FANUC AC SERVO MOTOR series

DESCRIPTIONS

B-54762E/03

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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".

CONTENTS

I. FANUC AC SERVO MOTOR SERIES

1. GENERAL

FANUC AC servo motor series are specially developed and designed as transistor-driven servo motors suitable for machine tool and industrial robot.

Totally enclosed, self-cooled and brushless structure greatly reduces periodic inspection and maintenance even in severe operating conditions. Brushless structure free-from flash-over, or commutation loss, enables high torque at high speed operation and high efficiency.

11 models covering wide torque range from 1 kg-cm to 380 kg-cm enables the designer to select the most suitable motor for their own machine. The features of FANUC AC servo motors are as follows.

(1) Outstanding cooling capacity, because the stator core directly makes up outer case (Patent Pending), realizes compact configuration and minimum heat transmission to machine tool.

(2) The unique rotor structure (Patent Pending) along with the above-mentioned stator enables compact size, high torque to inertia ratio, so quick start and stop.

(3) Smooth rotation without cogging is achieved through precise design of magnetic field.

(4) Large thermal capacity of armature employing high grade insulation material enables the motor to endure under the severe conditions of frequent overload.

(5) Heavy duty shaft and bearings, and rugged frame structure maintain long life and accurate alignment under the severe load conditions of high peak torque at acceleration and deceleration.

(6) Direct-coupled pulse encoder exhibit reliable and stable control characteristics free from any response delay caused by distortion or plays of coupling and gears.

(7) A high accuracy pulse encoder achieves smooth rotation, and assures fine finish with high precision.

(8) The mounting dimensions of shaft and flange are compatible with those of FANUC DC servo motors.

2. TYPES OF MOTORS AND THEIR DESIGNATION

(1) The types of respective models of AC servo motor series and their designation methods are as described below.

```
A06B-05□□-B□□□
       |   | |
       |   | └──── Feedback type
       |   └────── Motor options
       └────────── Motor model
```

(i) Model 5-0

```
A06B-0531-B0□1
            ||
            |└──────     with pulse coder (1000P/rev)
            ├────── 0 : Incremental pulse coder
            └────── 3 : Absolute pulse coder
```

(ii) Model 4-0, 3-0

```
A06B-053□-B□□□
        |   |
        |   └──────┬─ 001: with incremental pulse coder of
        |          |       2000P/rev
   ┌────┘          └─ 251: with absolute pulse coder of
   |                       2000P/rev
   ├─2: model 4-0
   └─3: model 3-0
```

(iii) Model 2-0, 1-0

```
A06B-052□-B□□□
        |   ||
        |   |└──────┬─ 1 : with pulse coder of 2000P/rev
        |   |       ├─ 2 : with pulse coder of 2500P/rev
        |   |       └─ 3 : with pulse coder of 3000P/rev
 ┌──────┘   └─────┐
 ├─1: model 2-0   ├─── 4 : Incremental pulse coder
 └─2: model 1-0   └─── 5 : Absolute pulse coder
```

(iv) Model 0, 5

```
A06B-051□-B□□□
        |  |||
        |  ||└──────┬─ 1 : with pulse coder of 2000P/rev
        |  ||       ├─ 2 : with pulse coder of 2500P/rev
        |  ||       └─ 3 : with pulse coder of 3000P/rev
   ┌────┘  |└─────┐
   ├─1: model 0   ├─── 0 : Incremental pulse coder
   └─2: model 5   └─── 3 : Absolute pulse coder
           |
           └──────┬─── 0 : standard
                  └─── 2 : with brake
```

(v) Model 10, 20M, 20, 30, 30R

A06B-050□-B□□□

- First □ (after 050):
  - 1: model 10
  - 2: model 20
  - 3: model 30
  - 5: model 20M
  - 6: model 30R
- First □ after B:
  - 0 : standard
  - 2 : with brake
  - 5 : taper shaft
  - 7 : taper shaft, with brake
- Second □ after B:
  - 0 : Incremental pulse coder
  - 3 : Absolute pulse coder
- Third □ after B:
  - 01: with pulse coder of 2000P/rev
  - 02: with pulse coder of 2500P/rev
  - 03: with pulse coder of 3000P/rev

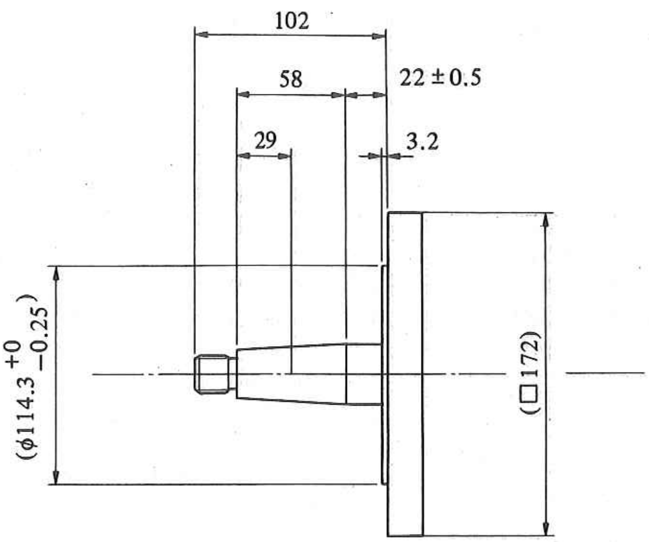
(2) Models 2-0, 1-0, 0, 5, 10, 20M, 20, 30, and 30R are provided with oil seal as the standard equipment.

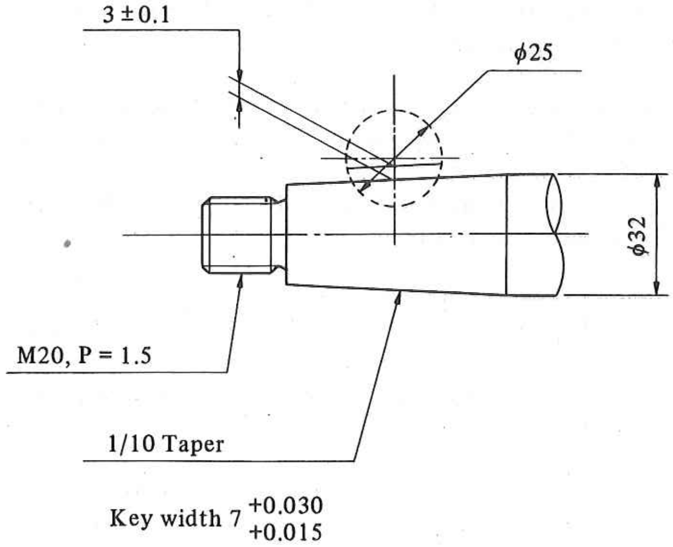
(3) Special pulse coder is directly mounted on the motor shaft. Conventional detectors being available on the market cannot be mounted.

(4) Holding brake can be available with model 0, 5, 10, 20M, 20, 30, 30R. Major specifications are as follows.

	For 0.5	For 10, 20M, 20, 30, 30R
Brake torque	60 kg-cm	180 kg-cm
Response time		
Brake release	95 ms	100 ms
Brake on	20 ms	60 ms
Power supply	DC 90V + 10% 0.4A —	DC 90V + 10% 0.6A —

(5) For model 10, 20M, 20, 30, and 30R straight shaft is standard, but taper shaft is also available. Shaft dimensions are as follows.





Shaft detail

3. CHARACTERISTICS OF FANUC AC SERVO MOTOR SERIES

3.1 Motor Models and Specifications

The next table shows model number of FANUC AC Servo Motors and their specifications.

Item \ Model	5-0	4-0	3-0	2-0	1-0	0	5	10	20M	20	30	30R
Output power kW	0.02	0.05	0.1	0.2	0.4	0.6	0.9	1.8	2.8	3.5	3.3	4
Rated torque at stall kg.cm	1	2.5	5	10	20	30	60	120	230	230	380	300
Max. torque kg.cm	8	11.3	22.6	80	160	270	540	800	1500	1500	2300	2300
Max. speed RPM	3000	3000	3000	2000	2000	2000	2000	2000	1500	2000	1200	2000
Rotor inertia $kg.cm.S^2$	$3.0x10^{-5}$	$3.8x10^{-4}$	$7.4x10^{-4}$	$3.7x10^{-3}$	$6.1x10^{-3}$	0.020	0.038	0.10	0.17	0.17	0.24	0.24
Mechanical time constant msec.	3.3	11	8	9	5	16	9	10	6	6	5	5
Thermal time const min.	11	15	15	15	20	45	50	60	65	65	65	65
Weight kg	0.5	1.2	1.8	3	4.5	10	15	23	34	34	45	45

The values in the table are those under the following conditions.

(1) The temperature of the motor is 20°C.
(2) Drive current is pure sine wave.

3.2 Performance Curves and Data Sheet

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

Performance Curves

The typical set of performance curves consists 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:

(1) Continuous RMS current at stall TENV: Is (Arms)

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

(2) Torque constant: Kt (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:

Kt (kg-cm/Arms) = 30.6 Kv (Volt-sec/rad)
Thus if Kv is reduced due to demagnetization of the magnetic field, Kt is also reduced in the same proportion.

(3) Back EMF (electromotive force) constant: Kv (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:

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

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

(4) Mechanical time constant: tm (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.

$$tm = \frac{Jm \cdot Ra}{Kt \cdot Kv}$$

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

(5) 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.

(6) Static friction: Tf (kg-cm)

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

(7) Max. current before demagnetization: Im (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)

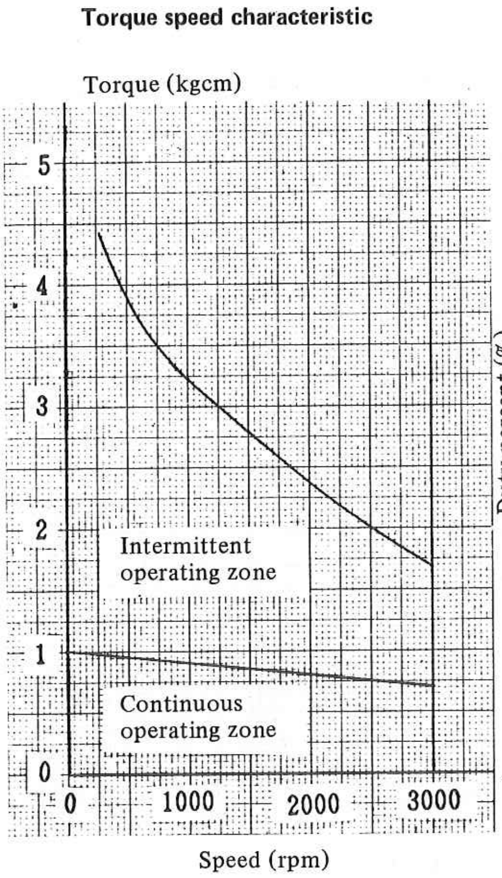
$$t_F = t_R \times \left(\frac{100}{\text{Duty percent}} - 1 \right) \quad \text{(a)}$$

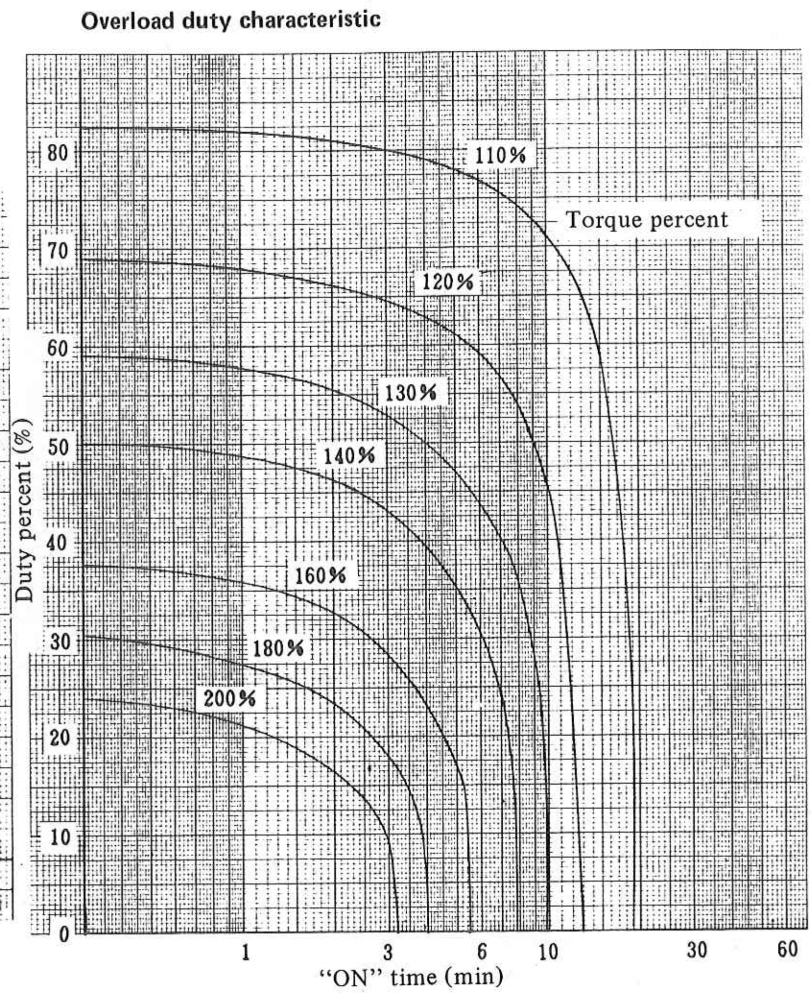
$$\text{Torque percent} = \frac{\text{Load torque}}{\text{Continuous rated torque}} \quad \text{(b)}$$

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.

Model 5-0



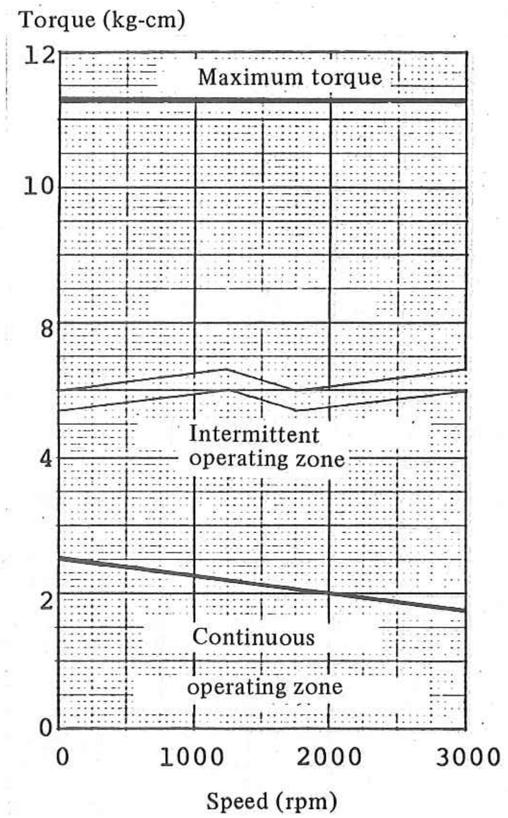


Data sheet

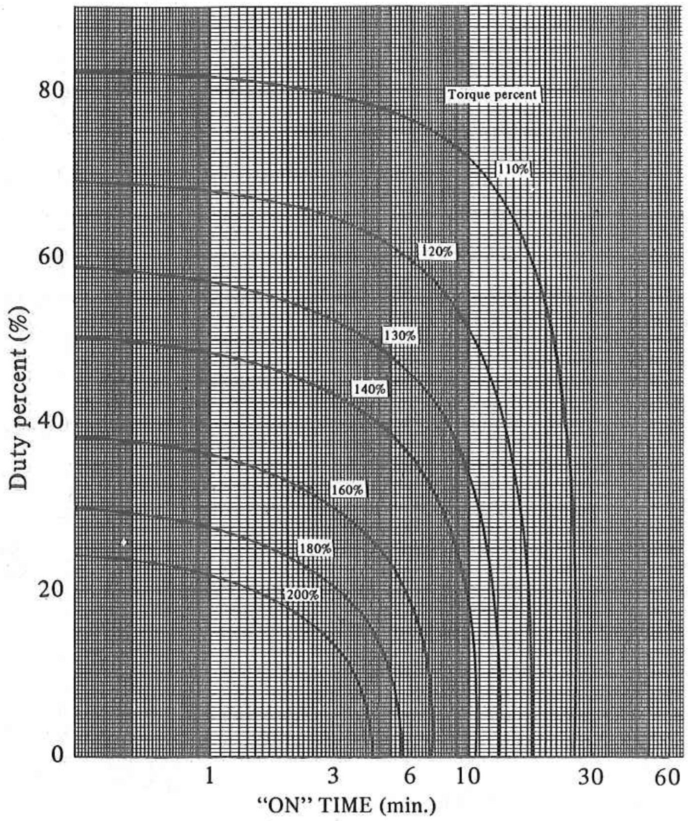
Parameters	Symbol	Value	Unit
Rotor inertia	Jm	3.0×10^{-5}	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	0.49	Arms
Torque constant	Kt	2.04	kgcm/Arms
Rated torque at stall TENV	Ts	1	kgcm
Back EMF constant (RMS voltage per phase)	Ke	7.0	Vrms/krpm
	Kv	0.067	Vrms.sec/rad
Armature resistance	Ra	15	Ohm
Mechanical time constant	tm	3.3×10^{-3}	sec.
Thermal time constant	tt	11	min.
Static friction	Tf	0.1	kgcm
Max. current before demagnetization	Im	5.5	A
Max. torque	Tm	8	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		0.5	kg

Model 4-0

Torque-speed characteristic



Overload duty characteristic

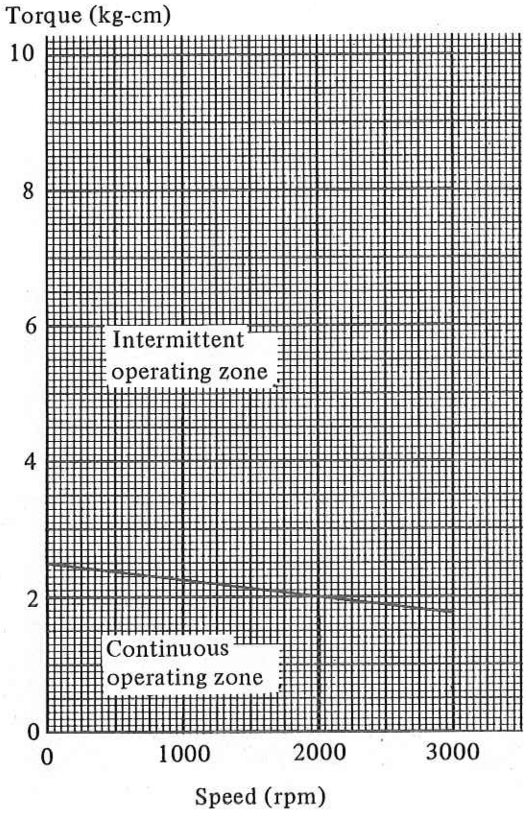


Data sheet

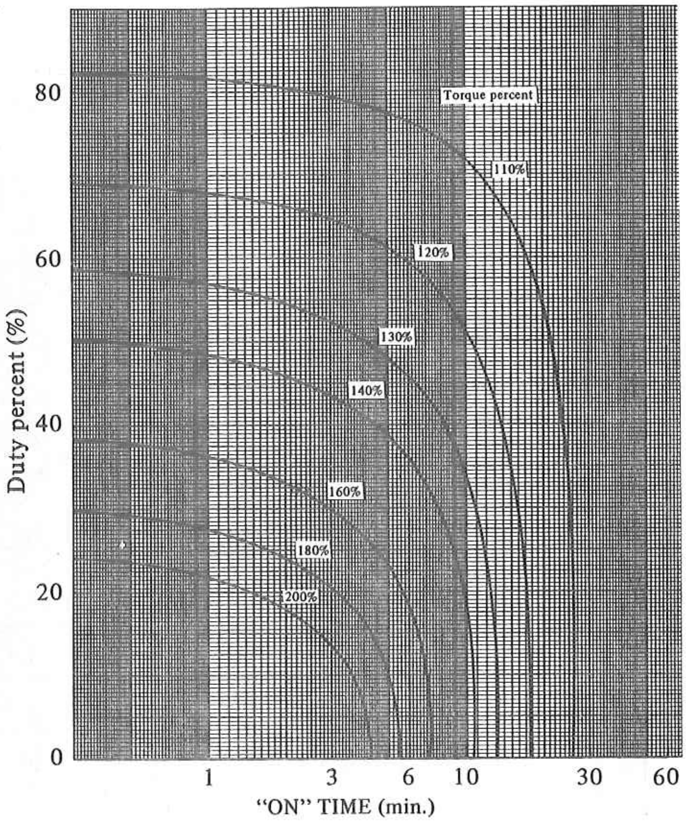
Parameters	Symbol	Value	Unit
Rotor inertia	Jm	3.8×10^{-4}	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	0.93	Arms
Torque constant	Kt	2.68	kgcm/Arms
Rated torque at stall TENV	Ts	2.5	kgcm
Back EMF constant (RMS voltage per phase)	Ke	9.2	V/krpm
	Kv	0.088	Vsec/rad
Armature resistance	Ra	6	Ohm
Mechanical time constant	tm	11×10^{-3}	sec.
Thermal time constant	tt	15	min.
Static friction	Tf	0.25	kgcm
Max. current before demagnetization	Im	4.2	A
Max. torque	Tm	11.3	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		1.2	kg

Model 3-0

Torque-speed characteristic



Overload duty characteristic

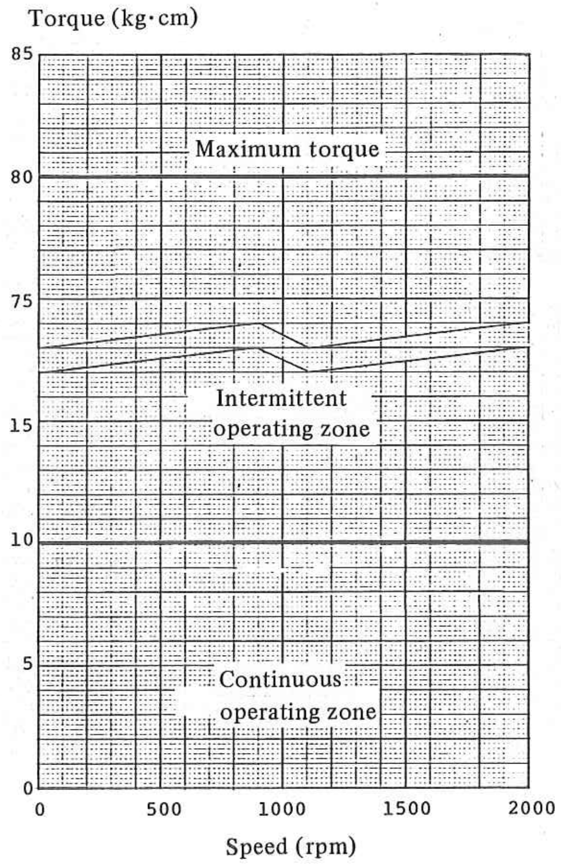


Data sheet

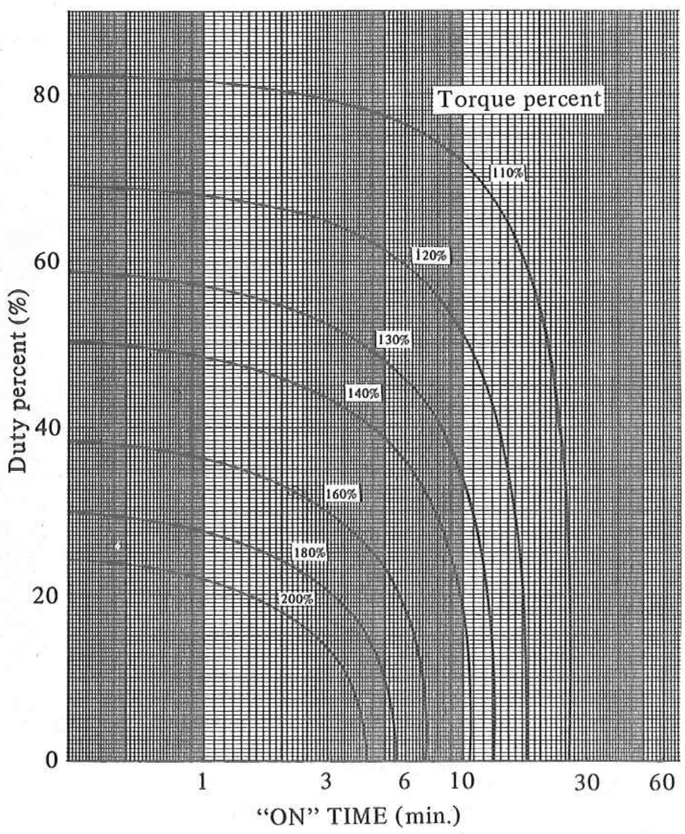
Parameters	Symbol	Value	Unit
Rotor inertia	Jm	7.4×10^{-4}	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	0.93	Arms
Torque constant	Kt	5.37	kgcm/Arms
Rated torque at stall TENV	Ts	5	kgcm
Back EMF constant (RMS voltage per phase)	Ke	18.4	V/krpm
	Kv	0.175	Vsec/rad
Armature resistance	Ra	8.7	Ohm
Mechanical time constant	tm	8×10^{-3}	sec.
Thermal time constant	tt	15	min.
Static friction	Tf	0.25	kgcm
Max. current before demagnetization	Im	4.2	A
Max. torque	Tm	22.6	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		1.8	kg

Model 2-0

Torque-speed characteristic



Overload duty characteristic

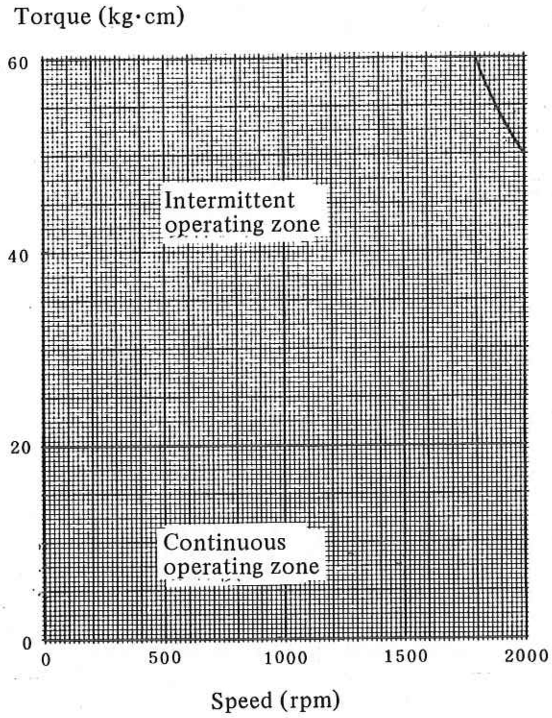


Data sheet

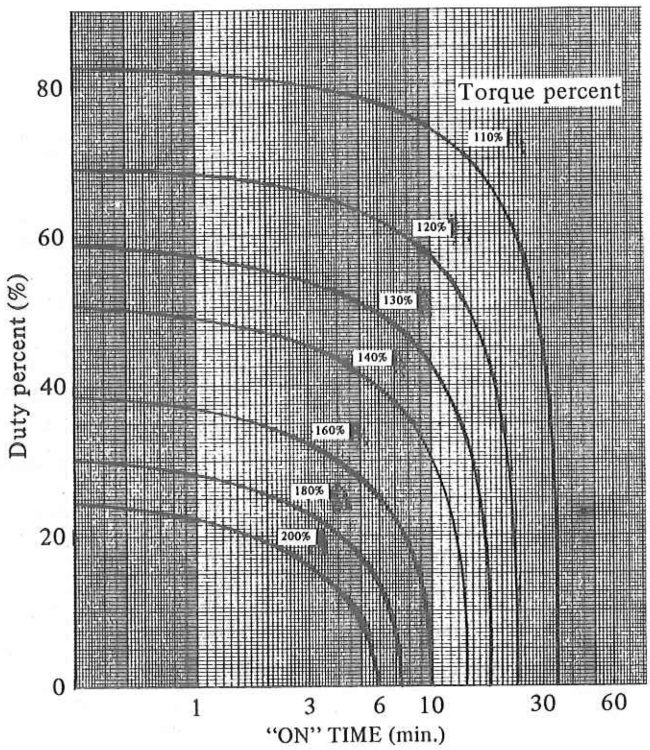
Parameters	Symbol	Value	Unit
Rotor inertia	Jm	0.0037	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	3.0	Arms
Torque constant	Kt	3.4	kgcm/Arms
Rated torque at stall TENV	Ts	10	kgcm
Back EMF constant (RMS voltage per phase)	Ke	12	V/krpm
	Kv	0.11	Vsec/rad
Armature resistance	Ra	0.95	Ohm
Mechanical time constant	tm	0.009	sec.
Thermal time constant	tt	15	min.
Static friction	Tf	1	kgcm
Max. current before demagnetization	Im	33	A
Max. torque	Tm	80	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		3.0	kg

Model 1-0

Torque-speed characteristic



Overload duty characteristic

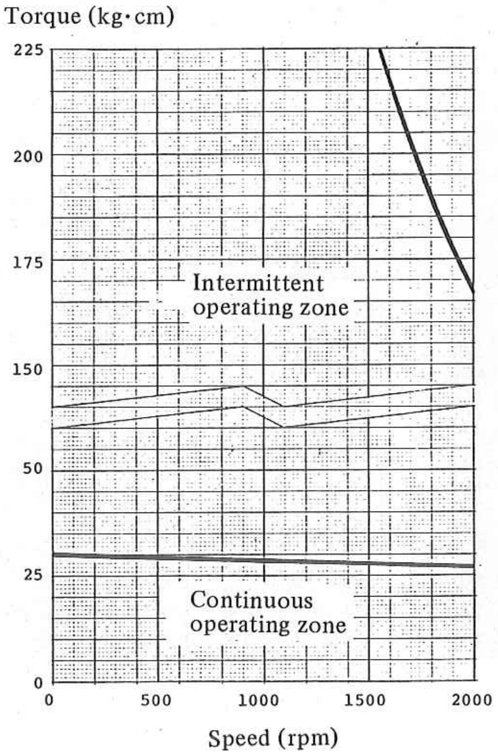


Data sheet

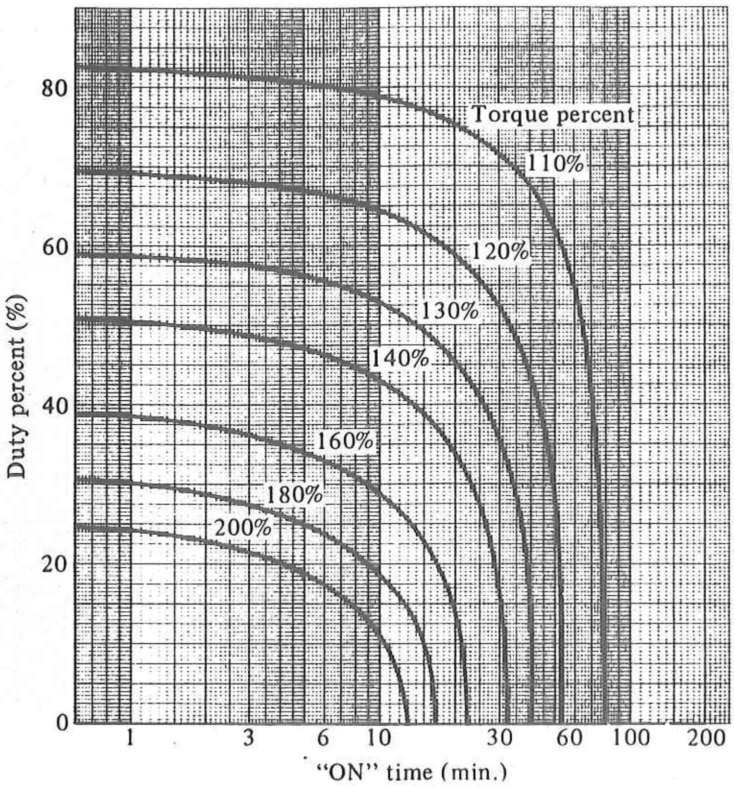
Parameters	Symbol	Value	Unit
Rotor inertia	Jm	0.0061	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	2.9	Arms
Torque constant	Kt	6.9	kgcm/Arms
Rated torque at stall TENV	Ts	20	kgcm
Back EMF constant (RMS voltage per phase)	Ke	23	V/krpm
	Kv	0.22	Vsec/rad
Armature resistance	Ra	1.3	Ohm
Mechanical time constant	tm	0.005	sec.
Thermal time constant	tt	20	min.
Static friction	Tf	1.5	kgcm
Max. current before demagnetization	Im	33	A
Max. torque	Tm	160	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		4.5	kg

Model 0

Torque-speed characteristic



Overload duty characteristic

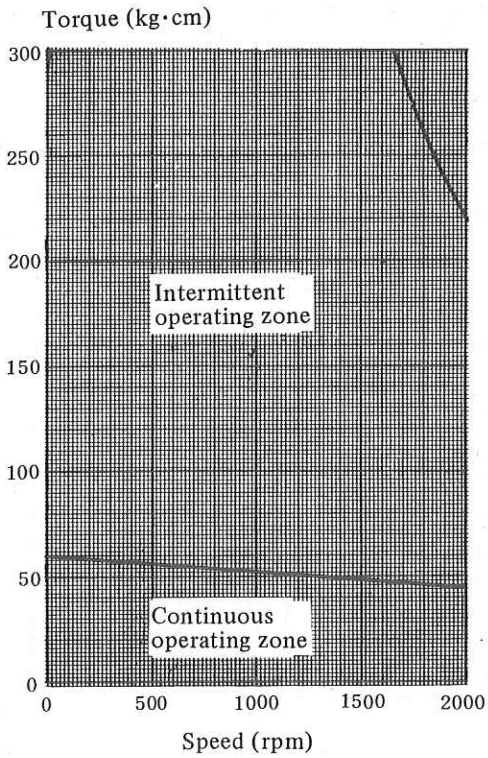


Data sheet

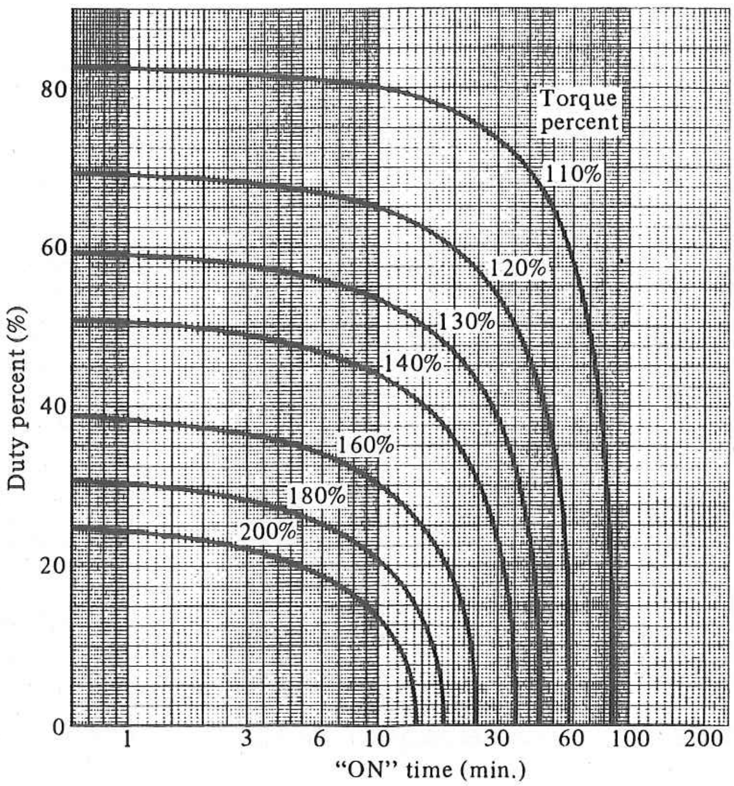
Parameters	Symbol	Value	Unit
Rotor inertia	Jm	0.020	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	6.9	Arms
Torque constant	Kt	4.3	kgcm/Arms
Rated torque at stall TENV	Ts	30	kgcm
Back EMF constant (RMS voltage per phase)	Ke	15	V/krpm
	Kv	0.14	Vsec/rad
Armature resistance	Ra	0.38	Ohm
Mechanical time constant	tm	0.016	sec.
Thermal time constant	tt	45	min.
Static friction	Tf	3	kgcm
Max. current before demagnetization	Im	80	A
Max. torque	Tm	270	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		10	kg

Model 5

Torque-speed characteristic



Overload duty characteristic

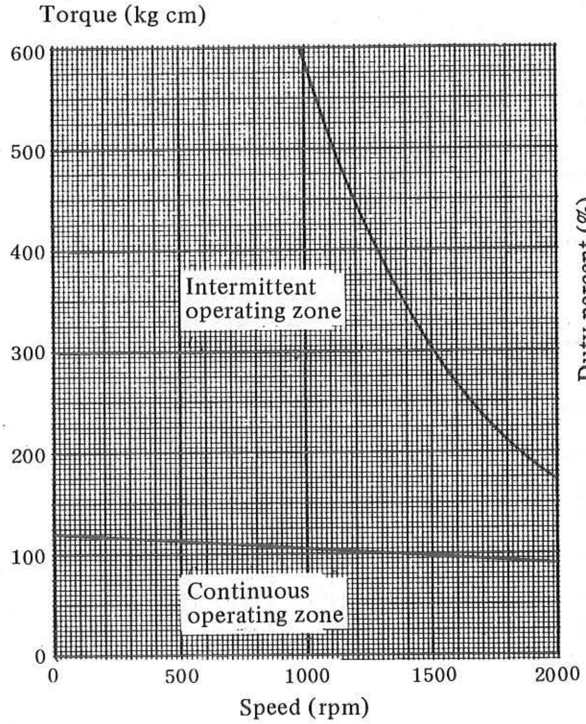


Data sheet

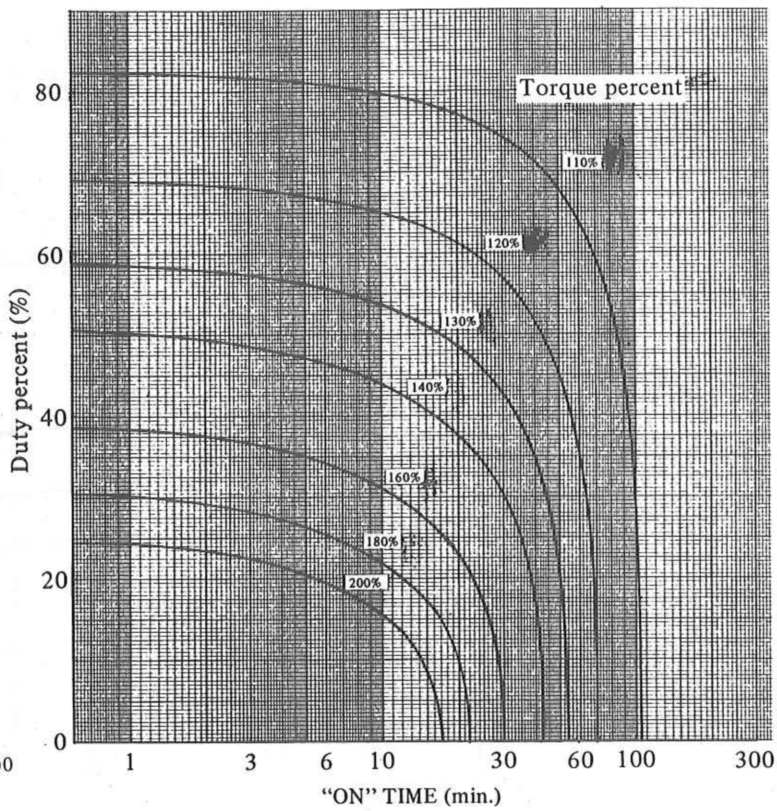
Parameters	Symbol	Value	Unit
Rotor inertia	Jm	0.038	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	6.8	Arms
Torque constant	Kt	8.8	kgcm/Arms
Rated torque at stall TENV	Ts	60	kgcm
Back EMF constant (RMS voltage per phase)	Ke	30	V/krpm
	Kv	0.29	Vsec/rad
Armature resistance	Ra	0.54	Ohm
Mechanical time constant	tm	0.009	sec.
Thermal time constant	tt	50	min.
Static friction	Tf	3	kgcm
Max. current before demagnetization	Im	80	A
Max. torque	Tm	540	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		15	kg

Model 10

Torque-speed characteristic



Overload duty characteristic

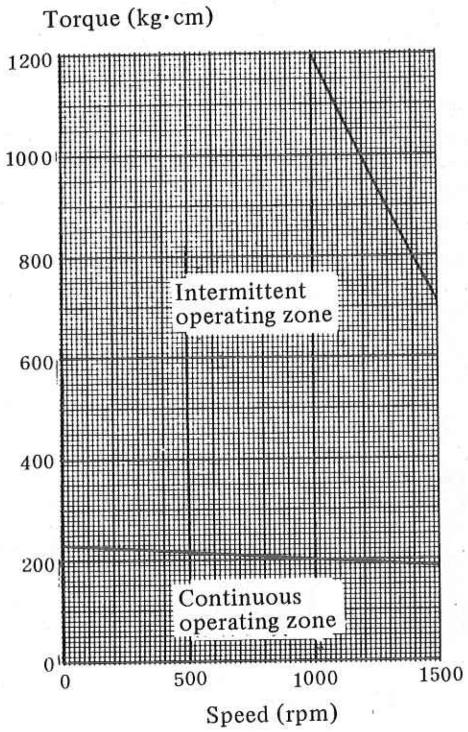


Data sheet

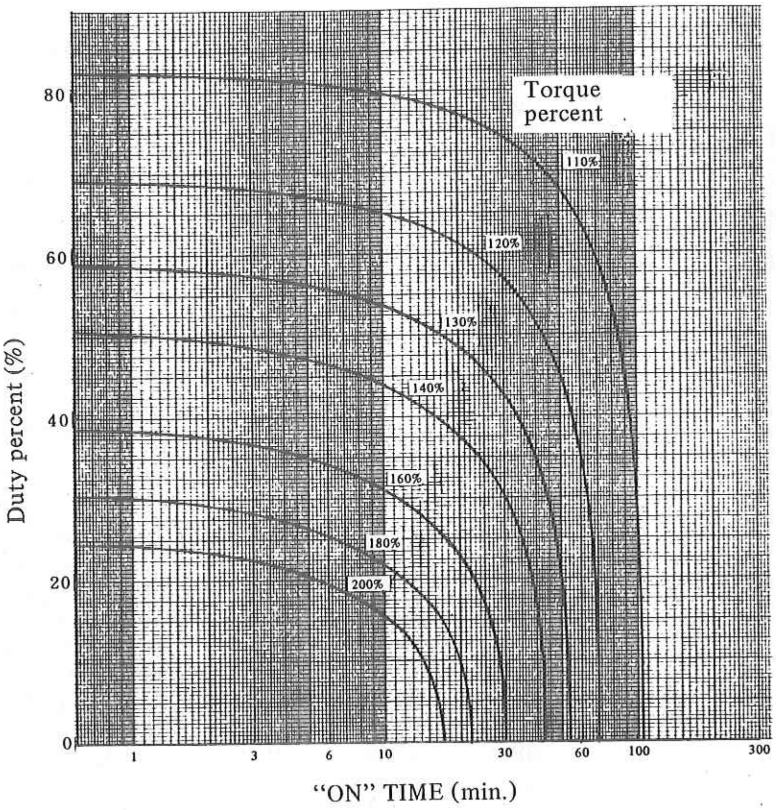
Parameters	Symbol	Value	Unit
Rotor inertia	Jm	0.10	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	11	Arms
Torque constant	Kt	11	kgcm/Arms
Rated torque at stall TENV	Ts	120	kgcm
Back EMF constant (RMS voltage per phase)	Ke	38	V/krpm
	Kv	0.37	Vsec/rad
Armature resistance	Ra	0.37	Ohm
Mechanical time constant	tm	0.010	sec.
Thermal time constant	tt	60	min.
Static friction	Tf	8	kgcm
Max. current before demagnetization	Im	85	A
Max. torque	Tm	800	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		23	kg

