

FANUC AC SERVO MOTOR series

DESCRIPTIONS

B-65092E/01

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In this manual, we endeavor to include all pertinent matters.

There are, however, a very large number of operations that must not or cannot be performed, and if the manual contained them all, it would be enormous in volume.

It is, therefore, requested to assume that any operations that are not explicitly described as being possible are "not possible".

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I. FANUC AC SERVO MOTOR SERIES

1. GENERAL

The FANUC AC Servo motor series is optimum for the feed axis of machine tool, and has the following features.

- (1) Smooth rotation
The unique magnetic pole shape designed to minimize torque ripple enables very smooth rotation by strict current control and precise pulse coder feedback.
- (2) Superior acceleration
The unique rotor structure makes the motor compact and light weight, providing high torque and superior acceleration performance.
- (3) High reliability
The totally enclosed brushless structure with no wearing parts permits inspection/maintenance free operation even in severe environments.
- (4) Integrated high precision detector
The optical encoder(pulse coder) with high precision is directly coupled to the motor shaft, permitting precise positioning.

2. PRECAUTION ON USE

2.1 Installation

The servo motor contains a precise 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 of the detector.

- (1) Secure the motor uniformly using four bolt holes on the front flange.
- (2) The mounting surface of machine needs to be sufficiently flat.
- (3) Take care not to apply a shock to the motor, when mounting on the machine.
- (4) Use plastic hammer and tap the front flange, when it is unavoidable to tap the motor to adjust mechanical alignment.

2.2 Coupling

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

- (1) 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.
- (2) Generally, in case of straight shaft, friction lock connection such as Spanning(Ringfeder) or Spieth is recommended.
- (3) In case of tapered shaft, match the surface of tapered shaft with that of power transmission element and fix by tightening the screw at the shaft end. When the woodruff key is too tight, do not tap it with a hammer. Use the woodruff key mainly for positioning, and use the tapered surface for the torque transmission. Machine the tapered surface so that over 70% of the whole area contacts.
- (4) To remove the connected power transmission element, be sure to use a jig such as gear puller.

- (5) When it is inevitable to tap motor to remove the tapered connection, tap in the radial direction to prevent heavy shock in the axial direction.
- (6) Suppress the rotary unbalance of the connected power transmission element to the level as low as possible. It is believed that there is no problem in the symmetrical form. Be careful when driving the asymmetrically shaped parts continuously. Even if the vibration caused by the unbalance is as small as 0.5 G, it may sometimes damage the motor bearing or the detector.
- (7) Specially designed oil seal is used in the front side of the motor. The oil seal surface is made of steel plate. So do not apply a force to the oil seal at installation or connection.

2.3 Axis Load

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

Motor model	Radial load	Axial load	Type of front bearing(ref.)
0,5	70 kg	20 kg	6205
10,20	450 kg	135 kg	6208

The above values are the reference assuming the use of axis feed of ordinary machine tool.

- (1) The allowable radial load is the value when the load is applied to the shaft end. It indicates the total force including both constant force applied always to the shaft, e.g., belt tension, and the force induced by load torque.
- (2) When timing belt is used, belt tension needs to be controlled within allowable range. Too tightened belt often causes the breakage of the shaft or other fault.
- (3) The diameter of connecting pulley or gear should be considered. For example, when using model 5 with a pulley/gear with the dia. 5 cm or less, the radial load from 180 kgcm torque will exceed 70 kg. In case of timing belt, as the belt tension is also applied, it is necessary to support the shaft end. To change the applied point of force closer to front bearing will reduce the possibility of shaft breakage.
- (4) When there is a possibility of using with higher load, the machine tool builder needs to examine the life by referring to the shaft diameter, bearing, etc.
- (5) Since the standard single row deep groove type bearing is used for the motor, large axial load cannot be received. Especially, when using worm gear or helical gear, it is necessary to prepare another bearing.
- (6) The motor bearing is generally fixed with C-stopper ring, and there is a play in the axial direction. When this end play influences the positioning, in the case of worm gear or helical gear, for example, it is necessary to fix it with another bearing.

2.4 Environment

(1) Ambient temperature: 0-40 deg. C

When operating at a higher temperature, it is necessary to lower the output power so that the motor temperature does not exceed the specified constant value.

(2) Vibration: less than 5G.

When the motor is stall, constant vibration should be avoided even if it is less than 5G.

(3) Height

0-1000m

: No particular care should be taken.

more than 1000m: If the ambient temperature is lowered 1 deg. C by every 100m higher than 1000m, there is no problem.

For example, at 1500m above sea level, there is no problem if the ambient temperature is lower than 35 deg. C..

In other conditions, it is necessary to limit the output.

(4) Protection

When the wiring part is appropriately treated, the protection grade of motor enclosure fulfill the IEC, IP55 (equivalent to JP55 in JIS C 4004-1980- General Rules for Rotating Electrical Machines). It is recommended to pay attention to the following points for safe long time operation. ^{ed}

(a) Do not always wet or stay liquid on the motor surface with 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 cannot completely prevent the leakage of the cutting fluid. Pay attention to the drop along the structure body, too.

(b) Prevent the cutting fluid from being led to the motor through the cable. When the motor connector is used in the laid position, make the cable slack in a certain portion to prevent it.

(c) When the motor connector is set upward, the cutting fluid may be collected in the cable connector through the cable. Turn the motor sideways or downward if possible. Most of the defects caused by the cutting fluid have occurred in cable connector. The standard MS connector cannot prevent the ingress of liquid when wetted. Waterproof type (R-class or equivalent) is recommended.

(5) Shaft seal

When lubricating with an oil bath at gear coupling, set the oil level height lower than the oil seal lip of the shaft so that the lip exposed to the oil splash.

The oil seal functions to exhaust the oil at rotation. However, when a pressure is applied for a long time at stall, the ingress of liquid is supposed. When it is unavoidable to wet the shaft with an oil by setting the shaft upward, set another oil seal in the machine and provide a drain so that the oil passing through the seal flows outside.

The shaft dia. at oil seal is as shown below.

Motor model	Diameter at oil seal
0,5	ϕ 24 mm
10,20	ϕ 35 mm

2.5 Acceptance and Storage

When the servo motor is delivered, check following items.

- Specifications ; model, shaft, detector.
- Damage caused by transportation.
- The shaft can be rotated smoothly by hand.
- The operation of brake.
- Any loose or play in screws.

FANUC servo motors are strictly checked before shipment, and the inspection at acceptance is usually unnecessary.

When the inspection is required, check the specifications (wiring, current, voltage, etc.) of the motor and detector.

- Store indoor
- Storage temperature : -20 deg. C ~ + 60 deg. C.
- Keep away from
 - /Extremely high humidity or dew
 - /Extreme change of temperature
 - /Continuous vibration
 - /Dust

3. INSTRUCTIONS

3.1 Drive Shaft Coupling

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

- . Direct connection through a flexible coupling
- . Connection through a gear coupling
- . Connection through timing belts

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

1) Direct connection through a flexible coupling

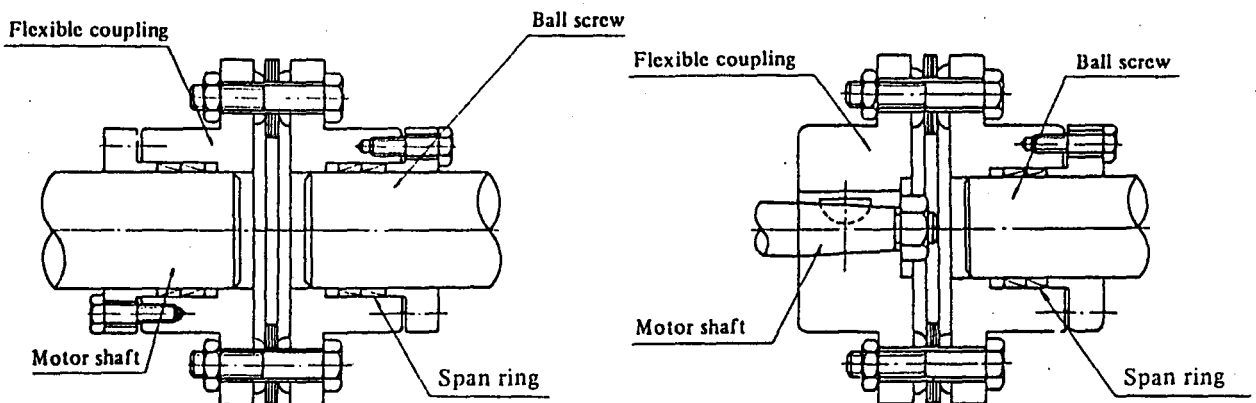
This method has the following advantages as compared to the other two methods:

- . Economical.
- . No adjustment operations are required at assembly process.
- . Connecting element generates no noise because of non backlash connection.

When connecting the motor shaft to the ball screw, align the centers of the both motor shaft and ball screw. The construction of machine should be so designed to assure this alignment, and farther more flexible coupling should be used; if a rigid coupling is used in its place, even a slight nonalignment can generate a large force to the shaft, which may damage the shaft.

In case the shaft is straight and has no key way, a span ring is used to connect the coupling to the shaft. The span ring makes the connection by the friction generated by fastening the screw. Since there is no backlash or stress concentration, the spanning enables stable and reliable connection. The transmission force obtained through the span ring depends on the rigidity of the parts used for connection, such as the screws, flange for fastening, coupling element and shaft.

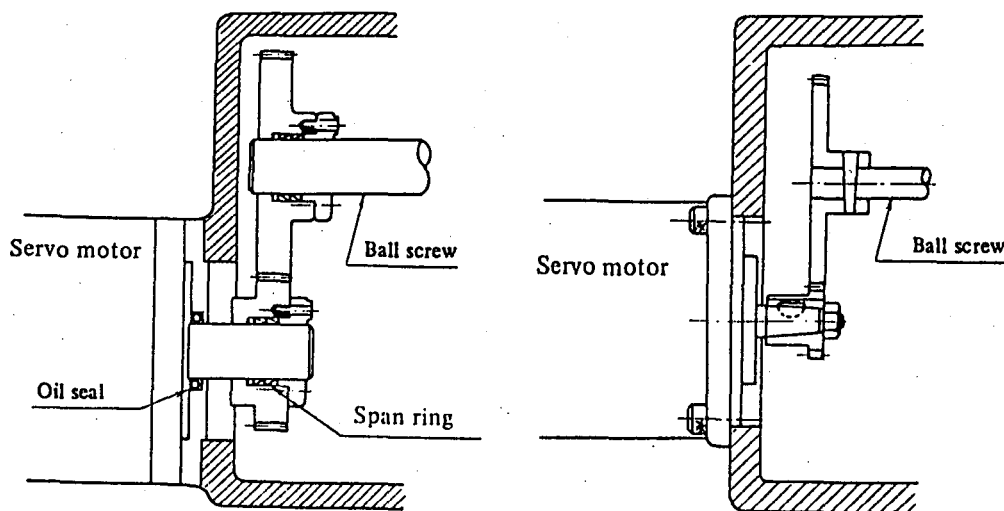
Refer to the instruction of span ring and make the most suitable design.



2) Gear coupling

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

- o 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.
- o Adjustment of backlash should be carefully performed. Generally, if there is too little backlash, a high-pitched unpleasant noise will occur during high-speed revolution, and if on the contrary, 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.



3) 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 drive, 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 system caused by reduction of rigidity by 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.

3.2 Machine Movement per 1 Revolution of Motor Shaft

The machine movement per 1 revolution of motor shaft shows how much the machine moves during one revolution of the motor. It 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 specification of position sensor mounted on the motor shaft. To determine this amount, the following conditions should be taken into consideration.

- o The machine movement per 1 revolution of motor shaft 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.
- o As the machine movement per 1 revolution of motor shaft goes small, 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 as possible with which the desired rapid traverse speed can be obtained.
- o Assuming that the accuracy of 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 seen from the machine's side, which can contribute system accuracy and to minimize influence of external load changes.
- o If the machine is to repeat acceleration and deceleration frequently, and the heat generated during these operations must be minimized, the machine movement per 1 rev of motor shaft should be such that the motor rotor inertia will be equal to the load inertia reflected to motor shaft. There may be some cases in punch press or printed circuit board drilling machine where this optimal condition can not be satisfied due to the limitation caused by the rapid traverse speed, even in such a case, the amount "L" should be as close to the optimal value as possible.
- o If the motor shaft has a position sensor, the machine movement per 1 rev of motor shaft is limited by the sensor and NC specifications. For farther details, refer to the manuals of each NC.

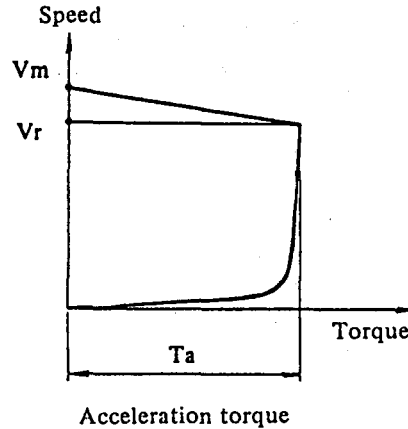
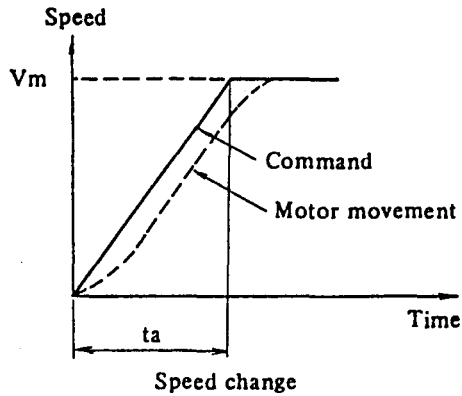
3.3 Selection of Motor by Load Conditions

There are two kinds of loads applied on the motor shaft, i.e., load torque and load inertia. When selecting a motor, these loads must be calculated correctly so that it can be confirmed that the values satisfy the following conditions:

- 1) Torque while the machine is operated without cutting, should be within the continuous rated torque of the motor in all speed range.
If torque increases and exceeds the rated torque because the friction coefficient increases during halt or at very low speeds, the motor may overheat because of the current that flows when it is halted. On the contrary, if the torque increases at high-speed influenced by viscosity, etc., and exceeds the rated torque, the acceleration time constant may increase excessively, because sufficient acceleration torque cannot be obtained.
- 2) The time set by the maximum cutting torque (duty percent and "ON" time) covers the desired value.
- 3) Acceleration can be made with the desired time constant. Generally, since load torque aids deceleration, if acceleration is possible, deceleration can be made with the same time constant. Check of acceleration is made according to the following procedure.
 - ① Acceleration rate is obtained assuming the motor shaft moves ideally according to the ACC/DEC mode determined by the NC.
 - ② Acceleration torque is calculated by multiplying the total inertia (motor inertia + load inertia) with acceleration rate.

- ③ Load torque (friction torque) is added to acceleration torque to obtain the torque necessary for the motor shaft.
- ④ It should be confirmed that the torque in Item 3 is less than the maximum motor torque (instantaneous maximum torque), and at the same time, less than the torque limited by the current limit of amplifier. Acceleration torque in Item 2 is calculated with the following equation.

For linear acceleration:



$$T_a = \frac{V_m}{60} \times 2\pi \times \frac{1}{t_a} (J_m + J_l) (1 - e^{-k_s \cdot t_a})$$

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

T_a : Acceleration torque (kg-cm)

V_m : Motor speed at rapid traverse (rpm)

t_a : Acceleration time (sec)

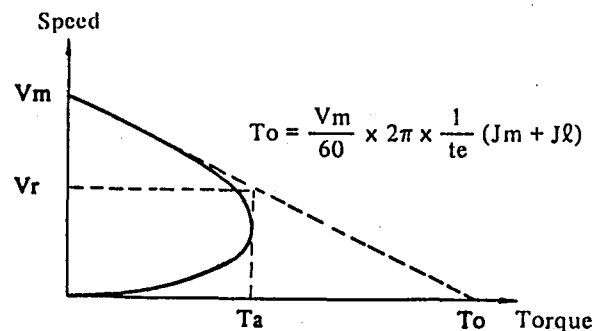
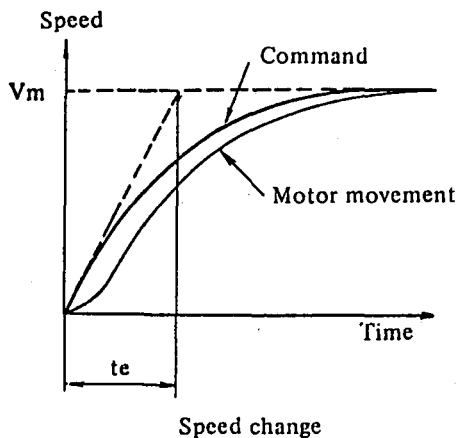
J_m : Motor inertia (kg-cm-s²)

J_l : Load inertia (kg-cm-s²)

V_r : Point where acceleration torque starts decreasing (difference from V_m) (rpm)

k_s : Servo position loop gain (sec⁻¹)

For exponential acceleration:



Acceleration torque necessary at each speed

In case $k_e \neq k_s$ where $k_e = \frac{1}{t_e}$ and $a = \frac{k_e}{k_s}$

$$T_a = \frac{V_m}{60} \times 2\pi \times a^{\frac{1}{1-a}} \times k_s (J_m + J_l)$$

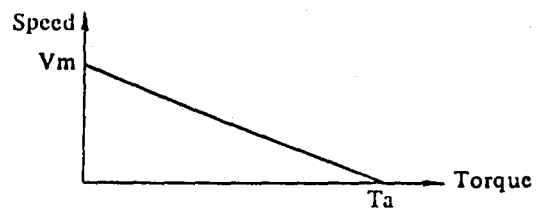
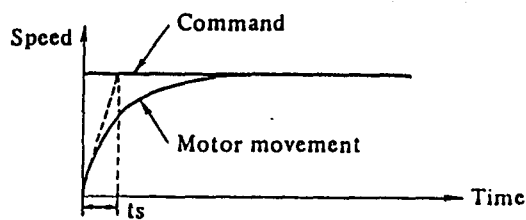
$$V_r = V_m \left(1 - a^{\frac{a}{1-a}}\right)$$

In case $k_e = k_s$

$$T_a = \frac{V_m}{60} \times 2\pi \times \frac{k_e}{e} (J_m + J_l), \quad e = 2.718$$

$$V_r = V_m \left(1 - \frac{1}{e}\right) = 0.632 V_m$$

In case the command speed is instantaneously raised

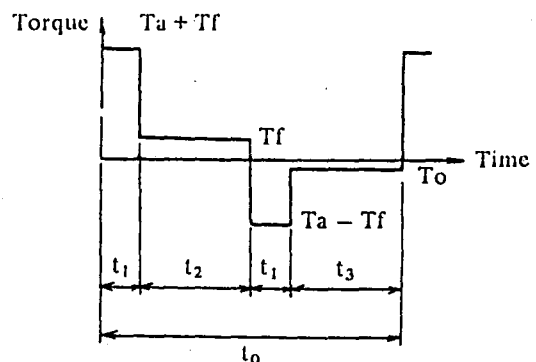
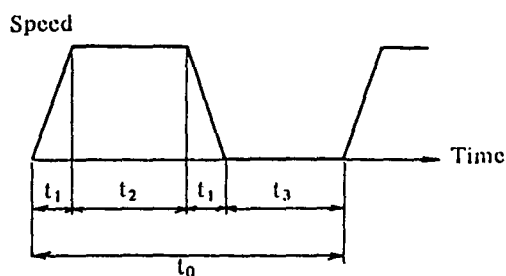


$$T_a = \frac{V_m}{60} \times 2\pi \times \frac{1}{t_s} (J_m + J_l) \quad \text{where } t_s = \frac{1}{k_s}$$

Symbols are as in the figure above.

4) Frequency of rapid traverse

Generally this item is not a problem in the ordinary cutting machining, but in special machining equipment that performs frequent rapid traverse, it is necessary to check whether the motor is overheated by the current necessary for acceleration/deceleration. In this case, value of Root Mean Square of the motor torque for 1 cycle should be calculated, and verify that this is less than the rated torque.



$$T_{rms} = \sqrt{\frac{(T_a + T_f)^2 t_1 + T_f^2 t_2 + (T_a - T_f)^2 t_1 + T_0^2 t_3}{t_0}}$$

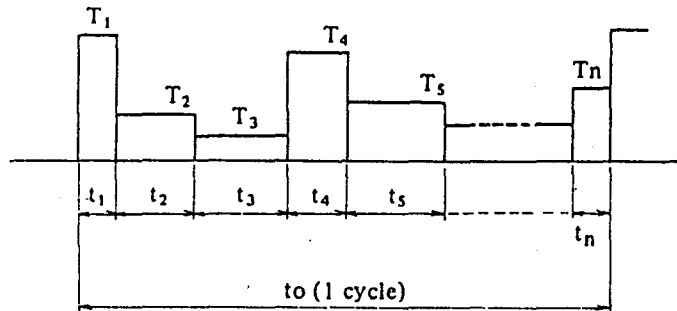
T_a: Acceleration torque

T_f: Friction torque

T₀: Torque at stop time

Usable if T_{rms} is less than the rated torque of the motor.

