Motion Control Products

Power Mate Model E

Description Manual

B-62112E/01

May 1993

Preface

This manual describes the following product and its abbreviation is:

Name of Product	Abbreviation	
FANUC Power Mate-MODEL E	Power Mate-E	Power Mate

The following manuals are also available for the Power Mate-E:

1) Power Mate-E Operator's Manual B-62114E
2) Power Mate-E Programming Manual B-62113E
3) Power Mate-E Connection and Maintenance Manual B-62115E

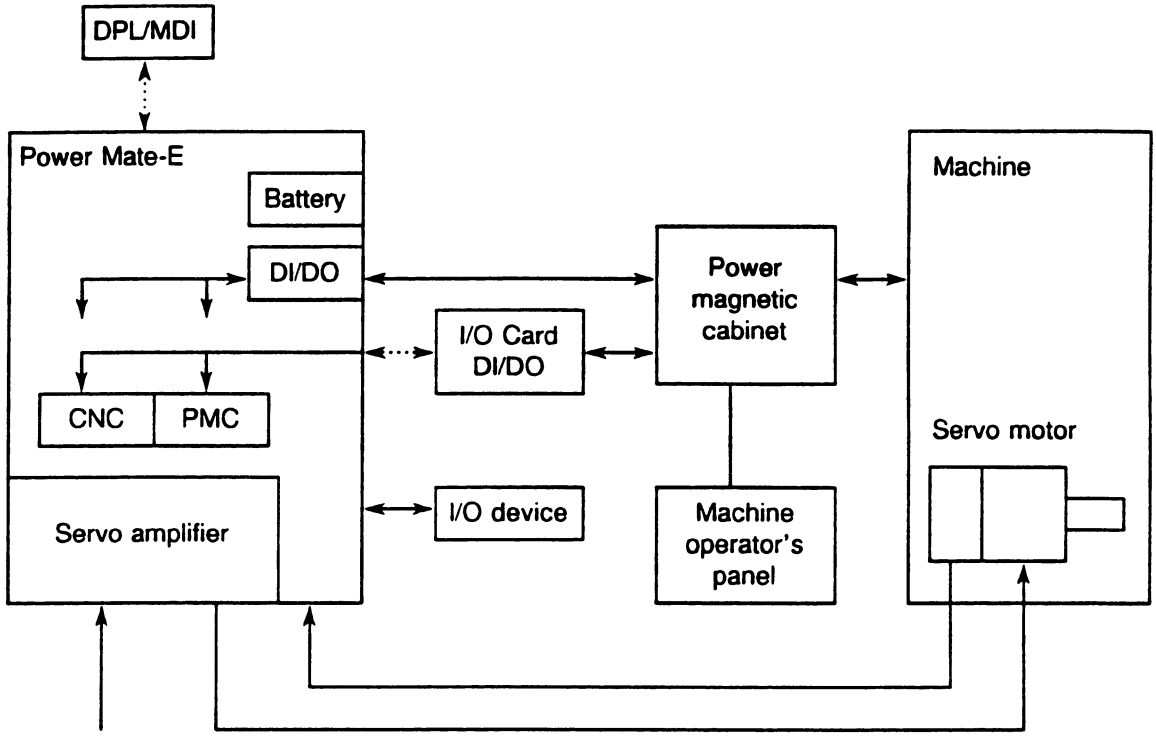
Although this manual refers to cutting feed, which means specifying a feedrate with an F code, the Power Mate-E cannot perform cutting due to the restrictions of the E series servo motors.

In this manual we have tried as much as possible to describe all the various matters.
However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.
Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".

CONTENTS

1. GENERAL

The Power Mate-E systems generally have the following configuration.



Item	Unit name	Location	Remarks
1	Power Mate-E controller	①	With the built-in servo amplifier
2	DPL/MDI	×	Detachable
3	I/O card	①	
4	AC power supply, transformer for power supply	① or ②	
5	Servo motor	②	
6	Battery (backup power supply for part program memory and parameter memory)	③	

① : To be built into the power magnetic cabinet or operator's panel
② : Mounted on the machine
③ : Mounted on the Power Mate
× : Detachable

Part programs, parameters, variables, etc. are stored in the CNC unit internal non-volatile memory. In general, these contents are not lost by the switching ON/OFF of the power. However, it is possible that a state can occur where precious data stored in the non-volatile memory has to be deleted, because of deletions from a maloperation, or by a failure restoration. In order to restore rapidly when this kind of mishap occurs, it is recommended that you create a copy of the various kinds of data beforehand.
The machine tool builder is requested to store created machining programs, parameters, variables, and other data on memory cards as backup data, and attach them to your machine.
If the end user modifies machining programs or other data, the end user is requested to update the contents of the memory cards attached to the machine accordingly.

The Power Mate-E is an economical positioning CNC unit designed for incorporating AC servo motors in machine tools which previously used a hydraulic or pneumatic control mechanism. This compact single-axis CNC unit has a high-precision servo control function, various CNC functions, and the PMC (programmable machine control) function.

Many custom LSI chips are used in the control unit to substantially reduce the number of circuit elements. As a result, reliability has been greatly improved. The combined control unit and servo amplifier can easily be built in the power magnetics cabinet on the machine.

The incorporated slave function for the FANUC I/O Link enables the Power Mate-E to be controlled by other CNC units or cell controllers. Together with E series servo motors, the Power Mate-E controls peripheral units of machine tools, such as an automatic tool changer (ATC), turret, and loader.

A fully electronic absolute position detector can be used to eliminate reference position return, which is normally required after power-on. Restart after power interruption is thus facilitated. Serial pulse coder C3 and serial pulse coder A can be used for the Power Mate-E.

○; Basic unit ☆; Option –; Function not available

Table 1(a) Function list (1/3)

Name	Specification	Remarks	Basic unit				Ref. item
			A1	A2	B1	B2	
Controlled axis	1 axis		○	○	○	○	2.1
Axis control by PMC	Yes		○	○	○	○	2.2
Least input increment	0.01mm/0.001inch		○	○	○	○	2.1
Least command increment	0.01mm/0.001inch		○	○	○	○	2.1
Max. programmable dimensions	±999999.99mm		○	○	○	○	2.1
Rapid traverse rate	1200m/min, 40000inch/min		○	○	○	○	5.1
Rapid traverse override	Fo, 25, 50, 100%		○	○	○	○	5.3.2
Range of feedrate Feed per minute (/mm)	0.001 to 99999.999mm/min 0.00001 to 999.99999inch/min		○	○	○	○	5.2.2
Automatic acceleration/deceleration	Yes	Rapid traverse: Liner type acceleration/ deceleration Cutting feed: Liner type acceleration/ deceleration Exponential acceleration/ deceleration Bell type acceleration/ deceleration	○	○	○	○	5.4
Feedrate override	0 to 150%	10% steps	○	○	○	○	5.3.1
Override cancel	Yes		○	○	○	○	5.3.3
Jog feed	Yes		○	○	○	○	18.1
Positioning	Yes		○	○	○	○	5.1
Rotary axis	Yes		○	○	○	○	8.4
Rotary axis rollover	Yes		○	○	○	○	8.5
Dual position feedback	Yes		–	–	☆	☆	16.7
Reference position return	Yes		○	○	○	○	6
Reference position return check	Yes		○	○	○	○	6.3
Return function	Yes	Return to 2nd and 3rd reference point	○	○	○	○	6.5
Reference position setting without dog	Yes		○	○	○	○	6.6

Table 1(a) Function list (2/3)

Name	Specification	Remarks	Basic unit				Ref. item
			A1	A2	B1	B2	
DPL/MDI	Liquid crystal 16 characters/line 2 lines	97mm×184mm×30mm Detachable cable: 2m	☆	☆	☆	☆	20.1
Position display	Yes		☆	☆	☆	☆	20.5
Long-distance DPL/MDI	Yes	Cable length can be up to 40m.	☆	☆	☆	☆	20.6
DPL/MDI switching circuit	Yes	Four Power Mates are switched.	☆	☆	☆	☆	20.7
Manual handle feed	Yes		–	–	☆	☆	18.3
Manual handle feed magnification	×1, ×10, ×M		–	–	○	○	18.3
Jog and handle simultaneous mode	Yes		○	○	○	○	18.3
Torque limit function	0% to 100%	256 steps	○	○	○	○	16.5
Step feed (incremental feed)	×1, ×10, ×100, ×1000		○	○	○	○	18.2
Reader/puncher interface	Yes		○	○	○	○	23.1
Dwell (per sec)	Yes		○	○	○	○	5.6
Interlock	Yes		○	○	○	○	27.3
Machine lock	Yes		○	○	○	○	19.1
Skip function	Yes		○	○	○	○	13
High speed skip	Yes		–	–	☆	☆	13.3
Skip function by PMC	Yes		○	○	○	○	13.4
Multi-step skip	3 points		–	–	○	○	13
Mechanical handle feed	Yes		○	○	○	○	16.1
Servo off	Yes		○	○	○	○	16.2
Manual absolute on/off	Yes		○	○	○	○	17.6.3
Reset	Yes	It is possible to initialize modal.	○	○	○	○	17.5.4
Dry run	Yes		○	○	○	○	19.3
Single block	Yes		○	○	○	○	19.4
Pitch error compensation	Yes		○	○	○	○	15.2
Rate feed function	Yes		○	○	○	○	5.2.3
Handle interrupt	Yes		–	–	○	○	17.6.1
FANUC I/O Link (slave)	Yes		○	○	○	○	24

Table 1(a) Function list (3/3)

Name	Specification	Remarks	Basic unit				Ref. item
			A1	A2	B1	B2	
RS-232-C Data input/output	Yes	One channel	○	○	○	○	23
I/O device external control	Yes		○	○	○	○	21.5
Waiting function	Depends on M code		○	○	○	○	10.2
External pulse input function	Yes	Manual pulse generation is used. Manual pulse generator cannot be used.	–	–	○	○	16.6
Specific DMR function (Flexible feed gear)	Yes		○	○	○	○	25
Memory card interface	Yes	Conforms to JEIDA	○	○	○	○	26
Self-diagnosis function	Yes		○	○	○	○	22
Emergency stop	Yes		○	○	○	○	27.1
Status display	CNC ready signal output Servo ready signal output Alarm signal Distribution signal output Cycle start lamp signal output Automatic operation start lamp signal output Feed hold signal output CNC reset signal Battery signal output		○	○	○	○	28
Control unit external dimensions	90mm (W) × 380mm (H) × 169mm (D)						A4
Power supply for control unit	3 phases 200VAC to 230VAC +10%, −15% 50/60Hz ±2Hz 1phase 200VAC to 230 VAC +10%, −15% 50/60Hz ±2Hz		○	○	○	○	32.2
Power supply for position display	24VDC ±10%, 0.6A		☆	☆	☆	☆	A6
Power supply for DPL/MDI switch circuit	24VDC ±10%, 0.2A		☆	☆	☆	☆	A6
Power supply for I/O card	24VDC ±10%, 1.5A		–	–	☆	☆	A6
Connectable servo motor	FANUC AC SERVO MOTOR E series (Digital)	2-0E, 1-0E	○	–	○	–	33
		0E, 5E	–	○	–	○	33
Regenerative discharge unit and additional regenerative register	Depends on regenerative energy	External setting	☆	☆	☆	☆	33.6
Dynamic brake unit	Yes	Externally mounted	☆	☆	☆	☆	33.7

Table 1(b) Function list (Machine operator's panel)

Name	Specification	Remarks	Basic unit				Ref. item
			A1	A2	B1	B2	
General purpose software switch function	Yes		○	○	○	○	20.4

Table 1(c) Function list (Position detector)

Name	Specification	Remarks	Basic unit				Ref. item
			A1	A2	B1	B2	
Serial pulse coder interface	Yes	Only serial pulse coder is available (incremental/absolute)	○	○	○	○	33
Separate pulse coder interface	Yes		–	–	○	○	33.3

Table 1(d) Function list (PMC)

Name	Specification	Remarks	Basic unit				Ref. item
			A1	A2	B1	B2	
PMC-MODEL P	18μs/step 2000steps	With high-speed M, T interface. RAM operation only	○	○	○	○	31
Points of DI/DO	DI 4points (•ESP, •DEC, SKIP, •RILK)/DO 4 points	Built-in I/O card Built-in I/O card is not available when I/O card A is used.	○	○	○	○	
	DI 48 points/DO 32 points (Total)	I/O card A	–	–	☆	☆	
Zone signal		Possible by PMC function command.	○	○	○	○	17.6.2
DPL screen generation by PMC	Yes		○	○	○	○	31.2
Key data reference by PMC	Yes		○	○	○	○	31.3

Table 1(e) Function list (Program input)

Name	Specification	Remarks	Basic unit				Ref. item
			A1	A2	B1	B2	
Coordinate system setting	Yes		O	O	O	O	7.1
Automatic coordinate system setting	Yes		O	O	O	O	7.2.1
Decimal point input	Yes		O	O	O	O	8.3
Custom macro A	Yes	M, T code call. 32 bit binary output with sign.	O	O	O	O	14
Inch/metric conversion	Yes		O	O	O	O	8.2
EIA/ISO automatic recognition	Yes		O	O	O	O	11.5
Mirror image	Yes		O	O	O	O	16.3
Sub program	Yes		O	O	O	O	11.3
Play back	Yes		O	O	O	O	21.4

Table 1(f) Function list (Function auxiliary function)

Name	Specification	Remarks	Basic unit				Ref. item
			A1	A2	B1	B2	
Miscellaneous function	M-2 digit		O	O	O	O	10.1
Miscellaneous function lock	Yes		O	O	O	O	19.2

Table 1(g) Function list (Tool function)

Name	Specification	Remarks	Basic unit				Ref. item
			A1	A2	B1	B2	
Tool function	T2 digit		O	O	O	O	9.1
Tool length compensation	Yes		O	O	O	O	15.1

Table 1(h) Function list (Editing/operation)

Name	Specification	Remarks	Basic unit				Ref. item
			A1	A2	B1	B2	
Part program storage length	10m		○	○	○	○	21.3
	20m (Total)		☆	☆	☆	☆	21.3
Registered programs	63 pieces		○	○	○	○	21.2
Sequence number search	Yes		○	○	○	○	17.2
Program number search	Yes		○	○	○	○	17.2
Optional block skip	9		○	○	○	○	11.10
Work number search	Yes (255)		○	○	○	○	29
Program protect	Yes		○	○	○	○	20.3
Background editing	Yes		○	○	○	○	21.6
Ladder display editing	Yes	DPL/MDI	○	○	○	○	20.2.8

Table 1(i) Function list (Display)

Name	Specification	Remarks	Basic unit				Ref. item
			A1	A2	B1	B2	
Change of axis name	Yes	X, Y, Z, U, V, W, A, B, C	○	○	○	○	2.1

- One of basic units A1, A2, B1 or B2 is selectable according to the functions available.

2. CONTROLLED AXES

2.1 Controlled Axes

(1) Controlled Axes
No. of controlled axes: one

(2) Name of Axes
X, Y, Z, U, V, W, A, B, C
X is used for the axis name in this manual. When an axis name other than X is used, alter X to it.

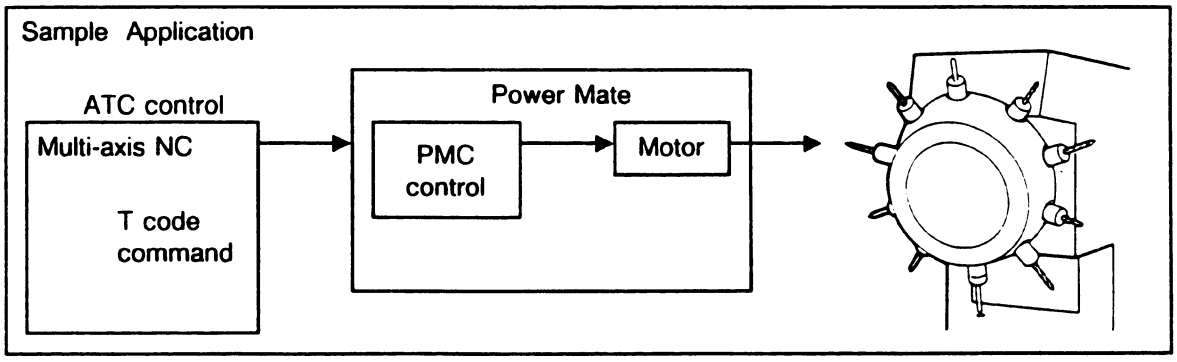
(3) Increment System

Least input increment	Least command increment	Maximum stroke
0.01 mm 0.001 inch 0.01 deg	0.01 mm 0.001 inch 0.01 deg	999999.99 mm 99999.999 inch 999999.99 deg

(4) Maximum Stroke
Maximum stroke
= Least command increment x 99999999

(Note 1) The least command increment is a minimum command unit that CNC gives to the machine.

2.2 Axis Control by PMC



Independent axes can be controlled by the command from PMC, not the command from CNC.

(1) Control by PMC
It is impossible to control axes by PMC during CNC control them.

(2) Axis name for DPL position display
An axis name alphabet can be selected by a parameter. (See 2.1(2).)

(3) Increment System

Least input increment	Least command increment	Maximum stroke
0.01 mm 0.001 inch 0.01 deg	0.01 mm 0.001 inch 0.01 deg	999999.99 mm 99999.999 inch 999999.99 deg

3. PREPARATORY FUNCTION (G FUNCTION)

Table 3. Preparatory Function

G code	Group	Function
G00 ★	01	Positioning (Rapid traverse)
G01 ★		Linear interpolation (Cutting feed)
G04	00	Dwell, Exact stop
G10		Data setting
G11		Data setting mode cancel
G20	02	Input in inch
G21		Input in mm
G27	00	Reference point return check
G28		Return to reference point
G29		Return from reference point
G30		2nd, 3rd reference point return
G31		Skip function
G43	06	Tool length compensation (+)
G44		Tool length compensation (−)
G49		Tool length compensation cancel
G65	01	Macro command
G90 ★	03	Absolute command
G91		Incremental command
G92	00	Coordinate system setting
G93	04	Feed rate
G94 ★		Feed per minute

A number following address G determines the meaning of the command for the concerned block. G codes are divided into the following two types:

Type	Meaning
One-shot G code	The G code is effective only in the block in which it is specified.
Modal G code	The G code is effective until another G code of the same group is specified.

(Example)
G01 and G00 are modal G codes in group 01.

```
G01  X·····;
     X·····;   } G01 is effective in this range.
     X·····;
G00  X·····;     G00 is effective from here.
```

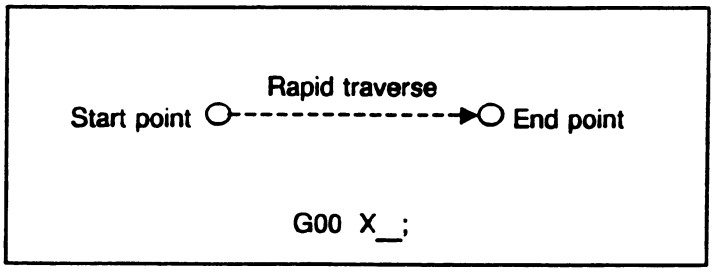
(Note 1) G codes marked ★ are initial G codes when turning power on. For G20 and G21, the G code before turning power off remains. G00 or G01 can be selected by parameter setting.
(Note 2) G codes of group 00 are G code of one shot.
(Note 3) If a G code not listed on the table of G codes is inputted, or optional G code not specified in the system is commanded, and alarm is displayed.
(Note 4) A number of G codes can be specified in the same block. When more than one G code of the same group is specified, the G code specified later is effective.

4. INTERPOLATION FUNCTIONS

This manual uses the following notation.

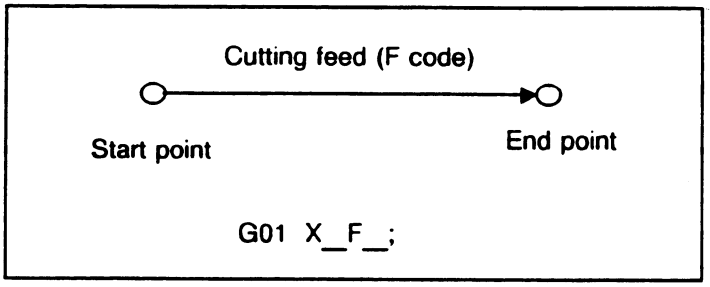
; : End of block (LF for ISO code, CR for EIA code)

4.1 Positioning (G00)



- Positioning is done by rapid feedrate. Rapid feedrate is set by parameter.
- It is decelerated to a stop at the end point, and inposition check is performed (checks whether the machine has come to the specified position). It is possible not to perform the inposition check by parameter. Width of inposition can be set as a parameter.

4.2 Liner Interpolation (G01)

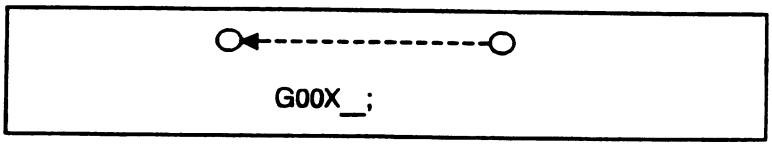


G01X___F___;

This command actuates the linear interpolation mode. The values of X define the distance of tool travel which will be conducted in absolute or incremental mode, according to the current status of G90/G91. For example, when this command is specified in the absolute mode, the tool moves to a certain point in the selected work coordinate system along a straight line at the feedrate specified by the F code. When commanded in the incremental mode, the tool moves from the current position to the point separated by a certain value along a straight line at the feedrate specified by the F code. Since the feedrate specified by the F code remains effective until a new feedrate is commanded, it need not be respecified.

5. FEED FUNCTIONS

5.1 Raped Traverse

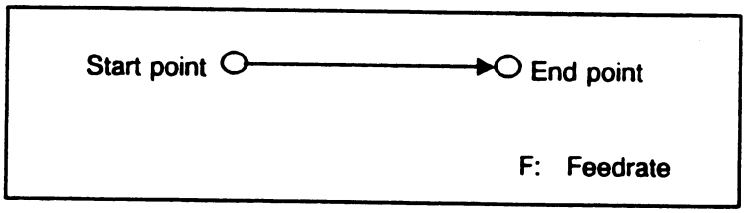


Least command increment	Rapid traverse rate range
0.01 mm	300-1200000 mm/min
0.001 inch	30-40000 inch/min

Positioning is done in rapid motion by the positioning command (G00).
There is no need to program rapid traverse rate, because the rates are set in the parameter (per axis). Rapid traverse rate can be overridden. (See 5.3.2.)
The above feedrates are limits according to the CNC's interpolation capacity.
When the whole system is considered, there are also limits according to the servo system.

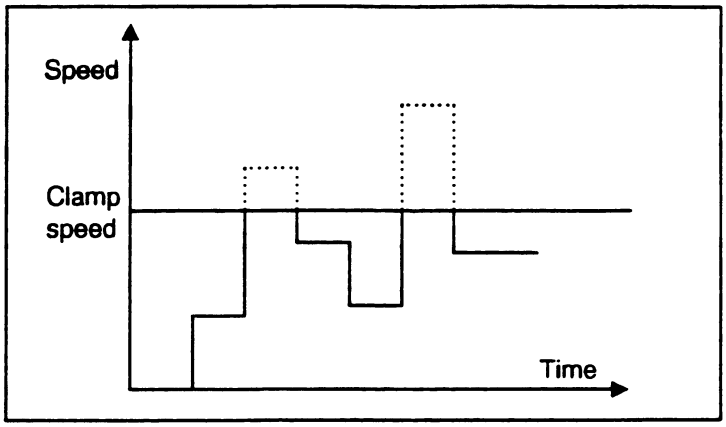
(Example)
Max. rapid traverse rate, when position gain is 30, is about 400 mm/min.

5.2 Cutting Feed



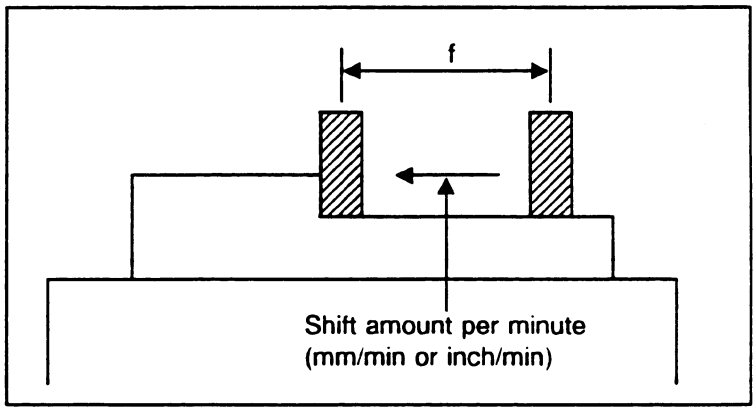
In the cutting feed mode, the tool moves at one of the feedrates specified by F codes.

5.2.1 Cutting feedrate clamp



Cutting feedrate upper limit can be set as parameters. If the actual cutting feedrate (feedrate with override) is commanded exceeding the upper limit, it is clamped to the upper limit of that value.

5.2.2 Feed per minute (G94)



Least command increment	Cutting feedrate range
0.01 mm	0.001-99999.999 mm/min
0.001 inch	0.00001-999.99999 inch/min

With the per minutes feed mode G94, tool feedrate per minute is directly commanded by numerical value after F.

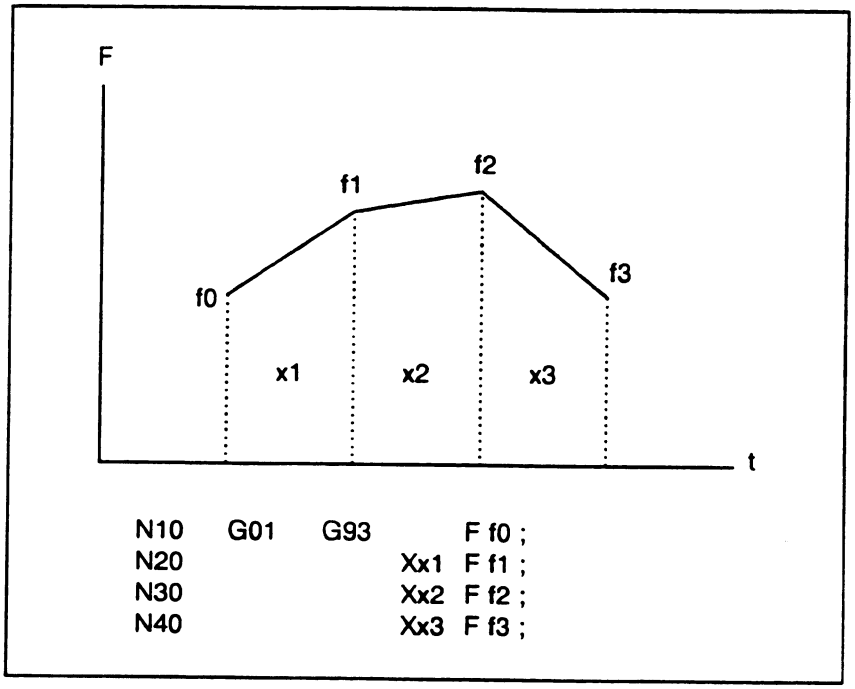
F can be set not to be commanded by setting the initial value of F in parameter. (F initial value setting.)

The above feedrates are limits according to the CNC's interpolation capacity.

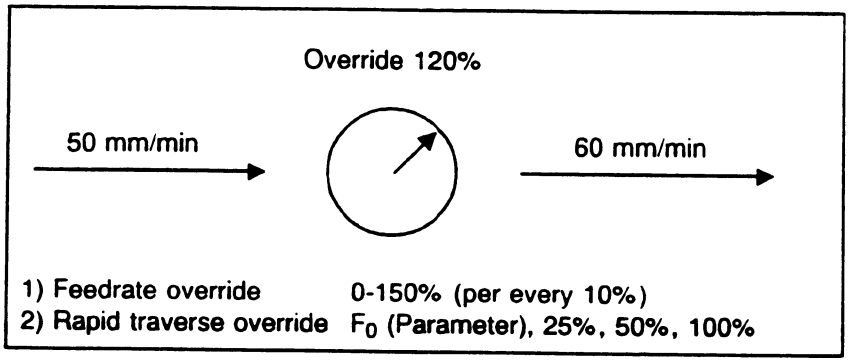
Note that the system is provided with the attached servo system for restriction.

5.2.3 Rate feed (G93)

Specify the rate feed mode by G93, and specify the tool's final velocity directly by the numeric value following F. Taking the value of F of the preceding block as initial speed, accelerate or decelerate at a certain ratio. Specify the unit of the value of F by mm/min or inch/mm. However, 0 cannot be specified for F. Once G93 is specified modal, it is valid until G94 (per minute feed) is specified.



5.3 Override



5.3.1 Feedrate override

The per minute feed (G94) can be overridden by: 0 to 150% (per every 10%)

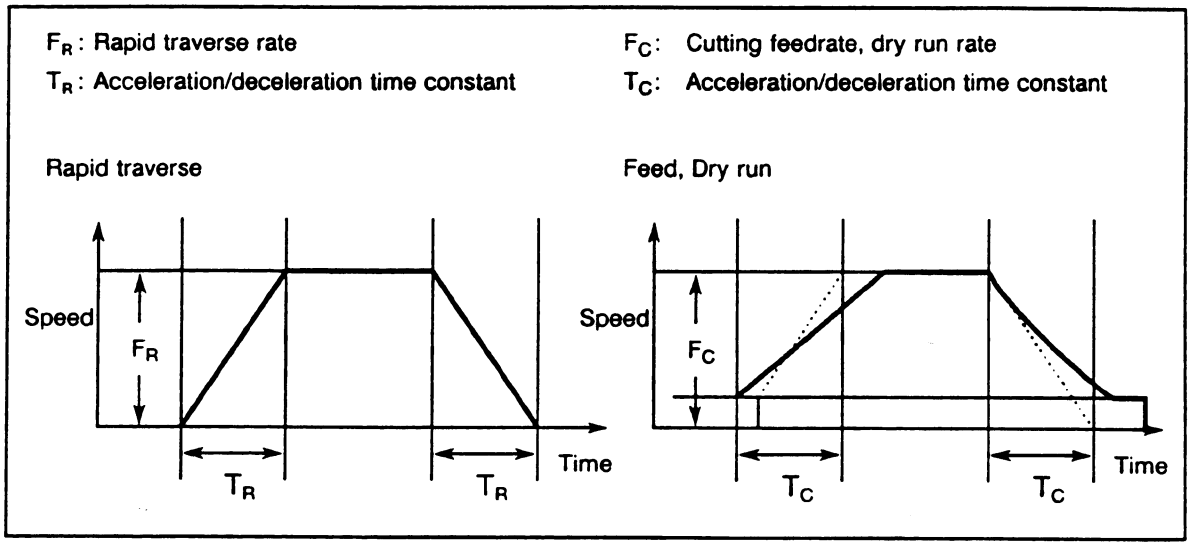
5.3.2 Rapid traverse override

Rapid traverse rate can be overridden by:
Fo, 25%, 50%, 100%.
Fo: A constant speed set by parameter

5.3.3 Override cancel

Feedrate override can be clamped in 100% by a machine side signal.
No rapid traverse override is effected.