Model 20M

Torque-speed characteristic



Overload duty characteristic

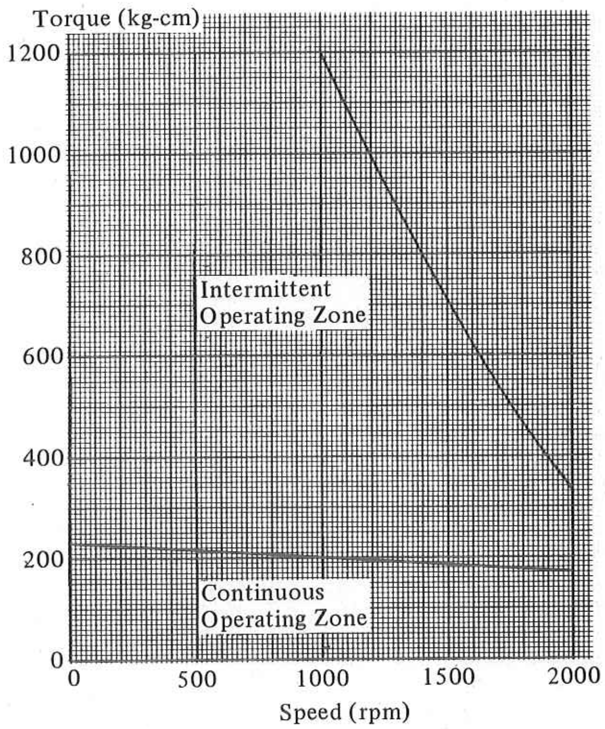


Data sheet

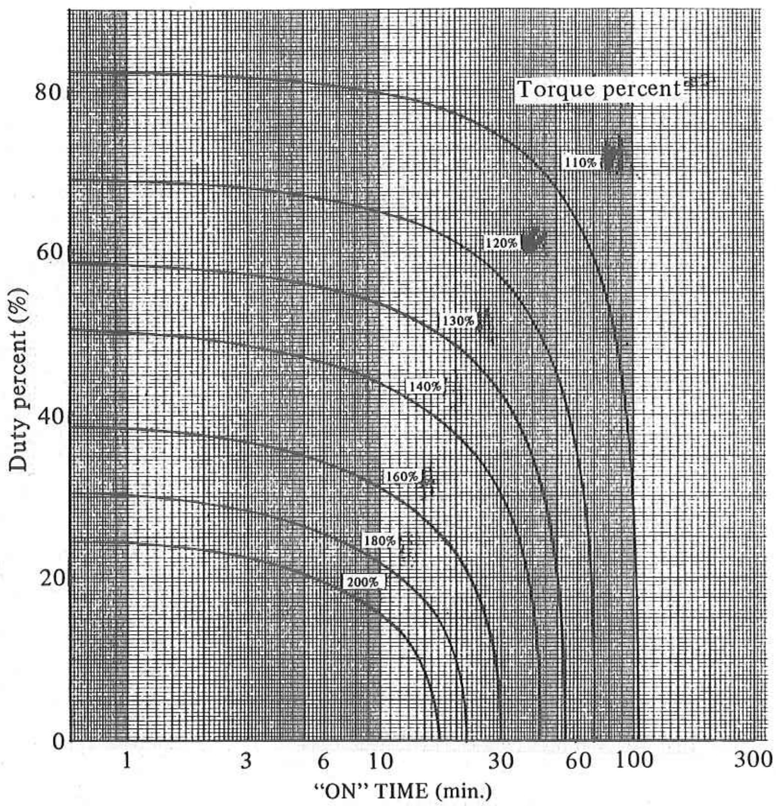
Parameters	Symbol	Value	Unit
Rotor inertia	Jm	0.17	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	15	Arms
Torque constant	Kt	15.5	kgcm/Arms
Rated torque at stall TENV	Ts	230	kgcm
Back EMF constant (RMS voltage per phase)	Ke	52	V/krpm
	Kv	0.49	Vsec/rad
Armature resistance	Ra	0.24	Ohm
Mechanical time constant	tm	0.006	sec.
Thermal time constant	tt	65	min.
Static friction	Tf	12	kgcm
Max. current before demagnetization	Im	130	A
Max. torque	Tm	1500	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		34	kg

Model 20

Torque-speed characteristic



Overload duty characteristic

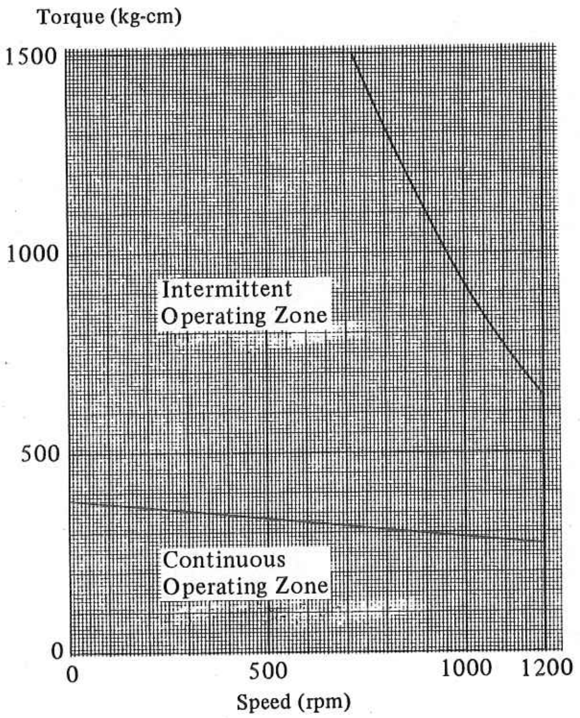


Data sheet

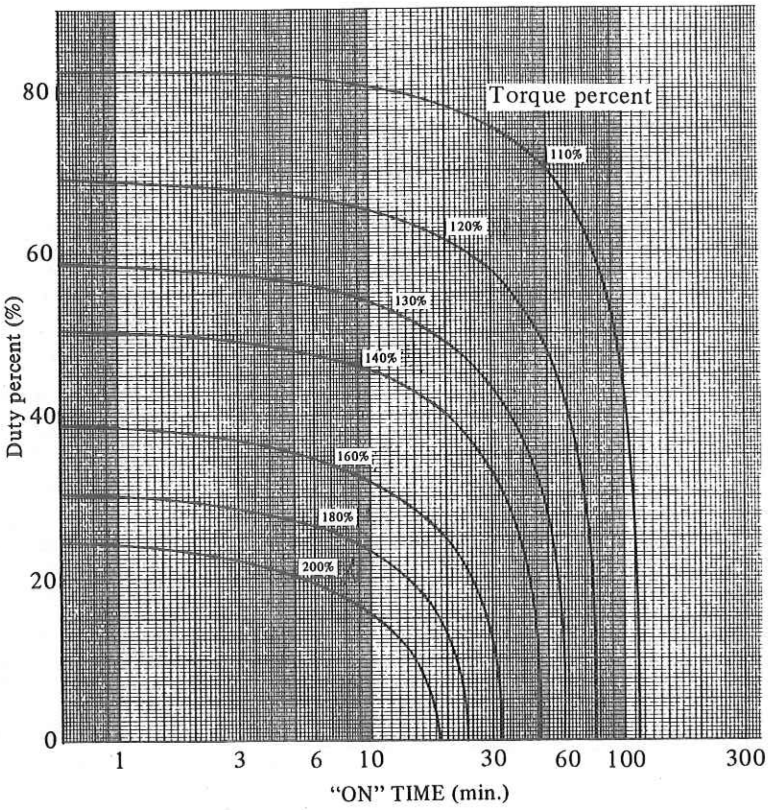
Parameters	Symbol	Value	Unit
Rotor inertia	Jm	0.17	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	20	Arms
Torque constant	Kt	12	kgcm/Arms
Rated torque at stall TENV	Ts	230	kgcm
Back EMF constant (RMS voltage per phase)	Ke	40	V/krpm
	Kv	0.38	Vsec/rad
Armature resistance	Ra	0.14	Ohm
Mechanical time constant	tm	0.006	sec.
Thermal time constant	tt	65	min.
Static friction	Tf	12	kgcm
Max. current before demagnetization	Im	170	A
Max. torque	Tm	1500	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		34	kg

Model 30

Torque-speed characteristic



Overload duty characteristic

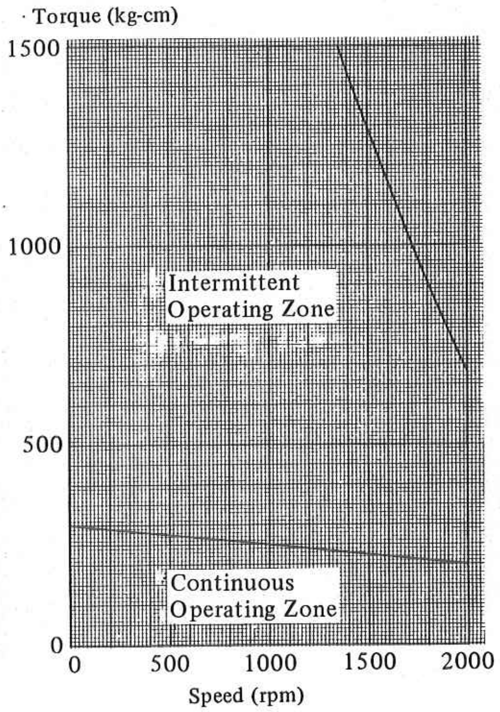


Data sheet

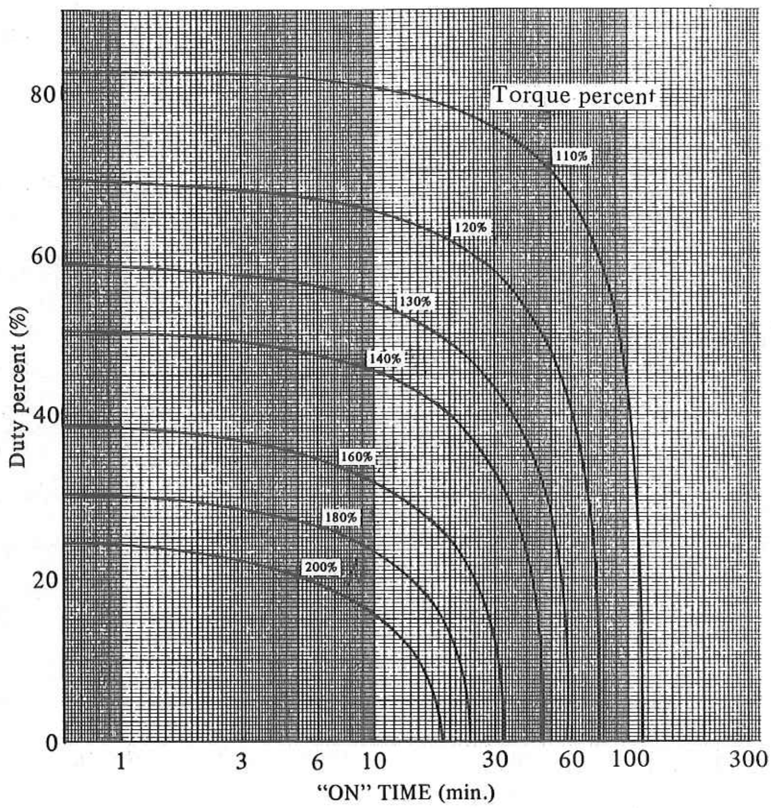
Parameters	Symbol	Value	Unit
Rotor inertia	Jm	0.24	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	22	Arms
Torque constant	Kt	17	kgcm/Arms
Rated torque at stall TENV	Ts	380	kgcm
Back EMF constant (RMS voltage per phase)	Ke	60	V/krpm
	Kv	0.57	Vsec/rad
Armature resistance	Ra	0.18	Ohm
Mechanical time constant	tm	0.005	sec.
Thermal time constant	tt	65	min.
Static friction	Tf	18	kgcm
Max. current before demagnetization	Im	170	A
Max. torque	Tm	2300	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		45	kg

Model 30R

Torque-speed characteristic



Overload duty characteristic

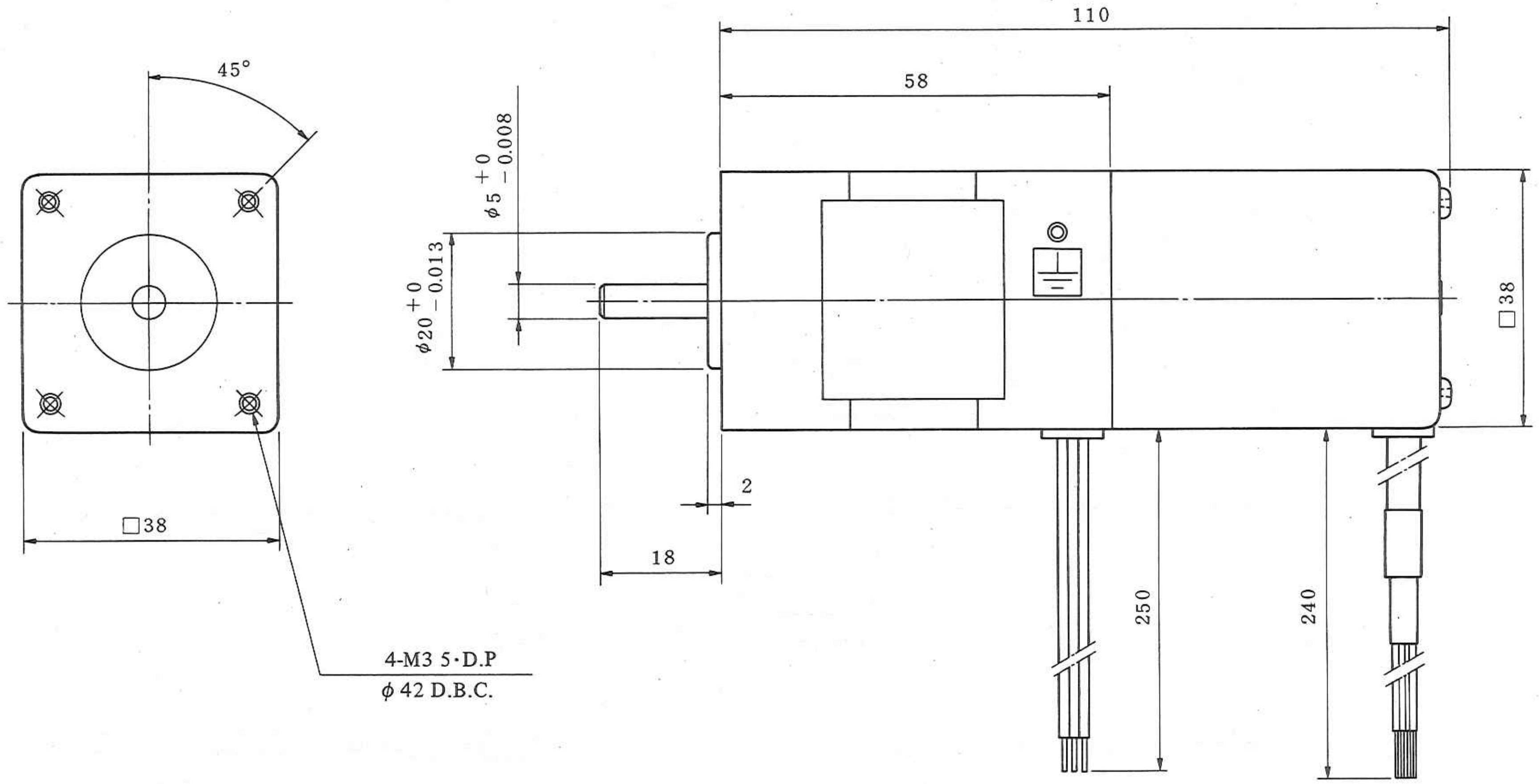


Data sheet

Parameters	Symbol	Value	Unit
Rotor inertia	Jm	0.24	$kgcmsec^2$
Continuous RMS current at stall TENV	Is	29	Arms
Torque constant	Kt	10.5	kgcm/Arms
Rated torque at stall TENV	Ts	300	kgcm
Back EMF constant (RMS voltage per phase)	Ke	36	V/krpm
	Kv	0.34	Vsec/rad
Armature resistance	Ra	0.064	Ohm
Mechanical time constant	tm	0.005	sec.
Thermal time constant	tt	65	min.
Static friction	Tf	18	kgcm
Max. current before demagnetization	Im	280	A
Max. torque	Tm	2300	kgcm
Max. winding temperature rise	Θm	125	°C
Weight		45	kg

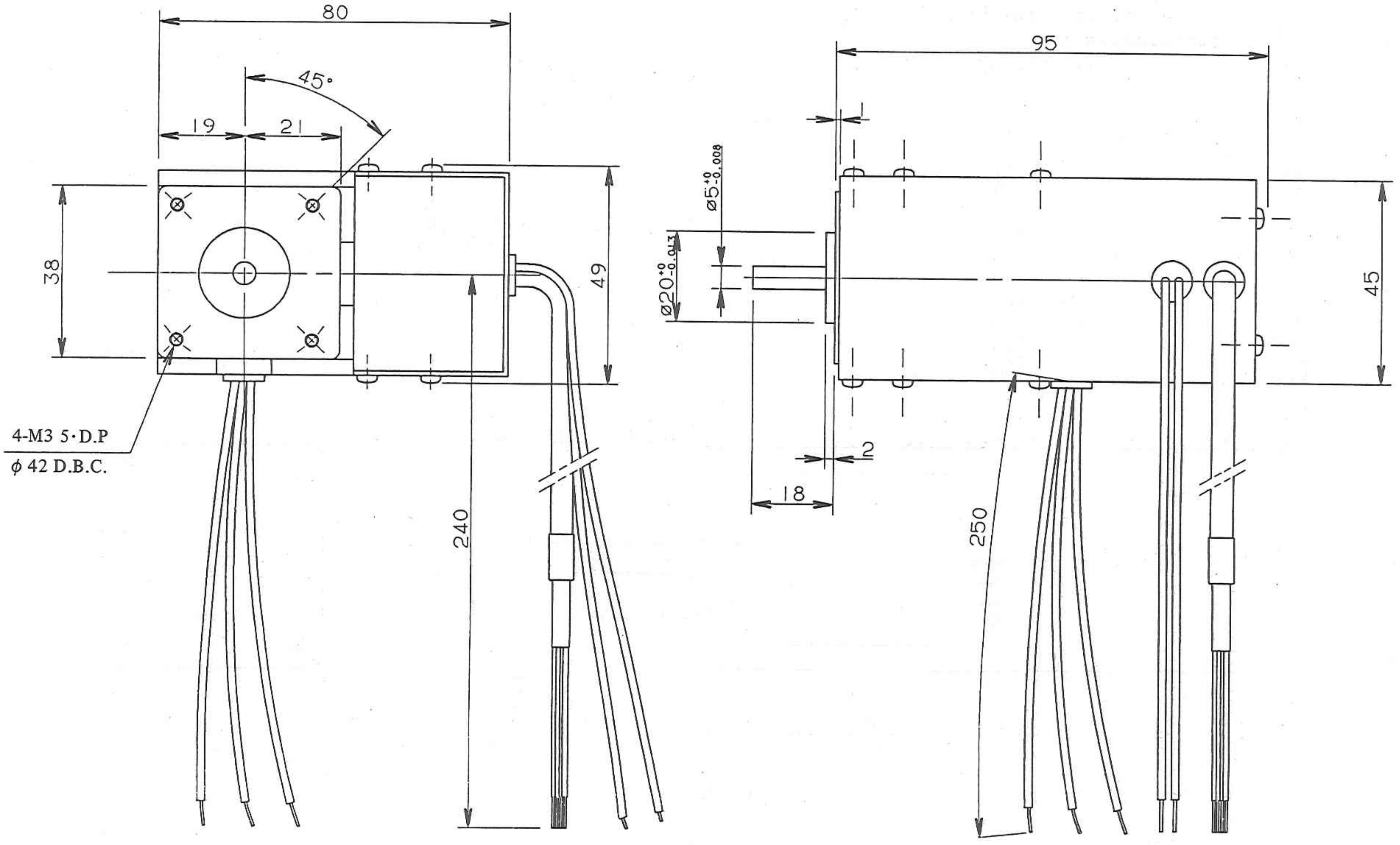
3.3 Outline Drawings

(1) FANUC AC SERVO MOTOR MODEL 5-0 (with Incremental pulse coder)

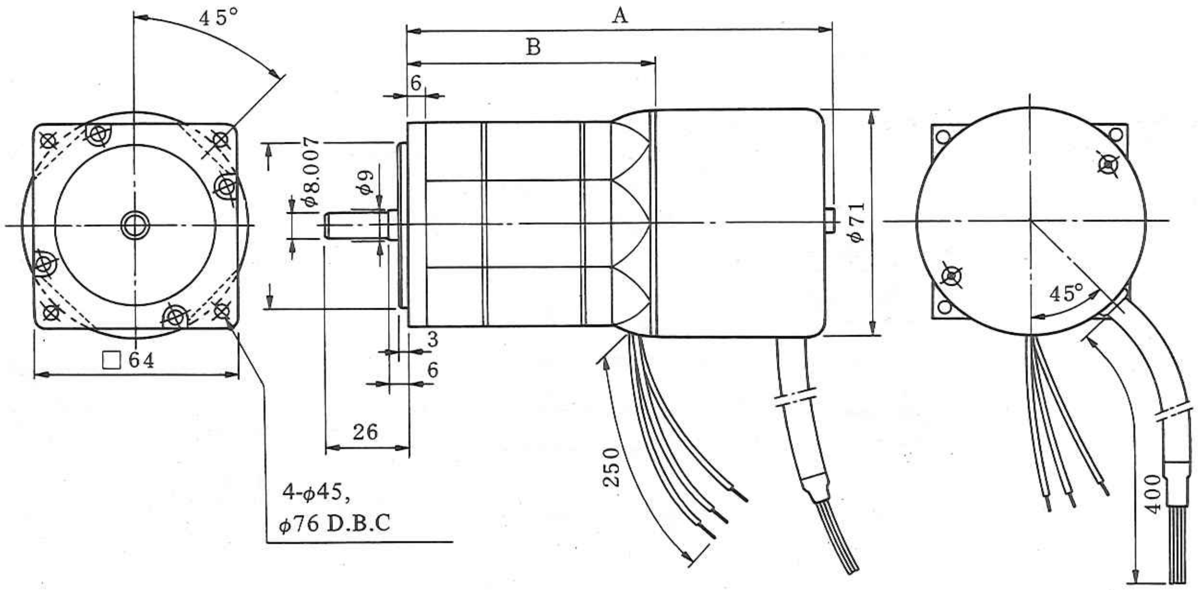


Note:	Shaft dia. runout	Max. 0.02mm
	Rabbet dia. eccentricity	Max. 0.04mm
	Mounting face runout	Max. 0.05mm
	Rated load	Radial 8 kg

Model 5-0 (with absolute pulse coder)



(3) MODEL 3-0, 4-0 (with incremental pulse coder)

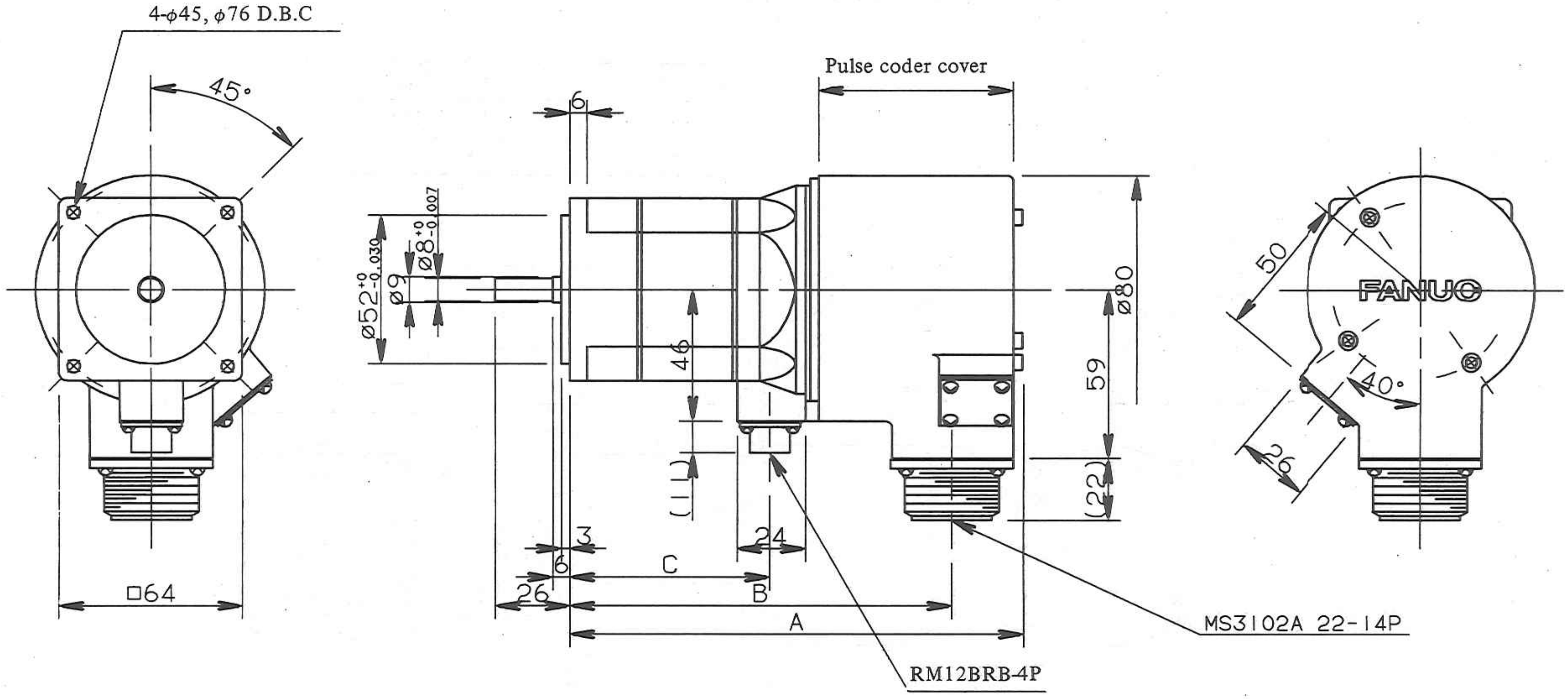


MOTOR	A	B
MODEL 4-0	136	81
MODEL 3-0	168	113

Notes:

Shaft dia. runout	Max. 0.02 mm
Rabbet dia. eccentricity	Max. 0.04 mm
Mounting face runout	Max. 0.06 mm
Rated load	Radial 8 kg

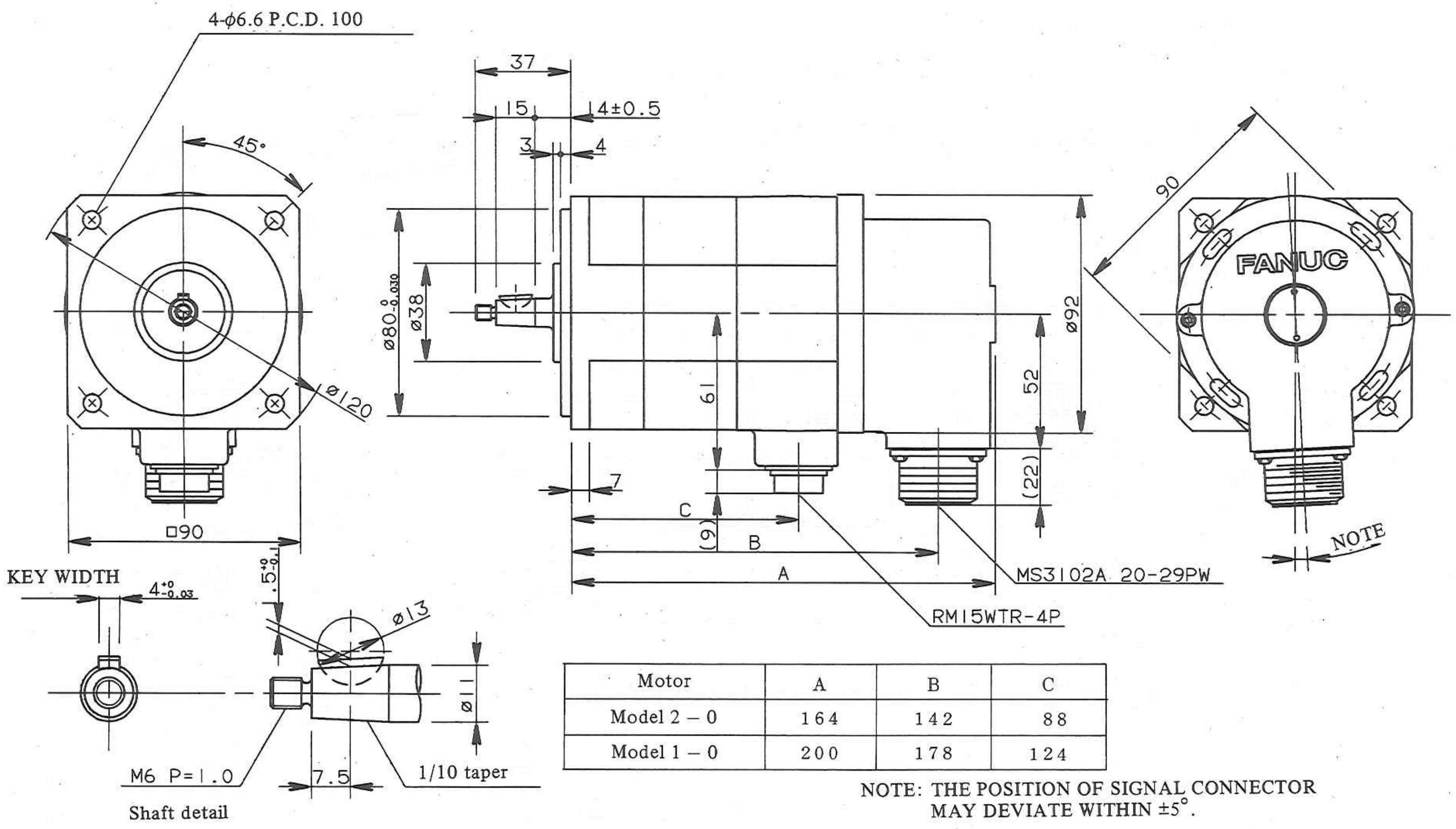
(4) Model 3-0, 4-0 (with absolute pulse coder)



Note) The pulse coder cover must be isolated with machine.

Motor	A	B	C
Model 4 – 0	158	134	70
Model 3 – 0	190	166	102

(5) MODEL 1-0, 2-0(with incremental pulse coder)

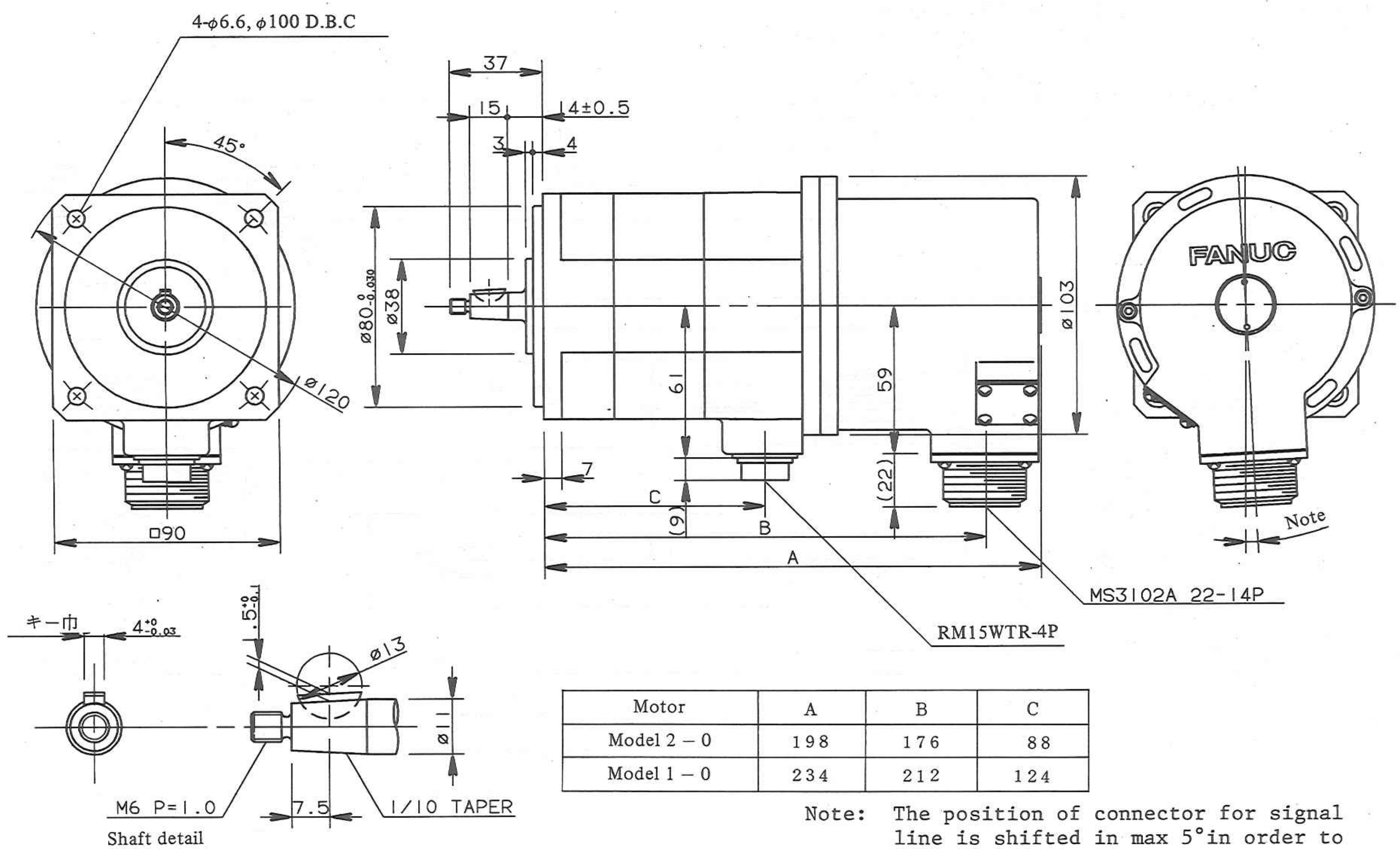


Motor	A	B	C
Model 2 – 0	164	142	88
Model 1 – 0	200	178	124

NOTE: THE POSITION OF SIGNAL CONNECTOR MAY DEVIATE WITHIN ±5°.

Note:		
	Shaft dia. runout	Max. 0.02mm
	Rabbet dia. eccentricity	Max. 0.04mm
	Mounting face runout	Max. 0.06mm
	Rated loads	Radial 25 kg

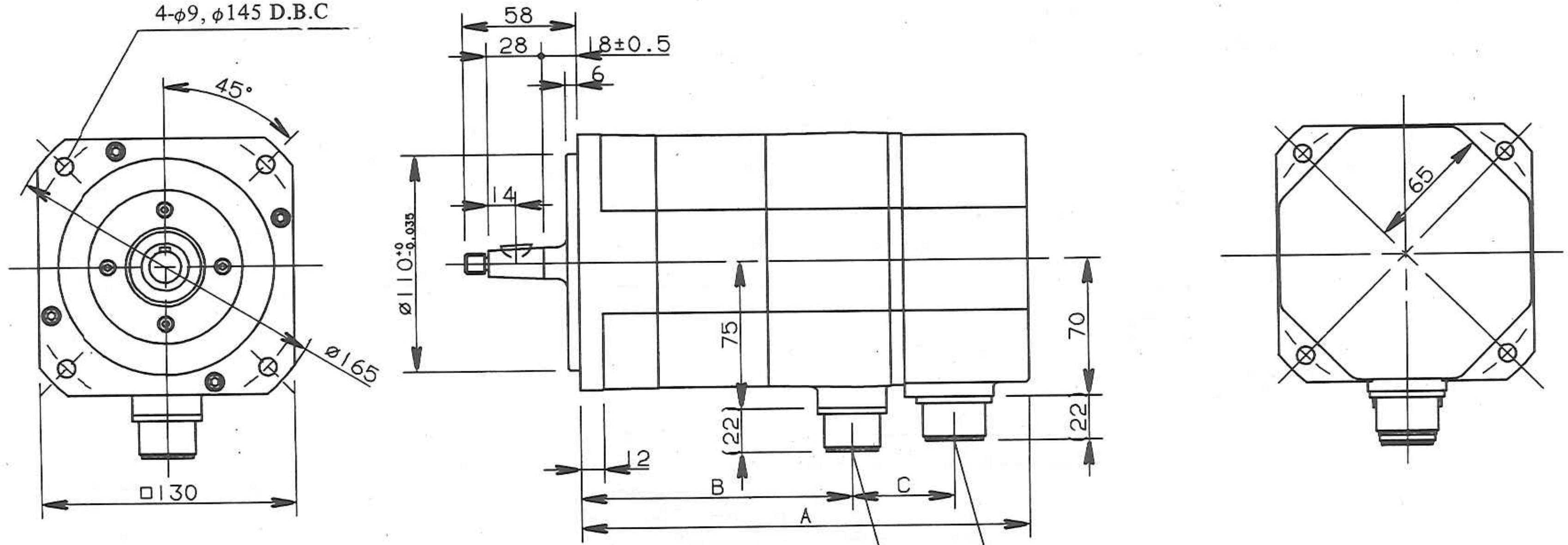
(6) Model 1-0, 2-0 (with absolute pulse coder)

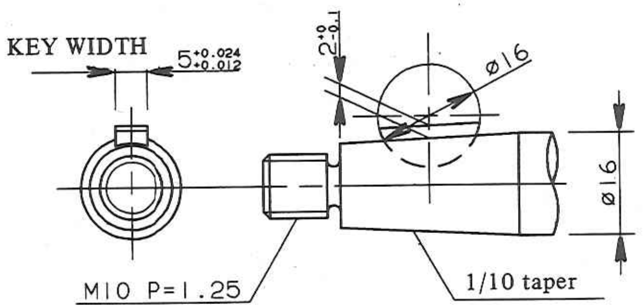


Motor	A	B	C
Model 2 − 0	198	176	88
Model 1 − 0	234	212	124

Note: The position of connector for signal line is shifted in max 5°in order to adjust.

(7) MODEL 0, 5



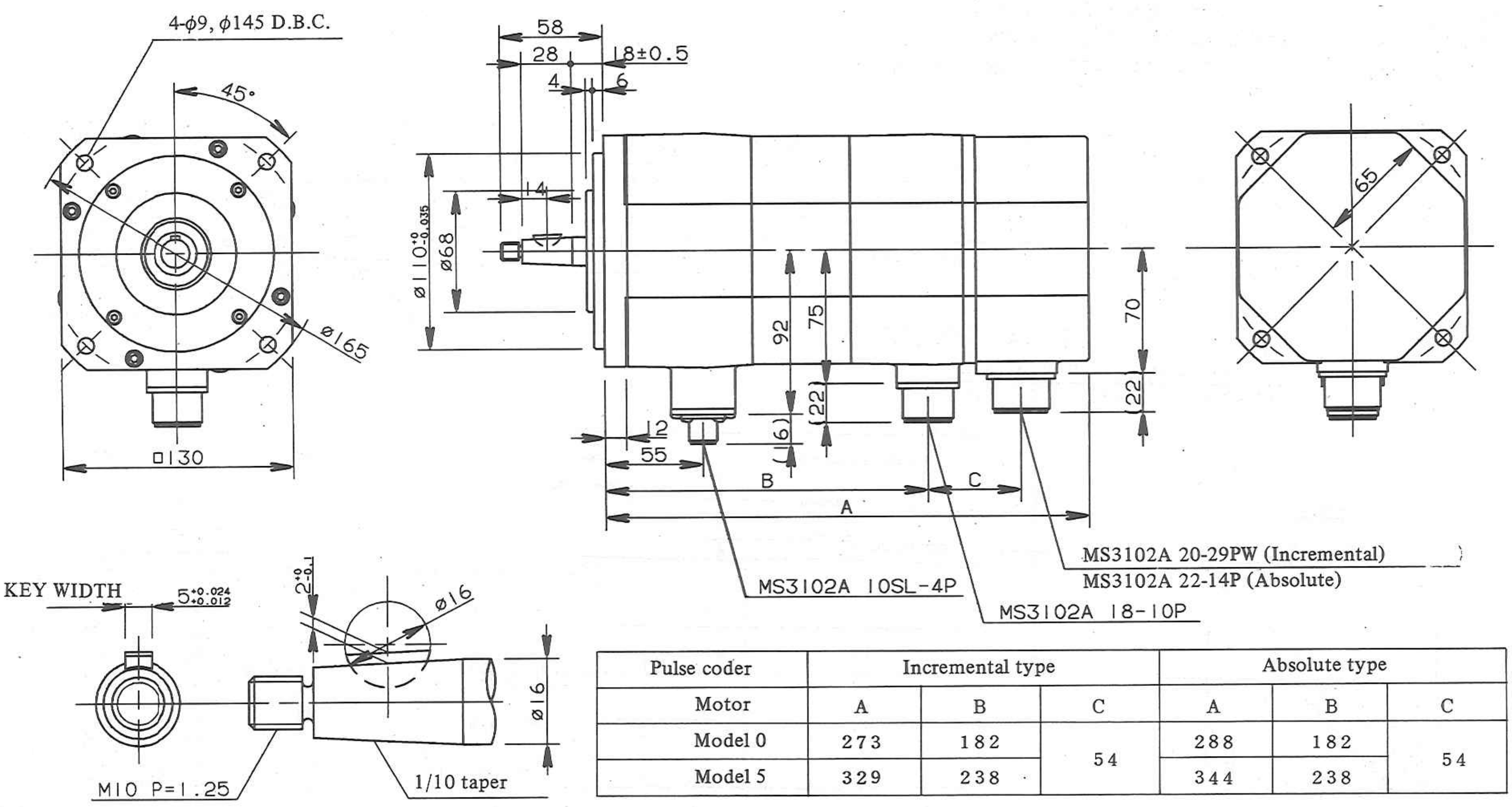


Pulse coder	Incremental type			Absolute type		
Motor	A	B	C	A	B	C
Model 0	230	139	52	245	139	54
Model 5	286	195		301	195	

Note:

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

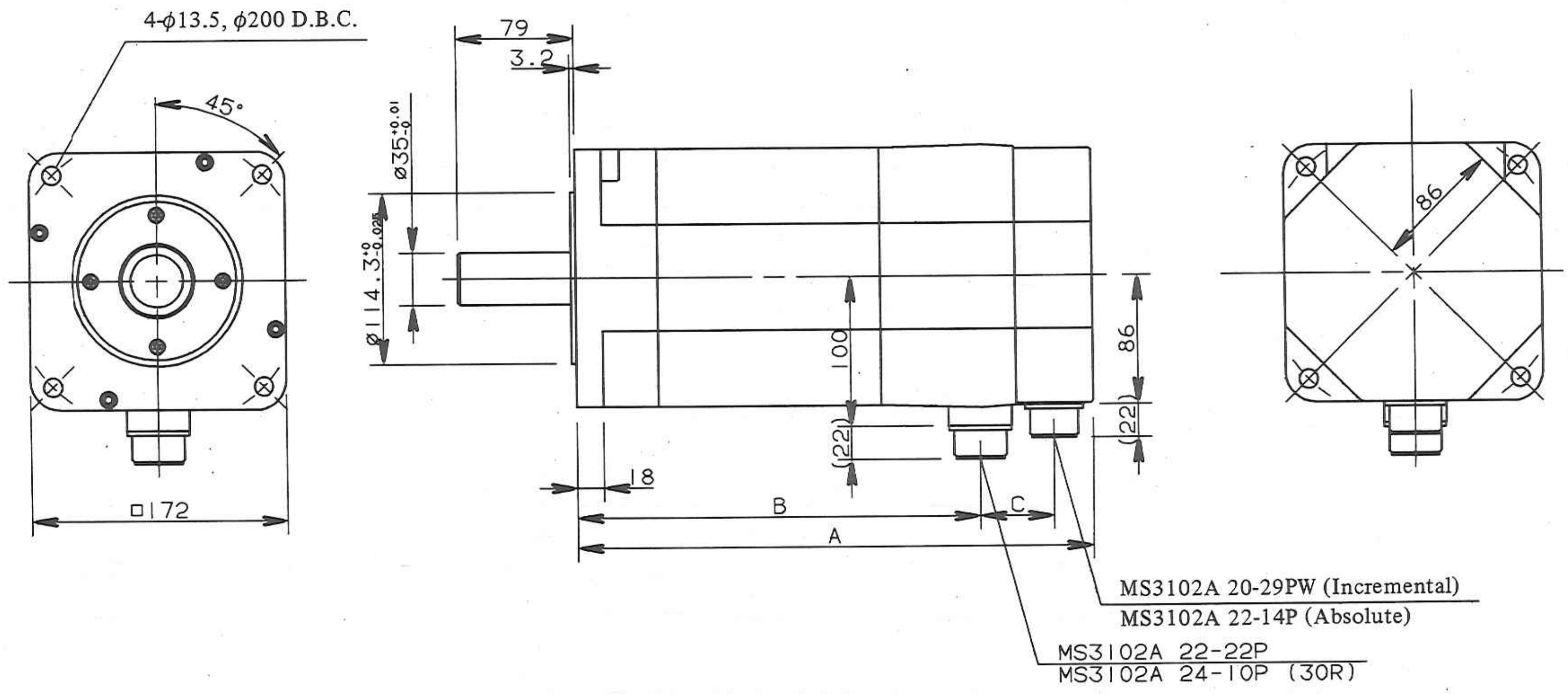
(8) MODEL 0, 5 (with Brake)



Pulse coder	Incremental type			Absolute type		
Motor	A	B	C	A	B	C
Model 0	273	182	54	288	182	54
Model 5	329	238		344	238	