- 5) When load conditions fluctuate during 1 cycle, calculated the value of Root Mean Square of torque as in item (4), and it is confirmed that this value is within the rated torque.



$$t_0 = t_1 + t_2 + \dots + t_n$$

$$T_{rms} = \sqrt{\frac{T_1^2 t_1 + T_2^2 t_2 + T_3^2 t_3 + \dots + T_n^2 t_n}{t_0}}$$

- 6) Limit of load inertia

The value of load inertia gives large influences to motor response and rapid traverse ACC/DEC time. With large load inertia, when the command speed changes, more time is required for the motor to reach that command speed, and when curves such as circular arcs are cut at high-speed by simultaneous two axes interporation, the error becomes larger than the case of small inertia. Usually, when the load inertia is less than the motor rotor inertia, such problems as mentioned above do not occur. If up to three times of the rotor inertia, the response may become somewhat poor but in a machine that cuts ordinary metals, there may not be any practical problems. However, in a special machine such as rooter that machines various curves of wood at high speed, it is proper to make load inertia lower than rotor inertia.

When load inertia is more than three times the rotor inertia, response time is considerably lowered. When this value is radically exceeded, there is a possibility that adjustment in servo amplifier cannot be made within the ordinary adjustment range, so the use of this kind of inertia should be avoided. When it cannot be reduced less than three times because of machine design, please contact us for advice.

3.4 Calculation of Load Torque and Load Inertia

1) Calculation of load torque

Load torque applied to the motor shaft is generally calculated by the following simple equation.

$$T_M: \frac{F \times l}{2\pi\eta} + T_c$$

T_M : Load torque at motor shaft (kg-cm)

F : Force necessary to make move the sliding mass (table or tool post) in the axial direction (kg)

η : Efficiency of drive system

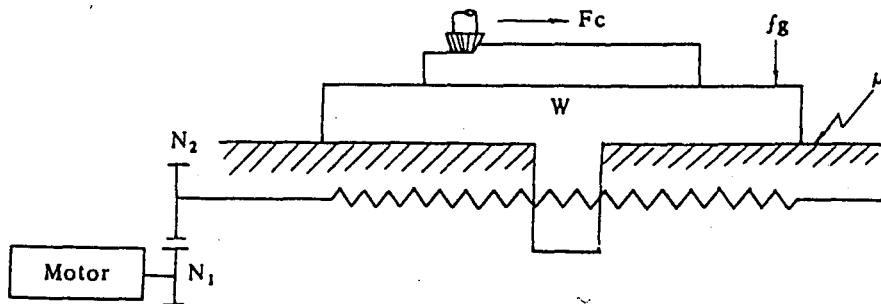
l : Machine movement per 1 rev. of motor shaft

T_c : Friction torque of ball screw nut section, bearing section etc. converted to motor shaft, which is not contained in " η "

Force F depends on the table weight, friction coefficient, whether the cutting thrust is applied, the axis direction is horizontal or vertical, and whether a counterbalance is used (in the case of vertical axis). In case of the horizontal direction, the value of F is given as an example in the following figure.

Non-cutting time: $F = \mu (W + fg)$

Cutting time: $F = F_c + \mu (W + fg + F_{cf})$



W : Weight of sliding mass (table and work) (kg)

μ : Friction coefficient

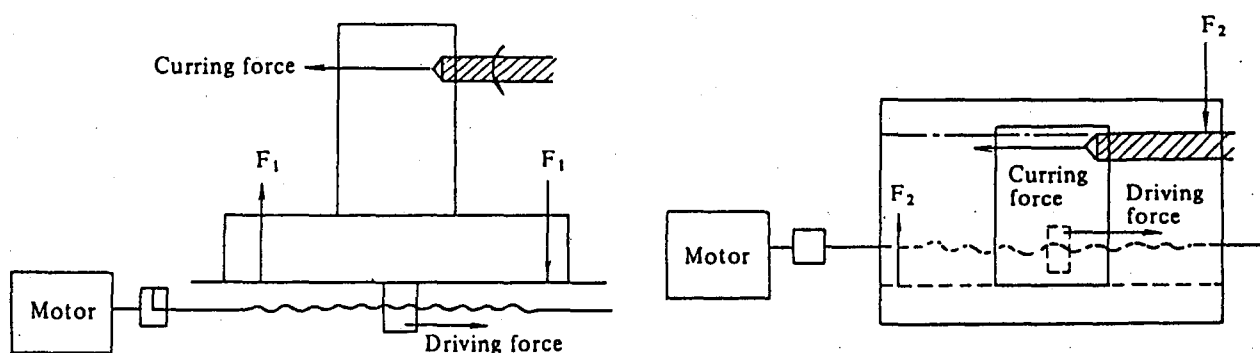
fg : Gib fastening (tightening) force

F_c : Thrust reaction force by cutting force (kg)

F_{cf} : Force of the table against the sliding surface by the moment due to the cutting force (kg)

When calculating torque, special attention must be paid to the following points.

- ① Friction torque due to the tightening of the gib must be duly considered. Generally, torque calculated only from weight of sliding mass and friction coefficient has a very small value. Please pay careful attention to the torque due to the tightening force of the gib and the precision of the sliding surface.
- ② There are cases when the friction torque of the rolling contact section due to the pre-load of the bearing and ball nut, and pre-tension of the screw cannot be ignored. Especially in the case of small light-weight machines, such torques influence the whole torque drastically, so attention must be paid.
- ③ Increase of friction of the sliding surface due to the cutting reaction force must be taken into consideration. Since the point that receives the cutting reaction force and the point that receives driving force are generally separated, the load of the sliding surface increases due to the moment on receiving large cutting reaction force as indicated in the figure. When calculating the torque during cutting, increase of friction torque due to this load must be taken into consideration.

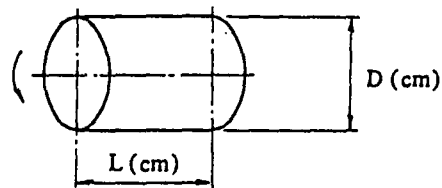


- ④ Friction torque can be strongly influenced by feed rate. Study and measurement must be made for the friction change due to the change of speed, the table support (sliding, rolling, static pressure), sliding surface material and lubrication conditions to produce the correct value.
- ⑤ Generally, friction torque varies according to the adjustment conditions, ambient temperature, or lubrication conditions, even within the same machine. When calculating the load torque, please try to obtain correct values with the aid of accumulated data of measurements from the same kinds of machine. Also, adjustment of gib tightening force or backlash must be made controlling the friction torque so that excessive torque will not be generated.

2) Calculation of load inertia

Different from the case of load torque, load inertia can be obtained correctly only by calculation. All the parts that is moved due to the revolution of the driving motor become motor load inertia regardless of whether it is revolutional or linear movement. The inertia can be obtained by calculating the inertia of these driven mass individually and summing them according to the rule. In this case, inertia of almost all cases can be calculated from the following basic equations.

① Inertia of cylindrical bodies



Inertia when a cylindrical body revolves around its central axis is calculated by the following equation. The ball screw, gear, etc. are calculated as cylindrical bodies.

$$J = \frac{\pi\gamma}{32 \times 980} D^4 L \text{ (kg}\cdot\text{cm}\cdot\text{sec}^2\text{)}$$

For steel ($\gamma = 7.8 \times 10^{-3} \text{kg/cm}^3$), it is approximated as follows.

$$J = 0.78 \times 10^{-6} D^4 L \text{ (kg}\cdot\text{cm}\cdot\text{sec}^2\text{)}$$

J: Inertia (kg·cm·sec²)

γ : Weight per unit volume (kg/cm³)

D: Diameter of the cylindrical body (cm)

L: Length of the cylindrical body (cm)

② Inertia of mass moved along linear axis

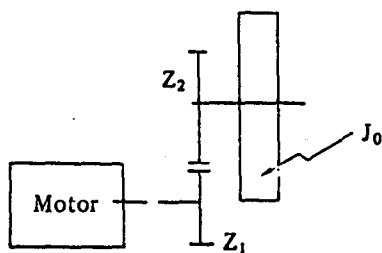
Inertia of table, work, etc. is applicable and it can be obtained from the following equation.

$$J = \frac{W}{980} \left(\frac{L}{2\pi} \right)^2 \text{ (kg}\cdot\text{cm}\cdot\text{sec}^2\text{)}$$

W: Weight of the Mass in linear movement (kg)

L: Amount of movement in the linear direction per motor 1 revolution (cm)

③ Inertia when the speed is changed mechanically against the motor shaft.

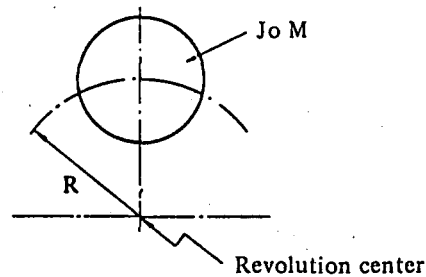


Z_1, Z_2 are the number of teeth of the gear.

Motor shaft conversion of inertia J_0 is as follows.

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

- ④ Inertia of a cylindrical body in which the center of revolution is displaced.



$$J = J_0 + \frac{M}{980} R^2 \text{ (kg}\cdot\text{cm}\cdot\text{sec}^2\text{)}$$

J_0 : Inertia around the center of the cylindrical body (kg·cm·sec²)

M : Weight of the cylindrical body (kg)

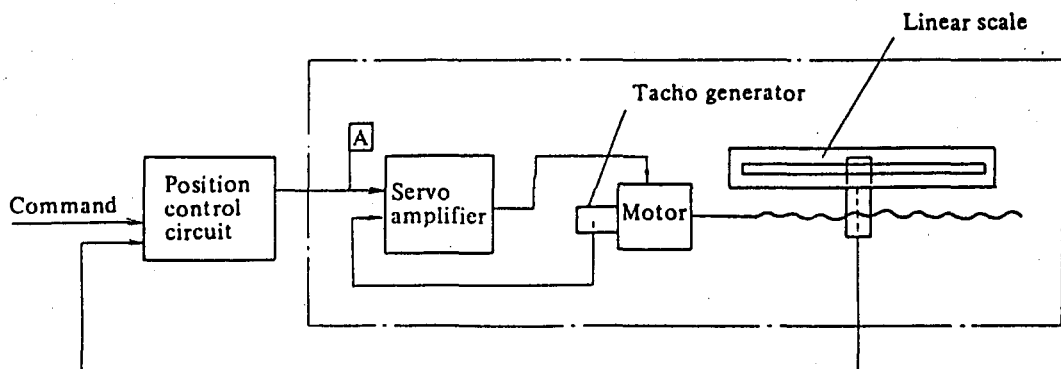
R : Revolution radius (cm)

The above equation is used for example, to calculate the inertia of gears or pulley of large diameter in which bores are made on a certain pitch circle to reduce inertia and weight.

3.5 Precautions for Using Linear Scale

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., and then feed back is given, the special considerations are necessary in comparison with the method where feedback is produced by detecting the motor shaft revolution, because the machine movement directly influences the characteristics of the control system.

1) Machine system natural frequency



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 the section where position signal is detected sufficiently shorter than the response time determined by the position loop gain, the system does not operate normally as a whole. In other words, when a command signal is put into point A, response time of the machine where position signals detected must be sufficiently shorter than the

response time defined by the position loop gain. On the contrary, when the response of the detector section is delayed, the position loop gain must be reduced to have the system operate normally, and as a result, the response of the whole system is delayed. The same problem is caused when inertia is great (see Section 3.3, Item 5)).

The main causes for the delay of the 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 more delayed 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.

$$\omega = \frac{1}{2\pi} \sqrt{\frac{K_m}{J\ell}} \quad (\text{Hz})$$

ω : Natural frequency (Hz)

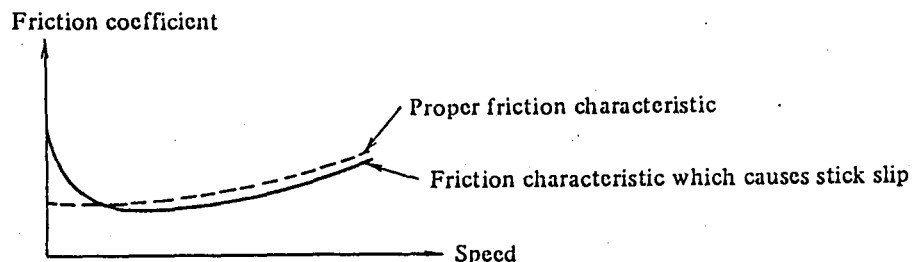
$J\ell$: Load inertia reflected to motor shaft (kg-cm-sec²)

K_m : Rigidity of machine system (kg-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 (sec⁻¹), it operates normally in most cases. That is to say, when setting 20 sec⁻¹ as the value of position loop gain, natural frequency of machine system must be at least more than 20 Hz. In this case, attention must be paid to the fact that response is becomes problem at extremely small amounts of movement. Consequently, the natural frequency should be calculated from the rigidity at extremely small displacement such as less than 10 μ m.

2) Stick slip

If machine movement causes a stick slip, the control system does not operate normally. That is, it does not stop at where it is supposed to, but a phenomenon occurs where it goes to and 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.



3) 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.

3.6 Motor Selection

Select a suitable motor according to the load condition, rapid traverse feedrate, increment system, and so on. You are recommended for selecting the motor securely to arrange its working conditions using the attached "servo motor selection data table".

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

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

Details of description contents of each item in this selection data table are as described below.

3.6.1 Blanks for those other than data

1) Address blank

Fill in this blank with machine tool builder's company name. However, this entry is not always needed.

2) Kind of machine tool

Fill in this blank with a general name of machine tools, such as lathe, milling machine, machining center, and others.

3) Type of machine tool

Fill in this blank with the type of machine tool decided by machine tool builder.

4) CNC equipment

Fill in this blank with the name of CNC (10T, 10M, 0M, etc.) employed. Enter the cabinet type (self-standing type, separate type, etc.) in parentheses.

5) Spindle motor output

Fill in this blank for reference when examining the servo motor output.

6) Names of axes

Fill in this blank with names of axes practically employed in NC command. If the number of axes exceeds 4 axes, enter them in the second sheet.

If names of axes other than entered X, Y, Z are used, delete these entered symbols with "/", and write correct names of axes aside.

7) Blanks of version number, date, name, and reference number.

Keep these blanks unwritten by the MTB.

3.6.2 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. Keep these blanks unwritten in such a case.

For details of entry contents, refer to the following description.

1) 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.

a) 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°)

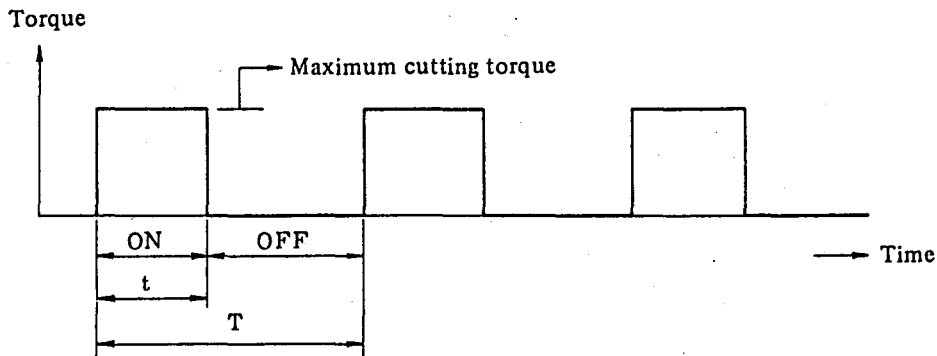
Whether their movement directions are horizontal or vertical (or slant) is necessary for calculating the regenerative energy. Fill in this blank without fail.

b) 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.

- c) Counter balance
Enter the weight of the counter balance in the vertical axis, if provided. Write the force in case of hydraulic balance.
- d) Table support
Enter the type of table slide way whether it is of the rolling, sliding, or static pressure type. If a special slide way material like Turcite is used, note it.
- e) Feed screw
Enter the diameter, pitch, and axial length of the feed screw in this order. Example: $\phi 40 \times 10 \times 1500$ (when the diameter is 40 mm, pitch is 10 mm, and axial length is 1500 mm)
- f) 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.
- 2) 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 para. 3.2 to 3.4.
- a) Movement per revolution of motor
Enter the movement of the machine tool when the motor rotates one turn.
Example: * When the pitch of ball screw is 12mm and the gear ratio is $2/3$,
 $12 \times 2/3 = 8 \text{ mm}$
* When the gear ratio is $1/72$ in rotary table;
 $360 \times 1/72 = 5 \text{ deg}$
This amount is restricted to certain specified values according to CNC specifications and detector specifications when the position detector with built-in motor is used.
For details, refer to the descriptions of each CNC.
Example: If a 2000P/rev pulse coder is used in CNC model 10M;
2 mm, (3 mm), 4 mm, (6 mm), 8 mm
- b) Least input increment of CNC
Enter the least input increment of NC command. The standard value is 0.001 mm in 0, 10, 11 and 12 series CNCs.
- c) Rapid traverse rate and cutting feedrate
Enter the rapid traverse rate and cutting feedrate required for machine tool specifications.
- d) Inertia
Enter a load inertia value converted into the motor shaft value. For details of this calculation, see para. 3.4.
It is not always necessary to enter this inertia value in detail. Enter it as a 2-digit or 1-digit value.
(Example: $0.2865 \rightarrow 0.29$ or 0.3)
Do not include any inertia of the motor proper in this value.
- e) Load torque
- o Since the torque produced in low speed without cutting may be applied even during the stop of motor, a sufficient allowance is necessary as compared with the continuous rated torque of the motor. Suppress this load torque to be lower than 60% of the rated torque.
 - o For the torque during rapid traverse, enter the torque during traveling at rapid traverse steady-state speed.
If this value largely exceeds the continuous rated area of the motor, brushes may be worn and the commutator may be damaged as a result. Keep this value within the continuous rated area. Do not include any torque required for acceleration/deceleration in this item.
 - o For the cutting thrust, enter the maximum value of the force being applied during cutting by the force in the feed axis direction.

- o 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.
 - o If the load torque values differ during lifting and lowering in the vertical axis, enter both values.
- f) Maximum cutting duty/ON time
Enter the duty time and ON time with the maximum cutting torque in (e) applied. These values mean as follows.



ON : Time the maximum cutting torque is being applied
 OFF: Time absent from the cutting torque
 Duty = $t/T \times 100$ (%)
 ON time = t (min)

- g) 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.
- 3) 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 by using a linear scale.

a) External 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 rotation of pulse coder
Number of pulses of pulse coder

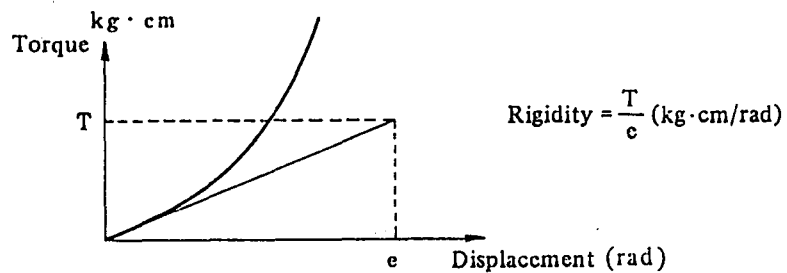
b) Rigidity of feed system machine tool

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 table has been fully locked. Fill in this value as a torque value required for the angular displacement of 1 radian.

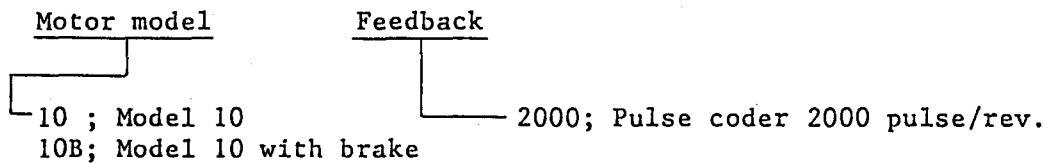
Example: If displacement of 5 deg. at 500 kg-cm torque as a calculation results,

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

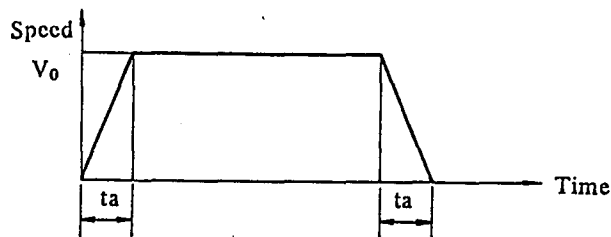
If the relation between the displacement and the torque is nonlinear, calculate the rigidity by the gradient in the vicinity of origin.