5.4 Automatic Acceleration/Deceleration



Acceleration and deceleration is performed when starting and ending movement, resulting in smooth start and stop.
Automatic acceleration/deceleration is also performed when feedrate changes, so change in speed is also smoothly done.
Rapid traverse:
Linear acceleration/deceleration (time constant is set by a parameter)
Cutting feed:
Linear acceleration/deceleration (time constant is set by a parameter)
Exponential acceleration/deceleration (time constant is set by a parameter)
Bell type acceleration deceleration (time constant is set by a parameter)
Jog feed:
Exponential acceleration/deceleration (time constant is set by a parameter)

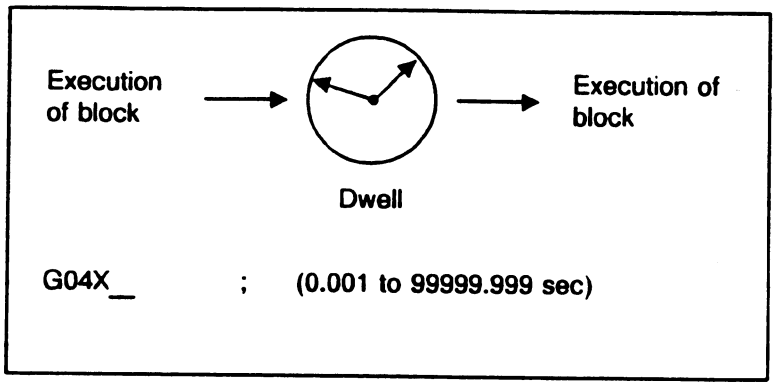
5.5 Velocity Control Value Instruction between Blocks

The following chart shows feedrate changes between blocks of information specifying different types of movement.

New block \ Previous block	Positioning	Cutting feed	Not moving
Positioning	×	×	×
Cutting feed	×	○	×
Not moving	×	×	×

×: The next block is executed after commanded rate has decelerated to zero.
○: The next block is executed sequentially so that the feedrate is not changed by very much.

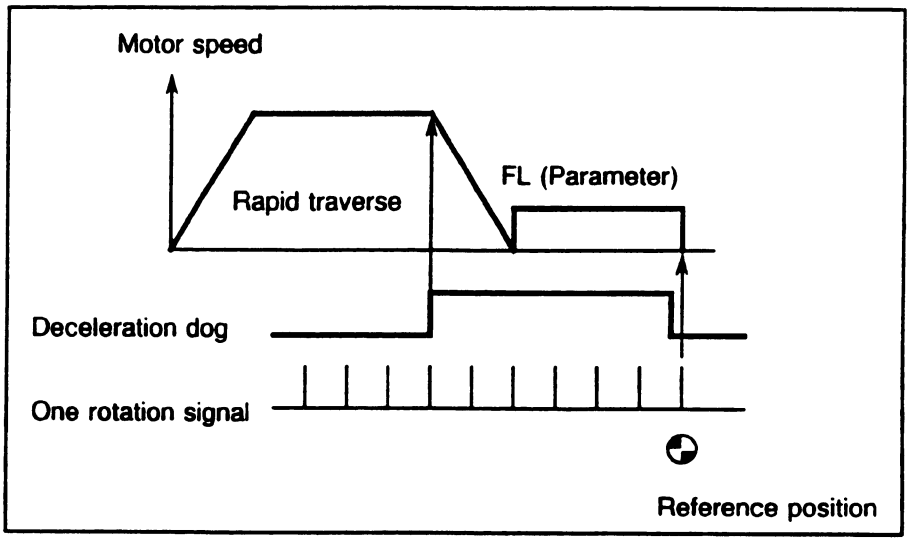
5.6 Dwell (G04)



With the G04 command, shifting to the next block can be delayed by the time specified.

6. REFERENCE POSITION

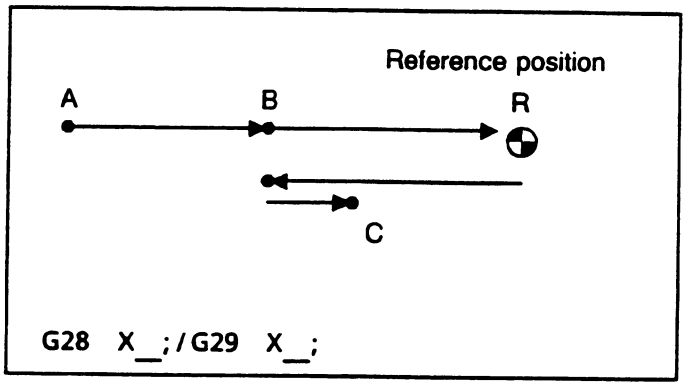
6.1 Manual Reference Position Return



Positioning to the reference position can be done by manual operation.
With jogging mode (JOG), manual reference position return signals, and signal for selecting manual reference position return axis on, the tool begins to move at rapid traverse mode. When deceleration limit switch mounted on the machine is turned on, it decelerates, and when it is turned off again, it stops at the first grid position, and reference position return end lamp lights. This position is the reference position.
Grid method:
A certain grid of the position detector is appositioned as the reference position.
The reference position can be electrically shifted by the grid shift function.

(Note) When the serial pulse coder C3 is used as a detector, one-revolution signal is issued 4 times per rotation of the motor.
When the serial pulse coder A is used as a detector, one-revolution signal is issued one time per rotation of the motor.

6.2 Automatic Reference Position Return (G28, G29)



(1) Return to reference position (G28)
With the G28 command, the commanded axis is positioned to the reference position via the commanded position (B in the above fig.). After positioning, the reference position return end lamp is lit. If G28 was commanded when reference position return is not performed after power on, reference position return is done in the same sequence as the manual reference position return.

(2) Return from reference position (G29)
With the G29 command, the commanded axis is positioned to the position commanded by G29 (C in the above fig.), via the intermediate position (B in the above fig.) commanded by G28.

6.3 Reference Position Return Check (G27)

Program returned to reference position

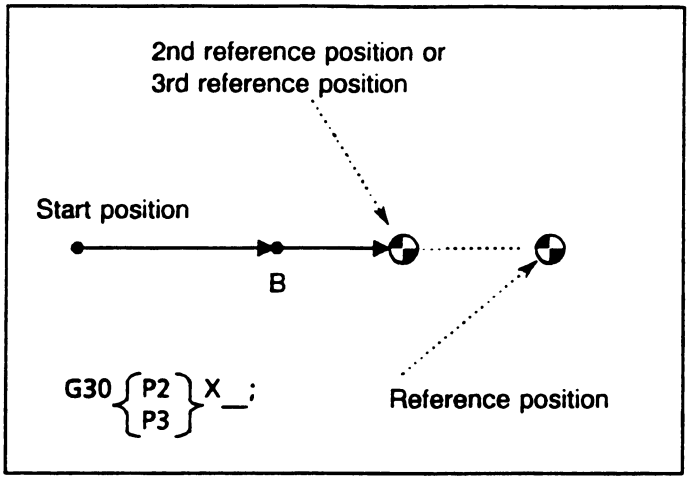
↓

- Completion lamp is lit when tool returned to the reference position correctly
- Alarm is generated when tool does not return to the reference position

This function is used to check whether the reference position return command was performed correctly.
When G27 is commanded, reference position return end signal is output if reference position return is performed to the correct position, and alarm arises if it is not positioned correctly to the reference position.
This function is available after power is turned on and reference position return is performed.

6.4 2nd, 3rd Reference Position Return (G30)

With the G30 command, the commanded axis is positioned to the 2nd or 3rd reference position. 2nd or 3rd reference position return end signal is output when portioning ends. Set the 2nd or 3rd reference position as parameters.



This function is available after power is tuned on and reference position return is performed. It is the same as reference position return G28 except tool returns to the 2nd or 3rd reference position. This command is usually used when the ATC position is different from reference position.

6.5 Return Function

When jog feed mode is specified and a return signal (RTN1, RTN2 or RTN3) is turned ON, the axis is moved to the reference position corresponding to each return signal with rapid traverse rate. When the axis reaches the reference position, "move" operation is completed after the corresponding reference position return completion output signal (ZP1, ZP2, or ZP3) is turned ON. Second and third reference positions are set by setting the distances from the (1st) reference position to their respective positions to the parameters.

6.6 Reference Position Setting without Dog

This function allows reference positions to be set without using deceleration dogs for reference position return when an absolute pulse coder is used. When a reference position has been established, reference position return can be performed at high speed.
This dog-less reference position setting function determines reference positions by one revolution signal of the position coder through grids.

7. COORDINATE SYSTEM

7.1 Coordinate System

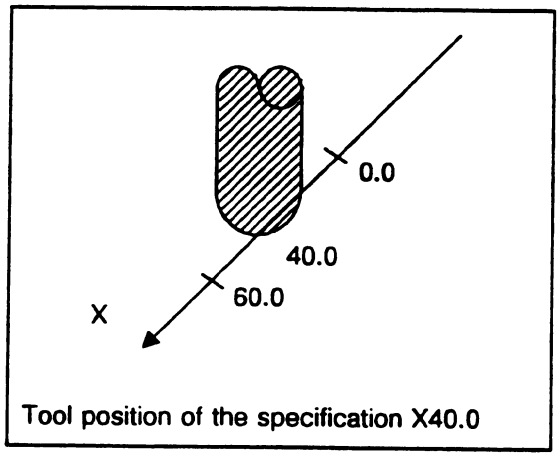
The function of the CNC is to move the machine, i.e. tool to a programmed position at a programmed rate. The position to be reached by the tool is given as a coordinate value in a coordinate system.

The following two types of coordinate systems are available.

(i) Machine coordinate system

(ii) Work coordinate system

The position to be reached by the tool is commanded with a coordinate value of one of the coordinate systems, as required.



Tool position of the specification X40.0

7.1.1 Machine coordinate system

The machine zero point is a standard point on the machine. The machine zero point is normally determined by the machine tool builder.

A coordinate system having the zero point at the machine zero point is called the machine coordinate system.

However, the zero point may be a point which the tool cannot reach.

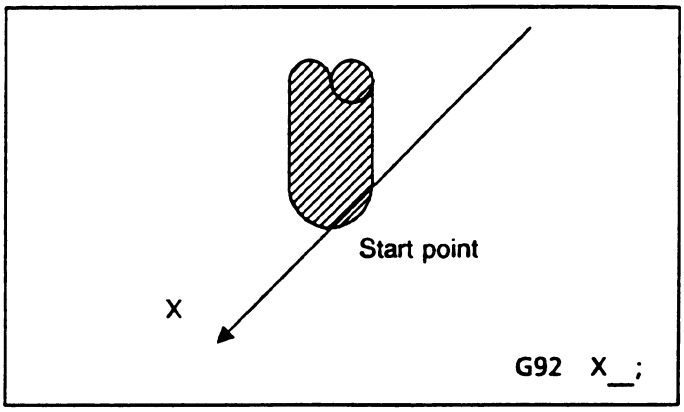
The machine coordinate system is established when the reference point return is first executed after the power is on.

Once the machine coordinate system is established, it is not changed by reset, change of work coordinate system (G92) or other operations unless the power is turned off.

7.1.2 Setting machine coordinate system

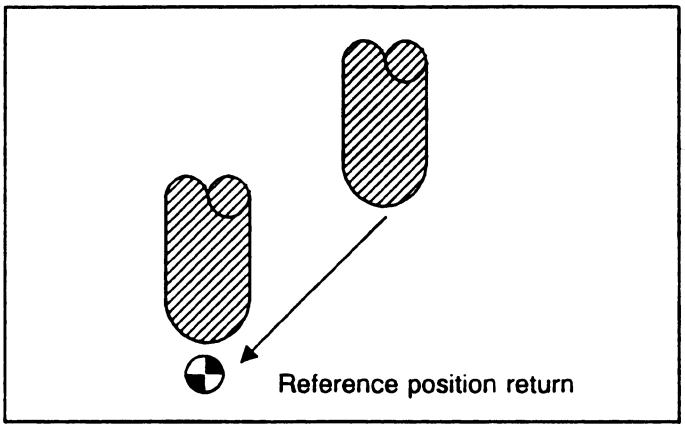
The machine coordinate system is inherent to each machine. It can be set through manual return to the reference point. The machine coordinate system is established.

7.2 Work Coordinate System Setting



A work coordinate system whose origin is at the specified distance (X0) from the current tool position is commanded by program. Once created, subsequent absolute commands refer to a coordinate value in this work coordinate system.

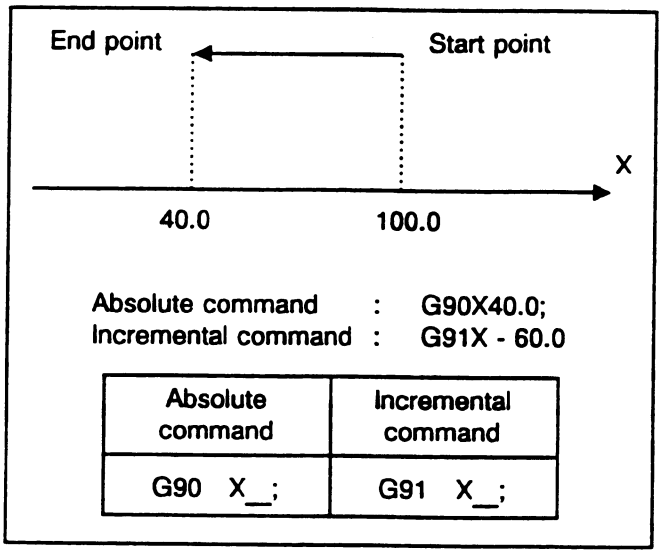
7.2.1 Automatic coordinate system setting



A coordinate system being preset by a parameter is set by returning the tool to the reference position by manual operation. As a result, a coordinate system is set as if G92_; were specified at the reference position.

8. COORDINATE VALUE AND DIMENSION

8.1 Absolute and Incremental Programming (G90, G91)



Absolute command	Incremental command
G90 X_;	G91 X_;

There are two ways to command travels along the axes; the absolute command, and the incremental command. In the absolute command, coordinate value of the end point is programmed; in the incremental command, move distance of the axis itself is programmed. Absolute command and incremental command are specified by G90 and G91, respectively.

8.2 Inch/Metric Conversion (G20, G21)

Either inch or metric input can be selected by G code.

Unit systems	G code	Least input Incremental
Inch	G20	0.001 inch
Millimeter	G21	0.01 mm

This G code must be specified in an independent block before setting the coordinate system at the beginning of the program. The unit systems of the following items can be changed with G codes:

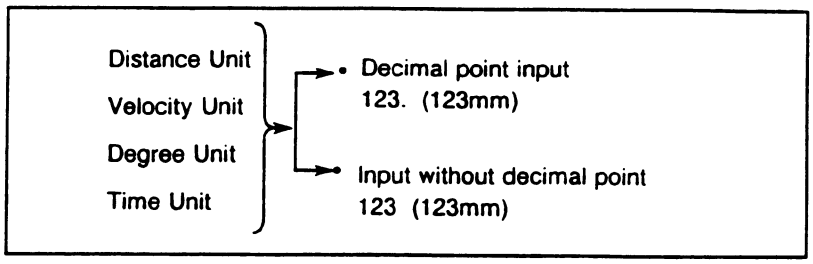
(1) Positional command
(2) Unit of scale for manual pulse generator
(3) Movement distance in step feed
(4) Some parameters

(Note 1) When the power is turned on, the NC status is the same as that held before the power was turned off.

(Note 2) G20 and G21 must not be switched during a program.

(Note 3) When the machine unit and the input unit systems are different, the maximum error is half of the least command increment. This error is not accumulated.

8.3 Decimal Point Input



Numerals can be input with decimal points. Decimal points can be used basically in numerals with units of distance, speed, angle and time. The position of the decimal point is at the mm, inch, deg, sec position.
Without decimal point, unit is mm, inch, deg, sec.

8.4 Linear Axis and Rotation Axis

A linear axis refers to an axis moving linearly, and for it values are specified in mm or inches.
A rotation axis refers to a rotating axis, and for it values are specified in degrees.
For rotation axes, note the following:

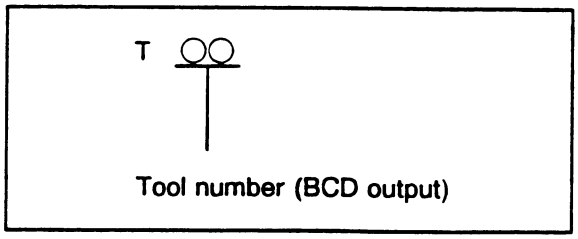
- Inch-metric switching is not performed.
- The machine coordinate system is normalized within 0° to a value set with a parameter.

8.5 Rotation Axis Roll-over Function

The rotation axis roll-over function rounds the absolute coordinate value and relative coordinate value of a rotation axis to a coordinate value within one rotation. This prevents coordinate values to overflow.
In an incremental command, the specified value is regarded as the amount of travel.
In an absolute command, the specified value is rounded to within one rotation. The resulting coordinate value is used as the end point. A parameter is used to specify whether to determine the move direction by the sign of the specified value or by the move distance (the shortest move distance to the end point is selected).

9. TOOL FUNCTIONS

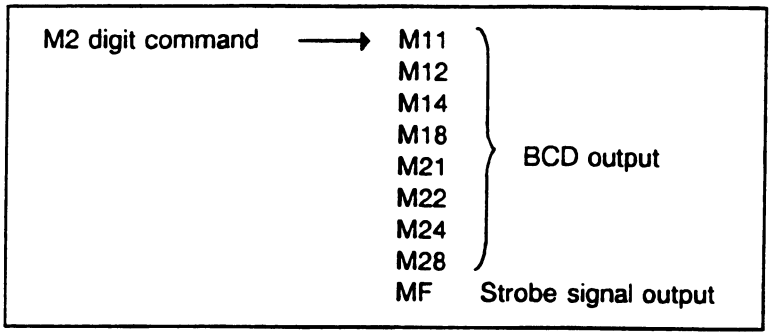
9.1 T Code Output



Selection of tools can be done by commanding tool numbers with a 2-digit numeral after address T. The tool number is issued to the machine side with a BCD code and a strobe signal. The code is held until the next T code is specified.

10. MISCELLANEOUS FUNCTIONS

10.1 Miscellaneous Function (M2 digit)



When a 2-digit number after address M is commanded, BCD 2-digit code signal and the M code read signal are output. This code is cleared by M and T function complete signal.
This function is used for on/off of various functions at the machine side. A single M code can be commanded in one block.
M98 (sub program call) and M99 (return from sub program) and always processed in the NC so, signal will not be output.

10.2 Waiting Function (M801-M815)

This is the waiting function activated by an M-code prepared for smooth waiting operation with another machine or peripheral equipment.

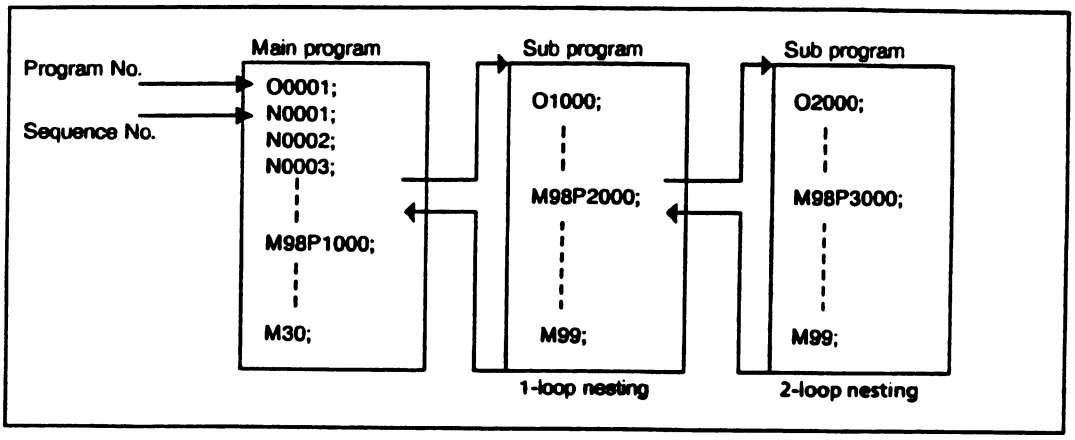
Command format

N___M8○○ G_X___F___ ;

M8○○: Waiting M-code
(M801-M815)

When a waiting M-code is specified, a corresponding signal is output to start an operation of that block after waiting for the input of the corresponding end signal.

11. PROGRAM CONFIGURATION



11.1 Program Number

A program number is given to each program to distinguish a program from other programs. The program number is given at the head of each program, with a 4-digit number after the address O. Program search of programs registered in the memory is done with the program number. The program number can be used in various other ways.

11.2 Main Program

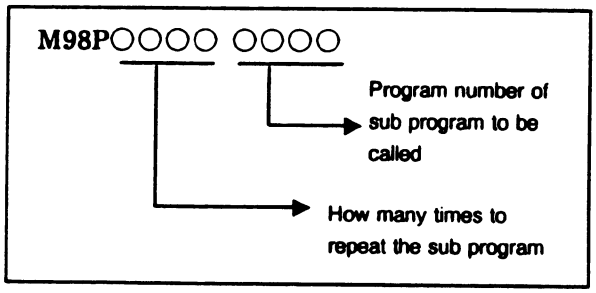
A program is divided into the main program and the sub program. The CNC normally operates according to the main program, but when a command calling a sub program(M98P__) is encountered in the main program, control is passed to the sub program. When a command indicating to return to the main program(M99) is encountered in the sub program, control is returned to the main program.

11.3 Sub Program

When there are fixed sequences or frequently repeated patterns in a program, programming can be simplified by entering these pattern as sub programs to the memory. Sub program is called by M98, and M99 commands return from the sub program. The sub program can be nested 2 folds.

Format

(1) Sub program call



When the repetition count specification is omitted, the number of the call is one.

(2) Return from sub program

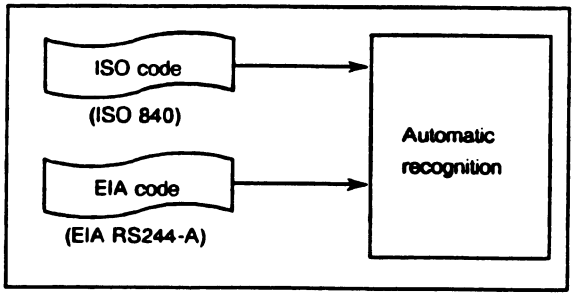
M99;

11.4 Sequence Number

Sequence number can be given in a 4-digit number after the address N at the head of the program block.

The sequence number of the program under execution is displayed on the DPL screen. The sequence number can also be searched in the program by the sequence number search function.

11.5 Tape Codes



Either the EIA or the ISO code can be used as tape code. The input program code is distinguished with the first end of block code (EIA: CR, ISO: LF).

See the List of Tape Codes for tape codes used.

11.6 Basic Addresses and Command Value Range

Function	Address	Input in mm Output in mm	Input in inch Output in mm	Input in mm Output in inch	Input inch Output in inch
Program number	:(ISO) O (EIA)	1 to 9999	1 to 9999	1 to 9999	1 to 9999
Sequence number	N	1 to 9999	1 to 9999	1 to 9999	1 to 9999
Preparatory function	G	0 to 99	0 to 255	0 to 255	0 to 255
Dimension word	X,Y,Z,A, B,C,Q,R	±999999.99mm	±99999.999inch	±999999.99mm	±99999.999inch
Feed per minute	F	0.001 to 999999.99 mm/min	0.00001 to 999.99999 inch /min	0.001 to 99999.999 mm/min	0.00001 to 999.99999 inch/min
Tool functions	T	0 to 99	0 to 99	0 to 99	0 to 99
Miscellaneous functions	M	0 to 99	0 to 99	0 to 99	0 to 99
Dwell	X, P	0 to 99999.999 sec.	0 to 99999.999 sec.	0 to 99999.999 sec.	0 to 99999.999 sec.
Designation of sequence number, number of repetitions	P	1 to 9999999 Repetition count / Program number	1 to 999999	1 to 9999999	1 to 9999999
Specification of sequence number	P	1 to 9999	1 to 9999	1 to 9999	1 to 9999
Specification of macro arithmetic operation and control commands	H	0 to 99	0 to 99	0 to 99	0 to 99

11.7 Tape Format

Metric input

N04.G02.αL + 0533.

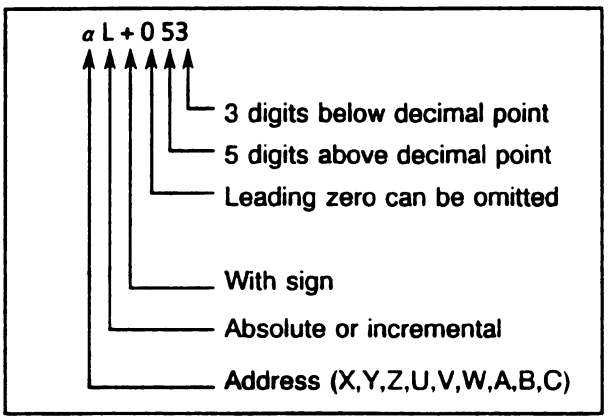
$\left\{ \begin{matrix} F032 \\ F053 \end{matrix} \right\}$. S02 T02 .M02:

Inch input

N04.G02.αL + 044.

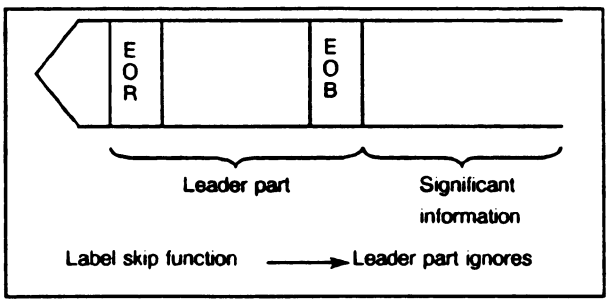
$\left\{ \begin{matrix} F014 \\ F035 \end{matrix} \right\}$. $\left\{ \begin{matrix} S02 \\ S04 \end{matrix} \right\}$ T02 .M02:

(Note 1) The above addresses and numerical values have the following meanings.



(Note 2) P, Q and H is used for some cases, so they are omitted.

11.8 Label Skip



Label skip function becomes valid in the following cases, and "LSK" is displayed on the CRT screen.

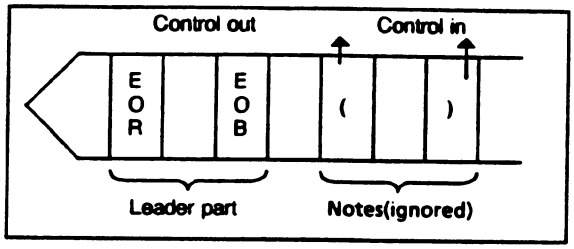
(1) When power is put on.

(2) When the CNC is reset.

When label skip function is valid, all codes to the first end of block (EOB) code encountered are ignored.

The ignored part is called "Leader part", and section after the first end of block (EOB) code, "significant information".

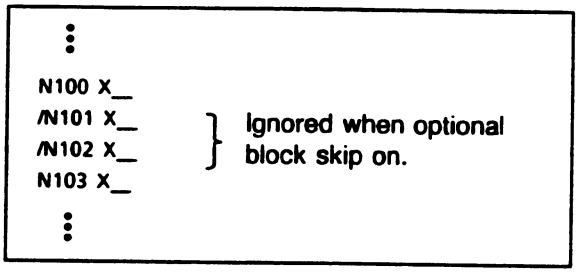
11.9 Control-in/Control-out



	ISO code	EIA code
Control out	)	Channel 2-4-5 on
Control in	(	Channel 2-4-7 on

Information between the control-in and the control-out are regarded as notes and are ignored.
The reset codes (ISO code: %, EIA code: ER) cannot be used in this part.
The ignored part is called "Notes".

11.10 Optional Block Skip



When a slash (/) is programmed at the head of a program, and when the machine is operated with the optional block skip switch on the machine operator's panel on, information in the block commanded is ignored.
If the optional block skip switch is turned off, information in the / commanded block will not be ignored. The block with / commanded can be skipped by the operator's selection.
Optional skips can be extended to the maximum of nine.

/1 (or /) ..... optional skip 1
/2 ..... optional skip 2
: :
/9 ..... optional skip 9

12. FUNCTIONS TO SIMPLIFYING PROGRAMMING

12.1 Programable Parameter Input Function

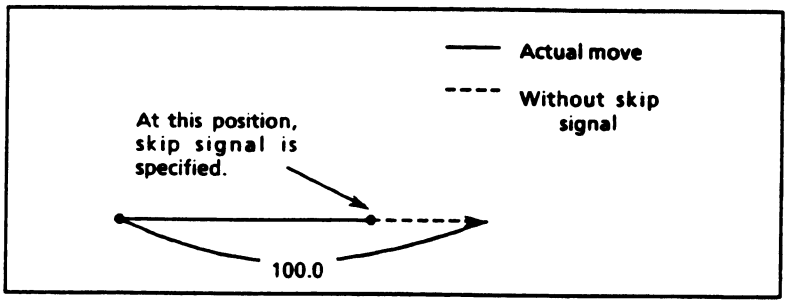
As parameters can be set in the program, this function is used for various uses such as altering parameters of maximum cutting rate, cutting time constant, etc. corresponding to each machining condition and so on.

(1) Command format
G10;
N___P___;
N___P___;
N___P___;
where,
G10: Parameter input mode
G11: Parameter input mode cancel
N___ : Parameter No.
P___ : Parameter setting

(Note) Other NC statements cannot be specified in parameter input mode.

13. MEASUREMENT FUNCTION

13.1 Skip Function (G31)



Linear interpolation can be designated as in G01 by programming axis movement following G31. Input of the skip signal during execution of this command interrupts the rest of the block and executes the next block. G31 is one-shot command, effective only in the block concerned.
The custom macro can use the coordinate values of the position where the skip signal was issued, since they are stored in system variables #5061 of the custom macro.

#5061 .... X coordinate value

The skip function can be used when the movement amount is not clear, as in fixed amount feed by grinder.

13.2 Multi-step Skip Function (G31)

$$G31 \left\{ \begin{matrix} P1 \\ P2 \\ P3 \end{matrix} \right\} X\_F\_ ;$$

It is possible to command linear interpolation by P1–P3 and a move command subsequent to G31 just as in G01. If a skip signal effective for the number specified by P is input from outside during the G31 command, the next block is executed by stopping the rest of the G31 command.