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

(9) MODEL 10, 20M, 20, 30, 30R

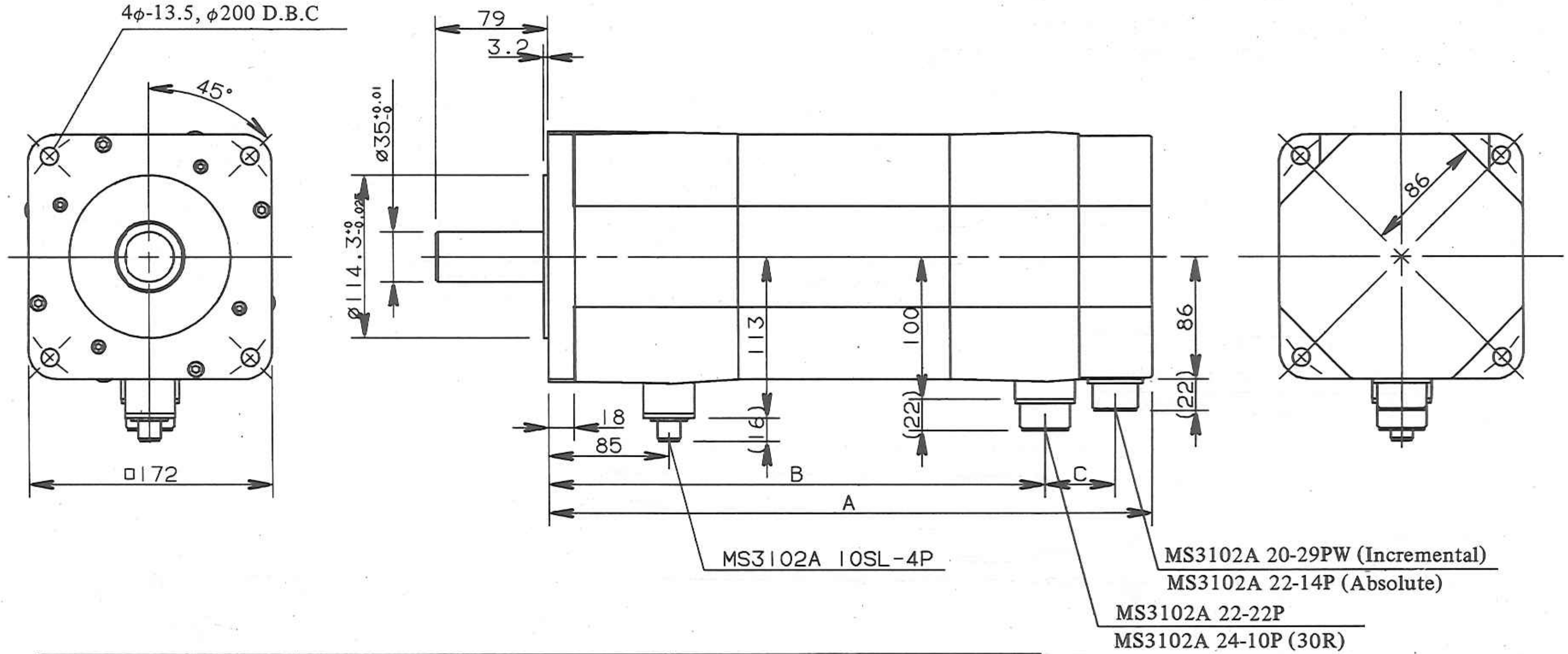


Pulse coder	Incremental type			Absolute type		
Motor	A	B	C	A	B	C
Model 10	271	196	49	286	196	54
Model 20M, 20	346	271		361	271	
Model 30, 30R	421	346		436	346	

Note:

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

(10) MODEL 10, 20M, 20, 30, 30R (with Brake)



Pulse coder	Incremental type			Absolute type		
Motor	A	B	C	A	B	C
Model 10	350	275	49	365	275	54
Model 20M, 20	425	350		440	350	
Model 30, 30R	500	425		515	425	

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

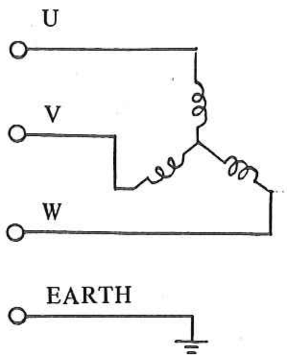
3.4 Motor Connections

(1) POWER LINE

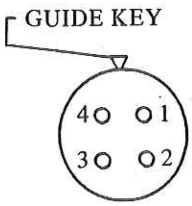
(a) MODEL 5-0, 4-0, 3-0

LEAD WIRE COLOR

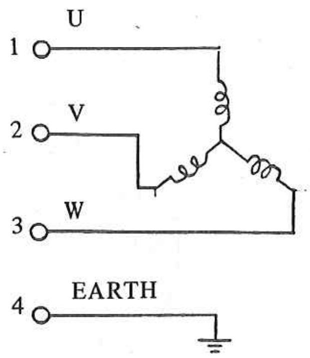
U	RED
V	WHITE
W	BLACK
EARTH	CONNECT WITH MOTOR BODY



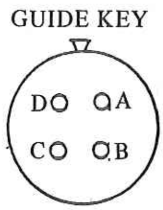
(b) MODEL 2-0, 1-0



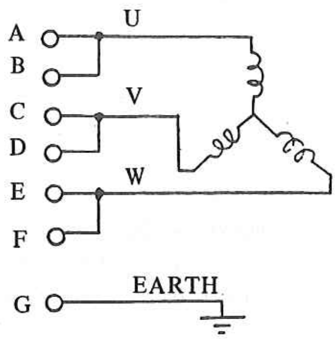
RT15WTR -4P (HIROSE)



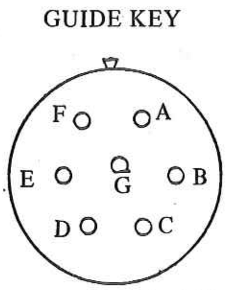
(c) MODEL 0, 5, 10, 20M, 20, 30



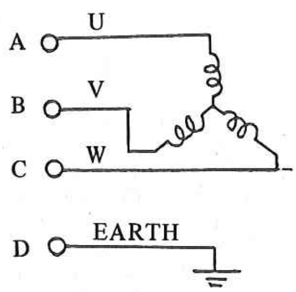
MS3102A 18 -10P (0, 5)
MS3102A 22 -22P (10, 20, 20M, 30)



(d) MODEL 30R

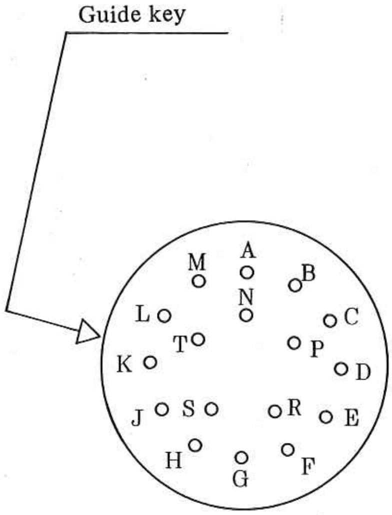


MS3102A 24 -10P



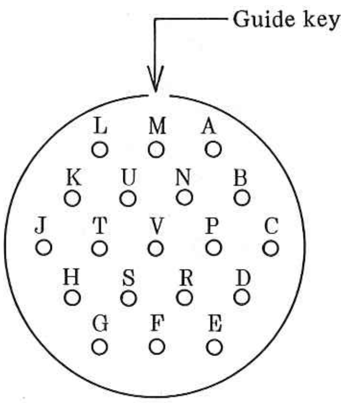
(2) SIGNAL LINE

(a) MODEL 2-0, 1-0, 0, 5, 10, 20M, 20, 30, 30R (Incremental pulse coder)



MS3102A 20-29PW

(b) MODEL 4-0, 3-0, 2-0, 1-0, 0, 5, 10, 20M, 20, 30, 30R (Absolute pulse coder)



MS3102A 22-14P

Signal	Incremental type MS3102A 20-29PW Pin name	Absolute type MS3102A 22-14P Pin name
A	A	A
$\overline{A}$	D	D
B	B	C
$\overline{B}$	E	D
Z	F	E
$\overline{Z}$	G	F
C1	C	G
C2	P	H
C4	L	J
C8	M	K
+5V	J, K	L
0V	N, T	M
Shield	H	N
0H1	R	P
0H2	S	R
REQ		S
+6VA		T
0VA		U

(c) MODEL 4-0, 3-0
(Incremental pulse coder)

Signal	Lead wire color	Signal	Lead wire color
A	Black	+5V	Red
$\overline{A}$	Black/White	+5V	Red/White
B	Blue	0V	Gray
$\overline{B}$	Blue/White	0V	Gray/White
Z	Green	SHIELD	Black
$\overline{Z}$	Green/White		
C1	Yellow/White	OH1	Yellow*
C2	Orange/White	OH2	Yellow*
C4	Brown/White		
C8	Violet/White		

* not included in a encloder cable, but separately lead near power lines.

(d) MODEL 5-0
(Incremental pulse coder)

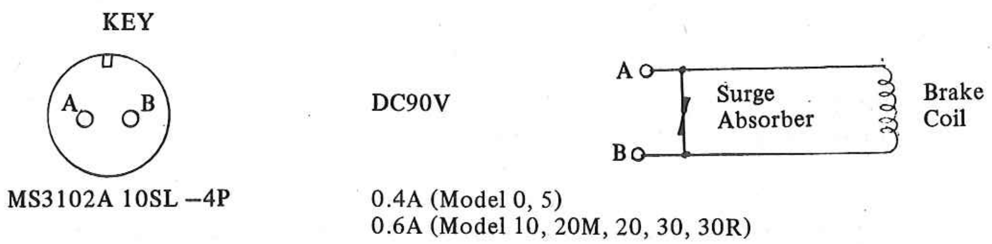
Signal	Lead wire color	Signal	Lead wire color
A	Black	C8	Brown/White
B	Blue	+5V	Red
$\overline{Z}$	Green	0V	Gray
C2	Yellow/White	SHIELD	Black
C4	Orange/White		

(e) MODEL 5-0
(Absolute pulse coder)

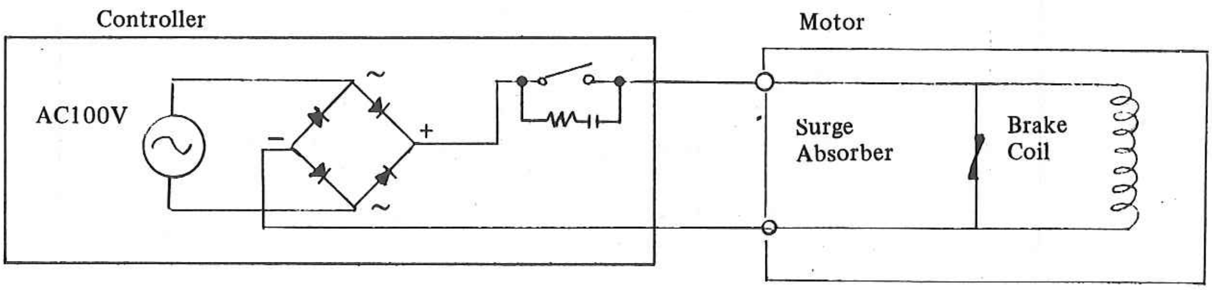
Signal	Lead wire color	Signal	Lead wire color
A	Black	0V	Gray
B	Blue	REQ	Orange
$\overline{Z}$	Green	+6VA	Red/White
C2	Orange/White	0VA	Gray/White
C4	Brown/White	SHIELD	Black (thick)
C8	Violet/White	+6VB	Red (thick) Note 1
+5V	Red	0VB	Gray (thick) Note 1

Note 1: These signals are not included in this encoder cable, through reed wires are provided near by power line.

(3) BRAKE LINE



Note: Brake wiring



4. FEEDBACK DETECTORS

4.1 Built-in Detectors

The built-in feedback detectors of AC servo motor series is pulse coder.

The characteristics of the built-in pulse coder are just the same as those of the external mounting type pulse coder described later, except signals for motor, and mounting dimensions which are made to meet the mounting places. The motor with built-in pulse cocer is controlled by this pulse coder only, i.e. both the velocity and position signal which is required to control the motor is derived from pulse coder, which result in simple and highly reliable servo systems to be composed.

4.2 External Mounting Type Position Detectors

There are cases in which the motor is to be controlled by detecting the rotating position of the ball screw or others on the machine side depending on the characteristics of the machine system. In this case, this type of detector units is mounted on the machine side.

(1) Resolver unit

In this resolver unit, an IX (2-pole) or 2X (4-pole) type resolver with appropriate gear train is employed. Its specifications are shown below.

A290-061-T5□□

24 :	Resolver	2X	Resolver gear ratio	5/1
25 :	"	1X,	"	5/1
31 :	"	2X,	"	4/1
32 :	"	2X,	"	3/1
51 :	"	1X,	"	4/1
52 :	"	1X,	"	3/1

For details, refer to 4.3 (1).

(2) Pulse coder unit

The specifications of this pulse coder unit are as shown below.

A860-0301-T0□□ (Incremental pulse coder)

01 :	Pulse coder	(2000P/rev)
02 :	"	(2500P/rev)
03 :	"	(3000P/rev)

For details refer to 4.3 (2).

A860-0324-T0□□ (Absolute pulse coder)

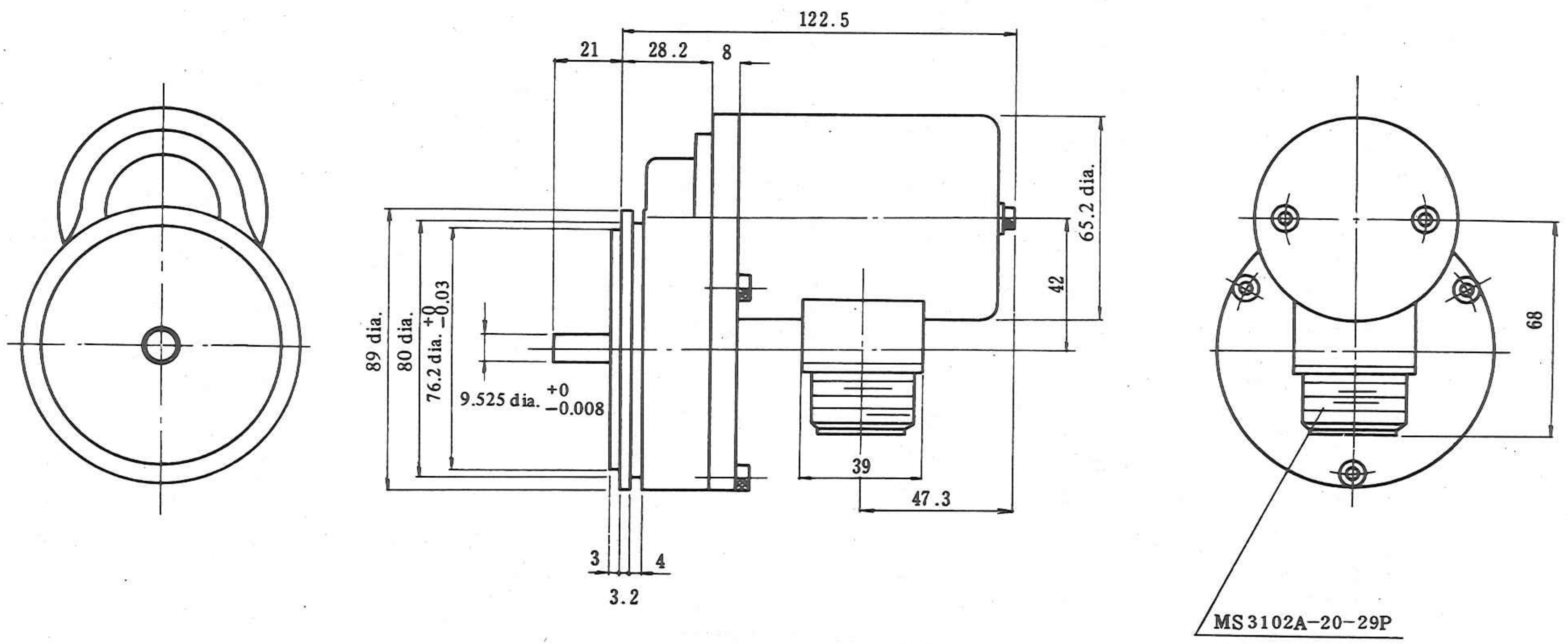
01 :	Pulse coder	(2000P/rev)
02 :	"	(2500P/rev)
03 :	"	(3000P/rev)

For details refer to 4.3 (3).

ABS pulse coder unit can connect with FANUC NC only.

4.3 Outline Drawings

(1) Resolver unit

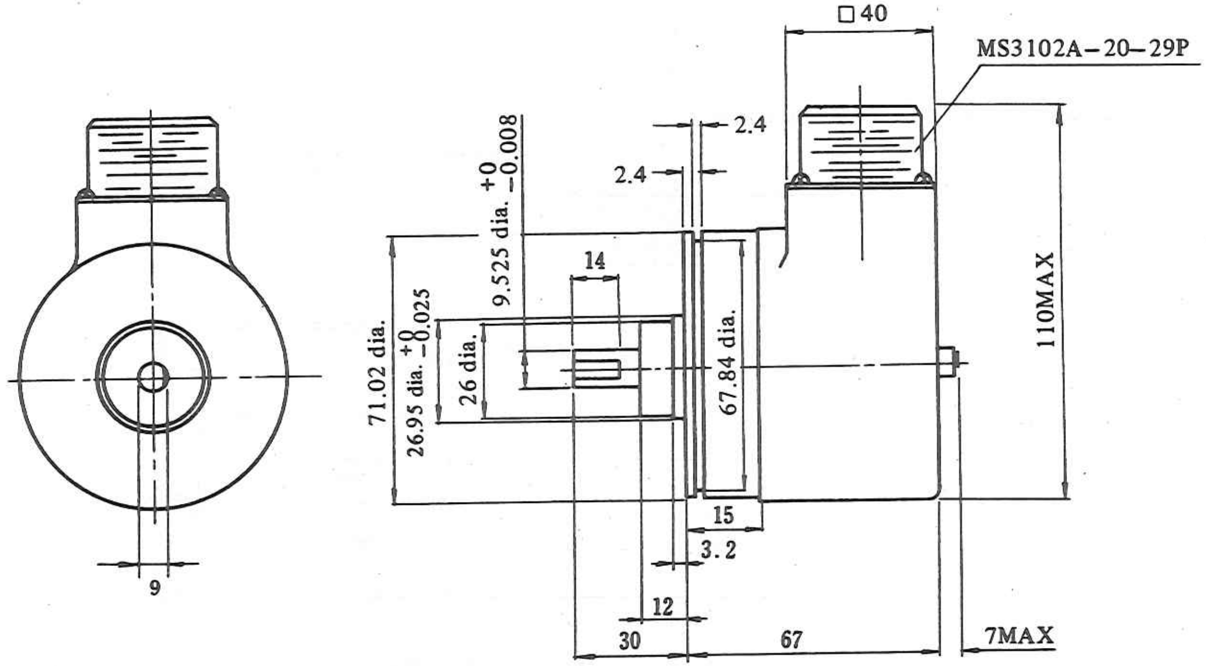


Signal	Terminal No.
S 1	F
S 2	D
S 3	G
S 4	E
R 1	J
R 2	K

Notes: 1. *Rated load* — *Radial 15kg*, *Axial 8kg*
2. *Weight* — *Max. 1.5kg*
3. *Rotor inertia* — *Max. 1.3g·cm·sec²*
4. *Friction torque* — *Max. 0.9kg·cm*

Outline Drawings of Resolver Unit

(2) Pulse coder unit



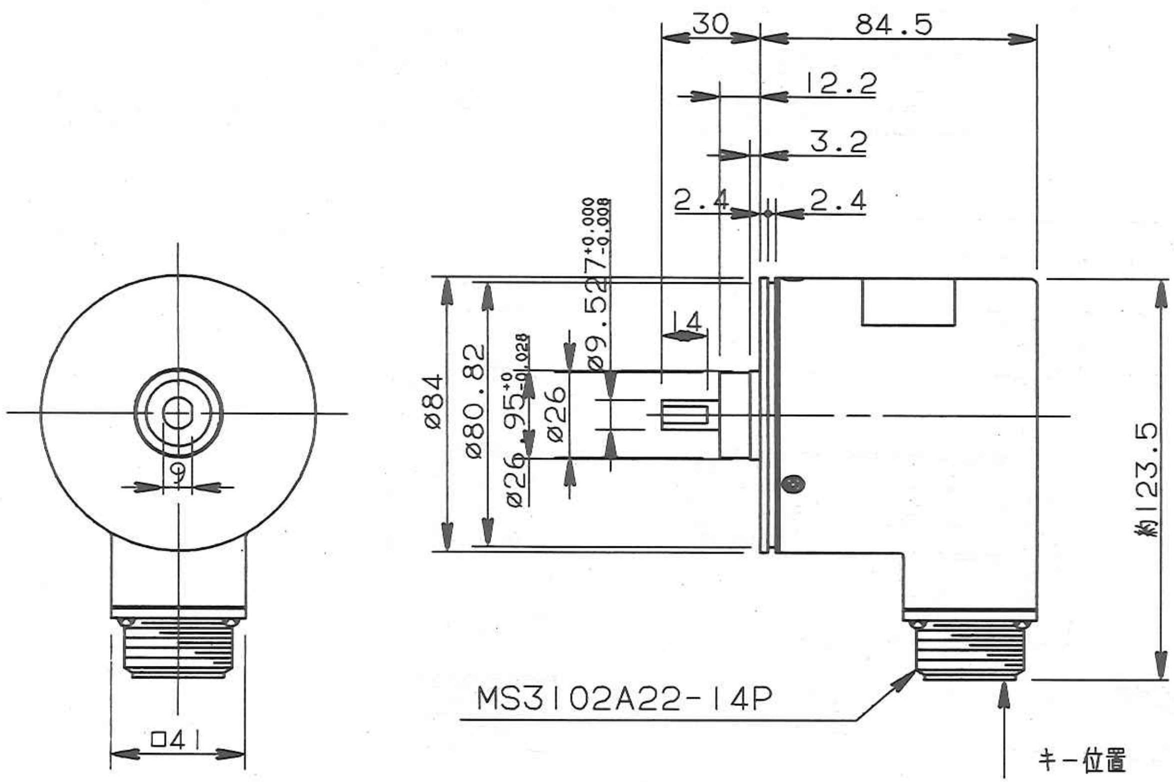
Note: Use flexible coupling.

Signal	Terminal No.
A	A
$\overline{A}$	D
B	B
$\overline{B}$	E
Z	F
$\overline{Z}$	G
+5V	G, J, K
0V	N, P, T
Shield	H

Power supply	5V ±5% 0.35A or less
Output	A, $\overline{A}$, B, $\overline{B}$, Z, $\overline{Z}$
No. of pulses	2000, 2500, 3000P/rev.
Maximum pulse rate	100kHz
Working temperature range	0°C ~ 60°C
Rated loads	Radial 2.0kg Axial 1.0kg
Shaft diameter runout	0.02mm
Weight	2.0kg
Rotor inertia	Max. 0.057g cm.sec^2
Friction torque	Max. 0.8kg.cm

Outline Drawings of Pulse Coder Unit

(3) Absolute pulse coder unit



Signal	Terminal No.
A	A
$\overline{A}$	B
B	C
$\overline{B}$	D
Z	E
$\overline{Z}$	F
C1	G
C2	H
C4	J
C8	K
+5V	L
0V	M
Shield	N
OH1	P
OH2	R
REQ	S
+6VA	T
0VA	U

Note 1) Use flexible coupling
Note 2) Pin Pand R in the MS connector are connected inside

5. INSTRUCTIONS

5.1 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 your machine.

(1) Direct connection through a flexible coupling

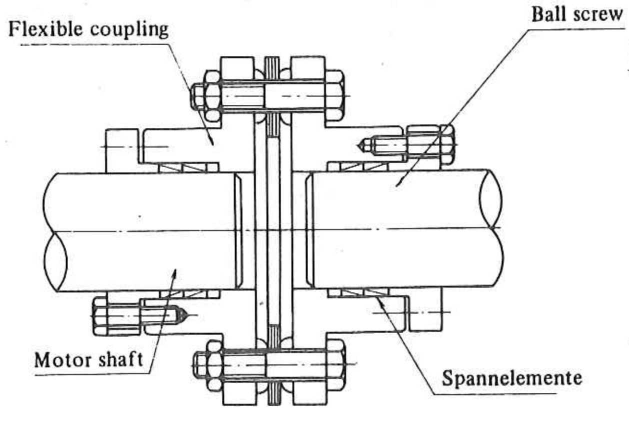
This method has the following advantages as compared to the other two methods:

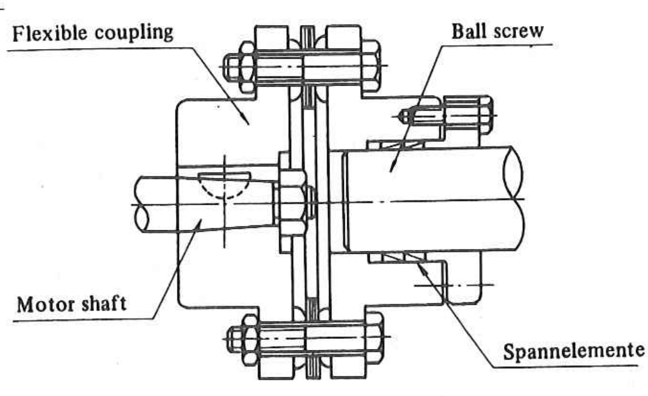
- Economical.
- No adjustment operations are required at assembly process.
- Connecting element generates no noise because of non backlash connection.

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 spannelemente is used to connect the coupling to the shaft. The spannelemente ring makes the connection by the friction generated by fastening the screw. Since there is no backlash or stress concentration, the spannelemente enables stable and reliable connection. The transmission force obtained through the spannelemente 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 spannelemente and make the most suitable design.



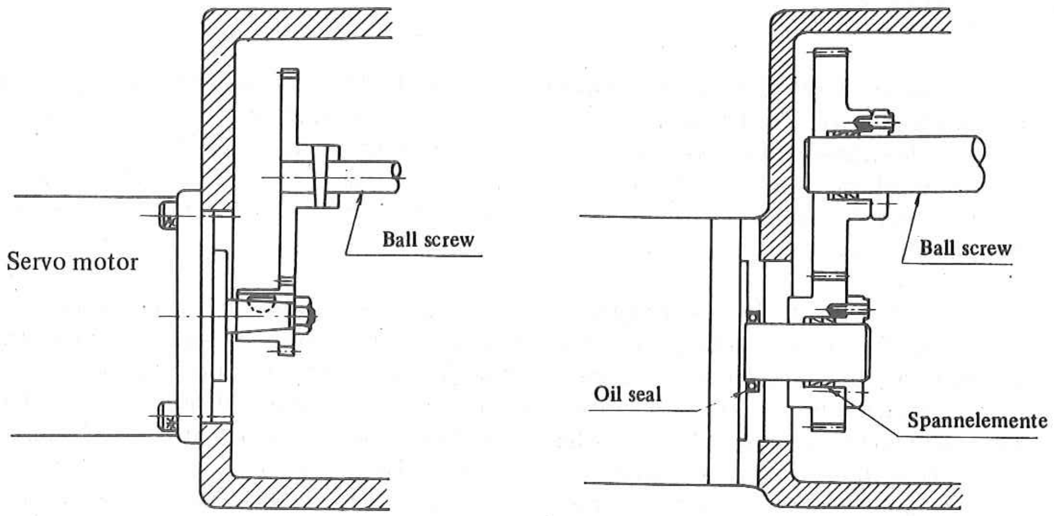


(2) Gear coupling

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.

5.2 Machine Movement per 1 Revolution of Motor Shaft (L)

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.

5.3 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.

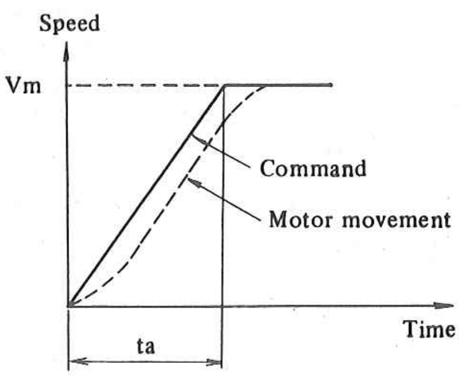
② Acceleration torque is calculated by multiplying the total inertia (motor inertia + load inertia) with acceleration rate.

③ Load torque (friction torque) is added to acceleration torque to obtain the torque necessary for the motor shaft.

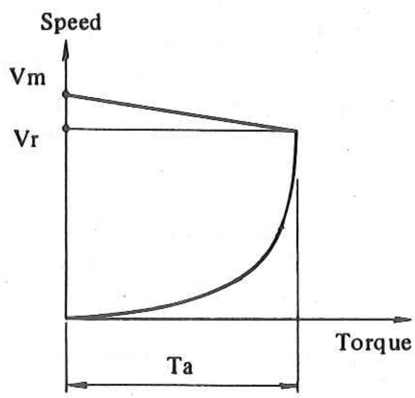
④ It should be confirmed that the torque in Item ③ is less than the maximum motor torque (instantaneous maximum torque), and at the same time, less than the torque limited by the current limit of amplifier.

Acceleration torque in Item ② is calculated with the following equation.

For linear acceleration:



Speed change



Acceleration torque

$$Ta = \frac{Vm}{60} \times 2\pi \times \frac{1}{ta} (Jm + J\ell)(1 - e^{-ks \cdot ta})$$

$$Vr = Vm \left\{1 - \frac{1}{ta \cdot ks} (1 - e^{-ks \cdot ta})\right\}$$

Ta: Acceleration torque (kg•cm)

Vm: Motor speed at rapid traverse (rpm)

ta: Acceleration time (sec)

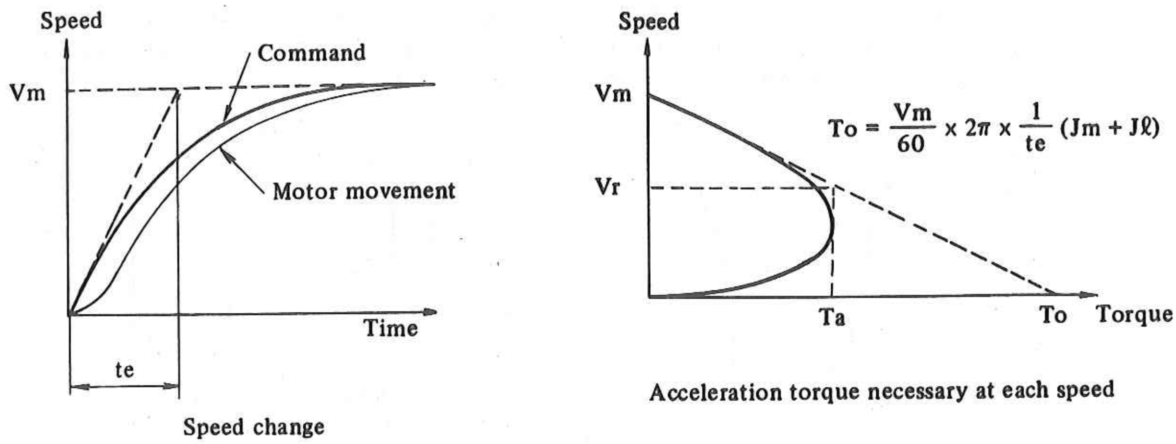
Jm: Motor inertia ($kg \cdot cm \cdot s^2$)

Jℓ: Load inertia ($kg \cdot cm \cdot s^2$)

Vr: Point where acceleration torque starts decreasing (difference from Vm) (rpm)

ks: Servo position loop gain (sec^{-1})

For exponential acceleration:



In case ke = ks where $ke = \frac{1}{te}$ and $a = \frac{ke}{ks}$

$$Ta = \frac{Vm}{60} \times 2\pi \times a^{\frac{1}{1-a}} \times ks \ (Jm + J\ell)$$

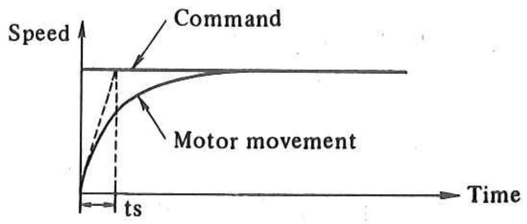
$$Vr = Vm \ (1 - a^{\frac{a}{1-a}})$$

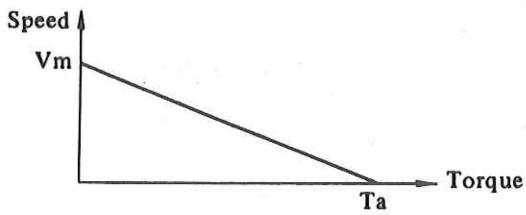
In case ke = ks

$$Ta = \frac{Vm}{60} \times 2\pi \times \frac{ke}{e} (Jm + J\ell), \quad e = 2.718$$

$$Vr = Vm \ (1 - \frac{1}{e}) = 0.632 \ Vm$$

In case the command speed is instanteneously raised



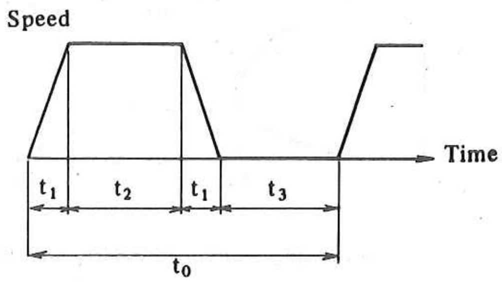


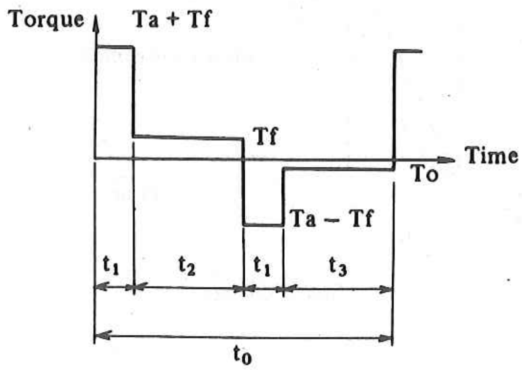
$$Ta = \frac{Vm}{60} \times 2\pi \times \frac{1}{ts} (Jm + J\ell) \quad \text{where } ts = \frac{1}{ks}$$

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.





$$Trms = \sqrt{\frac{(Ta + Tf)^2 t_1 + Tf^2 t_2 + (Ta - Tf)^2 t_1 + T_0{}^2 t_3}{t_0}}$$

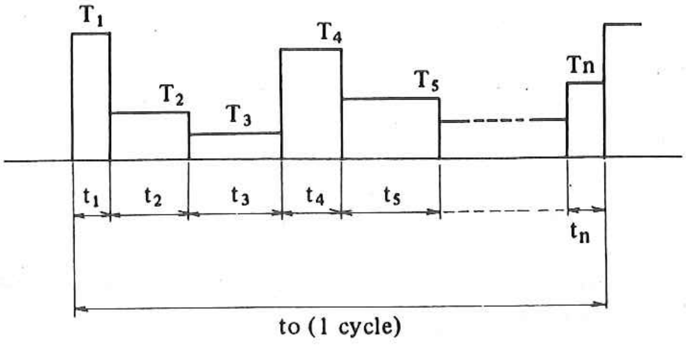
Ta: Acceleration torque

Tf: Friction torque

To: Torque at stop time

Usable if Trms 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.



$$Trms = \sqrt{\frac{T_1{}^2t_1 + T_2{}^2t_2 + T_3{}^2t_3 + \text{------} \; Tn^2tn}{t_0}} \qquad t_0 = t_1 + t_2 + \text{----} + tn$$

(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.

5.4 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.

$$T_M: \frac{F \times \ell}{2\pi\eta} + Tc$$

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)

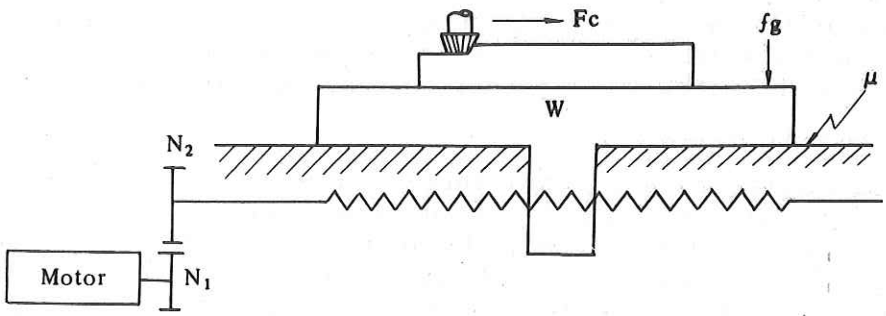
η : Efficiency of drive system

ℓ : Machine movement per 1 rev. of motor shaft

Tc: 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: $F = Fc + \mu\ (W + fg + Fcf)$



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

μ : Friction coefficient

fg : Gib fastening (tightening) force

Fc : Thrust reaction force by cutting force (kg)

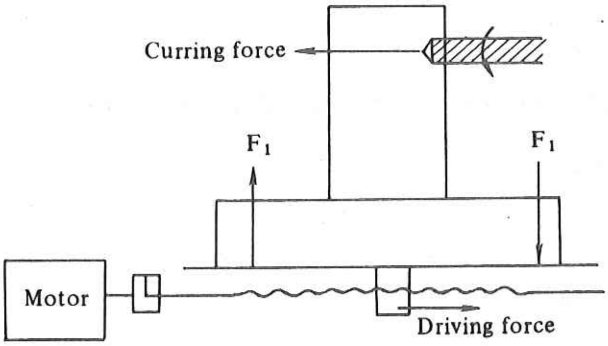
Fcf: Force of the table against the sliding surface by the moment due to the cutting force (kg)

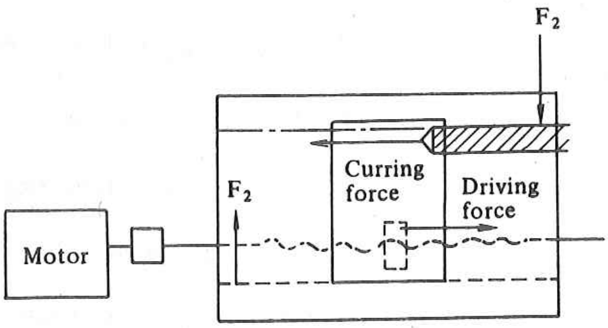
When calculating torque, special attention must be paid to the following points.

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.





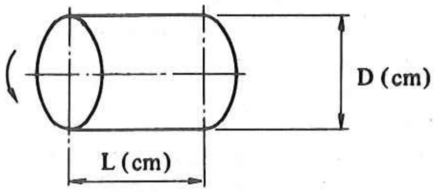
④ Friction torque can be strongly influenced by feed rate. Study and measurement must be made for the friction change due to the change of speed, the table support (sliding, rolling, static pressure), sliding surface material and lubrication conditions to produce the correct value.

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 cylinderical bodies.

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

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

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

J: Inertia ($kg \cdot cm \cdot sec^2$)

γ: Weight per unit volume (kg/cm^3)

D: Diameter of the cylindrical body (cm)

L: Length of the cylindrical body (cm)

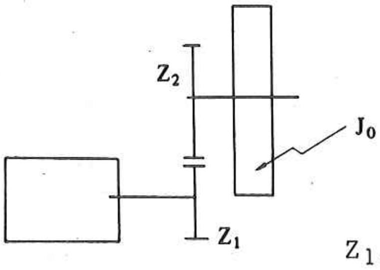
② Intertia of mass moved along linear axis
Inertia of table, work, etc. is applicable and it can be obtained from the following equation.

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

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.

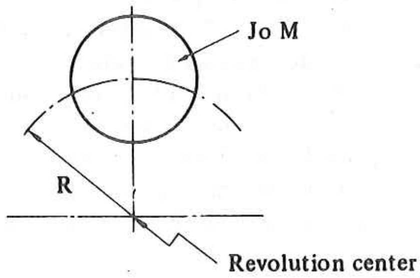


Z_1, Z_2 are the number of teeth of the gear.

Motor shaft conversion of inertia J_0 is as follows.

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

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



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

J_0: Inertia around the center of the cylindrical body ($\mathrm{kg \cdot cm \cdot sec^2}$)

M : Weight of the cylindrical body (kg)

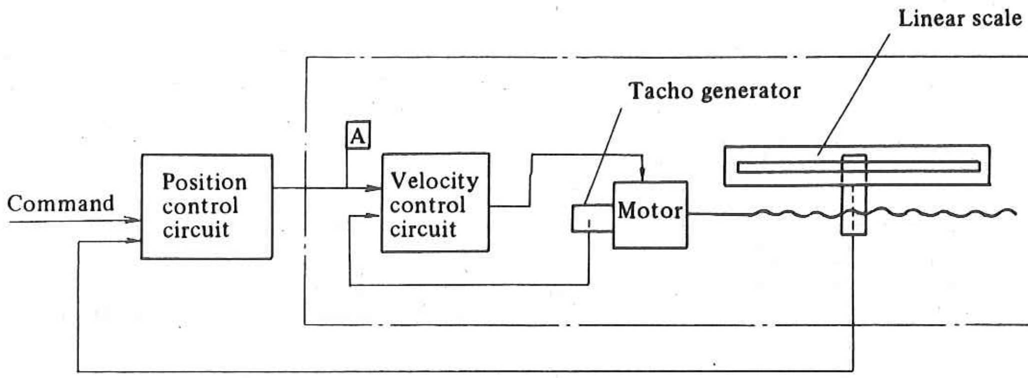
R : Revolution radius (cm)

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.

5.5 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 recolution, 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 4.3, 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.

$$\omega_m = \frac{1}{2\pi}\sqrt{\frac{Km}{J\ell}} \quad (Hz)$$

ω : Natural frequency (Hz)

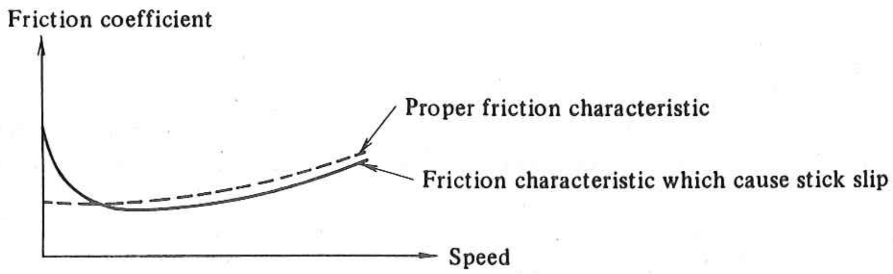
$J\ell$: Load inertia reflected to motor shaft ($kg \cdot cm \cdot sec^2$)

Km: 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 μm.

(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.

5.6 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 by using the attached "DC serve 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 FANUC.

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

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

5.6.1 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) NC equipment

Fill in this blank with the name of FANUC's NC equipment (6T, 6M, 3M, etc.) employed. Enter the cabinet type (self-standing type, separate type, etc.) in ( ).

(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. These blanks will be filled in by FANUC.

5.6.2 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, FANUC 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, if you don't mind.

ⓐ Axis movement direction

Enter the movement directions of driven parts such as table, tool post, etc. Write the angle from the horizontal level, if their movement directions are slant (Example: Slant 60°)
Whether their movement directions are horizontal or vertical (or slant) is necessary for calculating the regenerative energy. Fill in this blank without fail.

ⓑ Weight of driven parts

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

ⓒ Counter balance

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

ⓓ Table support

Enter the type of table slide way whether it is of the rolling, sliding, or static pressure type. If a special slide way material like Turcite is used, note it.

ⓔ Feed screw

Enter the diameter, pitch, and axial length of the feed screw in this order. Example: ϕ40 x 10 x 1500 (when the diameter is 40ϕmm, pitch is 10mm, and axial length is 1500mm)

ⓕ 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. 5.2 ∿ 5.4.

ⓐ 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 x 2/3 = 8mm
* When the gear ratio is 1/72 in rotary table;
360 x 1/72 = 5 deg

This amount is restricted to certain specified values according to NC specifications and detector specifications when the position detector with built-in motor is used.
For details, refer to the descriptions of each NC.

Example: If a 2000P/rev pulse coder is used in NC FANUC SYSTEM 6M; 2mm, (3mm), 4mm, (6mm), 8mm

ⓑ Least input increment of NC

Enter the least input increment of NC command. The standard value is 0.001mm in FANUC SYSTEM 3, 6, and 9.

ⓒ Rapid traverse rate and cutting feedrate

Enter the rapid traverse rate and cutting feedrate required for machine tool specifications.

ⓓ Inertia

Enter a load inertia value converted into the motor shaft value.
For details of this calculation, see para. 5.4.
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 → 0.29 or 0.3)
Don't include any inertia of the motor proper in this value.

ⓔ Load torque

- Since the torque produced in low speed without cutting may be applied even during the stop of motor, a sufficient allowance is necessary as compared with the continuous rated torque of the motor. Suppress this load torque to be lower than 60% of the rated torque.

- 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 commurator may be damaged as a result. Keep this value within the continuous rated area. Don't include any torque required for acceleration/deceleration in this item.

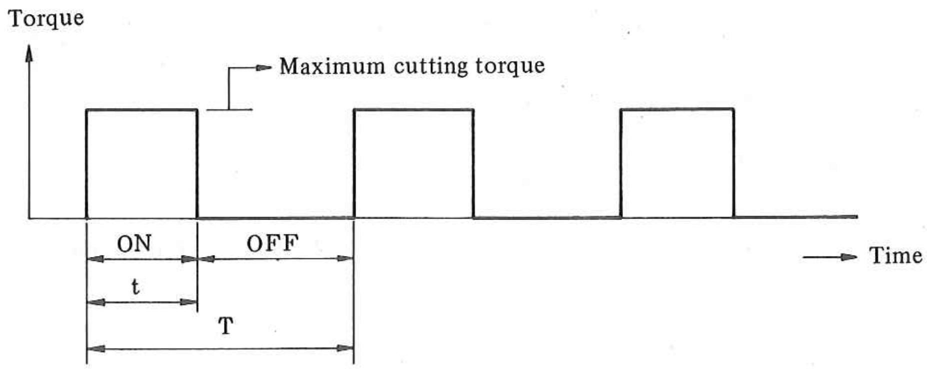
- For the cutting thrust, enter the maximum value of the force being applied during cutting by the force in the feed axis direction.