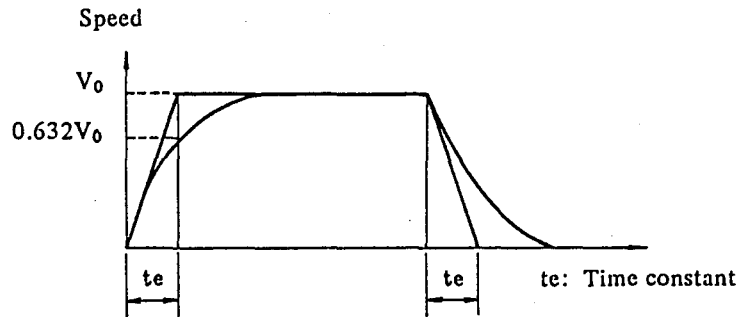
- c) Backlash amount
Enter the backlash amount between the motor and the final driven part like table by converting it into the move amount of the table.
- 4) No. 4 blank: Motor specifications
- a) Motor model Feedback (FB) type
Enter the model name of the motor employed and the specifications of the built-in feedback unit by using symbols.
(Example)



- b) Option, special specifications
Enter special specifications, if any, in this blank.
- 5) No. 5 blank
(The acceleration/deceleration time in this item is a commanded value. It does not mean any actual completion time of positioning.)
- a) 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 para. 3.3.
The acceleration/deceleration mode at rapid traverse is generally linear acceleration/deceleration in FANUC's CNC.



- b) 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.

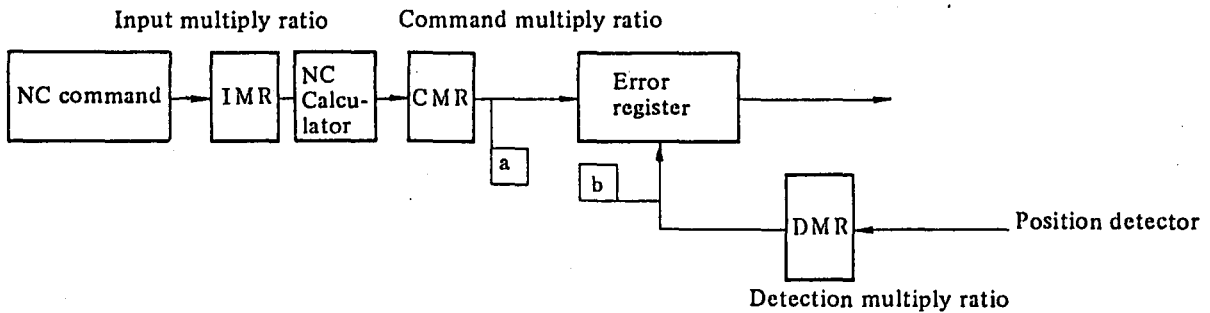


6) No. 6 blank

a) Input multiply ratio, command multiply ratio, and detection multiply 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 is as illustrated below.



These multiply ratios are set so that the least input increments of two inputs (a, b) of the error register are equal to each other in the above figure.

(Example)

IMR = 1, CMR = 1, and DMR = 4, if the least input increment of NC is $1\mu\text{m}$, the move amount of the machine tool per revolution of motor is 8 mm, and pulse coder 2000 P/rev is used.

b) 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 in practice, this value is determined after finally confirming it in the actual machine tool. If the positioned detector is mounted outside the motor, this value is largely affected by the machine tool rigidity, backlash amount, and friction torque value. Enter these values without fail.

7) No. 7 blank

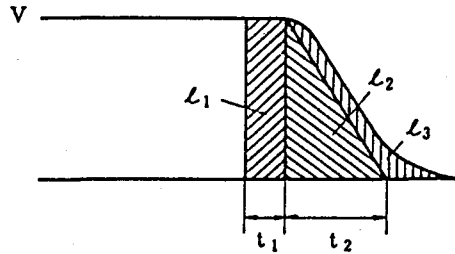
The coasting distance of the machine tool at the machine tool stroke end is entered in this blank. The stroke end is usually limited in 2 steps consisting of the deceleration stop in the first step and dynamic brake stop in the second step.

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.

a) Deceleration stop distance

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



V_m : Rapid traverse feedrate, mm/min or deg/min

L_1 : Coasting distance due to delay time t_1 of receiver

L_2 : Coasting distance due to deceleration time t_2

L_3 : Servo deflection amount

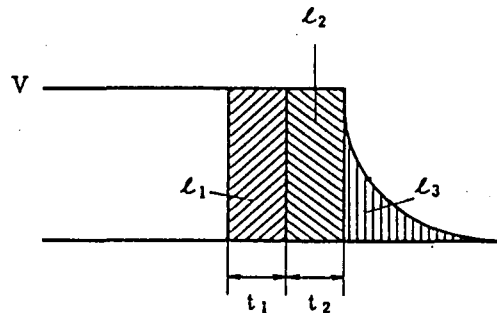
t_1 is usual about 0.02 seconds..

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

k_s : Position loop gain sec^{-1}

b) Dynamic brake stop distance

This is the 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.



V_m : Rapid traverse feedrate, mm/min or deg/min

L_1 : Coasting distance due to delay time t_1 of receiver

L_2 : Coasting distance due to operation time t_2 of magnet contactor

L_3 : Coasting distance by dynamic braking after magnet contactor has been operated

$(t_1 + t_2)$ is usual about 0.05 seconds.

$$\text{Coasting distance (mm or deg)} = \frac{V_m}{60} (t_1 + t_2) + (J_m + J_L) \times (A N_0 + B N_0^3) \times L$$

J_m : Motor inertia (kg.cm.sec²)

J_L : Load inertia (kg.cm.sec²)

N_o : Number of rotation at rapid traverse (rpm)

L : Machine movement per one rotation of motor (mm or deg)

$$N_o \times L = V_m$$

A and B are the constants relative to the motor models as shown below.

Model	A	B	J_m (kg.cm.sec ²)
0	8.4×10^{-3}	4.1×10^{-9}	0.02
5	3.8×10^{-3}	1.7×10^{-9}	0.038
10	4.3×10^{-3}	1.6×10^{-9}	0.10
20	1.9×10^{-3}	6.3×10^{-10}	0.17

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

8) No. 8 blank : Servo unit specification

a) Type of amplifier

Designate either AC servo or DC servo.

b) Transformer

Fill the transformer specification.

c) Specifications

Fill the specifications of amplifier and regenerative discharge unit.

AC servo motor selection data table

MTB

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

No.	Item	Axis	X	Y	Z	
1	Axis movement direction (horizontal, vertical rotation)					
	Weight of moving component parts (including workpiece, etc.)	kg				
	Counter balance	kg				
	Table support (sliding, rolling, static pressure)					
	Feed screw Diameter x pitch x axial length	mm				
	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	kg-cm-s ²				
	Load torque	Low feed without cutting	kg-cm			
		Rapid traverse	kg-cm			
		Cutting thrust	kg			
		Maximum cutting torque	kg-cm			
	Maximum cutting duty/ON time	%/min				
Rapid traverse positioning frequency	times/min					
3	External position detector					
	Feed system machine tool rigidity	kg-cm/rad				
	Backlash amount	mm				
4	Motor type, model - feedback type					
	FB type					
	Number of rotation at rapid traverse					
	Option/special specifications					
5	Acceleration/deceleration time at rapid traverse	msec				
	Acceleration/deceleration time at cutting feed	msec				
6	Input multiply ratio (IMR)					
	Command multiply ratio (CMR)					
	Detection multiply ratio (DMR)					
	Position loop gain	sec ⁻¹				
7	Deceleration stop distance	mm				
	Dynamic brake stop distance	mm				
8	Amplifier type					
	Transformer					
	Specifications	Amplifier				
		Regenerative unit				
Remarks			Version	Date	Name	
			1			
			2			
			3			

A. Ar 1870-

4. FEEDBACK DETECTOR

4.1 Built-in detector

A pulse coder (optical encoder) is built in every AC servo motor. The pulse coder generates an A/B phase (lead/delay) signal, a Z phase (1 rotation) signal, and a rotor phase signal necessary for motor control.

4.1.1 Incremental pulse coder (standard)

This is the most compact standard pulse coder. Available pulse number is 2,000, 2,500 and 3,000 (A phase) pulses per rotation.

When using with a digital servo, it can be used for up to 24m/min. by setting 1 μ m/pulse. It is different by NC in the setting of 1 μ m or less/pulse. Refer to the NC specifications.

When using with an analog servo, it can be used for up to 24 m /min. by setting 1 μ m/pulse. Up to 12 m/min. in the case of 0.5 μ m/pulse.

4.1.2 Absolute pulse coder

Even if the NC power is turned off, the pulse coder backed up with a battery memories the position, so eliminating the necessity of returning to the reference point at turning on the NC power.

The interface connector specifications are different from those of the incremental pulse coder.

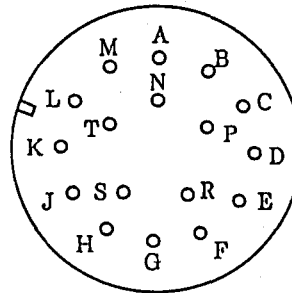
The restrictions on the feed rate are the same as those of the incremental pulse coder.

4.1.3 Detector signal output

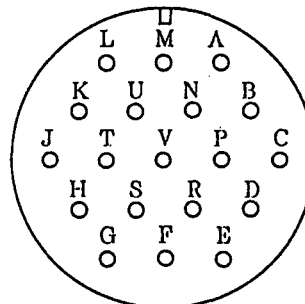
The detector signals are output as follows.

Signal name	Incremental	Absolute
A *A	A D	A B
B *B	B E	C D
Z *Z	F G	E F
C1 C2 C4 C8	C P L M	G H J K
+5V 0V Shield OH1 OH2 REQ +6VA 0VA	J,K N,T H R S - -	L M N P R S T U

Incremental
MS3102A 20-29PW



Absolute
MS3102A 22-14P



4.2 External Position Detector

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

- Increase the machine rigidity from the servo motor to the position detector, and make the structure less rattling. If the machine rigidity is low or the structure has many rattling, a vibration/fluctuation or other defects is likely to occur.
- Generally, when the separate type detector is used, the influence of ball screw pitch error or table inclination is decreased and the positioning accuracy and geometrical accuracy (circularness, etc.) are increased, but the smoothness (in drawing) may be deteriorated due to the elasticity and rattling in the machine from the servo motor to the position detector.
- It is necessary to use the built-in pulse coder with the resolution equal to or higher than that of the separate type position detector. Design the built-in pulse coder so that the ratio of resolution to that of the separate type is an integer value. Namely, when an optical scale of 1 μ m is used in a machine of 8mm per motor rotation, use the pulse coder of 2,000 or 10,000 pulses, rather than that of 2,500 pulses.

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. FANUC provides the following external position (rotary) detector.

(1) 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.

A 8 6 0 - 0 3 0 1 - T 0	□□	(Incremental pulse coder)
	0 1	2000P/rev (up to 3000rpm)
	0 2	2500P/rev (up to 2400rpm)
	0 3	3000P/rev (up to 2000rpm)

For the external dimensions, refer to item 4.3 (4).

(2) Absolute pulse coder unit

A 8 6 0 - 0 3 2 4 - T 1	□□	(Absolute pulse coder)
	0 1	2000P/rev (up to 3000rpm)
	0 2	2500P/rev (up to 2400rpm)
	0 3	3000P/rev (up to 2000rpm)
	0 4	4000P/rev (up to 1500rpm)

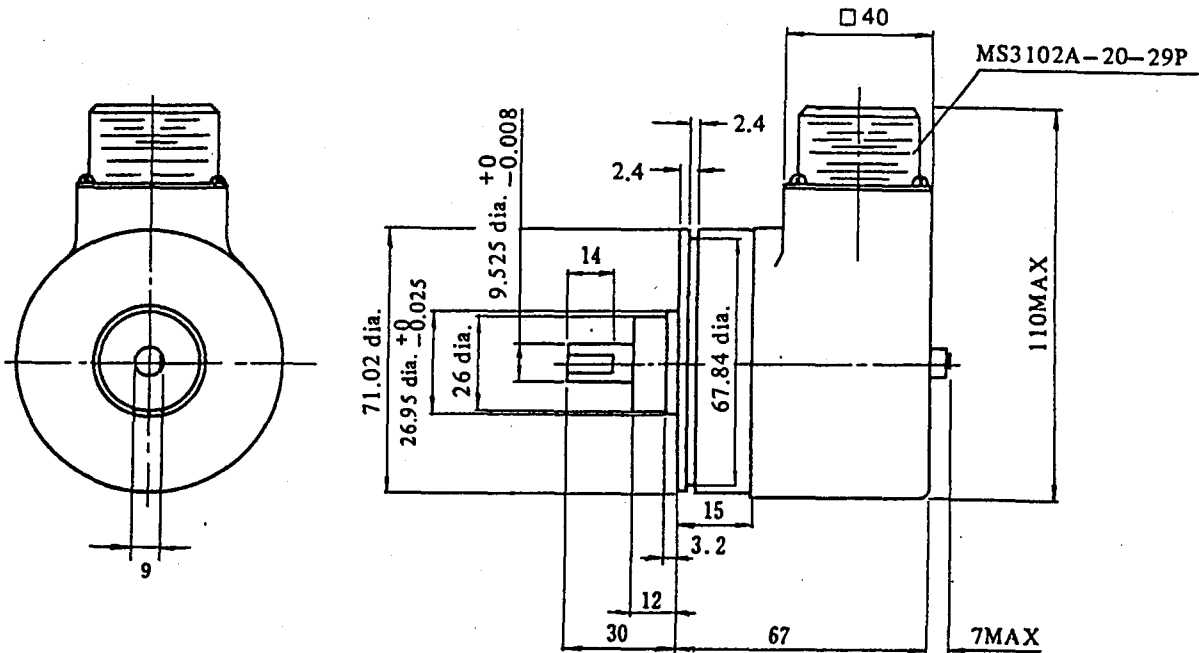
For the external dimensions, refer to item 4.3 (5).

(3) High-speed high resolution pulse coder unit

A 8 6 0 - 0 3 1 4 - T 1	□□	(High-speed high resolution pulse coder)
	1 1	2000P/rev (up to 3000rpm)
	1 2	2500P/rev (up to 2400rpm)
	1 3	3000P/rev (up to 2000rpm)

A signal conversion circuit is required for the connection with NC. For the external dimensions, refer to item 4.3 (5).

(4) Pulse coder unit



Note: Use flexible coupling.

Signal	Terminal No.	Power supply	5V \pm 5% 0.35A or less
A	A	Output	A, \bar{A} , B, \bar{B} , Z, \bar{Z}
\bar{A}	D	No. of pulses	2000, 2500, 3000 P/rev.
B	B	Maximum pulse rate	100kHz
\bar{B}	E	Working temperature range	0°C -60°C
Z	F	Rated loads	Radial 2.0 kg
\bar{Z}	G		Axial 1.0 kg
+5V	G, J, K	Shaft diameter runout	0.02 mm
0V	N, P, T	Weight	2.0 kg
Shield	H	Rotor inertia	Max. 0.057 g-cm-sec ²
		Friction torque	Max. 0.8 kg-cm

5. BUILT-IN BRAKE

As for the model 0 to 30, there is a motor containing a brake for holding a gravity axis, for example, to prevent falling. Such a motor is different in external dimensions and weight. For the outside dimensions, see the outline drawing. The built-in brake specifications are as shown below.

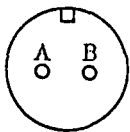
Motor model		0,5	10 ~ 30
Brake torque		60kg.cm	180kg.cm
Response time	Release	95msec	100msec
	Brake	20msec	60msec
Supply voltage ($\pm 10\%$) Current		DC90V 0.4A or less	DC90V 0.6A or less
Weight increased		Approx. 3kg	Approx. 8kg

Use the full-wave rectified AC100V or DC90V as a power supply. Don't use the half-wave rectified AC200V. The surge absorber may be broken.

Use a rectifier with dielectric strength of 400V or higher. Connect CR as shown in the drawing, to protect the contact of the switch. The equivalent CR is the Fujitsu S2-A.

- Note 1) This brake is used to hold the machine when the servo motor control becomes invalid. 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.
- Note 2) Take sufficient allowance for the timing of starting the servo motor control and 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 fixing the axis by the built-in brake or another fixing means. At this time, take sufficient allowance for the timing of fixing the axis and turning off the servo.
- Note 3) This built-in brake use the resin molded asbestos as a friction plate. Be careful when the use of asbestos is limited. As long as it is used in general holding operation, generation of dust is very small and beside, it is enclosed by the motor case.

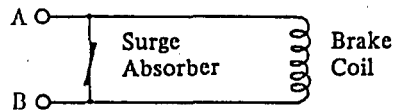
KEY



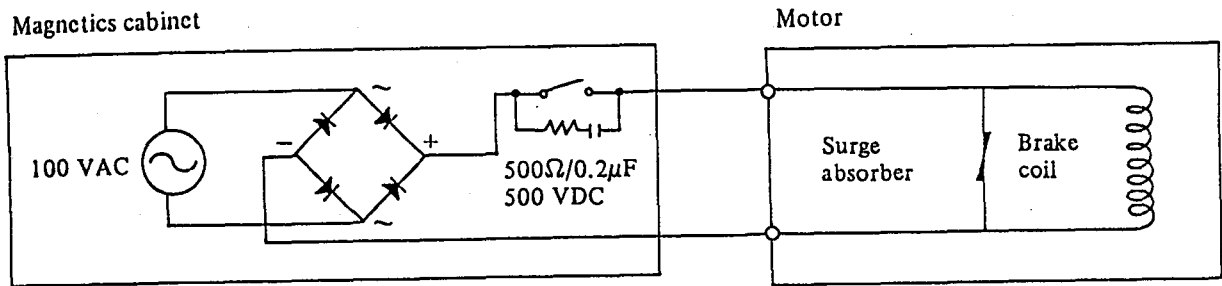
MS3102A 10SL-4P

90 VDC

0.4A (Model 0, 5)
0.6A (Model 10, 20, 30)



Note) Brake wiring



6. CONNECTOR PLUG OF CONNECTION CABLE

The connector plug of the cable corresponding to the connector receptacle used in the FANUC AC servo motor is as shown below.

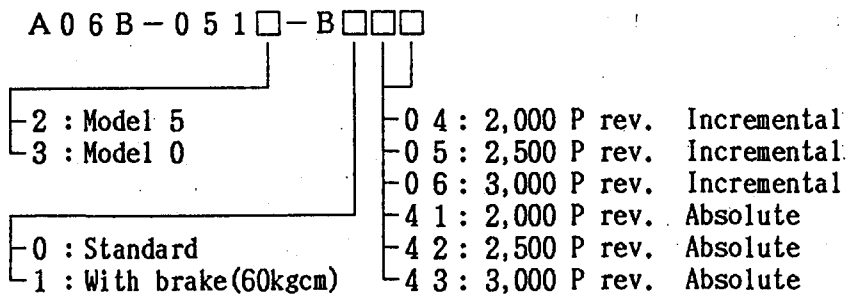
No. of pins	Receptacle	Straight plug	Angle plug	Cable clamp
2	MS3102A 10SL-4P	MS3106B 10SL-4S	MS3108B 10SL-4S	MS3057-4A
3	MS3102A 10SL-3P	MS3106B 10SL-3S	MS3108B 10SL-3S	MS3057-4A
4	MS3102A 18-10P	MS3106B 18-10S	MS3108B 18-10S	MS3057-10A
4	MS3102A 22-22P	MS3106B 22-22S	MS3108B 22-22S	MS3057-12A
7	MS3102A 24-10P	MS3106B 24-10S	MS3108B 24-10S	MS3057-16A
7	MS3102A 20-15P	MS3106B 20-15S	MS3108B 20-15S	MS3057-12A
17	MS3102A 20-29PW	MS3106B 20-29SW	MS3108B 20-29SW	MS3057-12A
19	MS3102A 22-14P	MS3106B 22-14S	MS3108B 22-14S	MS3057-12A
4	RM15WTR-4P	RM15TP-4S		
4	RM12BRB-4P	RM12BPG-4S		

Note) Keep the connector plug away from the splash of cutting fluid or other liquid. When there is a possibility of wetting the connector plug, use the R-class one for the MS connector and the water-proof plug such as RM15WTP-4S for the RM15 connector. Use the motor connector by setting it downward in the gravity direction as far as possible. When it is inevitable to set it sideways or upward, make the cable slack at a certain portion to prevent running of the cutting fluid along the cable to wet the connector plug. In any case, when there is a possibility of wetting the connector plug, use a cover or take the other suitable means.

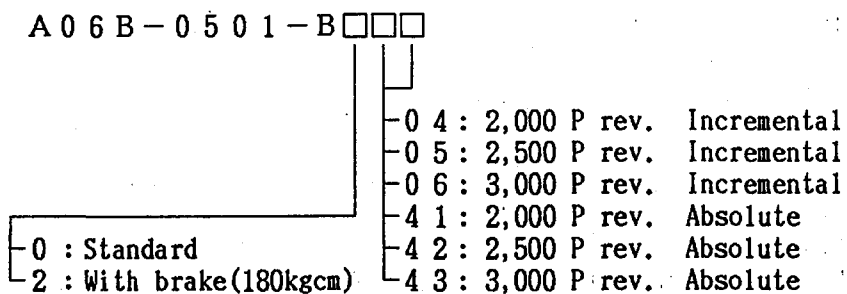
7. TYPES OF MOTORS AND DESIGNATION

The type and specifications are as follows.

