changed without prior notice.



**Model αC12/2000**

Specification : A06B-0141-B□□□



**Data sheet**

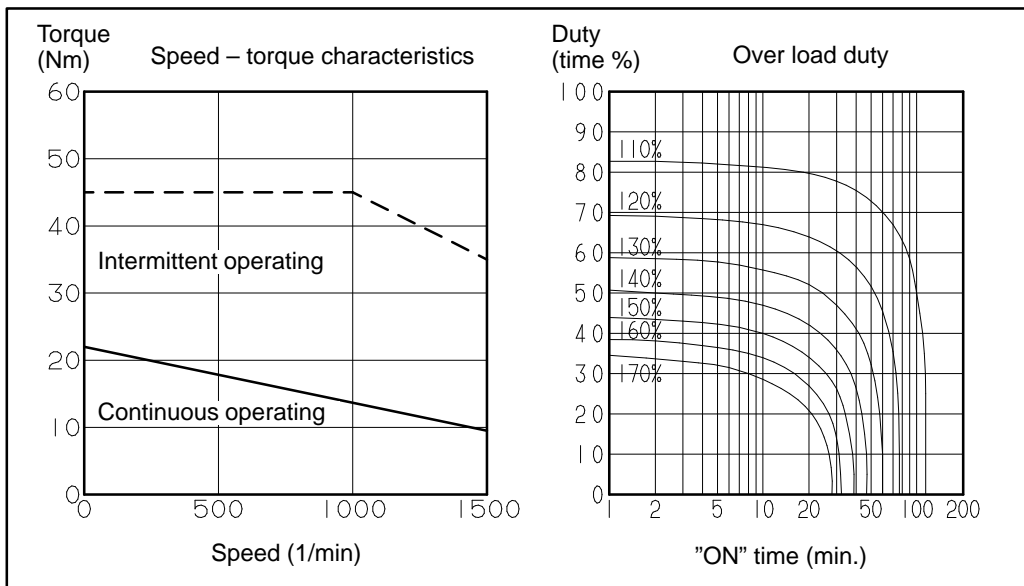
Parameter	Symbol	Value		Unit
Rating output speed	Nmax	2000		min <sup>-1</sup>
Rated torque at stall (*)	Ts	12		Nm
		122		kgfcm
Rotor inertia	Jm	0.0062		kgm <sup>2</sup>
		0.064		kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	5.9		A (rms)
Torque constant (*)	Kt	2.04		Nm/A (rms)
		20.8		kgfcm/A (rms)
Back EMF constant (*)	Ke	71		V/1000min <sup>-1</sup>
	Kv	0.68		Vsec/rad
Armature resistance (*)	Ra	1.092		Ω
Mechanical time constant (*)	tm	0.005		s
Thermal time constant	tt	60		min
Static friction	Tf	0.8		Nm
		8		kgfcm
Maximum allowable current	Im	46		A (peak)
Maximum theoretical torque	Tm	66		Nm
		670		kgfcm
Maximum theoretical acceleration		11000		rad/s <sup>2</sup>
Weight		18		kg

(\*) The values are the standard values at 20°C and the tolerance is ± 10%.

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.) These values may be changed without prior notice.

**Model αC22/1500**

Specification : A06B-0145-B□□□



**Data sheet**

Parameter	Symbol	Value	Unit
Rating output speed	Nmax	1500	min <sup>-1</sup>
Rated torque at stall (*)	Ts	22	Nm
		224	kgfcm
Rotor inertia	Jm	0.012	kgm <sup>2</sup>
		0.12	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	12.5	A (rms)
Torque constant (*)	Kt	1.76	Nm/A (rms)
		18.0	kgfcm/A (rms)
Back EMF constant (*)	Ke	62	V/1000min <sup>-1</sup>
		0.59	Vsec/rad
Armature resistance (*)	Ra	0.315	Ω
Mechanical time constant (*)	tm	0.004	s
Thermal time constant	tt	65	min
Static friction	Tf	1.2	Nm
		12	kgfcm
Maximum allowable current	Im	105	A (peak)
Maximum theoretical torque	Tm	130	Nm
		1400	kgfcm
Maximum theoretical acceleration		11000	rad/s <sup>2</sup>
Weight		30	kg

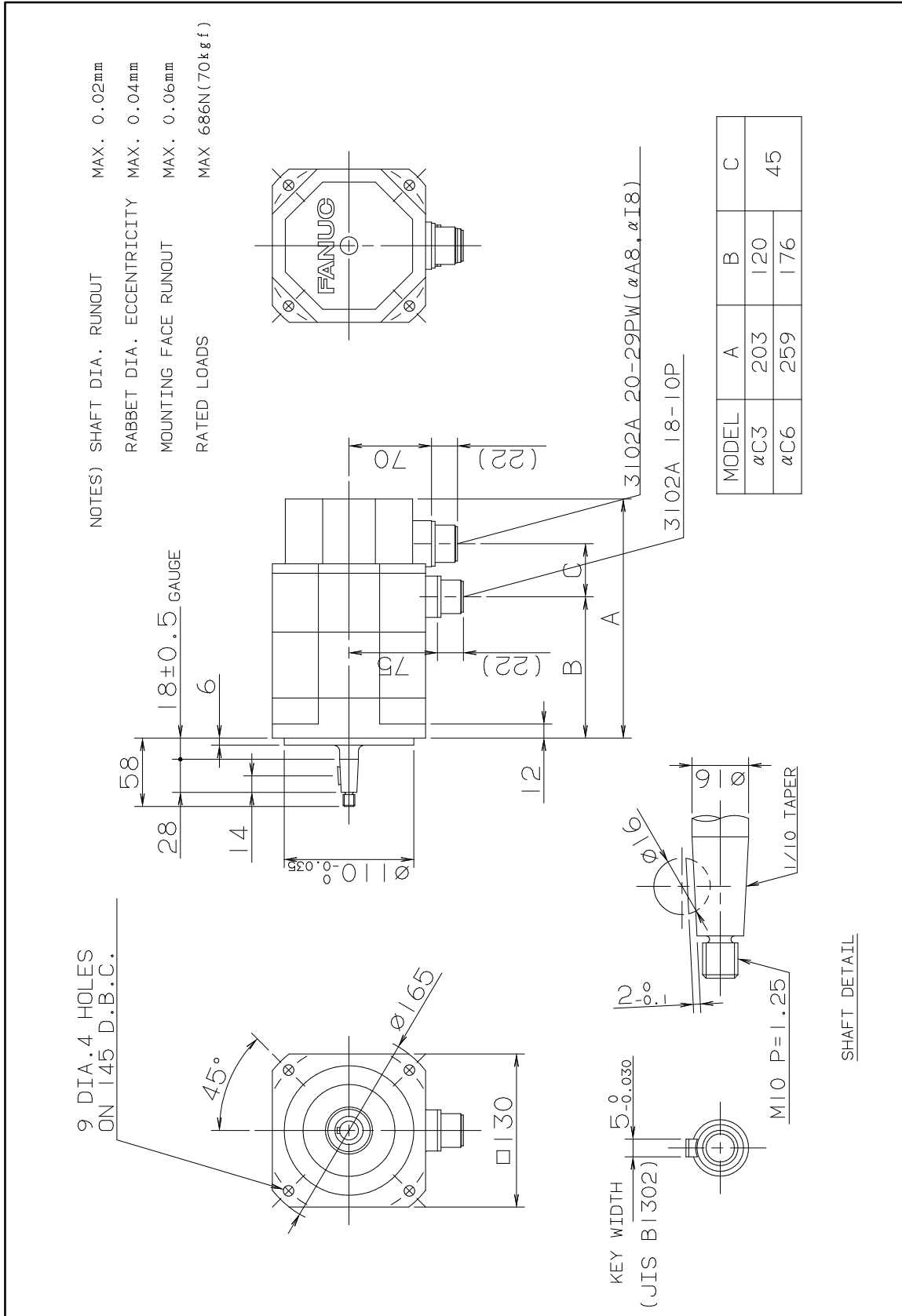
(\*)The values are the standard values at 20°C and the tolerance is ± 10%.

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.) These values may be changed without prior notice.

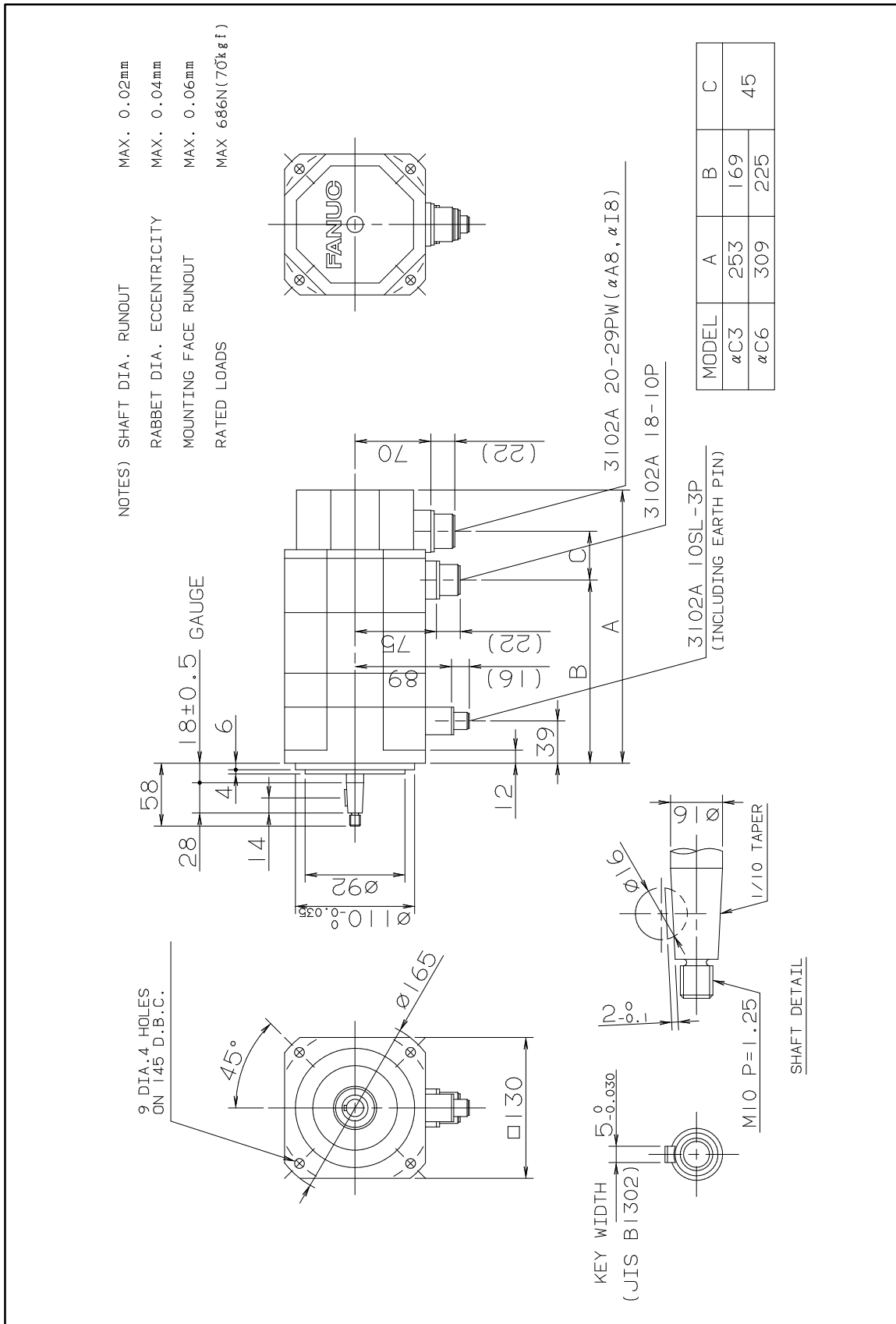
### 3.3 OUTLINE DRAWINGS

Model	Fig. No.
Models $\alpha$ C3/2000 and $\alpha$ C6/2000	Fig. 3.3(a)
Models $\alpha$ C3/2000 and $\alpha$ C6/2000 (with the brake)	Fig. 3.3(b)
Models $\alpha$ C3/2000 and $\alpha$ C6/2000 (shaft option)	Fig. 3.3(c)
Models $\alpha$ C12/2000 and $\alpha$ C22/1500	Fig. 3.3(d)
Models $\alpha$ C12/2000 and $\alpha$ C22/1500 (with the brake)	Fig. 3.3(e)
Models $\alpha$ C12/2000 and $\alpha$ C22/1500 (shaft option)	Fig. 3.3(f)