- For the maximum cutting torque, enter the torque value on the motor shaft corresponding to the maximum value of the above cutting thrust. Since the torque transfer efficiency may substantially deteriorate to a large extent due to the reaction from the slide way, etc. produced by the cutting thrust, obtain an accurate value by taking measured values in similar machine tools and other data into due account.

- If the load torque values differ during lifting and lowering in the vertical axis, enter both values.

(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 x 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.

(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

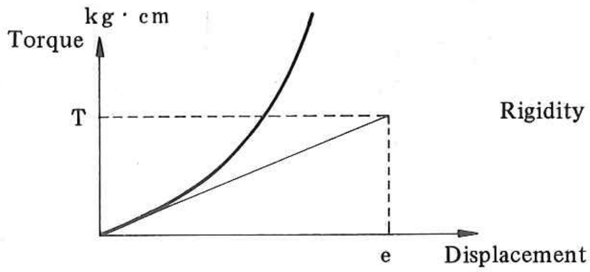
(b) Rigidity of feed system machine tool

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 tanle 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.



ⓒ 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

ⓐ Motor model 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)

Motor model — Feedback

- Motor model:
  - 10 ; Model 10
  - 10B; Model 10 with brake
  - 30R; Model 30R
- Feedback:
  - 2000; Pulse coder 2000 pulses

ⓑ Option, special specifications

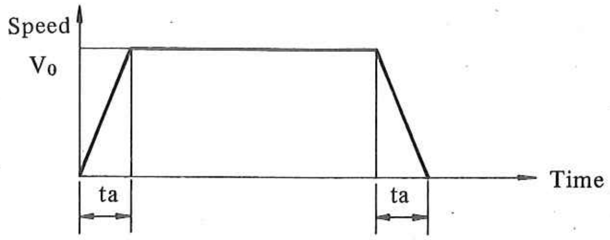
Enter special specifications, if any, in this blank.

(5) No. 6 blank

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

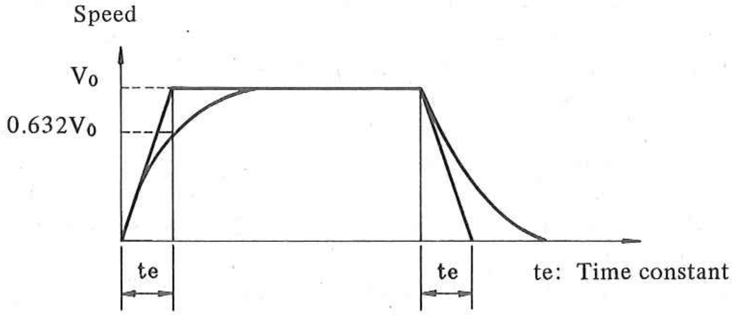
ⓐ Acceleration/deceleration time at rapid traverse

The acceleration/deceleration time is determined according to the load inertia, load torque, motor output torque, and working speed. For details of calculations, refer to para. 5.3.
The acceleration/deceleration mode at rapid traverse is generally linear acceleration/deceleration in FANUC's NC.



ⓑ Acceleration/deceleration time at cutting feed

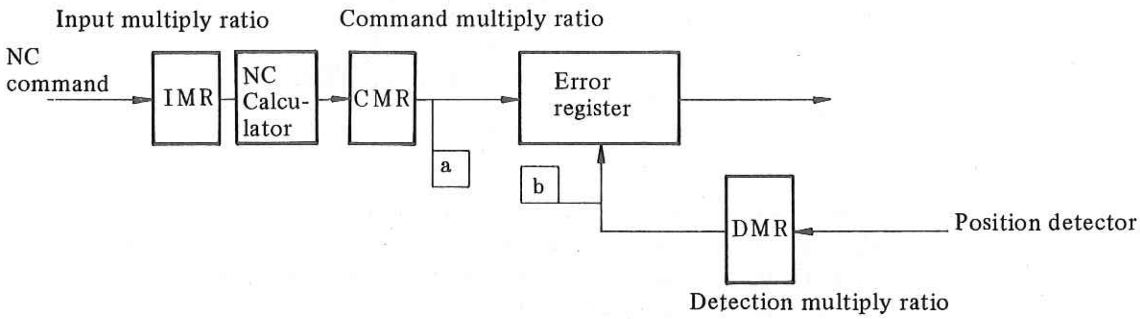
The acceleration/deceleration at cutting feed is expotential acceleration/deceleration in general. This blank is filled in with its time constant.



(6) No. 7 blank

ⓐ 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)

$IMR_1 = 1$, $CMR_2 = 1$, and $DMR_3 = 4$, if the least input increment of NC is 1μ, the move amount of the machine tool per revolution of motor is 8mm, and pulse coder 2000P/rev is used.

ⓑ 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. 8 blank

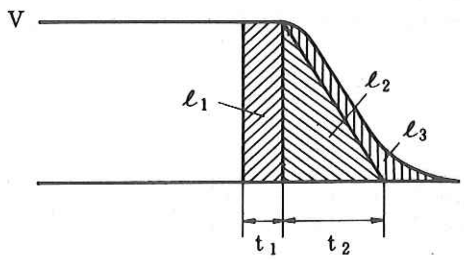
The coasting distance of the machine tool at the machine tool stroke end is entered in this blank. The stroke end is usually limited in 2 steps consisting of the deceleration stop in the first step and dynamic brake stop in the second step.

The position display accurately coincides with the stop position of the machine tool when the first step limit switch is depressed. However, this position is lost when the second step limit switch is depressed.

Mount this second limit switch without fail for preventing the machine tool from being damaged, because it is only one means of stopping the machine tool, if the machine tool should run away due to a control failure.

ⓐ Deceleration stop distance

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

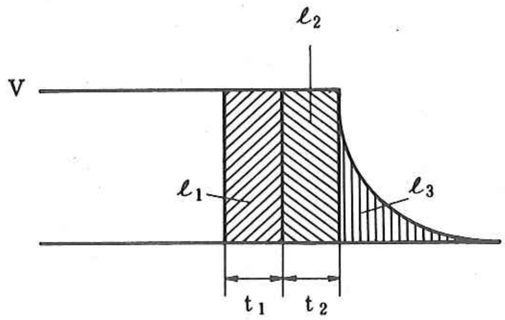


V : Rapid traverse feedrate mm/min
ℓ_1: Coasting distance due to delay time t_1 of receiver
ℓ_2: Coasting distance due to deceleration time t_2
ℓ_3: Servo deflection amount

Coasting distance = $\frac{V_m}{60} \times (t_1 + \frac{l_2}{2} + \frac{1}{Ks})$ Ks Position loop gain sec^{-1}

ⓑ 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
$\ell 1$: Coasting distance due to delay time t_1 of receiver
$\ell 2$: Coasting distance due to operation time t_2 of magnet contactor
$\ell 3$: Coasting distance by dynamic braking after magnet contactor has been operated

$$\text{Coasting distance} = \frac{V_m}{60}(t_1 + t_2) + (J_m + J_L) \cdot (ANo + BNo^3) \times L$$

Model	A	B	Jm ($kg \cdot cm \cdot s^2$)
5-0	1.87	1.4×10^{-8}	3.0×10^{-5}
4-0	0.43	2.7×10^{-8}	3.8×10^{-4}
3-0	0.15	1.7×10^{-8}	7.4×10^{-4}
2-0	3.8×10^{-2}	1.7×10^{-8}	3.7×10^{-3}
1-0	1.3×10^{-2}	6.4×10^{-9}	6.1×10^{-3}
0	9.5×10^{-3}	3.2×10^{-9}	0.020
5	3.3×10^{-3}	1.7×10^{-9}	0.038
10	3.5×10^{-3}	1.6×10^{-9}	0.10
20M, 20	1.6×10^{-3}	7.2×10^{-10}	0.17
30	7.5×10^{-3}	6.2×10^{-10}	0.24
30R	3.0×10^{-3}	2.1×10^{-9}	0.24

Jm: Motor inertia $kg \cdot cm \cdot s^2$
J_L: Load inertia $kg \cdot cm \cdot s^2$
No: Motor speed at rapid traverse rpm
L: Machine travel distance per motor revolution mm or deg.

Here, there is a relation No_L = Vm.
A and B are constants related to each model of motor, and the values for each model are as shown below.

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 $kg \cdot cm \cdot s^2$					
	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					
	Option/special specifications					
5	Amplifier type					
	Transformer					
	Specifications	Amplifier				
		Regenerative unit				
6	Acceleration/deceleration time at rapid traverse msec					
	Acceleration/deceleration time at cutting feed msec					
7	Input multiply ratio					
	Command multiply ratio					
	Detection multiply ratio					
	Position loop gain Sec^{-1}					
8	Deceleration stop distance					
	Dynamic brake stop distance					

Remarks

Version	Date	Name
1		
2		
3		

A. Ar 1870-

FANUC LTD.

5.7 Other Cautions

5.7.1 Outline

As a rule, AC servo motor is free from periodic maintenance because wearing parts are not included. But AC servo motor contains precise detector, so false operation or damage in transit might cause failure or trouble. It is recommended to check the motor referring to this manual at every chance.

5.7.2 Acceptance and storage

Immediately upon receipt of servo motor, check the following items.

- o Whether servo motor is exactly the specified one (check the type, detector type).
- o Whether there is any mechanical damage sustained in transit or not.
- o Whether the rotating part can be normally turned by hand.
- o In the case of the motor with brake, whether the brake is normal.
- o Whether there is any loosened screw or play.

Every servo motor undergoes strict inspection before shipment, therefore any special receipt inspection may not be required as a rule. If the receipt inspection is particularly needed, however, it is advisable to refer to the specifications regarding the wiring of servo motor and detector, current, and voltage so as to make the inspection without any mistake. Don't leave the received servo motor outdoors, but preserve it indoors. Avoid storing it in the place with an extremely high or low humidity, a radical change of temperature, and dust.

5.7.3 Mounting

Note the following points when mounting the servo motor.

(1) The water-proof structure of servo motor is not so strict. If cutting oil, lubricating oil, etc. penetrate into the inside of the motor, these may cause poor insulation, short-circuit of the coil. Therefore, due care should be taken so that the motor body will be kept away from such liquids as cutting oil and so on.

(2) When mounting the servo motor on the gear box where liquid lubrication is performed, if the lip of the oil seal is always exposed to oil, there is a possibility that the oil may penetrate little by little into the inside of the motor in the course of a long time. Therefore the height of the oil level must be lower than the oil seal lip. When the servo motor is mounted with the output shaft upward, mount another oil seal at machine side so as to make the structure where the oil which passed through the first oil seal can directly flow outside.
The oil seal used for the respective servo motors are listed in the following.

Motor model	Oil seal specification
1-0, 2-0	AB0598E0 (SB type)
0, 5	AB1314F0 (SB type)
10, 20M, 20, 30, 30R	AB2057G0 (SB type)

The oil seals used for the servo motors are the products of JAPAN OIL SEAL INDUSTRY Co., Ltd.

(3) The servo motor is coupled with the load through the direct coupling, gears, timing belt or such. In any case the force exerted on the motor shaft must not exceed the values shown in the following table, therefore due care should be taken for the operating condition, mounting method, and mounting accuracy.

Motor model	Permissible radial load
5-0	4 kg
3-0, 4-0	8 kg
1-0, 2-0	25 kg
0, 5	75 kg
10, 20M, 20, 30, 30R	450 kg

o The values of permissible radial loads are the ones when the load is imposed on the end of the shaft.

The values in this table indicate the maximum permissible loads which are the sum of the constant force always exerted on the shaft owing to the mounting method (e.g., the force given by the tension of the belt when the belt coupling is used) and the force generated by the load torque (e.g., the force transmitted from the gear face).

o As a rule, axial load to the shaft should be avoided. Servo motor contains precise detectors, so excess axial shock may give damage to detectors.

(4) Make the wiring between the servo motor and the control circuit without any mistake, just as specified in the specifications. (See the connection diagram of the machine.) A mistake made in the wiring may cause runaway or abnormal oscillation and may give damage to the motor or the machine. When the wiring is completed, measure the insulation between the power line and the motor frame before turning on the power. The measurement should be make with a 500V megger. Further, check the insulation between the signal lines and the motor frame with a multi-tester. Be sure not to use a megger especially for measuring the insulation of the signal lines for the pulse coder.

II. FANUC AC SERVO UNIT

1. GENERAL

FANUC AC servo unit has been specially designed and developed for machine tools and industrial robots as the drive unit for FANUC 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 function using no-fuse breaker, overcurrent alarm, detection of abnormal velocity feedback, detection of unusual high voltage, detection of 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, mounting design and maintenance.

Note 1: For applications expected so large regenerative discharge energy, separate regenerative discharge unit is available.

2. CONSTRUCTION

The AC servo unit consists basically of the velocity control unit and power transformer. In addition, the separate regenerative discharge unit may be required according to the load conditions.
Eight types of velocity control units are available according to AC servo motor models employed, and one velocity control unit applies to each servo motor. Six types of power transformers are also prepared according to the servo motor models, their combinations, loads, and primary input voltages. One power transformer applies to one to three servo motors.
Fig. 2.1 shows are example of the structure of the AC servo unit in a two-controlled axes NC system.

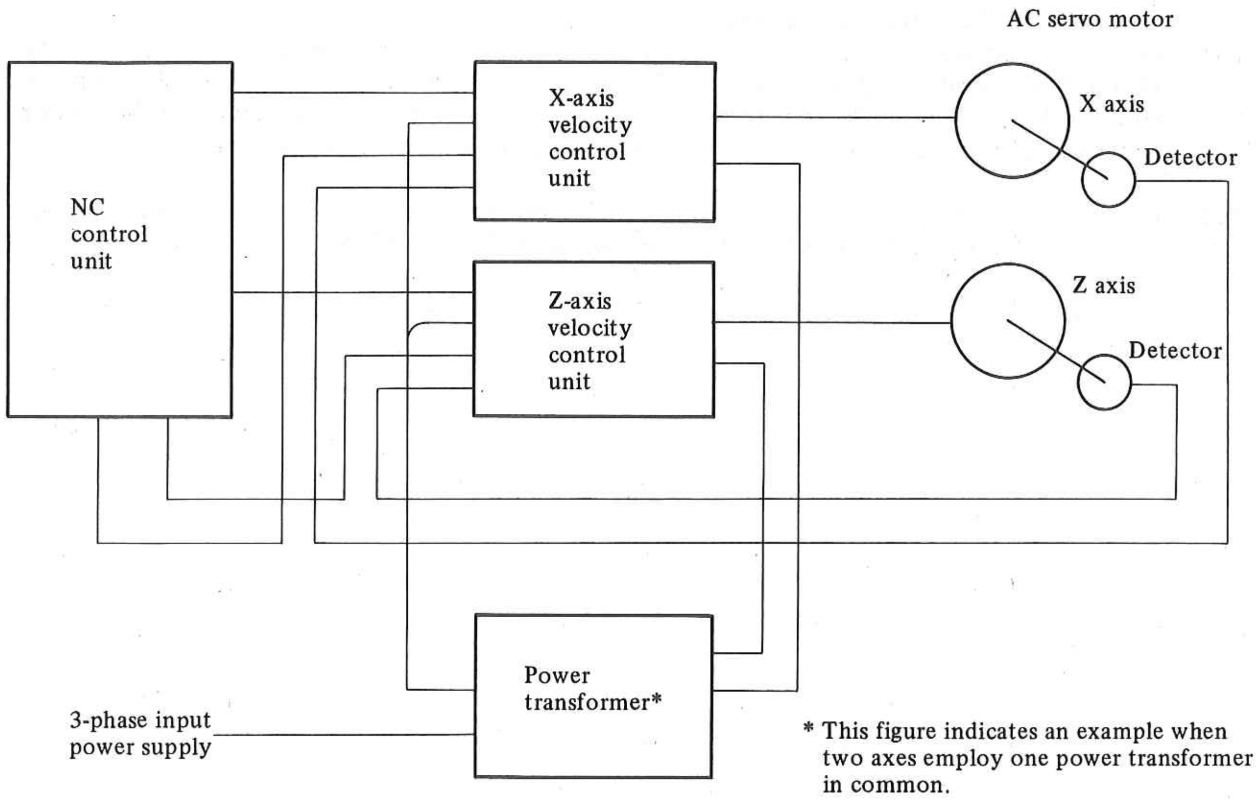


Fig. 2.1 Example of AC servo unit structure

2.1 Models and Designated Specifications of Units

Table 2.1 (a)

<table>
<tr><th colspan="3">Name</th><th>Specifications</th></tr>
<tr><td rowspan="8">Velocity control unit</td><td colspan="2">For Model 5-0</td><td>A06B-6050-H301</td></tr>
<tr><td colspan="2">For Model 4-0, 3-0</td><td>A06B-6050-H001</td></tr>
<tr><td colspan="2">For Model 2-0, 1-0</td><td>A06B-6050-H002</td></tr>
<tr><td colspan="2">For Model 0, 5</td><td>A06B-6050-H102</td></tr>
<tr><td colspan="2">For Model 10</td><td>A06B-6050-H103</td></tr>
<tr><td colspan="2">For Model 20M</td><td>A06B-6050-H113</td></tr>
<tr><td colspan="2">For Model 20, 30</td><td>A06B-6050-H104</td></tr>
<tr><td colspan="2">For Model 30R</td><td>A06B-6050-H005</td></tr>
<tr><td rowspan="3">Power Transformer</td><td rowspan="3">For all the countries 190V-550V</td><td>Transformer AAE</td><td>A06B-6050-H021</td></tr>
<tr><td>Transformer ABE</td><td>A06B-6050-H022</td></tr>
<tr><td>Transformer ACE</td><td>A06B-6050-H023</td></tr>
<tr><td colspan="3">Separate regenerative discharge unit*</td><td>A06B-6050-H050</td></tr>
<tr><td rowspan="2">Input connector**</td><td colspan="2">Soldering type</td><td>A06B-6050-K100</td></tr>
<tr><td colspan="2">Climp type</td><td>A06B-6050-K103</td></tr>
<tr><td>Spare part A</td><td colspan="2">Fuse for P.C.B.</td><td>A06B-6050-K101</td></tr>
</table>

* The unit (A06B-6050-H005) for model 30R normally needs the separate regenerative discharge unit.

** The input connector is used for the cable 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 (climp type).

Table 2.1 (b) Parts included input connector (soldering type)

Name	Q'ty	Use	Model	FANUC specifications
Connector and cover	1	CN1	MR-20LFH *	A63L-0001-0134/02
Connector and cover	1	CN5	MR-20LWMH *	A63L-0001-0134/15
Connector and cover	1	CN6	MR-20LWFH *	A63L-0001-0134/05
Housing	1	CN2	SMS6PW-5 **	A63L-0001-0202/6W
Pin	5	CN2	RC16M-SCT3**	A63L-0001-0226

* Manufacturer: HONDA Tsushin Co., Ltd.
** Manufacturer: Burndy Japan Co., Ltd.

Table 2.1 (c) Parts included input connector (climp type)

Name	Q'ty	Use	Model	FANUC specifications
Connector and cover	1	CN1	MR-20L,MRP-20F01 *	A63L-0001-0134/22
Connector and cover	1	CN5	MR-20LW,MRP-20M01*	A63L-0001-0134/35
Connector and cover	1	CN6	MR-20LW,MRP-20F01*	A63L-0001-0134/25
Contact	40	CN1,6	MRP-F112 *	A63L-0001-0135/F112
Contact	20	CN5	MRP-M112 *	A63L-0001-0135/M112
Housing	1	CN2	SMS6PW-5 **	A63L-0001-0202/6W
Pin	5	CN2	RC16M-S23A **	A63L-0001-0127/S23A

3. SPECIFICATIONS AND FUNCTIONS

3.1 Specifications

Table 3.1

Item	Specifications							
Applicable motor model	5-0	3-0 4-0	1-0 2-0	0,5	10	20M	20,30	30R
Rated output current (peak value) Note 1	0.7A	1.4A	4A	15A		22A	30A	40A
Input power supply / Transformer input / For Japan	-	3-phase 200/220V						
Input power supply / Transformer input / For other countries	-	3-phase 190/230/380/420/460/550						
Input power supply / Transformer input / Allowable voltage fluctuation	-	+10%, -15%						
Input power supply / Transformer input / Allowable frequency	-	±2Hz						
Input power supply / AC 100V	50Hz±2Hz 100V +10/-15%, 60Hz±2Hz 100 ∿ 110V +10/-15%							
Main circuit system	Transistor bridge							
Control system	Sine wave PWM control							
Velocity command voltage	3.5V/1000rpm		3.5V/1000rpm or 7V/1000rpm					
Velocity feedback voltage	1.5V/ 1000rpm	3.0V/1000rpm						
Current limit value Note 2	2A	3A	12A	45A		Note 4 45A	Note 3 80A	Note 3 90A
Alarm, protective function	Various functions							
Ambient temperature range	0°C ∿ +40°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%.

Note 3: If the velocity command is given by step function, the current limit setting of the PCB for model 20, 30, 30R should be changed to 60A limit or less because of discharge capacity.

Note 4: This value is effective from PCB A16B-1000-0560/11F edition.
This value is 40 before PCB A20B-1000-0560/10E edition.

Note 5: The velocity control unit for model 5-0 employs AC 100V only as a input power.

3.2 Protection and Fault Detecting Function

The AC servo unit provides the following functions to protect the motor from being overloaded and also detecting abnormal conditions inside the servo loop.

Table 3.2

No.	Kinds of functions	Indications	Description
1	Overload	Contacts' signal comes out at connector CN1	If the temperature of the radiation fin of the unit exceeds the set value to operate the thermostat or if the thermostat of power transformer operates, or if the thermostat of motor operates, this overload alarm is generated.
2	Velocity feedback disconnection detection	Light-emitting diode (LED) TG lights	If the feedback cable is disconnected, TG lamp lights. If a motor does not make a speedy start because of extremely large motor torque, the motor is stopped by dynamic braking with this alarm lamp lit.
3	No-use breaker	On button of NFB is protruded	If an abnormal current exceeding the operating current of no-fuse breaker flows, this NFB operates, causing the motor to be stopped by dynamic braking.
4	High voltage alarm	LED HV lights	If the DC voltage of the main power supply is abnormally high, the motor is stopped by dynamic braking with HV lamp lit.
5	Low voltage alarm	LED LV lights	If control voltage is abnormally low, or if the fuse for +5V on the PCB has blown out, the motor is stopped by dynamic braking with LV Lamp lit.
6	Circuit faul detection	LED HC lights	If abnormal current flows to the main circuit, the motor is stopped by dynamic braking with HC lamp lit.
		LED DC lights	If the regenerative discharge circuit becomes defective, the motor is stopped by dynamic braking with DC lamp lit. If the acceleration/deceleration rate is too high, DC lights.
7	Overcurrent alarm	LEC OVC lights	If current exceeding specified value is continuously applied longer than a certain time, the motor is stopped by dynamic braking with OVC lamp lit.

4. SELECTION METHOD OF POWER TRANSFORMER AND SEPARATE DISCHARGE UNIT

The power transformer must 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 para. 9.

4.1 Number of Axes and Power Transformers Employed

Table 4.1

No. of axes	No. of power transformers employed	Remarks
2 axes	1 - 2 units	See 4.2
3 axes	1 - 3 units	See 4.2
4 axes	2 - 4 units	See 4.2

4.2 Motors and Power Transformers Employed

Table 4.2

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.

4.3 Separate Discharge Unit

When the energy being regenerated from motor is large, separate discharge unit is required. Separate discharge unit have the capacity of three times larger than standard discharge circuit in the velocity control unit.

4.3.1 Move Direction of Axis Is Horizontal

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

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

In the equation (1),

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

$J = J_m + J_L$

Jm: Rotor inertia of motor ($kg \cdot cm \cdot sec^2$)
J_L: Motor axis conversion inertia of load ($kg \cdot cm \cdot sec^2$)
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 Move Direction of Axis is Up-Down

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

R = P + Q

P : Given in 2.2, (1)

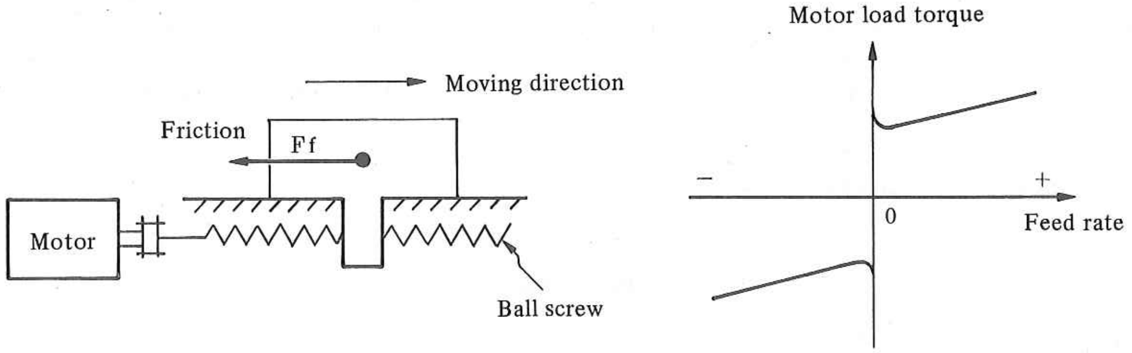
$$Q = 1.026 \times 10^{-2}\ ThV_m \times \frac{D}{100} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

In the equation (2),

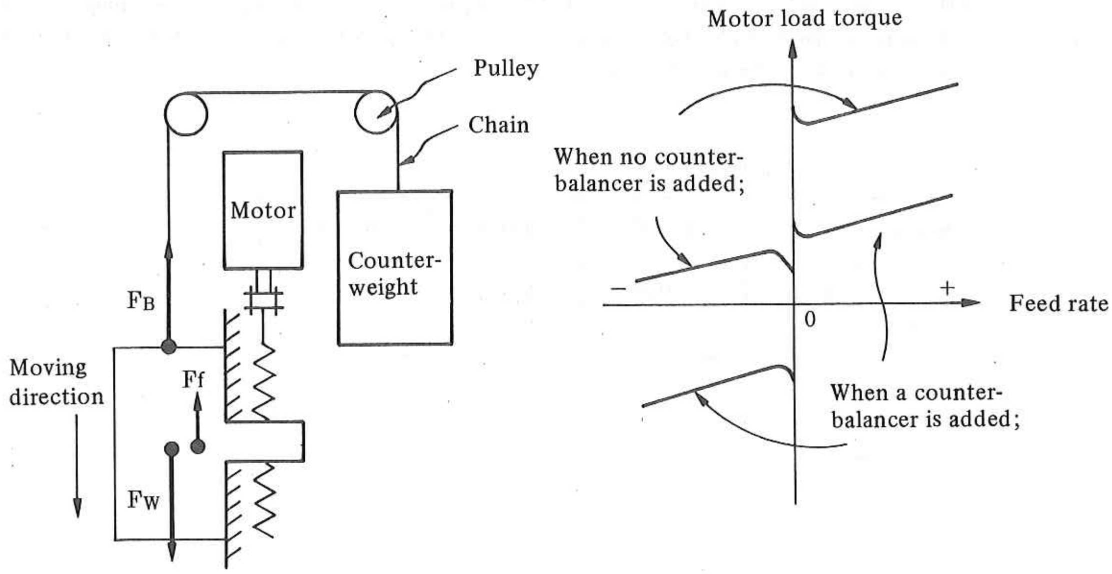
Th: Torque which is Supported upward by motor at lowering in rapid traverse (kg•cm)
V_m: Number of motor revolutions at rapid traverse (rpm)
D: Operation duty of rapid traverse lowering direction (%)
(Note: $D \leq 50$)

References Traverse direction of feed axis and load torque of motor

(1) A load torque of servo motor which travels in the horizontal direction is as follows due to friction.



(2) If a counter balancer is added to the vertical axis, a load torque almost caused by friction is applied to the motor, since gravity Fw acting to the moving part is nearly cancelled by lifting force F_B by the counter balancer.



(3) If gravity Fw is larger than friction Ff when no counter-balance is added to the vertical axis, the motor should produce a torque to support the machine upward by Fw-Ff at all times. When the moving direction is downward, the positional energy corresponding to (Fw-Ff) x feed distance is regenerated to the motor.

5. POWER SUPPLY

5.1 Input Power Supply

The AC servo unit employs a 3-phase power supply for main circuit and a single-phase 100V power supply for coils of the dynamic brake electromagnetic contactor (electromagnetic contractor and radiator cooling fan in case of the velocity control unit for 30R).
The velocity control unit for 5-0 employs a single phase 100V power supply only.

5.1.1 3-phase input power supply

Table 5.1.1 (a)

Power transformer	No. of phases	Voltage	Frequency
For all the countries	3 phase	200, 220, 230, 240, 380, 420, 460, 480, 550V +10% -15%	50/60Hz±2Hz

Note: If a 200, 220, 415, 440, or 480V input power supply is employed by using a transformer for overseas countries, set the primary voltage of the transformer as shown below.

Table 5.1.1 (b)

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

5.1.2 Single-phase 100V power supply

Table 5.1.2

Nominal voltage		AC 100V	
No. of phases		Single-phase	
Frequency		50Hz±2Hz	60Hz±2Hz
Voltage		100V +10% -15%	100V∿110V +10% -15%
Capacity*	For 5-0	30VA: Continuous 50VA: At turning on the contactor	
	For 4-0 ∿ 30	20VA: Continuous 90VA: At turning on the contactor	
	For 30R	50VA: Continuous 110VA: At turning on the contactor	

* Per velocity control unit

5.2 Power Supply Capacity (3-phase power supply)

The capacity of the power supply should be as specified in Table 5.2 as the continuous output kW of motor. In case the AC servo motor is rapidly accelerated, power of about twice the continuous rated value may be needed momentarily. Accordingly, use the power supply enough for acceleration.

Table 5.2

Motor model	Power capacity per motor unit
4 - 0	0.1 kVA
3 - 0	0.2 kVA
2 - 0	0.4 kVA
1 - 0	0.8 kVA
0	1 kVA
5	1.5 kVA
10	3 kVA
20M	4 kVA
20	5 kVA
30	5 kVA
30R	6 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 unit, respectively.

6. POWER DISSIPATION QUANTITY

Table 6.1

Motor model employed	Maximum power dissipation quantity of velocity control unit	Maximum power dissipation quantity of power transformer*
5 - 0	15 W	-
4 - 0	40 W	40 W
3 - 0	40 W	40 W
2 - 0	60 W	60 W
1 - 0	60 W	60 W
0	90 W	60 W
5	90 W	80 W
10	150 W	100 W
20M	180 W	150 W
20	250 W	150 W
30	250 W	150 W
30R	300 W	150 W

* The maximum power dissipation quantity of velocity control unit shows the value at the maximum continuous rated current of motor. It decreases according to the reduction of motor load.

(References)

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

7. INSTALLATION CONDITIONS AND CAUTIONS

7.1 Installation Conditions

7.1.1 Ambient temperature

0°C ∿ 40°C

7.1.2 Humidity

Lower than 95% RH

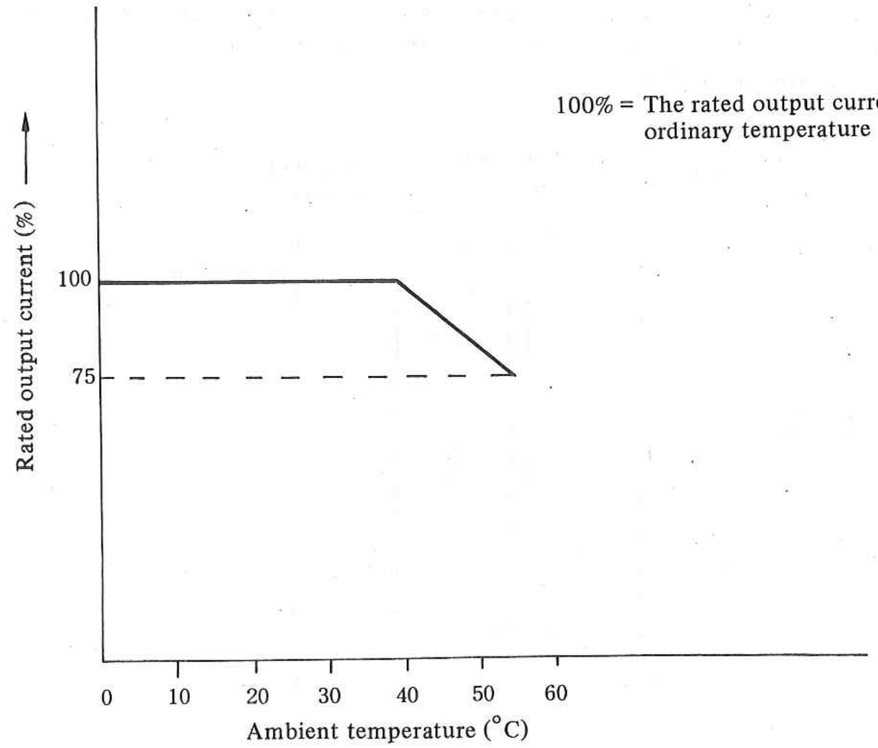
7.1.3 Vibrations

Less than 0.5G

7.1.4 Dust

Keep ventilation air clean in an environment where conductive dust or corrosive gas exists. It is recommended to use a closed cabinet which accommodates the velocity control unit.

Note: Rated output current for velocity control unit A06B-6050-H104 is decreased more than 40°C as follows.



7.2 Cautions on Installation and Housing

The velocity control units are designed to be accommodated in a cabinet. Be careful with the following items when designing the cabinet.

7.2.1 When velocity control units are housed in a closed type cabinet;

In case of a closed type cabinet, its internal air temperature generally increases.
Ventilate the internal air so that the ambient temperature of these unit becomes even.
The ventilation air speed should be about 1 ∿ 2 m/sec. Don't directly blow the fan or blower air to these units, otherwise dust may cling to the surfaces of these units and a trouble may result.

7.2.2 When velocity control units are housed inside open air ventilation type cabinet;

(1) Use an air filter at the open air inlet.
(2) Don't directly blow the ventilation fan air or blower air to these units, otherwise dust may cling to the surfaces of these units, and a trouble may result.
(3) Ingress of mist of the cutting liquid or dust from the air outlet, if any, may cause a trouble.
Particularly be careful with the air flow at outlet side.
(4) Securely seal the cable inlet/outlet, door, and other clearances.

7.2.3 Mounting position and other cautions

(1) Mount the units to make easy check, dismounting, and mounting during maintenance.
(2) Keep a space of more than 50 mm on both upper and lower sides of the velocity control unit respectively, so that the air from the radiator smoothly flows on the upper side and wiring can be done to the terminal boards on the lower side.

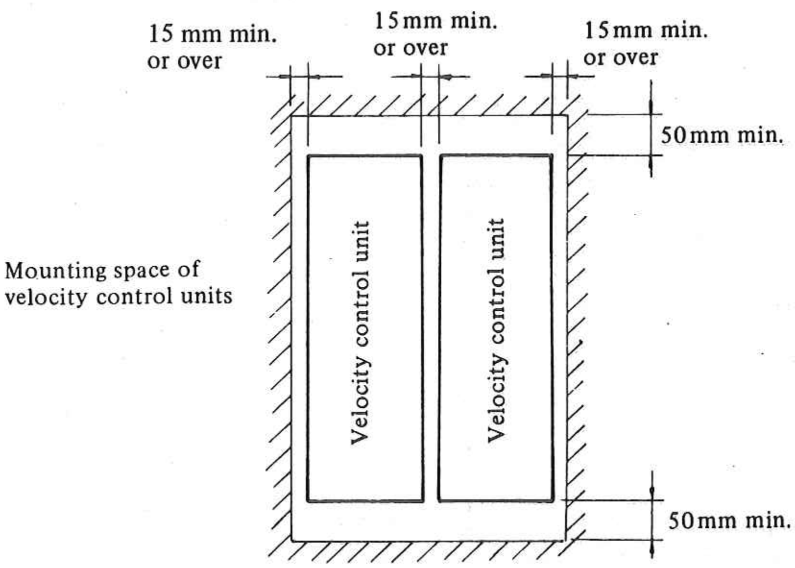


Fig. 7.2.3

(3) Precaution should be taken to the separation of cables between power line and signal line, frame grounding of the velocity control unit and transformer, and a countermeasure against noises.

8. OUTLINE DRAWINGS

8.1 Velocity Control Unit

8.1.1 Model 5-0 (A06B-6050-H301)

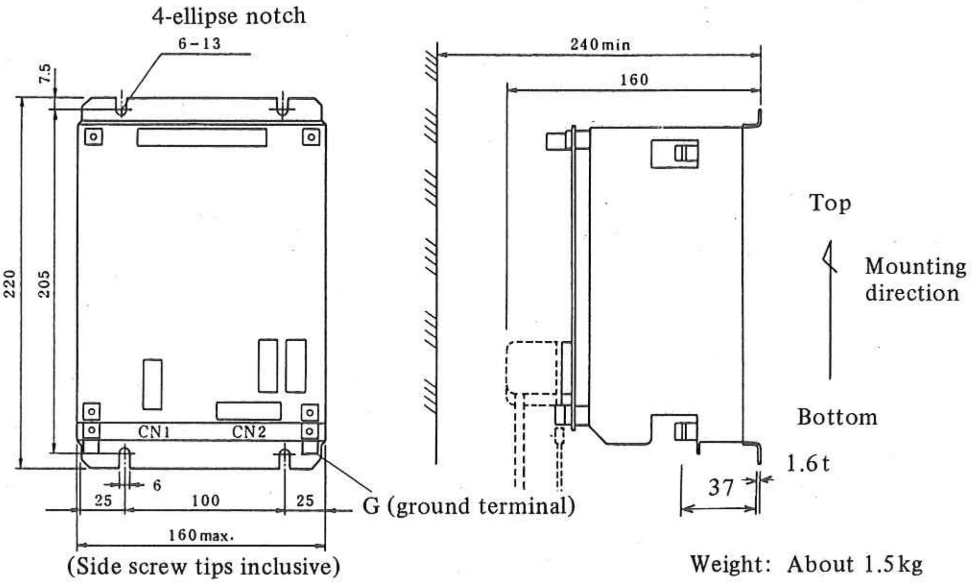


Fig. 8.1.1

8.1.2 For Model 3-0, 4-0 (A06B-6050-H001)

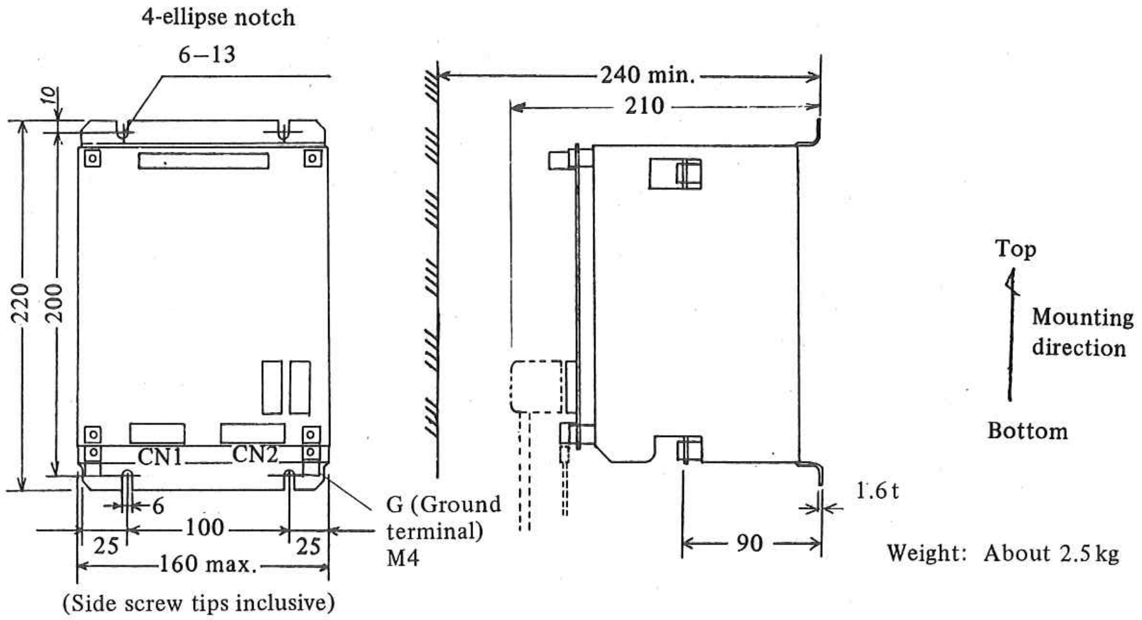


Fig. 8.1.2

8.1.3 For Model 2-0 to Model 30 (A06B-6050-H002, H102, H103, H113, H104)

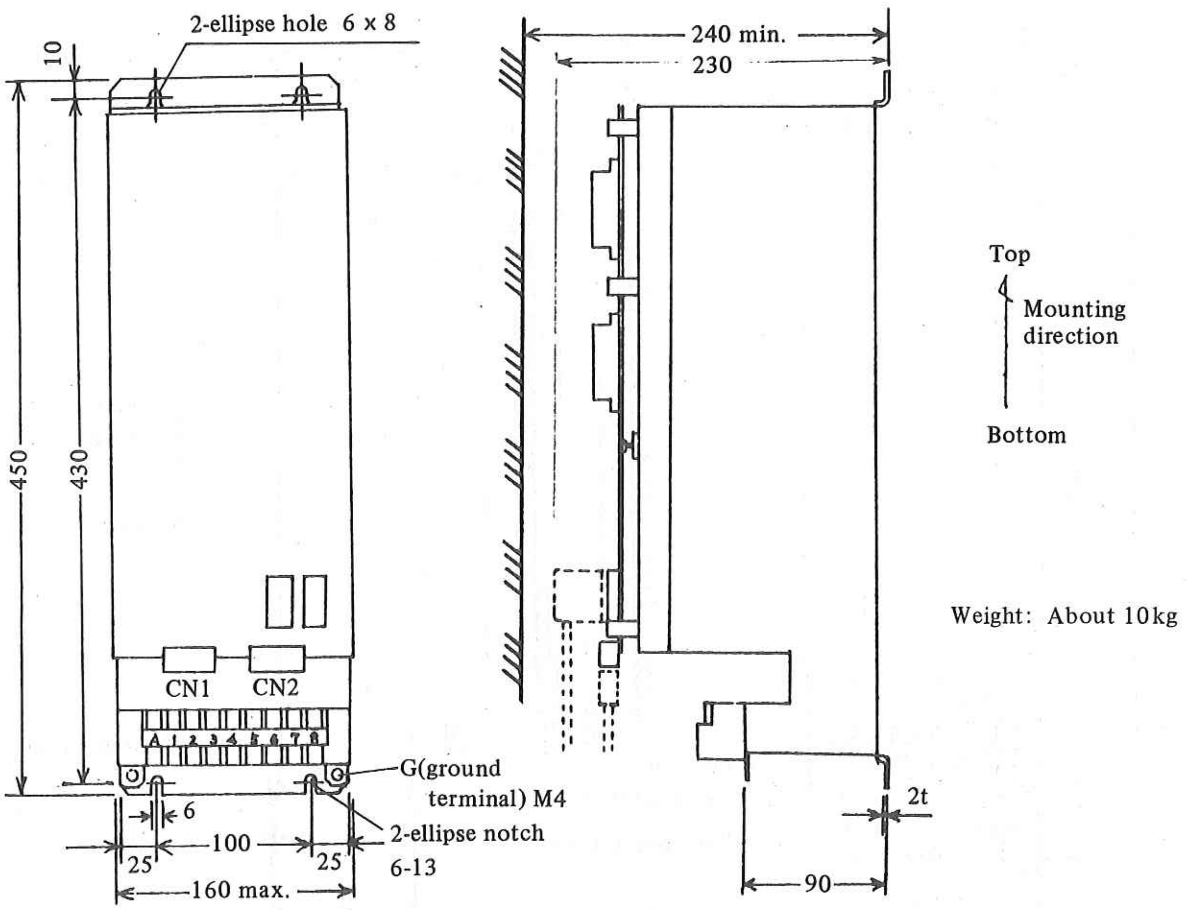


Fig. 8.1.3

8.1.4 For Model 30R (A06B-6050-H005)

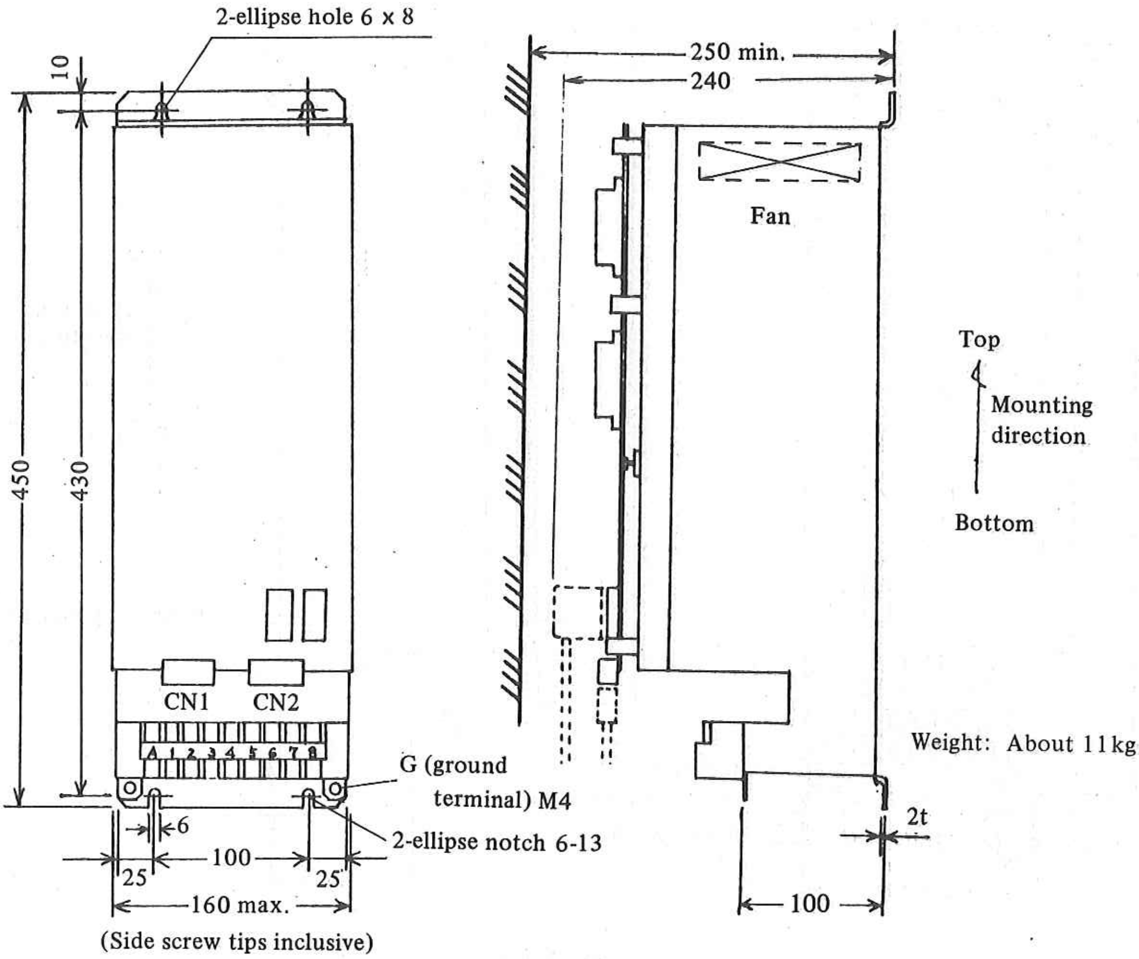
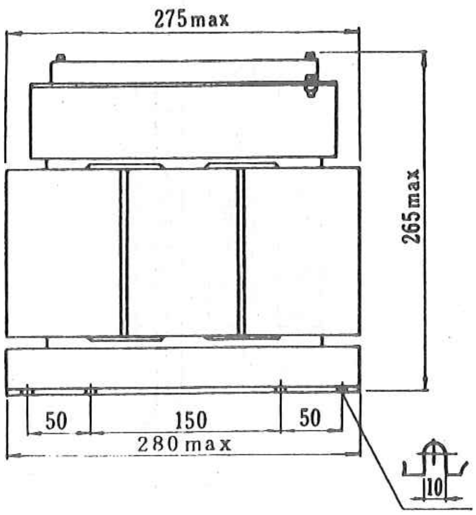
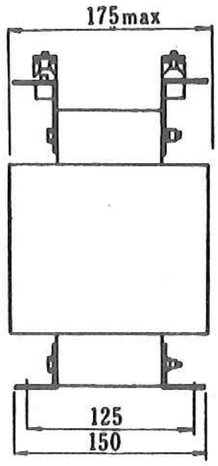