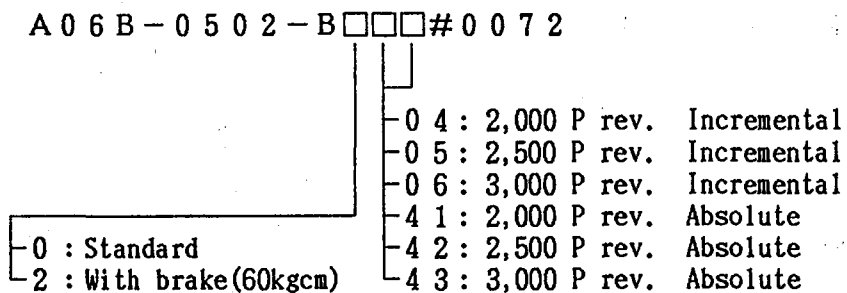
(1) Model 0, 5



(2) Model 10



(3) Model 20



8. SPECIFICATIONS AND CHARACTERISTICS

8.1 Types of Motors and Specifications

Item \ Model	Unit	0	5	10	20
Output	kW (HP)	0.55 (0.74)	0.9 (1.2)	1.8 (2.5)	3.5 (4.7)
Rated torque (*1)	N m (kg cm)	2.9 (30)	5.9 (60)	11.8 (120)	22.5 (230)
Max. torque (*2)	N m (kg cm)	26 (270)	53 (540)	78 (800)	147 (1 500)
Max. speed	rpm	2 000	2 000	2 000	2 000
Rotor inertia	N m s ² (kg cm s ²)	0.002 (0.02)	0.0037 (0.038)	0.01 (0.1)	0.017 (0.17)
Max. acceleration (*2)	rad/s ²	13 500	14 200	8 000	8 820
Mechanical time constant	ms	16	9	10	6
Thermal time constant	min	45	50	60	65
Weight	kg	10	15	23	34

(*1) Stall torque at 20 deg C.

(*2) Theoretical value of the motor only. The actual maximum torque is restricted by the current limit value of the drive amplifier.

8.2 Characteristic Curve and Data Sheet

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

Performance Curves

The typical characteristic curves consist of the followings.

1) Torque-speed characteristics

These are known as operating curves and describe the relationship between the output torque and speed of the motor. The motor can be operated continuously at any combination of speed and torque within the prescribed continuous operating zone. 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

- . The temperature of 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 above 20°C.

2) Overload duty characteristic

These curves are known as duty cycle curves and provide 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.

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.

- a) The temperature of the motor is 20°C.
- b) Drive current of the motor is pure sine wave.

Important parameters on the data sheet are defined as follows:

i) Continuous RMS current at stall TENV: I_s (Arms)

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

ii) Torque constant: K_t (kg·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 at the current rating. The torque constant is the 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:

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

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

iii) 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 conductor 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:

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

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

iv) 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.

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

, when J_m : rotor inertia ($\text{kg}\cdot\text{cm}\cdot\text{sec}^2$)

v) 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.

vi) Static friction: T_f ($\text{kg}\cdot\text{cm}$)

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

vii) 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.

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)

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

$$\text{Torque percent} = \frac{\text{Load torque}}{\text{Continuous rated torque}} \dots\dots\dots (b)$$

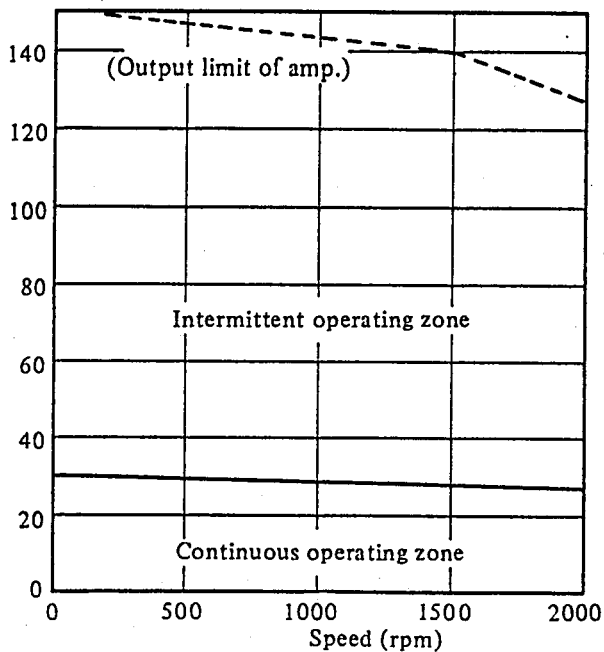
t_F : "OFF" time
 t_R : "ON" time

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 as 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 should be referred.

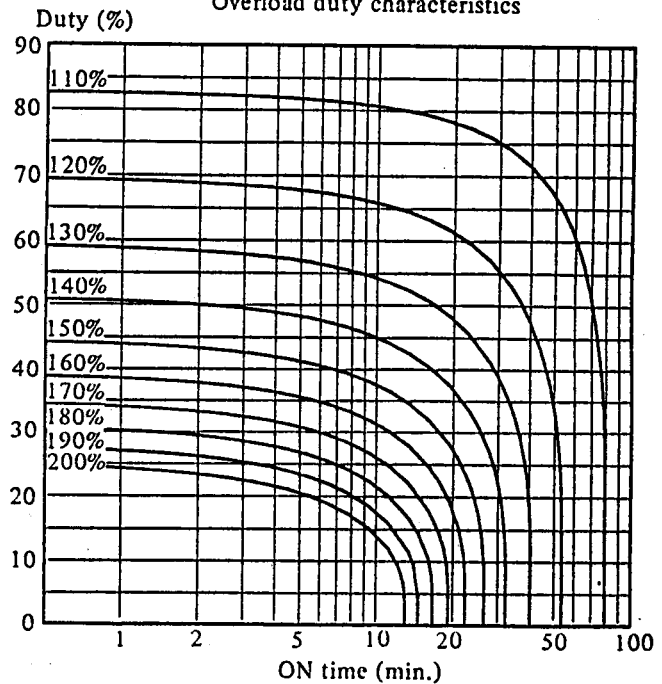
In the case of digital servo, the software protection is available to protect against a shorter time overload. This also limits the motor operating conditions.

MODEL 0 (A06B-0513-B□□□)

Torque (kg·cm) Torque-speed characteristics



Duty (%) Overload duty characteristics

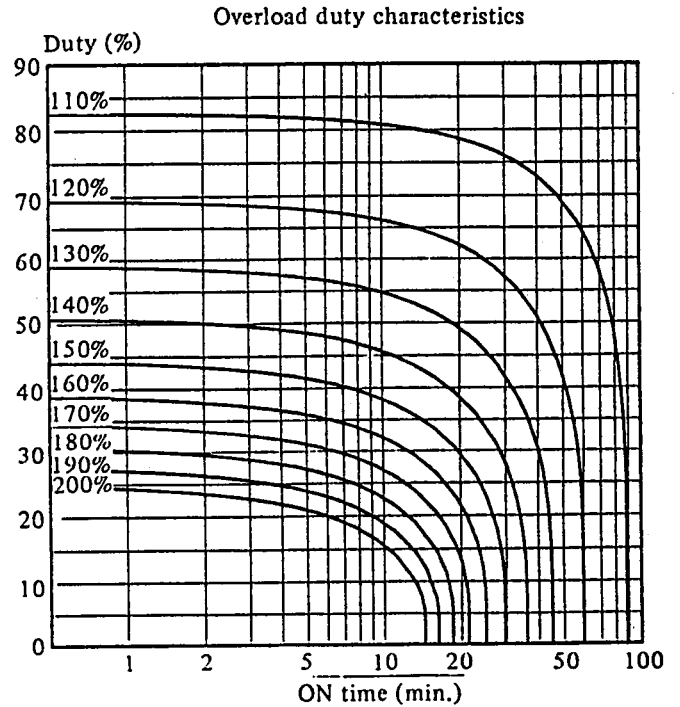
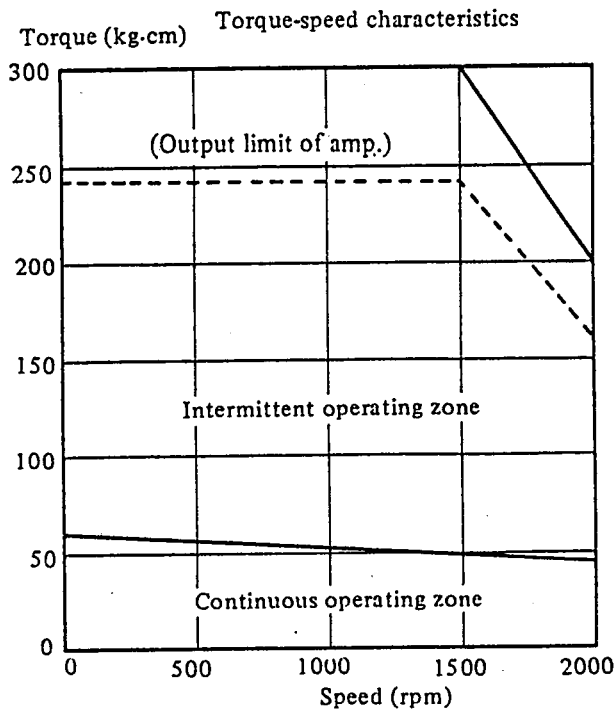


Data sheet

Parameters	Symbol	Value	Unit
Rotor inertia	J_m	0.02	$\text{kg} \cdot \text{cm} \cdot \text{s}^2$
Continuous RMS current at stall	I_s	4.6	Arms
Torque constant (Note)	K_t	6.5	$\text{kg} \cdot \text{cm}/\text{Arms}$
Rated torque at stall (Note)	T_s	30	$\text{kg} \cdot \text{cm}$
Back EMF constant (RMS voltage per phase) (Note)	K_e K_v	22 0.21	V/krpm $\text{V} \cdot \text{s}/\text{rad}$
Armature resistance (Note)	R_a	0.645	Ohm
Mechanical time constant (Note)	t_m	0.009	s
Thermal time constant	t_t	45	min
Static friction	T_f	3	$\text{kg} \cdot \text{cm}$
Max. allowable current	I_m	53	A
Max. torque	T_m	270	$\text{kg} \cdot \text{cm}$
Max. winding temperature rise	θ_m	125	$^{\circ}\text{C}$
Weight		9	kg

Note) 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,
servo parameter setting, and input voltage.
These values may be changed without prior notice.

MODEL 5 (A06B-0512-B□□□)

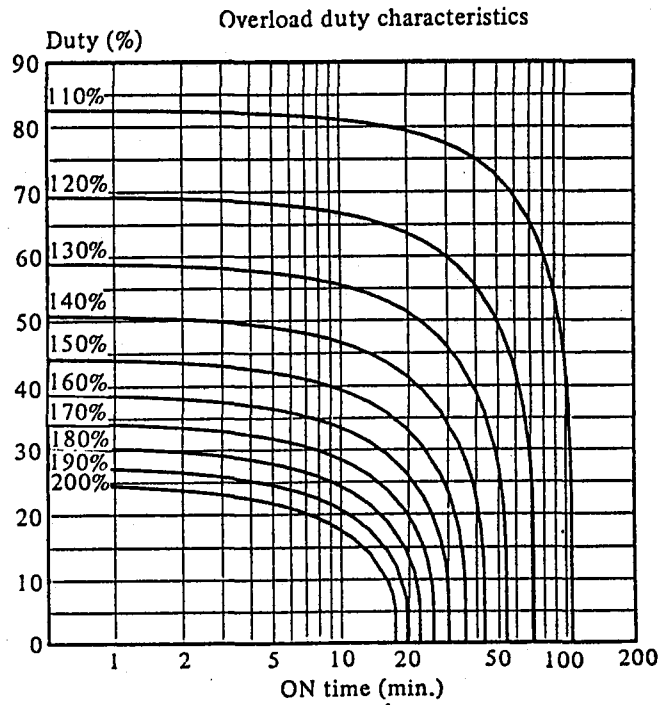
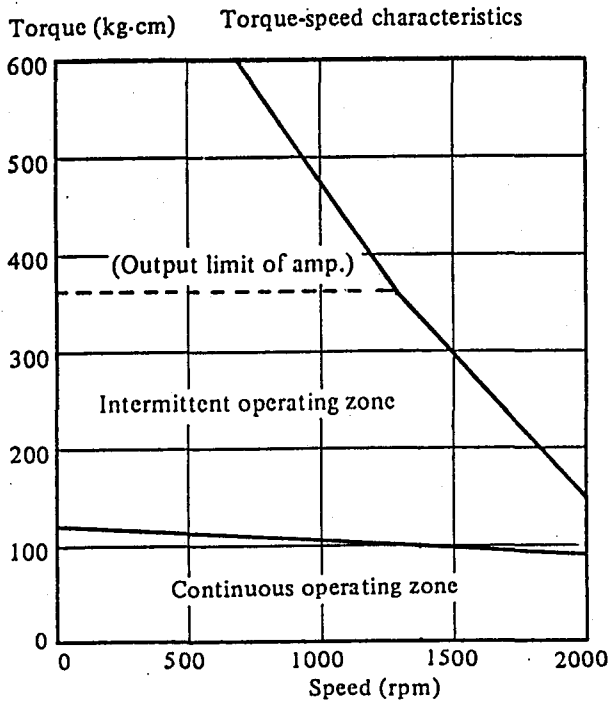


Data sheet

Parameters	Symbol	Value	Unit
Rotor inertia	J_m	0.038	$\text{kg} \cdot \text{cm} \cdot \text{s}^2$
Continuous RMS current at stall	I_s	6.8	Arms
Torque constant (Note)	K_t	8.8	$\text{kg} \cdot \text{cm}/\text{Arms}$
Rated torque at stall (Note)	T_s	60	$\text{kg} \cdot \text{cm}$
Back EMF constant (RMS voltage per phase) (Note)	K_e K_v	30 0.29	V/krpm $\text{V} \cdot \text{s}/\text{rad}$
Armature resistance (Note)	R_a	0.54	Ohm
Mechanical time constant (Note)	t_m	0.009	s
Thermal time constant	t_t	50	min
Static friction	T_f	3	$\text{kg} \cdot \text{cm}$
Max. allowable current	I_m	80	A
Max. torque	T_m	540	$\text{kg} \cdot \text{cm}$
Max. winding temperature rise	θ_m	125	$^{\circ} \text{C}$
Weight		14	kg

Note) 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, servo parameter setting, and input voltage. These values may be changed without prior notice.

MODEL 10 (A06B-0501-B□□□)

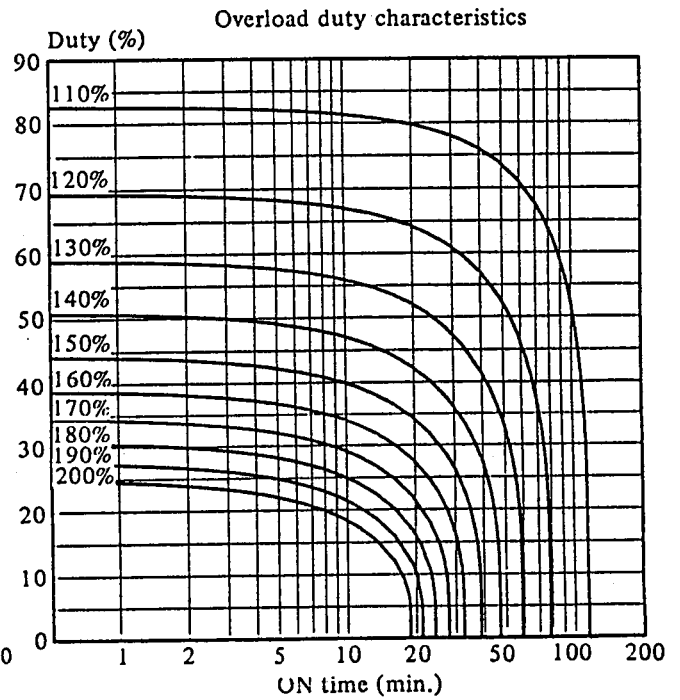
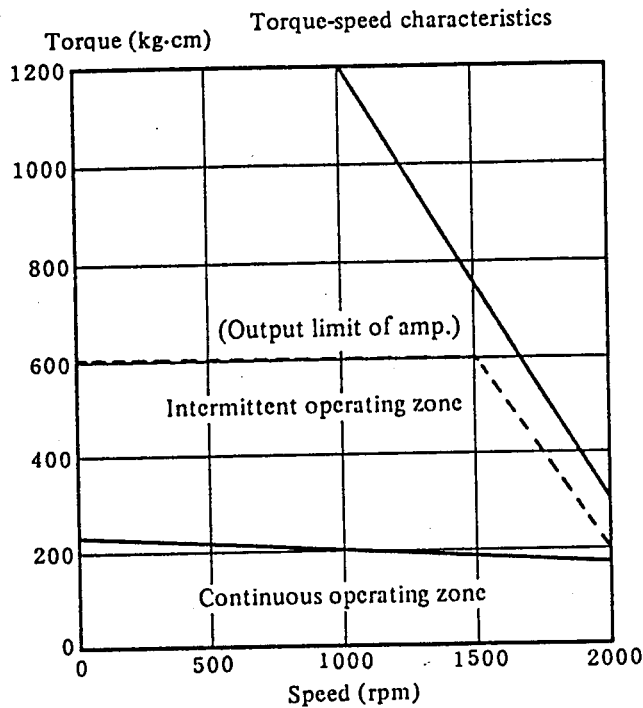


Data sheet

Parameters	Symbol	Value	Unit
Rotor inertia	J_m	0.10	$\text{kg} \cdot \text{cm} \cdot \text{s}^2$
Continuous RMS current at stall	I_s	11	Arms
Torque constant (Note)	K_t	11	$\text{kg} \cdot \text{cm}/\text{Arms}$
Rated torque at stall (Note)	T_s	120	$\text{kg} \cdot \text{cm}$
Back EMF constant (RMS voltage per phase) (Note)	K_e K_v	38 0.37	V/krpm $\text{V} \cdot \text{s}/\text{rad}$
Armature resistance (Note)	R_a	0.37	Ohm
Mechanical time constant (Note)	t_m	0.010	s
Thermal time constant	t_t	60	min
Static friction	T_f	8	$\text{kg} \cdot \text{cm}$
Max. allowable current	I_m	85	A
Max. torque	T_m	800	$\text{kg} \cdot \text{cm}$
Max. winding temperature rise	θ_m	125	$^{\circ}\text{C}$
Weight		23	kg

Note) 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, servo parameter setting, and input voltage. These values may be changed without prior notice.