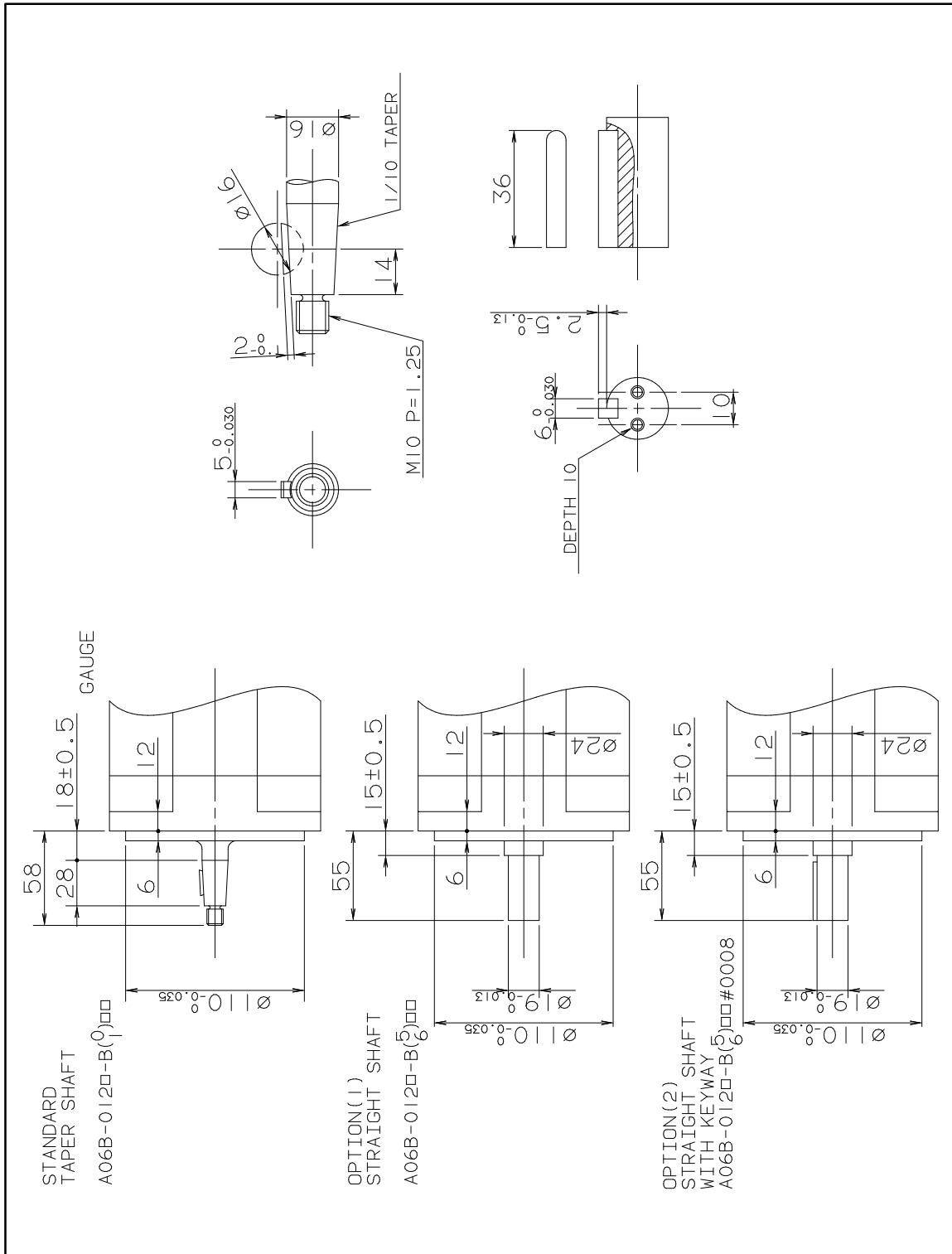
**Fig. 3.3 (a) Models αC3/2000 and αC6/2000**



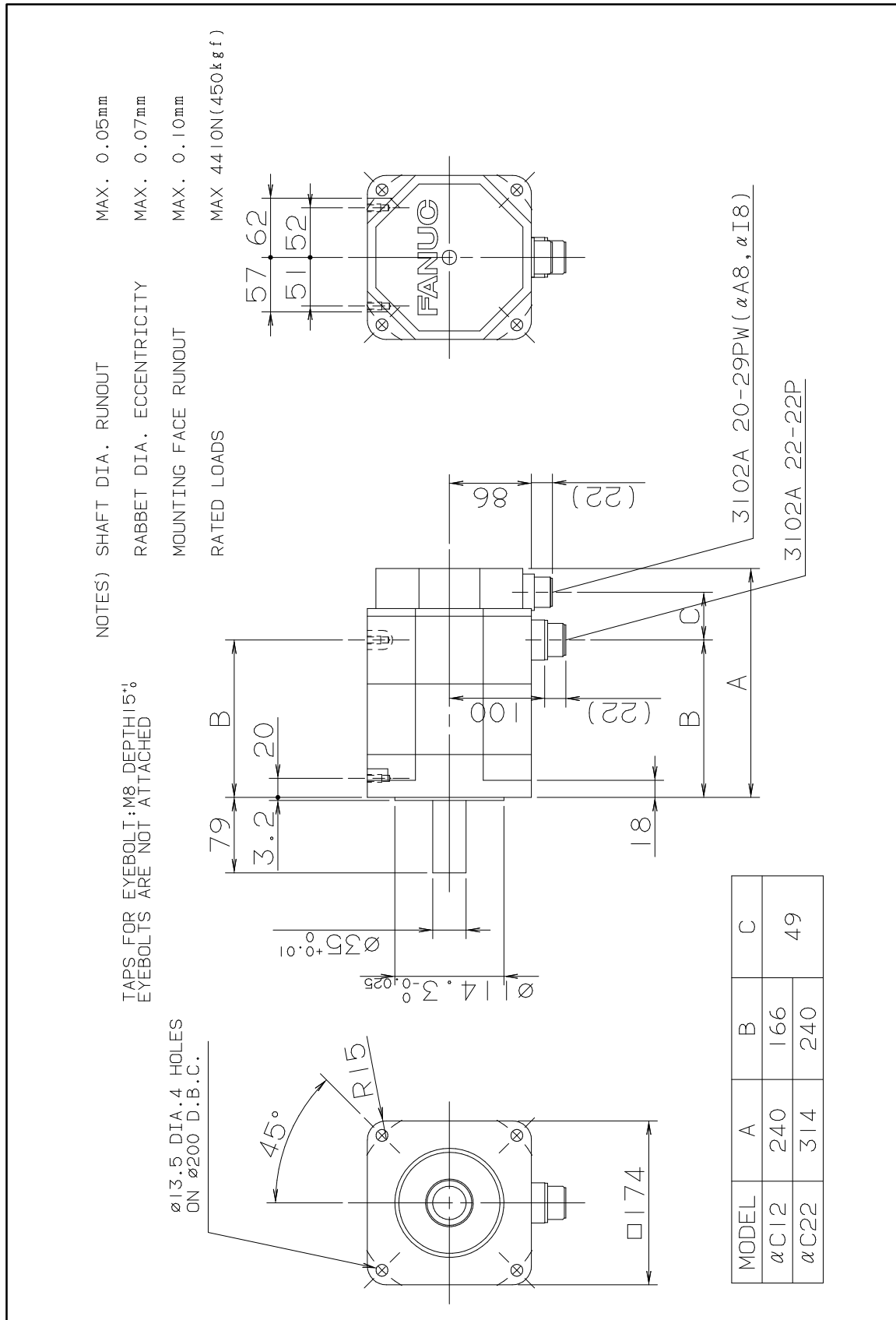
**Fig. 3.3 (b) Models αC3/2000 and αC6/2000 (with the brake)**



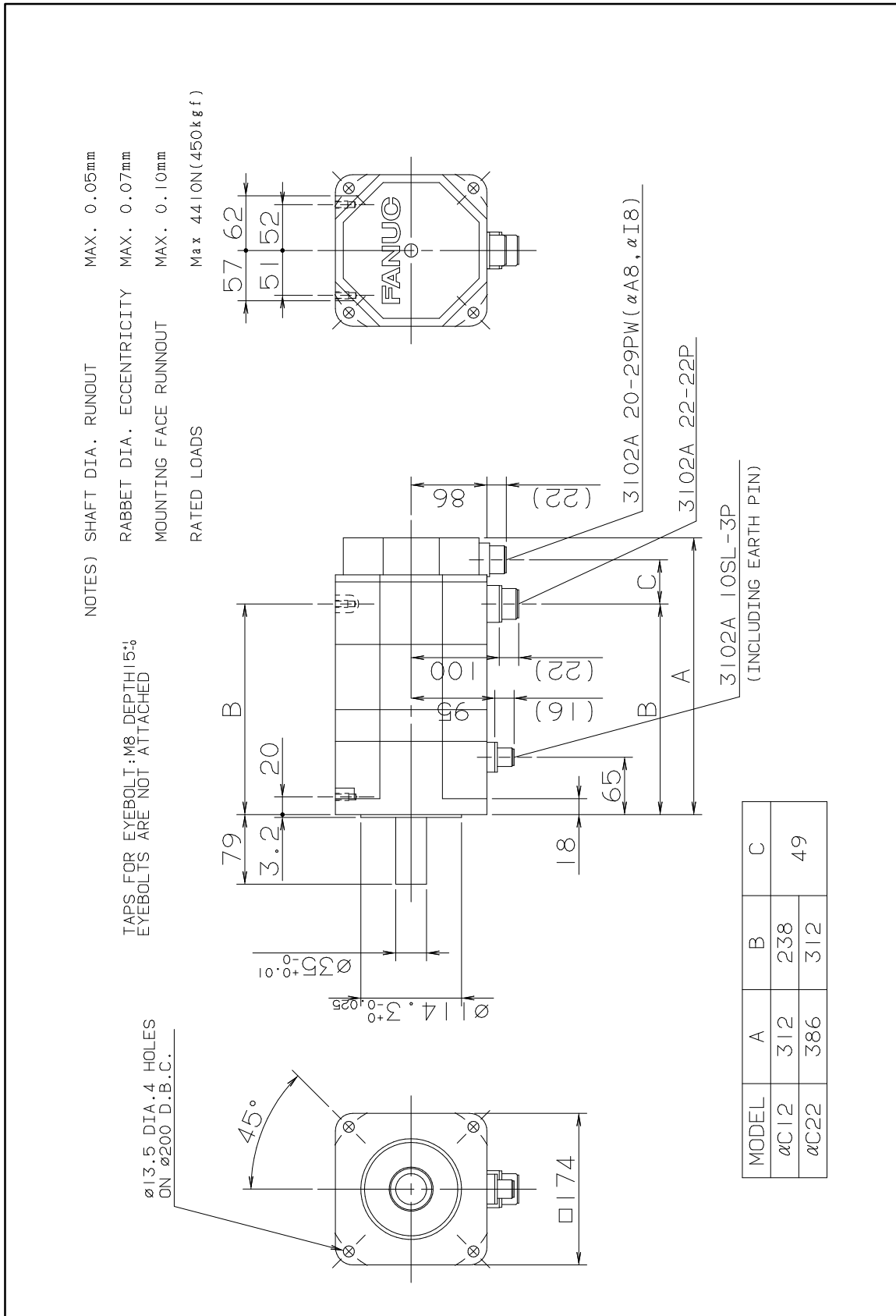
**Fig. 3.3 (c) Models αC3/2000 and αC6/2000 (shaft option)**