13.3 High-speed Skip Signal Input

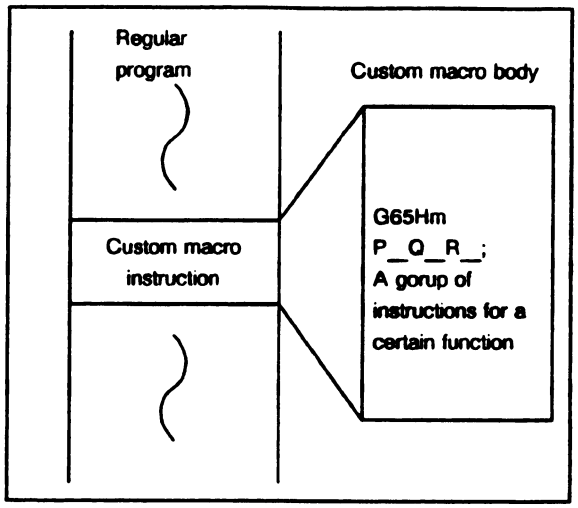
Delay and error of skip signal input is 0 - 4 msec at the NC side (not considering those at the PMC side).
This high-speed skip signal input function keeps this value to 0.1 msec or less, thus allowing high precision mesurement. This signal is connected directly to the NC; not via the PMC.

13.4 Skip Function by PMC

A skip signal can be input from the PMC ladder diagram.

14. CUSTOM MACRO

14.1 Custom Macro



The custom macro function previously loads macro instructions created by user into memory as subprograms, and uses them from CNC command programs by a simple procedure at all times.
This custom macro function can employ macro instructions, such as CNC commands using variables, arithmetic operation, conditional branch, etc. as well as ordinary CNC commands.
The following functions are applicable when programming the custom macro body.

(1) Variables

(a) Representation of variables

Variables are represented by variable numbers following # as follows.

#i (i = 1, 2, 3, ...)

(b) Quotation of variables

Numeric values following an address can be replaced with variables.

(Examples)

F#103 ..... Specifies the feedrate of #103 value.

G00Z-#100 .. Specifies the positioning to the -#100 position.

G#130 ..... Specifies G code by the #130 value.

If variable number i is replaced with variable #j, don't describe ##j, but describe #9j.

(where #j = i)

(Example)

#9100 = -500 when #100 = 105 and #105 = -500

(2) Kinds of variables

(a) Common variables

The common variables are variables common to main programs and respective macros to be called by these main programs. Accordingly, a common variable value arithmetically operated in a certain macro can also be used in the other macros.

(b) System variables

The system variables mean the variables whose applications are predetermined by the system. The interface input signals, position information, and other data can be known from the predetermined variables.

(3) Macro instruction

The macro instruction is generally represented in the following format.

G65 Hm P #i Q #j R #k ;

#i : Name of variable to which arithmetic result is entered.

#j : Name of variable to be calculated (A constant is also allowable.)

#k : Name of variable to be calculated (A constant is also allowable.)

Hm : Operator (For details, refer to the following table.)

(Note 1) Be careful since no decimal point is applicable to a variable value.

(Note 2) The unit of angle is 0.001°.

Macro Instructions

G code	H code	Functions	Definition
G65	H01	Definition, substitution	#i = #j
G65	H02	Addition	#i = #j + #k
G65	H03	Subtraction	#i = #j − #k
G65	H04	Multiplication	#i = #j × #k
G65	H05	Division	#i = #j ÷ #k
G65	H11	OR	#i = #j . OR . #k
G65	H12	AND	#i = #j . AND . #k
G65	H13	Exclusive OR	#i = #j . XOR . #k
G65	H21	Square root	#i = $\sqrt{\#j}$
G65	H22	Abeolute value	#i = I #j I
G65	H23	Remainder	#i = #j − trunc (#j / #k) ×#k trunc : Truncation of decimal part
G65	H24	Conversion from BCD	#i = BIN (#j)
G65	H25	Conversion into BCD	#i = BCD (#j)
G65	H26	Composite multiplication and diviation	#i = (#i × #j) ÷ #k
G65	H27	Composite square root 1	#i = $\sqrt{\#j^2 + \#k^2}$
G65	H28	Composite square root 2	#i = $\sqrt{\#j^2 - \#k^2}$
G65	H31	Sine	#i = #j · SIN (#k) (degree)
G65	H32	Cosine	#i = #j · COS (#k) (degree)
G65	H33	Tangent	#i = #j · TAN (#k) (degree)
G65	H34	Arc tangent	#i = ATAN (#j / #k) (degree)
G65	H80	Unconditional branch	GOTO n
G65	H81	Conditional branch 1	IF#j = #k, GoTo n
G65	H82	Conditional branch 2	IF#j ≠ #k, GoTo n
G65	H83	Conditional branch 3	IF#j > #k, GoTo n
G65	H84	Conditional branch 4	IF#j < #k, GoTo n
G65	H85	Conditional branch 5	IF#j ≥ #k, GoTo n
G65	H86	Conditional branch 6	IF#j ≤ #k, GoTo n
G65	H99	P / S alarm generation	Generation of P/S alarm 800 + n

(4) Others

The following functions are available .

(i) Entry of 16-bit external input signals.

(ii) Output of 16-bit data to the external devices.

15. COMPENSATION FUNCTIONS

15.1 Tool Length Compensation (G43, G44, and G49)

$$\left.\begin{matrix}G43\\G44\end{matrix}\right\} X\_\_\_ H\_\_\_ ;$$

or

$$\left.\begin{matrix}G43\\G44\end{matrix}\right\} H\_\_\_ ;$$

The above command enables shifting the end point of the move command inthe positive or negative direction by the value set in offset memory. By setting the difference between the length of a tool actually used for machining and the length of a tool assumed at programming, it is possible to offset the difference without changing the program.
Codes G43 and G44 specifies whether the value is incremented or decremented, and the H code specifies the offset value set in offset memory.

1) Offset direction
   G43: Increments the value (+)
   G44: Decrements the value (−)
2) Specification of the offset value
   The offset No. is specified by the H code. The offset value corresponding to the specified No., which is set in the offset memory, is added to or subtracted from the programmed command value. The offset No. can be H00 to H99.
   The offset values must be set in offset memory through the DPL/MDI beforehand, corresponding to the offset Nos.
   Because the offset memory corresponds to variable #1 to #99, allocate the offset values to variables #1 to #99 through the DPL/MDI.
   The table below indicates the range of the offset value.

	Input in millimeters	Input in inches
Offset value	0 to ±999.99 mm	0 to ±99.999 inch

3) Canceling tool length compensation
   To cancel offset, specify G49 or H00. The canceling operation is performed as soon as G49 or H00 is specified.

15.2 Pitch Error Compensation

It is possible to compensate for the ball screw pitch error in least command increment. This function is enabled after reference position return.
Set the following parameters in reference to the reference point return position.

Compensation origin (parameter No.2000)
Compensation pitch (parameter No.306)
Compensation amount (parameter No.2001 to 2128)

a) Number of compensation Points 128 (127 intervals)
b) Compensation Amount Range 0 to ±127 per compensation point
c) Compensation pitch

Moving Unit	Min. setting Pitch	Max. Setting Pitch	Unit
Metric system	8000	99999999	0.01 mm
Inch system	4000	99999999	0.001 inch

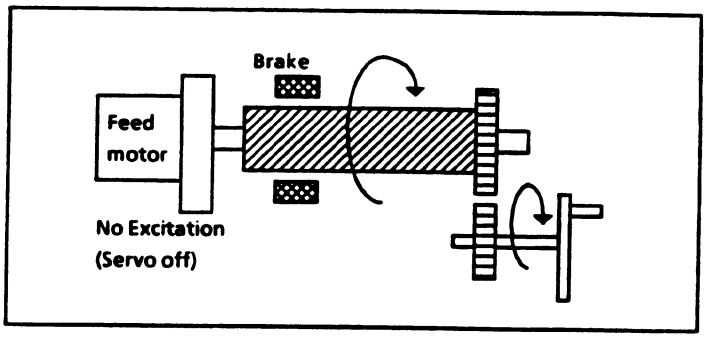
(Maximum compensation distance = setting pitch × 128)

For the actual compensation pitch, the optimal value is to be set in the range above according to the maximum compensation distance and the machine stroke.
If the setting pitch is set below the least input increment, compensation may not be performed at the expected position. In that case, it is necessary to withhold the feed rate low.
It is possible to obtain the minimum set value of the compensation pitch to the feed rate by the following formula.

Minimum compensation pitch = maximum feed rate (mm/min) × 40/75

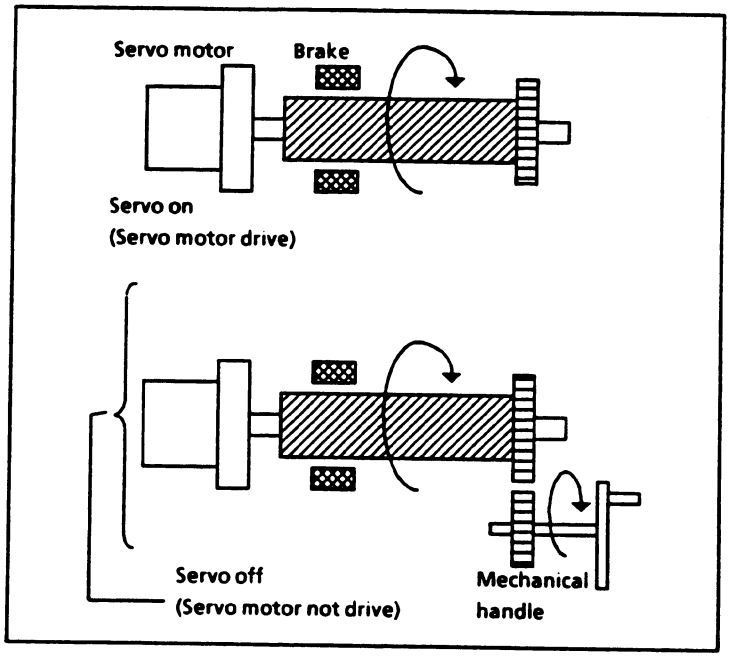
16. AXIS CONTROL

16.1 Mechanical Handle Feed



It is possible to move the machine by hand, using the mechanical handle installed on the machine; not by the CNC (servo motor).
Move distance by the mechanical handle is followed up and actual position in the CNC is revised. The mechanical handle feed is done by inputting the servo off signal of the axis fed. Machine side signal makes on/off of follow up function when servo off. However, the follow up cannot be applied when emergency stop is on or when servo alarm is on. Inch/metric conversion cannot be used when mechanical handle feed function is used.

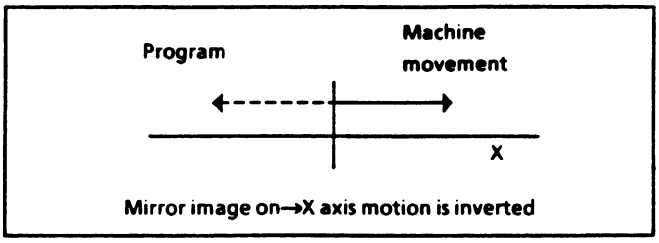
16.2 Servo Off



Servo on/off control per axis is possible by signals from the machine side.
Following functions can be executed by servo off.

(1) Workpiece install/remove fixing the machine at stated position.
(2) Machine operation by operator with mechanical handle.

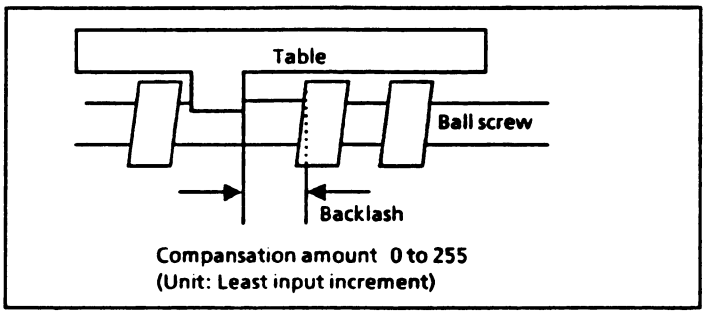
16.3 Mirror Image (M Series)



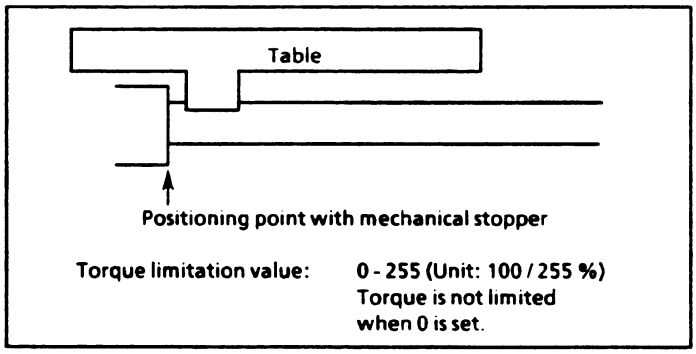
The signs of the X, Y axis motion can be inverted in automatic operation mode.
This mirror image is effective or ineffective according to DI signals.

16.4 Backlash Compensation

Backlash can be compensated for by specifying a backlash distance in the parameter.



16.5 Torque Limit Function



Positioning can be executed by limiting the torque of servo motor and hitting the table against the mechanical stopper.

16.6 External Pulse Input Function

This function inputs the external pulses in the CNC and drives the servo motor.
Axis feed operation by the external pulse signal using the manual handle feed funciton is possible.

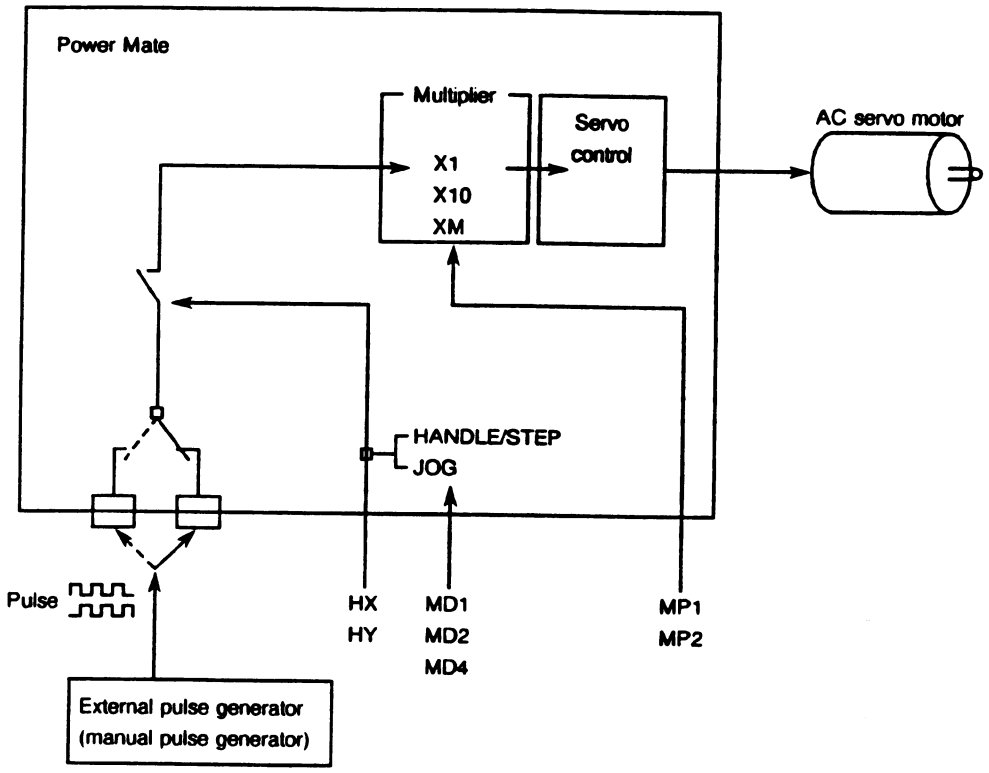


Fig. 16.6 External Pulse Input funciton

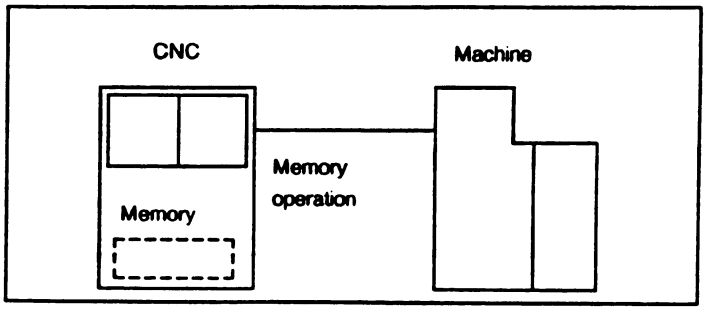
16.7 Dual Position Feedback Function

Generally, a machine with large backlash operates stable even in semi-closed loop, but may vibrate in full-closed loop.
This function controls such machine in full-closed loop, so stable as in semi-closed loop.

17. AUTOMATIC OPERATION

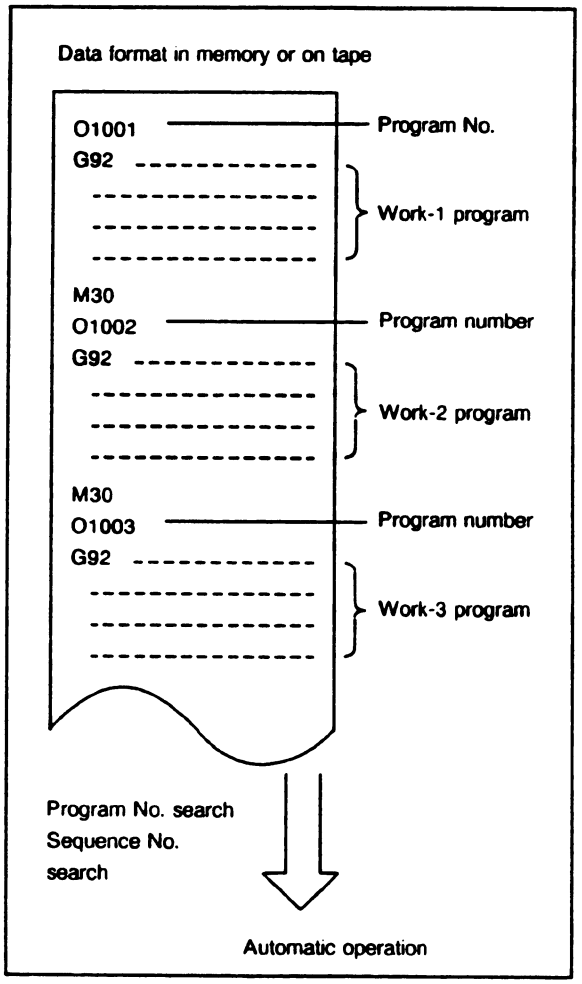
17.1 Operation Mode

(i) Memory operation



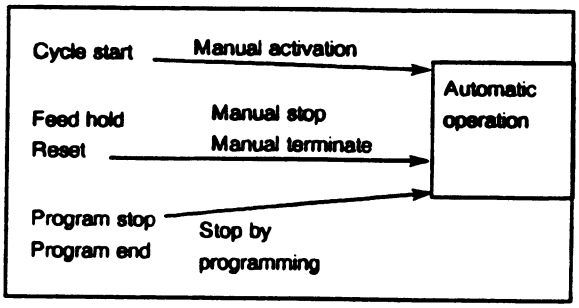
After the program is once registered in memory, the machine can be run according to the program instructions. This operation is called memory operation.

17.2 Selection of Execution Program



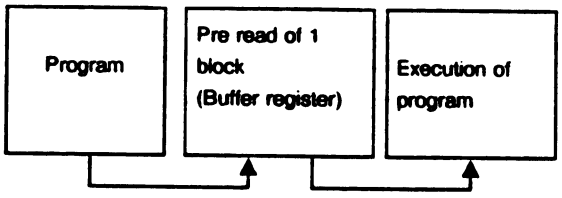
Program number search	Program number search by MDI (O .....)
	Program 0001 to 0015 search by signal from Machine side
Sequence number	Sequence number (N .....) search by MDI

17.3 Activation of Automatic Operation



Pressing the cycle start pushbutton causes automatic operation start. By pressing the feed hold or reset pushbutton, automatic running pauses or stops. By specifying the program stop or program termination command in the program, the running will stop during automatic operation. When each machining is completed, automatic operation stops.

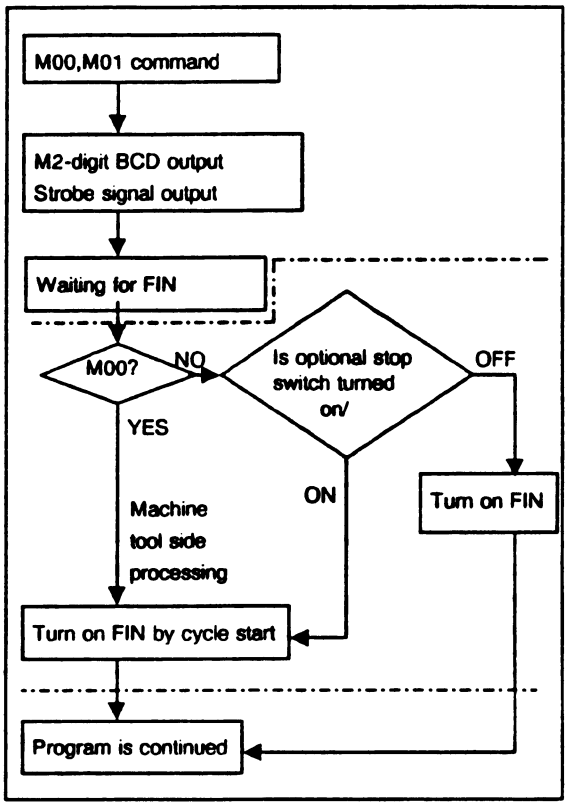
17.4 Execution of Automatic Operation



Buffer register equivalent to one block is available for program read and control of CNC command operation intervals caused by preproces time.

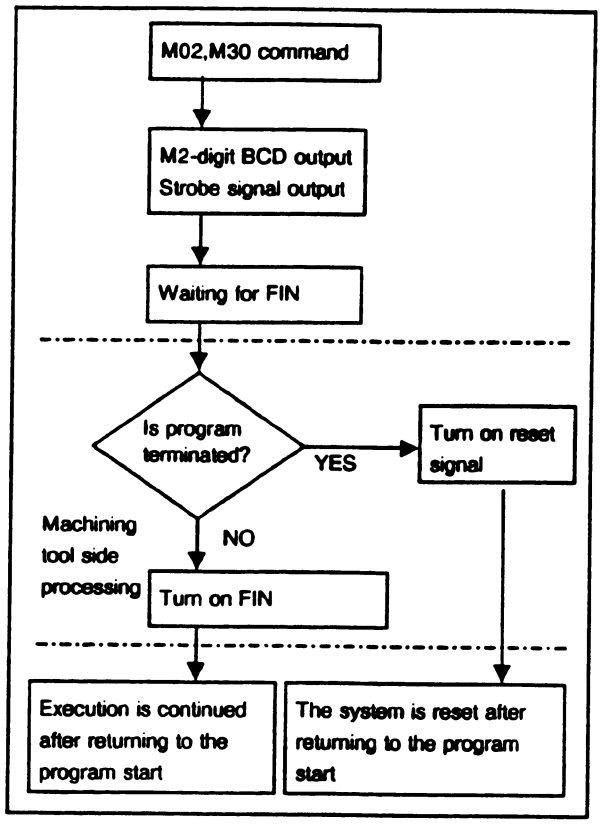
17.5 Automatic Operation Stop

17.5.1 Program stop (M00, M01)



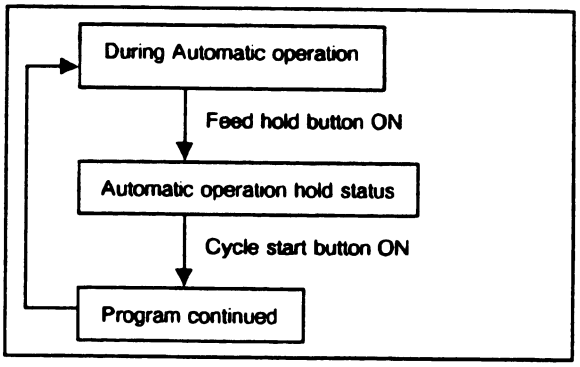
In a block where M00 (program stop) or M01 (optional stop) is specified, M code and M code read signals are sent to the machine tool in the same way as in general M codes.
Program stop processing must be done on the machine tool side.
Set CNC to be waiting for the end signal in case of M00 (program stop), and the CNC stops operating.
Send the end signal to CNC by the cycle start signal, and the program is continued.
Perform the same processing as in M00 only when the optional stop switch is turned on by the machine tool operator's panel in case of M01 (optional stop).

17.5.2 Program end (M02, M30)



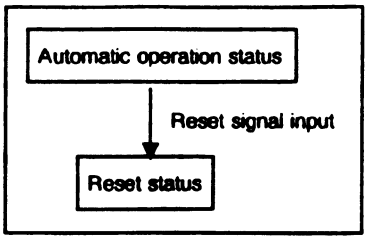
In a block where M02 (end of program) or M30 (end of tape) is specified, M code and M code read signals are sent to the machine tool in the same way as in general M codes.
Program end processing must be done on the machine tool side. By returning an external reset signal to M02 or M30, processing returns to the start of the executing program to reset the program.
By returning the end signal to M02 or M30, processing returns to the start of the executing program to continue the execution from the start again.

17.5.3 Feed hold



The CNC can be brought to an automatic operation hold status by pressing the feed hold button on the operator's panel. When feed hold is commanded during motion, it decelerates to a stop.
Automatic operation can be restarted by the cycle start button.

17.5.4 Reset



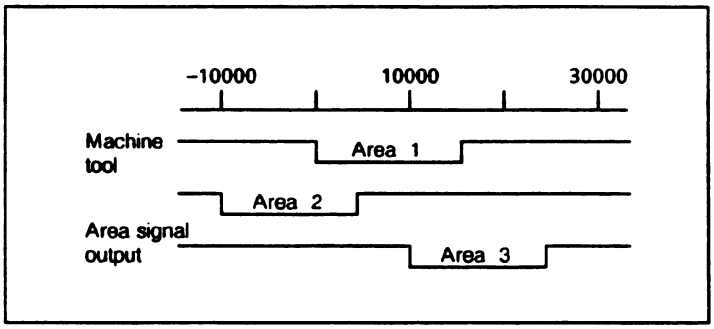
The automatic operation can be ended in a reset status by the external reset signal, etc. When reset is commanded during motion, it decelerates to a stop.
Modal information can be initialized by the parameter.

17.6 Handle Interrupt in Automatic Operation Mode

17.6.1 Handle interrupt signals

It is possible to enable handle interrupt ot always allow manual handle feed in the automatic operation mode. If feed is effected by handle interrupt, the machine coordinates only are changed and the program coordinates are not changed for the feed amount by such handle.
[Signal] HIX
[Funciton] Handle interrupt signal
1 : Enable handle interrupt.
0 : Disable handle interrupt.

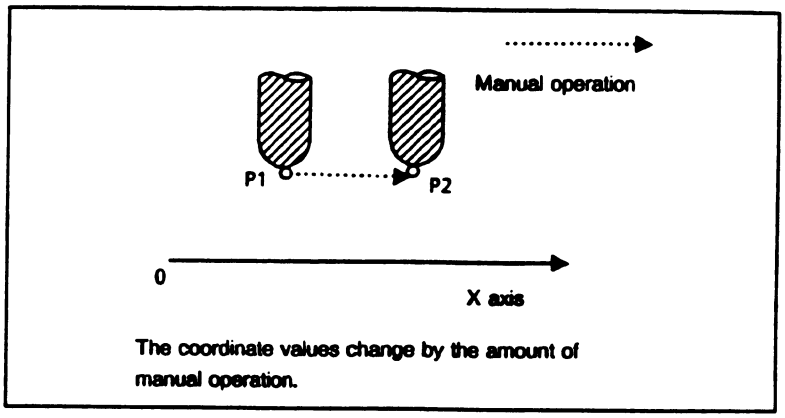
17.6.2 Zone signal output



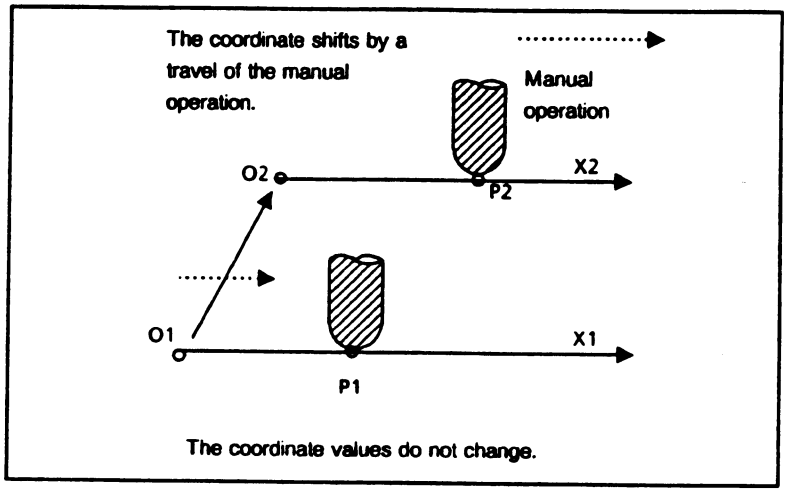
Current position of machine tool is compared with the area set to the PMC parameter and the corresponding area signal is outputted. As function command to read the area signal from PMC has been prepared, interlock at the machine tool position and so on can be easily executed using ladder program.
This signal acts as the PMC machine instruction (PSGN2).
By using two or more PSGN2 machine instructions, two or more area signals-can be output. These areas can overlap.

17.6.3 Manual absolute ON/OFF

(1) When the switch is ON.



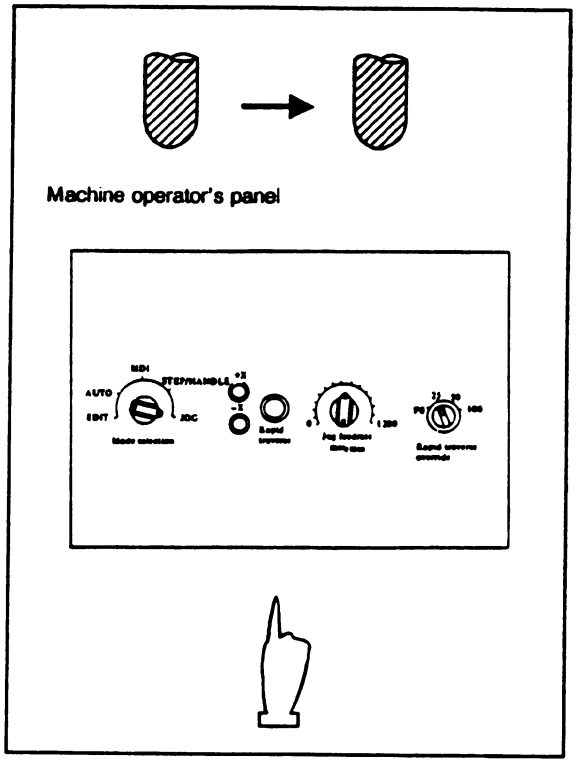
(2) When the switch is OFF.