MODEL 20 (A06B-0502-B□□□)

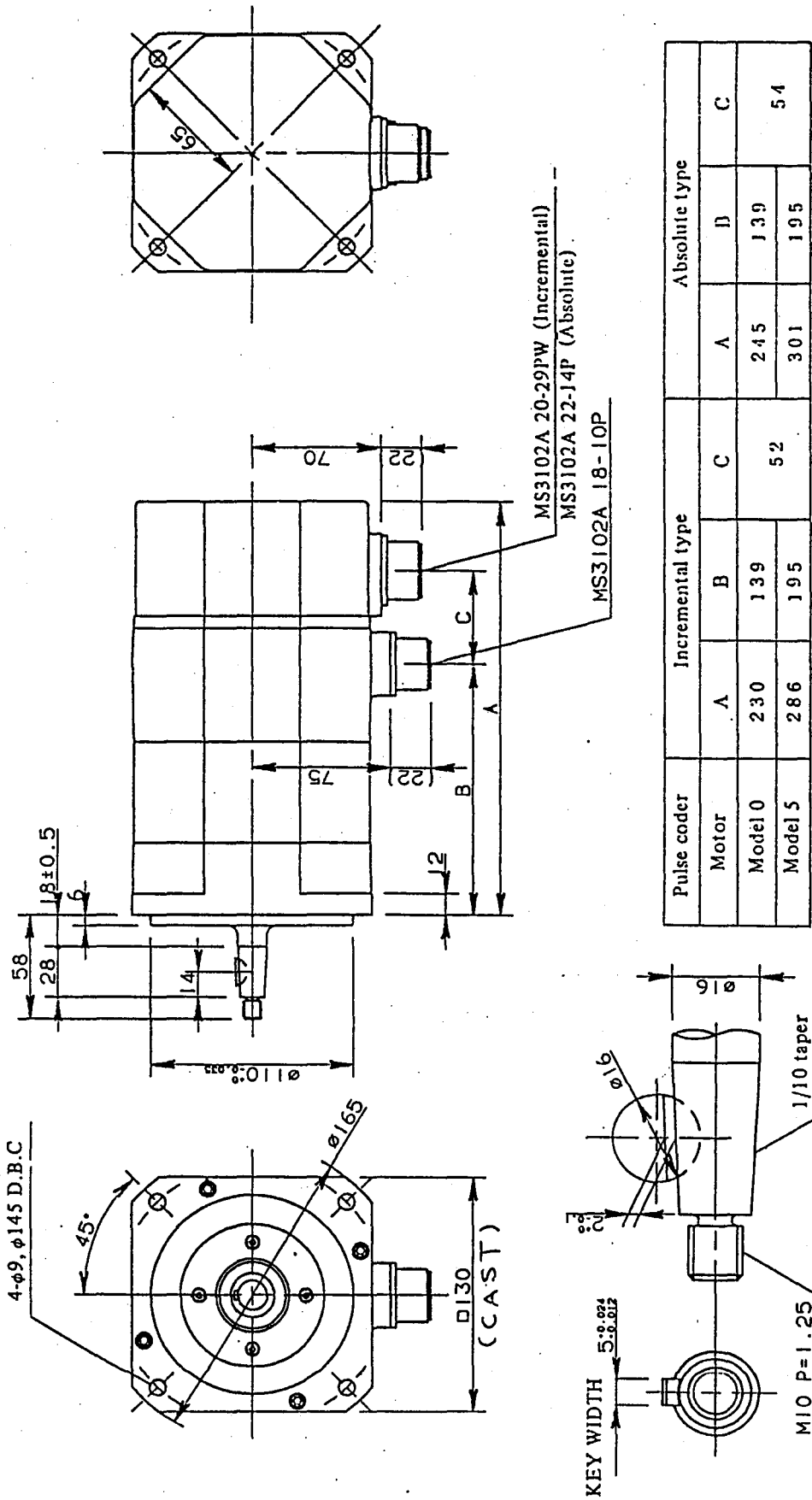


Data sheet

Parameters	Symbol	Value	Unit
Rotor inertia	J_m	0.17	$\text{kg} \cdot \text{cm} \cdot \text{s}^2$
Continuous RMS current at stall	I_s	19.7	Arms
Torque constant (Note)	K_t	11.7	$\text{kg} \cdot \text{cm}/\text{Arms}$
Rated torque at stall (Note)	T_s	230	$\text{kg} \cdot \text{cm}$
Back EMF constant (RMS voltage per phase) (Note)	K_e K_v	40 0.38	V/krpm $\text{V} \cdot \text{s}/\text{rad}$
Armature resistance (Note)	R_a	0.17	Ohm
Mechanical time constant (Note)	t_m	0.006	s
Thermal time constant	t_t	65	min
Static friction	T_f	12	$\text{kg} \cdot \text{cm}$
Max. allowable current	I_m	170	A
Max. torque	T_m	1500	$\text{kg} \cdot \text{cm}$
Max. winding temperature rise	θ_m	125	$^{\circ} \text{C}$
Weight		34	kg

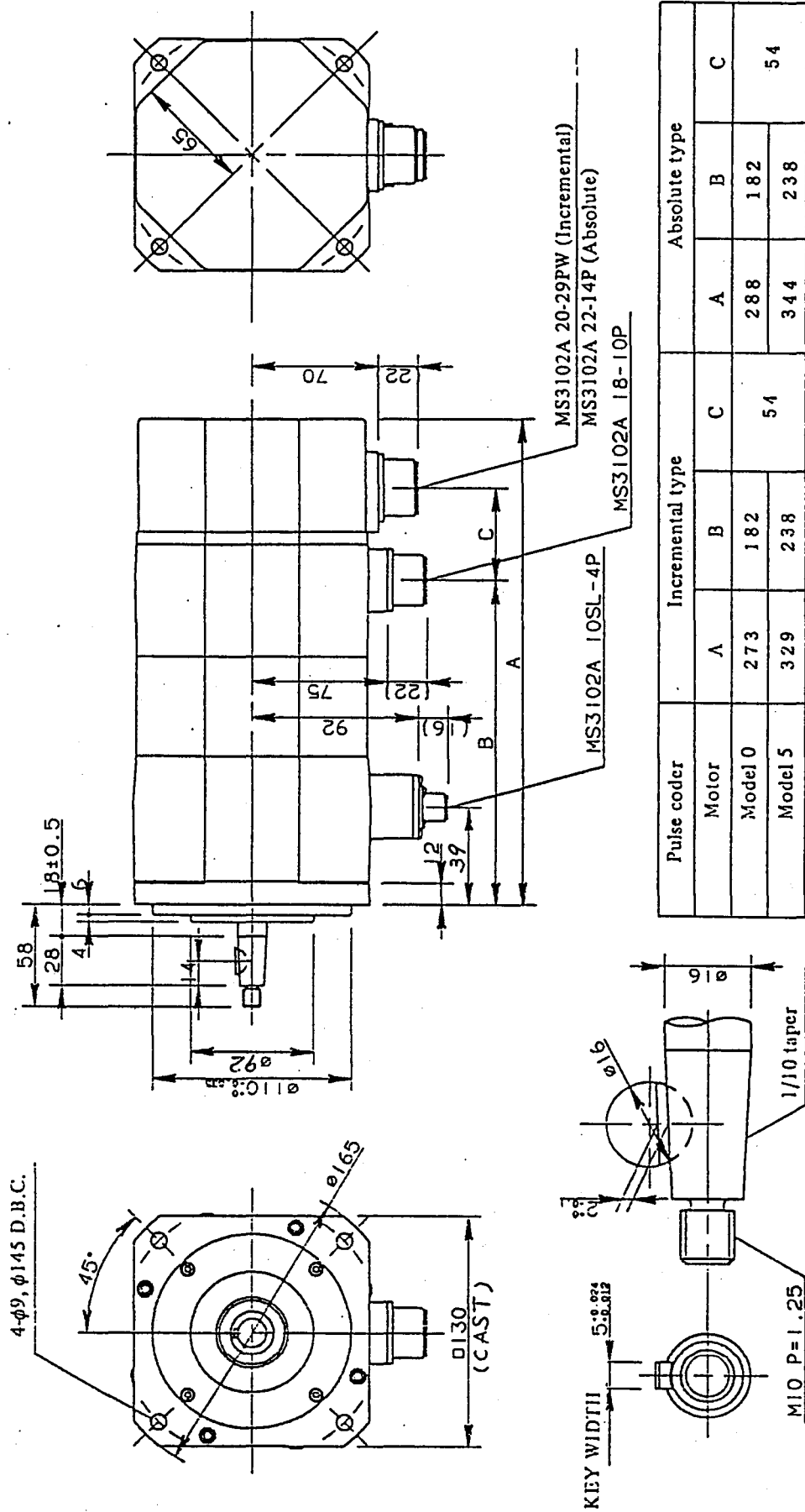
Note) The values are the standard values at 20° C and the tolerance is ±10%. The speed-torque characteristics vary depending on the type of software, servo parameter setting, and input voltage. These values may be changed without prior notice.

8.3 External Dimensions



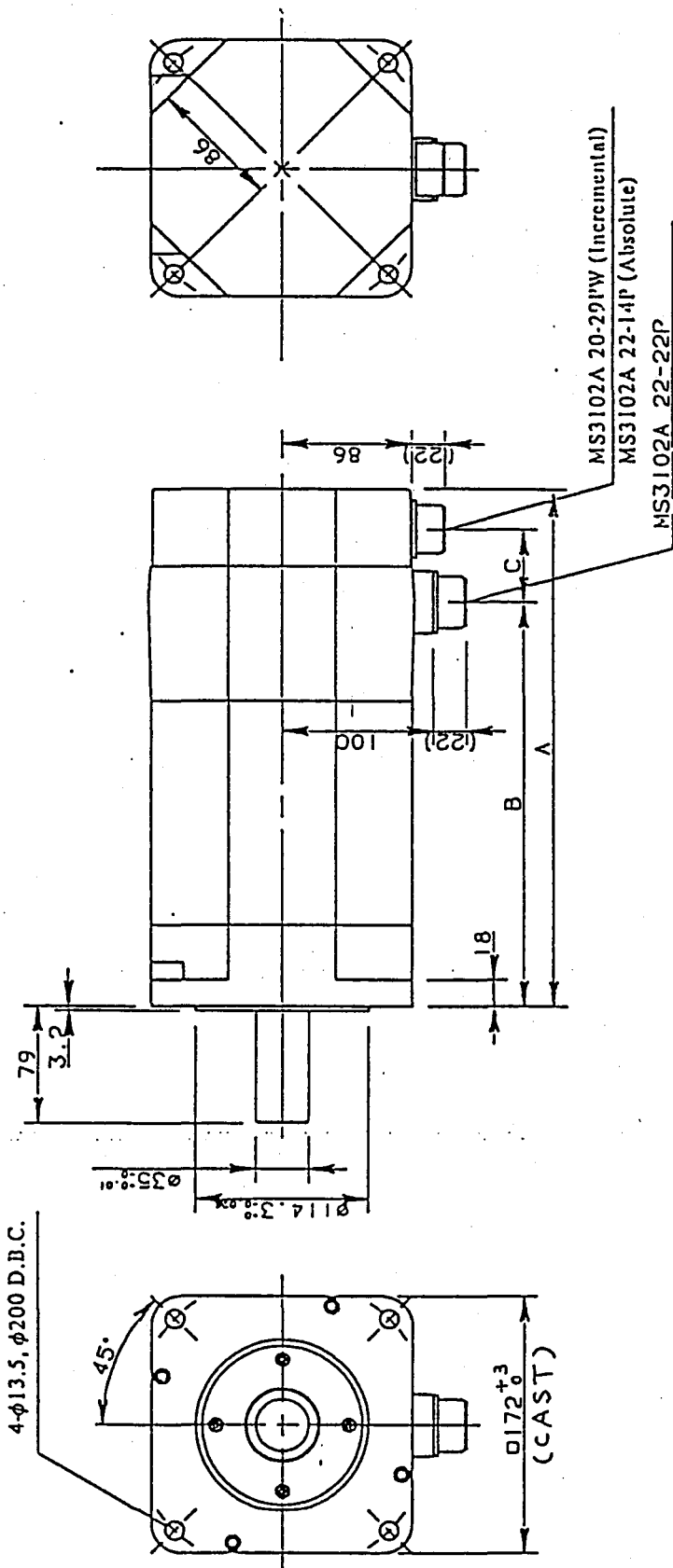
Note: Shaft dia. runout Max. 0.02mm
 Rabbet dia. eccentricity Max. 0.04mm
 Mounting face runout Max. 0.06mm
 Rated loads Radial 70 kg

Fig. 1.1 Outline drawing of FANUC AC Servo Motor model 0 and 5



Note: Shaft dia. runout Max. 0.02mm
 Rabbet dia. eccentricity Max. 0.04mm
 Mounting face runout Max. 0.06mm
 Rated loads Radial 70 kg

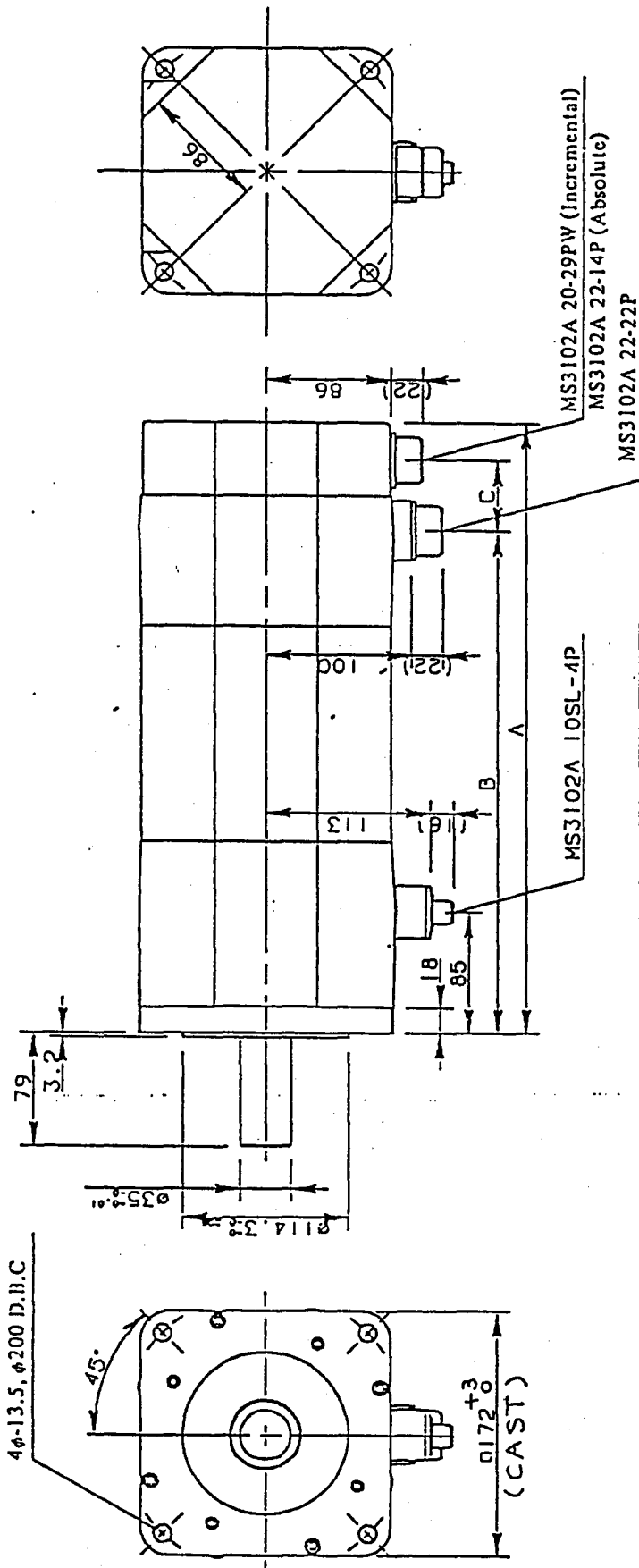
Fig.1.2 Outline drawing of FANUC AC Servo Motor model 0 and 5 with Brake



Pulse coder	Incremental type			Absolute type		
	A	B	C	A	B	C
Motor						
Model 10	271	196	49	286	196	54
Model 20	346	271		361	271	

Note: Shaft dia. runout Max. 0.05mm
 Rabbet dia. eccentricity Max. 0.07mm
 Mounting face runout Max. 0.1mm
 Rated loads Radial 450 kg

Fig. 1.3 Outline drawing of FANUC AC Servo Motor model 10 and 20



Pulse coder	Incremental type			Absolute type		
	A	B	C	A	B	C
Motor						
Model 10	350	275	49	365	275	54
Model 20	425	350		440	350	

Note: Shaft dia. runout Max. 0.05mm
 Rabbet dia. eccentricity Max. 0.07mm
 Mounting face runout Max. 0.1mm
 Rated loads Radial 450 kg

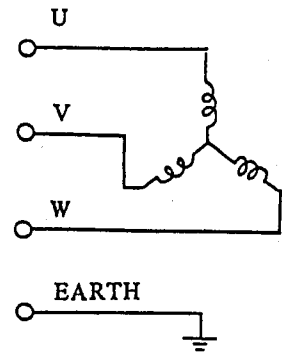
Fig.1.4 Outline drawing of FANUC AC Servo Motor model 10 and 20 with Brake

8.4 Connection of Power Line

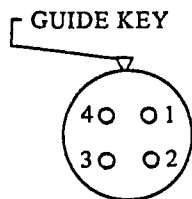
a) Model 5-0 and Models 4-0S, 3-0S with incremental pulse coder

Lead wire color

U	_____	RED	} or labels of U, V and W
V	_____	WHITE	
W	_____	BLACK	
EARTH	_____	Connect with motor Body	

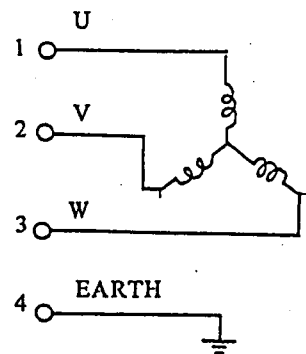


b) Models 2-0S, 1-0S and Model 4-0S, 3-0S with absolute pulse coder

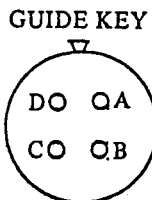


RM12BRB-4P (HIROSE) (4-0S, 3-0S)

RT15WTR-4P (HIROSE) (2-0S, 1-0S)

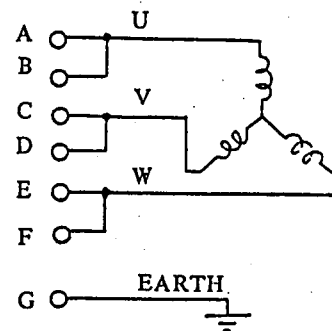


c) Models 0S, 5S, 10S, 20S/1500, 20S and 30S



MS3102A18-10P (0S, 5S)

MS3102A22-22P (10S, 20S/1500, 20S, 30S)



II. FANUC AC SERVO AMPLIFIER

1. GENERAL

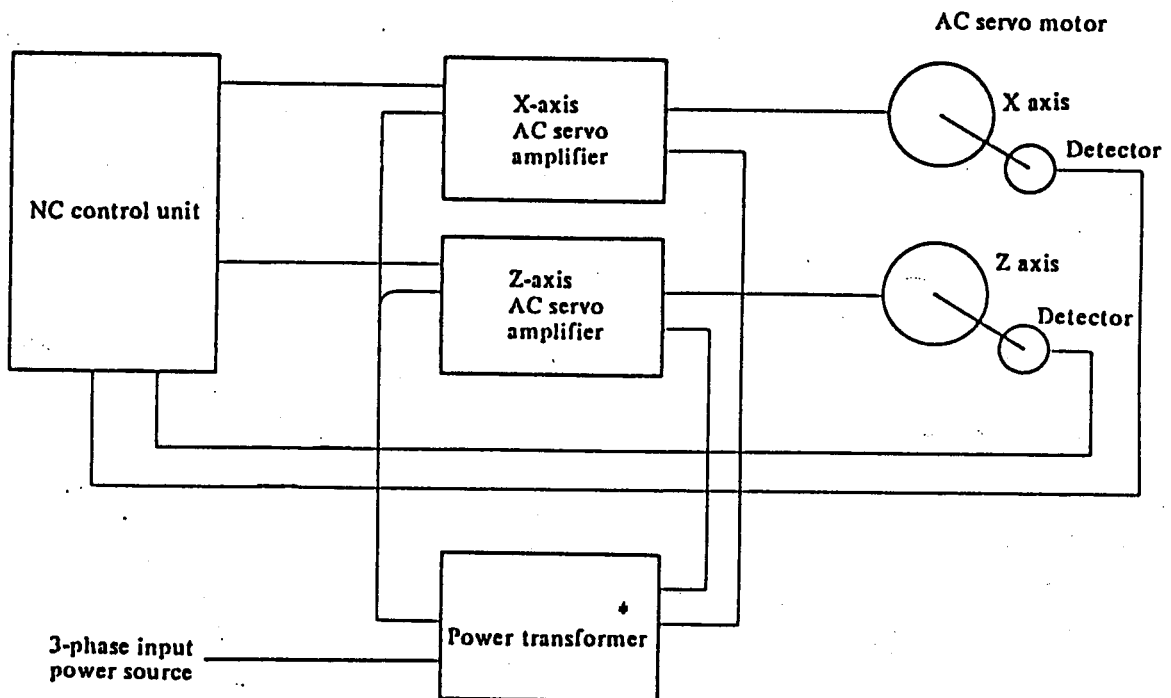
The AC servo amplifier has been specially designed and developed for high speed positioning driving the AC servo motor. The features are as follows.

- 1) Transistor PWM system assures smooth drive and excellent response.
- 2) Excellent acceleration/deceleration characteristic is obtained by adequate maximum control current.
- 3) Exclusive custom IC and the latest power module technique have realized high reliability with reduced number of parts.
- 4) The machine tools and AC servo motors are fully protected with fault detection of trip of no-fuse breaker, overcurrent alarm, abnormal velocity feedback, unusual high voltage, unusual circuit operation, etc.
- 5) The rectifier power circuit, dynamic brake circuit, regenerative discharge circuit (Note 1), and no-fuse breaker are assembled with the PWM amplifier circuit to realize a compact one-side maintenance structure featuring easy installation and maintenance.

Note 1) For applications having large regenerative discharge energy, separate regenerative discharge unit must be used. For details refer to section 4.3.

2. CONFIGURATION

Fig. 2 shows are example of the configuration of the AC servo amplifier in a 2-axis control NC system.



* This figure indicates an example when two axes employ one power transformer in common.

Fig. 2 Example of configuration

2.1 Types of Units and Specifications

Table 2.1(a) Types of units and specifications

Name	Applicable motor		Specifications
Servo amplifier	Model 0 , 5		A06B-6057-H004
	Model 10		A06B-6057-H005
	Model 20		A06B-6057-H006
Power transformer	Common to 200 - 550V	Transformer AAE (1.5 kVA)	A80L-0001-0453
		Transformer ABE (3.5 kVA)	A80L-0001-0454
		Transformer ACE (5 kVA)	A80L-0001-0455
Separate type regenerative discharge unit	Optional for motors 10, 20 (Note 1)		A06B-6050-H050
Input connector (Note 2)	Soldering type		A06B-6057-K100
	Crimp type		A06B-6057-K103
Spare part A	Fuse for PCB		A06B-6057-K101

Note 1) This unit is used when the regenerated energy is 100 to 400 W for A06B-6057-H005, H006.

Note 2) The input connector is used for the signal cable from CNC connection connected to the velocity control unit, and it comprises the following parts.