**Fig. 3.3 (d) Models αC12/2000 and αC22/1500**

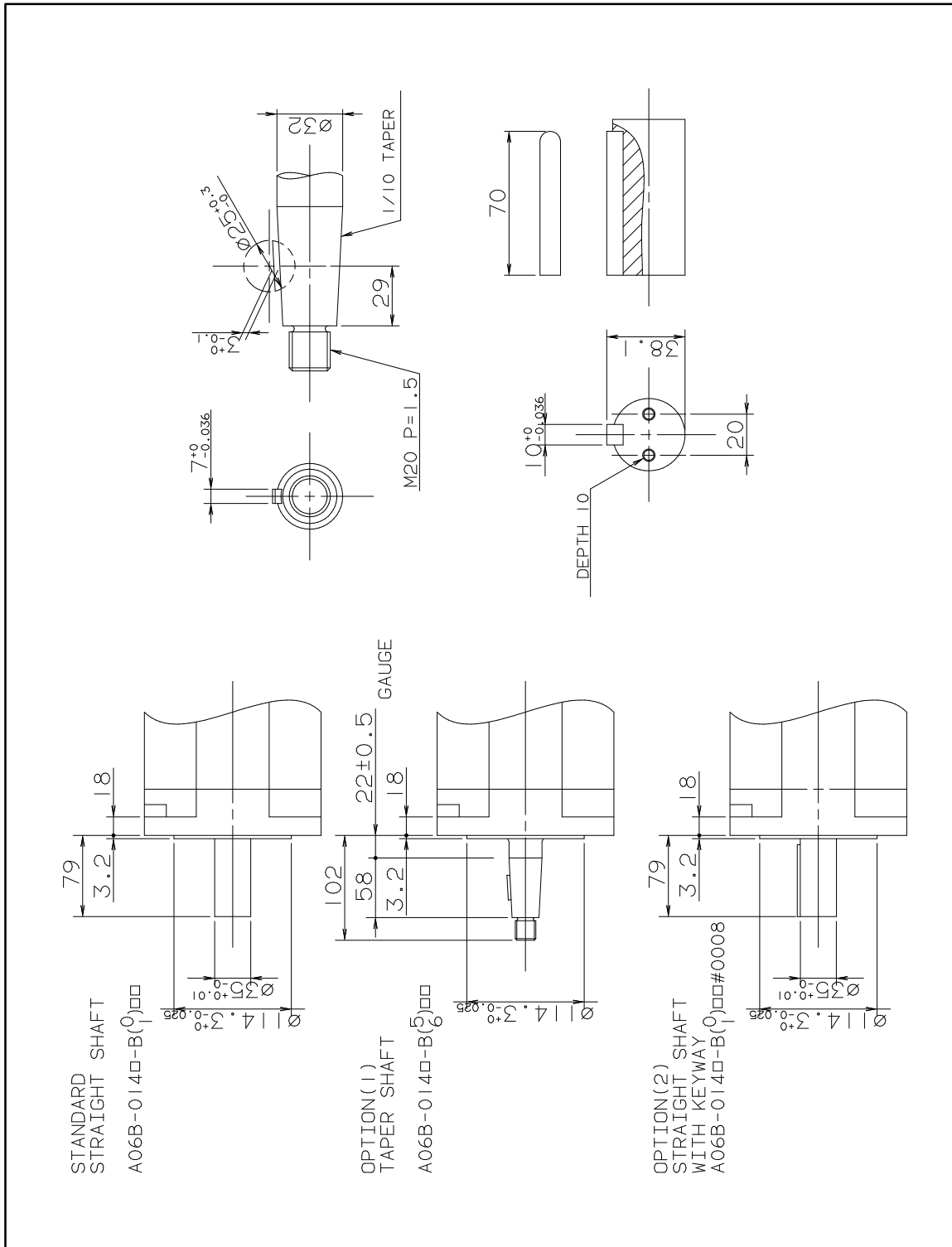


**Fig. 3.3 (e) Models αC12/2000 and αC22/1500 (with the brake)**



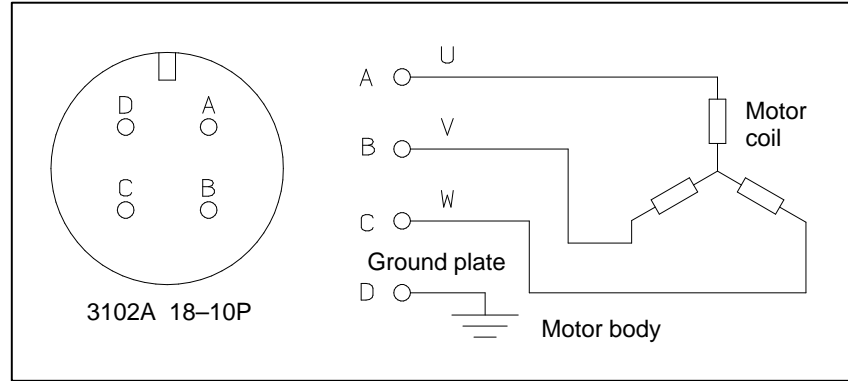


**Fig. 3.3 (f) Models αC12/2000 and αC22/1500 (shaft option)**

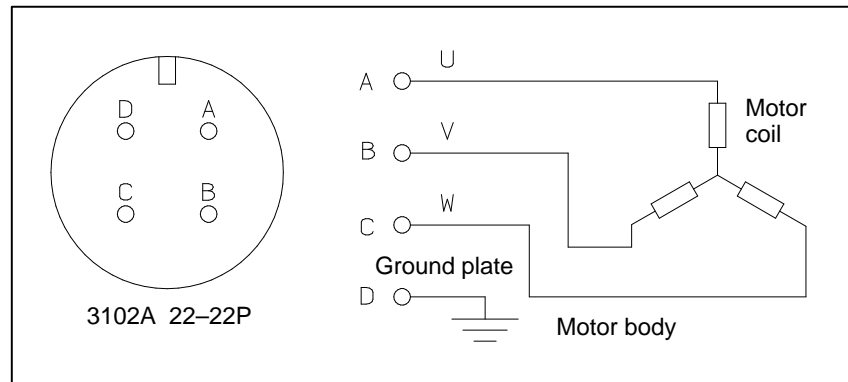


### 3.4 CONNECTION OF POWER LINE

**Models**  
 $\alpha$ C3/2000 and  $\alpha$ C6/2000



**Models**  
 $\alpha$ C12/2000 and  $\alpha$ C22/1500



## **V. FANUC AC SERVO MOTOR $\alpha$ M series**

# 1

## GENERAL

The FANUC AC servo motor  $\alpha$ M series is suitable for application to the feed axes of small machine tools. It has the following features:

### **Excellent acceleration characteristics**

A high maximum output torque and intermediate rotor inertia result in excellent acceleration characteristics.

### **Compact**

The use of the latest neodymium ferrite magnet further reduces the size and weight of the servo motors. This produces a servo motor that is sufficiently compact to allow its use in small machine tools.

### **Excellent waterproofing**

The use of waterproof connectors and FANUC's unique stator seal provide excellent waterproofing, ensuring that no liquid, such as coolant, can enter the motor.

### **Extended continuous-operation**

The use of the latest servo software minimizes the heat generated by high-speed rotation, allowing continuous operation over a wide range.

### **Smooth rotation**

Further improvements have been made to the unique magnetic pole shape to minimize torque ripple. The result is extremely smooth rotation.

### **Controllability**

The use of the latest servo software maintains controllability even when a disturbance occurs.

### **High-performance detector**

The AC servo motor  $\alpha$ M series are fitted with incremental pulse coder  $\alpha$ I64 or absolute pulse coder  $\alpha$ A64 as its standard pulse coder.

### **Powerful brake**

A powerful brake with an increased holding torque is available as an option. The brake uses an asbestos-free design. The  $\alpha$ M series includes  $\alpha$ M3,  $\alpha$ M6, and  $\alpha$ M9, for which mounting dimensions are compatible with those for  $\alpha$  series models  $\alpha$ 3 and  $\alpha$ 6.

# 2 TYPES OF MOTORS AND DESIGNATION

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

## Models

$\alpha$ M3/3000,  $\alpha$ M6/3000, and  
 $\alpha$ M9/3000

**A06B-01**□□-B☆○○

□□

**61** : Model  $\alpha$ M3/3000

**62** : Model  $\alpha$ M6/3000

**63** : Model  $\alpha$ M9/3000

☆

**0** : Taper shaft (standard)

**1** : Taper shaft with the brake (8Nm)

**5** : Straight shaft

**6** : Straight shaft with the brake (8Nm)

○○

**75** : With the pulse coder  $\alpha$ A64

**77** : With the pulse coder  $\alpha$ I64

**84** : With the serial pulse coder A

The standard shafts used for  $\alpha$ M series are taper shafts. Use a taper shaft as far as circumstances, such as the delivery time and maintenance, permit.

# 3

## SPECIFICATIONS AND CHARACTERISTICS



### 3.1 TYPES OF MOTORS AND SPECIFICATIONS

Item	Unit	$\alpha$ M3/3000	$\alpha$ M6/3000	$\alpha$ M9/3000
Output	kW	0.9	1.4	1.8
	HP	1.3	1.9	2.4
Rated torque at stall	Nm	3.0	6.0	9.0
	kgf·cm	31	61	92
Rating output speed	1/min	3000	3000	3000
Maximum theoretical torque	Nm	31	63	130
	kgf·cm	320	650	1300
Rotor inertia	kg·m <sup>2</sup>	0.0007	0.0013	0.0025
	kgf·cm·s <sup>2</sup>	0.008	0.014	0.026
Maximum theoretical acceleration	rad/s <sup>2</sup>	42000	47000	52000
Weight	kg	5	8	12

The above values are under the condition at 20°C.

#### Note

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.

## 3.2 CHARACTERISTIC CURVE AND DATA SHEET

### Speed-torque characteristics

The intermittent operation zone is determined by the input voltage applied to the drive amplifier. The curve shown is the value for the rated input voltage (200V).

### Overload duty characteristic

The overload duty characteristic curves are determined based on the temperature restriction for the single motor unit (the temperature is restricted by means of a thermal trip built into the motor). 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 the motor shaft is locked. (An overcurrent flows in the motor windings until the thermal trip operates. The temperature rises momentarily.)

To detect such an abrupt temperature rise, the FANUC digital servo system provides a software thermal function that uses servo software to observe the current. During operation that is characterized by frequent acceleration/deceleration cycles, control is imposed by the software thermal function.

Driving units (such as amplifiers) and built-in detectors 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.

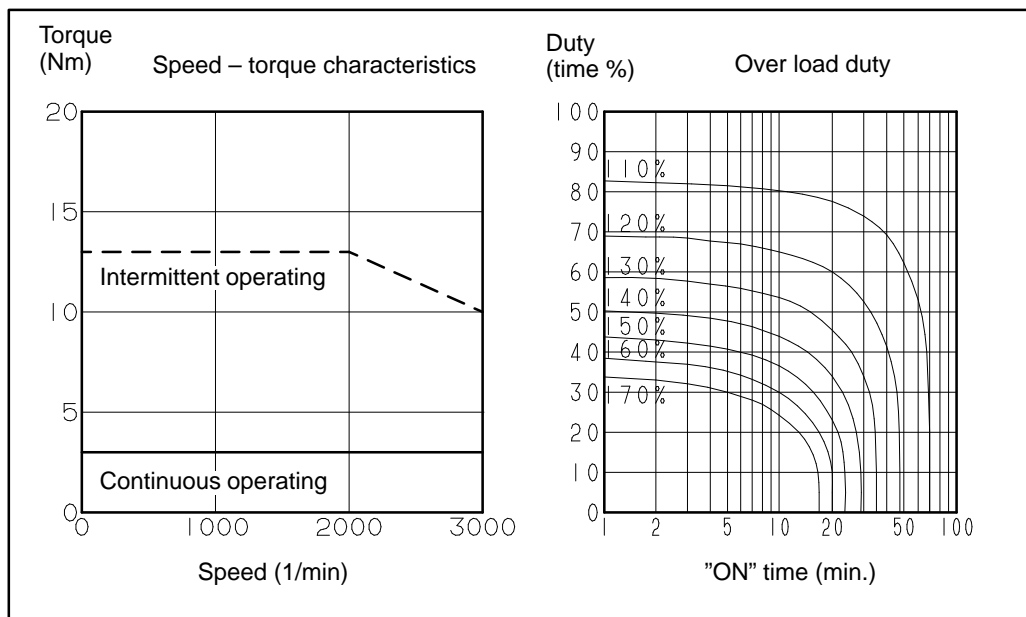
This value is for reference only. The actual value will vary depending on changes in the power supply, as well as variations in motor parameters and amplifier limit values.

In some models, if the maximum current flows in the motor, the actual maximum torque is affected by, for example, magnetic saturation. As a result, the actual maximum torque will be lower than the calculated value. The intermittent operation area (maximum torque value) indicated in the speed to torque characteristics is the effective value, determined according to the combination with the amplifier.