Fig. 8.1.4

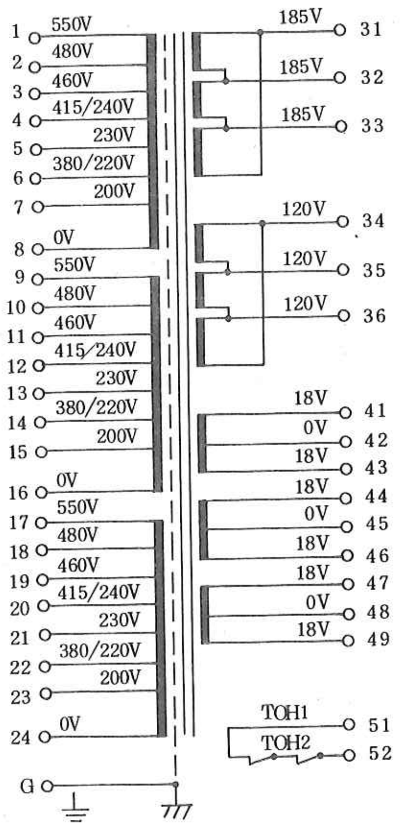
8.2 Power Transformer





Power transformer	Weight
AAE	About 20kg
ABE	About 30kg
ACE	About 36kg

Connection diagram of power transformer AAE



Terminal layout of power transformer AAE

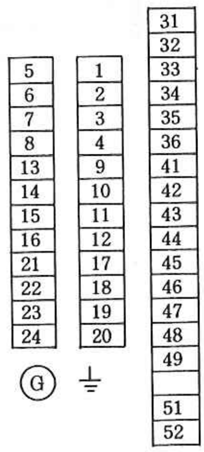
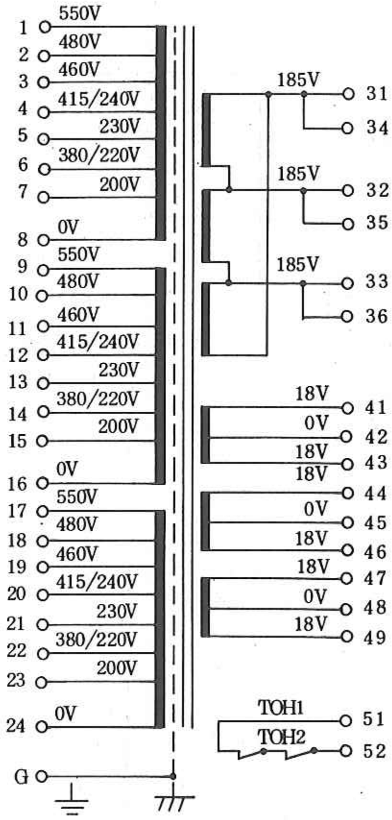


Fig. 8.2 (a)

Connection diagram of power
transformer ABE or ACE



Terminal layout of power
transformer ABE or ACE

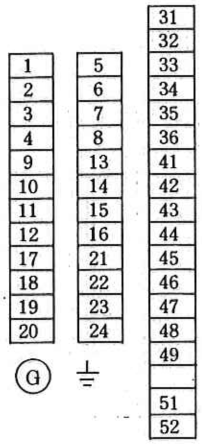


Fig. 8.2 (b)

8.3 Separate Regenerative Discharge Unit

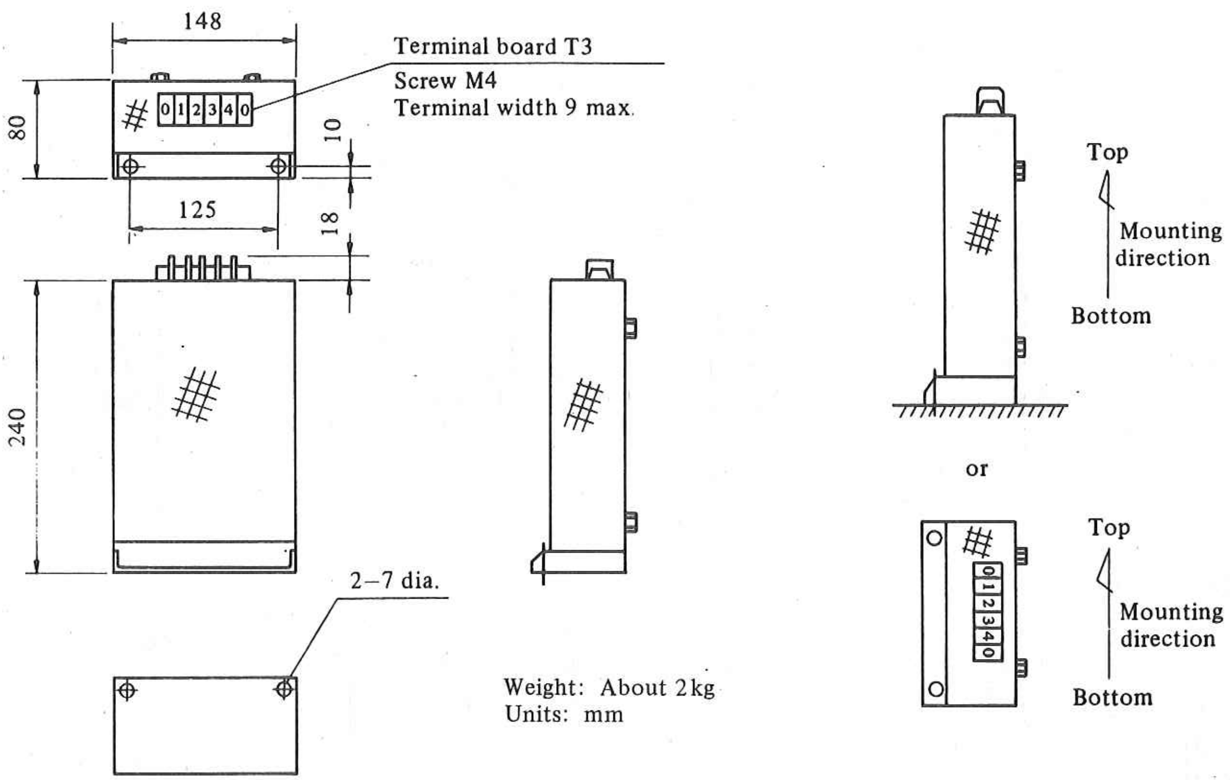


Fig. 8.3

8.4 Input Connector

(1) Connector CN1

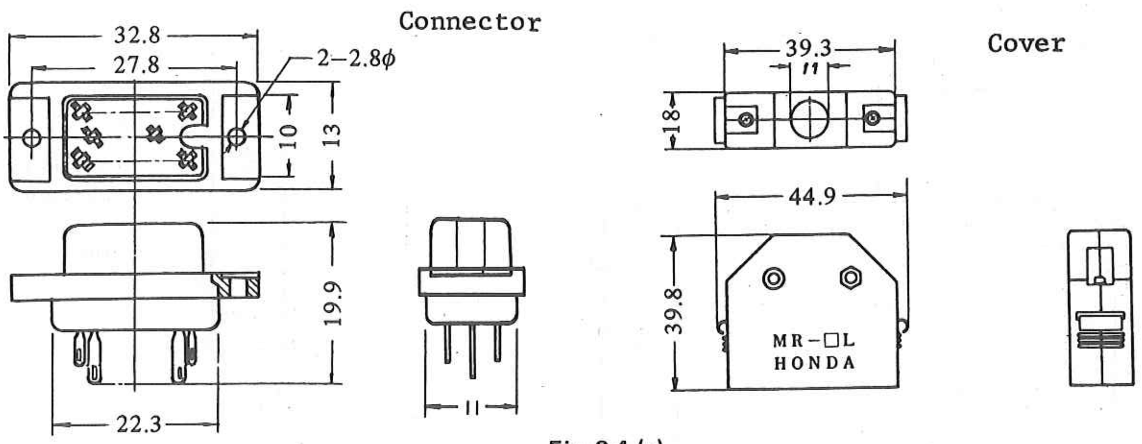


Fig. 8.4 (a)

(2) Connector CN5

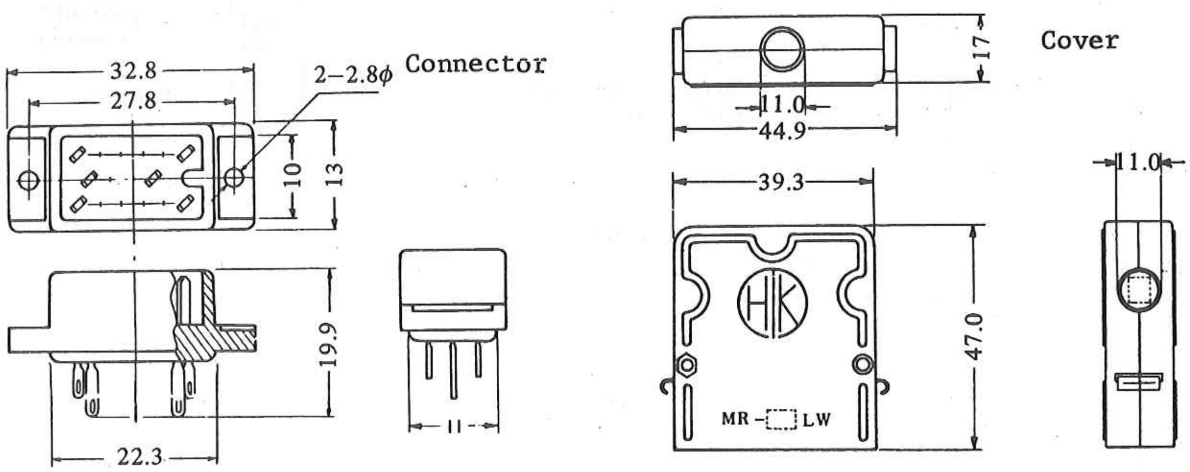


Fig. 8.4 (b)

(3) Connector CN6

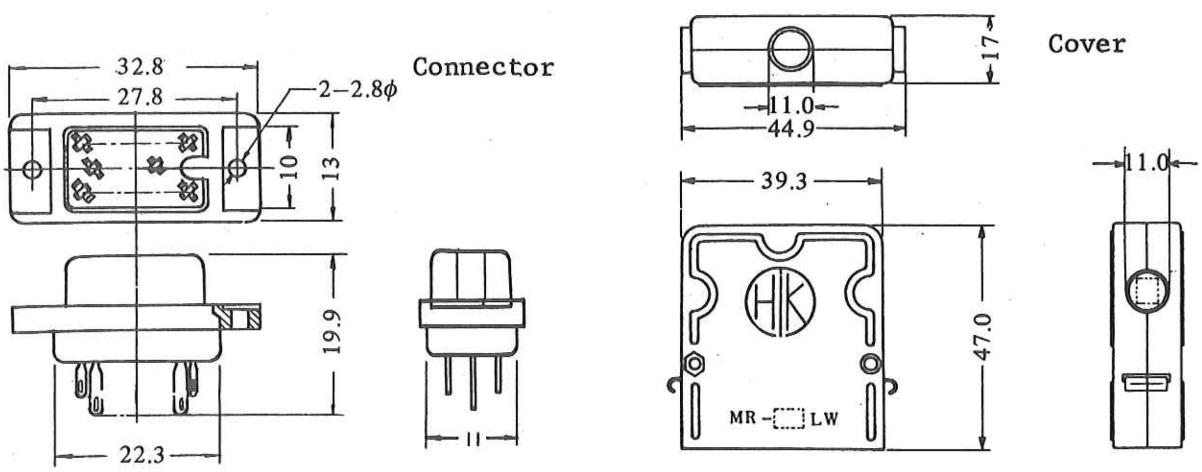


Fig. 8.4 (c)

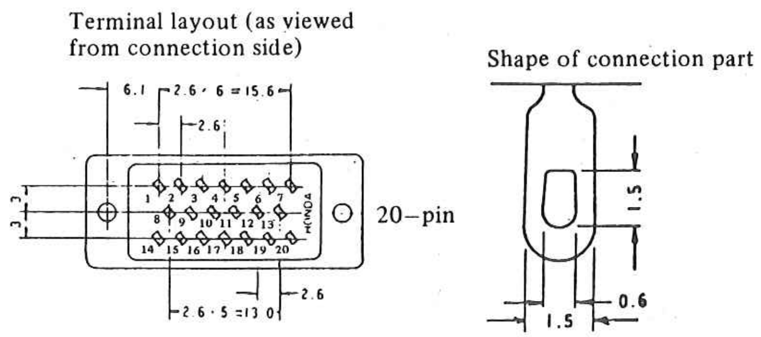
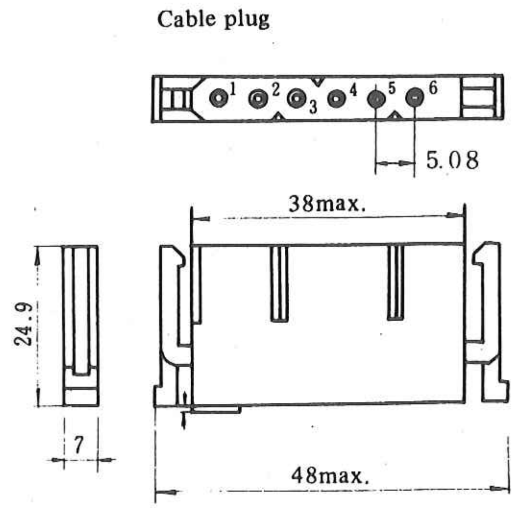


Fig. 8.4 (d)

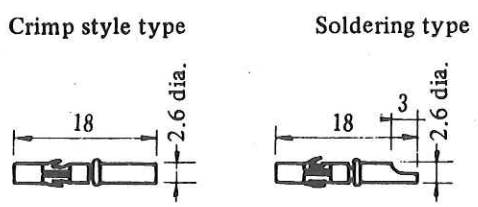
Table 8.4 (a)

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
Connector (with cover)	MR-20LWMH	Honda Tsushin Kogyo Co.	1	0.18∿0.3	CN5
Connector (with cover)	MR-20LWFH	Honda Tsushin Kogyo Co.	1	0.18∿0.3	CN6

(4) Connector CN2



Cable contact



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

Fig. 8.4 (e)

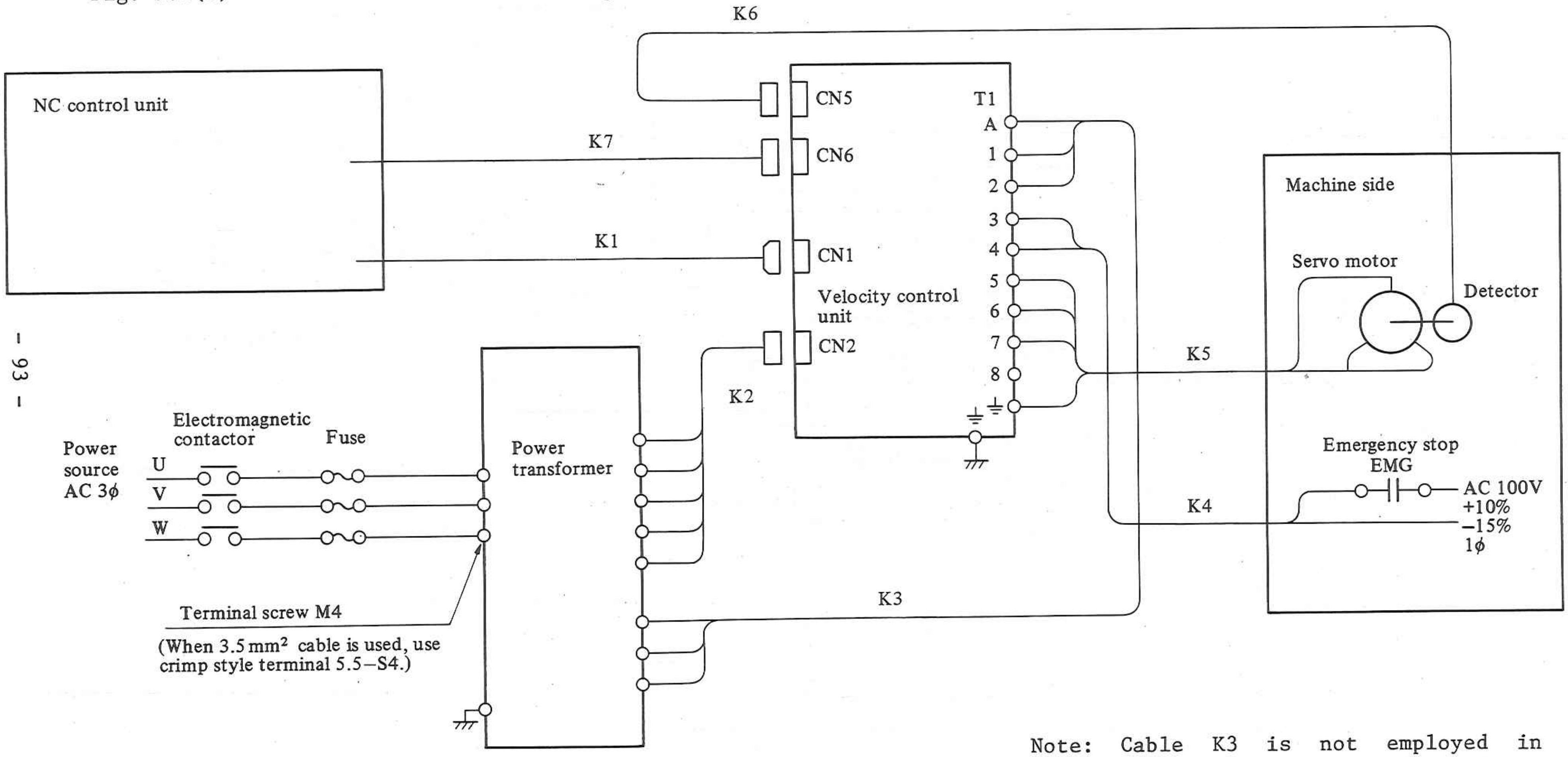
Table 8.4 (b)

<table>
<tr><th colspan="2">Name</th><th>Specifications (Connector maker's model)</th><th>Name of maker</th><th>No. of connectors employed per axis</th><th>Remarks</th></tr>
<tr><td colspan="2">Cable plug</td><td>SMS6PW-5</td><td rowspan="3">Nippon Bundy Co.</td><td>1</td><td rowspan="3">For climping tool, etc., contact the connector maker.</td></tr>
<tr><td rowspan="2">Contact</td><td>Crimp style type</td><td>RC16M-23</td><td rowspan="2">5</td></tr>
<tr><td>Soldering type</td><td>RC16M-SCT3</td></tr>
</table>

9. CONNECTIONS

9.1 Connection Diagram

Fig. 9.1(a) is a standard connection diagram.



Note: Cable K3 is not employed in velocity control unit for 5-0.

Fig. 9.1 (a)

Fig. 9.1(b) shows connection diagram when the separate regenerative discharge unit is employed.

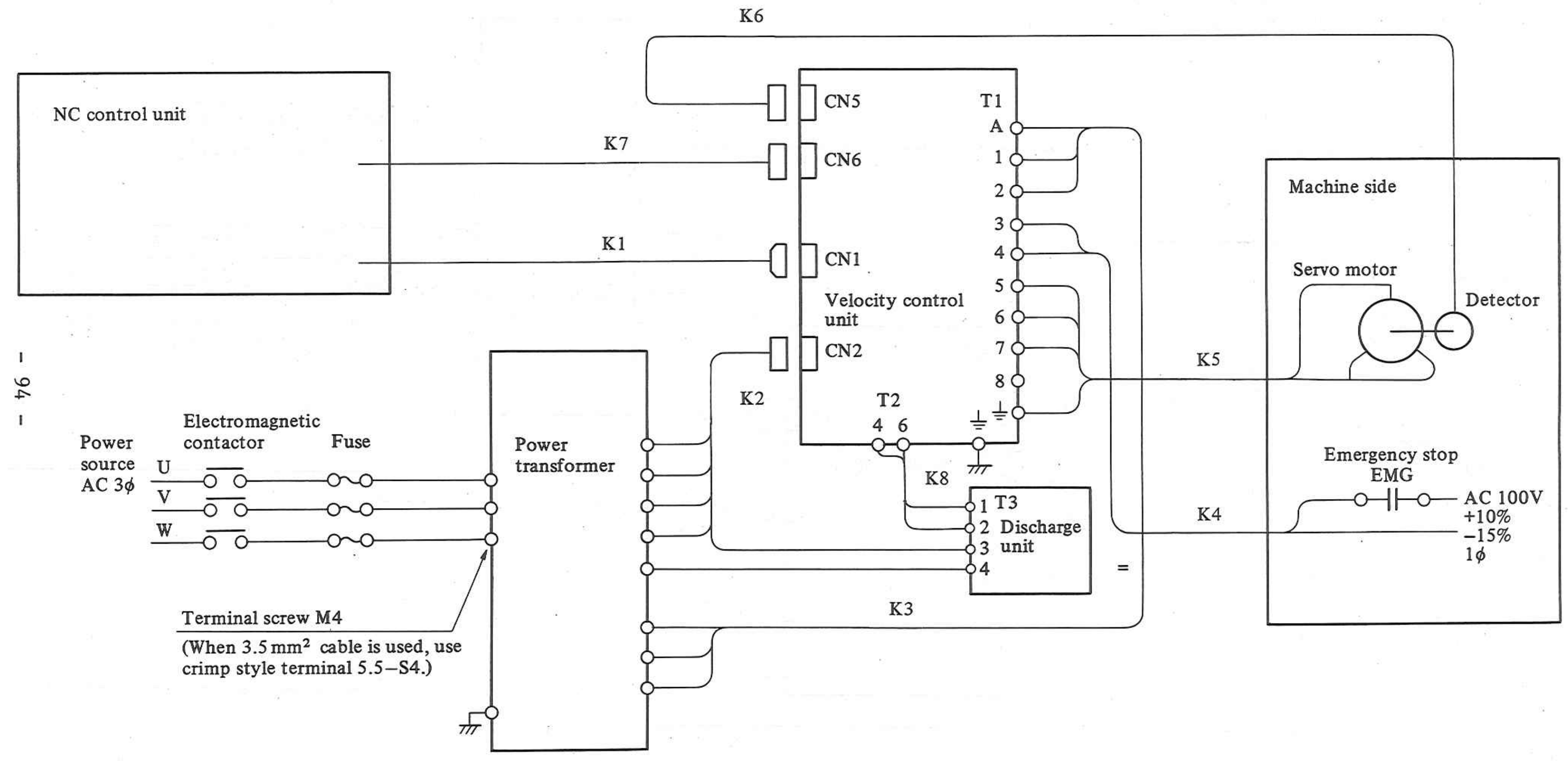
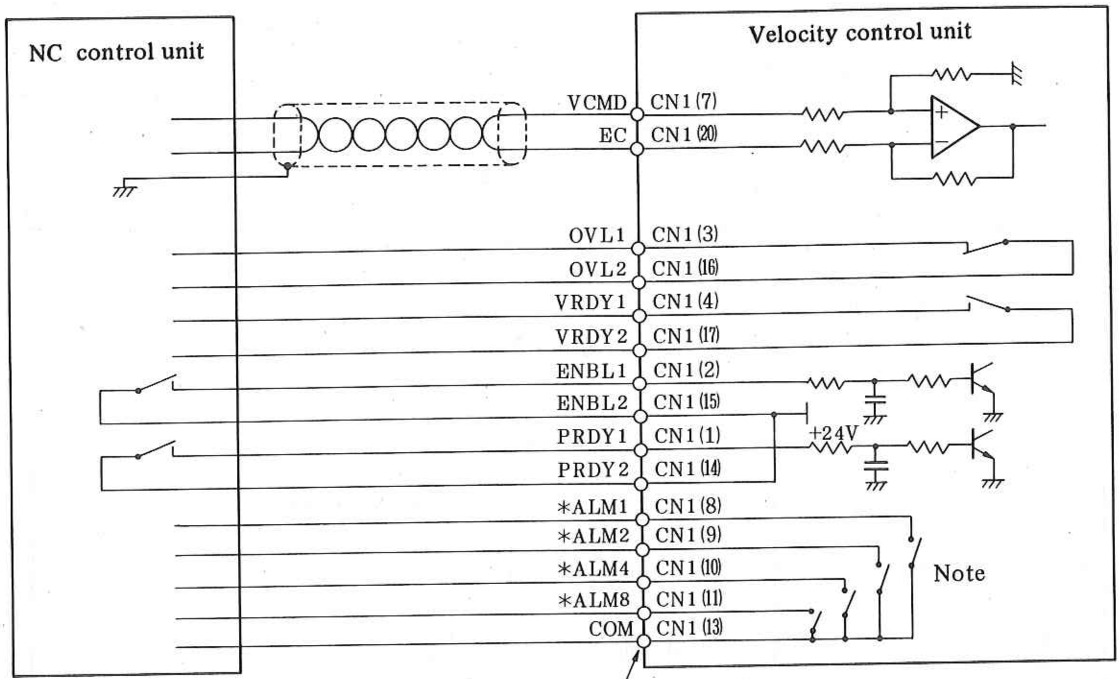


Fig. 9.1 (b)

9.1.1 Details of connections of cable K1



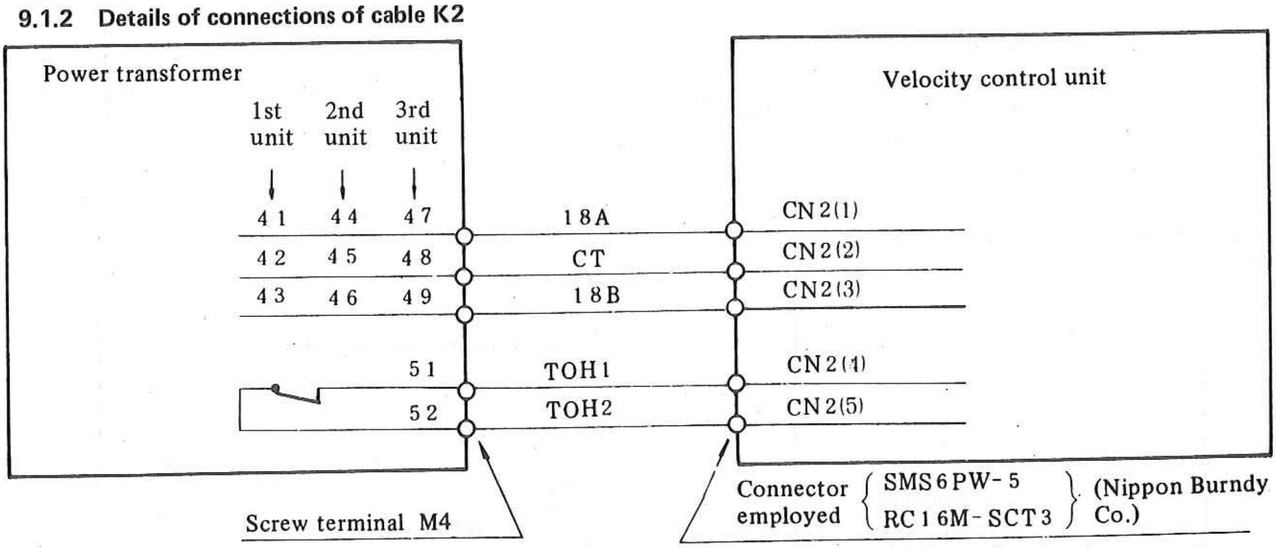
Cable employed:
For VCMD/EC, $0.1 \sim 0.18mm^2$ paird shielded cable.
For others; $0.18 \sim 0.3mm^2$ 200V vinyl wire

Connector employed MR20LFH (Honda Tsushin Kogyo, Co. Ltd.)
(For mounting layout of connector terminals, see 8.4)

Note: These signals are not provided for model 5-0, 4-0 and 3-0 velocity control unit.

Fig. 9.1.1

9.1.2 Details of connections of cable K2



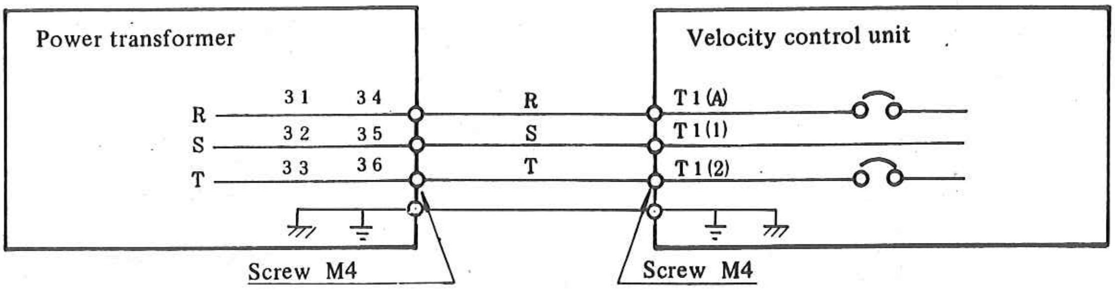
Screw terminal M4

Connector employed { SMS6PW-5 / RC16M-SCT3 }. (Nippon Burndy Co.)
(For mounting layout of connector terminals, see 8.4)

Cable employed: $0.75\ mm^2$ (30/0.18) 200V heat-resistive vinyl cable.

Fig. 9.1.2

9.1.3 Details of connections of cable K3



(Use crimp style terminal 5.5–S4, if 3.5mm^2 cable is used)

Fig. 9.1.3

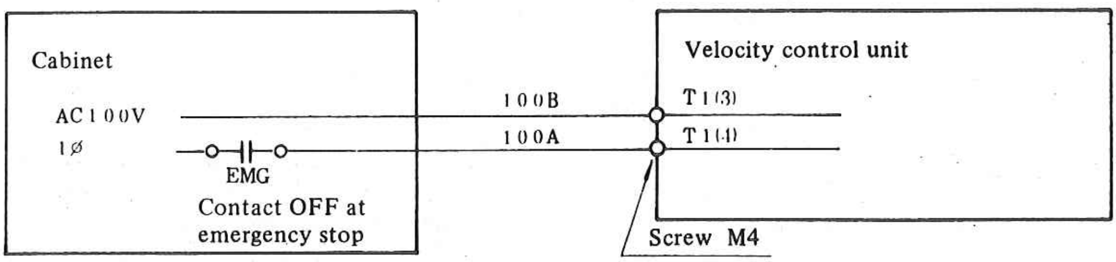
Table 9.1.3 (a)

Motor employed	Cable employed	
Model 3-0, 4-0	0.75 mm^2	600V heat-resistive vinyl cable
Model 2-0, 1-0 Model 0, 5	2.0 mm^2	
Model 10, 20M, 20, 30	3.5 mm^2	
Model 30R	5.5 mm^2	

Table 9.1.3 (b)

Motor employed	Input voltage
Model 4-0, 2-0, 1-0	AC 120V
Model 3-0 Model 0, 5 Model 10, 20M, 20, 30 Model 30R	AC 185V

9.1.4 Details of connections of cable K4

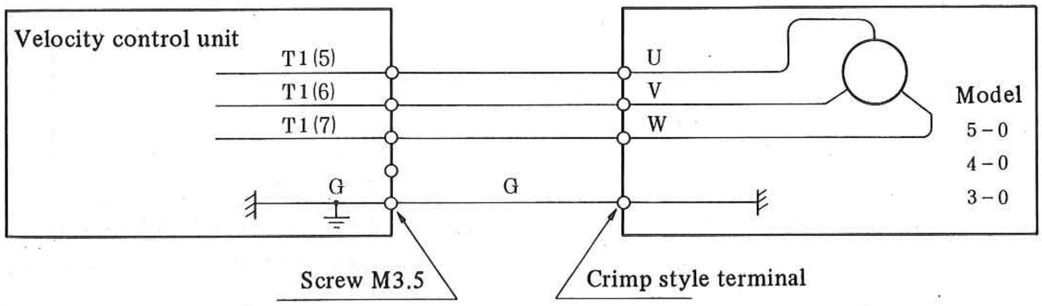


Cable material: 0.75mm^2 200V vinyl cable

Fig. 9.1.4

9.1.5 Details of connections of cable K5

(1) For Model 5-0, 4-0, 3-0

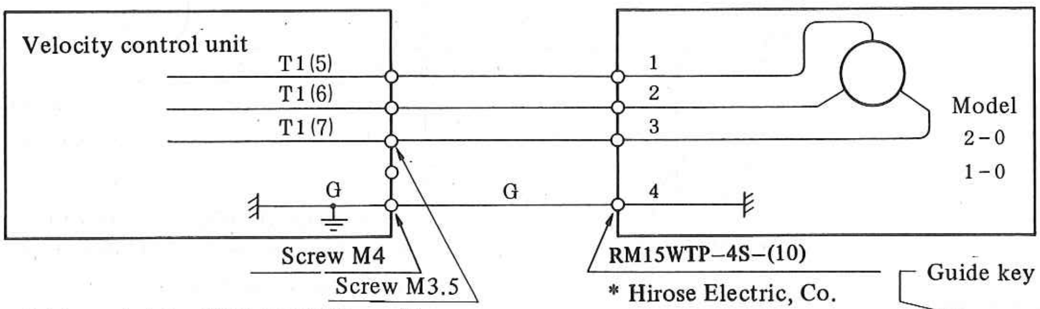


Cable material: 30/0.18 (0.75 mm²)
4-conductor vinyl cord

Reed wire color
U : Red
V : White
W : Black
Earth : Connect to motor body

Fig. 9.1.5 (a)

(2) For Model 2-0, 1-0



Cable material: 30/0.18 (0.75 mm²)
4-conductor vinyl cabtyre cable

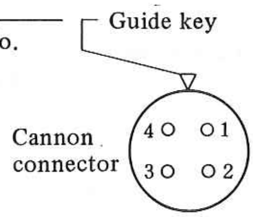


Fig. 9.1.5 (b)

(3) For Model 0 and 5

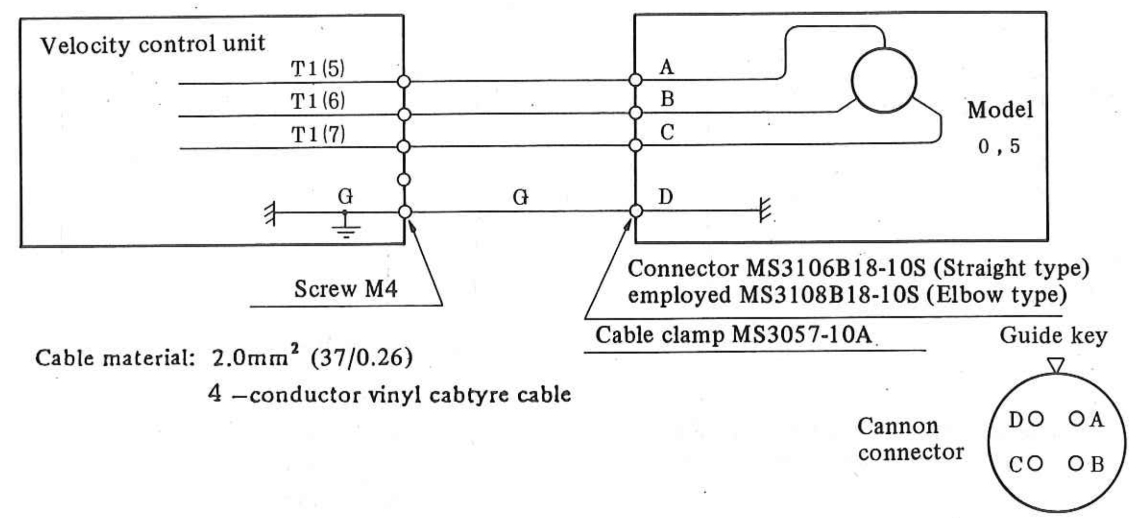


Fig. 9.1.5 (c)

(4) for Model 10, 20M, 20, 30

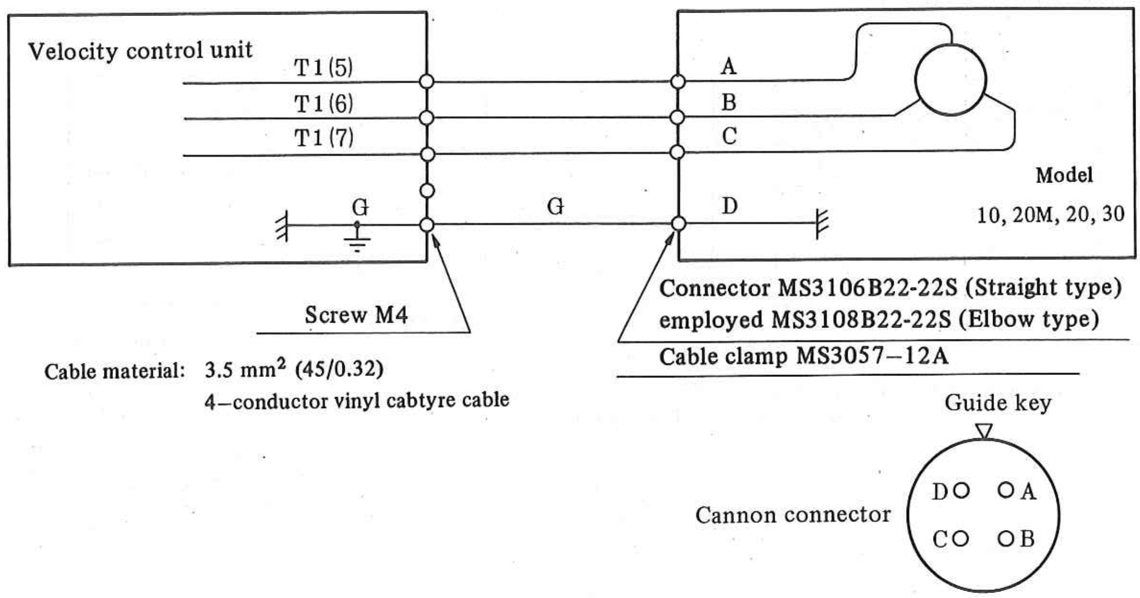


Fig. 9.1.5 (d)

(5) For Model 30R

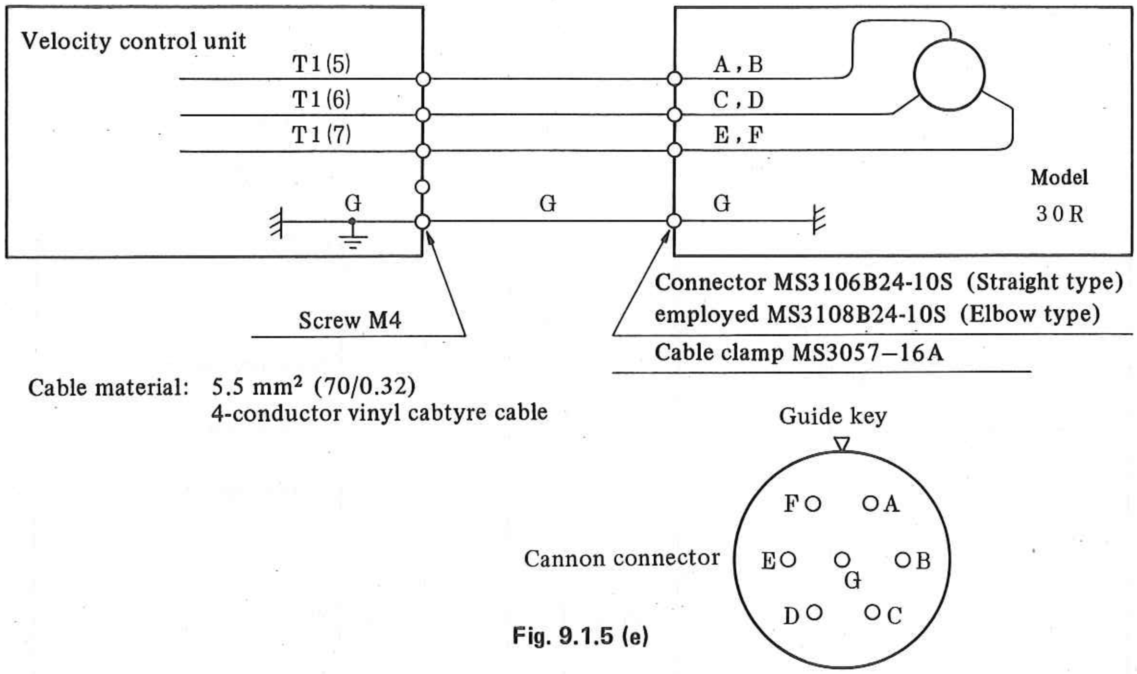
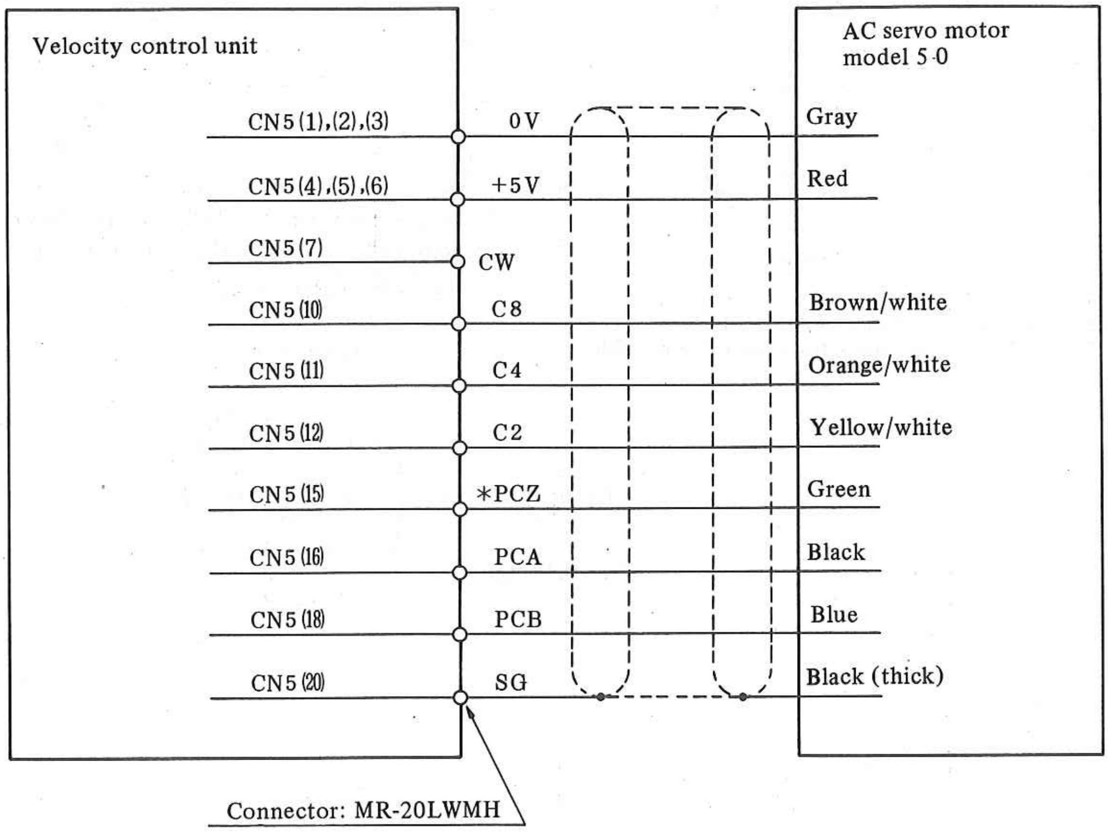


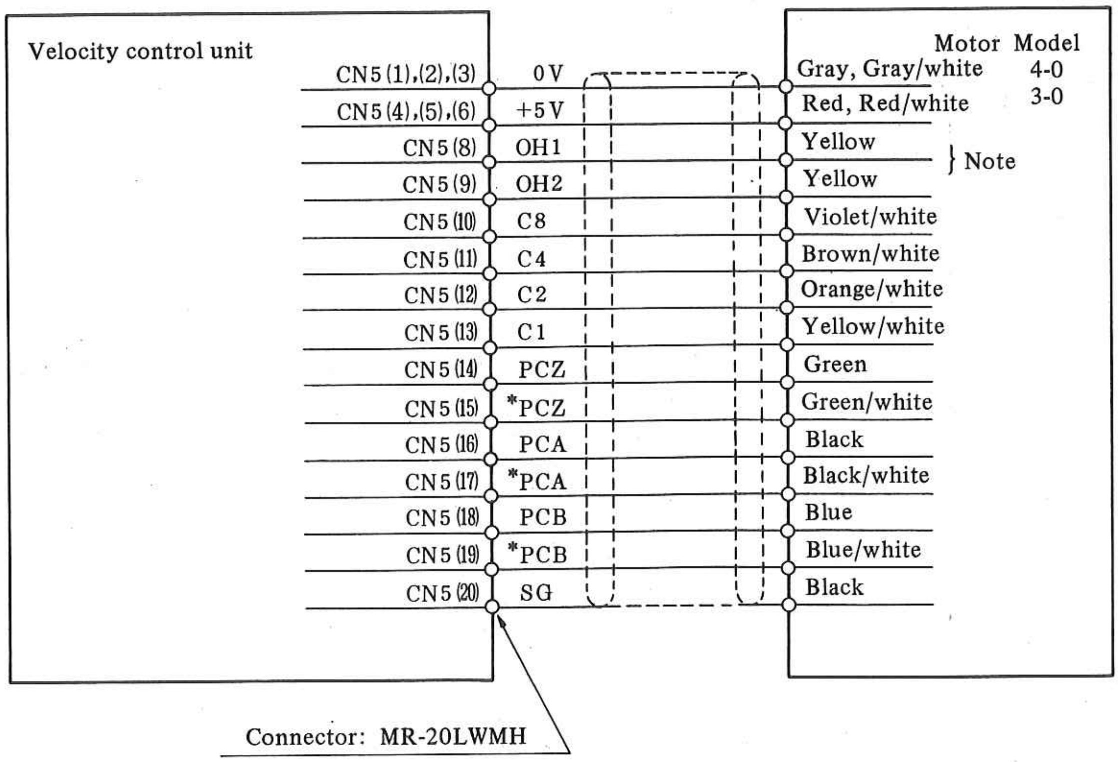
Fig. 9.1.5 (e)

9.1.6 Details of connections of cable K6

(1) Model 5-0



(2) Model 4-0, 3-0



Note: These signals are not included in this encoder cable, through reed wires are provided near by power line.