One set of the input connector is required for each axis.

Table 2.1(b) shows parts included input connector (soldering type).
 Table 2.1(c) shows parts included input connector (crimp type).

Table 2.1(b). Parts Included Input connector (soldering type)

Name	Qty	Use	Model	Specifications
Connector and cover	1	CN1	MR-20LFH *	A63L-0001-0134/02
Housing	1	CN2	SMS6PW-5 **	A63L-0001-0202/6W
Pin	5	CN2	RC16M-SCT3**	A63L-0001-0226

* Manufacturer: HONDA Tsushin Co., Ltd.

** Manufacturer: Nihon Burndy Co., Ltd.

Table 2.1(c) Parts Included input connector (crimp type)

Name	Qty	Use	Model	Specifications
Connector and cover	1	CN1	MR-20L, MRP-20F01 *	A63L-0001-0134/22
Contact	20	CN1	MRP-F112 *	A63L-0001-0135/F112
Housing	1	CN2	SMS6PW-5 **	A63L-0001-0202/6W
Pin	5	CN2	RC16M-S23A **	A63L-0001-0127/S23A

* Manufacturer: HONDA Tsushin Co., Ltd.

** Manufacturer: Nihon Burndy Co., Ltd.

3. SPECIFICATIONS

3.1 Specifications

Table 3.1 Specifications

Item		Specifications	
Applicable motor model		0, 5, 10	20
Rated output current (peak value) (Note 1)		15 A	30 A
Input power supply	Transformer input	Common to all use	3-phase 200/220/230/240/380/415/460/480/550 VAC
		Allowable voltage fluctuation	+10%, -15%
		Allowable frequency	+2 Hz
	100 VAC	50 Hz \pm 2 Hz, 100 VAC +10/-15%, 60 Hz \pm 2 Hz, 100 to 110 VAC +10/-15%	
Main circuit system		Transistor bridge	
Control system		Sine wave PWM control	
Current limit value (Note 2)		40 A	80 A
Alarm, protective function		<ul style="list-style-type: none"> . Circuit breaker . Overvoltage . Low voltage . Over regeneration . Circuit abnormality detection 	
Ambient temperature range		0°C to +55°C	

Note 1) The rated output is guaranteed at rated input voltage. If the input voltage fluctuates, the rated current is not always guaranteed, even if the input voltage fluctuation is within the allowable fluctuation range.

Note 2) The current limit value is the preset standard value. The deviation of the operating value due to the circuit constants is about +10%.

3.2 Protection and Error Detection Function

There are protection and error detection functions in AC servo amplifier.

Table 3.2 Protection and error detection function

No.	Item	Display	Content
1	Circuit breaker	The lever of the circuit breaker turns off	If abnormal current exceeding the circuit breaker operating current flows, the circuit breaker operates, and the motor comes to a dynamic brake stop.
2	Alarm of overvoltage	LED HV lights	If DC voltage of main circuit power supply is abnormally high, an overvoltage alarm is produced, and HV lamp lights up, then the motor comes to a dynamic brake stop.
3	Low voltage alarm	LED LV lights	If the control supply voltage is abnormally low, LV lamp lights up, and the motor comes to a dynamic brake stop.
4	Overheat	LED OH lights	If the contact point connected to the thermostat with the amplifier or terminal plate CN2 is open, OH lamp lights up, and the motor comes to a dynamic brake stop.
5	Over regeneration	LED DC lights	If the regenerative discharge time is abnormally long, DC lamp lights up, and the motor comes to a dynamic brake stop. If the acceleration/deceleration frequency is too high, this occurs, for example, when the regenerative discharge circuit fails.
6	Circuit abnormality detection alarm	LED HC Lights	If an abnormally large current flows into the main circuit, HC lamp lights up, and the motor comes to a dynamic brake stop.

In addition to the above, the unit detects the following abnormalities at the digital servo controller side and displays those abnormalities on the display unit of NC device, thus allowing an alarm stop. (The following relate only to the velocity control system.)

- 1) Motor over load : Action of thermostat of motor
- 2) Feedback disconnection alarm : Abnormality of feedback signal
- 3) Over current alarm (OVC alarm): Excessive motor current

4. POWER TRANSFORMER AND SEPARATE TYPE REGENERATIVE DISCHARGE UNIT

The power transformer should be selected according to the models and load conditions of the AC servo motors employed. The power transformer is provided with secondary output terminals so that 2 axes or 3 axes can share each power transformer within the continuous output rating. For connections, refer to section 9.

4.1 Number of Axes and Power Transformer

No. of axes	No. of power transformers
2 axes	1 - 2 units
3 axes	1 - 3 units
4 axes	2 - 4 units

4.2 Motors and Power Transformer

1st axis	2nd axis	3rd axis	Power transformer	Remarks
Model 4-0,3-0,2-0	Model 4-0,3-0,2-0	Model 4-0,3-0,2-0	Transformer AAE (1.5kVA)	Model 4-0, 3-0 (2000rpm max.) 2-0, 1-0 and 0 employ transformer output terminals 34, 35, 36 while Model 3-0 (3000rpm max.) and Model 5 employ transformer output terminals 31, 32, 33.
Model 4-0,3-0,2-0	Model 4-0,3-0,2-0	Model 5		
Model 4-0,3-0,2-0, 1-0	Model 1-0,0			
Model 4-0,3-0,2-0, 1-0,0	Model 5			
Model 5	Model 5	Model 5	Transformer ABE (3.5kVA)	
Model 5, 10	Model 10			
Model 20M,20,30				
Model 5	Model 5	Model 10	Transformer ACE (5kVA)	See Note.
Model 5	Model 20M,20,30			
Model 30R				

Note: Two or more transformers ACE become necessary according to the load conditions in case of Model 10, 20, 30 x 3 axes. For details, contact FANUC LTD., referring to AC servo motor selection data sheet.

Select the transformer according to the motor used, load condition, usage condition, etc. Refer to the servo motor selection data sheet described in section I-3.6 and section III-3.

4.3 Separate Type Discharge Unit

When the energy being regenerated from motor is large, separate discharge unit is required.

4.3.1 Horizontal move axis

The regenerative discharge unit is required when a motor is used continuously at P equals 100 to 400.

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

In the equation (1),

F : Rapid traverse acceleration/deceleration frequency (sec/time)
(Note: When not designated specially, the frequency is approx. 5 sec/time.)

$$J = J_m + J_L$$

J_m: Rotor inertia of motor (kg·cm·sec²)
J_L: Motor axis conversion inertia of load (kg·cm·sec²)
V_m: Number of motor revolutions at rapid traverse (rpm)
t_a: Rapid traverse acceleration/deceleration time (sec)
T_L: Machine friction torque (Motor-axis conversion) (kg·cm)

4.3.2 Vertical move axis

The regenerative discharge unit is required when a motor is used continuously at R equals 100 to 400.

$$R = P + Q$$

P : Given in equation (1)

$$Q = 1.026 \times 10^{-2} T_h V_m \times \frac{D}{100} \dots \dots \dots (2)$$

In the equation (2),

T_h: Torque which is supported upward by motor at lowering in rapid traverse (kg·cm)
V_m: Number of motor revolutions at rapid traverse (rpm)
D : Operation duty of rapid traverse lowering direction (%)
(Note: $D \leq 50$)

Note) If value P of equation (1) or value Q of equation (2) exceeds 400 (W), contact FANUC.

5. POWER SOURCE

5.1 Input Power Source

The AC servo amplifier employs a 3-phase power source for main circuit and a single-phase 100 V power source for coils of the dynamic brake electromagnetic contactor

5.1.1 Three-phase power source

a) Primary side tap voltage of power transformer

Power transformer	No. of phases	Voltage	Frequency
For all the countries	3 phases	200, 220, 230, 240, 380, 415, 460, 480, 550 VAC +10%, -15%	50/60 Hz \pm 2 Hz

Input voltage	415 V	440 V	480 V
Transformer primary voltage setting	420 V	420 V	460 V

b) Power transformer and fuses on primary side

Power voltage	Fuse type		Utsunomiya Electric Co., Ltd. PC type (A)	Fuji Electric Co., Ltd. FCF type (A)
	Transformer capacity (kVA)			
200 V to 220 V	1.5		15	20
	3.5		30	30
	5		30	30
	10		40	40
	15		50	50
380 V to 440 V	1.5		10	10
	2.5		10	15
	5		15	15
	10		25	30
	15		30	30

Power voltage	Fuse type	
	Transformer capacity (kVA)	Utsunomiya Electric Co., Ltd. JG type (A)
480 V to 550 V	1.5	10
	2.5	10
	5	15
	10	20
	15	25

5.1.2 Single-phase 100 VAC power source

Nominal voltage	100 VAC	
No. of phases	Single-phase	
Frequency	50 Hz \pm 2 Hz	60 Hz \pm 2 Hz
Voltage	100 VAC +10%, -15%	100 - 110 VAC +10%, -15%
Capacity	0 to 20	20 VA: Continuous 90 VA: At turning on the contactor

5.2 Capacity of Three-phase Power Source

The capacity of the power source should be as specified in table below as the continuous rated output of motor. When the AC servo motor is rapidly accelerated, power of about twice the continuous rated value may be needed momentarily. Accordingly, use the power source suitable for acceleration.

Motor	Power capacity per motor
0	1 kVA
5	1.5 kVA
10	3 kVA
20	5 kVA

Calculation method of power source capacity

The power capacity for using two or more motors can be obtained by adding the power capacity per motor, respectively.

6. HEAT LOSS

Motor model	Maximum power dissipation of servo amplifier	Maximum power dissipation of power transformer
0	90 W	60 W
5	90 W	80 W
10	150 W	100 W
20	250 W	150 W

For thermal design of cabinets which accommodate the servo amplifier and servo transformer, it may be a general rule that the power dissipation quantity is about 50% of the maximum power dissipation value taking the servo motor load into consideration.

7. INSTALLATION CONDITION AND NOTES

7.1 Installation Condition

Ambient temperature: 0°C - +55°C

Humidity : 95% RH or less (no dew condensation)

Vibration : 0.5 G or less

Atmosphere: The unit should not be exposed directly to the splash of cutting oil, lubricant or cutting chips.

7.2 Cautions on Installation and Housing

The servo amplifier is designed to be mounted in a cabinet. Be careful with the following items when designing the cabinet.

7.2.1 Housed in closed type cabinet

In the closed type cabinet, the internal air temperature generally increases. Circulate the internal air so that the ambient temperature of these unit becomes even. The air speed should be about 1 to 2 m/sec. Do not blow the fan or blower air directly on these units, otherwise dust may cling to the surfaces of these units and trouble may result.

7.2.2 Housed in open air ventilation type cabinet

- 1) Use an air filter at the open air inlet.
- 2) Do not blow the fan or blower air directly on these units, otherwise dust may cling to the surfaces of these units, and trouble may result.
- 3) Ingress of mist of the cutting oil or dust from the air inlet, if any, may cause trouble. Be careful with the air flow at outlet side so it is not blocked.
- 4) Securely seal the cable entrance, door, and other openings.

7.2.3 Mounting position and other cautions

- 1) Mount the units so they are easy to check, remove, and mount during maintenance.
- 2) Keep a space of more than 50 mm above and below the velocity control unit, so that the air for the heat sink smoothly flows to the upper side and wiring can be done to the terminal boards on the lower side.

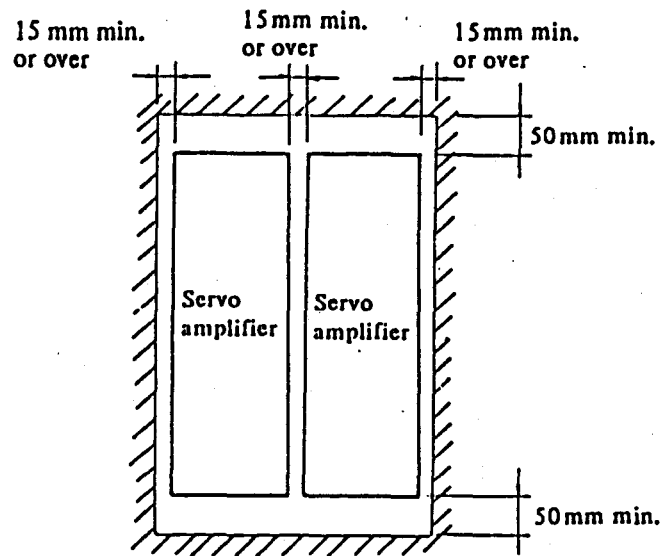
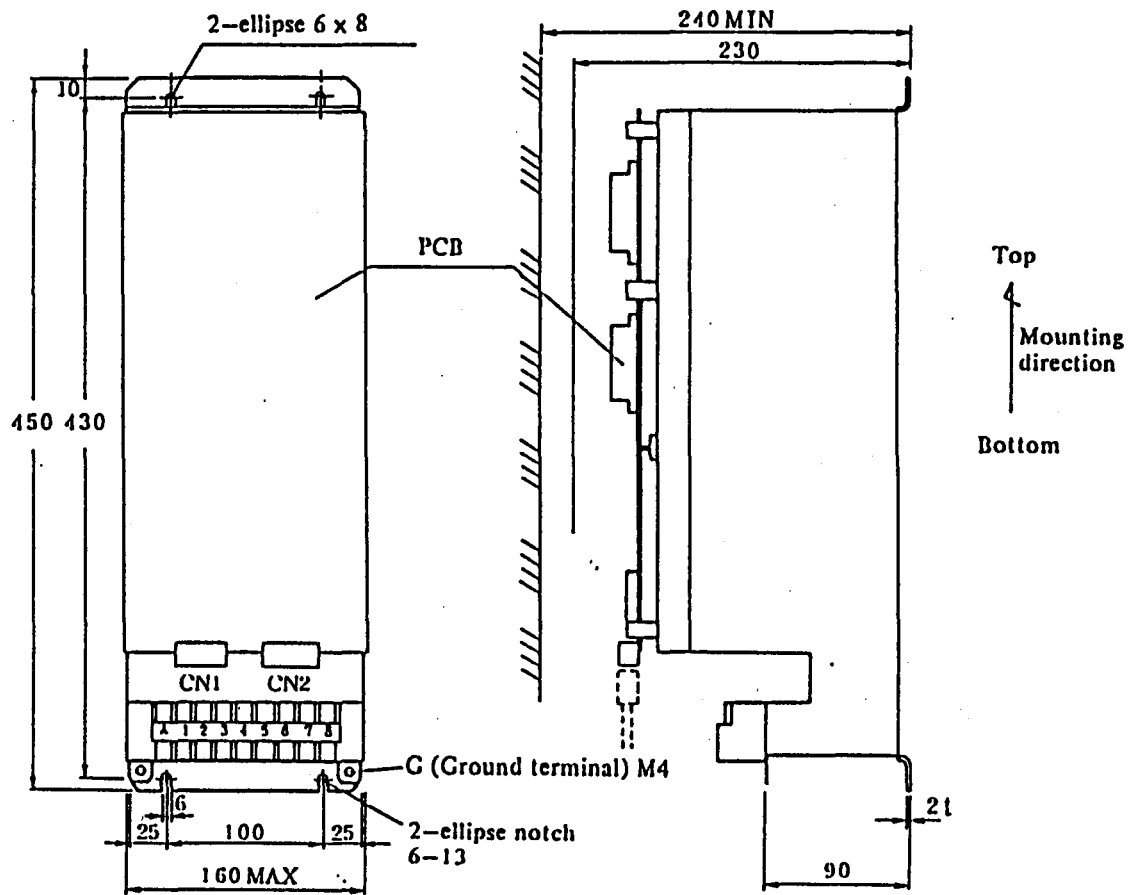


Fig. 7.2.3 Mounting space of servo amplifier

- 3) Precaution should be taken to separate of cables for power line and signal line, ground frame of the servo amplifier and transformer, and a protect against noises.

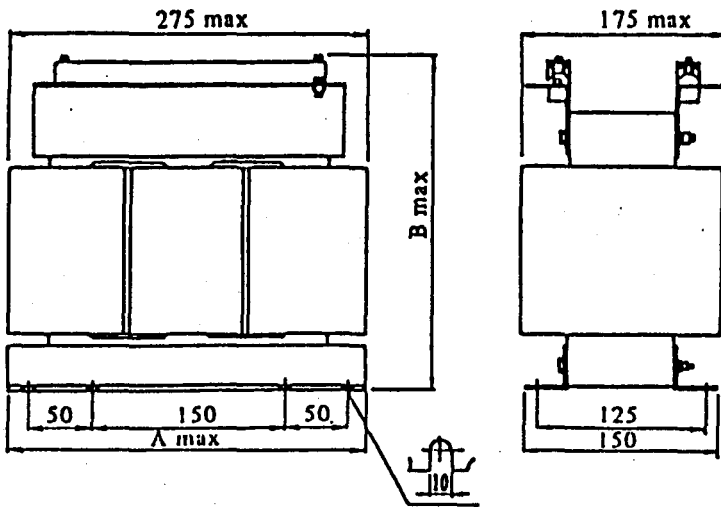
8. EXTERNAL DIMENSIONS

- 1) External dimensions of servo amplifier A06B-6057-H004, H005, H006 for models 0 to 20



Weight: About 10kg

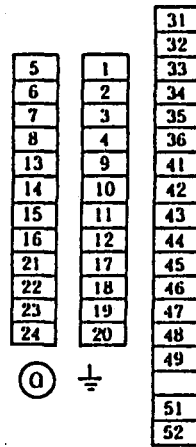
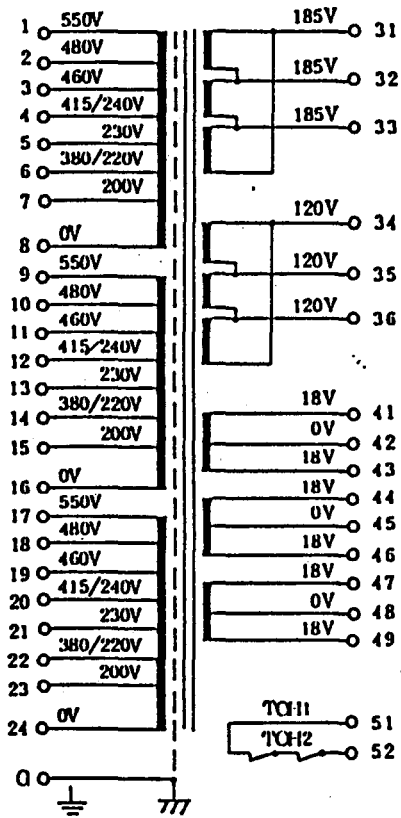
2) Power transformer



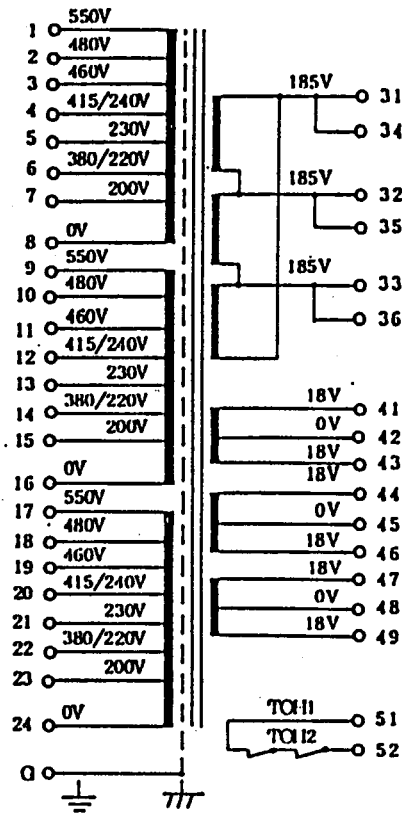
Power transformer	Weight	A	B
AAE	About 20 kg	280	265
ABE	About 30 kg		
ACE	About 36 kg		

Connection diagram of power transformer AAE

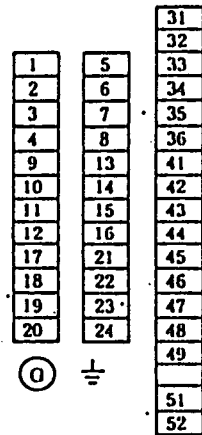
Terminal layout of power transformer AAE



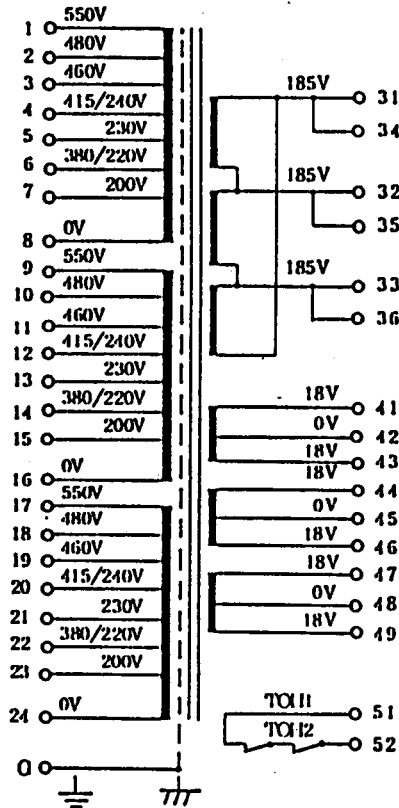
Connection diagram of power transformer ABE