**Model αM3/3000**

Specification : A06B-0161-B□□□



**Data sheet**

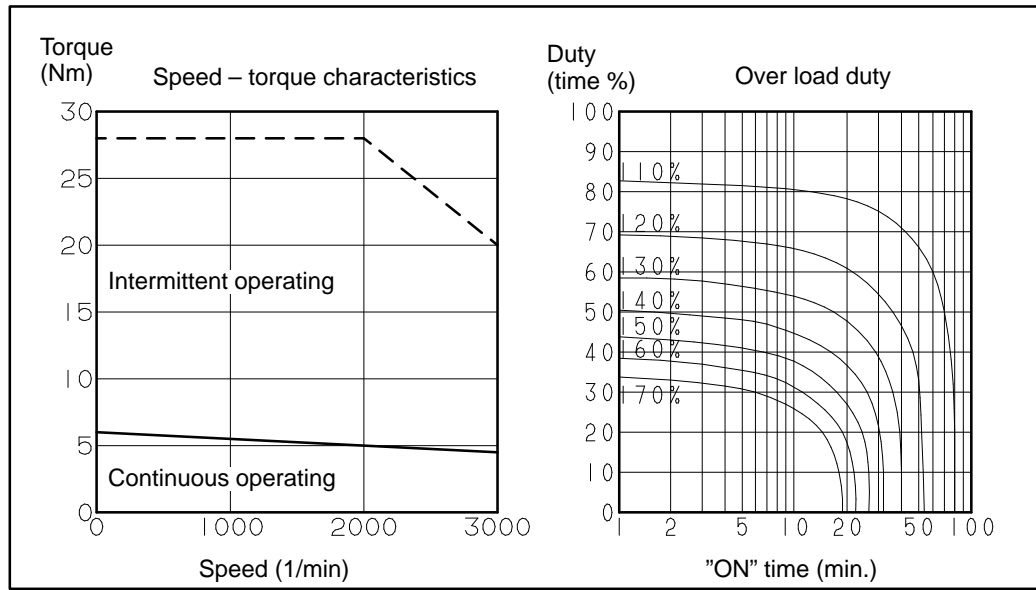
Parameter	Symbol	Value		Unit
Rating output speed	Nmax	3000		min <sup>-1</sup>
Rated torque at stall (*)	Ts	3.0		Nm
		31		kgfcm
Rotor inertia	Jm	0.0007		kgm <sup>2</sup>
		0.008		kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	5.3		A (rms)
Torque constant (*)	Kt	0.57		Nm/A (rms)
		5.8		kgfcm/A (rms)
Back EMF constant (*)	Ke	20		V/1000min <sup>-1</sup>
	Kv	0.19		Vsec/rad
Armature resistance (*)	Ra	0.695		Ω
Mechanical time constant (*)	tm	0.005		s
Thermal time constant	tt	40		min
Static friction	Tf	0.3		Nm
		3		kgfcm
Maximum allowable current	Im	75		A (peak)
Maximum theoretical torque	Tm	31		Nm
		320		kgfcm
Maximum theoretical acceleration		42000		rad/s <sup>2</sup>
Weight		5		kg

(\*) The values are the standard values at 20°C and the tolerance is ±10%.

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.) These values may be changed without prior notice.

Model  $\alpha$ M6/3000

Specification : A06B-0162-B□□□



## Data sheet

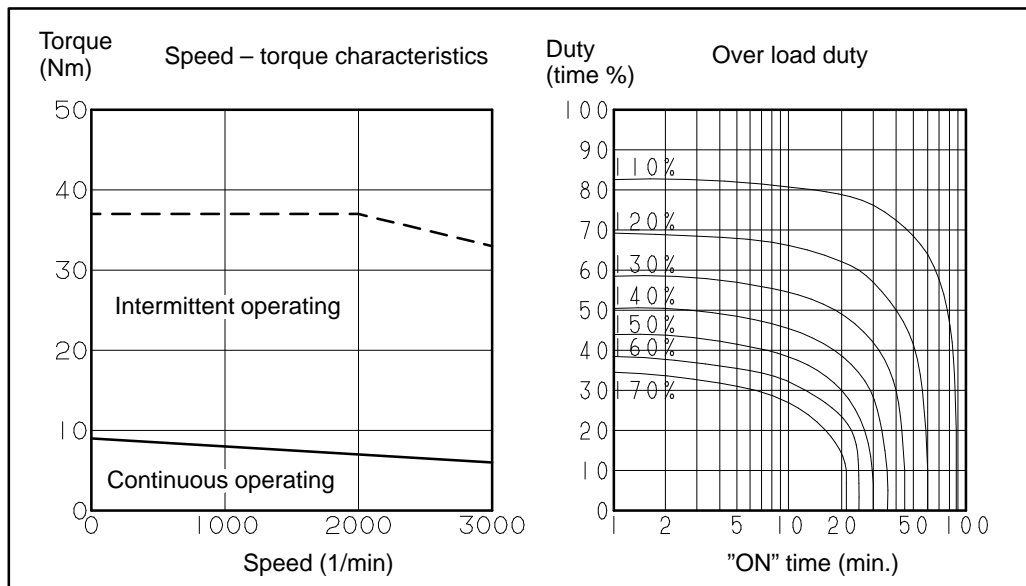
Parameter	Symbol	Value		Unit
Rating output speed	Nmax	3000		min <sup>-1</sup>
Rated torque at stall (*)	Ts	6.0		Nm
		61		kgfcm
Rotor inertia	Jm	0.0013		kgm <sup>2</sup>
		0.014		kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	8.0		A (rms)
Torque constant (*)	Kt	0.75		Nm/A (rms)
		7.6		kgfcm/A (rms)
Back EMF constant (*)	Ke	26		V/1000min <sup>-1</sup>
	Kv	0.25		Vsec/rad
Armature resistance (*)	Ra	0.463		$\Omega$
Mechanical time constant (*)	tm	0.003		s
Thermal time constant	tt	45		min
Static friction	Tf	0.3		Nm
		3		kgfcm
Maximum allowable current	Im	120		A (peak)
Maximum theoretical torque	Tm	63		Nm
		650		kgfcm
Maximum theoretical acceleration		47000		rad/s <sup>2</sup>
Weight		8		kg

(\*) The values are the standard values at 20°C and the tolerance is  $\pm 10\%$ .

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.) These values may be changed without prior notice.

**Model αM9/3000**

Specification : A06B-0163-B□□□



**Data sheet**

Parameter	Symbol	Value	Unit
Rating output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	9.0	Nm
		92	kgfcm
Rotor inertia	Jm	0.0025	kgm <sup>2</sup>
		0.026	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	10.4	A (rms)
Torque constant (*)	Kt	0.86	Nm/A (rms)
		8.8	kgfcm/A (rms)
Back EMF constant (*)	Ke	30	V/1000min <sup>-1</sup>
	Kv	0.29	Vsec/rad
Armature resistance (*)	Ra	0.181	Ω
Mechanical time constant (*)	tm	0.002	s
Thermal time constant	tt	50	min
Static friction	Tf	0.3	Nm
		3	kgfcm
Maximum allowable current	Im	216	A (peak)
Maximum theoretical torque	Tm	130	Nm
		1300	kgfcm
Maximum theoretical acceleration		52000	rad/s <sup>2</sup>
Weight		12	kg

(\*) The values are the standard values at 20°C and the tolerance is ± 10%.

The speed–torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.

### 3.3 OUTLINE DRAWINGS

Model	Fig. No.
Models $\alpha$ M3, $\alpha$ M6 and $\alpha$ M9	Fig. 3.3 (a)
Models $\alpha$ M3, $\alpha$ M6 and $\alpha$ M9 (with the brakeK)	Fig. 3.3 (b)
Models $\alpha$ M3 and $\alpha$ M6 (shaft option)	Fig. 3.3 (c)
Model $\alpha$ M9 (shaft option)	Fig. 3.3 (d)

**Fig. 3.3 (a) Models αM3,αM6, and αM9**

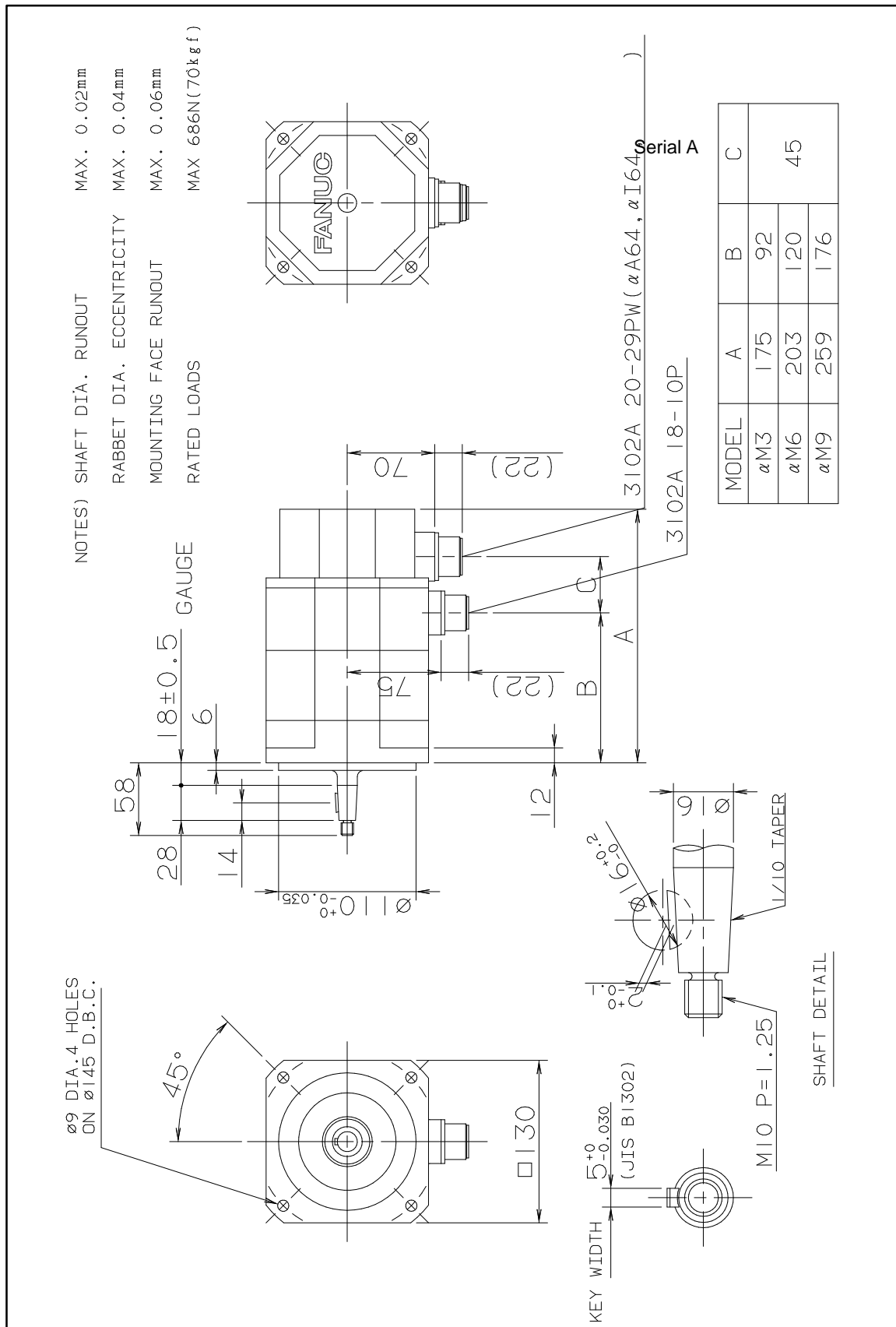
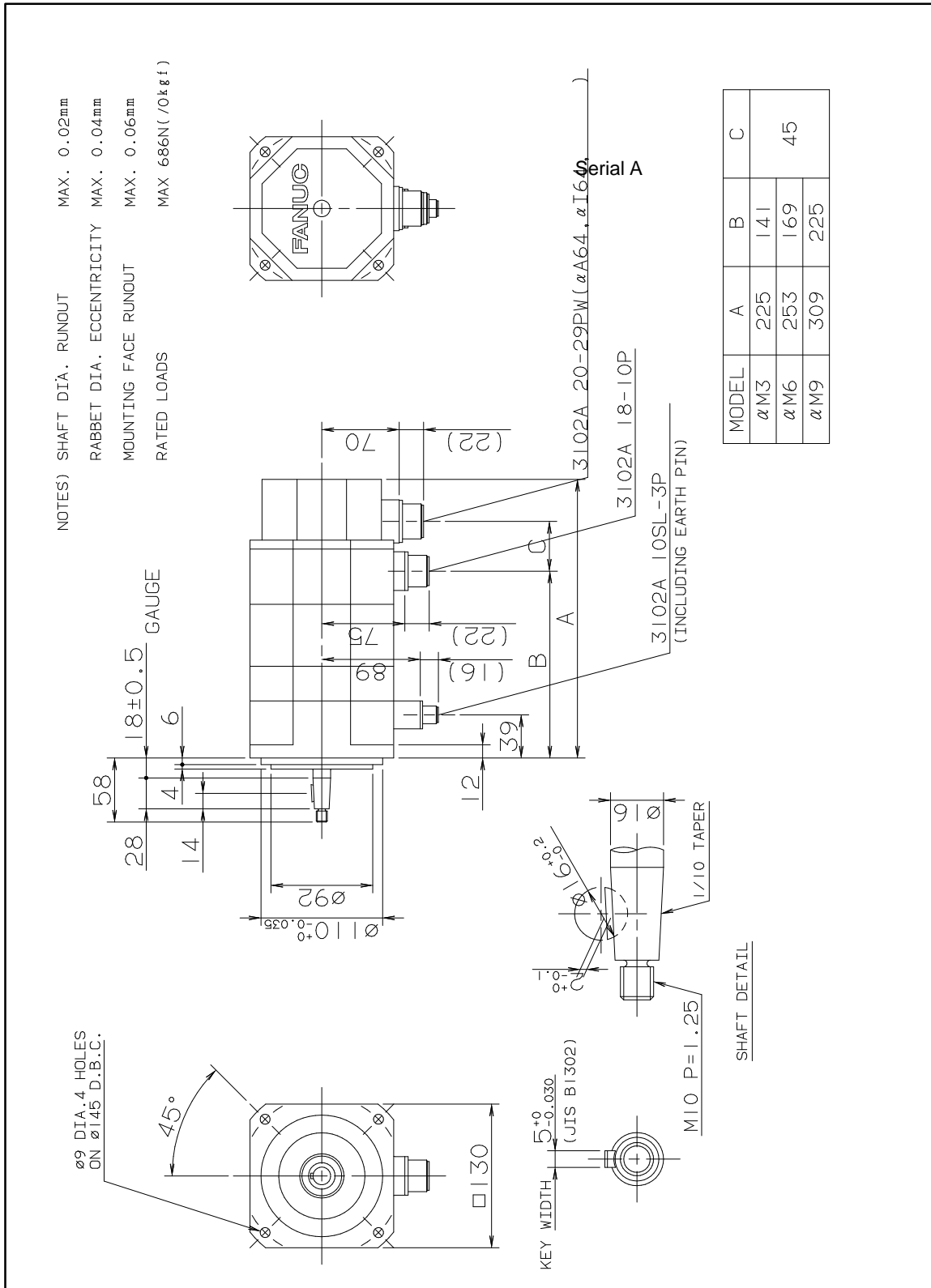
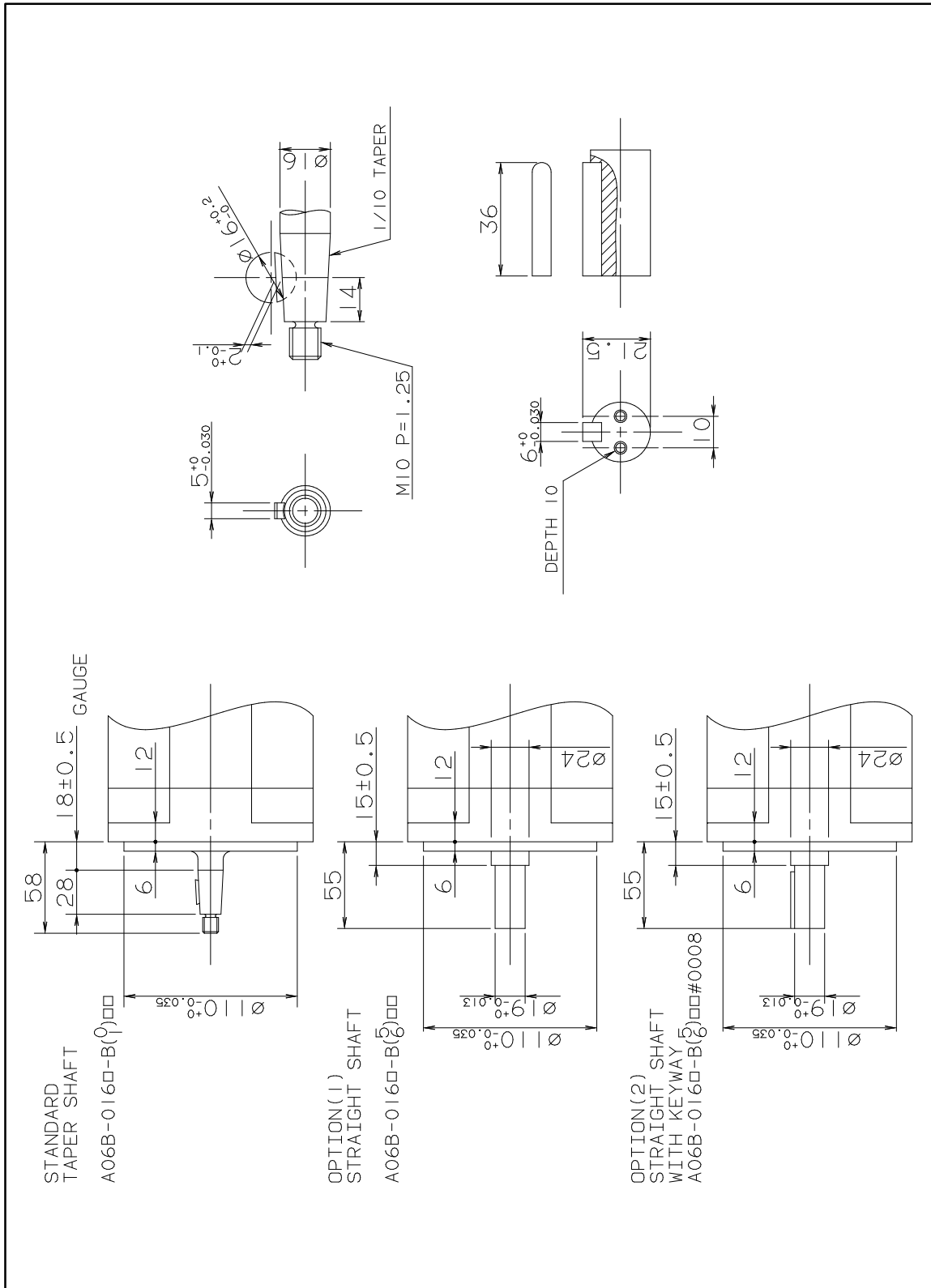