(3) Model 2-0 ∿ 30R

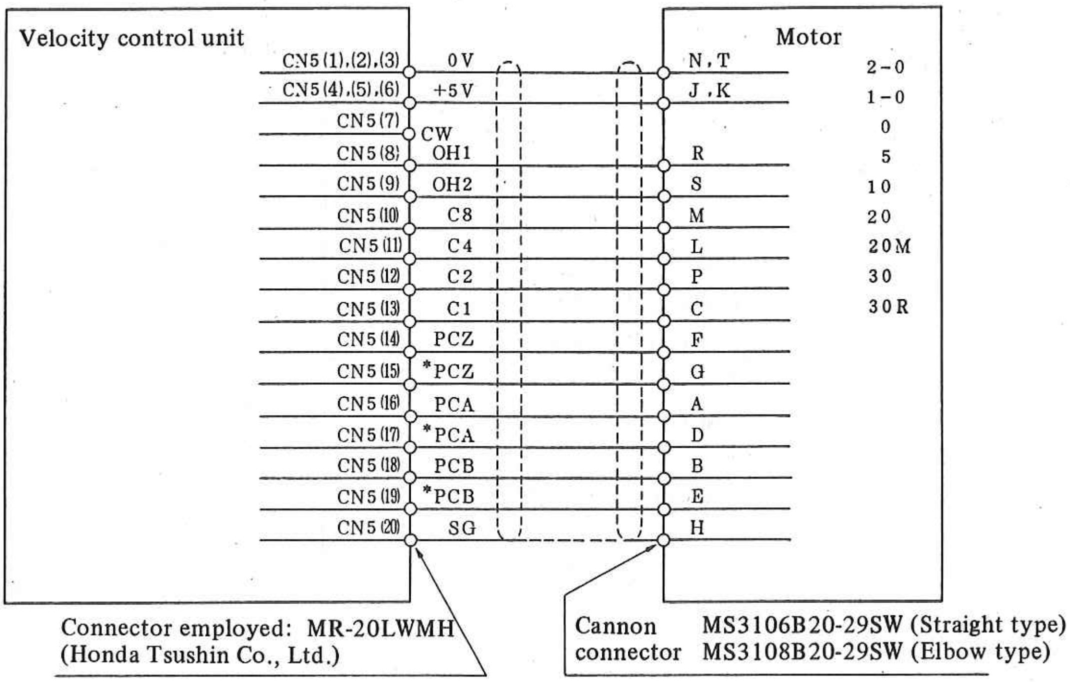
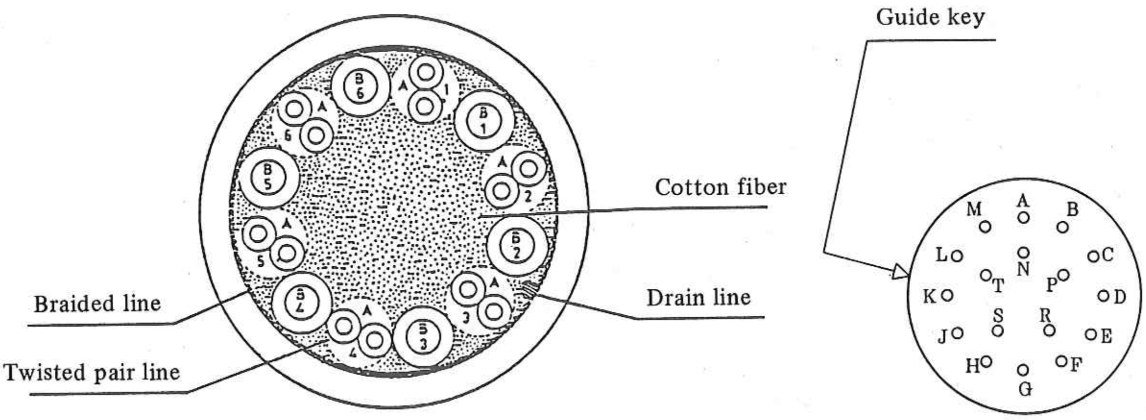


Fig. 9.1.6 (a)



Designation	A1 ∿ 6 for signal	B1 ∿ 6 for power	Cable specification
A06B-6050-K050 / K051	0.18 mm^2	1.25 mm^2	A66L-0001-0161
A06B-6050-K053 / K054	0.18 mm^2	0.75 mm^2	A66L-0001-0199

Fig. 9.1.6 (b)

9.1.7 Details of connections of cable K7

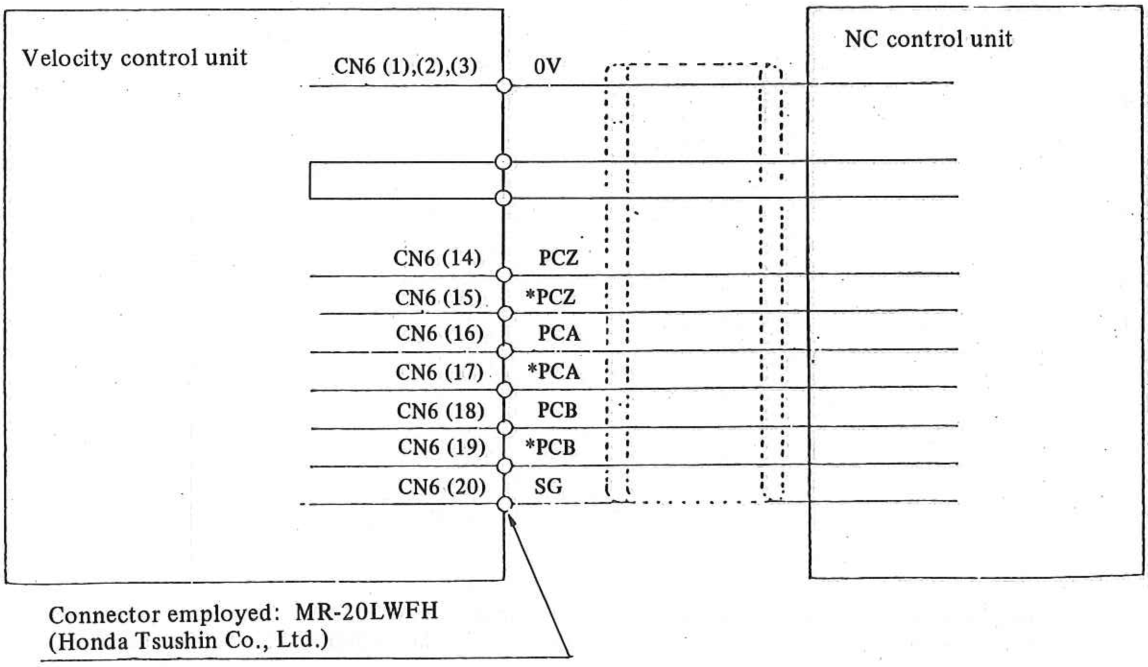


Fig. 9.1.7

9.1.8 Connections of separate discharge unit

Note 1:
Disconnect the jumper wire from terminals T2(4) - T2(5) when the separate regenerative discharge unit is employed.

Cable employed: 2.0mm² (37/0.26)
600V heat-resistive vinyl cable

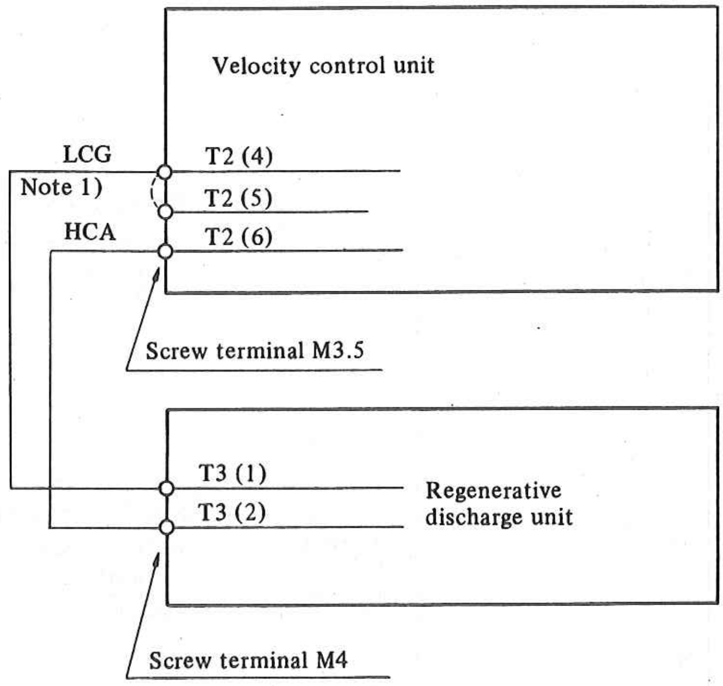
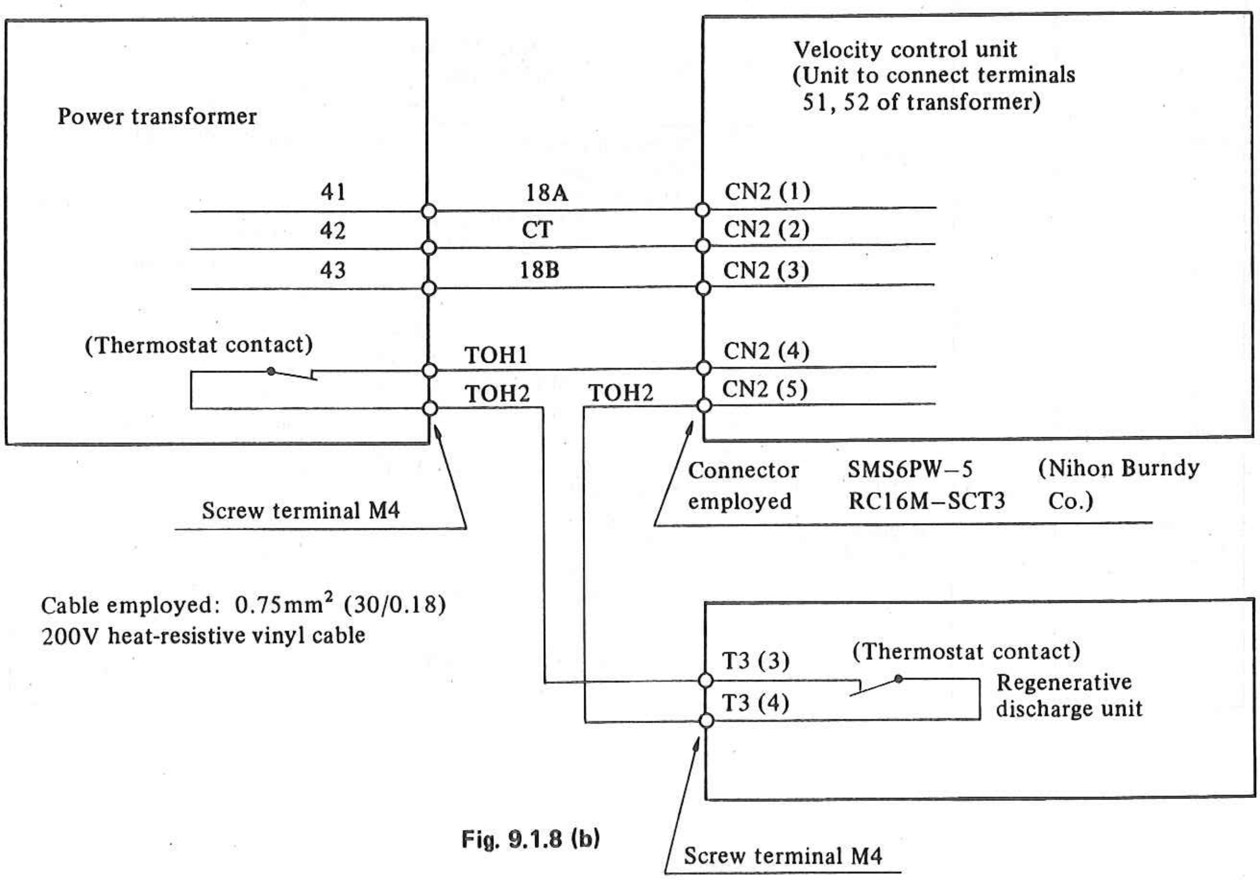


Fig. 9.1.8 (a)

For connections of cable K2 in 9.1.2, change the connection of TOH1 and TOH2 as follows.

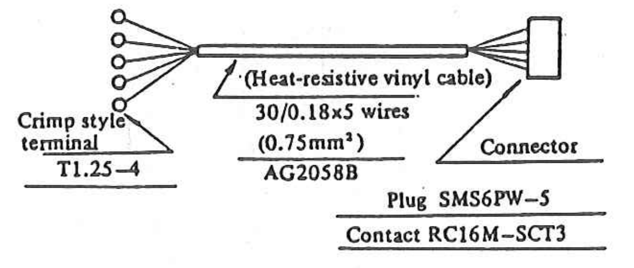
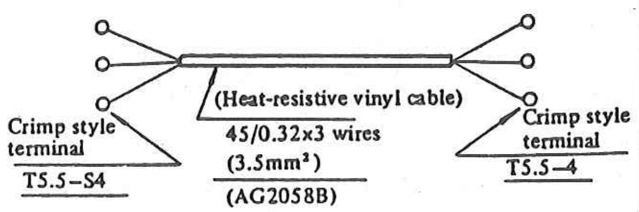
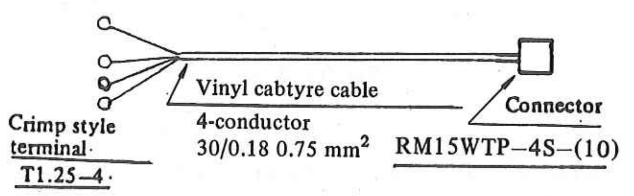
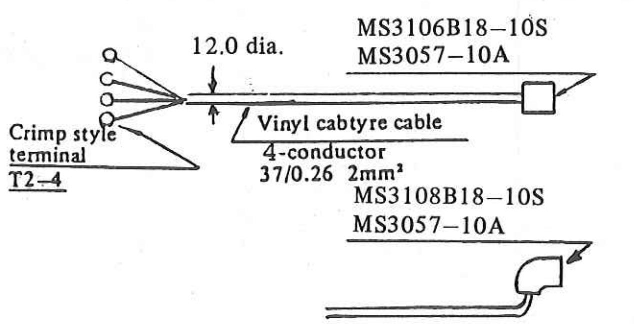
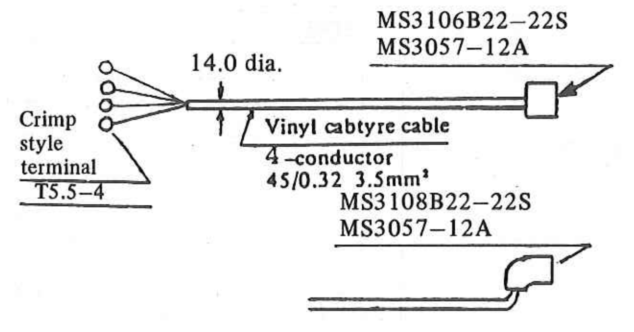


Cable employed: 0.75mm² (30/0.18)
200V heat-resistive vinyl cable

Fig. 9.1.8 (b)

9.2 Cable Assembly of Cables K2, K3, K5, K6, and K7

Table 9.2

Use	Symbol	Specifications	Designation	Length
Power transformer ↕ Velocity control unit (CN2)	K2		-	-
Power transformer ↕ Velocity control unit	K3		-	-
Velocity control unit ↕ Servo motor Model 2-0 1-0	K5		A06B-6050-K003	14m
Velocity control unit ↕ Servo motor Model 0,5	K5		Straight type A06B-6050-K005 Elbow type A06B-6050-K006	14m
Velocity control unit ↕ Servo motor Model 10 20M 20 30	K5		Straight type A06B-6050-K007 Elbow type A06B-6050-K008	14m

<table>
<tr><th>Use</th><th>Symbol</th><th>Specifications</th><th>Designation</th><th>Length</th></tr>
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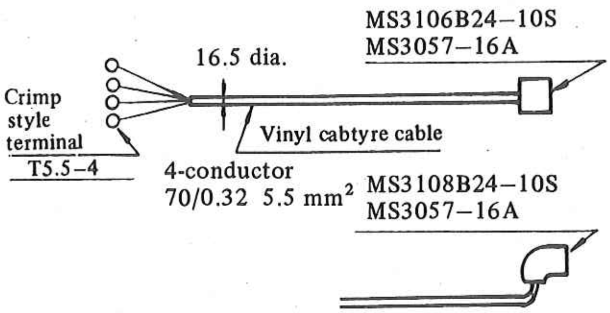
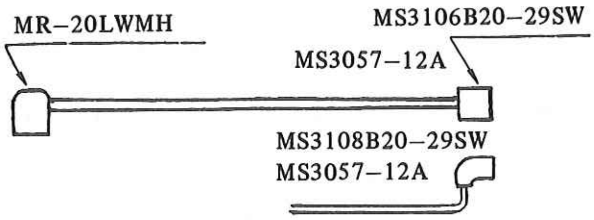
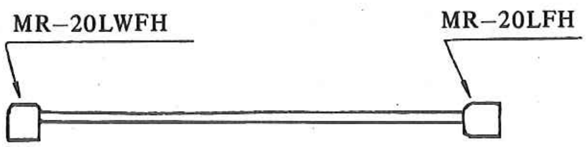
↕
Servo motor
Model 30R</td><td rowspan="2">K5</td><td rowspan="2">
</td><td>Straight type
A06B-6050-K009</td><td rowspan="2">14m</td></tr>
<tr><td>Elbow type
A06B-6050-K010</td></tr>
<tr><td rowspan="4">Velocity control unit
↕
Servo motor</td><td rowspan="4">K6</td><td rowspan="4">
</td><td>Straight type
A06B-6050-K053</td><td rowspan="4">14m</td></tr>
<tr><td>Elbow type
A06B-6050-K054</td></tr>
<tr><td>Straight type
A06B-6050-K050</td></tr>
<tr><td>Elbow type
A06B-6050-K051</td></tr>
<tr><td>Velocity control unit
↕
Control unit</td><td></td><td>
</td><td>A06B-6050-K052</td><td>4.5m</td></tr>
</table>

9.3 Connections of Power Transformer

9.3.1 Primary connections

For the connecting positions of power cable U, V, W and connection between terminals, refer to Tables 9.3.1(a) or (b) according to the input voltage.

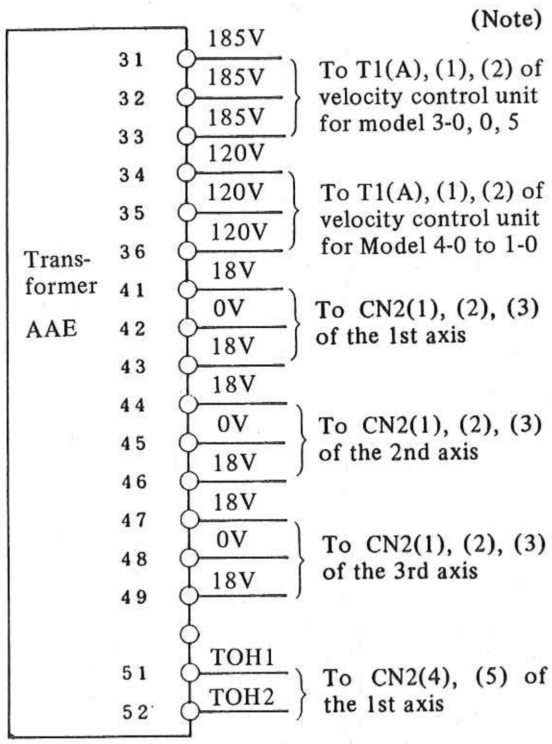
(1) For power transformers AAE, ABE, ACE (for all the countries)

Table 9.3.1 (a)

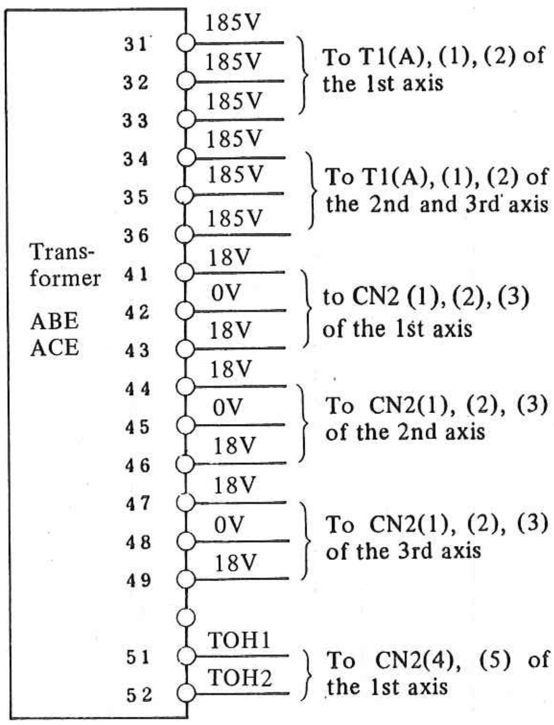
Power voltage	Connection of transformer primary terminal		Connection type
	Connection of power cable U, V, W	Jumper between transformer terminals	
200V	U-7, V-15, W-23	8-15, 16-23, 24-7	Delta connection
220V	U-6, V-14, W-22	8-14, 16-22, 24-6	
230V	U-5, V-13, W-21	8-13, 16-21, 24-5	
240V	U-4, V-12, W-20	8-12, 16-20, 24-4	
380V	U-6, V-14, W-22	8-16, 16-24 or (8-16-24)	Star connection
420V	U-4, V-12, W-20		
460V	U-3, V-11, W-19		
480V	U-2, V-10, W-18		
550V	U-1, V- 9, W-17		

9.3.2 Secondary connections

(1) For power transformers, AAE



(2) For power transformers ABE, ACE



Note:
The output voltage of the power transformer differs for Model 4-0 to 0.
(The voltage lower than the voltages for other motors is employed.)
If the power transformer for other motors should be connected to the velocity control unit for Model 4-0 to 0 by mistake, it causes a trouble. Particularly be careful with connection, accordingly.

Fig. 9.3.2

9.4 Details of Signals

Table 9.4

No.	Name of signal	Signal contents	Type	Significant level	Send direction	Details
1	PRDY1 PRDY	Velocity control unit ON signal	Contact	ON (closed)	NC → Velocity control unit	When the contact is turned on, electromagnetic contactor MCC inside the velocity control unit turns on. When it is turned off, the motor is stopped by dynamic braking.
2	ENBL1 ENBL2	Enable signal	Contact	ON (closed)	NC → Velocity control unit	When this contact is turned on, the PWM control circuit operates. When it is turned off, no power flows to the motor.
3	OVL1 OVL2	Overload alarm signal	Contact	OFF (open)	NC → Velocity control unit	This contact is turned off, if power transformer's power semiconductors' fin's or motor's thermostat operates.
4	VRDY1 VRDY2	Velocity control unit ready signal	Contact	ON (closed)	NC → Velocity control unit	This contact is turned on when electromagnetic contactor MCC in the velocity control unit turns on.
5	VCMD EC	Velocity command signal	Analog voltage signal	0∿±12V	NC → Velocity control unit	Motor speed is set to 2,000 rpm at ±7V.
6	100A 100B	Power supply for electro-magnetic contactor	AC voltage 1ϕ 100V	AC 100V	Cabinet → Velocity control unit	For emergency stop, electromagnetic contactor inside the velocity control unit is turned off irrespective of PRDY1 and 2 by turning off the AC 100V, so that the motor is stopped by dynamic braking.
7	*ALM1 *ALM2 *ALM4 *ALM8 COM	Alarm interface signal	Non-contact signal	ON (closed)	NC → Velocity control unit	(see table below)

	TG	OVC	HC	HV	DC
*ALM1	0	1	1	0	1
*ALM2	1	0	1	1	0
*ALM4	1	1	0	0	0
*ALM8	0	0	0	0	0

1: OFF (open) 0: ON (closed)

(1) Contact input signals PRDY1/PRDY2, ENBL1/ENBL2

Circuit diagram is shown in the following figure.

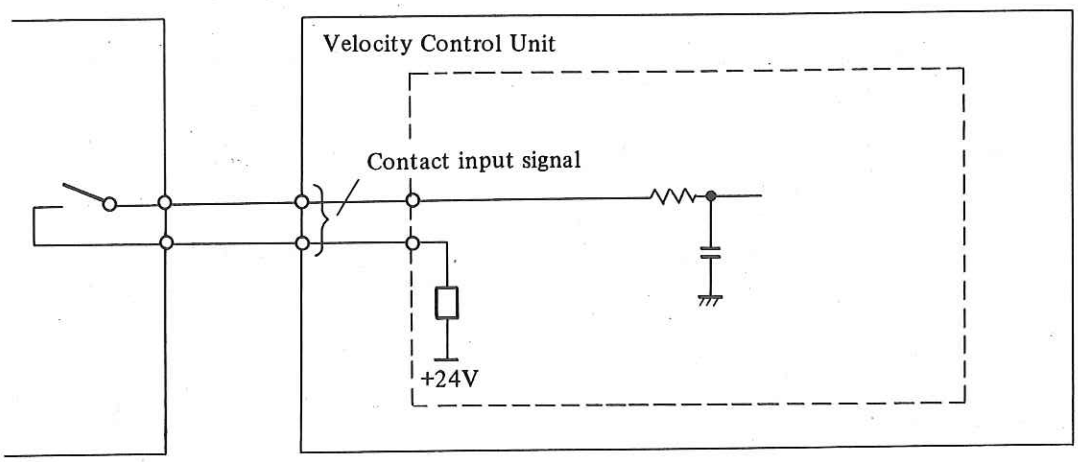


Fig. 9.4 (a)

(a) The contact capacity must be above 30V and 16mA.
(b) The signal wire should be floating against the ground.

(2) Contact output signals VRDY1/VRDY2, OVL1/OVL2

(a) The contact capacity of the velocity control unit is as follows.

Rated voltage at contacts: DC 50V or less
Contact capacity: 5VA or less

Our recommendation is that the voltage applied to the contact is DC 24V, and that the current is 5 to 10 mA.

(b) When an inductive load such as a relay is connected, a spark killer must be inserted as close to the load (within 20 cm) as possible.

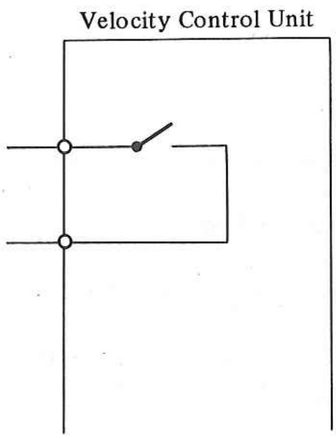


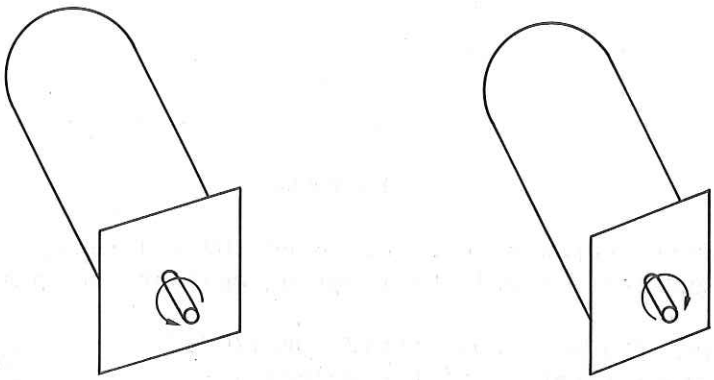
Fig. 9.4 (b)

9.5 Reverse Connection

9.5.1 Connection and rotational direction

For AC servo unit there are connection cables of power supply, feedback signals and motor power.
There are standard connection and reverse connection for the feedback signal cable and motor power cable according to the rotational direction which follows the feed command from the control unit.
The rotational direction corresponding to the (+) feed command

Standard connection (+) Command — Reverse connection (+) Command



To make reverse connection, next procedure should be taken.

9.5.2 Method

(1) For Model 2-0 ∿ 30R

Change the connection of connector mounted on velocity control unit side of feedback signal cable K6 (between motor and CN5).

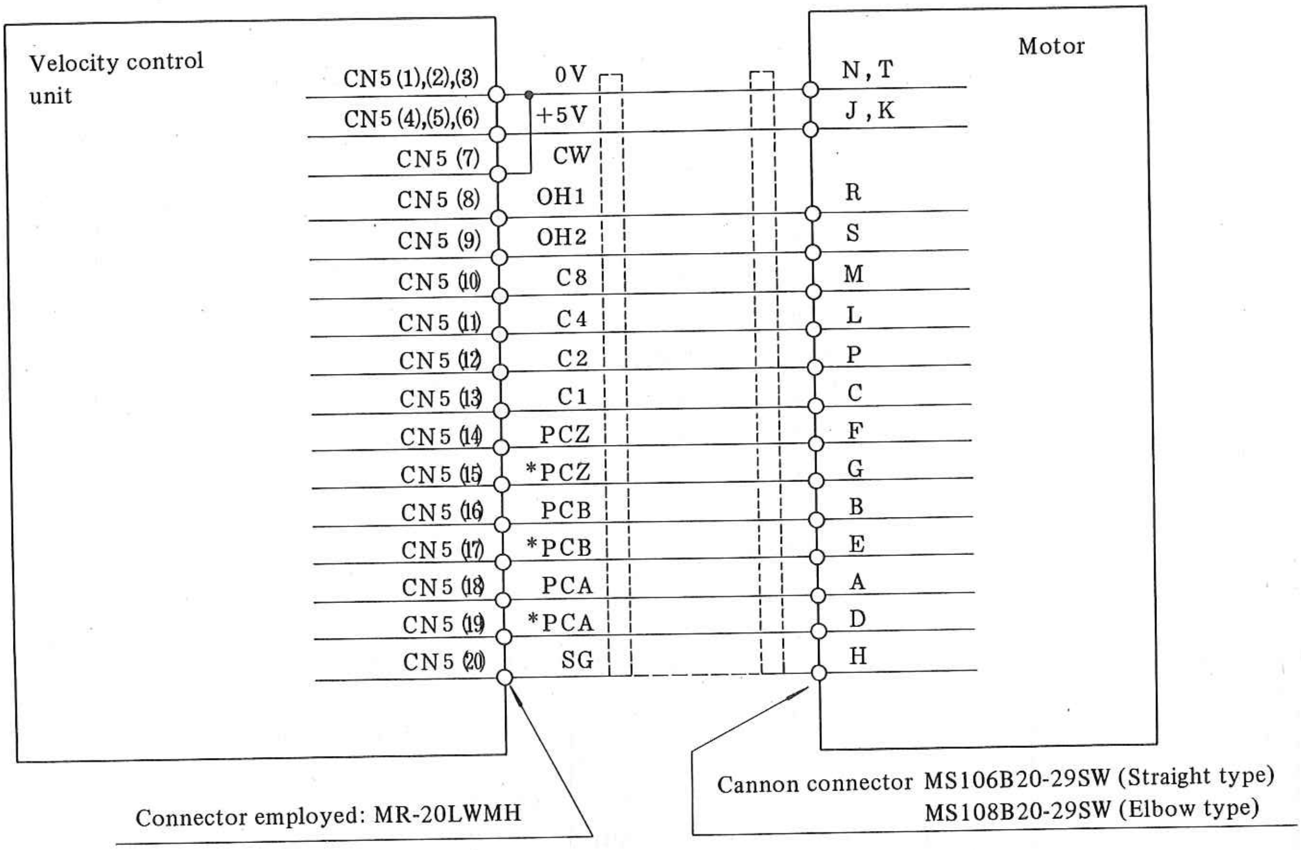
①	Signals PCA and PCB should be replaced each other in cable K6.
②	Signals *PCA and *PCB should be replaced each other in cable K6.
③	Signals CW and OV (terminal 1 or 2 or 3) should be connected.

Note 1: Connection of motor power line is not changed.

Note 2: This method can apply to edition C or after of velocity control unit PCB (A20B-1000-0560).
The method in item (2) apply to the edition A and B of PCB.

Note 3: This method can apply to AC SERVO UNIT for 2 axes control and AC SERVO UNIT for 3 axes control. Reconstruct cable K6 for axis to be reverse connection according to above changing.

Detail of connection of cable K6 in reverse connection.



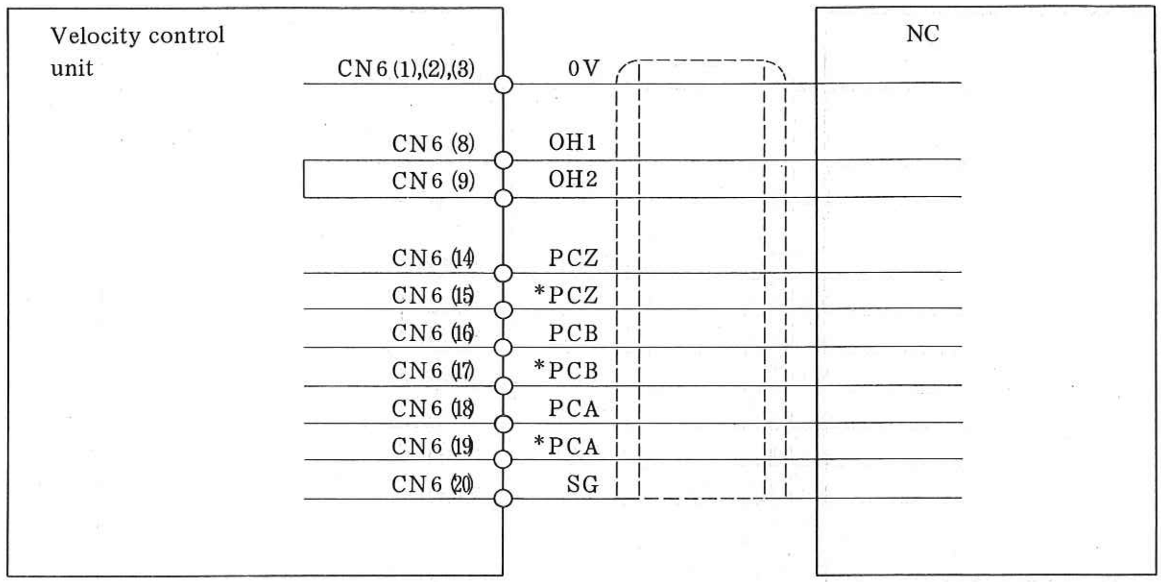
(2) For Model 4-0, 3-0

Change the connection of connector mounted on velocity control unit side of cable K1 and K7 between NC and velocity control unit.

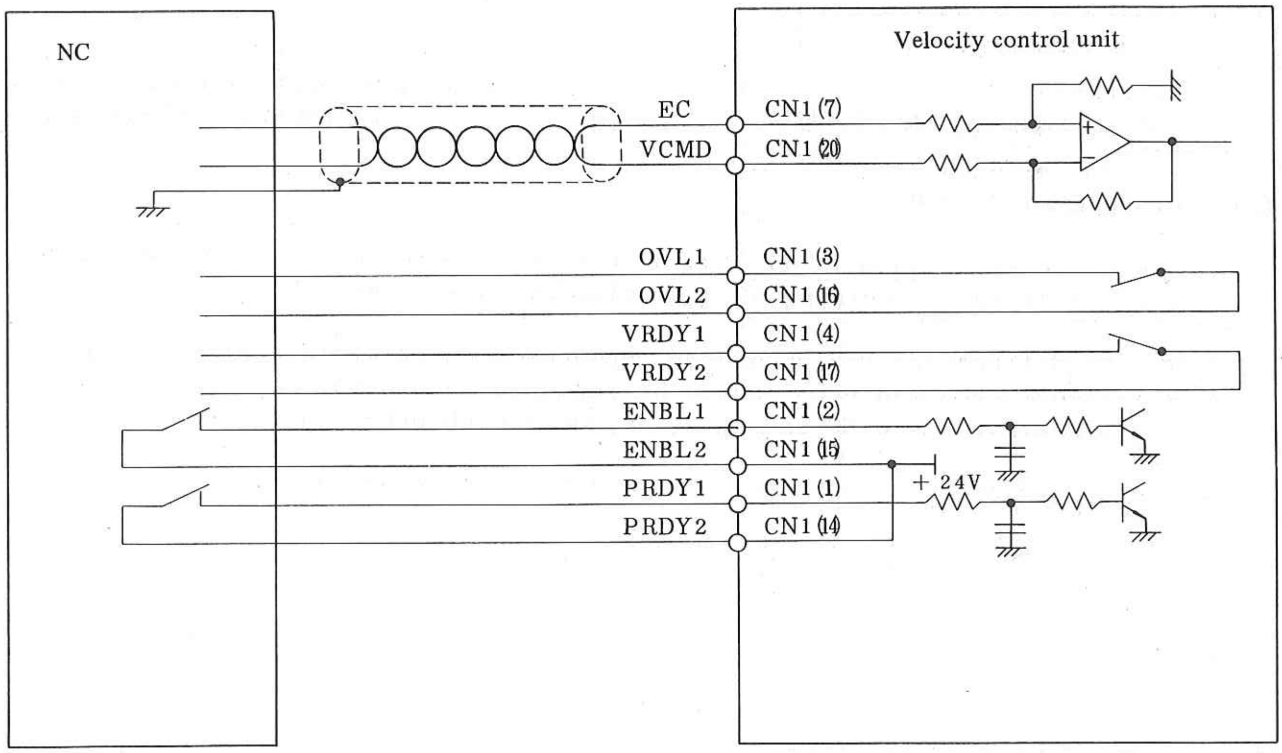
①	Signal PCA and PCB should be replaced each other in cable K7.
②	Signal *PCA and *PCB should be replaced each other in cable K7.
③	Signal VCMD and EC should be replaced each other in cable K1.

Note 1: Connection of motor power line is not changed.

Detail of connection of cable K7 in reverse connection.



Detail of connection of cable K7 in reverse connection.



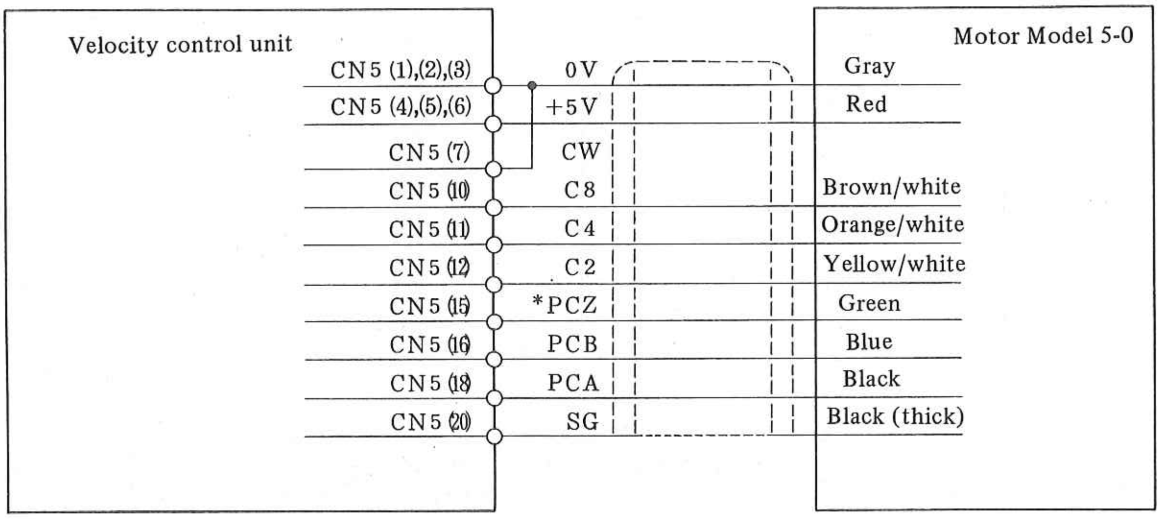
(3) For Model 5-0

Change the connection of connector mounted on velocity control unit side of feedback signal cable K6 (between motor and CN5).

① Signal PCA and PCB should be replaced each other in cable K6. ② Signal CW and OV (terminal 1 or 2 or 3) should be connected.

Note 1: Connection of motor power line is not changed.

Detail of connection of cable K6 in reverse connection.



10. POWER TRANSFORMERS AND APPLICABLE FUSES ON PRIMARY SIDE

Table 10

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

Power voltage	Transformer capacity (KVA) \ Fuse type	Utsunomiya Electric Co., Ltd. JG type	Fuji Electric Co., Ltd. Plug type
480V 550V	1.5 KVA	10A	10A
	2.5	10	15
	5	15	20
	10	20	30
	15	25	30

III. FANUC AC SERVO UNIT (FOR 2 AXES)

1. GENERAL

The FANUC AC servo unit for 2 axes has recently been developed to enable users to design a compact cabinet when comparatively small type FANUC AC servo motors are employed in a small machine tool. Its features are as follows.

(1) The velocity control unit drives two AC servo motors in a space corresponding to a space for about one conventional servo unit for one axis. (Combinations of two motors are restricted.)
(2) The motor output characteristic is equal to that of the unit for one-axis type.
(3) Various protective functions are provided in the same way as in conventional servo units for one axis.

2. CONSTRUCTION

The AC servo unit for 2 axes consists of the velocity control unit and power transformer. Three types of velocity control units are available according to the combinations of AC servo motor models employed. One velocity control unit applies to two servo motors. The specifications of the power transformer are the same as those of a power transformer employed when two servo units for one axis are used according to the combinations of motor models.

Fig. 2.1 shows a configuration example in an NC system of 2 controlled axes.