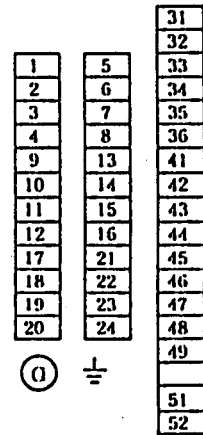
Terminal layout of power transformer ABE



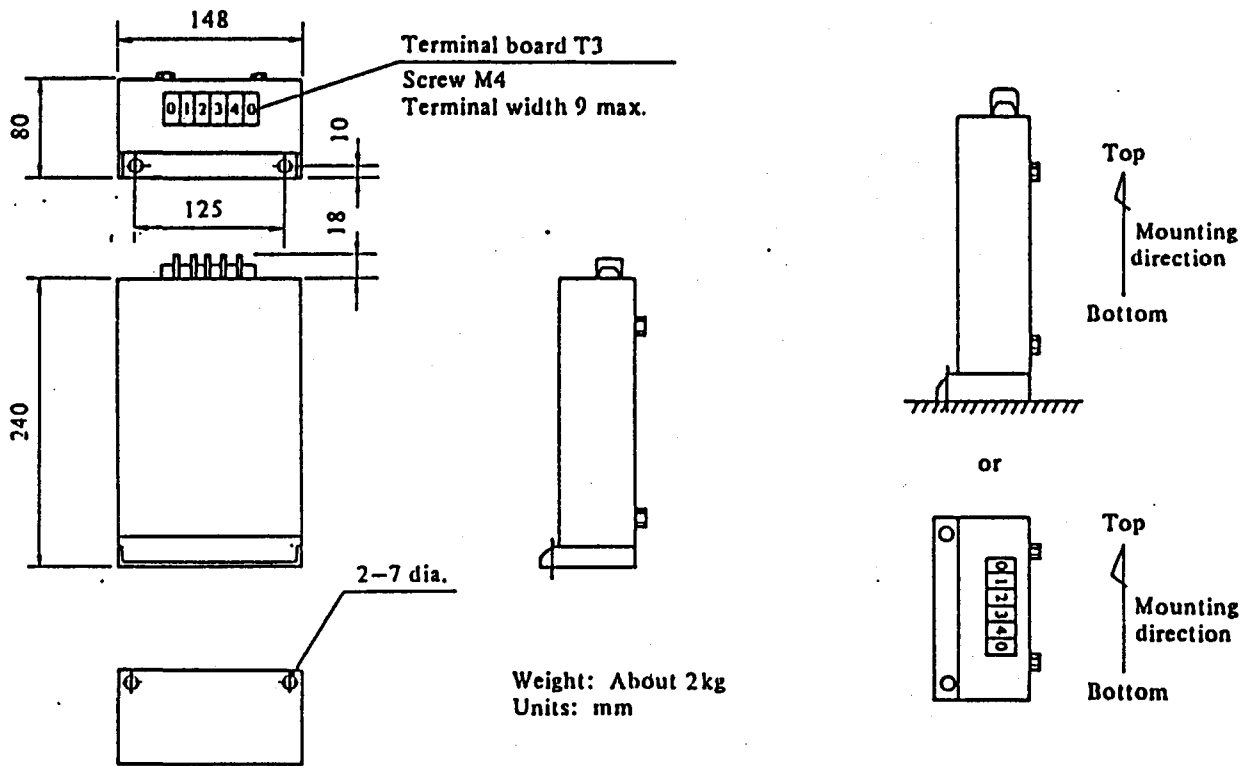
Power transformer ACE connection



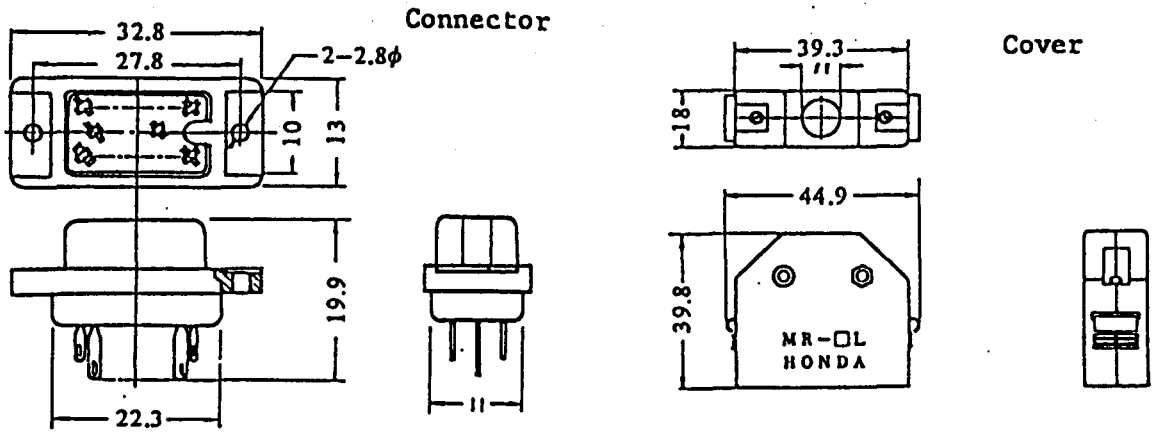
Terminal of power transformer ACE



3) Separate type regenerative discharge unit
 a) Regenerative discharge unit A06B-6050-H050 (A06B-6050-C050)

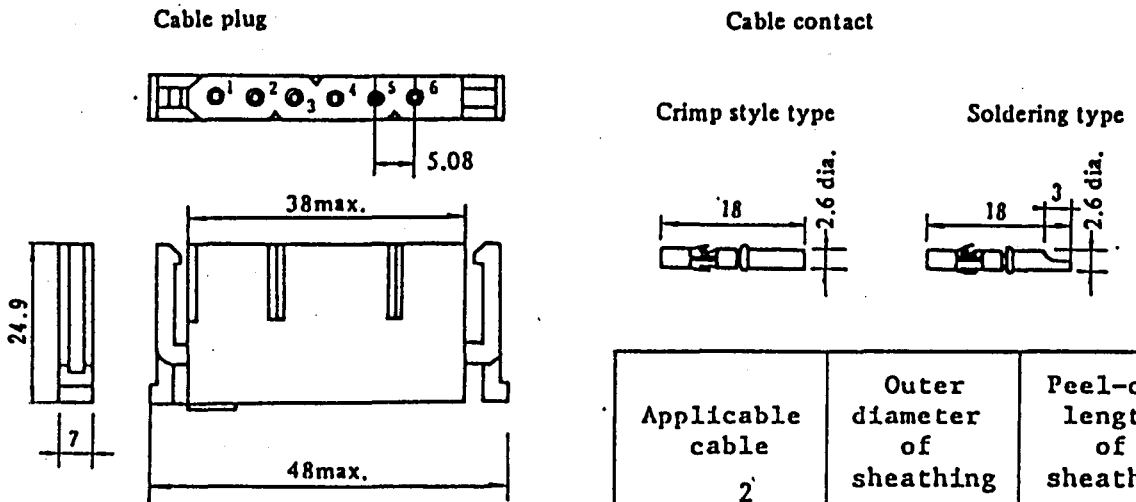


4) Input connector
a) Connector CN1



Name	Specifications (Connector maker's model)	Name of maker	No. of connectors employed per axis	Applicable cable mm ²	Remarks
Connector (with cover)	MR-20LFH	Honda Tsushin Kogyo Co.	1	0.18 - 0.3	CN1

b) Connector CN2

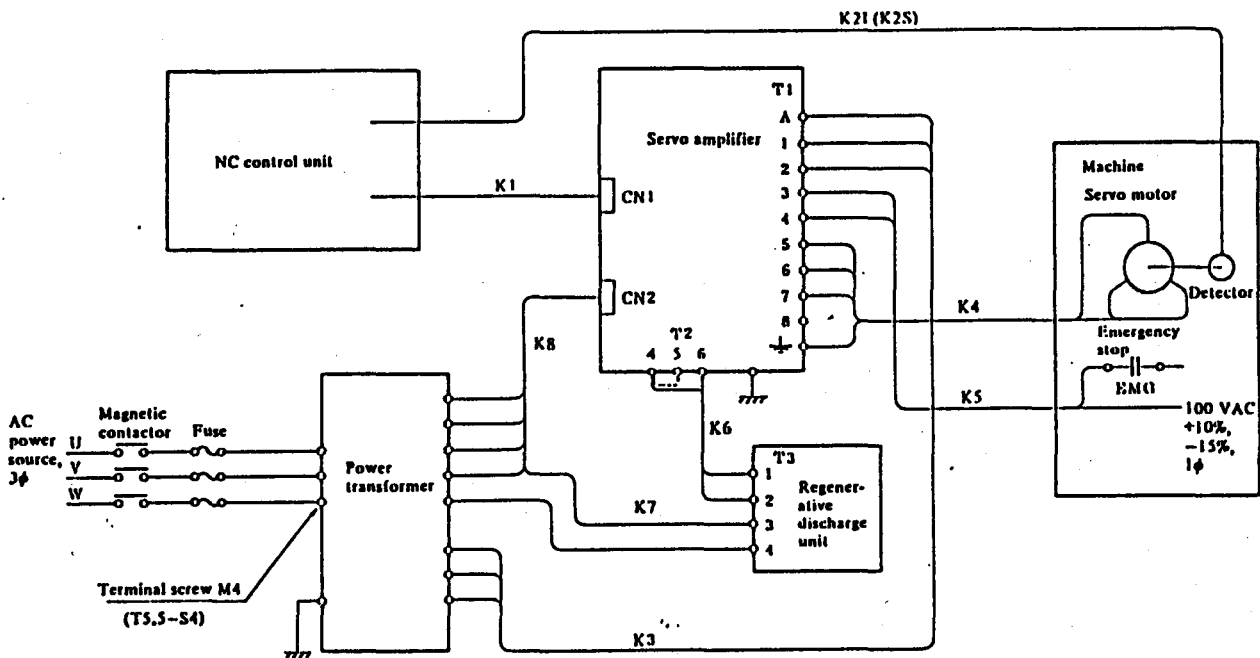


Applicable cable mm ²	Outer diameter of sheathing mm	Peel-off length of sheathing mm
0.75 (30/0.18)	2.80 max	7.2

Name		Specifications (Connector maker's model)	Name of maker	No. of connectors employed per axis	Remarks
Cable plug		SMS6PW-5	Nihon Burndy Co.	1	For crimping tool, etc., contact the connector maker.
Contact	Crimp style type	RC16M-23		5	
	Soldering type	RC16M-SCT3			

9. CONNECTION

9.1 Connection Diagram



Note 1) For cable connection details, refer to Appendix 1 and 2.

Note 2) When using the separate type regenerative discharge unit for models 10 and 20 remove the jumper between terminals of T2(4) and T2(5).

9.2 Power Transformer Connections

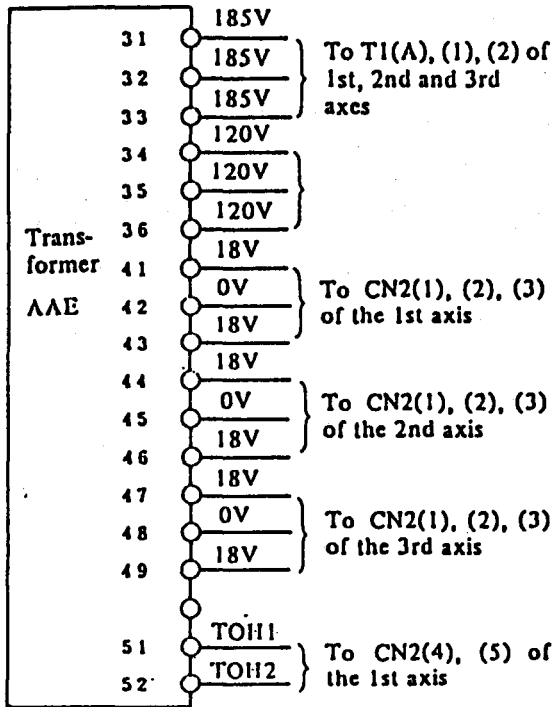
a) Primary connections

For the connecting positions of power cable U, V, W and connection between terminals, refer to Tables 9.2(a) or (b) according to the input voltage.

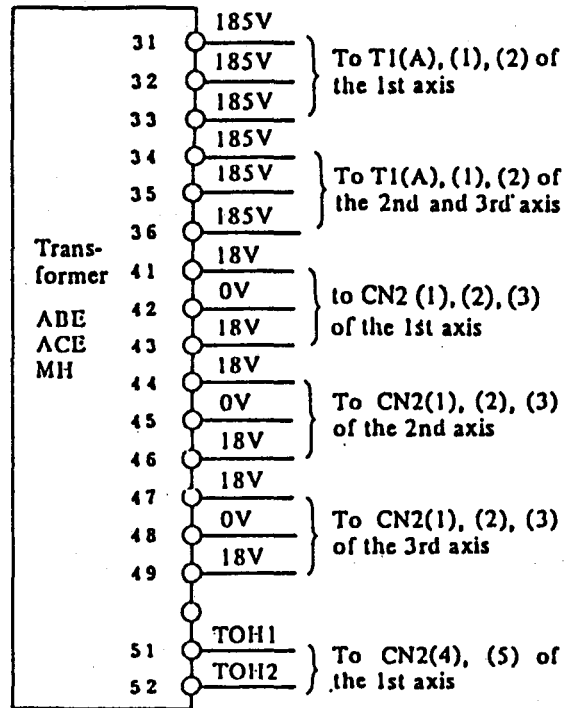
Table 9.2(a) Power transformers AAE, ABE, ACE (Common to all use)

Power voltage	Connection of transformer primary terminal		Connection type
	Connection of power cable U, V, W	Jumper between transformer terminals	
200 V	U-7, V-15, W-23	8-15, 16-23, 24-7	Delta connection
220 V	U-6, V-14, W-22	8-14, 16-22, 24-6	
230 V	U-5, V-13, W-21	8-13, 16-21, 24-5	
240 V	U-4, V-12, W-20	8-12, 16-20, 24-4	
Delta connection			
380 V	U-6, V-14, W-22	8-16, 16-24 or (8-16-24)	Star connection
415 V	U-4, V-12, W-20		
460 V	U-3, V-11, W-19		
480 V	U-2, V-10, W-18		
550 V	U-1, V- 9, W-17		
Star connection			

b) Secondary connections
For power transformers, AAE



For power transformers ABE, ACE, MH



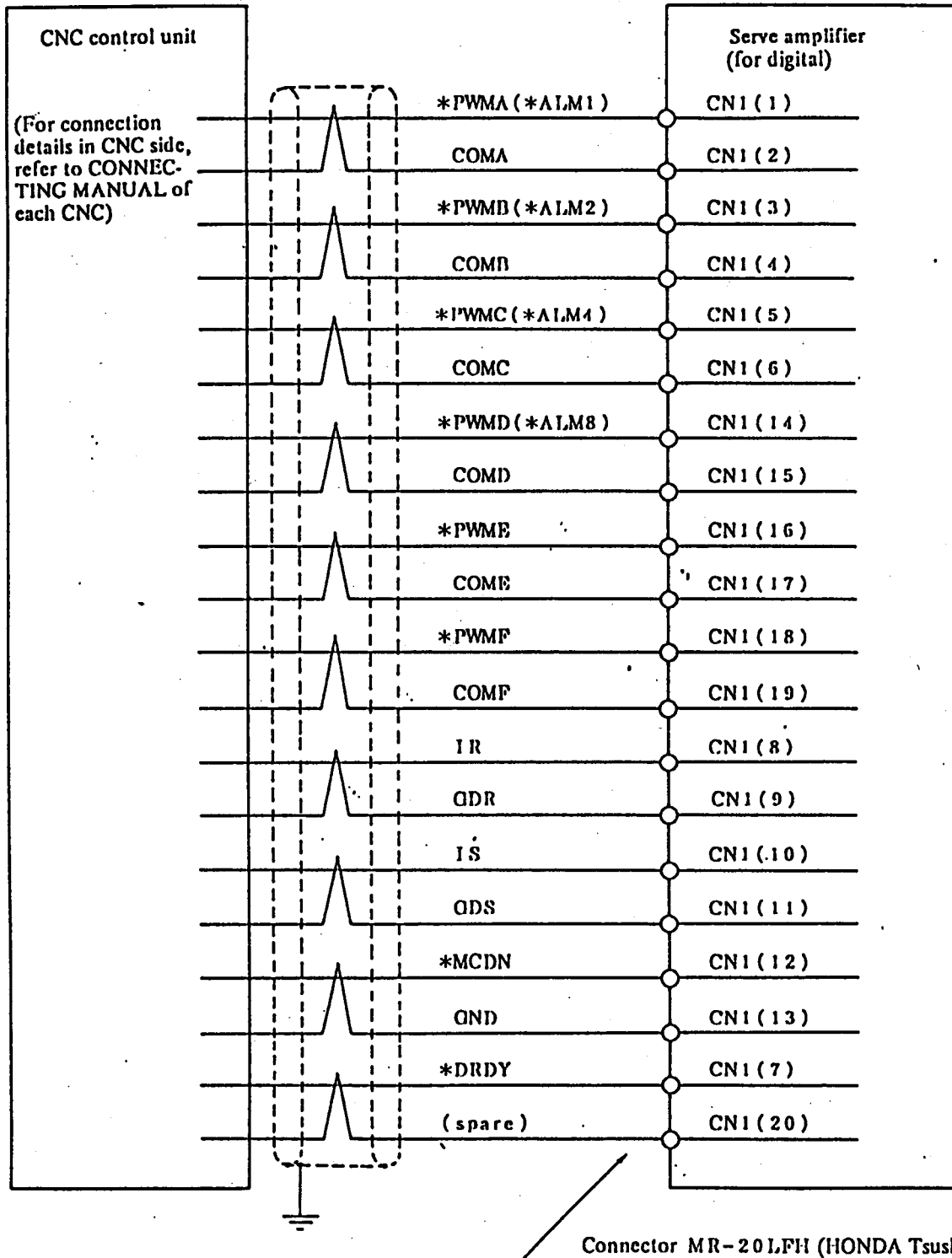
APPENDIX

A'

2

APPENDIX 1 CONNECTION DETAILS OF CABLE

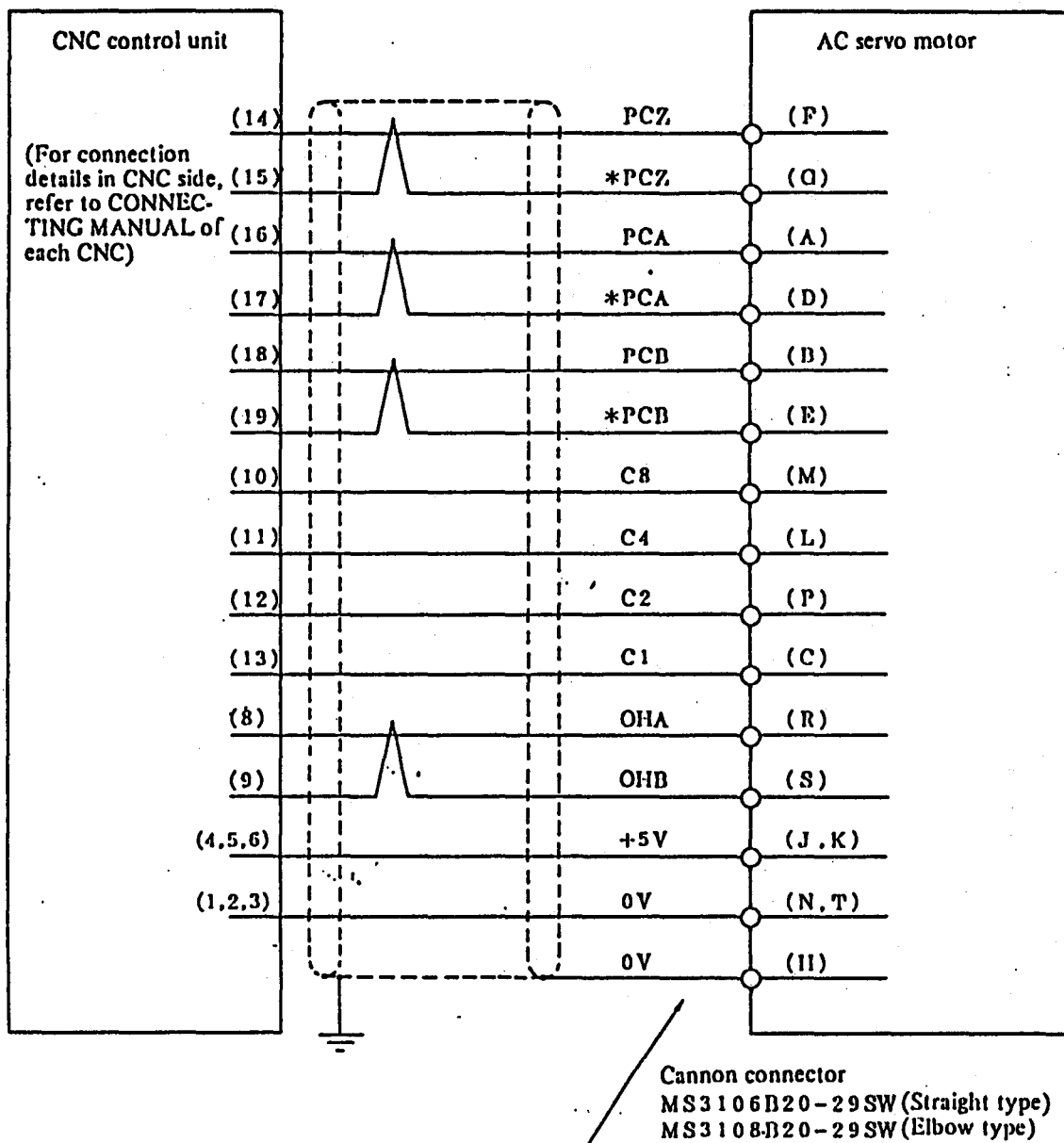
1. CABLE K1 (AMPLIFIER COMMAND SIGNAL LINE)



Wire material : 0.2mm² twisted pair totally shielded cable (10 pairs)

2. CABLE K2 (MOTOR FEEDBACK SIGNAL LINE)

2.1 Cable K2I (incremental standard pulse coder)



Wire material : +5V, 0V... Six or more 0.2mm² vinyl wires are connected in parallel (length 14m or less).
 C8, C4, C2, C1... 0.2mm² vinyl wire is used.
 Others... 0.1mm² or thicker twisted pair totally shielded wire.