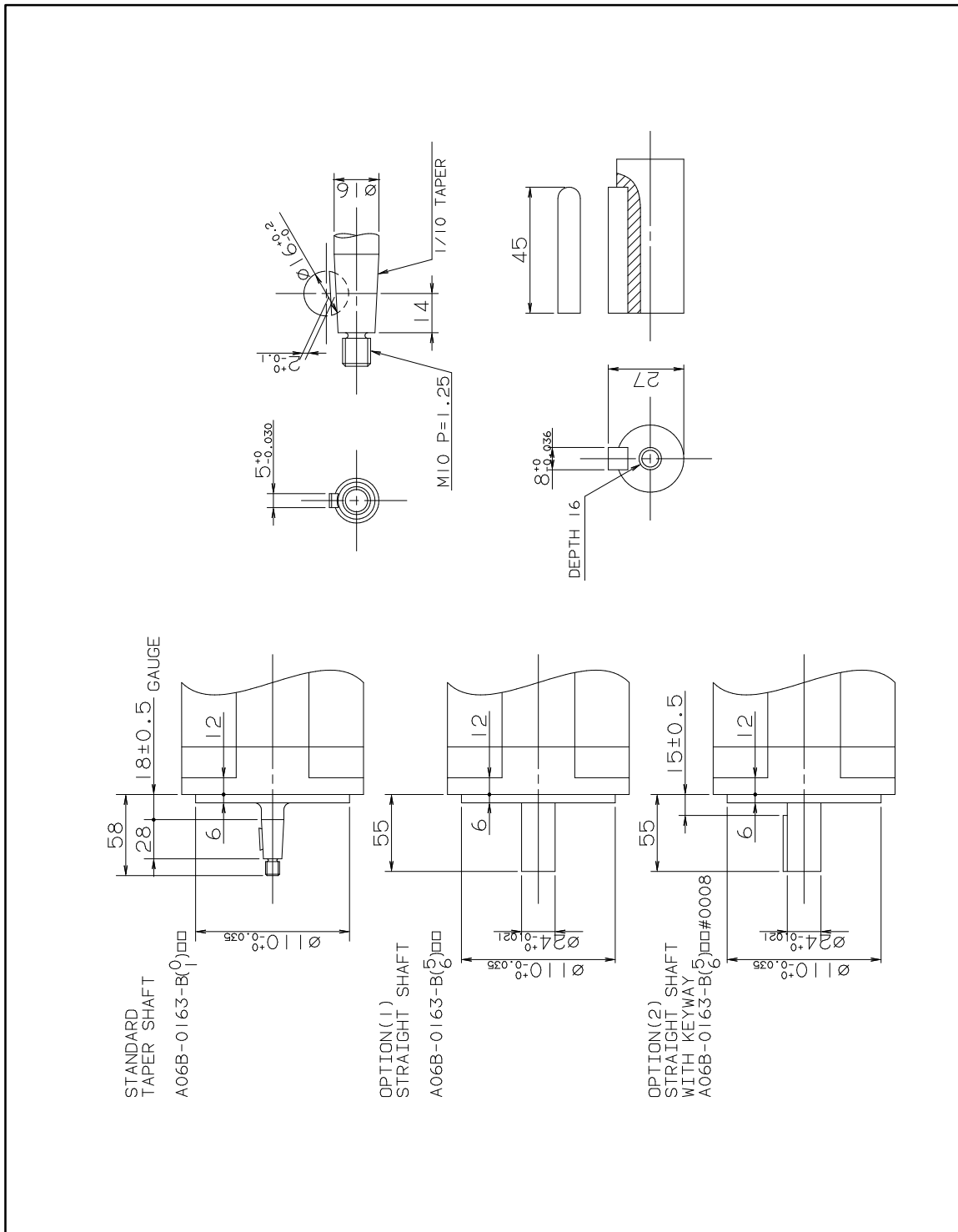
Fig. 3.3 (b) Models αM3,αM6, and αM9 (with the brake)



**Fig. 3.3 (c) Models αM3, and αM6 (shaft option)**



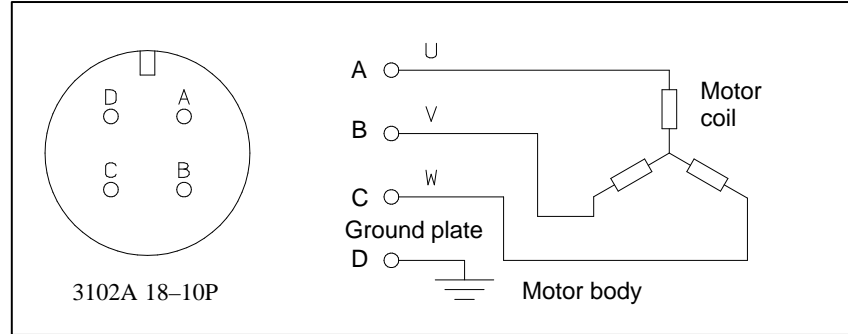
**Fig. 3.3 (d) Model αM9 (shaft option)**





### 3.4 CONNECTION OF POWER LINE

**Models**  
αM3/3000, αM6/3000,  
and αM9/3000



## **VI. FANUC AC SERVO MOTOR $\alpha$ L series**

# 1

## GENERAL

The FANUC AC servo motor  $\alpha$ L series is suitable for high-speed positioning. It has the following features:

### **Excellent acceleration characteristics**

The latest neodymium ferrite magnet is employed, and the rotor inertia is minimized. The result is a motor that offers excellent acceleration.

### **Excellent waterproofing**

The use of waterproof connectors and FANUC's unique stator seal provide excellent waterproofing, ensuring that no liquid, such as coolant, can enter the motor.

### **Extended continuous-operation**

The use of the latest servo software minimizes the heat generated by high-speed rotation, allowing continuous operation over a wide range.

### **Smooth rotation**

Further improvements have been made to the unique magnetic pole shape to minimize torque ripple. The result is extremely smooth rotation.

### **Controllability**

The use of the latest servo software maintains controllability even when a disturbance occurs.

### **High-performance detector**

The AC servo motor  $\alpha$ L series are fitted with incremental pulse coder  $\alpha$ I64 or absolute pulse coder  $\alpha$ A64 as its standard pulse coder.

### **Powerful brake**

A powerful brake with an increased holding torque is available as an option. The brake uses an asbestos-free design.

The L series models  $\alpha$ L3,  $\alpha$ L6, and  $\alpha$ L9, all of which are compatible with series models  $\alpha$ 3 and  $\alpha$ 6 in their installation size, and models  $\alpha$ L25 and  $\alpha$ L50, which are compatible with series models  $\alpha$ 12 and  $\alpha$ 22 in their installation size. All these  $\alpha$ L series models are compatible with the conventional FANUC AC servo motor  $\alpha$ L series in their installation size.

# 2 TYPES OF MOTORS AND DESIGNATION

The types and specifications of αL series servo motors are described as follows.