This switch selects whether the amount of manual movement is to be added to the absolute value.

18. MANUAL OPERATION

18.1 Manual Feed



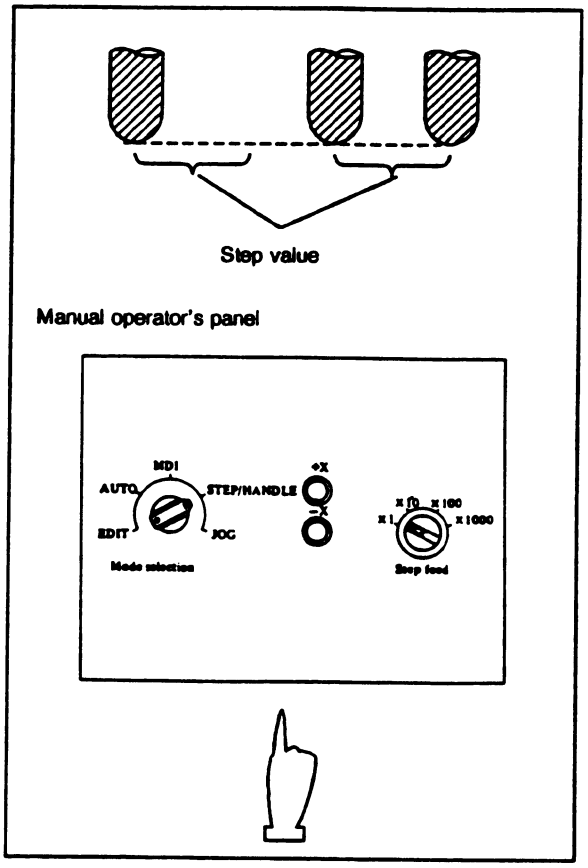
Rotary switch position	Feed rate	
	Metric input mm/min	Inch input inch/min
0	0	0
1	2.0	0.08
2	3.2	0.12
3	5.0	0.2
4	7.9	0.3
5	12.6	0.5
6	20	0.8
7	32	1.2
8	50	2.0
9	79	3.0
10	126	5.0
11	200	8.0
12	320	12
13	500	20
14	790	30
15	1260	50

Manual pulse generator is usable in the JOG mode .

(1) Jog feed The jog feedrate can be selected in 15 steps as tabulated below by a rotary switch.These 15-step ratios form geometrical series.(Refer to the next table.)

(2) Manual rapid traverse The rapid traverse is also effective during manual operation. Manual rapid traverse is set as parameter, but this parameter is different from the automatic operated rapid traverse.The rapid traverse rate preset by parameters can also be overridden in 4 steps.

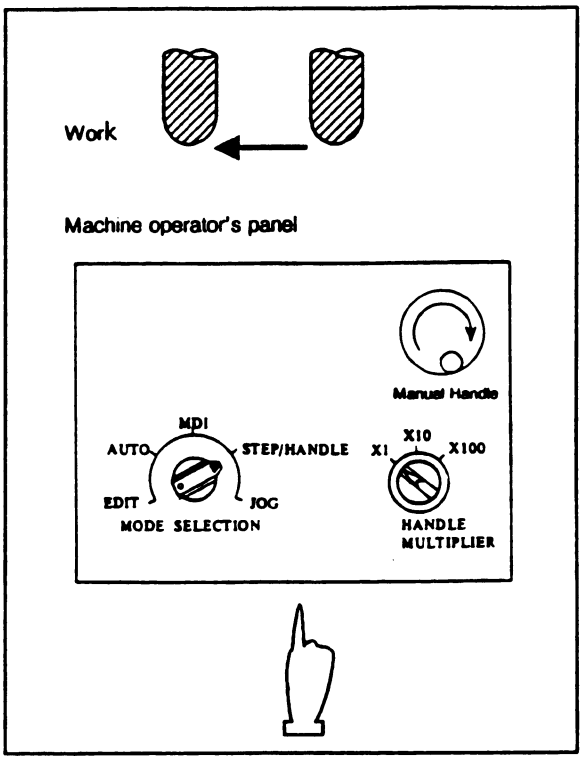
18.2 Step Feed



High-efficiency positioning can be realized in the manual mode by using the step value given below.

Input	×1	×10	×100	×1000
Metric input	0.01mm	0.1mm	1mm	10mm
Inch input	0.001 inch	0.01 inch	0.1inch	1inch

18.3 Manual Handle Feed



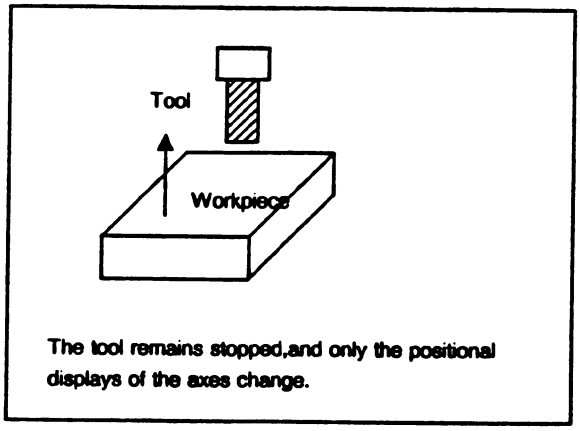
In the jog or step mode, turning on the manual handle-feed enable signal enables the operator to move a workpiece at a distance corresponding to the pulses generated by the manual pulse generator. The manual pulse generator generates 100 pulses per rotation. Move amount per pulse can be specified from the following magnifications:

x1, x10, xm

Input	×1	×10	×m
Metric input	0.01mm	0.1mm	0.01mm ×m
Inch input	0.001inch	0.01inch	0.001inch×m

19. PROGRAM TEST FUNCTIONS

19.1 Machine Lock



In machine lock condition,the machine does not move,but the position display is updated as if the machine were moving.

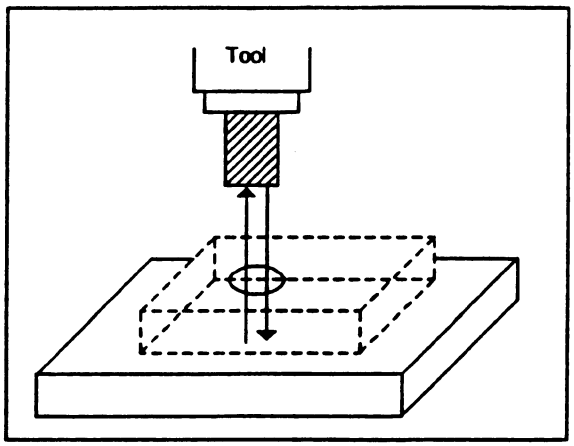
(Note 1) When the G27, G28 or G30 command is specified, the machine does not move to the reference point and the REFERENCE POINT RETURN lamp does not light.
(Note 2) The M and T functions are executed.

19.2 Auxiliary Function Lock

If automatic operation is executed in the condition of auxiliary function lock,the auxiliary functions (M and T functions such as tool change,coolant on/off) stop operation.

(Note) M00, M01, M02, M30, M98 and M99 are executed under the auxiliary function lock.

19.3 Dry Run



Remove the work,check only movement of the tool. Select the tool movement rate using the dial on the operator's panel

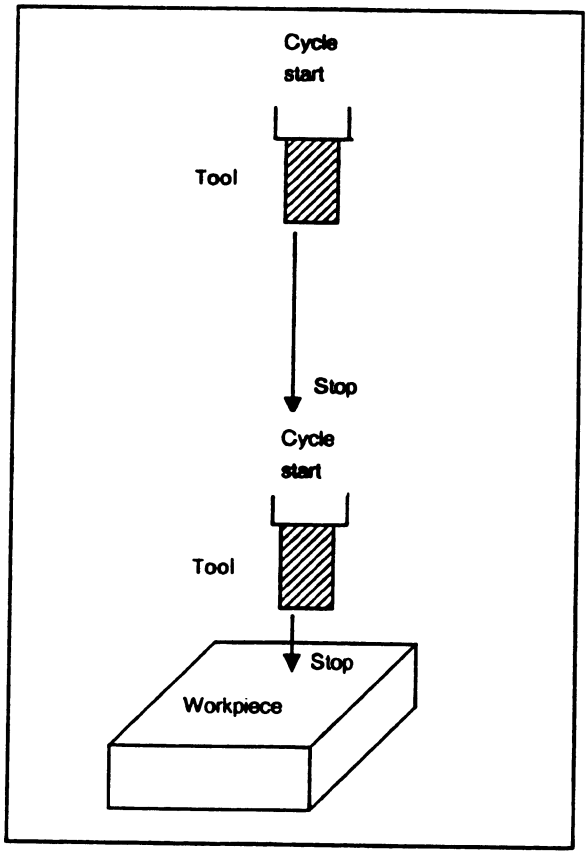
The feed rate specified in the program is ignored,and the machine is fed at the following feed rate.

Rapid traverse button ON/OFF	Rapid traverse	Cutting feed
Rapid traverse button ON	Rapid traverse	Max. JOG feed rate
Rapid traverse button OFF	JOG feed rate(Note)	JOG feed rate

(Note) Dry run for rapid traverse can be made effective by the parameter setting.

19.4 Single Block

When the single block switch is turned on, one block of the program is executed and operation stops.



When the cycle start pushbutton is pressed, the tool executes one operation then stops. By pressing the cycle start again, the tool executes the next operation then stops.The program is checked in this manner.

(Note 1) SINGLE BLOCK is effective at an intermediate point in G28, G29 and G30.
(Note 2) SINGLE BLOCK is not effective to the block M98_;,M99,and G65.However if M98,M99 blocks have the address other than O,N,P,SINGLE BLOCK is effective.

20. DISPLAY FUNCTION

20.1 DPL/MDI

20.1.1 DPL/MDI

(1) DPL/MDI

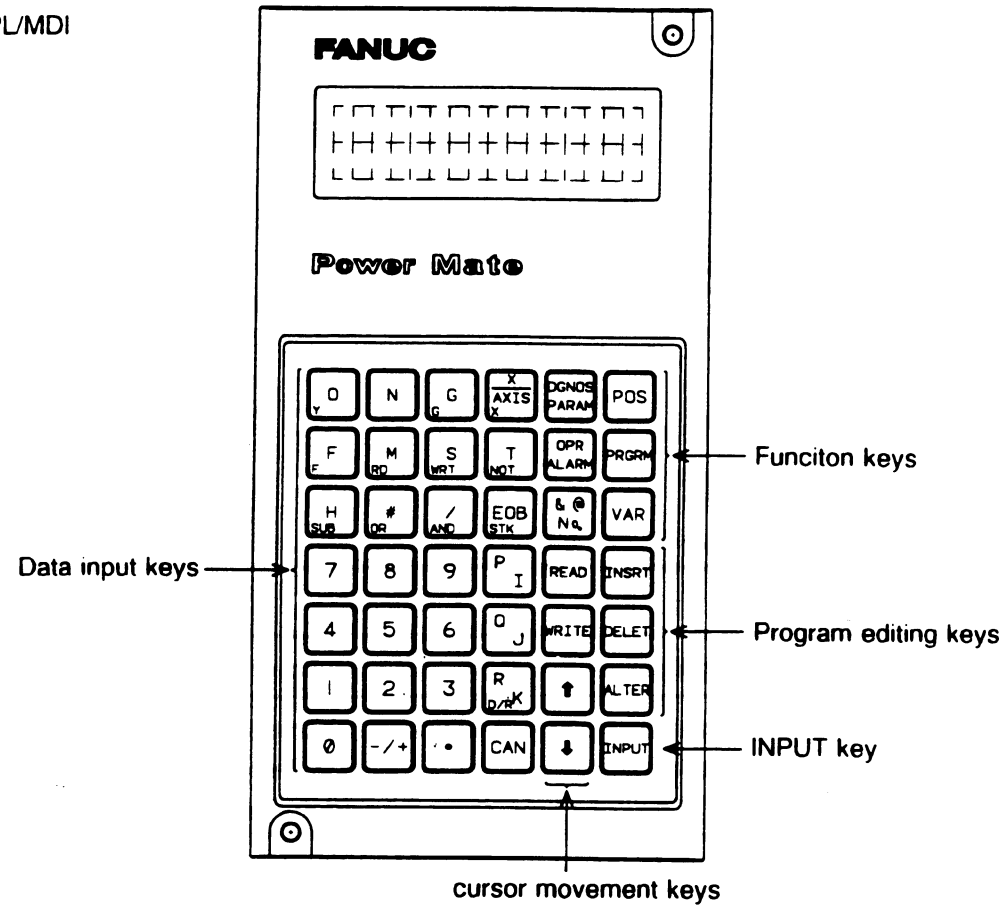


Fig. 20.1.1 (a) DPL/MDI

20.1.2 Function buttons

Function buttons indicate large items like chapters in a document.

<POS>

Indicates the current position.

<PRGRM>

conducts the following:

In EDIT mode ... edits and displays the program in the memory

In automatic operaiton ... displays command value.

<VAR>

Setting and display of variable.

<PARAM DGNOS>

Setting and display of parameter, and display of diagnostic data.

<ALARM>

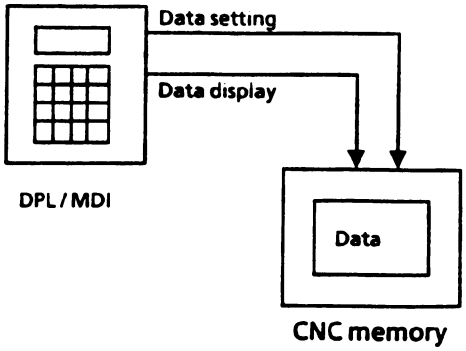
Display of Alarm number.

20.1.3 Keyboard functions

Table 20.1.3 MDI Keyboard Functions

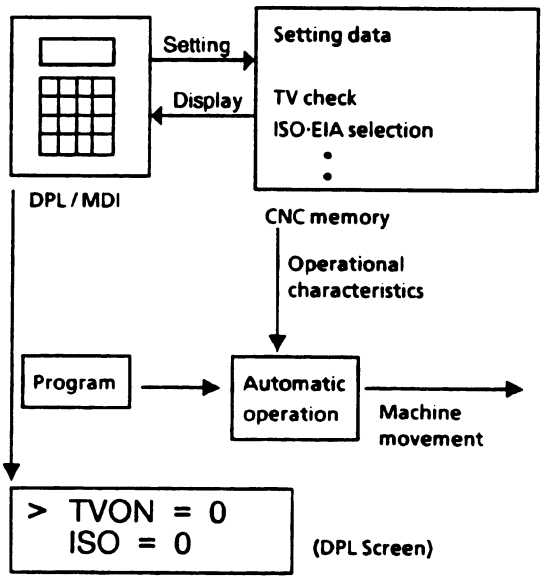
Key	Functions
Address/numerical key	Press these keys to input alphabetic, numeric, and other characters.
INPUT key	When an address or a numerical key is pressed, the letter or the numeral is input once to the key input buffer, and it is displayed on the DPL. To input the data, press the INPUT key.
Cancel (CAN) key	Press this key to cancel character or sign input to the key input buffer. (Example) When the input buffer displays N0001, N0001 is cancelled with this key. When an alarm is displayed, depressing CAN will reset the alarm message.
cursor shift keys	There are two kinds of cursor shift key described below. ↓ : This key is used to shift the cursor a short distance in the forward direciton. ↑ : Ths key is used to shift the cursor a short distance in the reverse direction.
READ/WRITE key	Press this key to move I/O device.

20.2 Setting and Display



With keys, data stored in CNC memory is updated and displayed on the DPL screen.

20.2.1 Setting and display of setting data

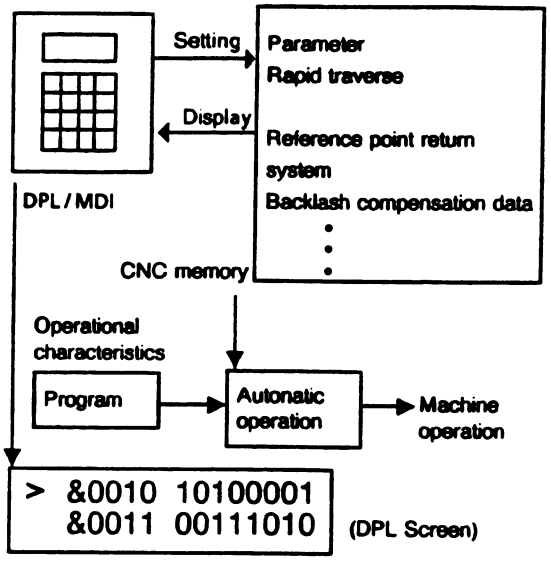


Apart from parameters, there is data that is set by the operator in operation. This data causes machine characteristics to change. For example, it specifies the following:

(1) Setting of TV check effective/ineffective
(2) ISO/EIA setting
(3) Inch/metric setting

The above data is called setting data.

20.2.2 Setting and display of parameter



The CNC functions have versatility in order to take action in characteristics of various machines.For example, CNC can specify the following:

(1) Rapid feed rate of each axis.

(2) Setting of least input increment (inch system/metric system)

(3) Setting of CMR/DMR

Data to make the above specification is called parameters. Parameters are characterized by each machine tool.

20.2.3 Display and setting of PMC data

PMC data can be displayed and set.

```
> @0320 10100001
  @0321 00111010
```
(DPL Screen)

By changing the data format, the following display formats are available.

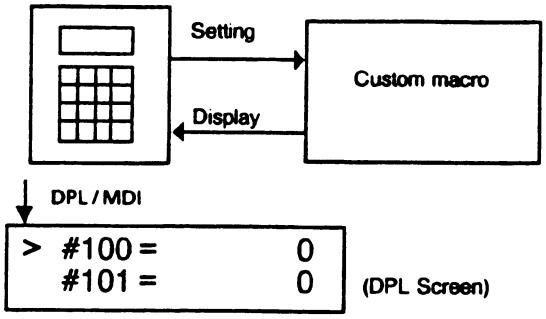
(1) Data is displayed in 2-byte decimal notation.

```
> @0320    -32683
  @0322       170
```
(DPL Screen)

(2) Data is displayed in 4-byte decimal notation.

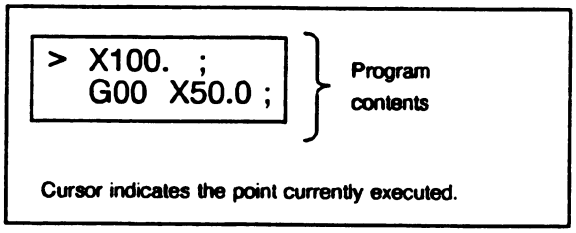
```
> @0320 11173973
  @0324        0
```
(DPL Screen)

20.2.4 Setting and display of custom macro variables

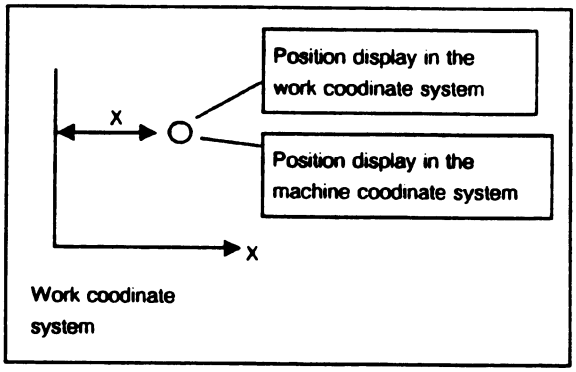


Common variables (#1-#199, #500-#599) can be set and displayed on DPL.

20.2.5 Program display and setting



20.2.6 Current position display



Position of the current tool can be displayed by coordinate values of each coordinate system.

WORK X	-12345.678
MCHN X	500.023

a) Position in the workpiece coordinate systm (ABSOLUTE)
b) Position in the machine coordinate system (MACHINE)

20.2.7 Alarm display

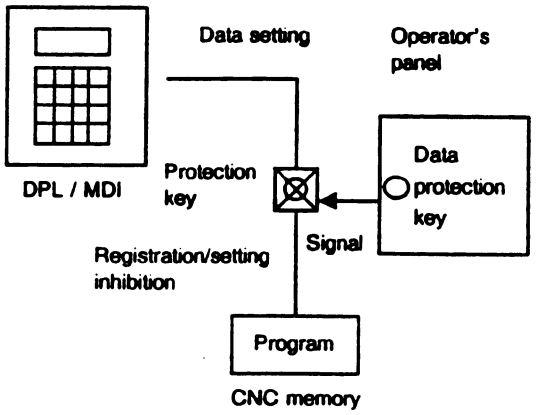
When an alarm occurs, the screen automatically displays the alarm screen. Alarm numbers are displayed.

```
ALARM
  010  102  402  500
```

20.2.8 Ladder editing

Ladder programs can be displayed and edited by using the DPL/MDI.

20.3 Program Protect Key



Program memory is protected from breaking according to error operation by issuing a signal from machine side to inhibit writing erroneous program to the program memory.Provide this switch on machine side operator's panel.

20.4 General Purpose Software Switch Function

This function can be used to turn the PMC input signal ON and OFF from DPL/MDI, one bit at a time. The switch condtion is backed up. Each switch name can be set by parameters.

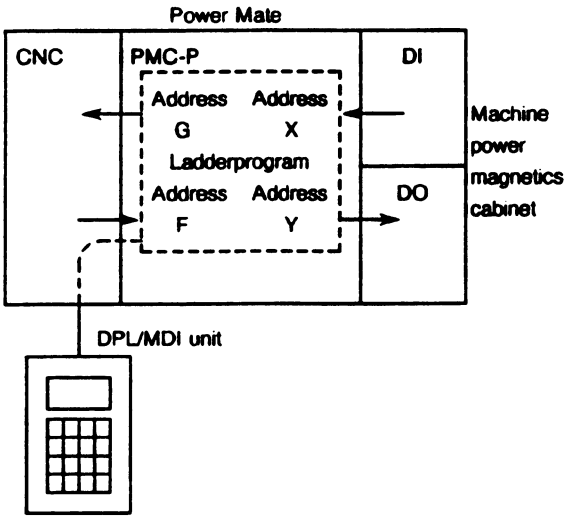
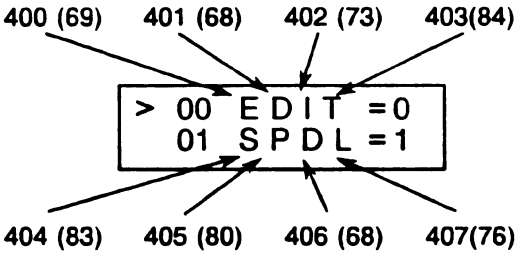


Fig. 21.4 General Purpose Software Switch Function

The switch signal set from the DPL/MDI unit can be used for purposes such as CNC mode selection input signal with ladder program processing.
Each switch name can be specified by setting a macimum of 4 optional characters to parameters Nos. 0400–0463. The m character (n = 0 ~ 15, m = 1 ~ 4) is set to parameter No.400 + n × 4 + m–1.



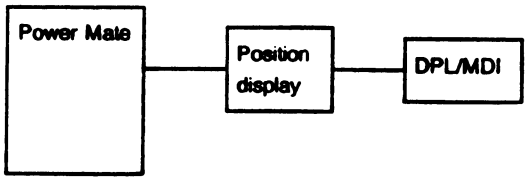
The relationship between parameter number and each switch name.
The above figure shows the screen dispalyed when the following parameter values are specified:

Parameter	Value (code)		Character
&400	69	→	E
&401	68	→	D
&402	73	→	I
&403	84	→	T

(Note) See the corresponding table for the relationships between values and characters.

20.5 Position Display

A position display can be connected to the Power Mate.
DPL/MDI can also be connected when the position display is installed in the system.



Position display specifications

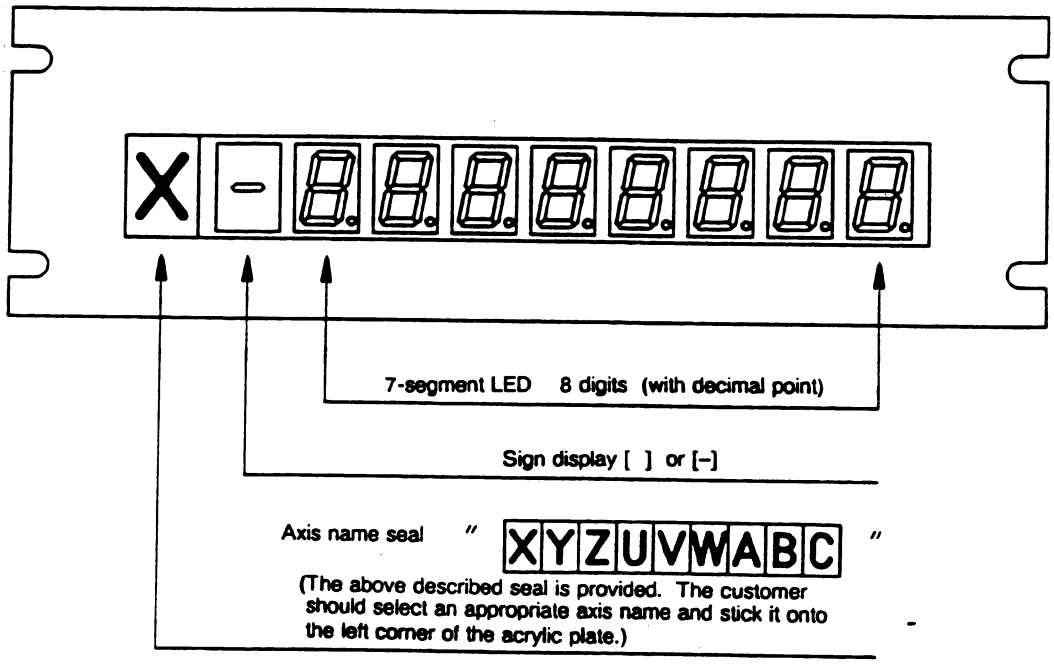
a) 8 digit display
b) Display data switch-over function

Current position of Work corrdinates
Curent position of machine coordinates
Custom macro variables data (#599)
} Selection

System alarm (automatic display when system alarm is displayed)

c) Decimal point switch-over function
System alarms (automatic display when system alarms occur)

Front



20.6 Long-distance DPL/MDI

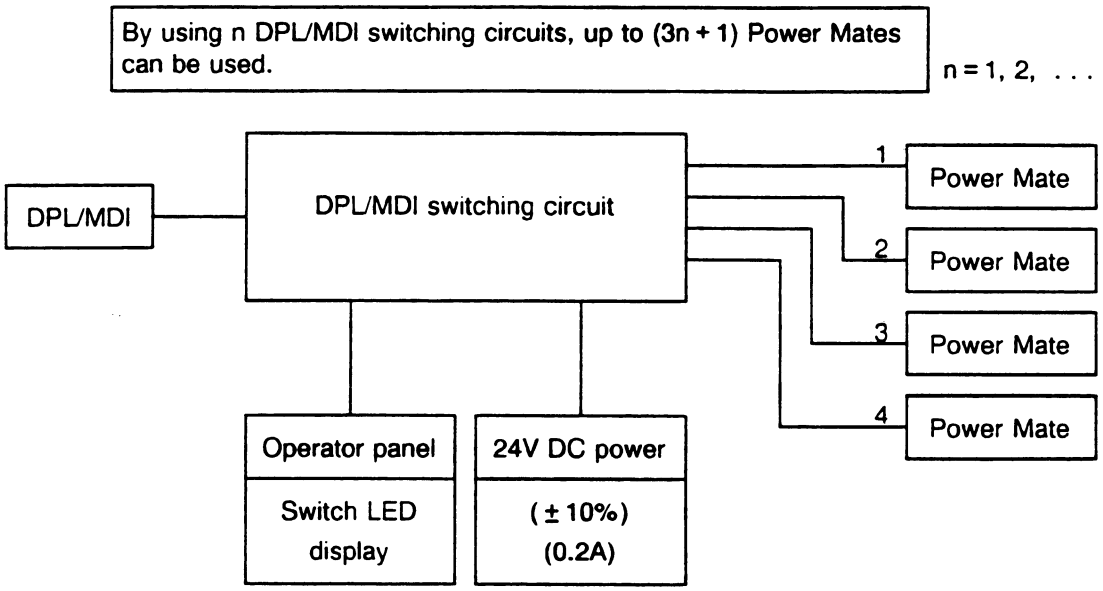
The existing DPL/MDI is delivered with a 2-m cable. For the long-distance DPL/MDI, the cable length can be extended up to 40 m. (However, the total resistance of the cable conductors must be 3.8Ω or less to keep the voltage drop below a specific level.)
The following three types of cables can be purchased:

- 2 meter cable
- 7 meter cable
- 14 meter cable

20.7 DPL/MDI Switching Circuit

The DPL/MDI switching circuit is used to switch one DPL/MDI in a system containing two or more FANUC Power Mates.

- This circuit can switch one DPL/MDI to four Power Mates. By using two or more DPL/MDI switching circuits, five or more Power Mates can be used.

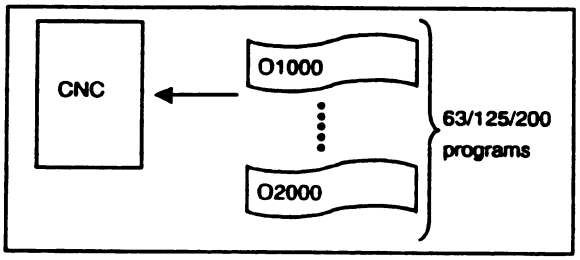


21. PART PROGRAMSTORAGE & EDITING

21.1 Part Program Storage & Editing

(1) A number of main programs and subprograms can be input from MDI and stored into the memory.Programs can also be input from the paper tape, etc. by using the optional reader/puncher interface.
(2) Main programs and subprograms being stored in the memory can be edited (modified, deleted, or inserted).
(3) An optional main program being stored in the memory can be called and edited.
(4) An optional program can be deleted.
(5) Several sequential blocks can be deleted at a time (program delete).
(6) Sequence number automatic insertion
The sequence number, where a certain increment value is added to the sequence number of the previous block can be automatically inserted at the head of each block in preparation of programs by the part program editing.
The initial value of sequence number and a certain increment amount can be set.