Note) When the wire is longer than 14m, provide wire sized to limit the voltage drop of +5V to -0.02V or less.

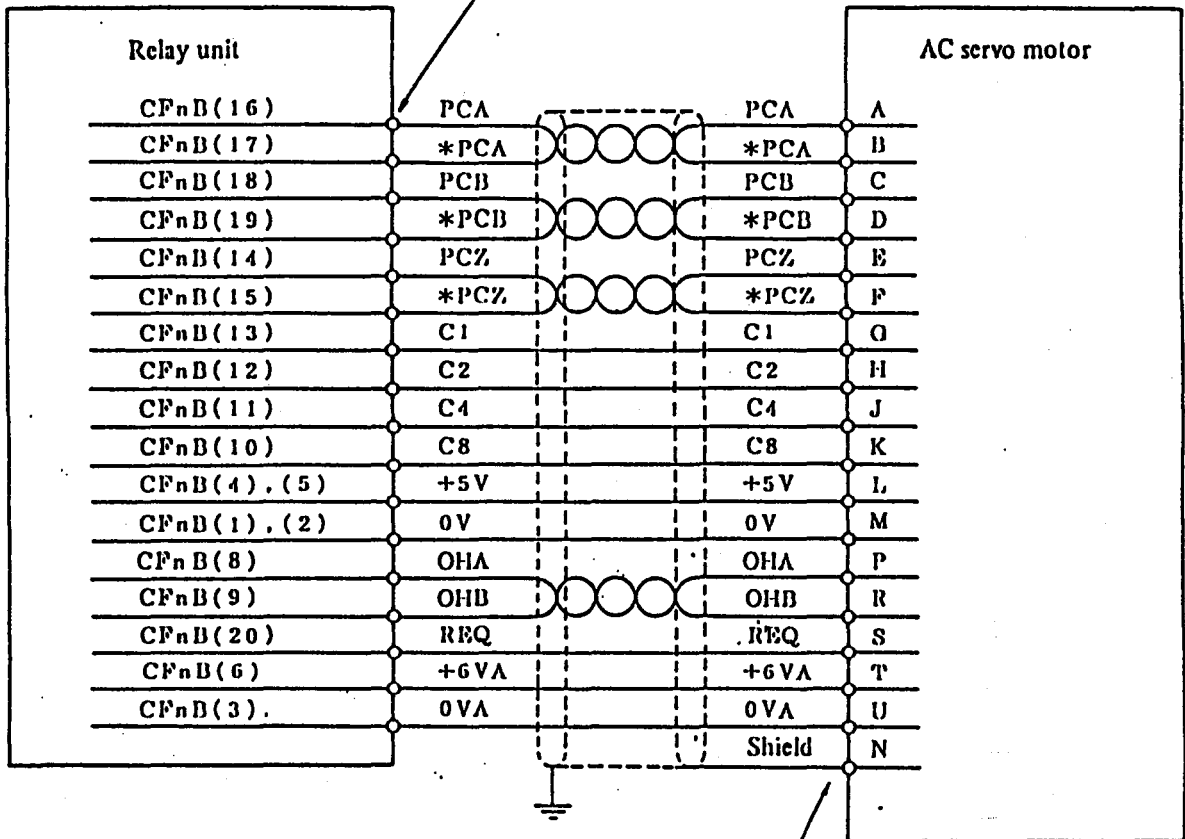
[Reference] Specified specification when purchasing the cable from FANUC:
 Cable wire material only : A66L-0001-0199 (wire length 14m max.)
 Cable with connector (14m long) :

With straight Cannon connector A02B-0074-K802
 With elbow Cannon connector A02B-0074-K803

2.2 Cable K2A (absolute pulse coder)

Connector

MR-20LWFH (by HONDA Tsushin Co., Ltd.) or equivalent



Connector

MS3106D22-14S or
MS3108D22-14S

Cable material

(when the sum of cable length K2A and K2N is 14m or less)

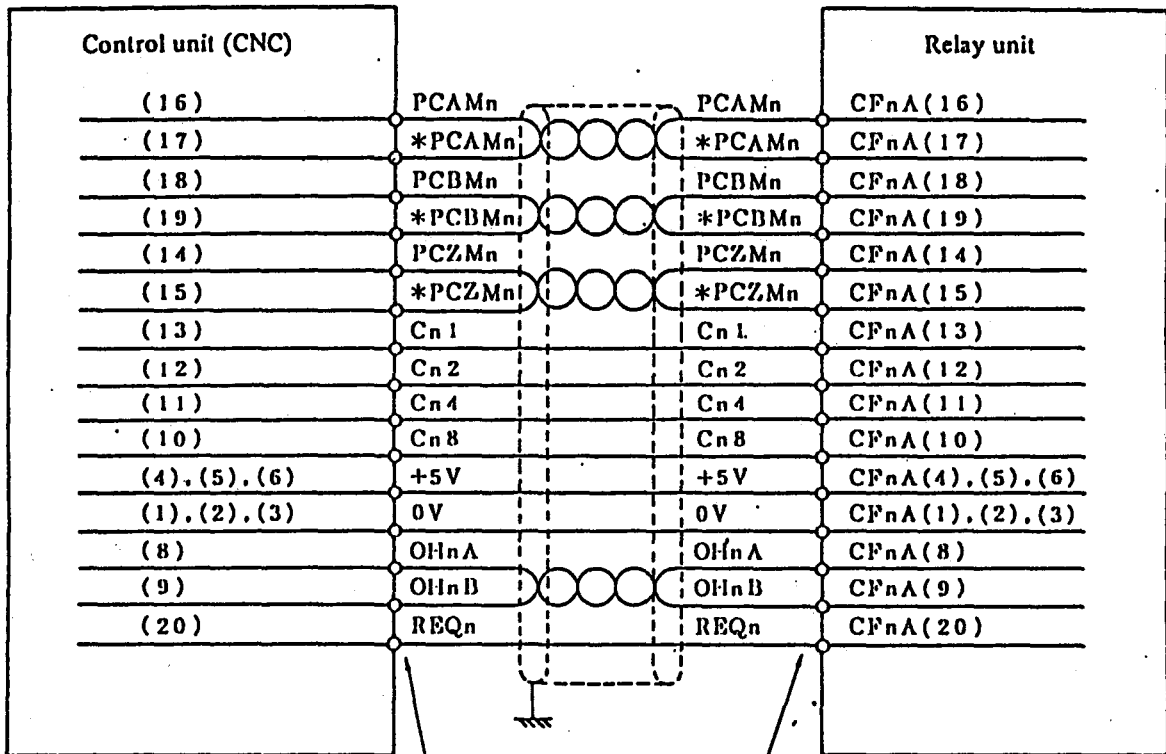
PCA, *PCA, PCB, *PCB, PCZ, *PCZ, OHA, OHB

: 0.18mm² twisted pair wire

-5V, 0V : 0.5mm² x 2

Others : 0.18mm²

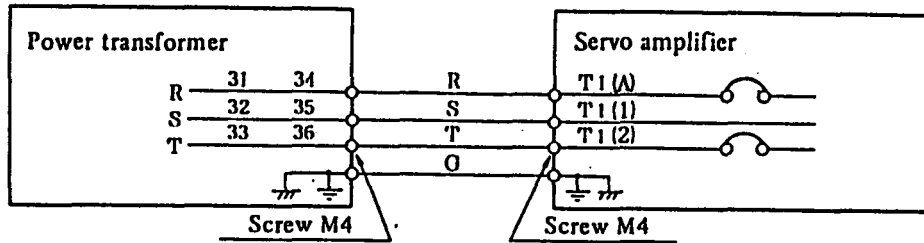
2.4 Cable K2N (absolute pulse coder)



Connector
MR-20LWFH (by HONDA Tsushin Co., Ltd.)
or equivalent

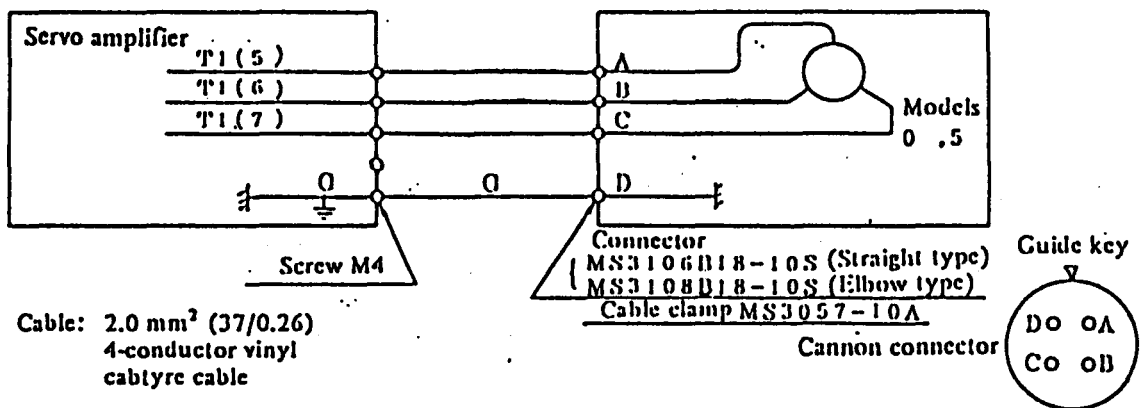
Connector
MR-20LFH (by HONDA Tsushin Co., Ltd.)
or equivalent

3. CABLE K3 (AMPLIFIER POWER LINE)

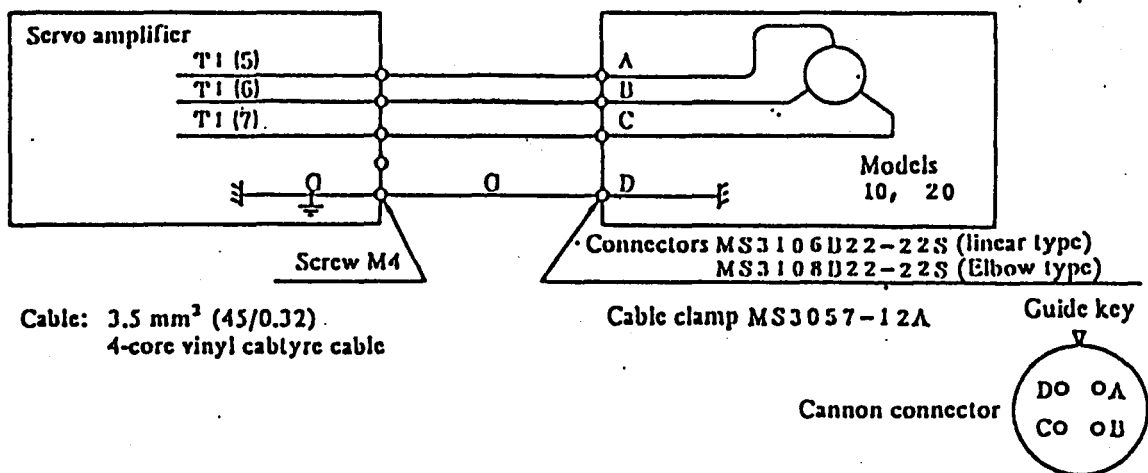


4. CABLE K4 (MOTOR POWER LINE)

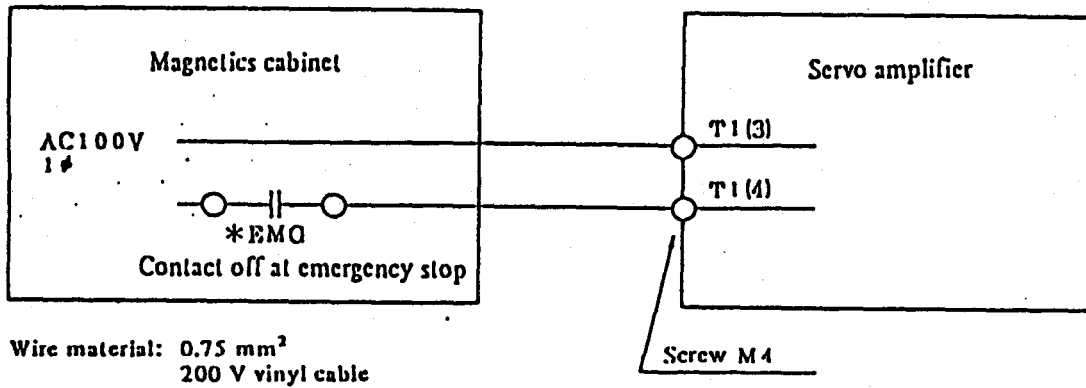
1) Models 0, 5



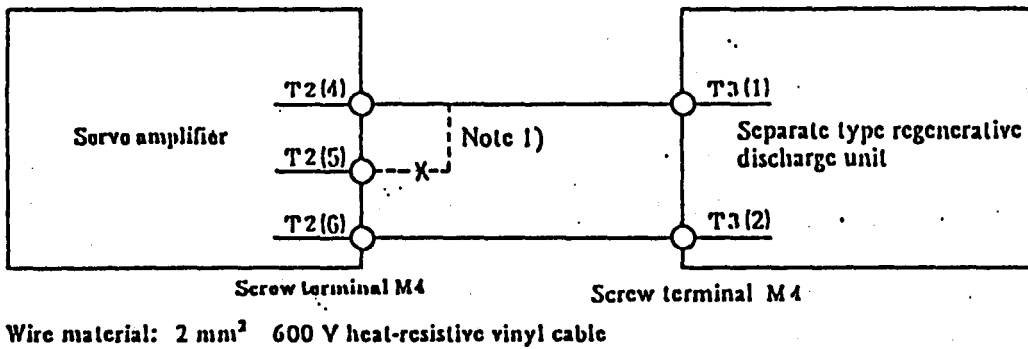
2) Models 10, 20



5. CABLE K5 (MAGNETIC CONTACTOR LINE)



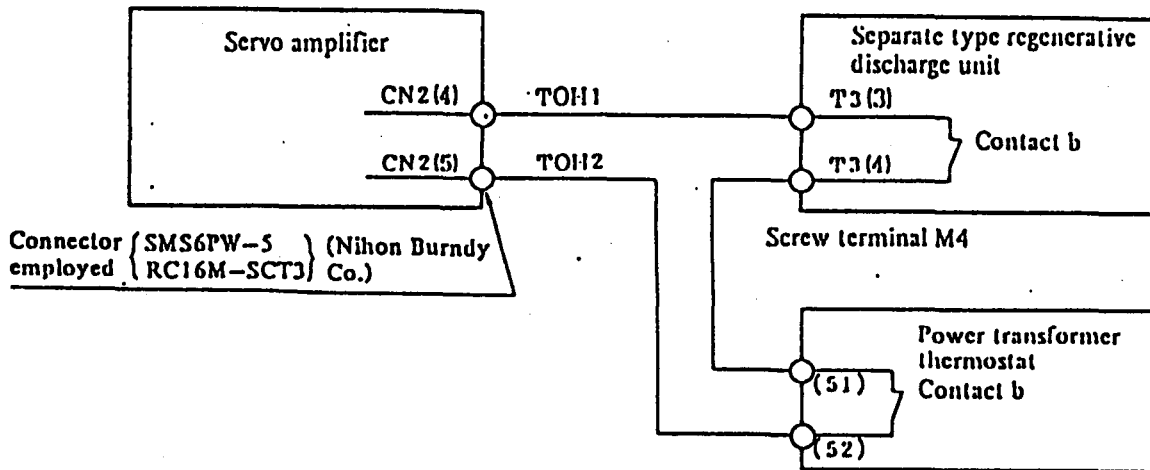
6. CABLE K6 (REGENERATIVE DISCHARGE RESISTOR LINE)



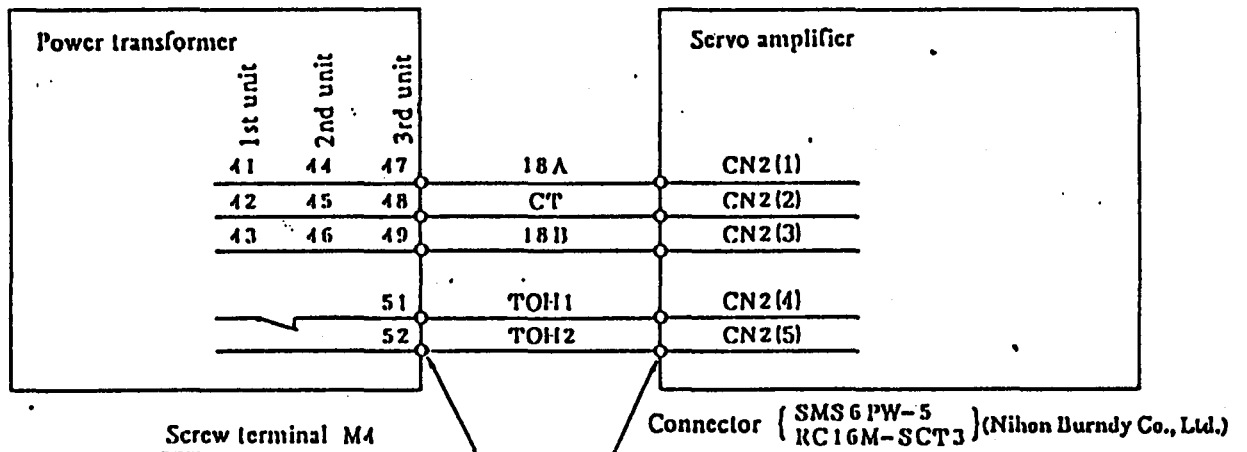
Note 1) When using the separate type regenerative discharge unit, remove the short bar between T2(4) and T2 (5).

7. CABLE K7 (THERMOSTAT LINE)

When a transformer is used, bury a thermostat into the transformer and connect the contact b as shown below.

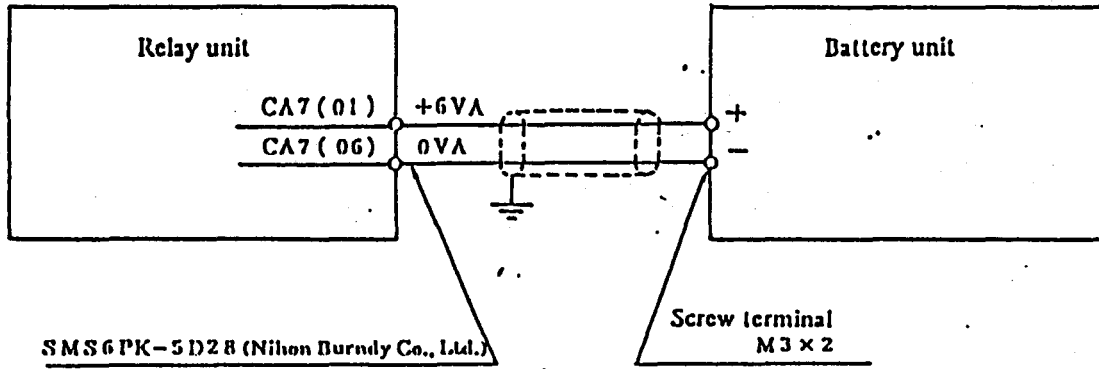


8. CABLE K8 (CONTROL POWER LINE)



Wire material: 0.75 mm² (30/0.18)
200 V heat-resistive vinyl cable

9. CABLE K9 (BATTERY LINE)



SMS 6 PK-5 D28 (Nihon Burndy Co., Ltd.)

Wire material: Shielded wire (0.18 mm² or more)

JR AUTOMATION TECHNOLOGIES INC*
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JDOWLING

B-65092E/01



* B - 6 5 0 9 2 E / 0 1 *