## Models

αL3/3000, αL6/3000, and  
αL9/3000

**A06B-05□□-B☆○○**

□□

**61** : Model αL3/3000

**62** : Model αL6/3000

**64** : Model αL9/3000

☆

**0** : Taper shaft (standard)

**1** : Taper shaft with the brake (8Nm)

○○

**75** : With the pulse coder αA64

**77** : With the pulse coder αI64

**84** : With the serial pulse coder A

## Models

αL25/3000 and  
αL50/2000

**A06B-05□□-B☆○○**

□□

**71** : Model αL25/3000

**72** : Model αL50/2000

☆

**0** : Taper shaft (standard)

**2** : Taper shaft with the brake (18Nm)

**3** : Taper shaft with the brake (40Nm)

○○

**75** : With the pulse coder αA64

**77** : With the pulse coder αI64

**84** : With the serial pulse coder A

# 3

## SPECIFICATIONS AND CHARACTERISTICS



### 3.1 TYPES OF MOTORS AND SPECIFICATIONS

Item	Unit	$\alpha$ L3/3000	$\alpha$ L6/3000	$\alpha$ L9/3000
Output	kW	0.9	1.4	2.0
	HP	1.2	1.8	2.7
Rated torque at stall	Nm	3.0	6.0	9.0
	kgf·cm	31	61	92
Rating output speed	1/min	3000	3000	3000
Maximum theoretical torque	Nm	12	24	47
	kgf·cm	120	240	480
Rotor inertia	kg·m <sup>2</sup>	0.00025	0.00049	0.00098
	kgf·cm·s <sup>2</sup>	0.0025	0.0050	0.010
Maximum theoretical acceleration	rad/s <sup>2</sup>	48000	48000	48000
Weight	kg	7	11	17

Item	Unit	$\alpha$ L25/3000	$\alpha$ L50/2000
Output	kW	3.5	6.0
	HP	4.7	8.0
Rated torque at stall	Nm	25	50
	kgf·cm	255	510
Rating output speed	1/min	3000	2000
Maximum theoretical torque	Nm	74	150
	kgf·cm	750	1500
Rotor inertia	kg·m <sup>2</sup>	0.0054	0.0098
	kgf·cm·s <sup>2</sup>	0.055	0.10
Maximum theoretical acceleration	rad/s <sup>2</sup>	14000	15000
Weight	kg	25	42

The above values are under the condition at 20°C.

#### Note

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.

## 3.2 CHARACTERISTIC CURVE AND DATA SHEET

### Speed-torque characteristics

The intermittent operation zone is determined by the input voltage applied to the drive amplifier. The curve shown is the value for the rated input voltage (200V).

### Overload duty characteristic

The overload duty characteristic curves are determined based on the temperature restriction for the single motor unit (the temperature is restricted by means of a thermal trip built into the motor). 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 the motor shaft is locked. (An overcurrent flows in the motor windings until the thermal trip operates. The temperature rises momentarily.)

To detect such an abrupt temperature rise, the FANUC digital servo system provides a software thermal function that uses servo software to observe the current. During operation that is characterized by frequent acceleration/deceleration cycles, control is imposed by the software thermal function.

Driving units (such as amplifiers) and built-in detectors 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).

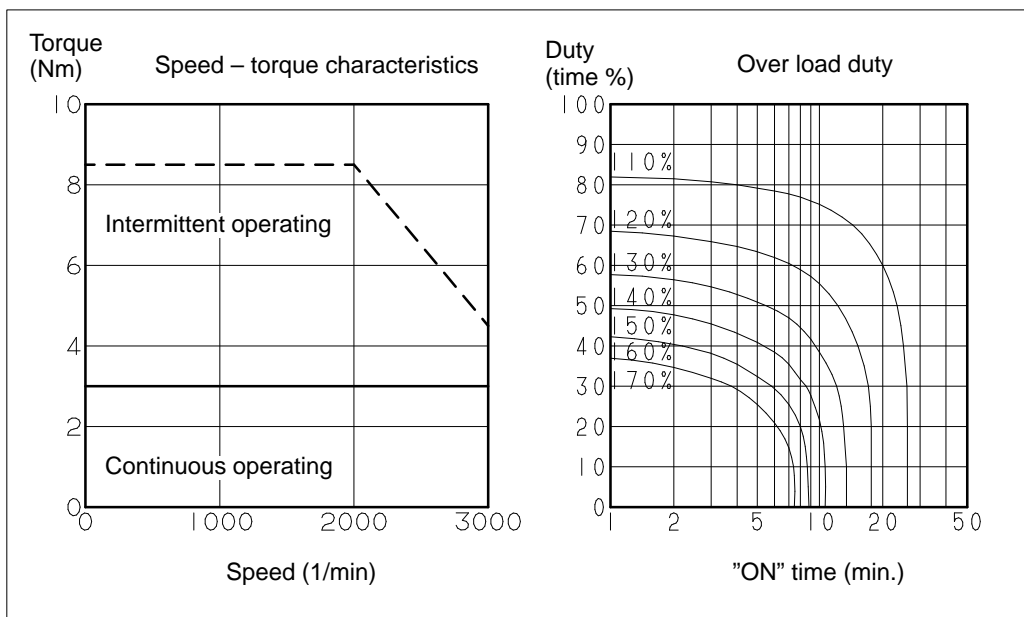
The maximum torque that can be produced during acceleration or deceleration in actual use is calculated as the approximate product of the motor torque constant and the current limit value of the amplifier.

This value is for reference only. The actual value will vary depending on changes in the power supply, as well as variations in motor parameters and amplifier limit values.

In some models, if the maximum current flows in the motor, the actual maximum torque is affected by, for example, magnetic saturation. As a result, the actual maximum torque will be lower than the calculated value. The intermittent operation area (maximum torque value) indicated in the speed to torque characteristics is the effective value, determined according to the combination with the amplifier.

**Model αL3/3000**

Specification : A06B-0561-B□□□



**Data sheet**

Parameter	Symbol	Value		Unit
Rating output speed	Nmax	3000		min <sup>-1</sup>
Rated torque at stall (*)	Ts	3.0		Nm
		31		kgfcm
Rotor inertia	Jm	0.00025		kgm <sup>2</sup>
		0.0025		kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	5.8		A (rms)
Torque constant (*)	Kt	0.51		Nm/A (rms)
		5.2		kgfcm/A (rms)
Back EMF constant (*)	Ke	18		V/1000min <sup>-1</sup>
	Kv	0.17		Vsec/rad
Armature resistance (*)	Ra	0.810		Ω
Mechanical time constant (*)	tm	0.002		s
Thermal time constant	tt	15		min
Static friction	Tf	0.3		Nm
		3		kgfcm
Maximum allowable current	Im	55		A (peak)
Maximum theoretical torque	Tm	11.8		Nm
		120		kgfcm
Maximum theoretical acceleration		48000		rad/s <sup>2</sup>
Weight		7		kg

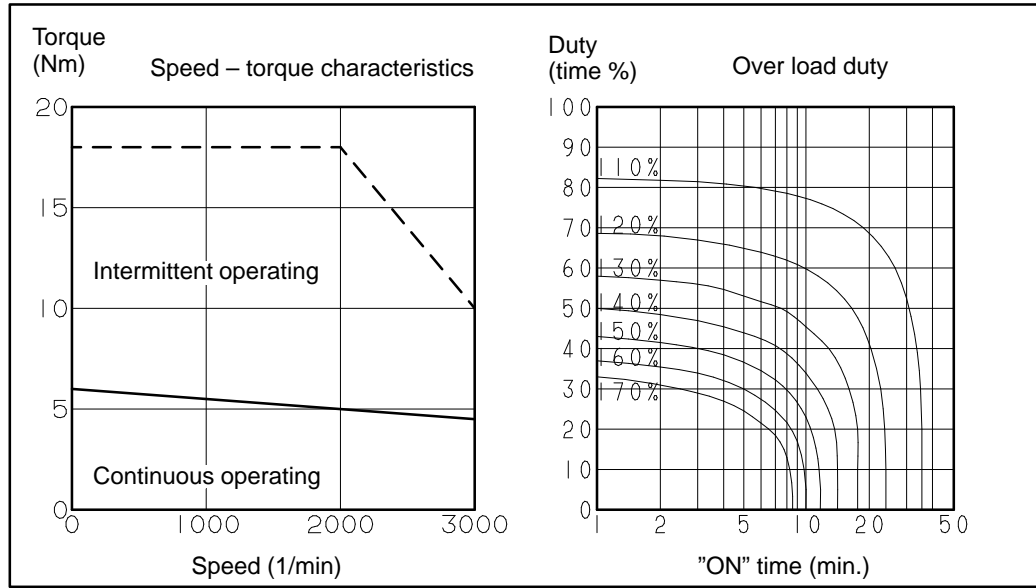
(\*) The values are the standard values at 20°C and the tolerance is ±10%.

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.) These values may be changed without prior notice.



Model  $\alpha$ L6/3000

Specification : A06B-0562-B□□□



## Data sheet

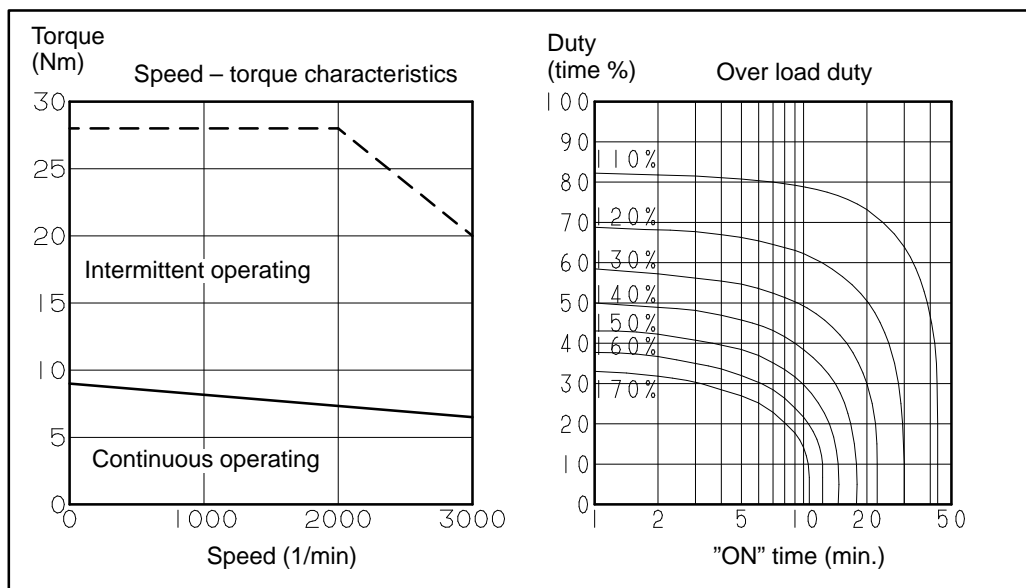
Parameter	Symbol	Value	Unit
Rating output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	6.0	Nm
		61	kgfcm
Rotor inertia	Jm	0.00049	kgm <sup>2</sup>
		0.0050	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	11.4	A (rms)
Torque constant (*)	Kt	0.52	Nm/A (rms)
		5.3	kgfcm/A (rms)
Back EMF constant (*)	Ke	18	V/1000min <sup>-1</sup>
	Kv	0.17	Vsec/rad
Armature resistance (*)	Ra	0.275	$\Omega$
Mechanical time constant (*)	tm	0.001	s
Thermal time constant	tt	20	min
Static friction	Tf	0.5	Nm
		5	kgfcm
Maximum allowable current	Im	80	A (peak)
Maximum theoretical torque	Tm	23.5	Nm
		240	kgfcm
Maximum theoretical acceleration		48000	rad/s <sup>2</sup>
Weight		11	kg

(\*) The values are the standard values at 20°C and the tolerance is  $\pm 10\%$ .

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.) These values may be changed without prior notice.