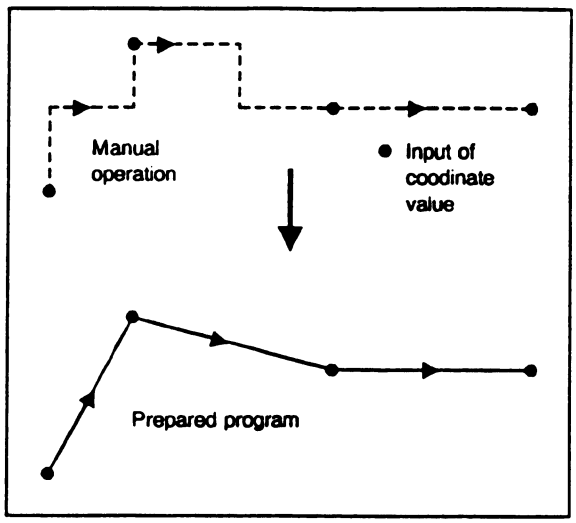
21.2 Number of Registered Programs



21.3 Part Program Storage Length

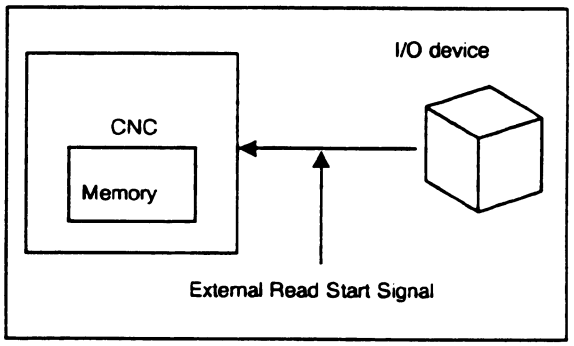
Program capacity	10/20m (option)
Memory element	IC memory
Battery	Back-Up

21.4 Play Back



The TEACH IN JOB mode and TEACH IN HANDLE mode can be created by loading the machine tool position obtained by manual operaiton into memory as a program position. Words (O, N, G, R, F, H, I, K, M, T, P, Q, C, EOB) other than X, Y, Z, A, B, C are also be loaded into memory by just the same operation as in the EDIT mode.

21.5 I/O Device External Control

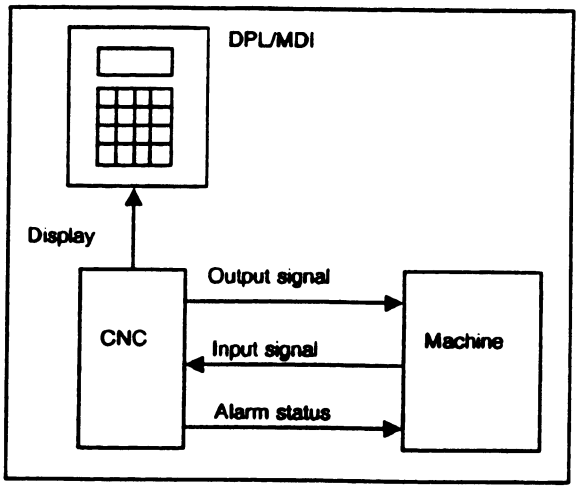


Part program registration can be commanded externally.A part program can be registered in memory in the edit mode through the input device selected for editing using the external read start signal.

21.6 Background Editing

Editing in the background is possible regardless of mode selection and CNC conditions (i.e. doesn't matter whether or not the system is in automatic operation mode, etc.). Even if an alarm occurs during background editing, the alarm does not effect foreground operation. An alarm occurring in the foreground does not effect background editing.

22. SELF-DIAGNOSTIC FUNCTION



Various status can be displayed by the DPL/MDI panel.

(1) On-off signals input to the NC can be indicated on the DPL display.

(2) On-off signals output from CNC can be sent in the unit of bit via MDI panel.

(3) Various parameter values such as acceleration/deceleration time constant, rapid traverse rate, etc. can be checked on the DPL display.

(4) Details of alarms which may occur accidentally can be classified and checked on the DPL or CRT display. These alarms comprise overheat, overtravel, servo alarm, and program errors.

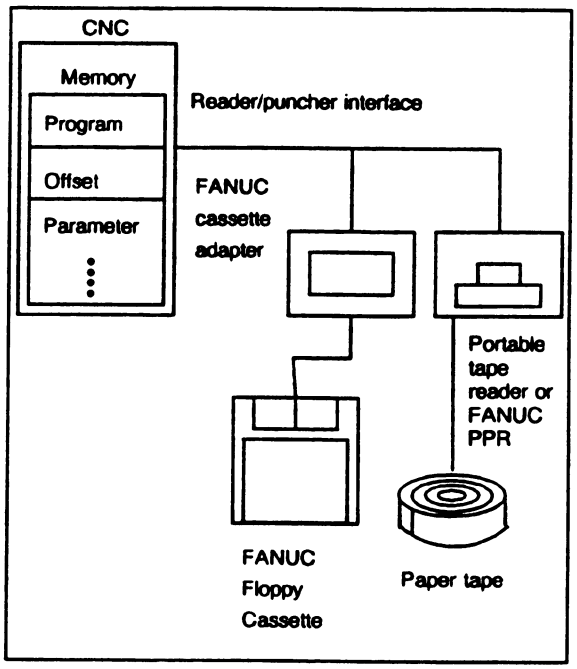
(5) The condition of servo system can be observed.

Diagnostic data display

```
> @0010   01001100
  @0011   11110000
```

23. DATA INPUT/OUTPUT

23.1 Reader/Puncher Interface



The following can be input/output via the reader/puncher interface.

(1) Part program registration

(2) Parameter input

(3) Part program punch

(4) Parameter punch

In order to input a program into CNC memory or output the input program to an external data storage medium by using the MDI panel, a unit equipped with such FANUC reader/puncher interface as FANUC cassette/FANUC PPR/ can be connected. EIA RS244-A or ISO840 is employable as data codes.

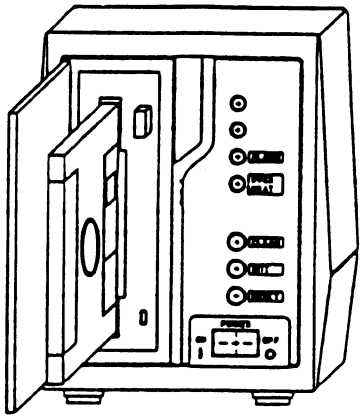
These ISO/EIA codes are automatically identified from each other in case of data input.

Either ISO codes or EIA codes is selectable by setting parameters in case of data output.

Since program input/output can be started by signals from the machine tool as well as by MDI panel operations, program can be loaded automatically.

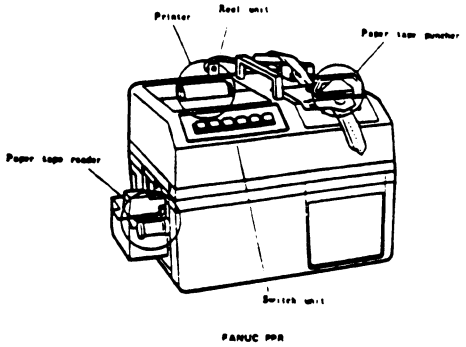
23.2 Input Devices

23.2.1 FANUC floppy cassette



CNC data can be stored in the floppy cassette and be input from this cassette.
Used with FANUC Cassette Adaptor.
Outer dimensions : 94×90×3.3(mm)
Weight : 24g
Memory capacity : Equivalent to 2.5Km of tape length

23.2.2 FANUC PPR



FANUC PPR

An I/O device with paper tape reader, tape punch, and printer in one system.
Paper tape reader read speed: 150 ch./sec or more
Paper tape punch punching speed: 50 ch./sec
Printer characters per line: 40 ch. (dot impact method)
Printing speed: 1.2 line/sec

23.2.3 FANUC PROGRAM FILE Mate

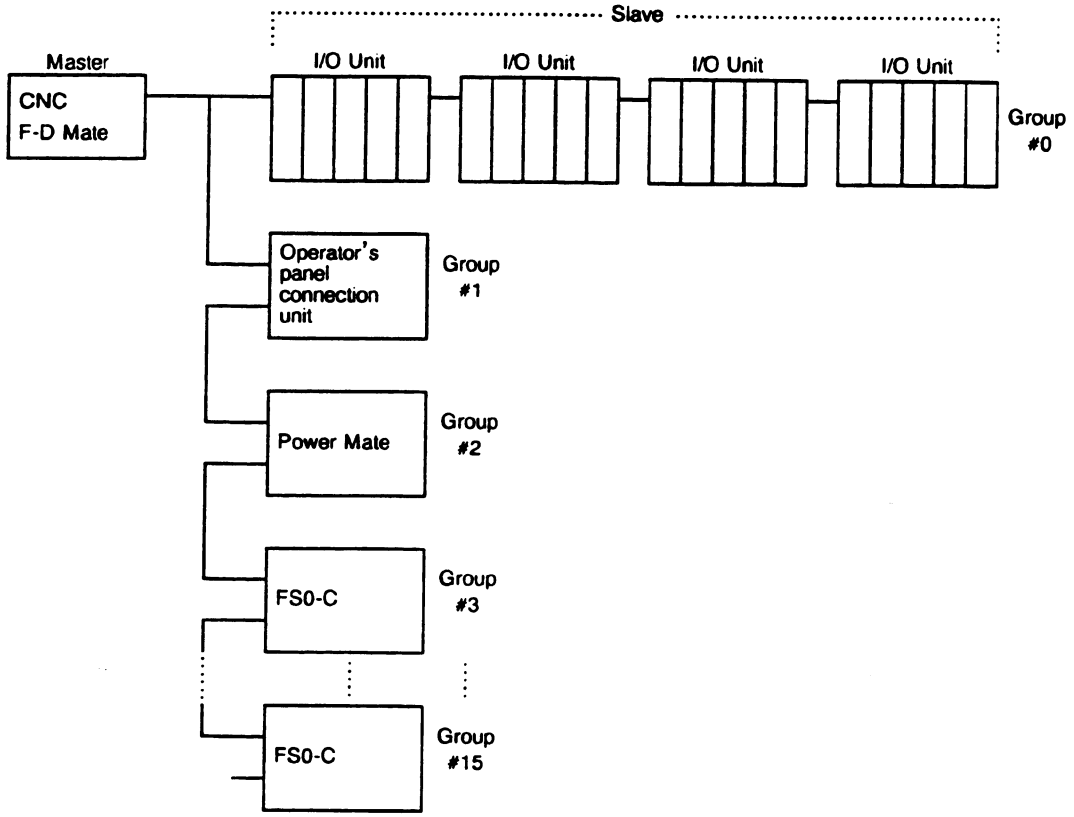
The built-in hard disk enables data to be stored and it can be connected to the reader/puncher interface to input data to CNC. This hard disk has a large storage capacity of approximately 50,000m of paper tape data,so it can register maximum 1024 command programs.
The hard disk is sealed to be continuously used under the factory environment.

24. FANUC I/O Link FUNCTION

(1) OUTLINE

The FANUC I/O Link is a serial interface that transfers I/O signals (bit data), programs and parameters between CNC or cell controllers and I/O Unit-MODEL A and Power Mate at high speed.

(2) MAKE UP



(a) FANUC I/O Link is made up of 1 master and many slave units.

Master : FS0-C, FS15, F-D Mate, FS16, FS18, Power Mate-D
FS16/FS18 only transfer I/O signals.

Slave : I/O Unit-MODEL A, Power Mate, Operator's panel connection unit, FS0-C.

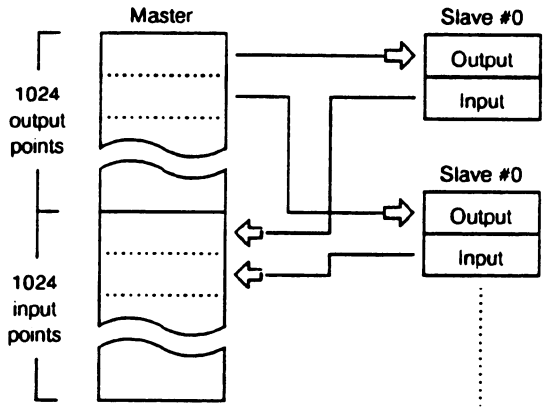
(b) A maximum of 16 groups of slaves can be connected to 1 I/O Link.
The number of slave connections per 1 group are as follows.

I/O Unit ..... Maximum 4 units (4 base)
Power Mate ..... 1 unit
Power panel connection unit .... 1 unit
FS0-C or other CNC ..... 1 unit

(c) Any slave can be connected to any group. Note however, that it is not possible to mix different kinds of slave in 1 group.

(3) I/O DATA OPERAITON

FANUC I/O Link has 1024 input and 1024 output I/O points on the Master. I/O data are transferred periodically between the master and slaves by allotting these input and output signals to each slave.



Each slave has a fixed number of I/O points and the maximum number of slaves possible on 1 I/O Link is :

Input point : 1024

Output points : 1024

The number of I/O points possessed and the actual number of I/O points may differ.

Slave type		Actual I/O points		Dedicated I/O points		Remakrs
		Input points	Output points	Input points	Output points	
I/O Unit-MODEL A		Number of points for each input module	Number of points for each output module	Actual I/O points / Dedicated I/O points Less than 32 → 32 points Less than 64 → 64 points Less than 128 → 128 points Less than 256 → 265 points Refer to "FANUC I/O Unit-MODEL A Connection Manual (B-61813E)" for further details.		
		A maximum of 256 input and 256 output points are possible per 1 group.				
Operator's panel connection unit	A	96	64	128	64	
	B	64	32			
Power Mate		32	32	32	32	It is possible to assign all I/O points.
		64	64	64	64	
FS0-C or other CNC		32	32	32	32	It is possible to assign all I/O points.
		64	64	64	64	

25. SPECIFIC DMR FUNCTION (FLEXIBLE FEED GEAR)

This function multiplies the number of feedback pulses by any number.

Calculated number of feedback pulses = real number of feedback pulses $\times \frac{n}{m}$

The numbers n and m are specified by parameters.

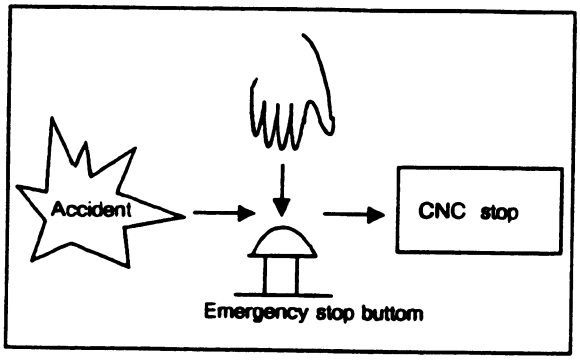
(Note) When a serial pulse coder is used, only a specific DMR can be used.

26. MEMORY CARD

The Power Mate-E has a memory card interface conforming to the JEIDA standard mounted in the controller section.
Parameters, programs, and ladders can be saved. Commercially available memory cards can be used. We can also offer the cards. Please ask about compatible memory card types.

27. SAFETY FUNCTIONS

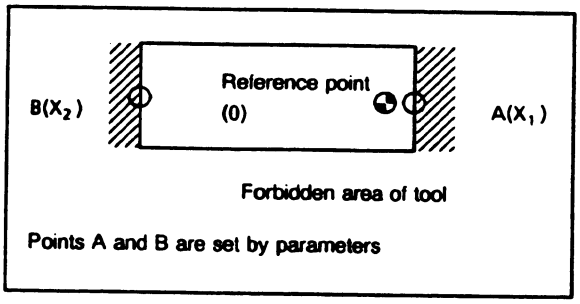
27.1 Emergency Stop



With the emergency stop, all commands stops, and the machine stops immediately.Connect the "emergency stop" signal both to the control unit and to the servo unit side.
When emergency stop is commanded, servo excitation is also reset, and servo ready signal will also turn off.After resetting the emergency stop, continue the operation after performing the reference point return operation.

27.2 Overtravel Functions

27.2.1 Stored stroke limit

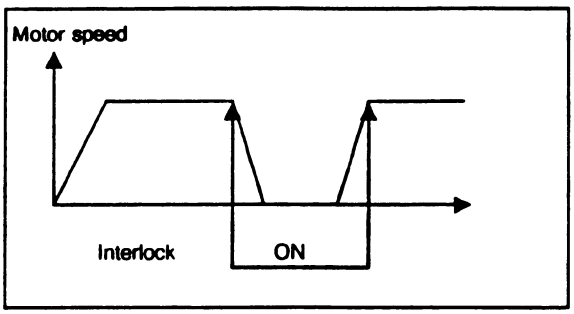


The area outside an area preset by a parameter is defined as a forbidden area.If the machine tool enters the forbidden area, the axis motion is decelerated and stopped with overtravel alarm display.(stored stroke limit)
The distance from the reference return position is set to the parameter. Stored stroke limit function can be made to be ineffective by parameter setting.

27.2.2 External setting function of stored stroke limit

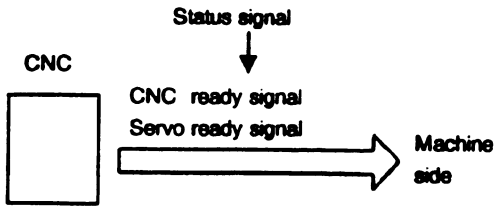
When changing a tool, this function rewrites the machine position (machine coordinate) of that time into parameter values as the stored stroke limit by adapting its tip position to the end of the limit area and depressing the SETTING key.
Setting signals are provided for each direction (+X, -X).
In addition, by turning the common LIMIT RELEASE button for all axes to the ON position, it is also possible to arrange that the stroke limit may not be checked.

27.3 Interlock



This function inhibits the axis movement of the machine tool. High speed interlock input can be used.
When this interlock signal is applied, the moving part of the machine tool stops after being decelerated. When this interlock signal is released, the machine tool starts moving again after being accelerated.
This interlock function is effective for both automatic and manual operation modes.

28. STATUS OUTPUT



28.1 CNC Ready Signal

This signal is sent to the machine side when CNC power is on and control becomes possible. Sending of this signal will be stopped when CNC power is turned off.

28.2 Servo Ready Signal

This signal is sent to the machine side when the servo system becomes operatable. Axes necessary to be braked must be braked when this signal is not sent. When this signal is interrupted, NOT READY is displayed on DPL/MDI panel.

28.3 CNC Alarm Signal

This signal is transmitted when the CNC comes under an alarm status. Alarm type signal is also sent out.

28.4 Distribution End Signal

This signal is sent out when pulse distribution of the M or T functions has ended, so that they can be used after move of the commanded block ends.

28.5 Automatic Operation Signal

This signal is sent out when it is under automatic operation.

28.6 Automatic Operation Start Lamp Signal

This signal is sent out when automatic operation is being activated.

28.7 Feed Hold Signal

This signal is sent out when automatic operation is held by feed hold.

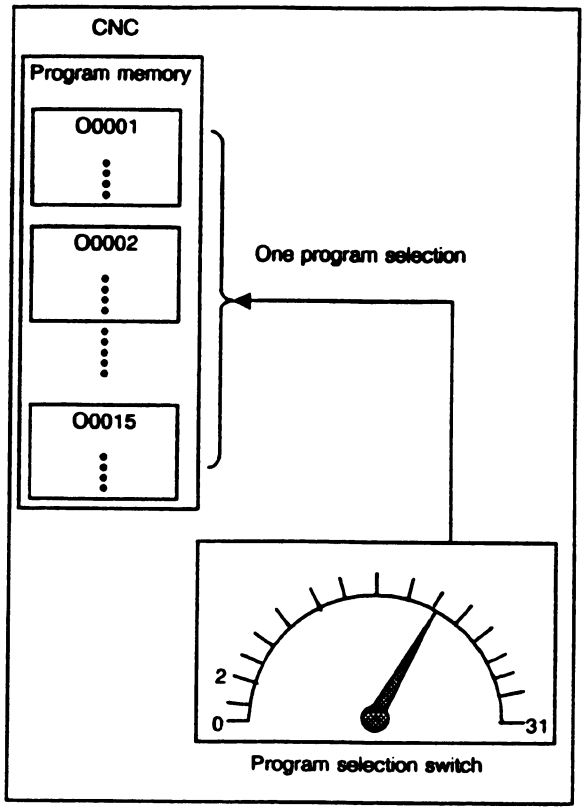
28.8 CNC Reset Signal

This signal is sent out to show that the CNC has been reset.

28.9 Battery Alarm Signal

This signal is output when the voltage of the battery for holding memory data during power interruption has become lower than the specified value. Since DPL/MDI is usually detachable, inform an operator of the necessity of battery exchange by the LED indication using this signal. A battery alarm is displayed also on the DPL/MDI.

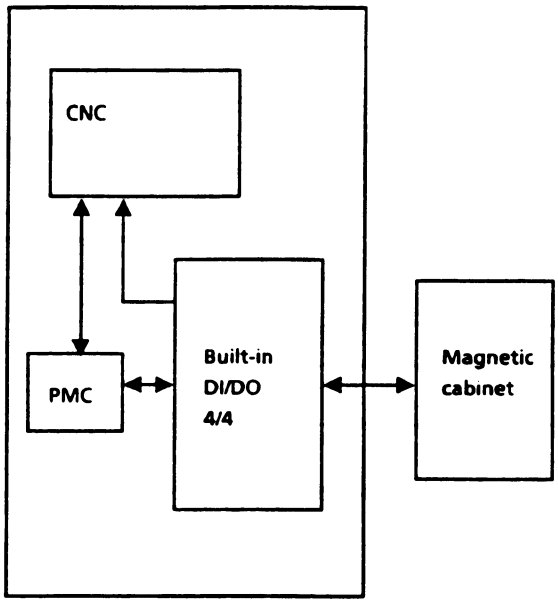
29. WORK NUMBER SEARCH



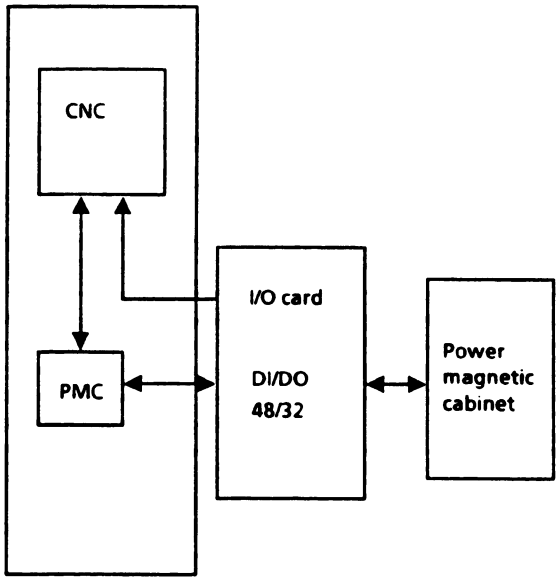
By specifying work numbers of 01 to 255 externally (from the machine side,etc.), a program corresponding to the work number can be selected. The work number equals the program number. For example, when work number 12 is specified, program O0012 is selected. (The first 2 digits of the program number is 00.)

30. MACHINE INTERFACE

(1) When built-in I/O is used

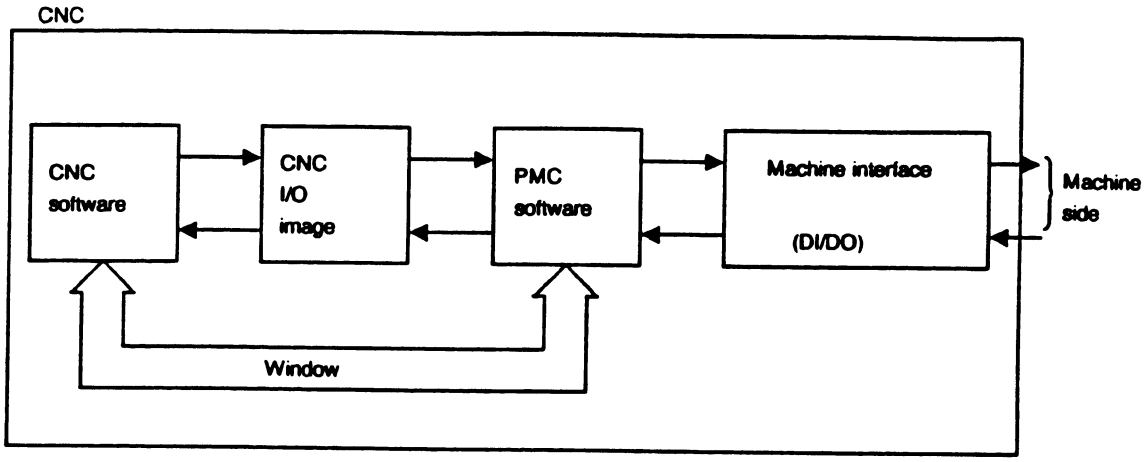


(2) When external I/O card is used



(Note) When built-in I/O and external I/O card are used at the same time, the built-in I/O cannot be used.

31. PROGRAMMABLE MACHINE CONTROLLER(PMC-P)



Magnetics sequence circuit can be incorporated in the CNC.

	Max.No. of inputs	Max.No. of outputs	No. of step	Time of processing	Remarks
Power Mate-E (PMC-P)	48	32	2000 steps	18μ/step	High-speed M and T interface is available.

31.1 Window Function

In this function, PMC can request CNC to transfer data to the PMC side.

(1) The following kinds of data are transferred from the CNC.

Data type (CNC→PMC)
Current position in the machine coordinate system
Current position in the workpiece coordinate system
Skip position
Remaining move quantity
Value in the position control error register
Cumulative acceleration/deacceleration value
Modal information O, N
Modal information G
Modal information F
Real feedrate

Data type (CNC→PMC)
Number of programs being used
Block end position
Tool length compensation
Current monitor value for the motor load
Values of macro variables #1 to #99
Values of macro variables #100 to #199
Values of macro variables #500 to #599
Parameters including parameter 1
Alarm number

(2) Data transferred from PMC side to CNC side

Data type (CNC ← PMC)
Values of macro variables #1 to #99
Values of macro variables #100 to #199
Values of macro variables #500 to #599

31.2 DPL Screen Generation by PMC

This function displays messages in the CNC DPL screen.
Message data to be displayed is specified after functional instruction parameters. One DISP functional instruction can define up to 16 types of messages. Messages can be displayed by specifying 1 for control condition ACT. By setting the display request bit associated with the number of message data to be displayed to 1, the message data can be displayed.
One operator message can be displayed on a screen. If an attempt is made to display an operator message when another operator message is already displayed on the screen, it will fail. The display request bit associated with the operator message displayed on the screen is set to 0 when another operator message can be displayed.

(Note) An already displayed message cannot be deleted even when the display request bit is set to 0. This message is replaced when the next message is displayed. Therefore, in order to delete an already displayed message, display a blank message.

31.3 Key Data Reference Function Using PMC (Output)

The key input status of the DPL/MDI is output to the PMC.

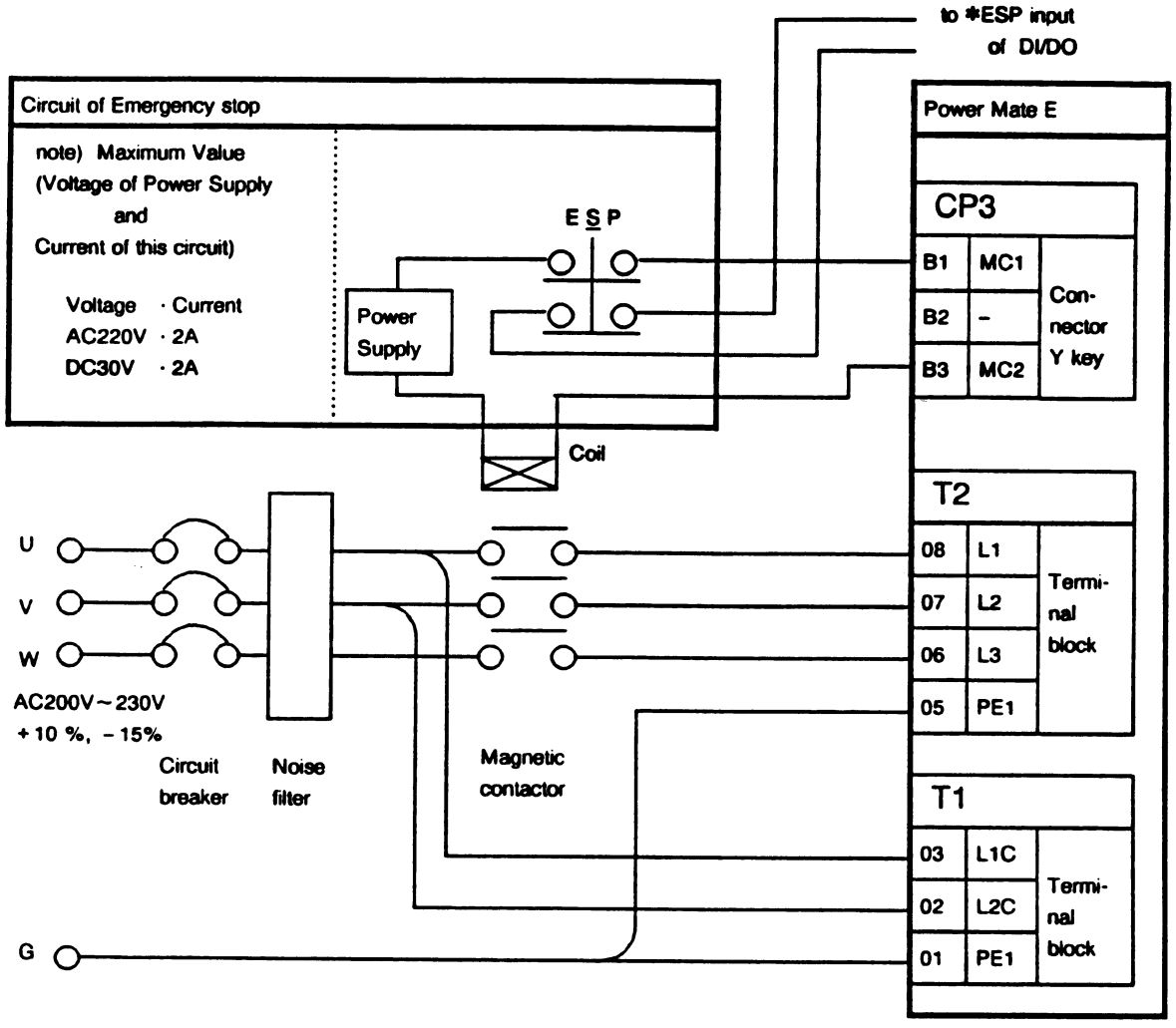
32. CONTROL UNIT

32.1 Control Part

The control unit is a panel mount type integrated with the servo amplifier.
For external dimension and weight, refer to APPENDIX 4.