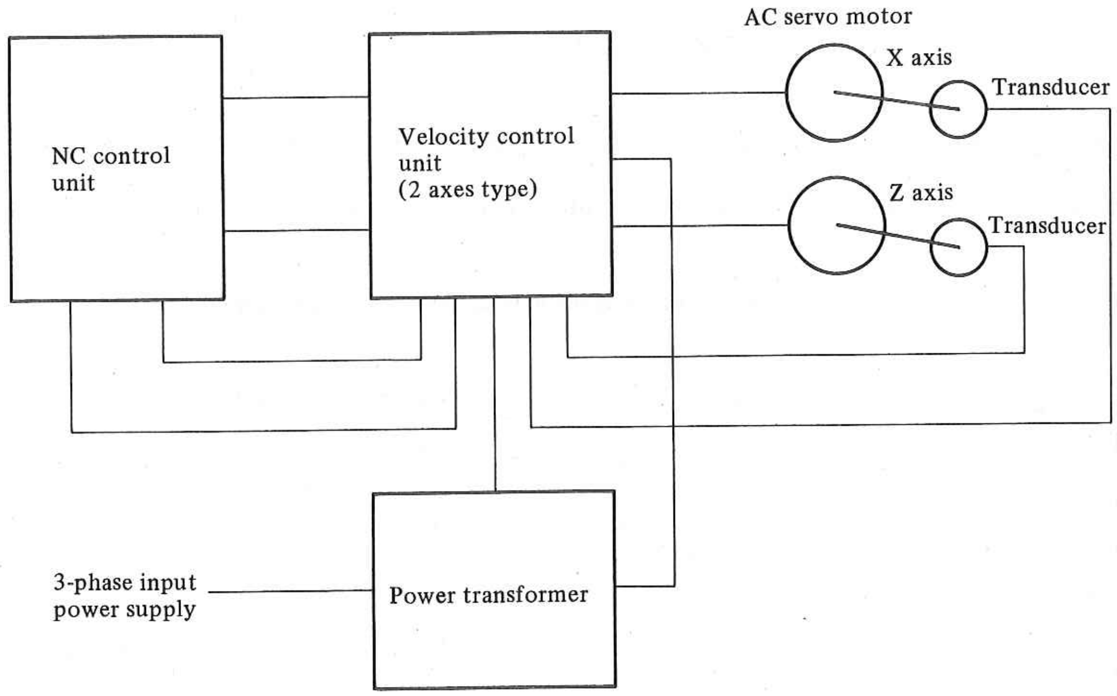


Fig. 2.1 A configuration example of using AC servo unit for 2 axes

2.1 Types of Units and Designated Specifications

Table 2.1 (a) Types of units and designated specifications

Name	Applicable motor		Specifications	Remarks
	L axis	M axis		
Velocity control unit	2-0/1-0	2-0/1-0	A06B-6050-H201	
	2-0/1-0	0/5	A06B-6050-H202	
	0/5	0/5	A06B-6050-H203	
Power transformer			Refer to 2.1 in Chapter II	
Input connector (Note)			A06B-6050-K200	Soldering type
			A068-6050-K201	Clim type

(Note) The input connector is used for the cable connected to the velocity control unit, and it comprises the following parts. One set of the input connector is required for 2 axes.

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

TAble 2.1.(c) shows the parts included input connector (climp type).

Table 2.1 (b) Parts included in input connector (soldering type)

Name	Q'ty	Use	Model	FANUC specifications
Connector + cover	2	CN1L,M	MR-20LFH *	A63L-0001-0134/02
Connector + cover	2	CN5L,M	MR-20LWMH *	A63L-0001-0134/15
Connector + cover	2	CN6L,M	MR-20LWFH *	A63L-0001-0134/05
Housing	1	CN2	SMS6PW-5 **	A63L-0001-0202/6W
Pin	5	CN2	RC16M-SCT3**	A63L-0001-0226

* Manufacturer: HONDA Tsushin Co., Ltd.
** Manufacturer: Burndy Japan Ltd.

Table 2.1 (c) Parts included input connector (climp style type)

Name	Q'ty	Use	Model	FANUC specifications
Connector + cover	2	CN1	MR-20L,MRP-20F01 *	A63L-0001-0134/22
Connector + cover	2	CN5	MR-20LW,MRP-20M01*	A63L-0001-0134/35
Connector + cover	2	CN6	MR-20LW,MRP-20F01*	A63L-0001-0134/25
Contact	80	CN1,6	MRP-F112 *	A63L-0001-0135/F112
Contact	40	CN5	MRP-M112 *	A63L-0001-0135/M112
Housing	1	CN2	SMS6PW-5 **	A63L-0001-0202/6W
Pin	5	CN2	RC16M-S23A **	A63L-0001-0127/S23A

3. SPECIFICATIONS AND FUNCTIONS

3.1 Specifications

Table 3.1

<table>
<tr><th colspan="3">Items</th><th colspan="2">Specifications</th></tr>
<tr><td colspan="3">Applicable motor model</td><td>2-0, 1-0</td><td>0, 5</td></tr>
<tr><td colspan="3">Rated output current
(Peak value) Note 1</td><td>4A</td><td>15A Note 2</td></tr>
<tr><td rowspan="4">Input power supply</td><td rowspan="3">Trans-former input</td><td>Input voltage</td><td colspan="2">3-phase 200/220/230/240/380/415/460/480/550V
(When transformer AAE, ABE, or ACE is used)</td></tr>
<tr><td>Allowable voltage fluctuations</td><td colspan="2">+10%, -15%</td></tr>
<tr><td>Allowable frequency fluctuation</td><td colspan="2">±2Hz</td></tr>
<tr><td colspan="2">100V AC</td><td colspan="2">50Hz±2Hz 100V +10%,-15%
60Hz±2Hz 100V∿110V +10%,-15%</td></tr>
<tr><td colspan="3">Main circuit system</td><td colspan="2">Transistor bridge</td></tr>
<tr><td colspan="3">Control system</td><td colspan="2">Sine wave PWM control</td></tr>
<tr><td colspan="3">Velocity command voltage</td><td colspan="2">3.5V/1,000rpm</td></tr>
<tr><td colspan="3">Velocity feedback voltage</td><td colspan="2">3.0V/1,000rpm</td></tr>
<tr><td colspan="3">Current limit value Note 3</td><td>12A</td><td>45A Note 4</td></tr>
<tr><td colspan="3">Alarm, protective function</td><td colspan="2">Various functions</td></tr>
<tr><td colspan="3">Ambient temperature range</td><td colspan="2">0°C ∿ 55°C</td></tr>
</table>

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

Note 2: The use of model 5 x 2 may be limited at the maximum rating of the 2-axes simultaneous type.

Note 3: The current limit value shows the present standard value. The deviation of the operating value due to the circuit constants is about ±10%.

Note 4: This value is effective from PCB A20B-1001-0470/06B edition. This value is 40 before PCB A20B-1001-0470/05A edition.

3.2 Protection and Fault Detection Functions

Refer to 3.2 in Chapter II.

4. POWER TRANSFORMER SELECTION METHOD

5. POWER SUPPLY

6. POWER DISSIPATION QUANTITY

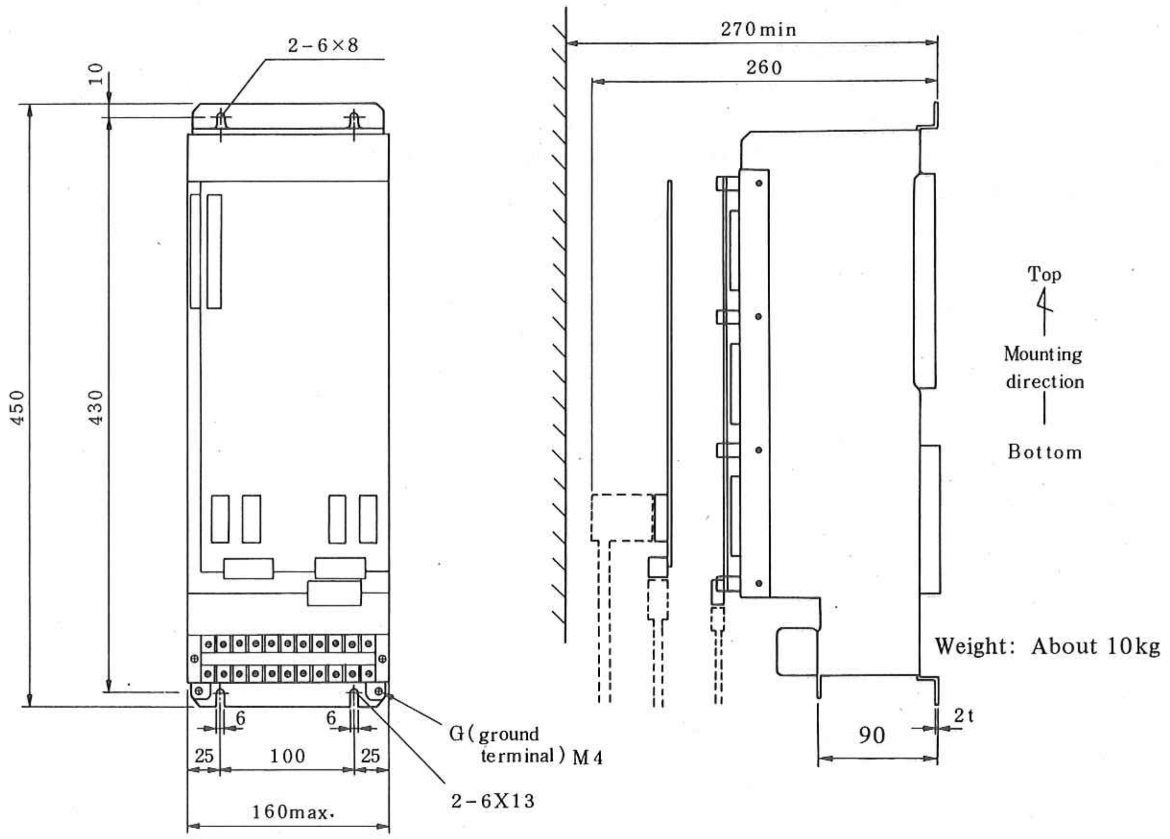
7. INSTALLATION CONDITIONS AND CAUTIONS

For subsection 4 ∿ 7, refer to the same subsections in Chapter II. The Chapter II covers the values per axis. Add the values for 2 axes of the motor model employed when 2 axes are used.

8. EXTERNAL VIEWS

For the external views of the power transformer and input connector, see 8.2 and 8.4 in Chapter II.

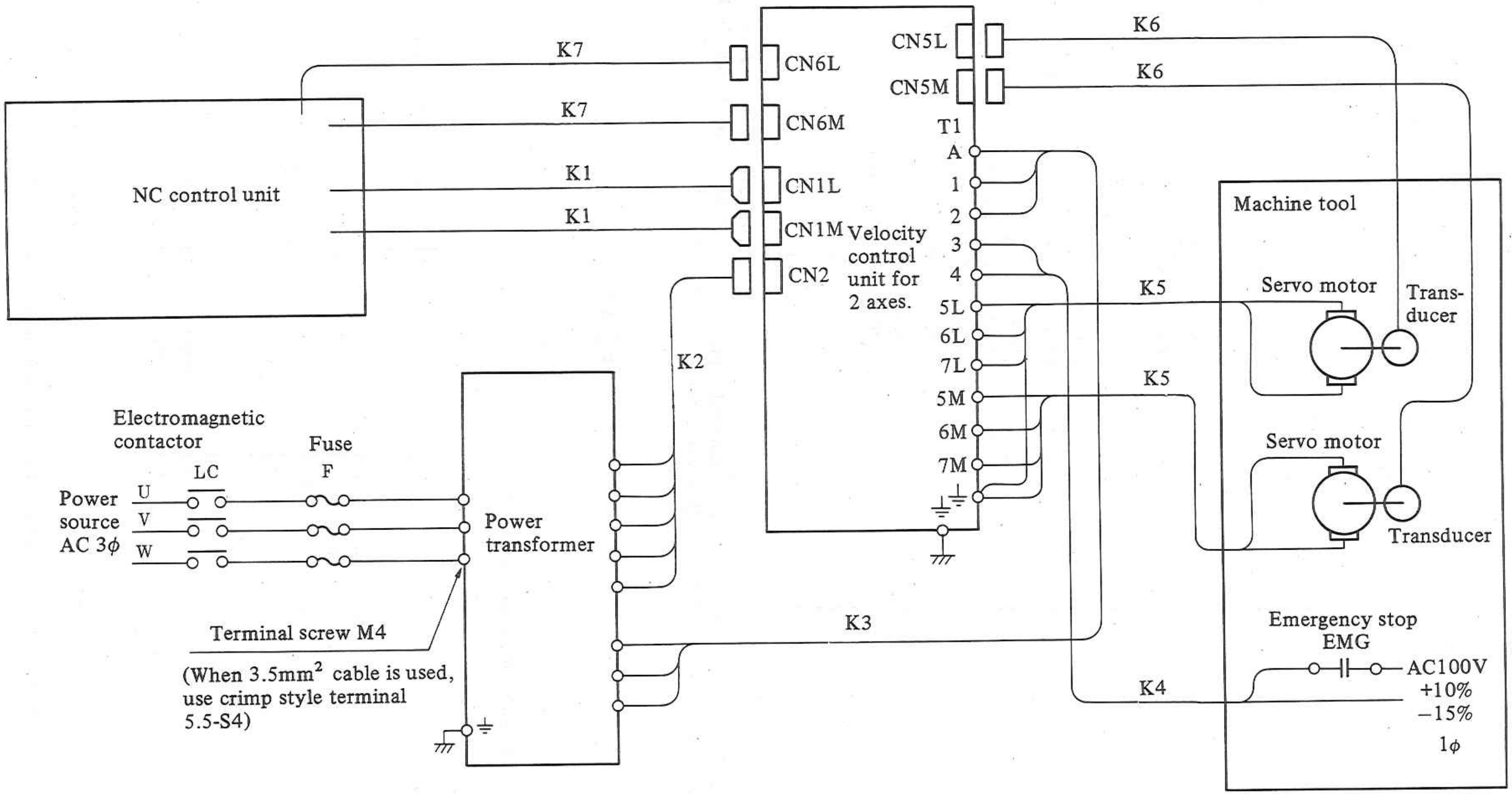
8.1 Velocity Control Unit (A06B-6050-H201 to H203)



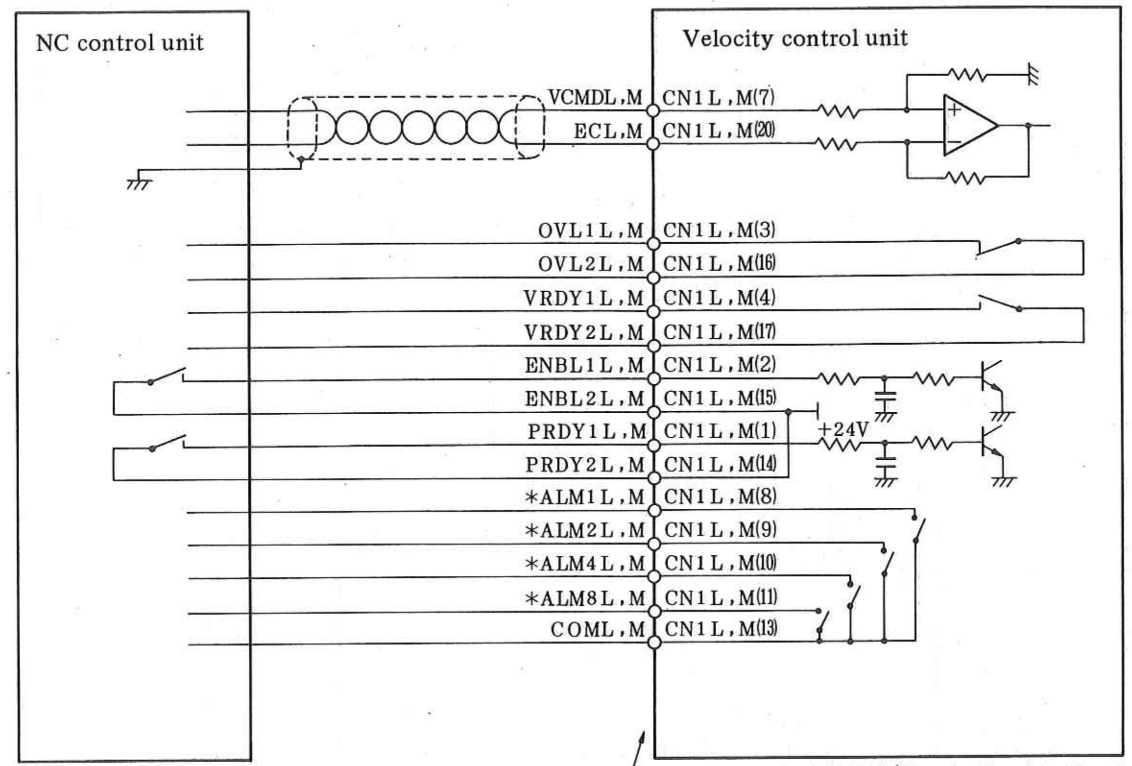
9. CONNECTIONS

9.1 Connection Diagram

(Note 1) For details of cables K1 ~ K7, see 9.1.1 ~ 9.1.7.
(Note 2) Connections of cables K1 and K7 differ according to NC control unit. For details, see the connecting manual for each NC.



9.1.1 Details of connections of cable K1

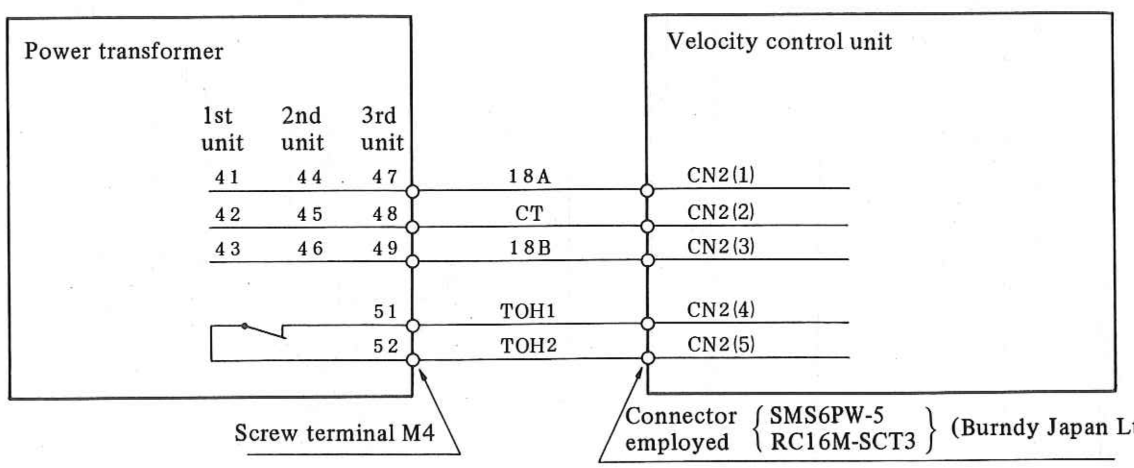


Cable employed:
VCMD/EC; 0.1 ~ 0.18mm^2 paired shielded cable
Other cases; 0.18 ~ 0.3mm^2 200V vinyl wire

Connector MR20LFH (Honda Tsushin Co., Ltd.)
(For the connector terminal arrangement, see 8.4)

Fig. 9.1.1

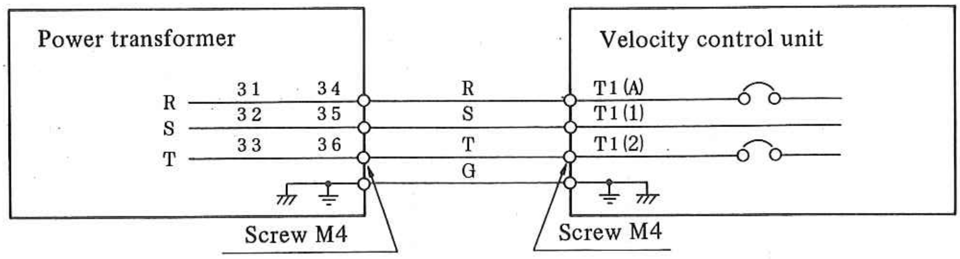
9.1.2 Details of connections of cable K2



Cable employed : 0.75mm^2 (30/0.18) 200V heat-resistive vinyl cable.

Fig. 9.1.2

9.1.3 Details of connections of cable K3

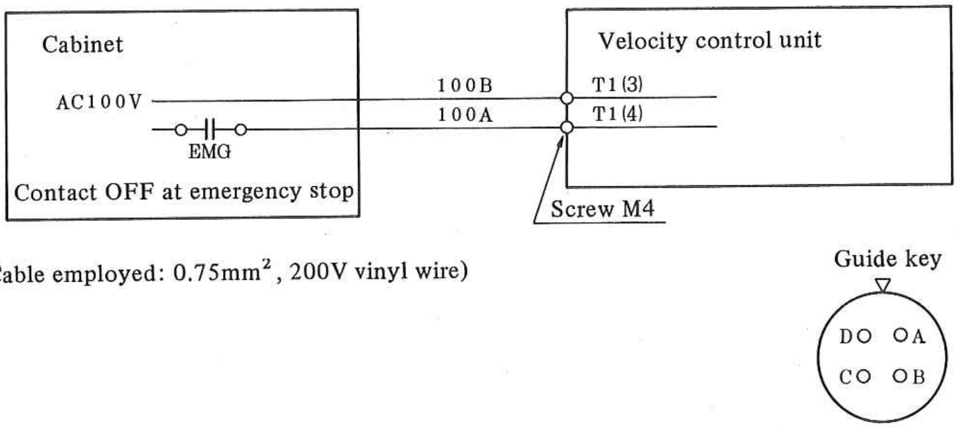


(Cable employed: 2.0mm², 600V heat-resistive vinyl wire)

Note) Input voltage of velocity control unit is 185V.

Fig. 9.1.3

9.1.4 Details of connections of cable K4

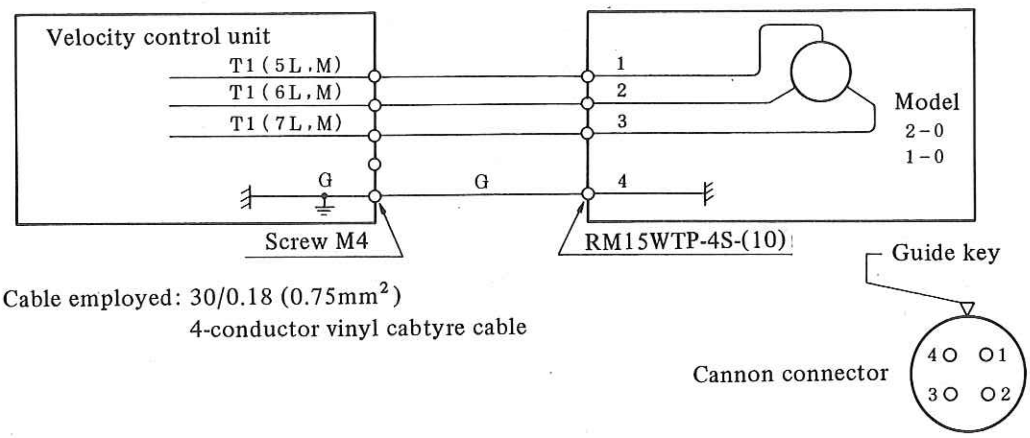


(Cable employed: 0.75mm², 200V vinyl wire)

Fig. 9.1.4

9.1.5 Details of connections of cable K5

(1) Model 2-0, 1-0



Cable employed: 30/0.18 (0.75mm²)
4-conductor vinyl cabtyre cable

Fig. 9.1.5 (a)

(2) Model 0 and 5

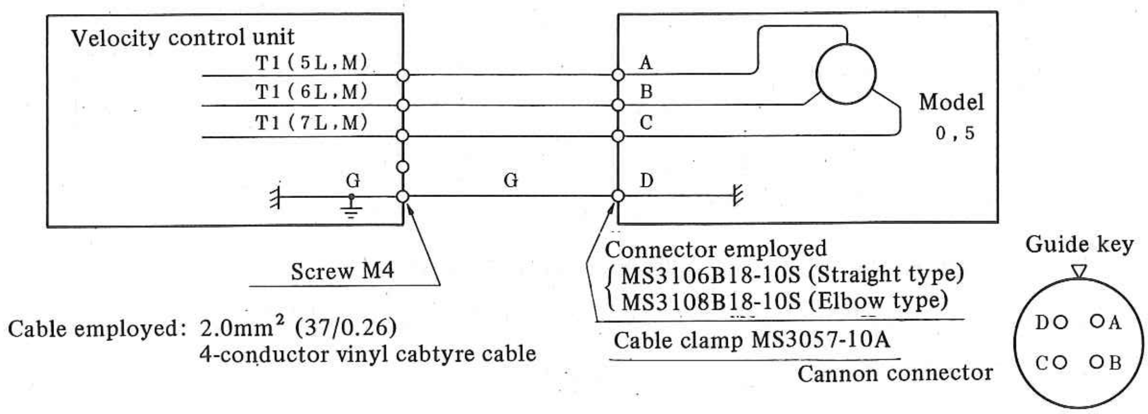
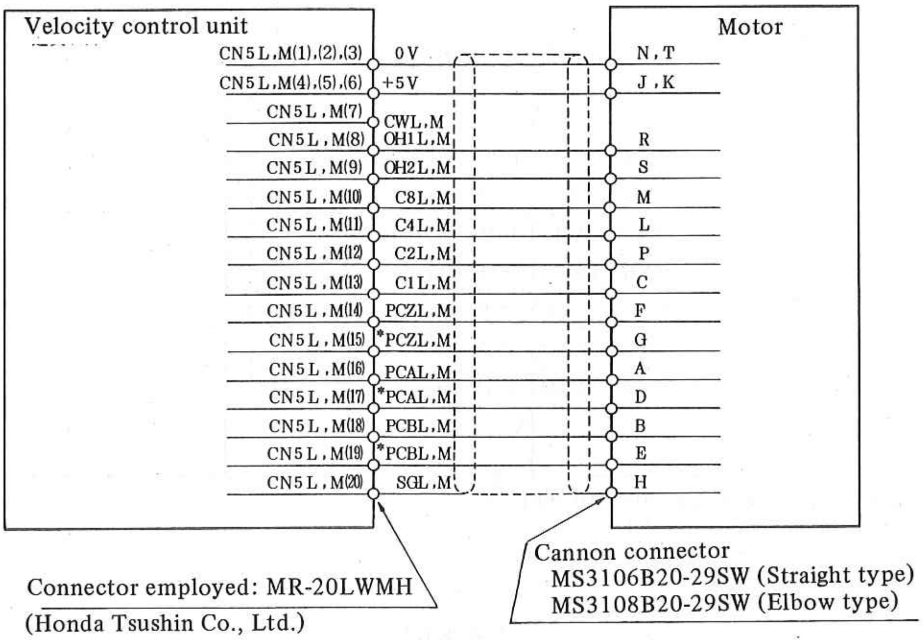
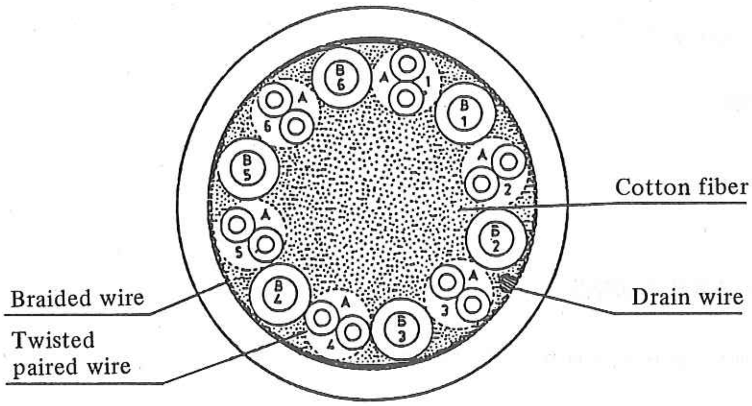
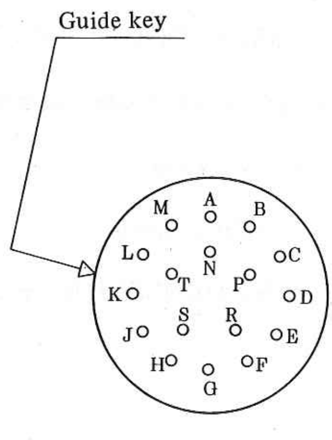


Fig. 9.1.5 (b)

9.1.6 Details of connections of cable K6







Designation	For A1∿6 signals	For B1∿6 power supply	Cable specifications	Cable length
A06B-6050-K050/K051	0.18mm^2	1.25mm^2	A66L-0001-0161	14m or more
A06B-6050-K053/K054	0.18mm^2	0.75mm^2	A66L-0001-0199	14m or less

Fig. 9.1.6

9.1.7 Details of connection of cable K7

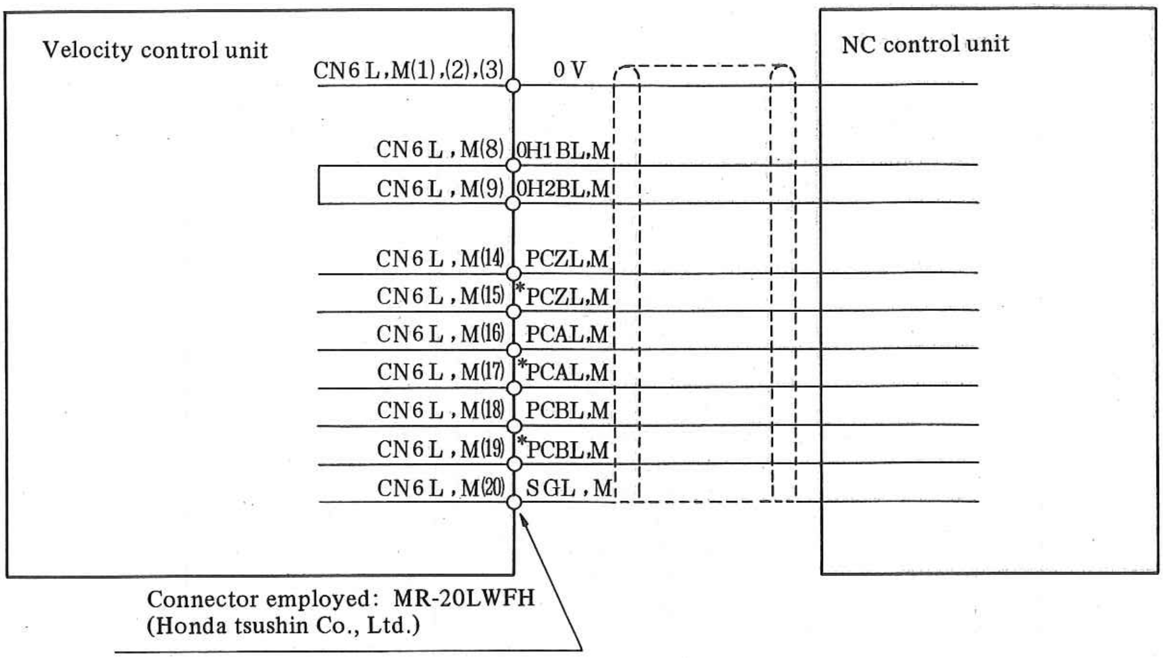


Fig. 9.1.7

9.2 Assembly of Cables K2, K3, K5, K6, K7

9.3 Connection of Power Transformer

9.4 Details of Signals

9.5 Reverse Connection

10. POWER TRANSFORMER PRIMARY FUSES

For 9.2 ∿ 10, refer to the same subsections in Chapter II.

IV. FANUC AC SERVO UNIT (FOR 3 AXES)

1. GENERAL

The FANUC AC servo unit for 3 axes has recently been developed to enable users to design a compact cabinet when comparatively small type FANUC AC servo motors are employed in a small machine tool. As the 3 axes control circuit, power circuit and power supply are integrated, installating and connecting of the servo unit can be done more easily.

Note: The combination of the motors for 3 axes is limited. The load is also limited when the motors are used continuously and simultaneously according to the motor combination. See the item 3 "Specification" for details.

2. CONSTRUCTION

The AC servo unit for 3 axes consists of the velocity control unit, the power transformer and the discharge unit.
Four types of velocity control unit are available according to the combinations of AC servo motor models employed. One velocity control unit applies to three servo motors.
One power transformer is employed according to the combinations of motor model.
A regenerative discharge unit is a resistor unit which consumes the regenerated energy by the motor.
If the AC servo motor models employed are rather small type having a little regenerative energy, a regenerative discharge unit may be unnecessary.
Fig. 2.1 shows a configuration example of an NC system with 3 controlled axes.

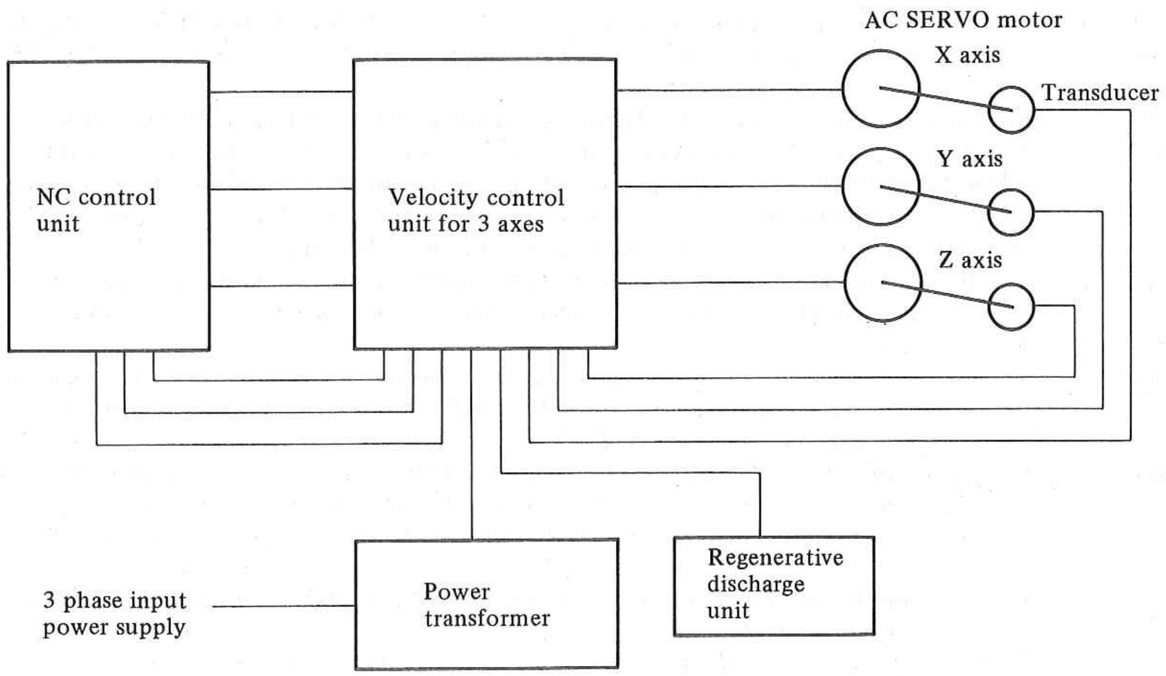


Fig. 2.1 A typical configuration using an AC servo unit for 3 axes

2.1 Types of Unit and Specification Number

Table 2.1.1 Types of units and specification number

Name	Applicable motor			Specification	Remarks
	L	M	N		
Velocity control unit	0/5	0/5	0/5	A06B-6050-H401	
	0/5	0/5	10	A06B-6050-H402	
	0/5	10	10	A06B-6050-H403	
Note 1	10	10	10	A06B-6050-H404	
Power transformer Note 2	Common to all countries 190V - 550V		Transformer ABE	A06B-6050-H022	
			Transformer ACE	A06B-6050-H023	
Regenerative discharge unit DCUA				A06B-6050-H050	Note 3
Regenerative discharge unit DCUB				A06B-6050-H052	Note 4
Regenerative discharge unit DCUC				A06B-6050-H051	Note 5
Input connector (Soldering type)				A06B-6050-K202	Note 6
Input connector (Crimp style type)				A06B-6050-K203	Note 6

Note 1: Specification number differs according to a motor combination.

Note 2: If the specifications of the velocity control unit are A06B-6050-H401 or -H402, one of transformers ABE should be used.
If the specifications of velocity control units are A06B-6050-H403 or -H404, one of transformers ACE should be used.

Note 3: To be used when the regenerative energy from the motors of three axes is rather large employing the velocity control unit A06B-6050-H401.

Note 4: To be used when the regenerative energy from the motors of three axes is rather large employing the velocity control unit A06B-6050-H402 or A06B-6050-H403,

Note 5: One set should be used for one velocity control unit A06B-6050-H404.

Note 6: Input connector includes connectors to be employed on the connecting cables to the velocity control unit. One set should be used for 3 axes.
Parts contained in the input connector (soldered type) are indicated in the Table 2.1.2.
Parts contained in the input connector (crimp style type) are indicated in the Table 2.1.3.

Table 2.1.2 Parts included in input connector (soldering type)

Name	Q'ty	Use	Model	FANUC specifications
Connector + cover	3	CN1L,M,N	MR-20LFH *	A63L-0001-0134/02
Connector + cover	3	CN5L,M,N	MR-20LWMH *	A63L-0001-0134/15
Connector + cover	3	CN6L,M,N	MR-20LWFH *	A63L-0001-0134/05
Housing	1	CN2	SMS6PW-5 **	A63L-0001-0202/6W
Pin	5	CN2	RC16M-SCT3 **	A63L-0001-0226

* Manufacturer: HONDA Tsushin Co., Ltd.
** Manufacturer: Burndy Japan Ltd.

Table 2.1.3 Parts included in input connector (crimp style type)

Name	Q'ty	Use	Model	FANUC specifications
Connector + cover	3	CN1L,M,N	MR-20L,MRP-20F01 *	A63L-0001-0134/22
Connector + cover	3	CN5L,M,N	MR-20LW,MRP-20M01*	A63L-0001-0134/35
Connector + cover	3	CN6L,M,N	MR-20LW,MRP-20F01*	A63L-0001-0134/25
Contact	120	CN1,6	MRP-F112 *	A63L-0001-0135/F112
Contact	60	CN5	MRP-M112 *	A63L-0001-0135/M112
Housing	1	CN2	SMS6PW-5 **	A63L-0001-0202/6W
Pin	5	CN2	RC16M-S23A **	A63L-0001-0127/S23A

* Manufacturer: HONDA Tsushin Co., Ltd.
** Manufacturer: Burndy Japan Ltd.

3. SPECIFICATIONS AND FUNCTIONS

3.1 Specifications

Table 3.1

<table>
<tr><th colspan="3">Items</th><th colspan="2">Specifications</th></tr>
<tr><td colspan="3">Applicable motor model</td><td>0, 5</td><td>10</td></tr>
<tr><td colspan="3">Rated output current
(Peak value) Note 1</td><td>10A</td><td>15A</td></tr>
<tr><td rowspan="4">Input power supply</td><td rowspan="3">Trans-former input</td><td>Input voltage</td><td colspan="2">3-phase 200/220/230/240/380/415/460/480/550V
(When transformer ABE, or ACE is used)</td></tr>
<tr><td>Allowable voltage fluctuation</td><td colspan="2">+10%, -15%</td></tr>
<tr><td>Allowable frequency fluctuation</td><td colspan="2">±2Hz</td></tr>
<tr><td colspan="2">100V AC</td><td colspan="2">50Hz±2Hz 100V +10%,-15%
60Hz±2Hz 100V~110V +10%,-15%</td></tr>
<tr><td colspan="3">Main circuit system</td><td colspan="2">Transistor bridge</td></tr>
<tr><td colspan="3">Control system</td><td colspan="2">Sine wave PWM control</td></tr>
<tr><td colspan="3">Velocity command voltage</td><td colspan="2">3.5V/1,000rpm or 7V/1000rpm</td></tr>
<tr><td colspan="3">Velocity feedback voltage</td><td colspan="2">3.0V/1,000rpm</td></tr>
<tr><td colspan="3">Current limit value Note 2</td><td colspan="2">45A</td></tr>
<tr><td colspan="3">Alarm, protective function</td><td colspan="2">Various functions</td></tr>
<tr><td colspan="3">Ambient temperature range</td><td colspan="2">0°C ~ 55°C</td></tr>
</table>

Note 1: The rated output is guaranteed at rated input voltage. If the input voltage fluctuates, the rated output is not always guaranteed, even if the input voltage fluctuation is within the allowable fluctuation range.
Allowable continuous load of the velocity control unit is not more than two model 10 motors with maximum continuous load.

Note 2: The current limit value shows the present standard value. The deviation of the operating value due to the circuit constants is about ±10%.

3.2 Protection and Fault Detection Function

Refer to 3.2 in Chapter II.

4. SELECTION OF POWER TRANSFORMER AND REGENERATIVE DISCHARGE UNIT

4.1 Power Transformer Selection

Table 4.1

Specification of velocity control unit	Power transformer	Remarks
A06B-6050-H401, H402	ABE	3.5 KVA Note 1
A06B-6050-H403, H404	ACE	5 KVA

Note: ACE is required when the total output of motor used continuously is more than 2.2 KW.

4.2 Regenerative Discharge Unit Selection

(Preparation) Regarding to the vertical axis, calculate Q by the following formula.

$$Q = 1.026 \times 10^{-2} Th\ Vm \times D/100 \quad \ldots\ldots\ldots\ldots \quad (1)$$

where, Th : Torque of a motor which rotates supporting axis upwards when a tool or a table goes down at rapid traverse (kg.cm)

Vm : Motor speed at rapid traverse (rpm)

D : Downward run hour duty at rapid traverse (%)

4.2.1 In case of velocity control unit A06B-6050-H401 is employed

1 pce. of the regenerative discharge unit A06B-6050-H050 should be used, if one of the following conditions is satisfied.

1) Q calculated from (1) exceeds 100.
2) Q is less than 100 and total rapid acceleration/deceleration times of all axes per 10 sec. exceed 'N' and a motors are continuously operated.
   $N = 3\times(150-Q)/50$ (times) (Note 1)
3) Some axis has load inertia exceeding rotor inertia of the motor employed.

Note: It differs according to the acceleration/deceleration time constant. For details, please contact to our sales department with your load conditions.

4.2.2 In case of velocity control unit A06B-6050-H402, and -H403 are employed

1 pce. of the regenerative discharge unit A06B-6050-H052 should be used if one of the following conditions is satisfied.

1) Q calculated from (1) exceeds 100.
2) Q is less than 100 and total rapid acceleration/deceleration times of all axes per 10 sec. exceed 'N' and motors are continuously operated.
   $N = 3\times(150-Q)/100$ (times) (See Note 1 of 4.2.1)
3) Some axis has load inertia exceeding rotor inertia of the motor employed.

5. POWER SUPPLY

5.1 Input Power Supply

3 phase power supply for main circuit and single phase 100V power supply for coil of the magnetic contactor for a dynamic brake are employed.

5.1.1 3 phase input power supply

Table 5.1.1 (a)

Power transformer	Number of phase	Voltage	Frequency
ABE, ACE	3 phase	200, 220, 230, 240, 380, 420, 460, 480, 550V +10%, -15%	50/60Hz ±2Hz

5.1.2 Capacity of 3-phase power supply

The capacity of the power supply for the continuous output is specified in Table 5.1.2. In case the AC servo motor is rapidly accelerated, power of about twice the continuous rated value may be needed momentarily. Accordingly, use the power supply enough for the load.

Table 5.1.2

Specification of velocity control unit	Capacity of 3-phase input power
A06B-6050-H401, H402	5KVA
A06B-6050-H403, H404	7.5KVA

5.2 Single-phase 100V power supply

Table 5.2

Rated voltage	AC 100V	
Number of phase	Single phase	
Frequency	50Hz±2Hz	60Hz±2Hz
Voltage	100V +10%, -15%	100V ∿ 110V +10%, -15%
Capacity	Continuous: 40VA, At turning on the contactor: 180VA	

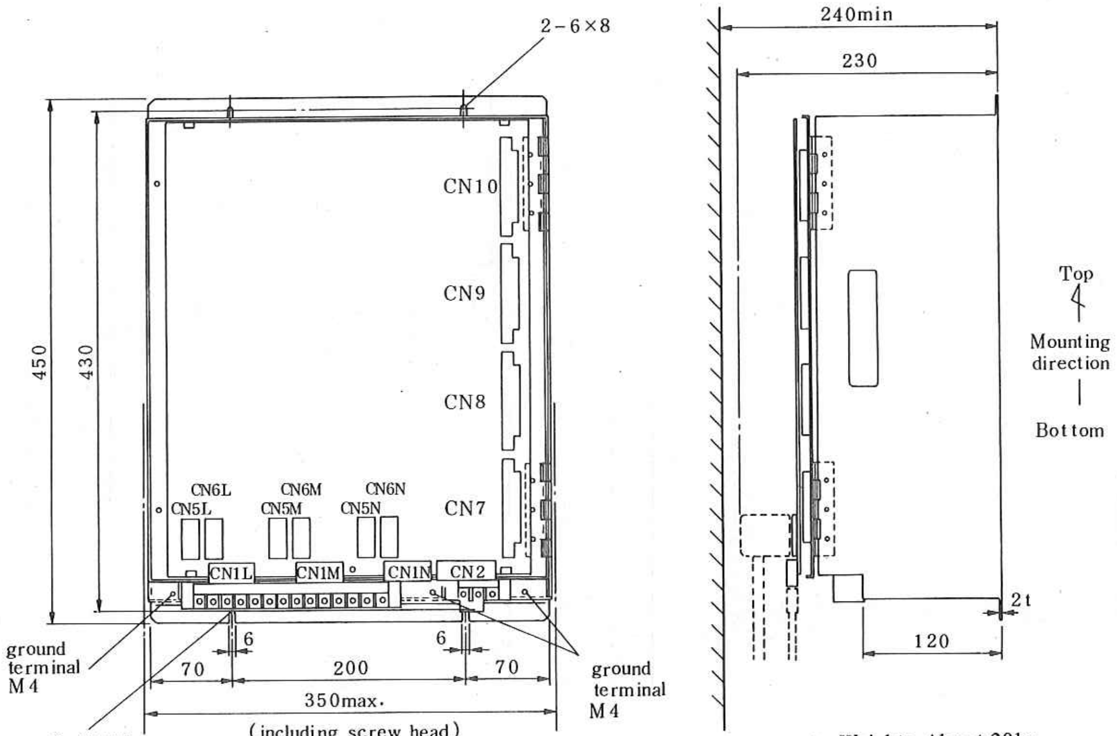
6. POWER DISSIPATION QUANTITY

7. INSTALLATION CONDITIONS AND CAUTIONS

For subsection 6 and 7, refer to the same subsections in Chapter II. The Chapter II covers the values per axis. Add the values for 3 axes of the motor model employed when 3 axes are used.