**Model αL9/3000**

Specification : A06B-0564-B□□□



**Data sheet**

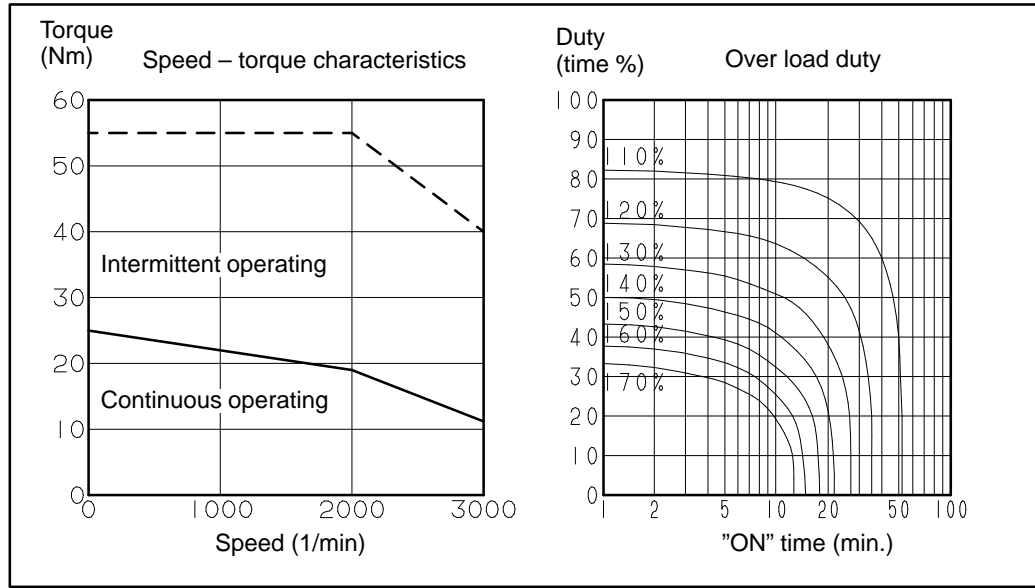
Parameter	Symbol	Value	Unit
Rating output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	9.0	Nm
		92	kgfcm
Rotor inertia	Jm	0.00098	kgm <sup>2</sup>
		0.010	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	16.9	A (rms)
Torque constant (*)	Kt	0.52	Nm/A (rms)
		5.3	kgfcm/A (rms)
Back EMF constant (*)	Ke	18	V/1000min <sup>-1</sup>
	Kv	0.17	Vsec/rad
Armature resistance (*)	Ra	0.110	Ω
Mechanical time constant (*)	tm	0.001	s
Thermal time constant	tt	25	min
Static friction	Tf	0.9	Nm
		9	kgfcm
Maximum allowable current	Im	140	A (peak)
Maximum theoretical torque	Tm	47.0	Nm
		480	kgfcm
Maximum theoretical acceleration		48000	rad/s <sup>2</sup>
Weight		17	kg

(\*) The values are the standard values at 20°C and the tolerance is ± 10%.

The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.

Model  $\alpha$ L25/3000

Specification : A06B-0571-B□□□



## Data sheet

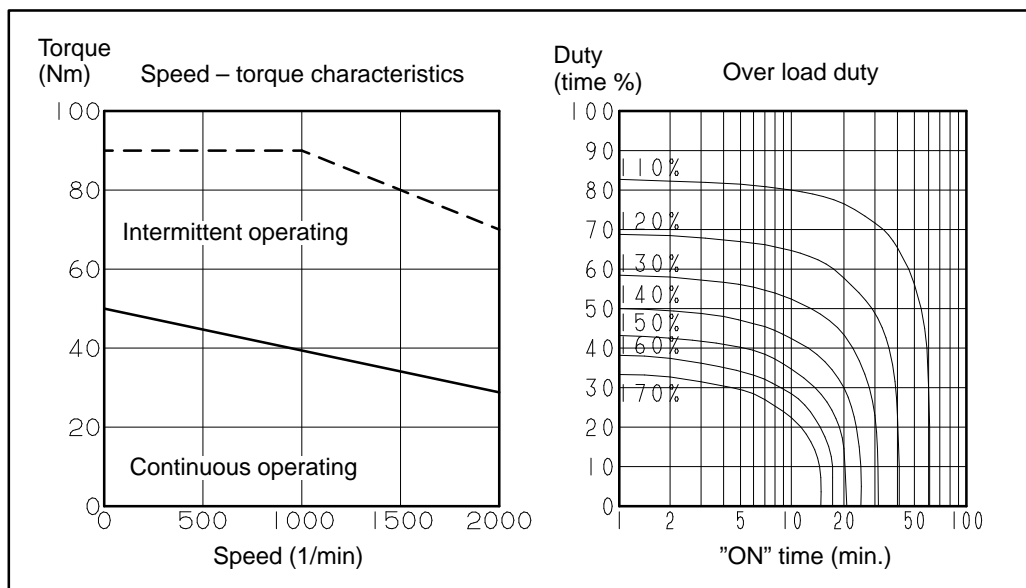
Parameter	Symbol	Value	Unit
Rating output speed	Nmax	3000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	25	Nm
		255	kgfcm
Rotor inertia	Jm	0.0054	kgm <sup>2</sup>
		0.055	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	37	A (rms)
Torque constant (*)	Kt	0.66	Nm/A (rms)
		6.8	kgfcm/A (rms)
Back EMF constant (*)	Ke	23	V/1000min <sup>-1</sup>
	Kv	0.22	Vsec/rad
Armature resistance (*)	Ra	0.049	$\Omega$
Mechanical time constant (*)	tm	0.001	s
Thermal time constant	tt	30	min
Static friction	Tf	1.2	Nm
		12	kgfcm
Maximum allowable current	Im	200	A (peak)
Maximum theoretical torque	Tm	74	Nm
		750	kgfcm
Maximum theoretical acceleration		13600	rad/s <sup>2</sup>
Weight		25	kg

(\*) The values are the standard values at 20°C and the tolerance is  $\pm 10\%$ .

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.) These values may be changed without prior notice.

**Model αL50/2000**

Specification : A06B-0572-B□□□



**Data sheet**

Parameter	Symbol	Value	Unit
Rating output speed	Nmax	2000	min <sup>-1</sup>
Rated torque at stall (*)	Ts	50	Nm
		510	kgfcm
Rotor inertia	Jm	0.0098	kgm <sup>2</sup>
		0.10	kgfcms <sup>2</sup>
Continuous RMS current at stall (*)	Is	51	A (rms)
Torque constant (*)	Kt	0.96	Nm/A (rms)
		9.8	kgfcm/A (rms)
Back EMF constant (*)	Ke	33	V/1000min <sup>-1</sup>
	Kv	0.32	Vsec/rad
Armature resistance (*)	Ra	0.038	Ω
Mechanical time constant (*)	tm	0.001	s
Thermal time constant	tt	35	min
Static friction	Tf	1.8	Nm
		18	kgfcm
Maximum allowable current	Im	280	A (peak)
Maximum theoretical torque	Tm	147	Nm
		1500	kgfcm
Maximum theoretical acceleration		15000	rad/s <sup>2</sup>
Weight		42	kg

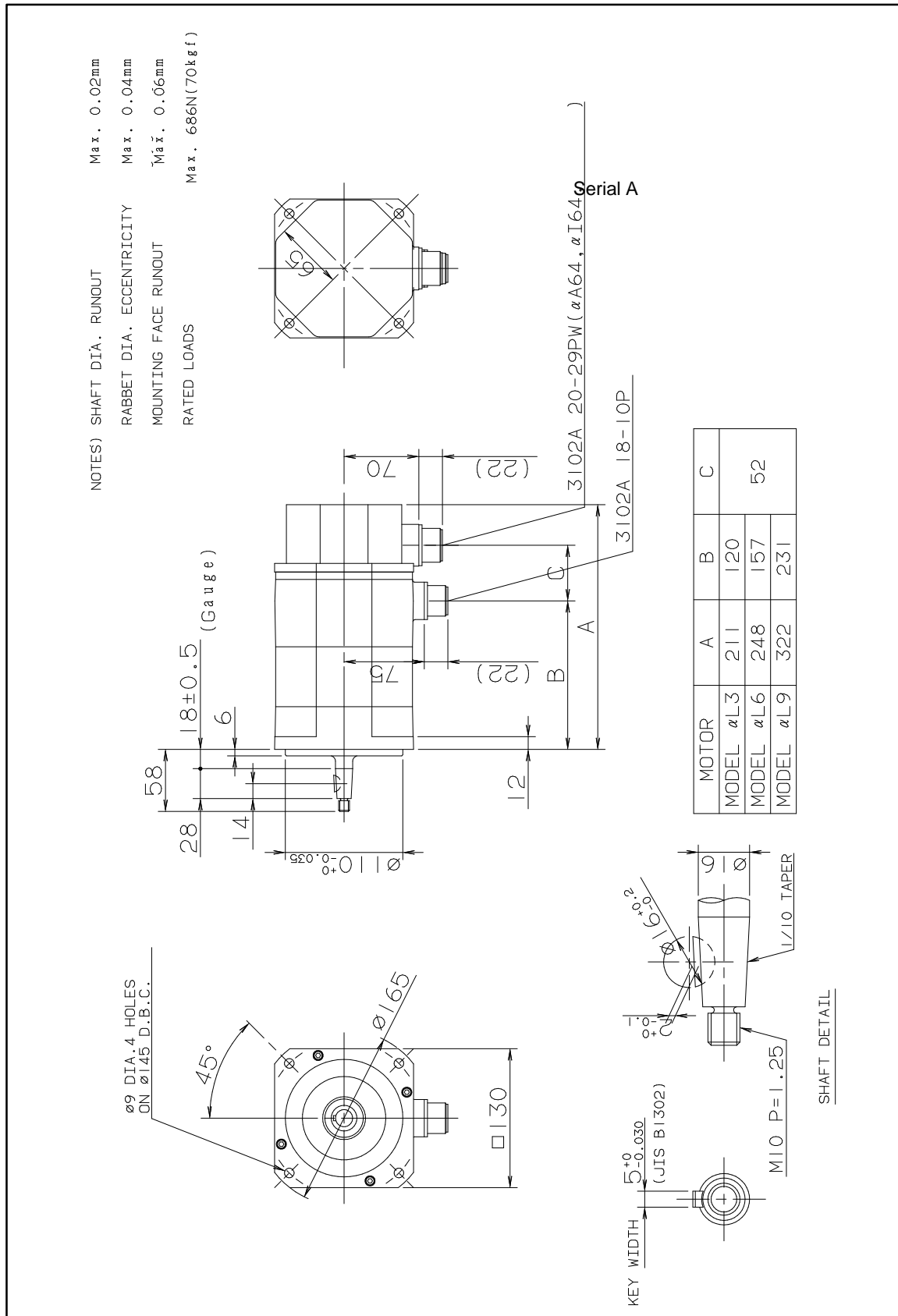
(\*) The values are the standard values at 20°C and the tolerance is ± 10%.

The speed-torque characteristics very depending on the type of software, parameter setting, and input voltage of the digital servo motor. (The above figures show average values.) These values may be changed without prior notice.

### 3.3 OUTLINE DRAWINGS

Model	Fig. No.
Models $\alpha$ L3/3000, $\alpha$ L6/3000, and $\alpha$ L9/3000	Fig. 3.3 (a)
Models $\alpha$ L3/3000, $\alpha$ L6/3000, and $\alpha$ L9/3000 (with the brakeK)	Fig. 3.3 (b)
Models $\alpha$ L25/3000 and $\alpha$ L50/2000	Fig. 3.3 (c)
Models $\alpha$ L25/3000 and $\alpha$ L50/2000 (with the brakeK)	Fig. 3.3 (d)