32.2 Power Supply

32.2.1 Connection



32.2.2 Input power supply

(1) Three-phase power supply
Capacity of three-phase power supply connected to the terminal block T2 (L1, L2, L3)

200VAC to 230VAC +10%, −15%, 50/60Hz ± 2Hz
Capacity of three-phase power supply

Motor model	Capacity/One moter	Phase current (Power supply voltage 170VAC)
2-0E	0.45 [KVA]	1.5 [Arms]
1-0E	0.83 [KVA]	2.8 [Arms]
0E	1.3 [KVA]	4.4 [Arms]
5E	1.5 [KVA]	5.1 [Arms]

(Note 1) When two motors or more are used, the power supply capacity will be obtained as the sum of power supply capacity for each motor.
(Note 2) The power supply capacity of the above table is enough in continuous rating. However, the capacity of about two times continuous ratings will be momentarily occasionally needed when the servo motor is rapidly accelerated/decelerated.
(Note 3) When the power supply is turned on, max. about 18A current (253VAC input) flows for 30msec.

(2) Single-phase power supply for the control
Capacity of single phase power supply for the control connected to the terminal block T1 (L1C, L2C).

200VAC to 230VAC +10% ~ −15%, 50/60Hz ± 2Hz
Capacity of single phase power supply for control

Capacity of power supply/Power-Mate E	50VA

(Note 1) When the power supply is turned on, max. about 35A current (253VAC input) flows for 5msec.
(Note 2) No external fuse is required because the 5A fuse is mounted for the single phase power supply for the control in the Power-Mate E.

32.2.3 Breaker

(1) Capacity

Select the breaker referring to the Input Power Supply in item 32.2.2.

(2) Earth leakage breaker

When the earth leakage breaker is used, use the earth leakage breaker corresponding to the invertors.

Table 32.2.3 Earth leakage breaker

Maker	Type	Applied situation
Fuji Electric, LTD	EG-A Series SG-A Series	Completely corresponding to the invertor from 1983.7
Hitachi, LTD	ES100C Type ES225C Type	Completely corresponding to the invertor from 1984.7
Matsusita CO., LTD	Earth leakage breaker C Earth leakage breaker KC	Completely corresponding to the invertor from 1984.11

32.2.4 Noise filter

(1) Application

Use the noise filter to decrease the effect of high-cycle noise to the power supply.

(2) Capacity

Select the capacity of the noise filter reffering to the Input Power Supply in item 32.2.2.

(3) Selection

(a) Commercial noise filter

Prepare the suitable noise filter for customer's system.

(b) AC line filter (Option)

The AC line filter is prepared as an option of Power-Mate E.

Two or more Power-Mate E can be connected to the AC line filter within the range shown in Table 32.2.4.

Select the capacity of AC line filter referring to the Input Power Supply in item 32.2.2.

Table 32.2.4 AC line filter

Type	Application	Specification
Type A	9KVA Max.	A81L-0001-0083#3C
Type B	18KVA Max.	A81L-0001-0101#C

32.2.5 Contactor

(1) Capacity
Select a contactor referring to the Input Power Supply in item 32.2.2.

(2) Standard
Use the MCC to which IEC Pub.158-1 and Pub.292-1 are applied.

32.2.6 Power transformer

A power transformer may be required according to the input power source voltage.
The power transformer should be mounted in the machine side.

32.3 Battery

Mount the battery units for the control and for the absolute pulse coder on the NC side.

32.4 Environmental Requirements

(1) Ambient temperature
0°C - 55°C when operating
-20°C - 60°C when stored or delivering Change in temperature Max. 1.1°C/min
(2) Humidity 75% or less (relative humidity) generally Max. 95% for a short time (within 1 month)
(3) Vibration 0.5G or less when operating
(4) Circumstances
When using in places with thick dust, cutting oil, or organic solvent, consult us.

33. SERVO

33.1 Position Detector

For the Power Mate-E, the serial pulse coder C3 can be used.
The serial pulse coder C3 is a detector of 5,000 pulses per revolution.

33.2 Absolute Position Detector (Absolute Pulse Coder)

The machine coordinate system once set is not lost even if the CNC power is turned off by the electric absolute position detector.
The reference position return operation, which was conventionally required at time of power on, is no longer necessary. And the NC start can be immediately put on. Power Mate E can use the serial pulse coder A. The serial pulse coder A is a detector of 1,000,000 pulses per revolution.

33.3 Separate Type Pulse Coder

Full-closed loop control is possible.

33.4 Servo Motor

FANUC AC SERVO MOTOR E series are offered.

33.5 Velocity Control Unit

Various velocity control units are offered according to types of AC servo motors.

33.6 Connection of Regenerative Discharge Unit and Additional Discharge Resistor

33.6.1 When the regenerative discharge unit and the additional discharge resistor is not needed

(1) When energy regenerated per deceleration is fewer than the energy shown in the following table, the regenerative discharge unit and additional discharge resistor are not required.

Motor model	Regenerative energy per deceleration
2-0E 1-0E	15 [J]
0E 5E	20 [J]

(2) Method of calculating regenerative energy per deceleration

a) When machine moves in horizontal direction

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

- $J = J_M + J_L$
- J_M ; Rotor inertia of motor (kg·cm·sec^2)
- J_L ; Motor axis conversion inertia of load (kg·cm·sec^2)
- V_m ; Motor speed at rapid traverse (rpm)
- t_a ; Rapid traverse acceleration/deceleration time (sec)
- T_L ; Machine friction torque (motor-axis converse) (kg·cm)

b) When machine moves in vertical direction

$$Q = 1.026 \times 10^{-2} Th V_m \times t_a \text{ (J)} \quad \ldots\ldots\ldots\ldots \quad (2)$$

R is regenerative energy when machine moves in vertical direction.

$$R = P + Q \text{ (J)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

- Th = Torque which supports the machine upward by motor when the machine lowers at rapid traverse (kg·cm)
- V_m ; Motor speed at rapid traverse (rpm)
- t_a ; Rapid traverse acceleration/deceleration time (sec)

33.6.2 When the regenerative discharge unit and the additional discharge resistor is needed

When regenerative energy per deceleration exceeds that shown in Table 33.6.1, the DC link overvoltage alarm will occur. At this time, the regenerative discharge unit and additional discharge resistor are needed.

(1) When the average regenerative energy is 20W or less, connect the regenerative discharge unit. However, the surrounding temperature is assumed 55°C.

(2) When the average regenerative energy is 50W or less, connect the regenerative discharge unit and the additional discharge resistor.
However, the surrounding temperature is assumed 55°C.

(3) The additional discharge resistor can be used by exceeding 50W by ventilating it.

(4) An internal thermostat will operate and the external overheating alarm occurs, when the regenerative discharge unit and the additional discharge resistor generate excessive heat.

(5) Refer to the "FANUC AC SERVO MOTOR DESCRIPTIONS (B-65002E)" for a method of calculating the average regenerative energy.

33.7 Dynamic Brake Unit

When an emergency stop or an alarm occurs while the motor is rotating, since excitation turns off the motor keeps free-running. However, when the dynamic brake unit is connected, if an emergency stop or an alarm is generated while the motor is running, the motor decelerates to a stop. When the motor is used for a vertical axis, or any force is applied to the motor, however, the motor may not stop.

APPENDIX

APPENDIX 1. RANGE OF COMMAND VALUE

Linear Axis with a Millimeter Feed Screw

	Input in millimeters	Input in inches
Least input increment	0.01 mm	0.001 inch
Least command increment	0.01 mm	0.01 inch
Maximum specified value	±99999.999 mm	±9999.9999 inch
Maximum feedrate in rapid traverse (*1)	1200000 mm/min	1200000 inch/min
Feedrate range (*1)	0.001 - 99999.999 mm/min or 1 - 1000000 mm/min 0.01 - 500.00 mm/rev	0.00001 - 999.99999 inch/min or 0.01 - 2000.00 inch/min 0.0001 - 9.9999 inch/rev
Step feed	0.01, 0.1, 1, 10 mm/step	0.001, 0.01, 0.1, 1 inch/step
Backlash compensation	0 - ±2.55 mm	0 - ±2.55 inch
Dwell	0 - ±99999.999 sec	0 - 99999.999 sec

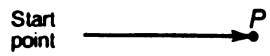
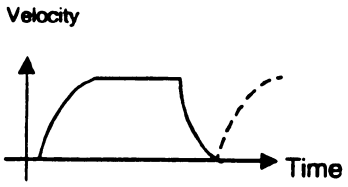
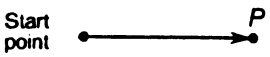
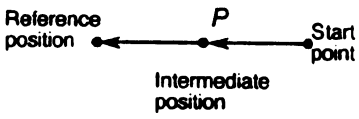
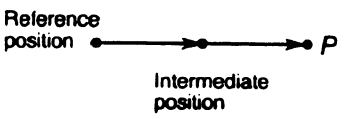
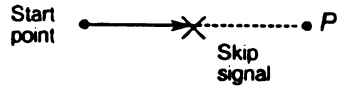
Linear Axis with an Inch Feed Screw

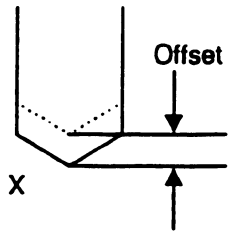
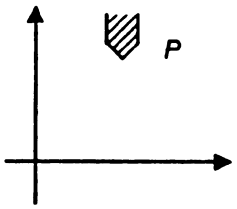
	Input in millimeters	Input in inches
Least input increment	0.01 mm	0.001 inch
Least command increment	0.001 inch	0.001 inch
Maximum specified value	±999999.99 mm	±99999.999 inch
Maximum feedrate in rapid traverse (*1)	40000 inch/min	40000 inch/min
Feedrate range (*1)	0.001 - 99999.999 mm/min or 1 - 1000000 mm/min 0.01 - 500.00 mm/rev	0.00001 - 999.99999 inch/min or 0.01 - 20000.00 inch/min 0.0001 - 9.9999 inch/rev
Step feed	0.01, 0.1, 1, 10 mm/step	0.001, 0.01, 0.1, 1 inch/step
Backlash compensation (*2)	0 - ±0.255 inch	0 - ±0.255 inch
Dwell	0 - 99999.999 sec	0 - 99999.999 sec

*1 Note that the feedrate above is specified depending on the capacity of interpolation in the CNC. Also, additional restrictions caused by the servo and mechanical systems apply to the feedrate in the whole system.

APPENDIX 2. FUNCTIONS AND TAPE FORMAT LIST

As seen above, the format consists of a combination of arbitrary axis addreses among X, Y, Z, U, V, W, A, B and C.
The symbols in the list represent the followings.
I*P*___: X___Y___Z___A ···___

Functions	Illustrations	Tape format
Positioning (G00)		G00*P*——;
Linear interpolation (G01)		G01*P*——F——;
Dwell (G04)		G04 { X– / P– };
Exact stop(G04)		
Chnage of offset value by program (G10, G11)		G10; N – P – ; N – P – ; G11;
Inch/metric conversion (G20,G21)		Inch input: G20; Metric input: G21;
Reference position return check (G27)		G27*P* – :
Reference position return (G28) 2nd reference position return (G30)		G28*P* – : G30*P* – :
Return from reference position (G29)		G29*P* – :
Skip function (G31)		G31*P* – F – :

Functions	Illustrations	Tape format
Tool length compensation (G43, G44, G49)		{G43 / G44} X__H__; {G43 / G44} H__; H: Tool length offset G49: Cancel
Custom macro (G65)	General format G65HmP#iQ#jR#k; m: Specifies macro functions with 01 to 99 #i: Variable number of operation result #j: Variable number used in operation (or constant) #k: Variable number used in operation (Meaning)#i = #j ⊕ #k ↑ Operation Hm	G65HmP#iQ#jR#k;
Absolute/incremental programming (G90/G91)		G90_____; Absolute G91_____; Incremental
Change of work coordinate (G92)		G92*P*___;

APPENDIX 3. LIST OF CODE

ISO code										EIA code										Meaning
Character	8	7	6	5	4		3	2	1	Character	8	7	6	5	4		3	2	1	
0			○	○		•				0			○			•				Numeral 0
1	○		○	○		•			○	1						•			○	Numeral 1
2	○		○	○		•		○		2						•		○		Numeral 2
3			○	○		•		○	○	3				○		•		○	○	Numeral 3
4	○		○	○		•	○			4						•	○			Numeral 4
5			○	○		•	○		○	5				○		•	○		○	Numeral 5
6			○	○		•	○	○		6				○		•	○	○		Numeral 6
7	○		○	○		•	○	○	○	7						•	○	○	○	Numeral 7
8	○		○	○	○	•				8					○	•				Numeral 8
9			○	○	○	•			○	9				○	○	•			○	Numeral 9
A		○				•			○	a		○	○			•			○	? Address A
B		○				•		○		b		○	○			•		○		Address B
C	○	○				•		○	○	c		○	○	○		•		○	○	? Address C
D		○				•	○			d		○	○			•	○			Address D
E	○	○				•	○		○	e		○	○	○		•	○		○	? Address E
F	○	○				•	○	○		f		○	○	○		•	○	○		Address F
G		○				•	○	○	○	g		○	○			•	○	○	○	Address G
H		○			○	•				h		○	○		○	•				Address H
I	○	○			○	•			○	i		○	○	○	○	•			○	Address I
J	○	○			○	•		○		j		○		○		•			○	Address J
K		○			○	•		○	○	k		○		○		•		○		Address K
L	○	○			○	•	○			l		○				•		○	○	? Address L
M		○			○	•	○		○	m		○		○		•	○			Address M
N		○			○	•	○	○		n		○				•	○		○	Address N
O	○	○			○	•	○	○	○	o		○				•	○	○		Not used at significant information section in ISO code. Assumed as program No. in EIA code.
P		○		○		•				p		○		○		•	○	○	○	Address P
Q	○	○		○		•			○	q		○		○	○	•				Address Q
R	○	○		○		•		○		r		○			○	•			○	Address R
S		○		○		•		○	○	s			○	○		•		○		Address S
T	○	○		○		•	○			t			○			•		○	○	Address T
U		○		○		•	○		○	u			○	○		•	○			? Address U
V		○		○		•	○	○		v			○			•	○		○	? Address V
W	○	○		○		•	○	○	○	w			○			•	○	○		? Address W
X	○	○		○	○	•				x			○	○		•	○	○	○	Address X
Y		○		○	○	•			○	y			○	○	○	•				Address Y
Z		○		○	○	•		○		z			○		○	•			○	Address Z
DEL	○	○	○	○	○	•	○	○	○	Del		○	○	○	○	•	○	○	○	• Delete (cancel an error punch).
NUL						•				Blank						•				• Not punched. Can not be used in significant section in EIA code.
BS	○				○	•				BS			○		○	•		○		• Back space
HT					○	•			○	Tab			○	○	○	•	○	○		• Tabulator
LF or NL					○	•		○		CR or EOB	○					•				End of block
CR	○				○	•	○		○											• Carriage return
SP	○		○			•				SP				○		•				• Space
%	○		○			•	○		○	ER					○	•		○	○	Absolute rewind stop
(			○		○	•				(2-4-5)				○	○	•		○		Control out (a comment is started)
)	○		○		○	•			○	(2-4-7)		○			○	•		○		Control in (the end of a comment)
+			○		○	•		○	○	+		○	○	○		•				• Positive sign
-			○		○	•	○		○	-		○				•				Negative sign
:			○	○	○	•		○												Colon
/	○		○		○	•	○	○	○	/			○	○		•			○	Optional block skip
.			○		○	•	○	○		.		○	○		○	•		○	○	Period (A decimal point)
#	○		○			•		○	○											• Sharpe
$			○			•	○													• Dollar sign
&	○		○			•	○	○		&					○	•	○	○		• Ampersand
'			○			•	○	○	○											• Apostrophe
*	○		○		○	•		○												• Asterisk
,	○		○		○	•	○			,			○	○	○	•		○	○	• Comma
;	○		○	○	○	•		○	○											• Semicolon
<			○	○	○	•	○													• Left angle bracket
=	○		○	○	○	•	○		○											• Equal
>	○		○	○	○	•	○	○												• Right angle bracket
?			○	○	○	•	○	○	○											• Question mark
@	○	○				•														• Commercial at mark
"			○			•		○												• Quotation

(Note 1) * : When read in the significant data zone, the codes are ignored.

(Note 2) ? : The codes are invalid in the significant data zone, but are registered in the memory.

(Note 3) Codes not in this table are ignored if their parity is correct.

(Note 4) Codes with incorrect parity cause the TH alarm. But they are ignored without generating the TH alarm when they are in the comment zone.

(Note 5) A character with all eight holes punched does not generate TH alarm even in EIA code.

APPENDIX 4. EXTERNAL DIMENSIONS

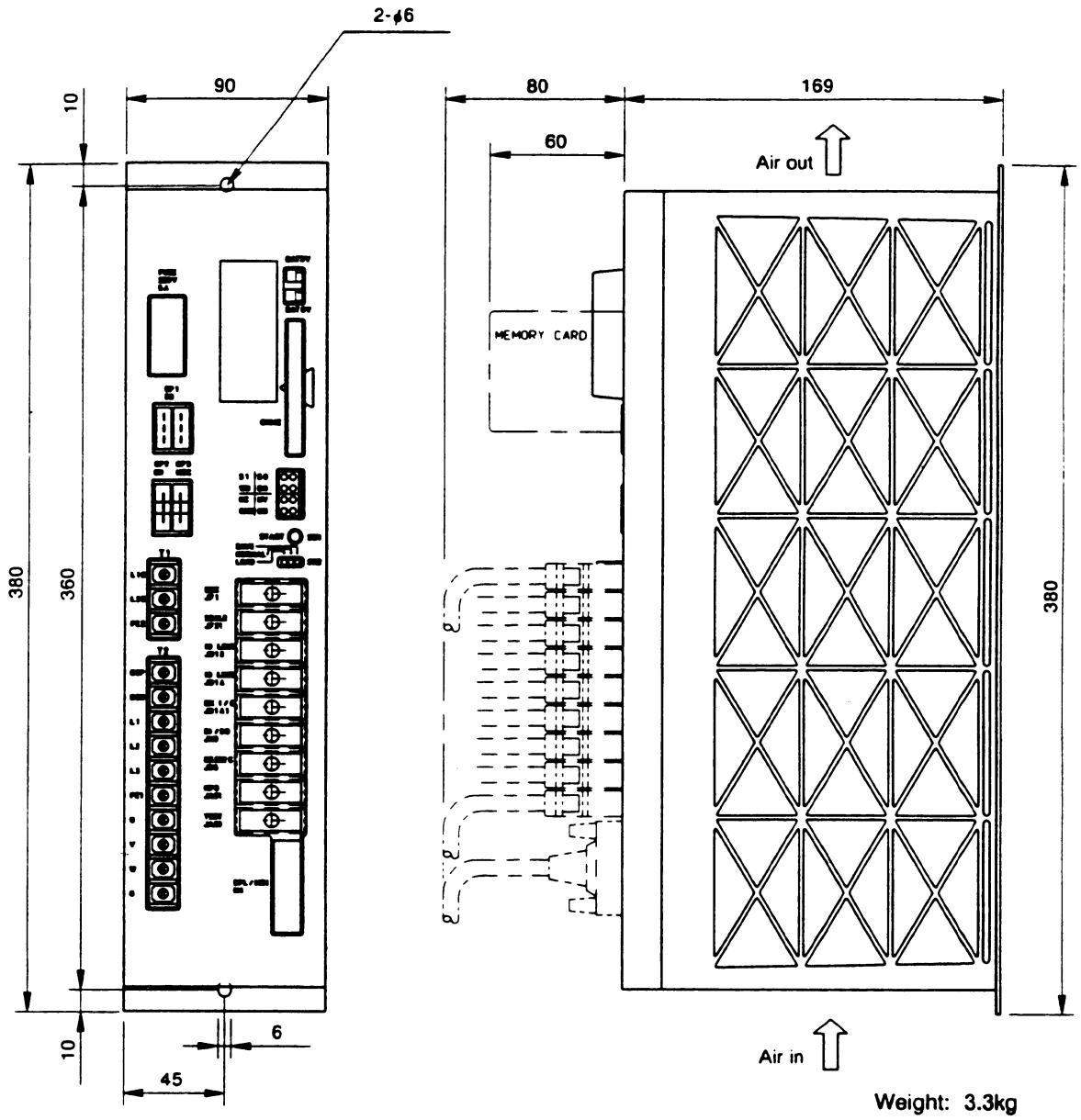
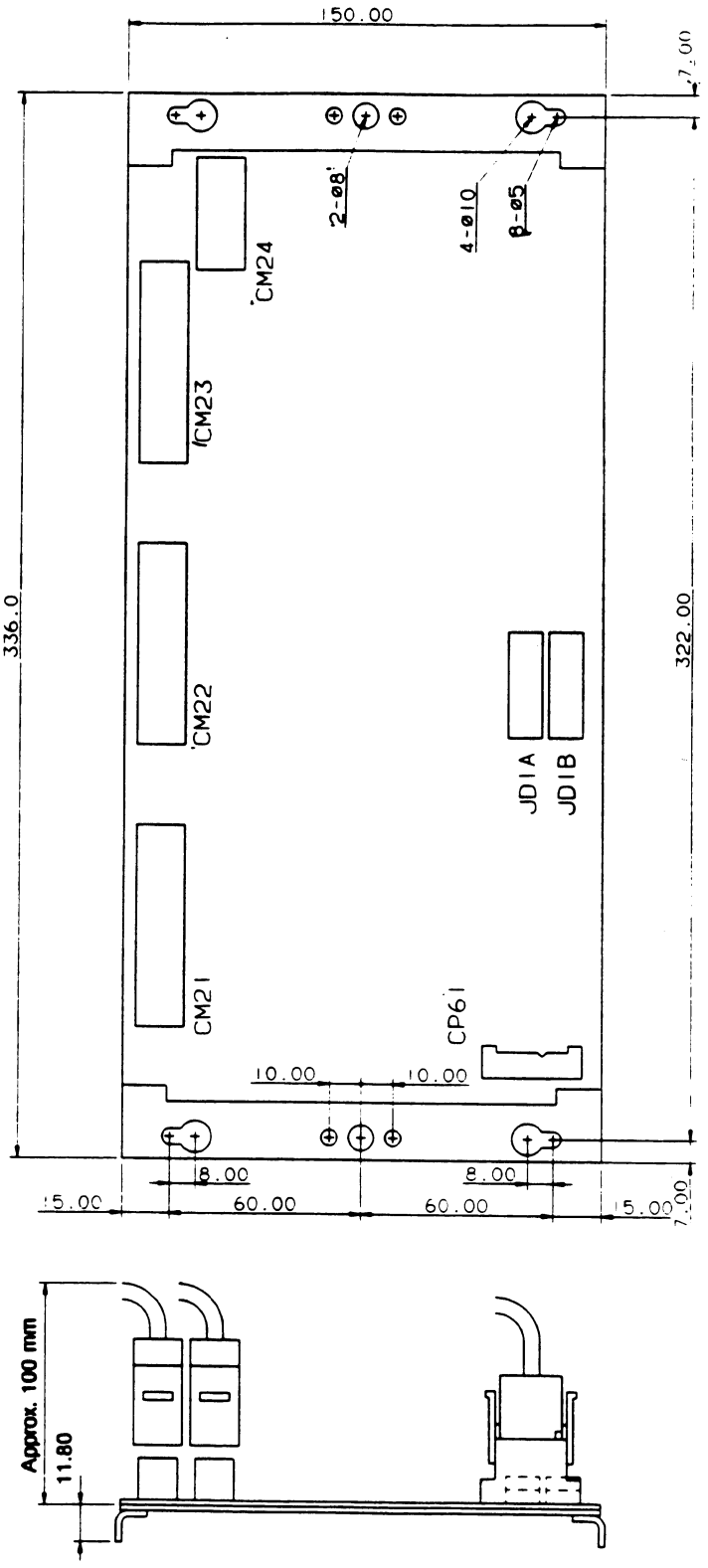


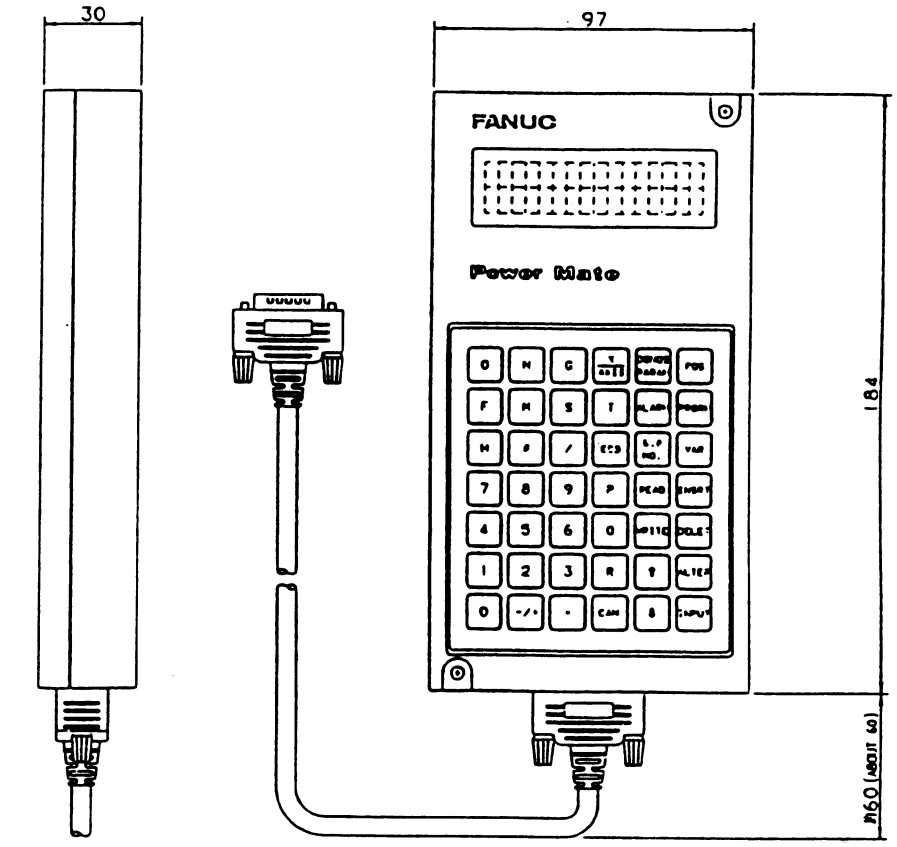
Fig. 1 Outline Drawings of the Power Mate-E



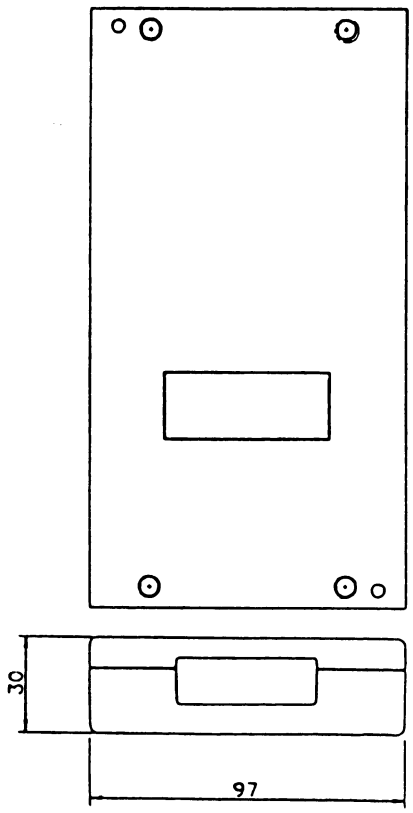
Specification A16B-2201-0071 (DI/DO = 48/32)
A16B-2201-0070 (DI/DO = 96/64)

Weight: 0.8kg

Fig. 2 Outline Drawing of the I/O Card

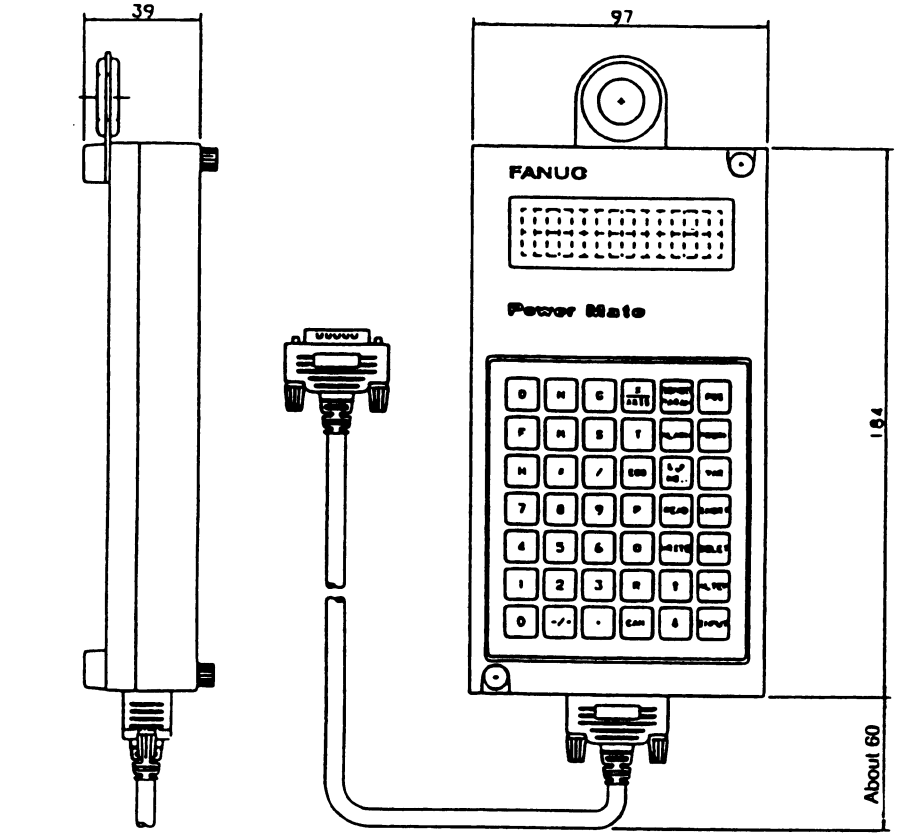


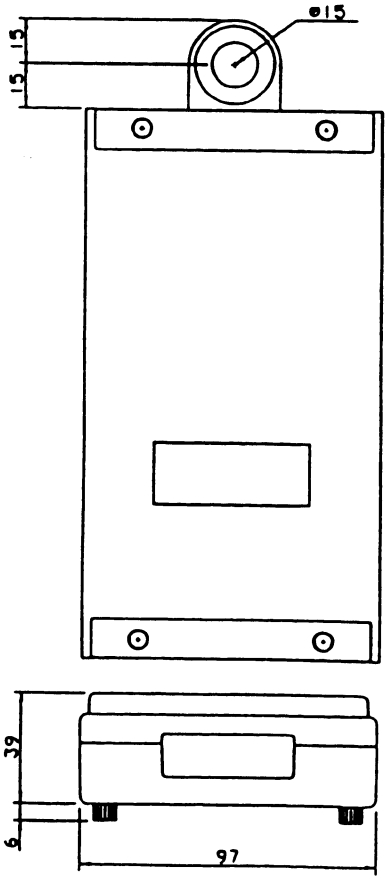
NOTE 1) K010 includes a connecting cable (2m).
C030 does not include a connecting cable.