8. OUTLINE DRAWINGS

8.1 Velocity Control Unit A06B-6050-H401, H402, H403, H404



Weight: About 20kg

8.2 Power Transformer

Refer to 8.2 in Chapter II for outline drawings of power transformer.

8.3 Regenerative Discharge Unit

8.3.1 Regenerative discharge unit A06B-6050-H050

Refer to 8.3 in Chapter II for outline drawings of regenerative discharge unit A06B-6050-H050, H052.

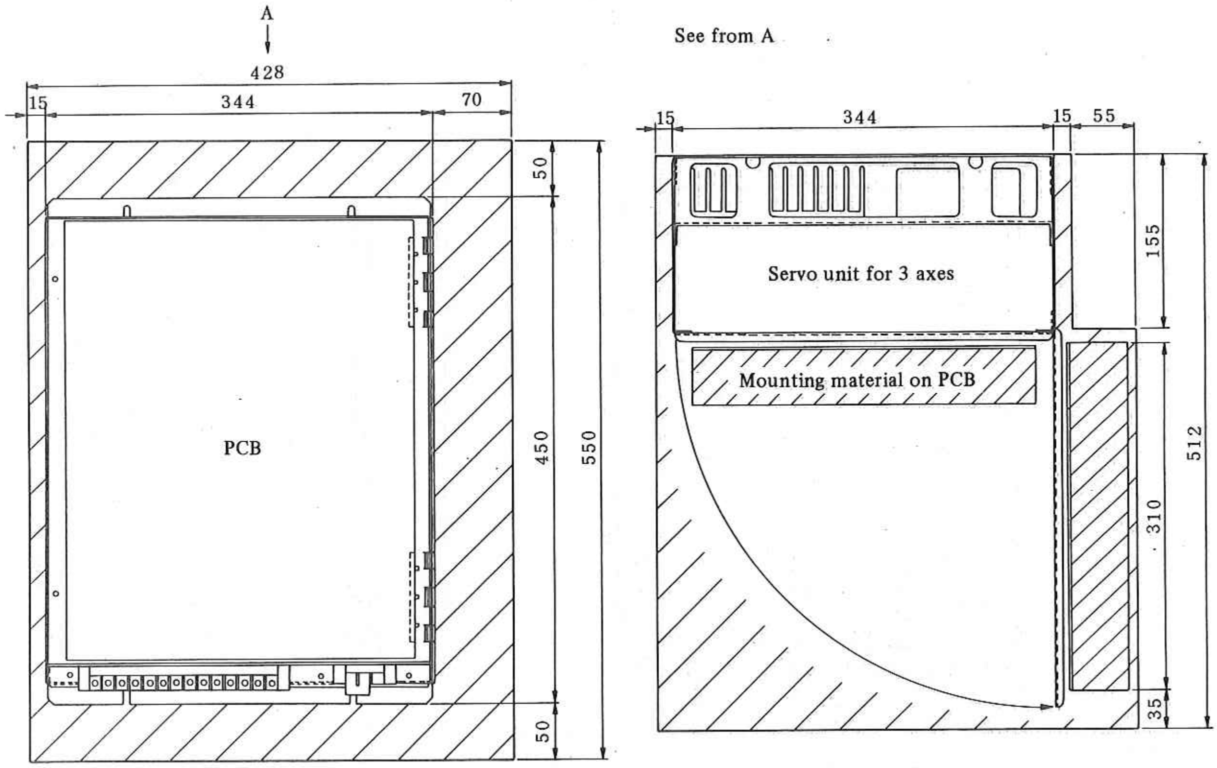
8.3.2 Regenerative discharge unit A06B-6050-H051

Regenerative discharge unit A06B-6050-H051 consists of 2 sets of the separate regenerative discharge unit which dimension is described item 8.3 in Chapter II. Notice that at the installation designing.

8.4 External View of Input Connector

Refer to 8.4 in Chapter II for outline drawing of input connector.

8.5 Maintenance Area of Velocity Control Unit



9. CONNECTIONS

9.1 Connection Diagram

Fig. 9.1(a) shows standard connection diagram of A06B-6050-H401 - H403.

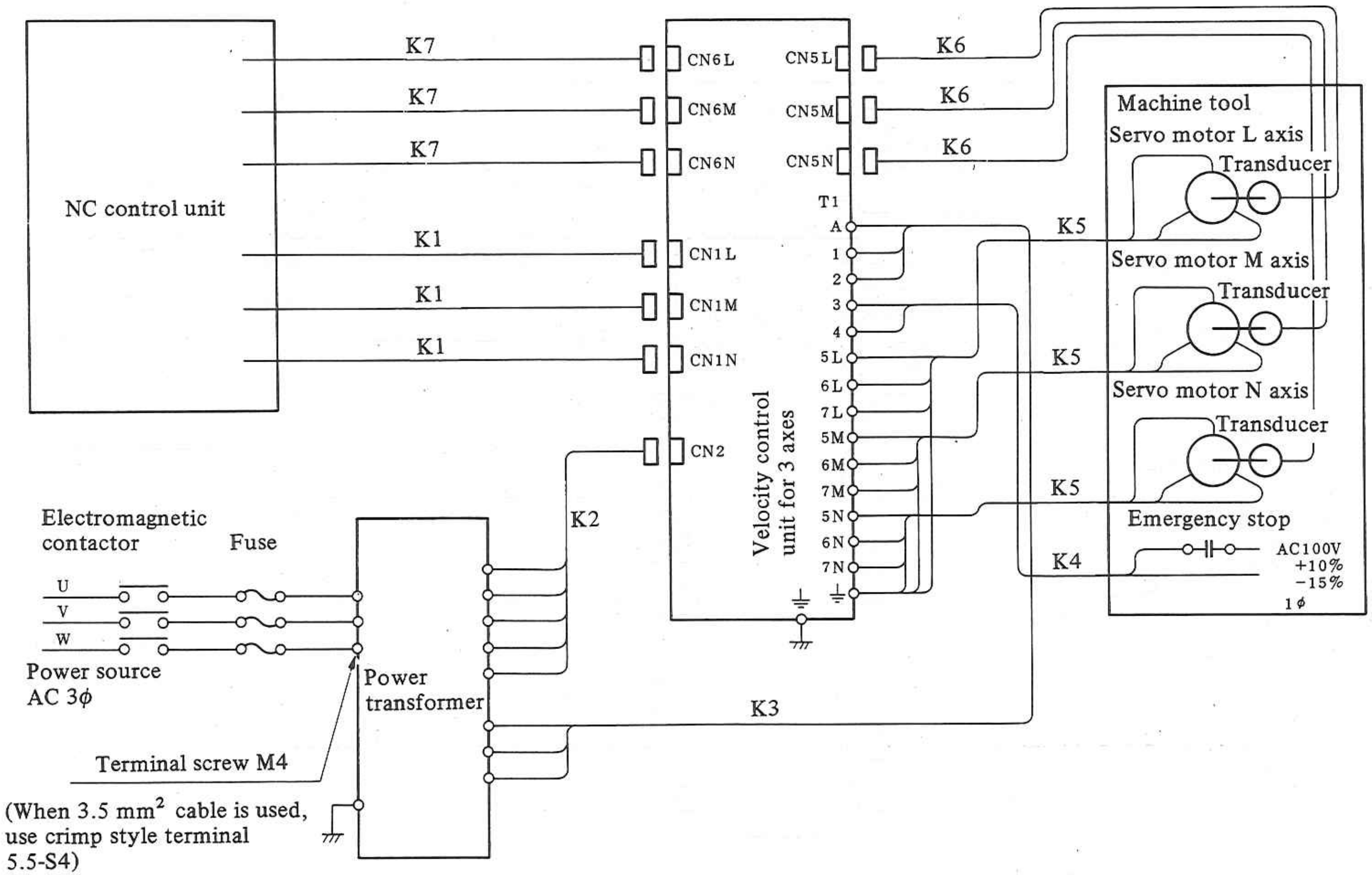


Fig. 9.1 (a)

Fig. 9.1(b) shows connection diagram of A06B-6050-H401 - H403 with regenerative discharge unit.

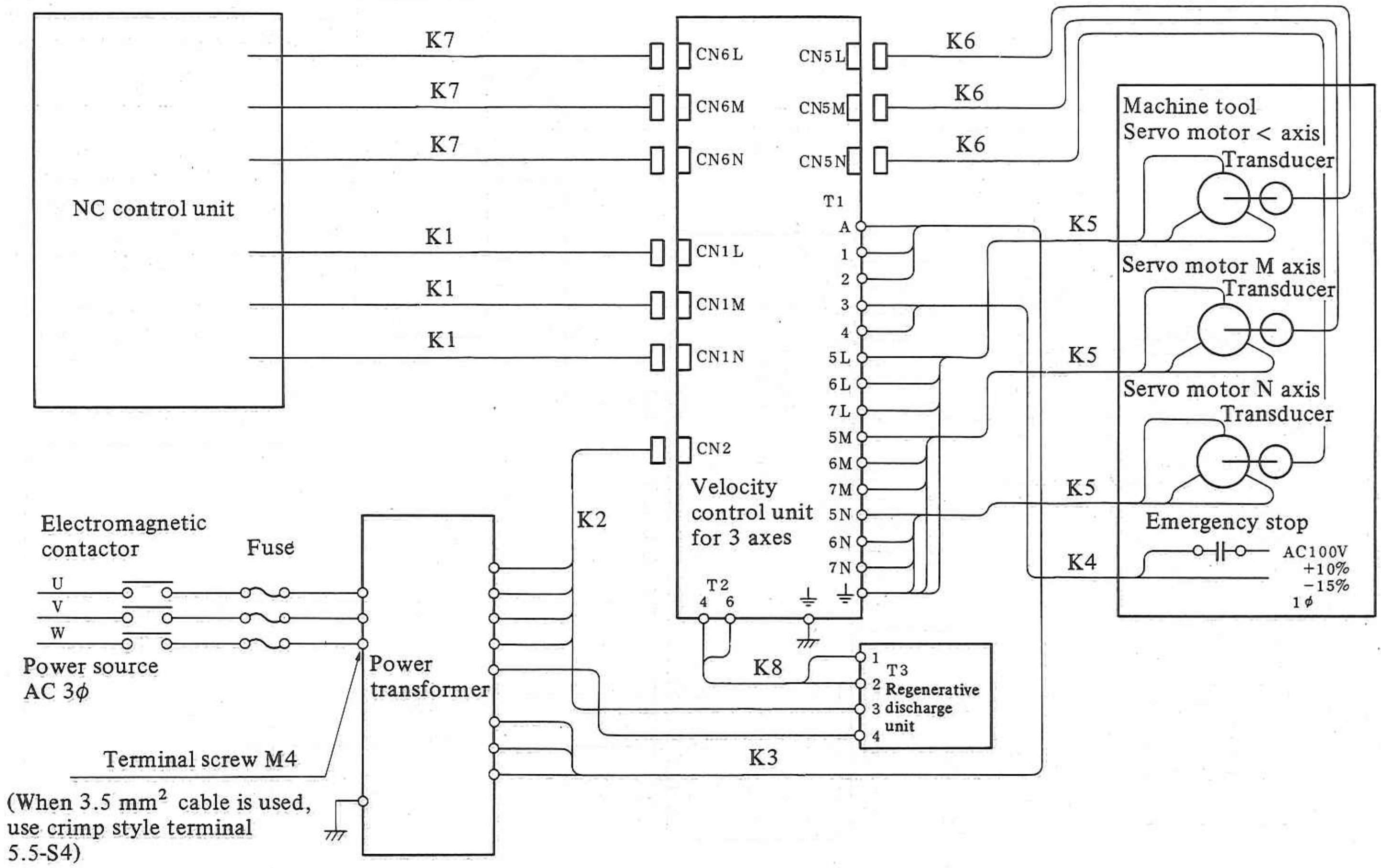


Fig. 9.1 (b)

Fig. 9.1(c) shows standard connection diagram of A06B-6050-H404.

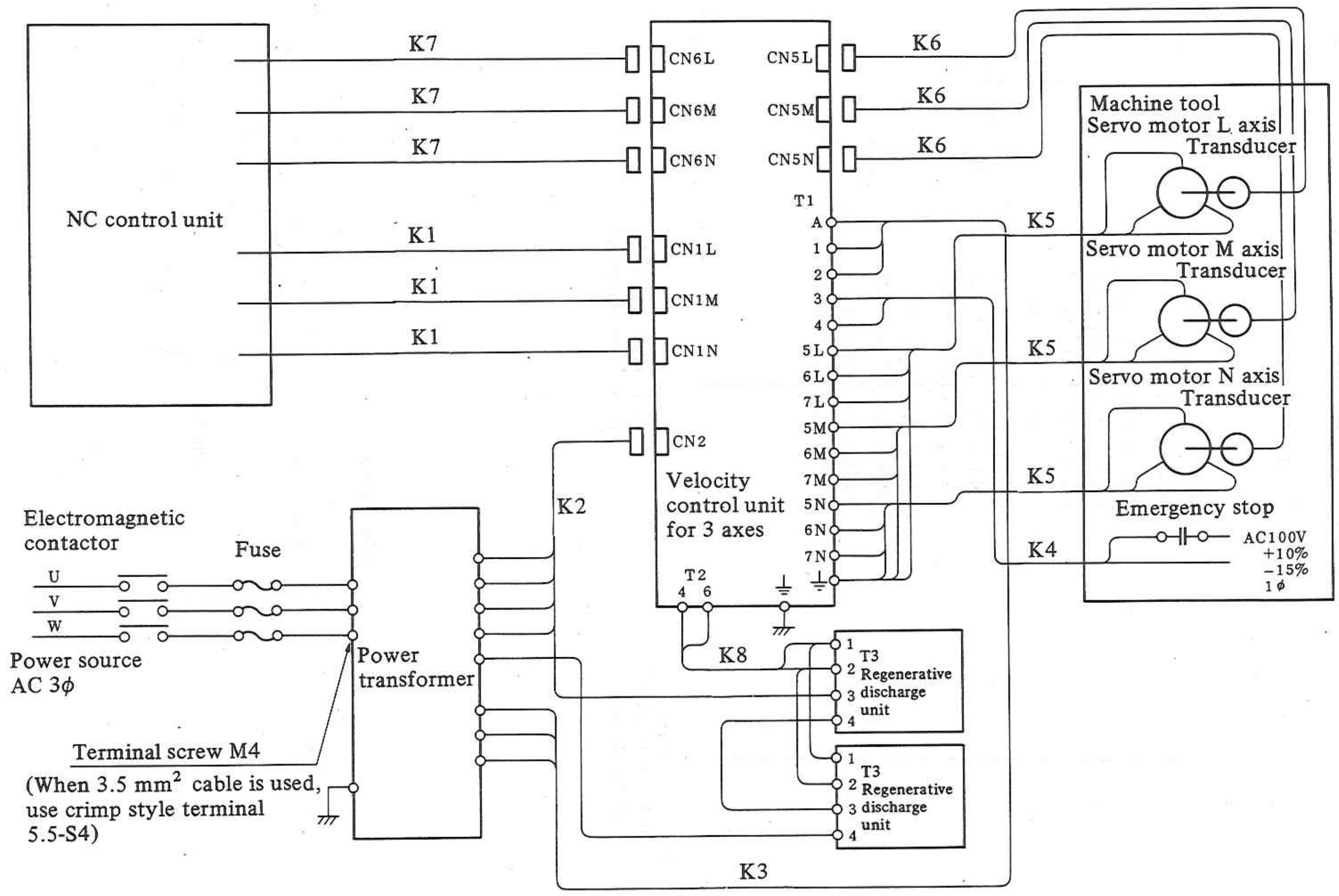
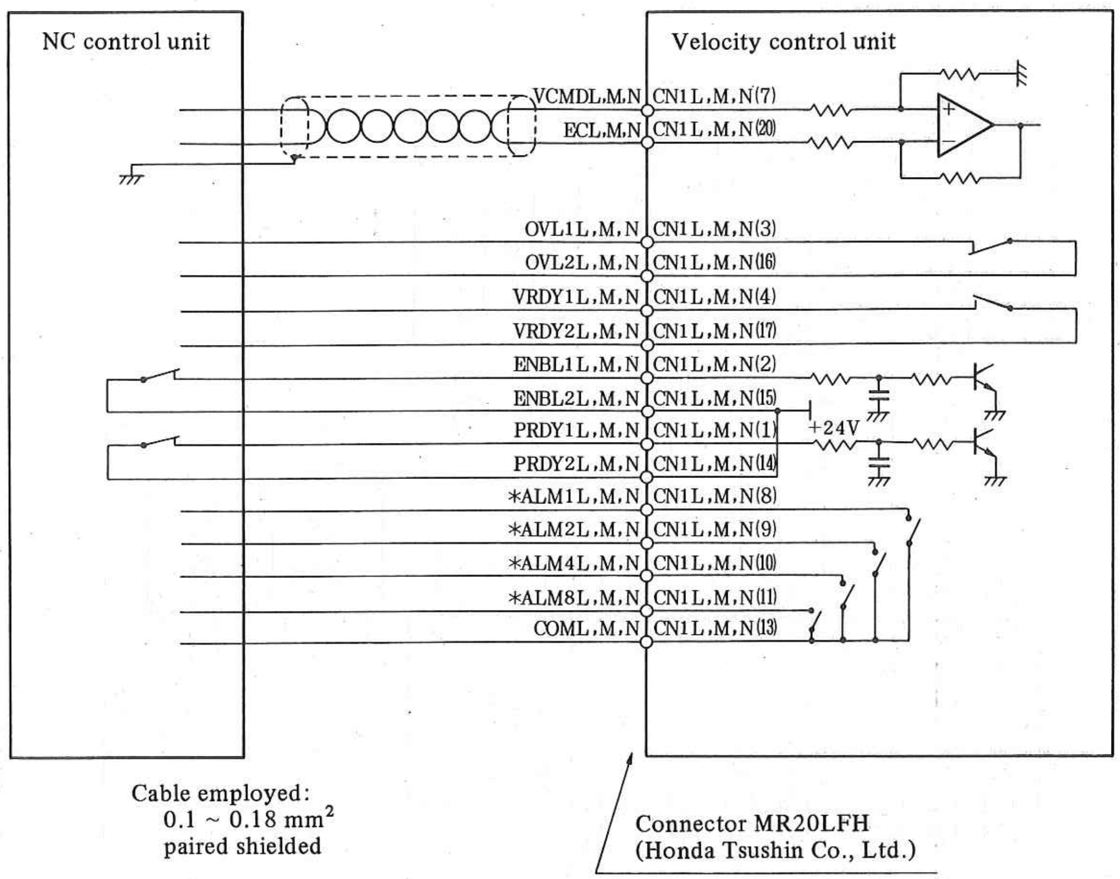


Fig. 9.1 (c)

9.1.1 Details of connection of cable K1



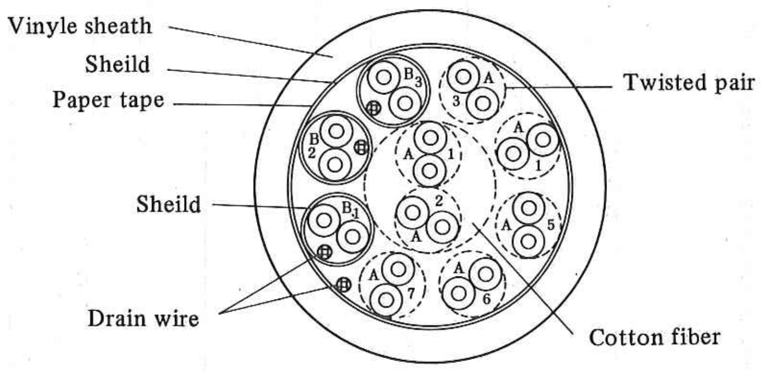


Fig. 9.1.1

9.1.2 Details of connections of cable K2

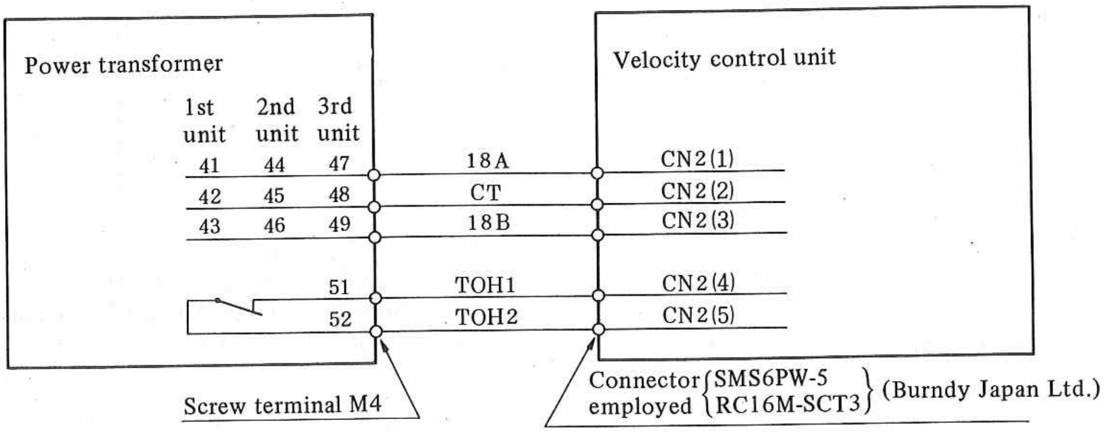


Fig. 9.1.2

9.1.3 Details of connections of cable K3

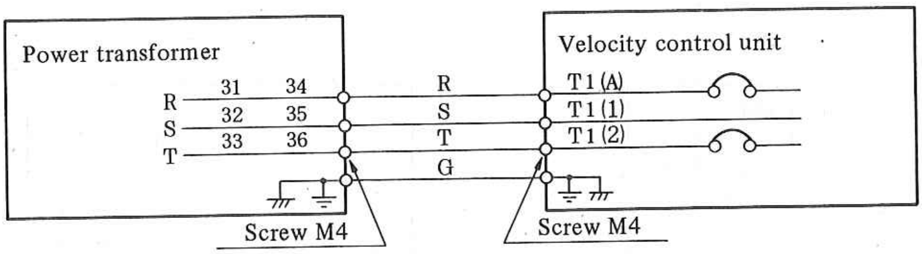


Fig. 9.1.3

9.1.4 Details of connections of cable K4

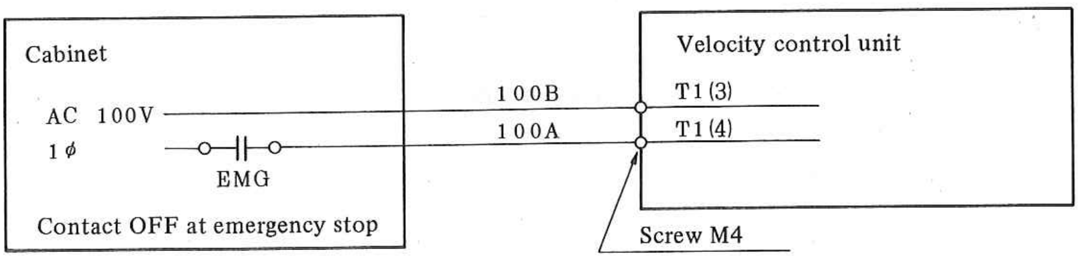


Fig. 9.1.4

9.1.5 Details of connections of cable K5

(1) Model 5, 0

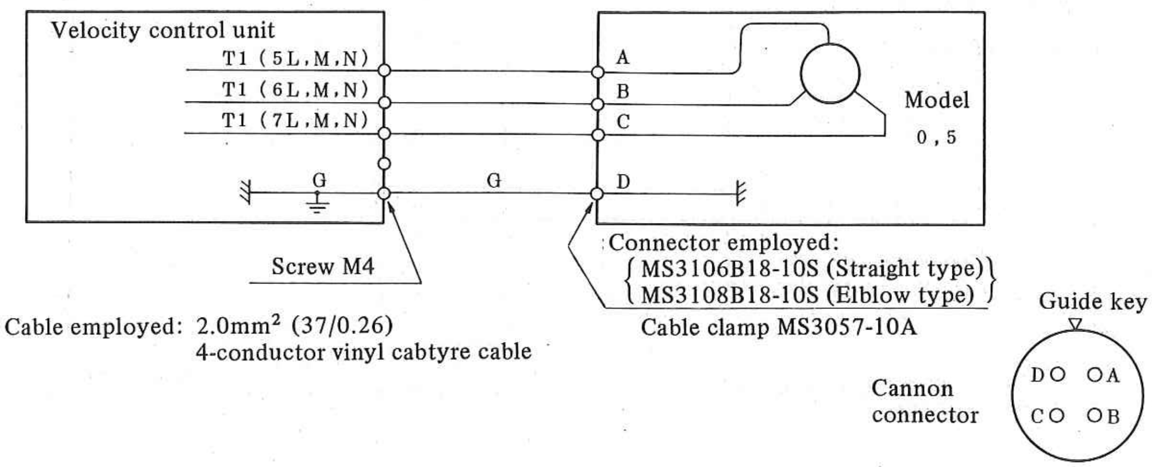


Fig. 9.1.5 (a)

(2) Model 10

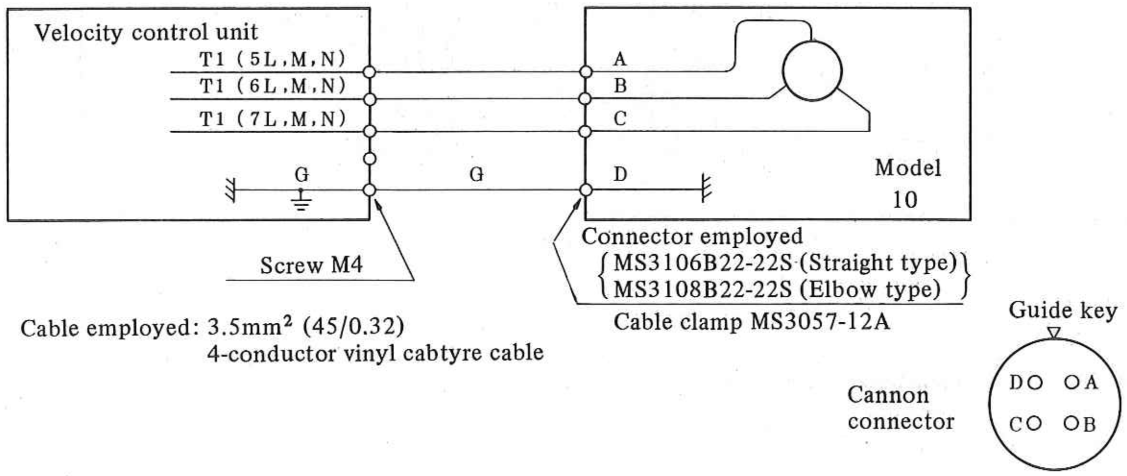
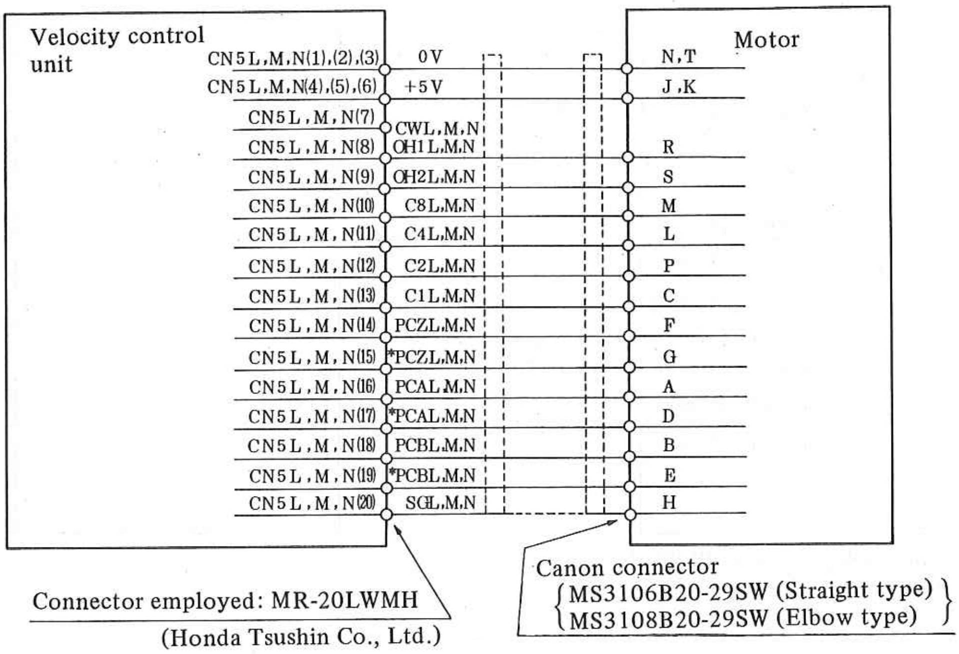


Fig. 9.1.5 (b)

9.1.6 Details of connections of cable K6



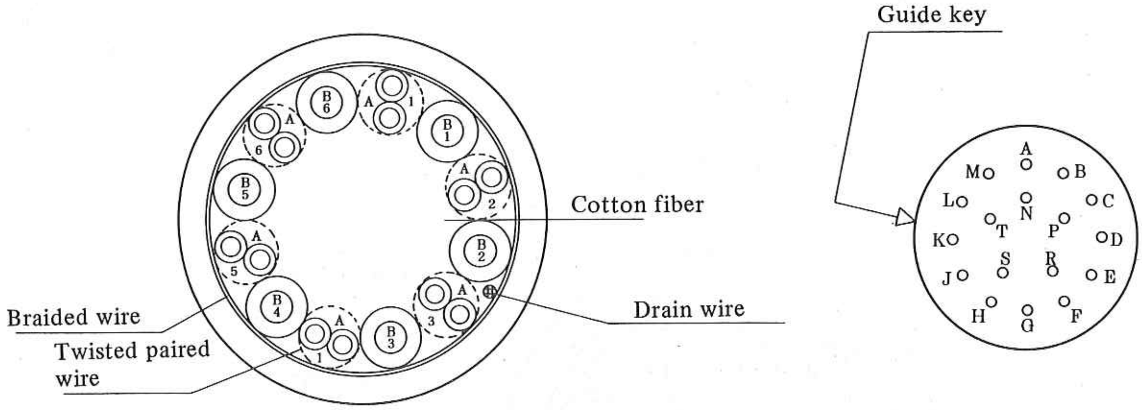
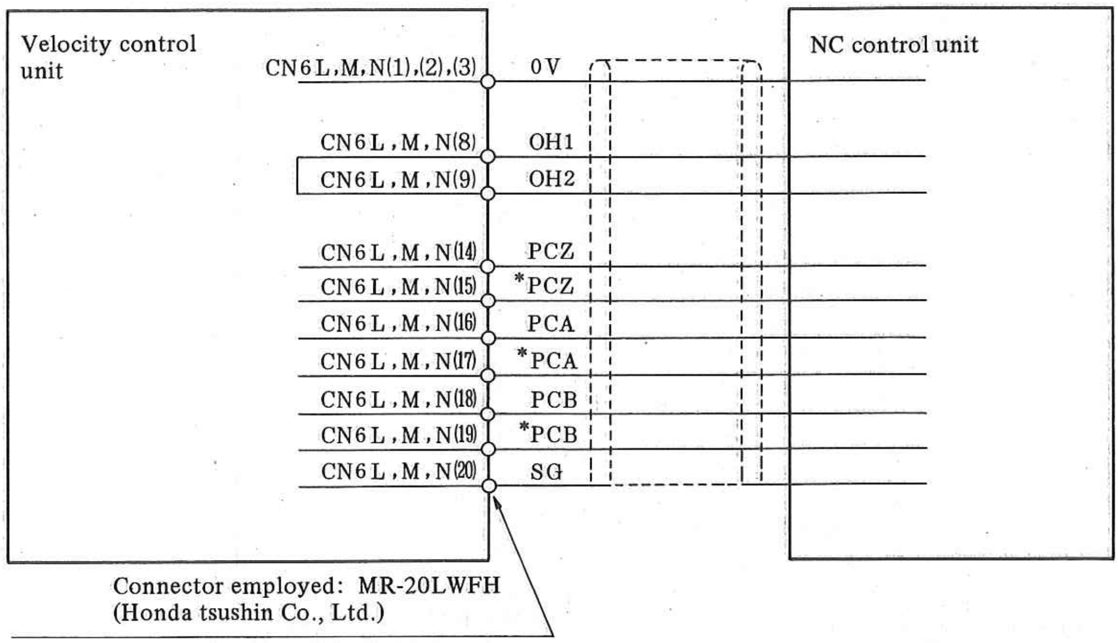


Fig. 9.1.6

9.1.7 Details of connections of cable K7



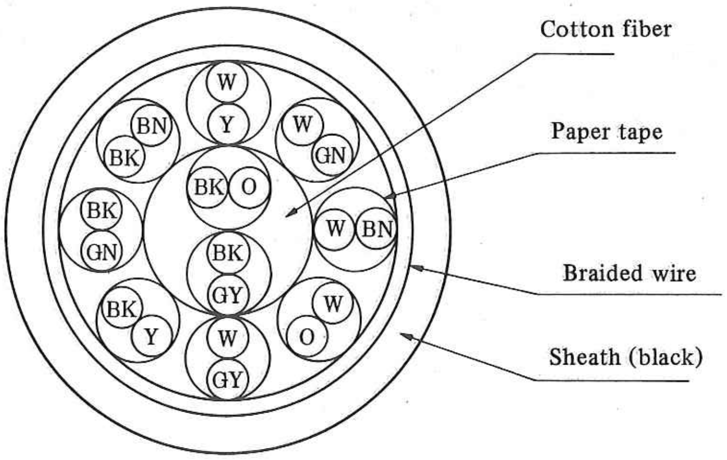


Fig. 9.1.7

9.1.8 Connections of separate discharge unit

(1) In case of A06B-6050-H401 - H403 (option)

(i) Details of connection of regenerative discharge unit

Disconnect the jumper wire from terminals T2 (4) - T2 (5) when the separate regenerative discharge unit is employed.

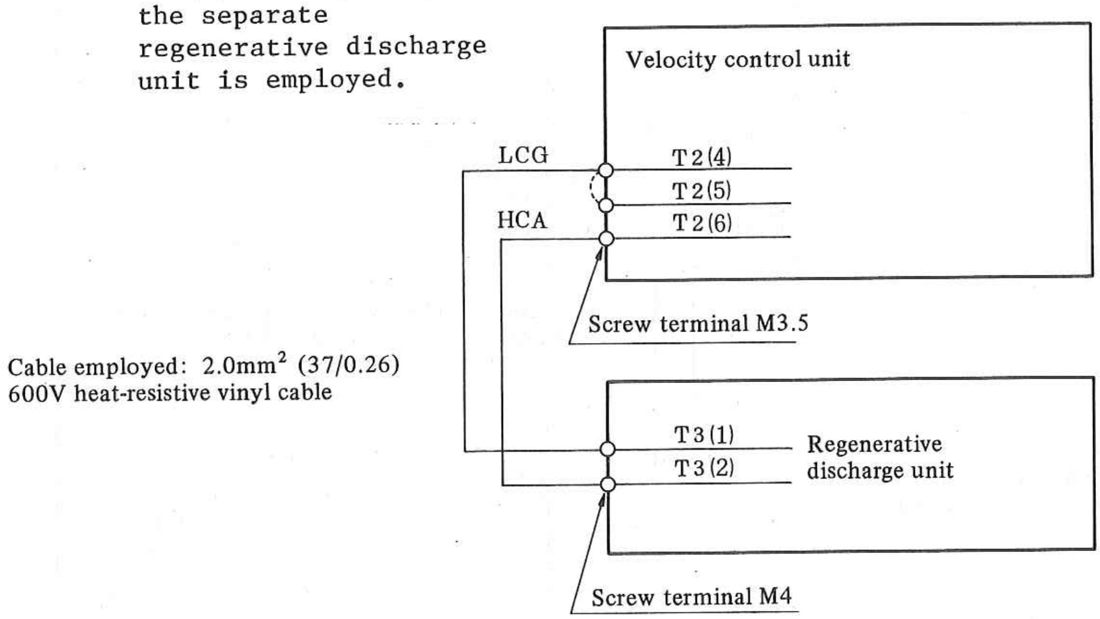


Fig. 9.1.8 (a)

(ii) Details of connection of cable K2
For connections of cable K2 in 9.1.2, change the connection of TOH1 and TOH2 as follows.

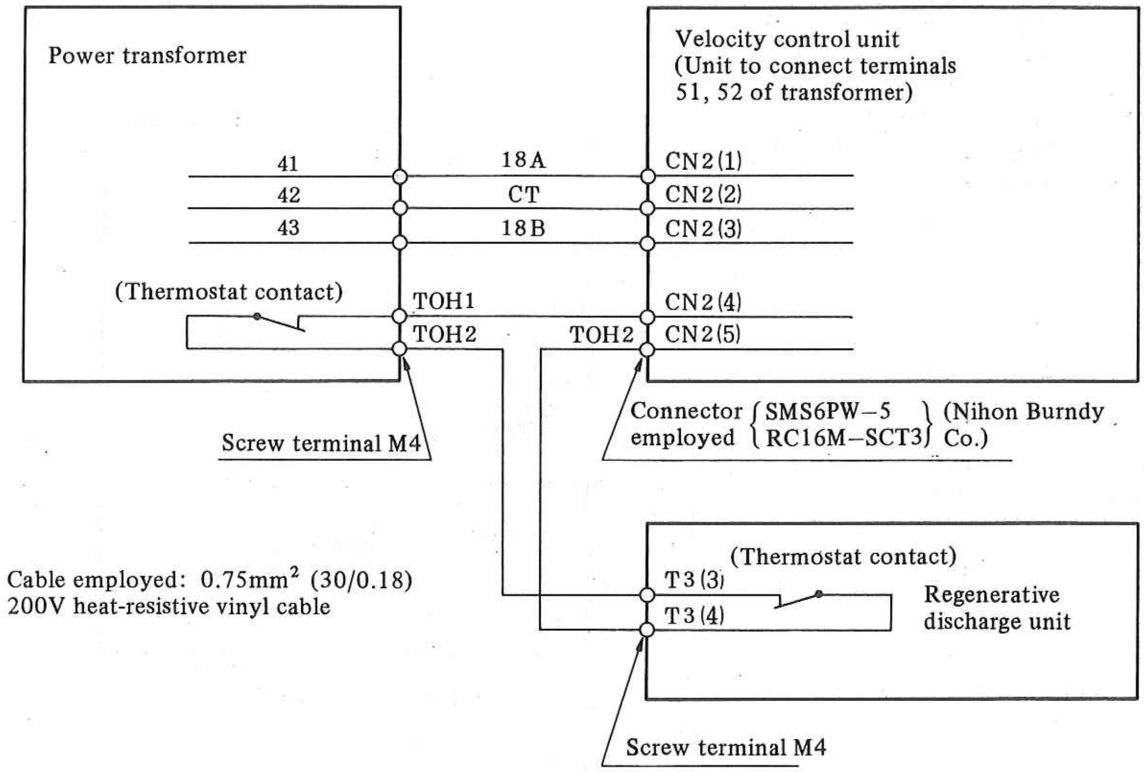


Fig. 9.1.8 (b)

(2) In case of A06B-6050-H404 (standard)

(i) Details of connection of regenerative discharge unit

Disconnect the jumper wire from terminals T2 (4) - T2 (5) when the separate regenerative discharge unit is employed.

Cable employed: 2.0mm^2 (37/0.26)
600V heat-resistive vinyl cable

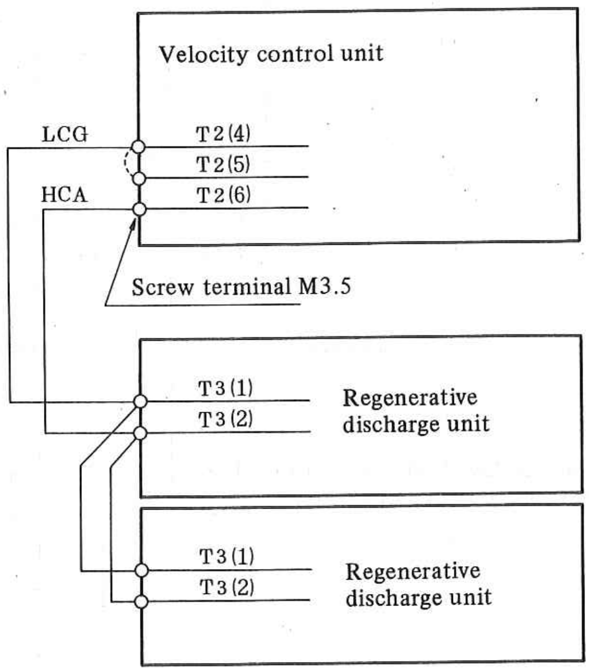


Fig. 9.1.8 (c)

(ii) Details of connection of cable K2

For connections of cable K2 in 9.1.2, change the connection of TOH1 and TOH2 as follows.

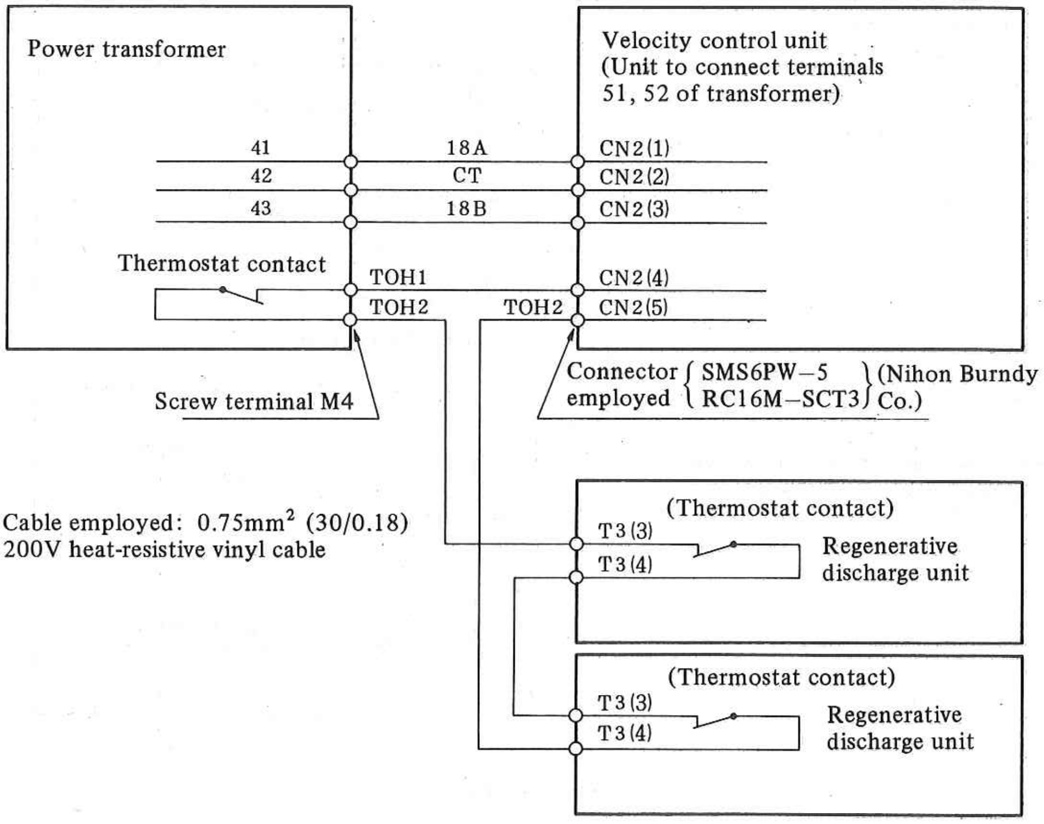


Fig. 9.1.8 (d)

9.2 Cable Assembly of Cable K2, K3, K5, K6, and K7

9.3 Connection of Power Transformer

9.4 Details of Signal

9.5 Reverse Connection

10. POWER TRANSFORMERS AND APPLICABLE FUSE ON PRIMARY SIDE

For subsection 9.2 - 10 refer to the same subsection in Chapter II.

Revision Record

FANUC AC SERVO MOTOR series DESCRIPTIONS (B-54762E)

Edition	Date	Contents	Edition	Date	Contents
03	May 1986	· Servo unit for Model 5-0 is added. · Servo unit for Model 20M is added. · Servo unit for 2 axes control is added. · Servo unit for 3 axes control is added. · Motor Model 5-0 is added. · Motor Model 20M is added. · Change the specification of power transformer.			
02	Feb. 1984	Change the motor characteristics.			
01	Dec. 1983	———			

B-54762E/03

* B - 5 4 7 6 2 E / 0 3 *