**Fig. 3.3 (a) Models  $\alpha$ L3/3000,  $\alpha$ L6/3000, and  $\alpha$ L9/3000**



**Fig. 3.3 (b) Models αL3/3000, αL6/3000, and αL9/3000 (with the brake)**

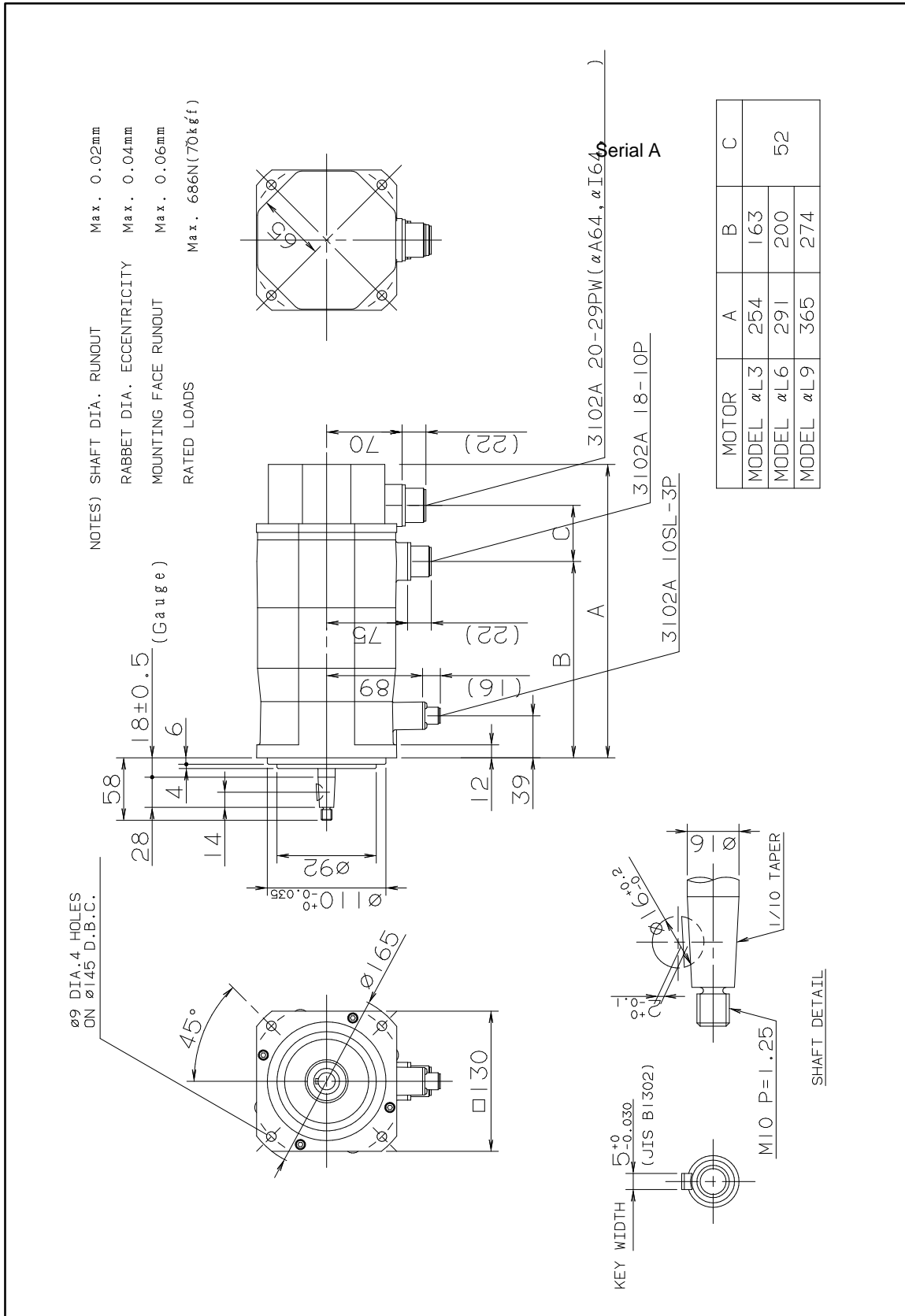
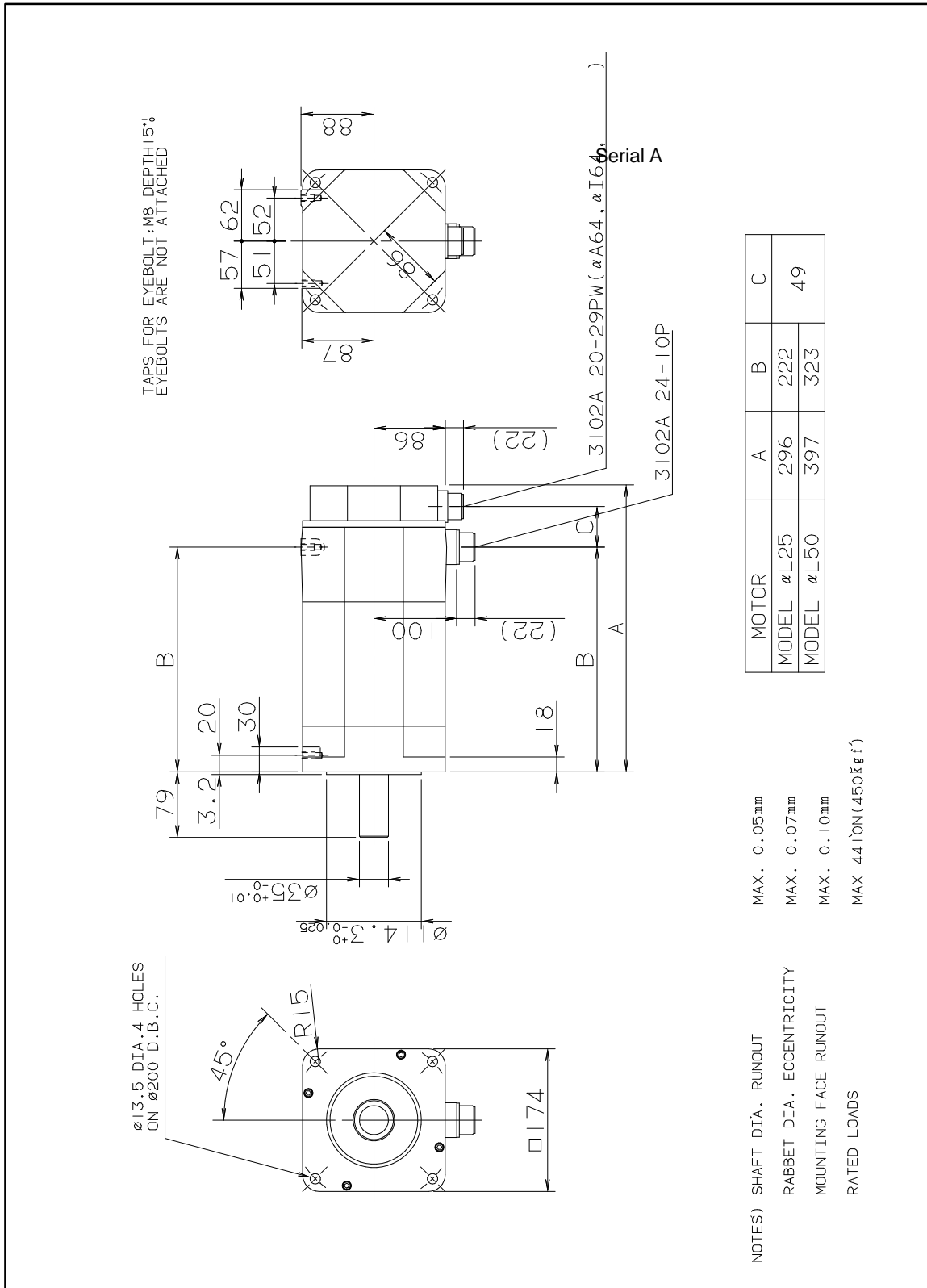
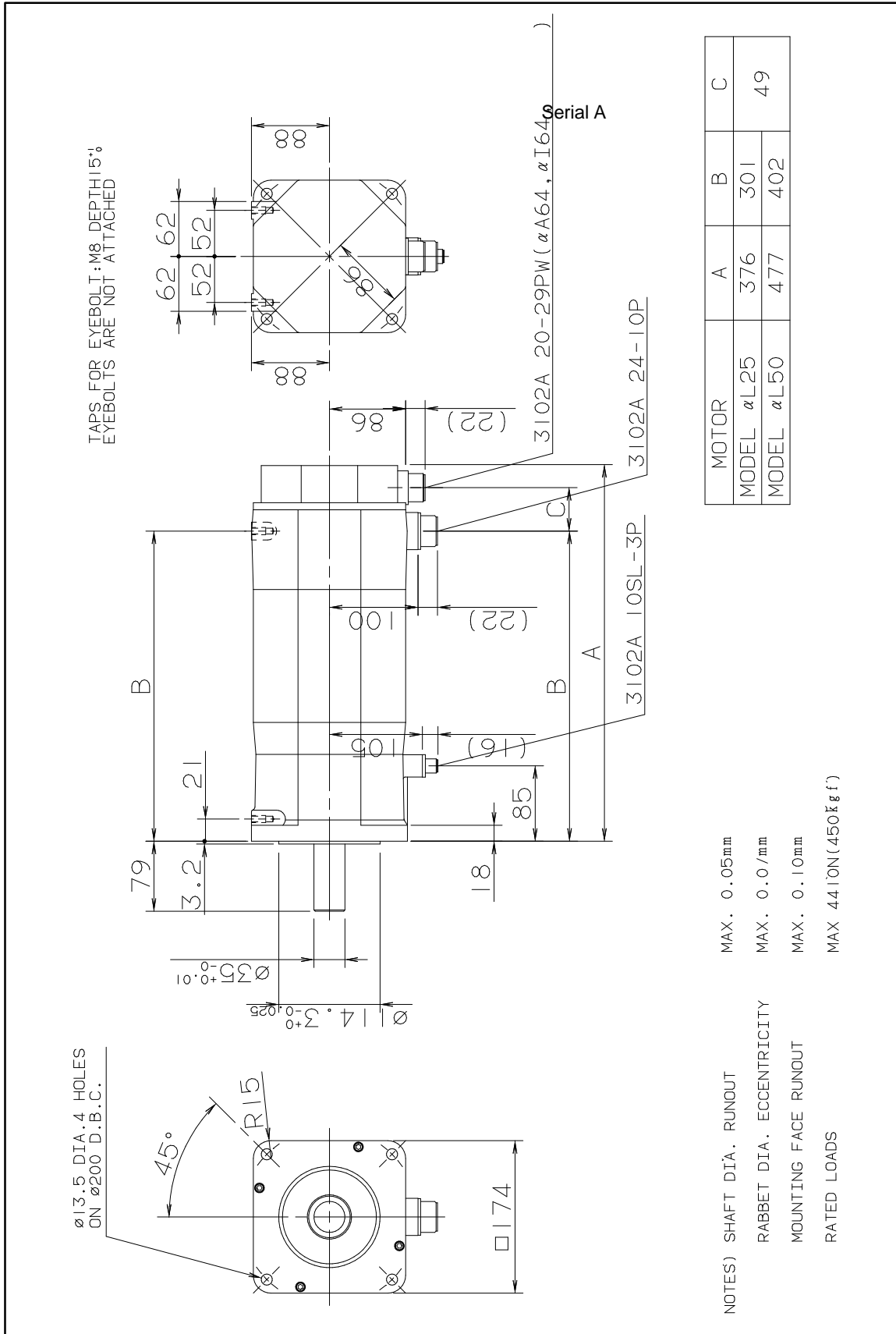


Fig. 3.3 (c) Models αL25/3000 and αL50/2000





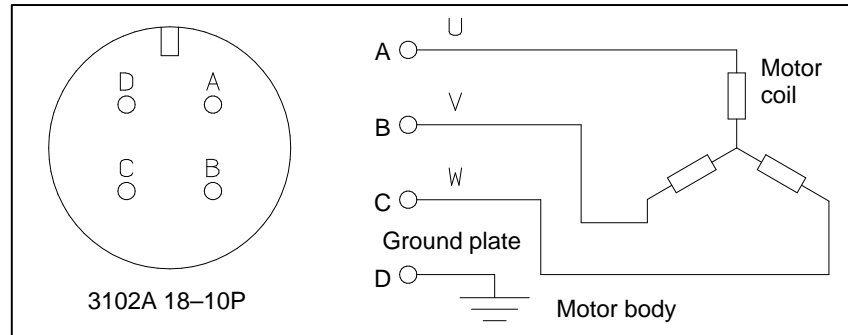
**Fig. 3.3 (d) Models αL25/3000 and αL50/2000 (with the brake)**



### 3.4 CONNECTION OF POWER LINE

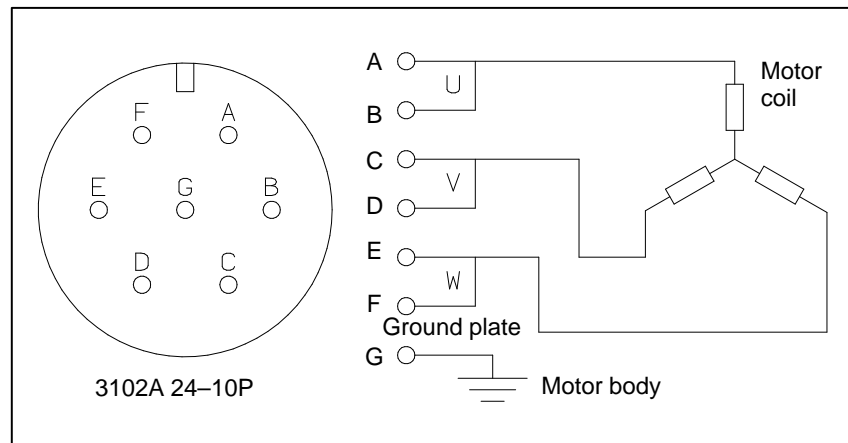
#### Models

αL3/3000, αL6/3000, and αL9/3000



#### Models

αL25/3000 and αL50/2000



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Revision Record

FANUC AC SERVO MOTOR  $\alpha$  series DESCRIPTIONS (B-65142E)

Edition	Date	Contents	Edition	Date	Contents
02	Mar., '95	Addition of "5. CONDITIONS FOR APPROVAL RELATED TO THE IEC34 STANDARD" in Part I Addition of "8. CONNECTORS" in Part I Addition of "III. FANUC AC SERVO MOTOR a(HV) series"			
01	Mar., '94	<hr/>			

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