Weight: 0.4kg

Fig. 3 (a) DPL/MDI Unit (Table-mount type A02B-0118-K010)
DPL/MDI Unit Used at a Distance (Table-mount type A02B-0118-C030)

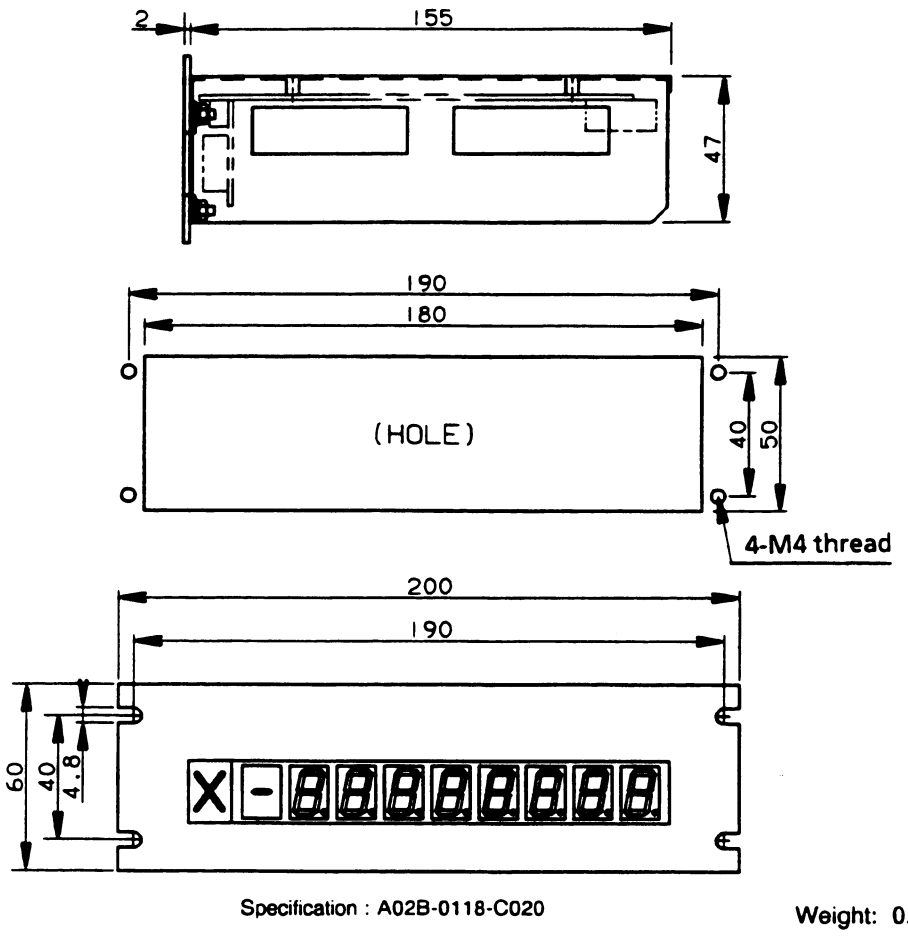




NOTE 1) K011 includes a connecting cable (2m).
C031 does not include a connecting cable.

Weight: 0.4kg

Fig. 3 (b) DPL/MDI Unit (Wall-mount type A02B-0118-K011)
DPL/MDI Unit Used at a Distance (Wall-mount type A02B-0118-C031)



Specification : A02B-0118-C020

Weight: 0.8kg

Fig. 4 External Position Display

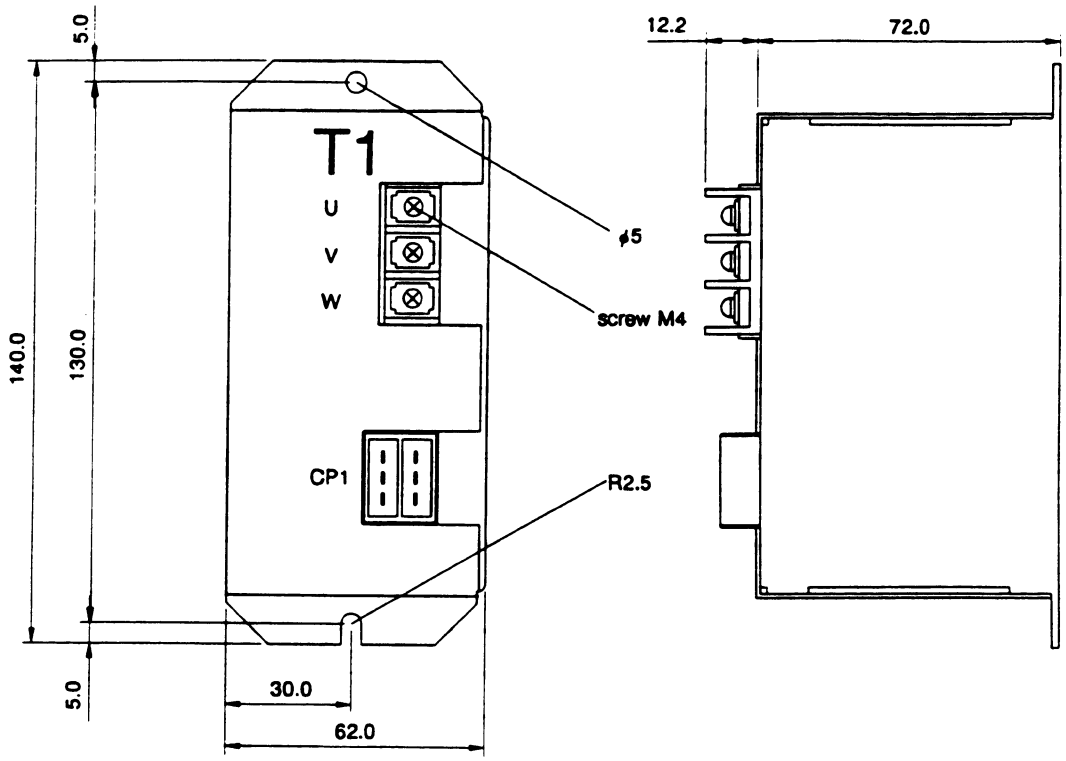


Fig. 5 External View of Dynamic Brake Unit (A06B-6070-H600)

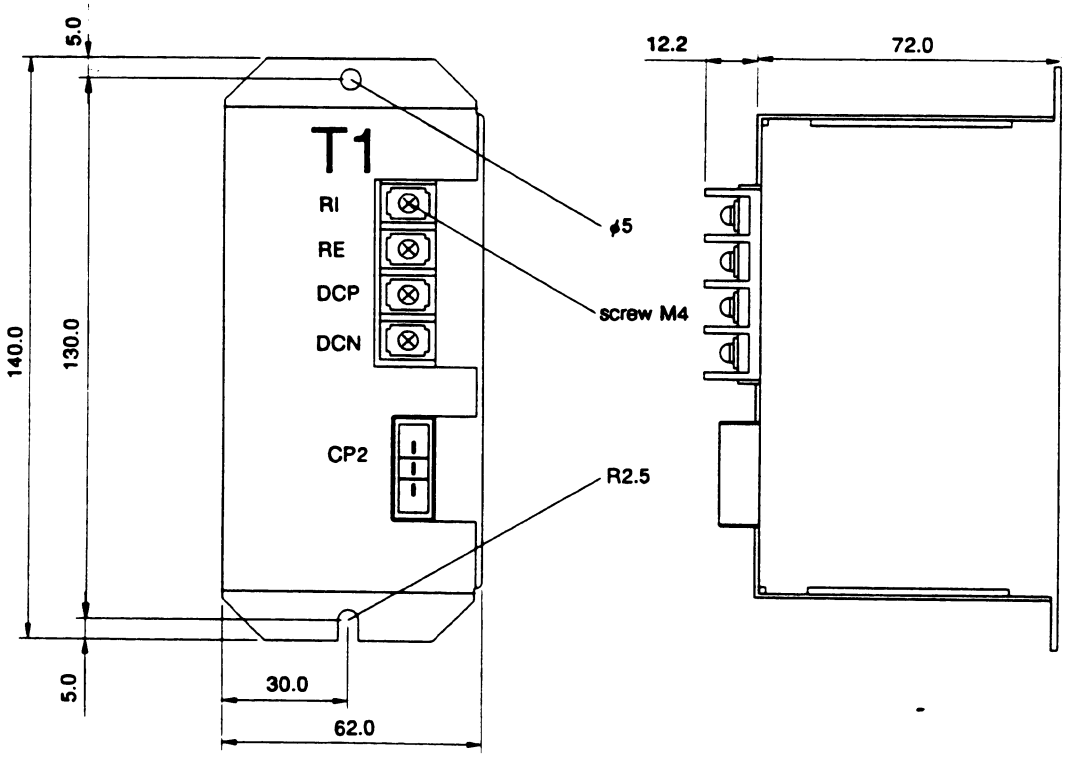


Fig. 6 External View of Regenerative Discharge Unit (A06B-6070-H500)

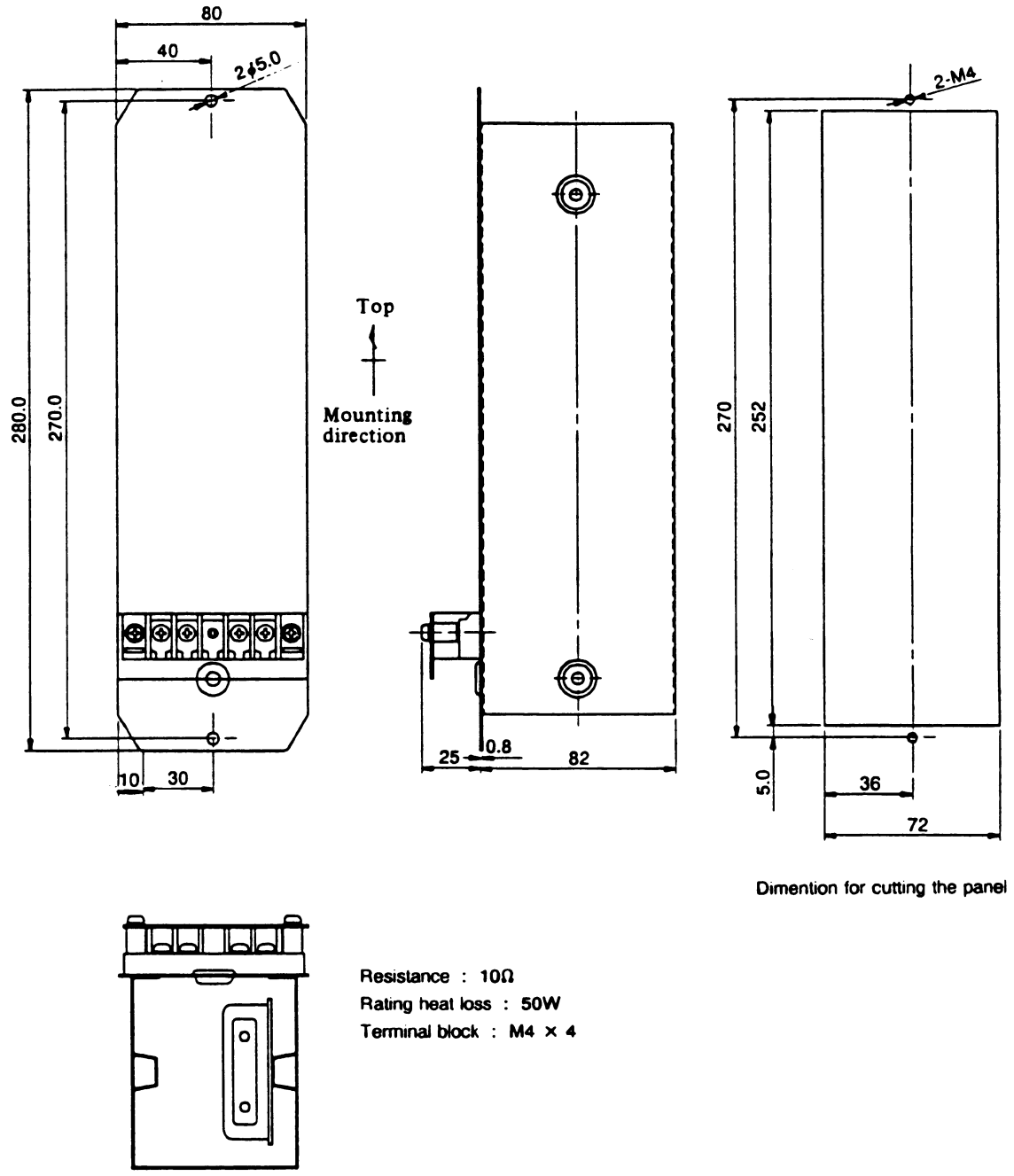


Fig. 7 External View of Additional Regenerative Discharge Resistor (A06B-6070-H550)

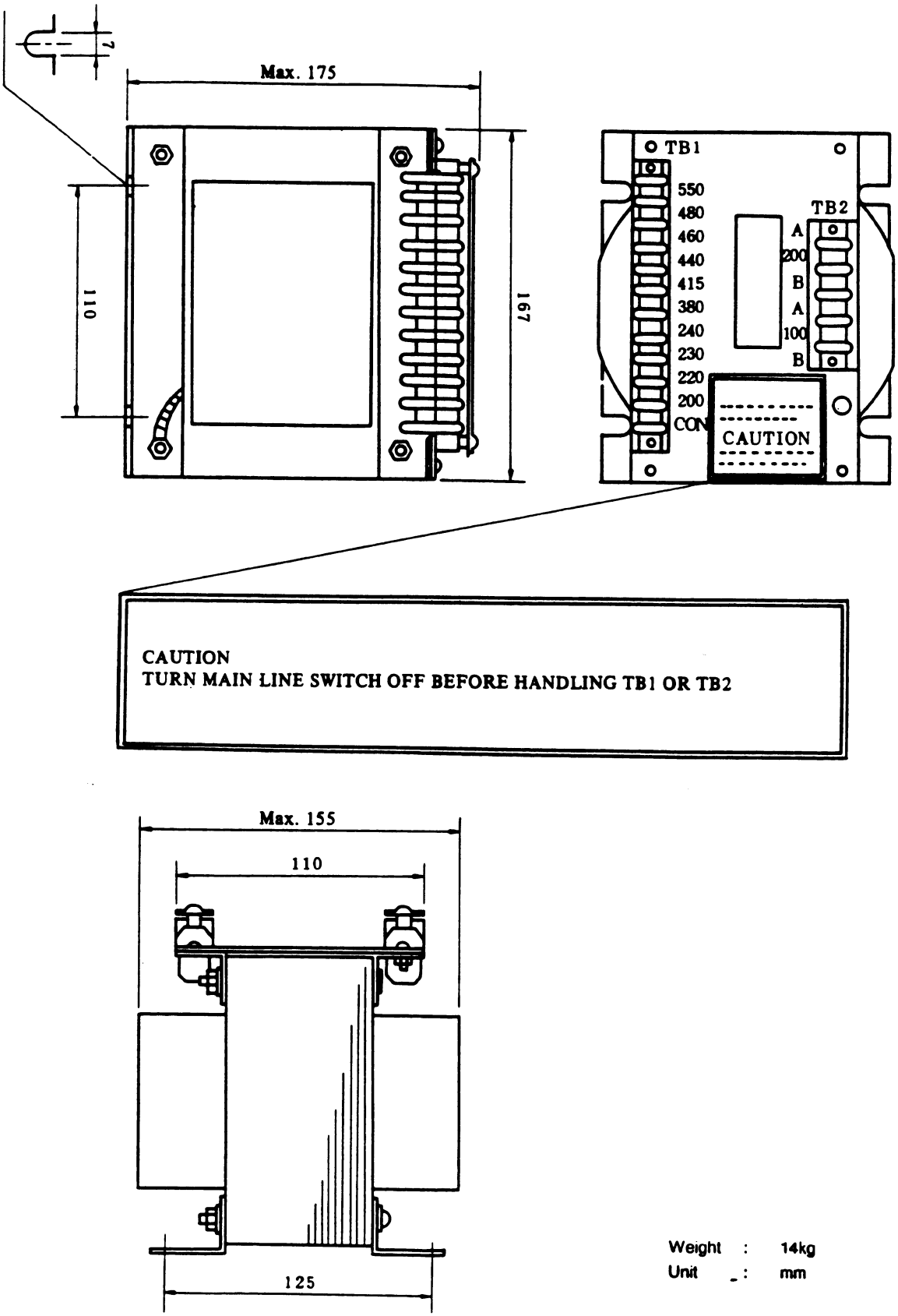


Fig. 8 External View of Transformer for Servo Amp. Separate Type Power Mate (A80L-0001-0176)

Specification of control transformer

(1) Primary side rated voltage
AC200V/220V/230V/380V/415V/440V/460V/480V/550V

(2) Voltage fluctuation
Primary side rated voltage +10%, −15%

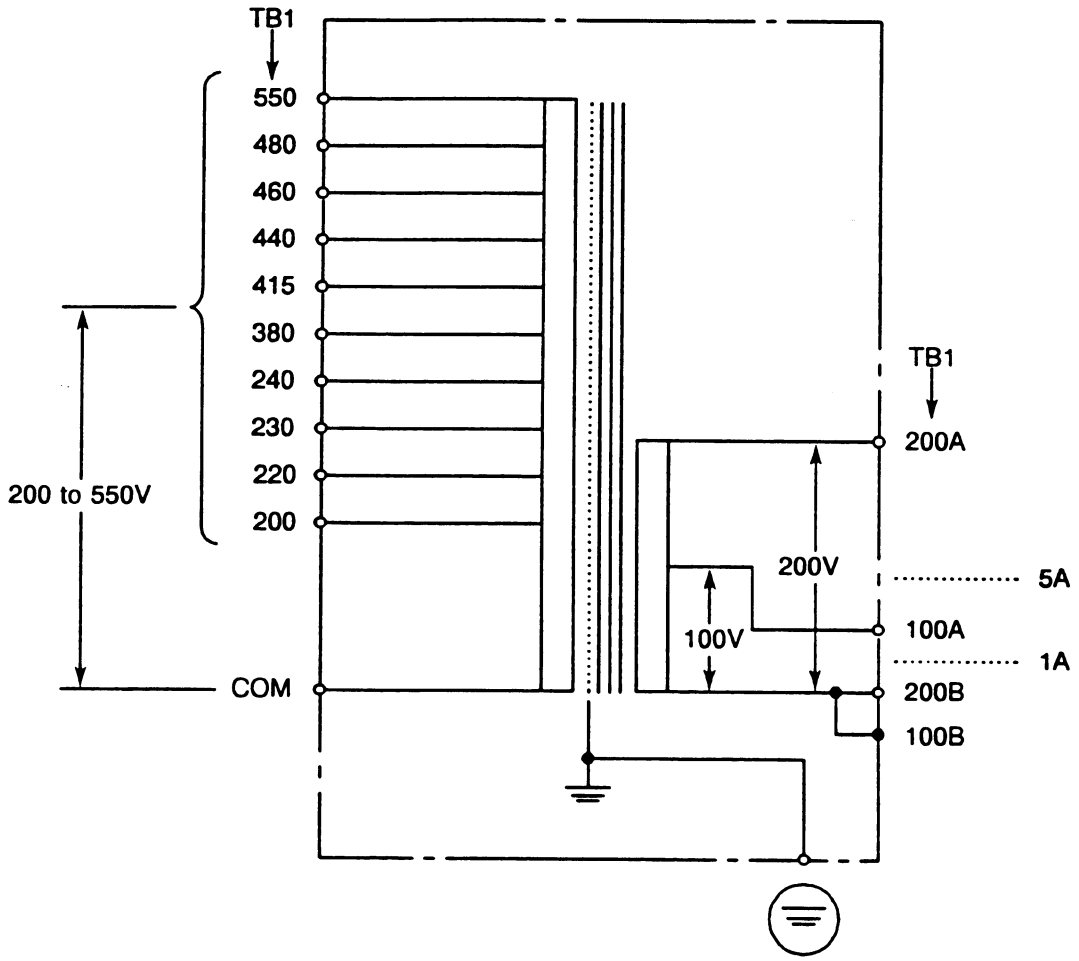
(3) Frequency
50Hz/60Hz ±3Hz

(4) Secondary side line voltage
See the figure below.

(5) Secondary side voltage deviation
Less than ±3%

(6) Secondary side voltage regulation
Less than 7%

(7) Transformer ambient temperature and humidity
−5°C + 60°C 10 to 95% (Relative humidity)



Specification of Transformer for Servo Amp. Separate Type Power Mate

(1) A860-0202-T001 Weight: 350g

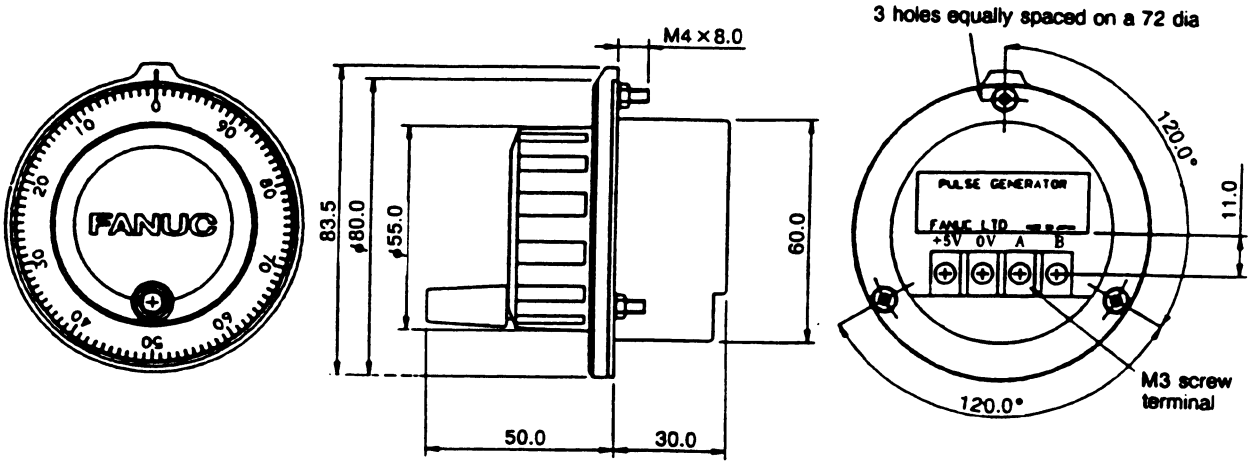
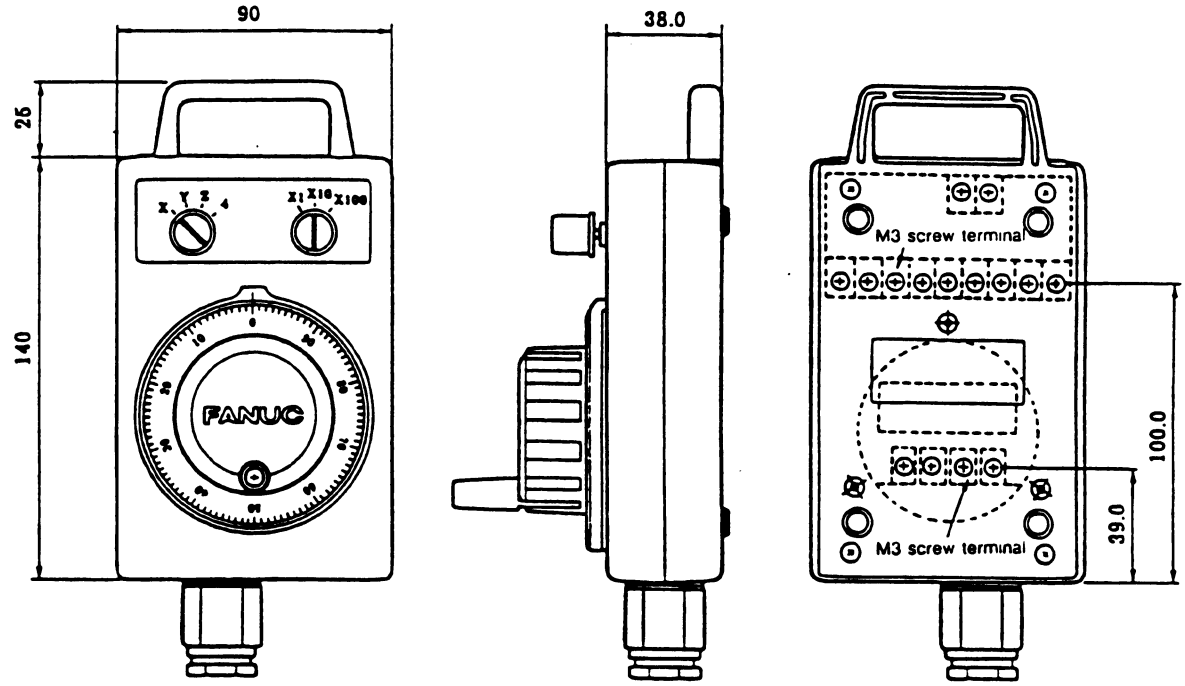


Fig.9 (a) External View of Manual Pulse Generator (A860-0202-T001)

(1) A860-0202-T004 to T009 Weight: 600g



(2) A860-0202-T010 to T015 Weight: 600g

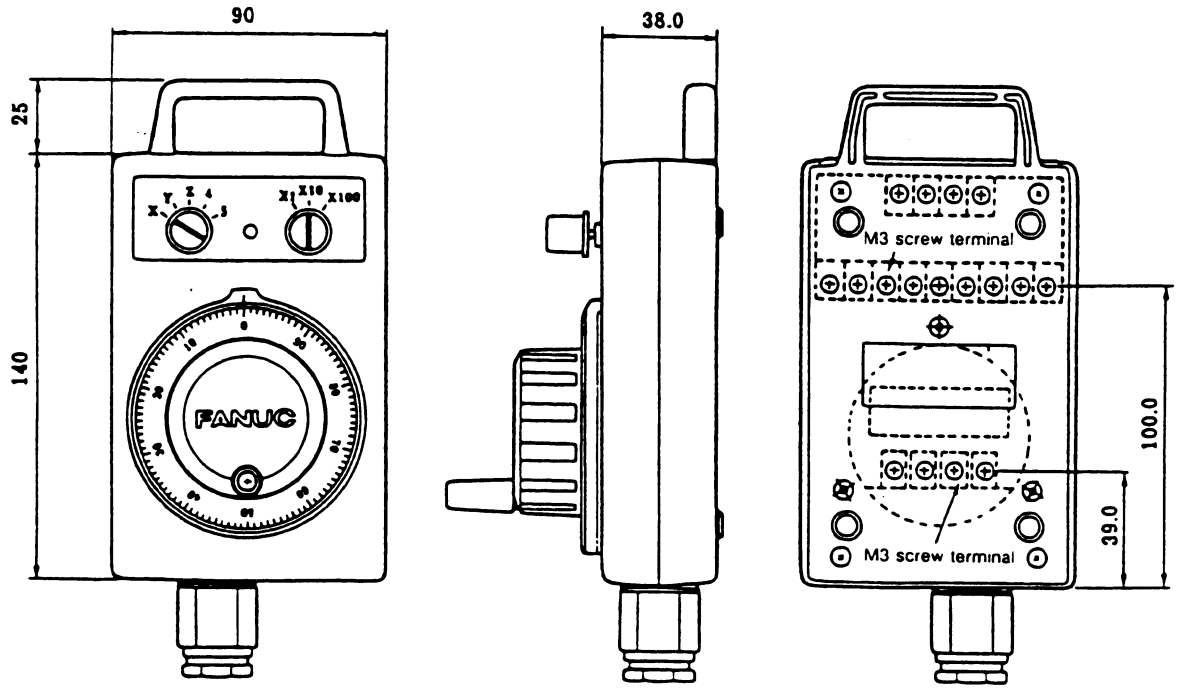


Fig.9 (b) External View of Pendant-type Manual Pulse Generator_
(A860-0202-T004 to T015)

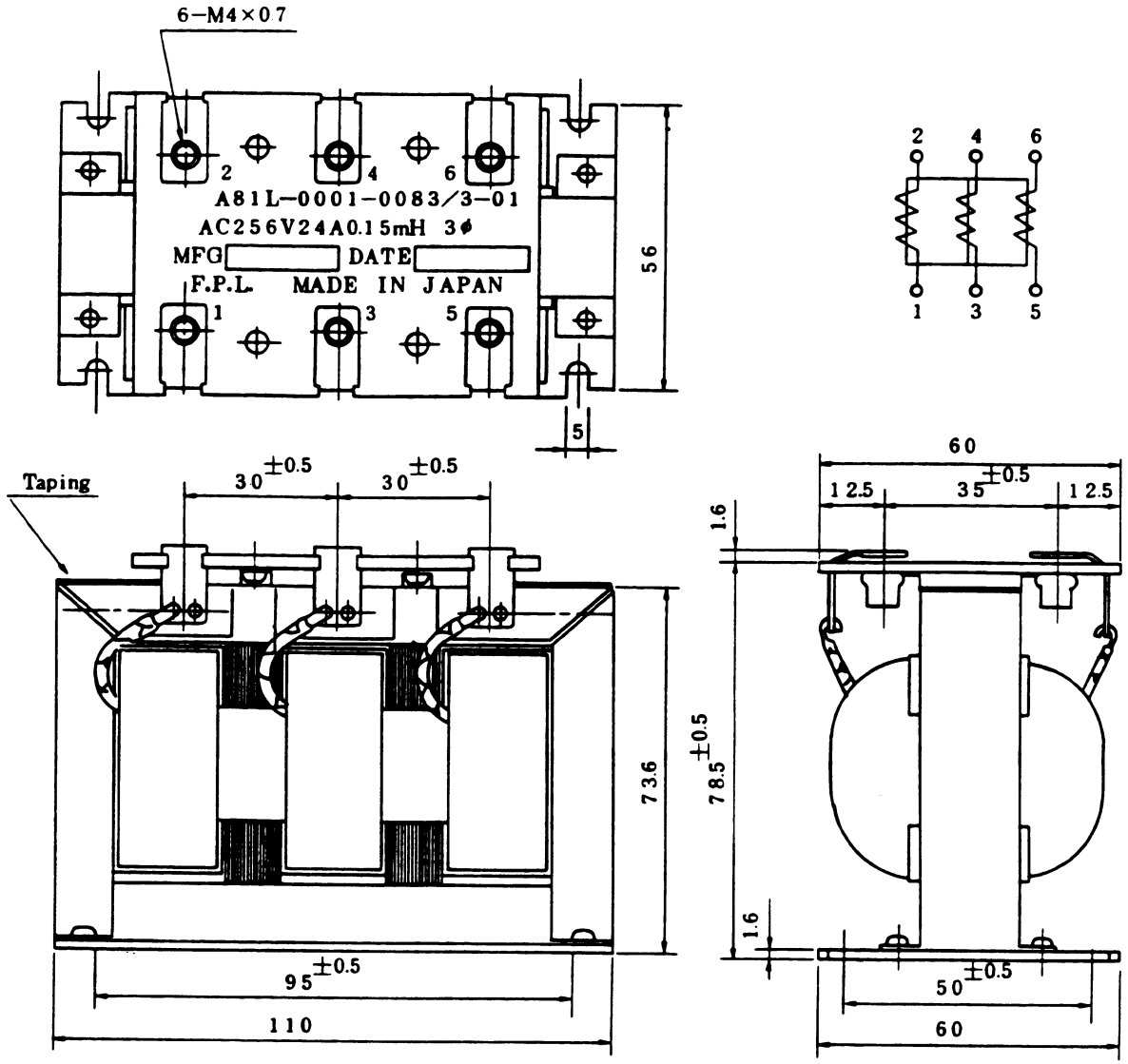


Fig. 10 (a) AC Line Filter External View (Type A: A81L-0001-0083#3C)

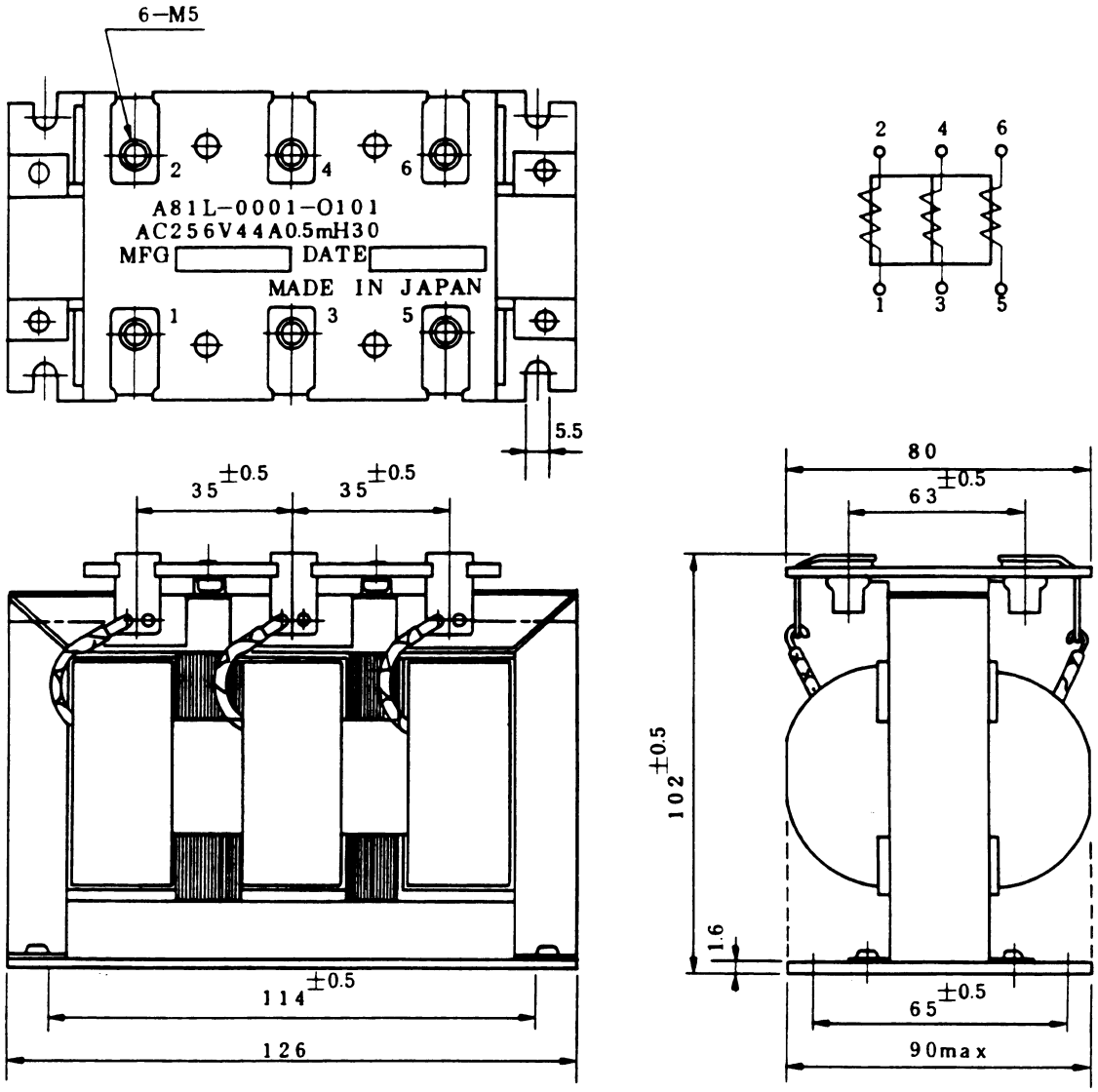
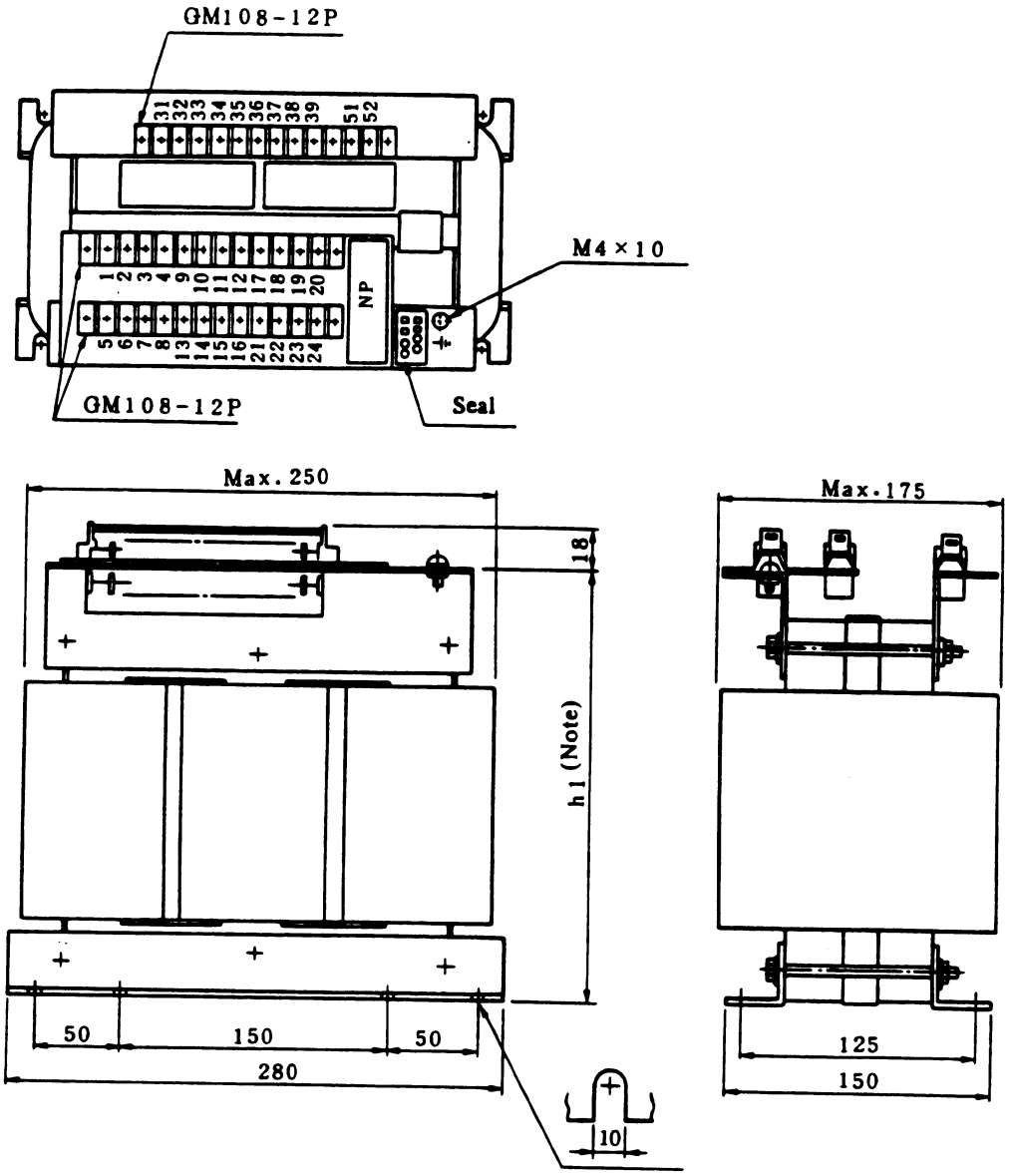


Fig. 10 (b) AC Line Filter External View (Type B: A81L-0001-0101#C)



h1 Height of Transformer

Power transformer	Weight	Height
SAE	About 21kg	217mm
SBE	About 27kg	217mm
SCE	About 36kg	247mm
SDE	About 42kg	247mm

Fig. 11 (a) External View of Power Transformer

Connecting Power Cable to the Transformer Input and Connecting Cables on the Primary Side Terminals

Power voltage	Connection of power cables U, V, W	Connection of primary-side terminals	Remarks
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
415V	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		

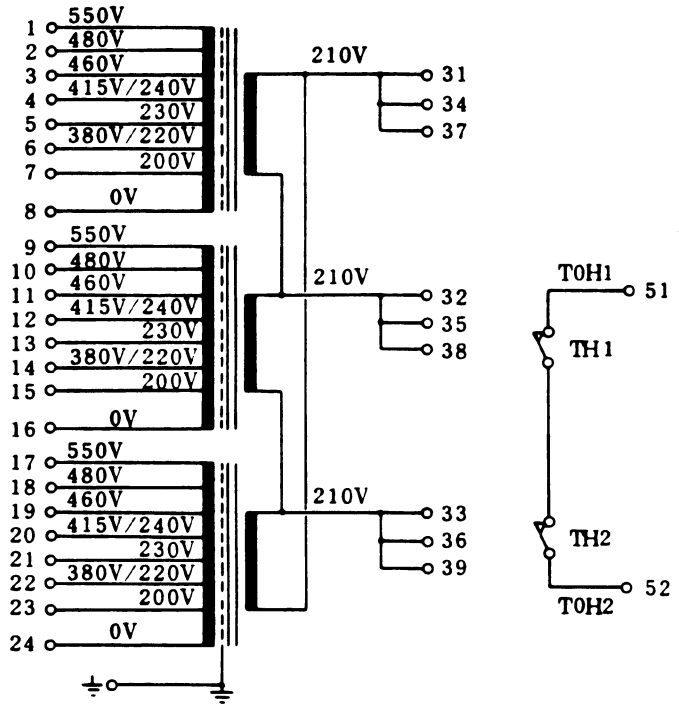
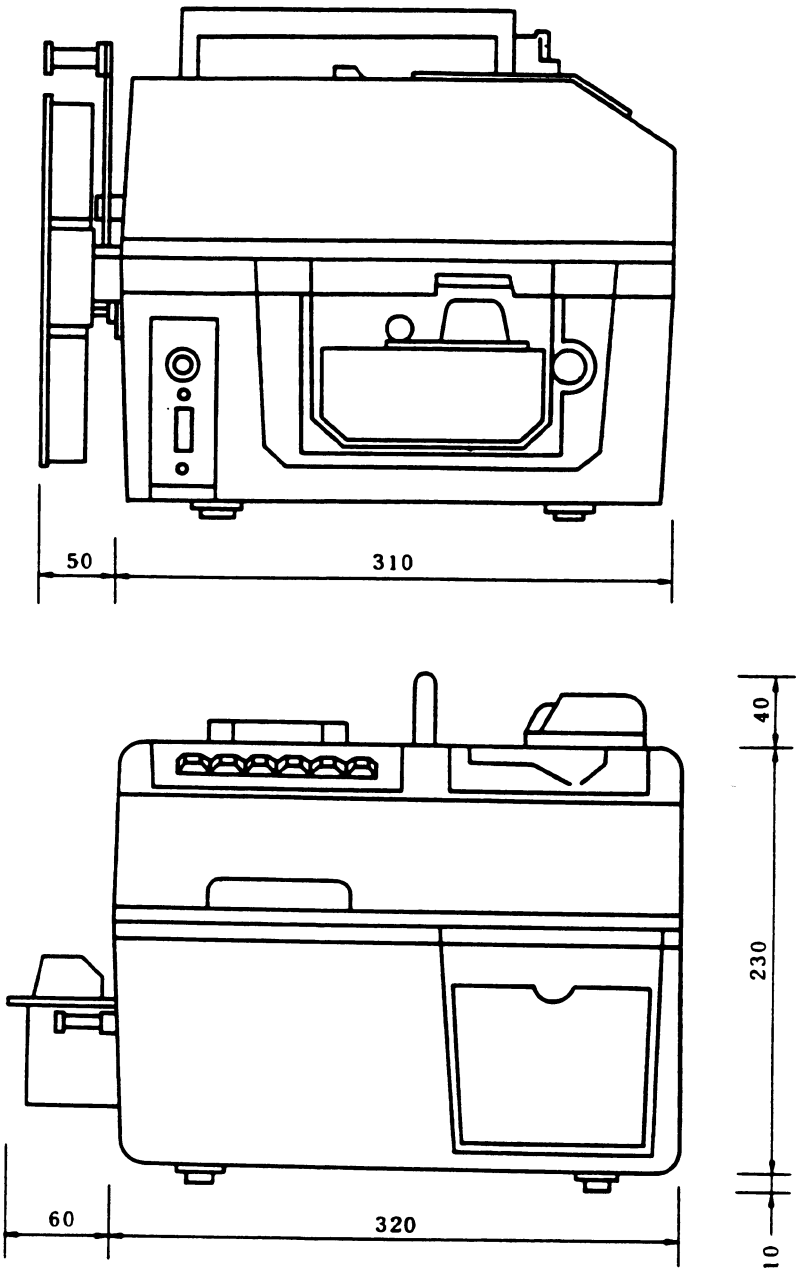


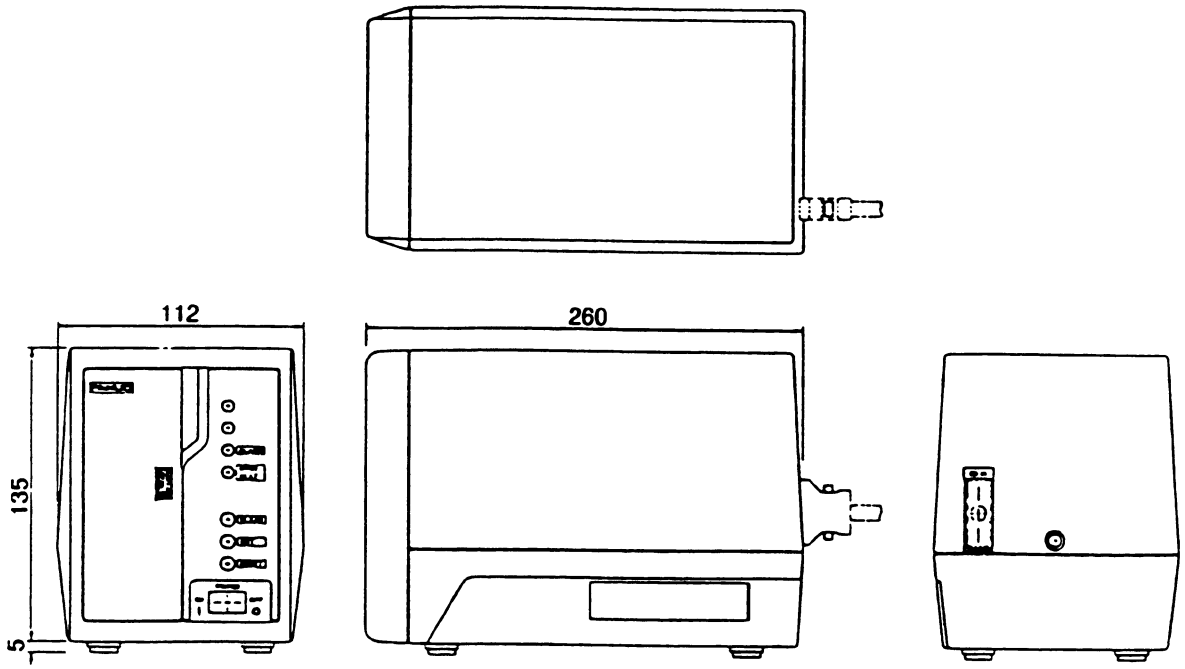
Fig. 11 (b) Connection Diagram of Power Transformer and Terminal Layout



Cable length: 1.5 m
Weight: about 1.2 kg
Unit: mm

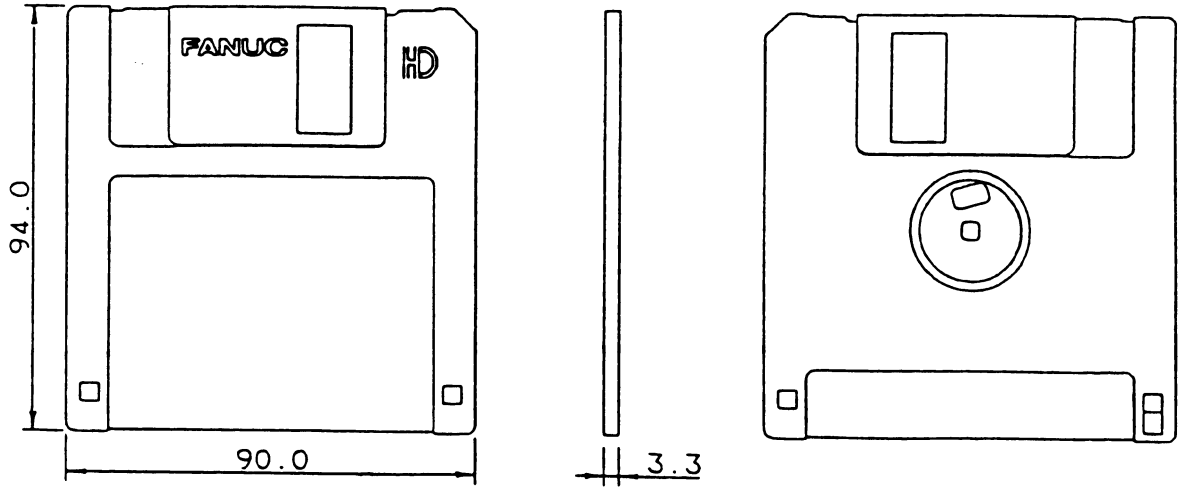
Specification :A13B-0117-B001 (100 VAC input)

Fig. 12 External View of FANUC PPR



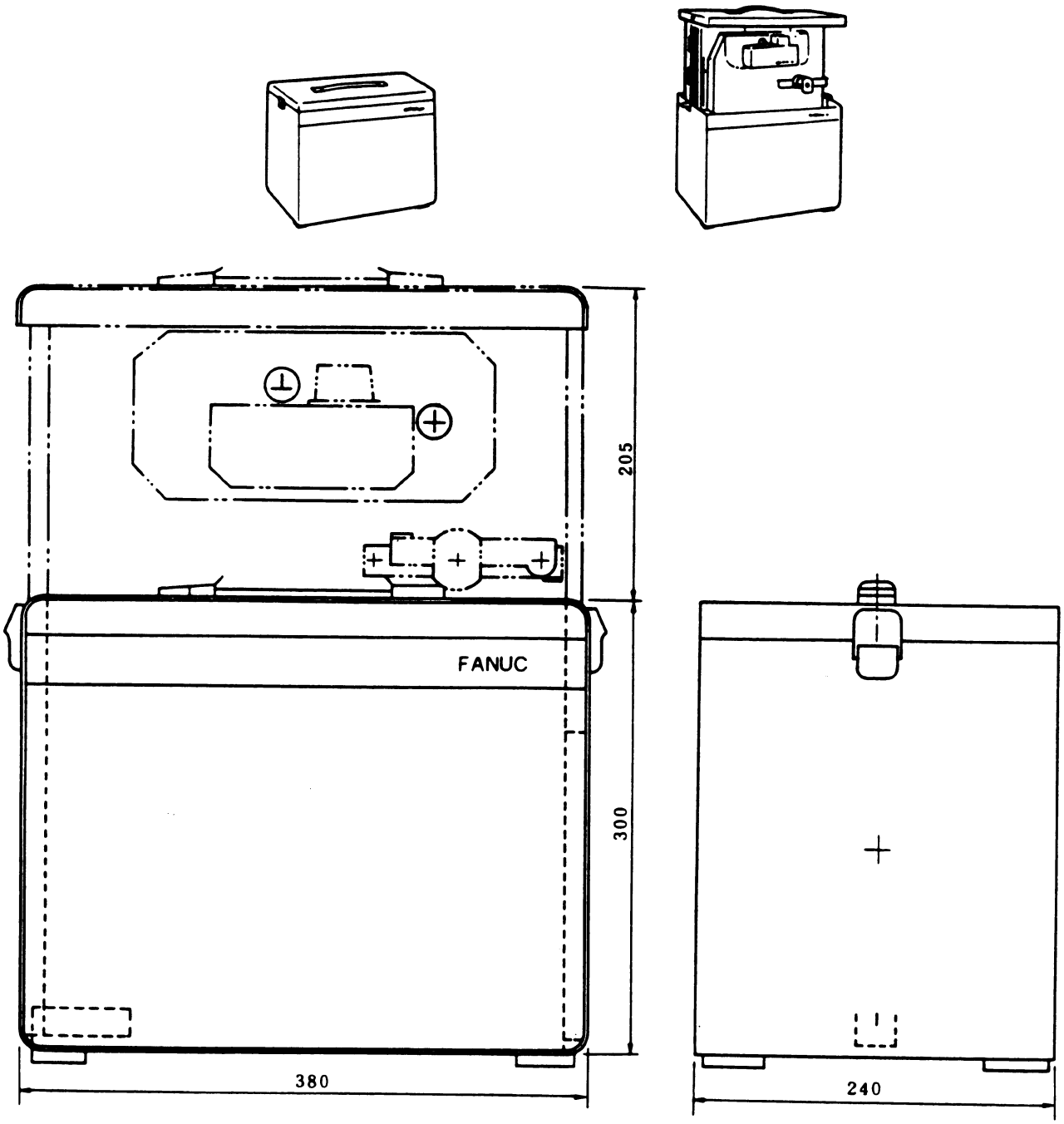
Specification :A13B-0150-B001

FLOPPY CASSETTE



Specification :A87L-0001-0039

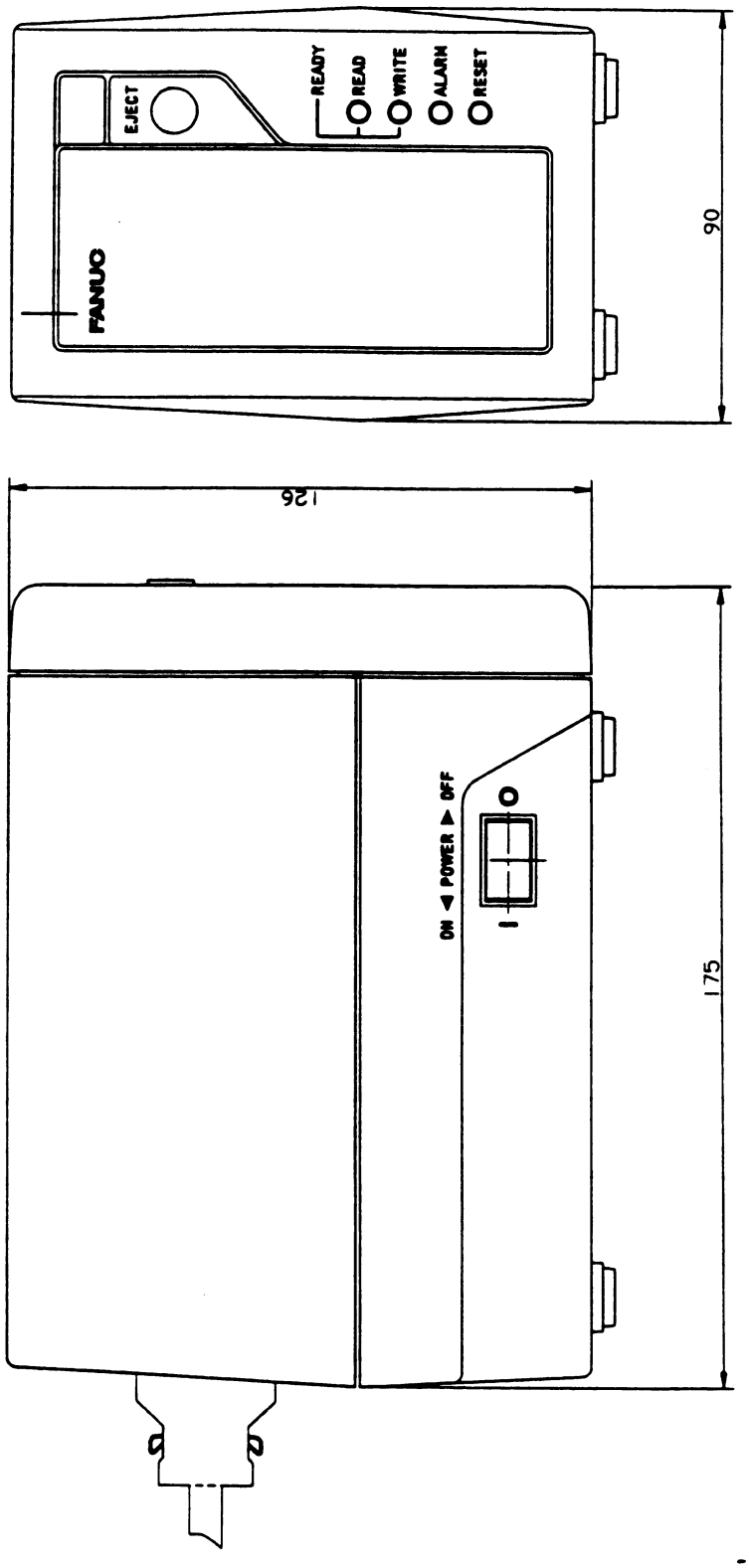
Fig. 13 External View of FANUC Floppy Cassette and Adapter



Painting: Munsell No. 5GY3.5/0.5 leather tone finish
Weight: about 15 kg

Specification : A13B-0074-B001 (without reel)
A13B-0087-B001 (with reel)

Fig. 14 External View of Portable Tape Reader



Specification : A13B-0148-B001

Fig. 15 FANUC FA Card Adapter

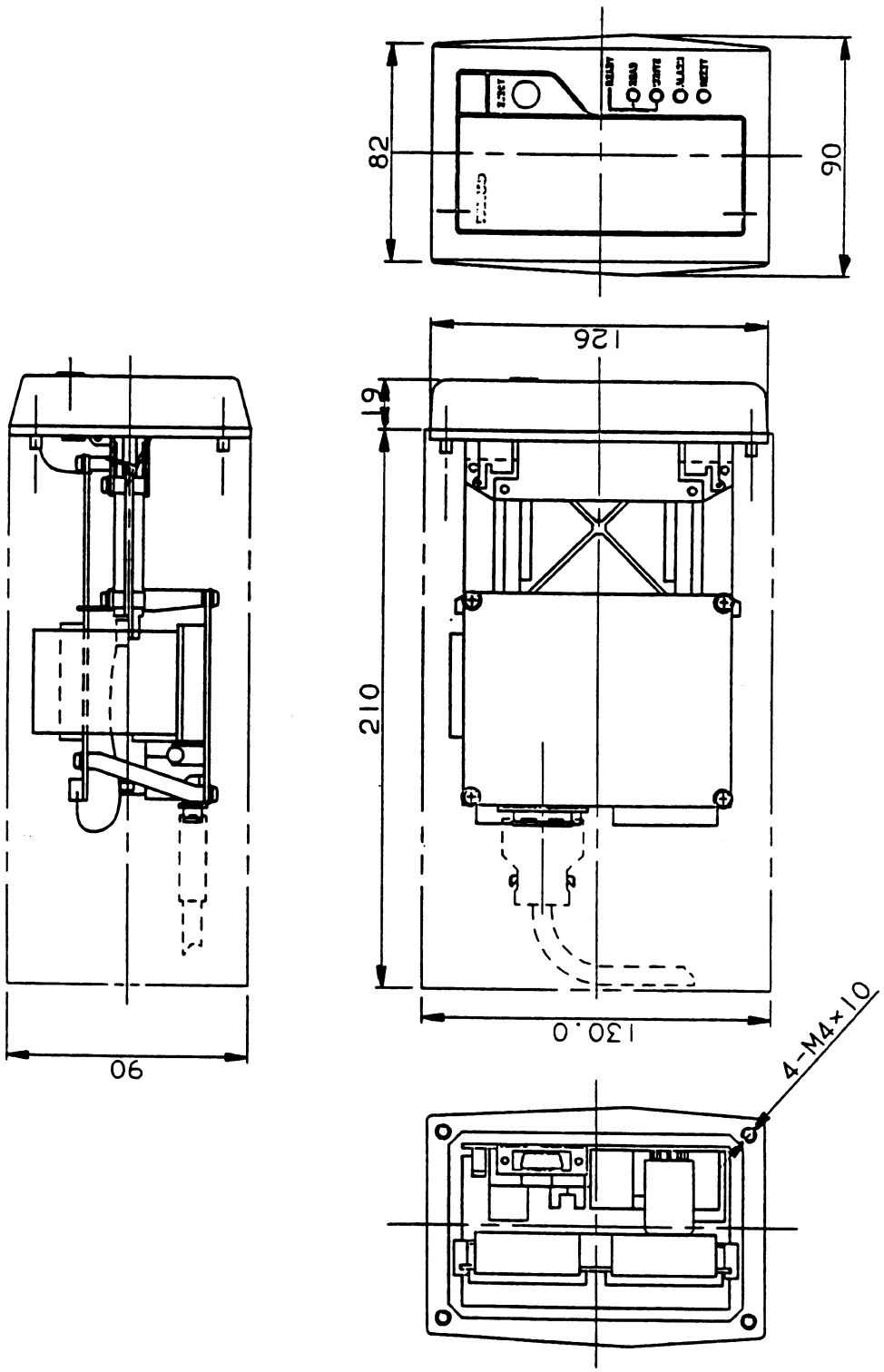
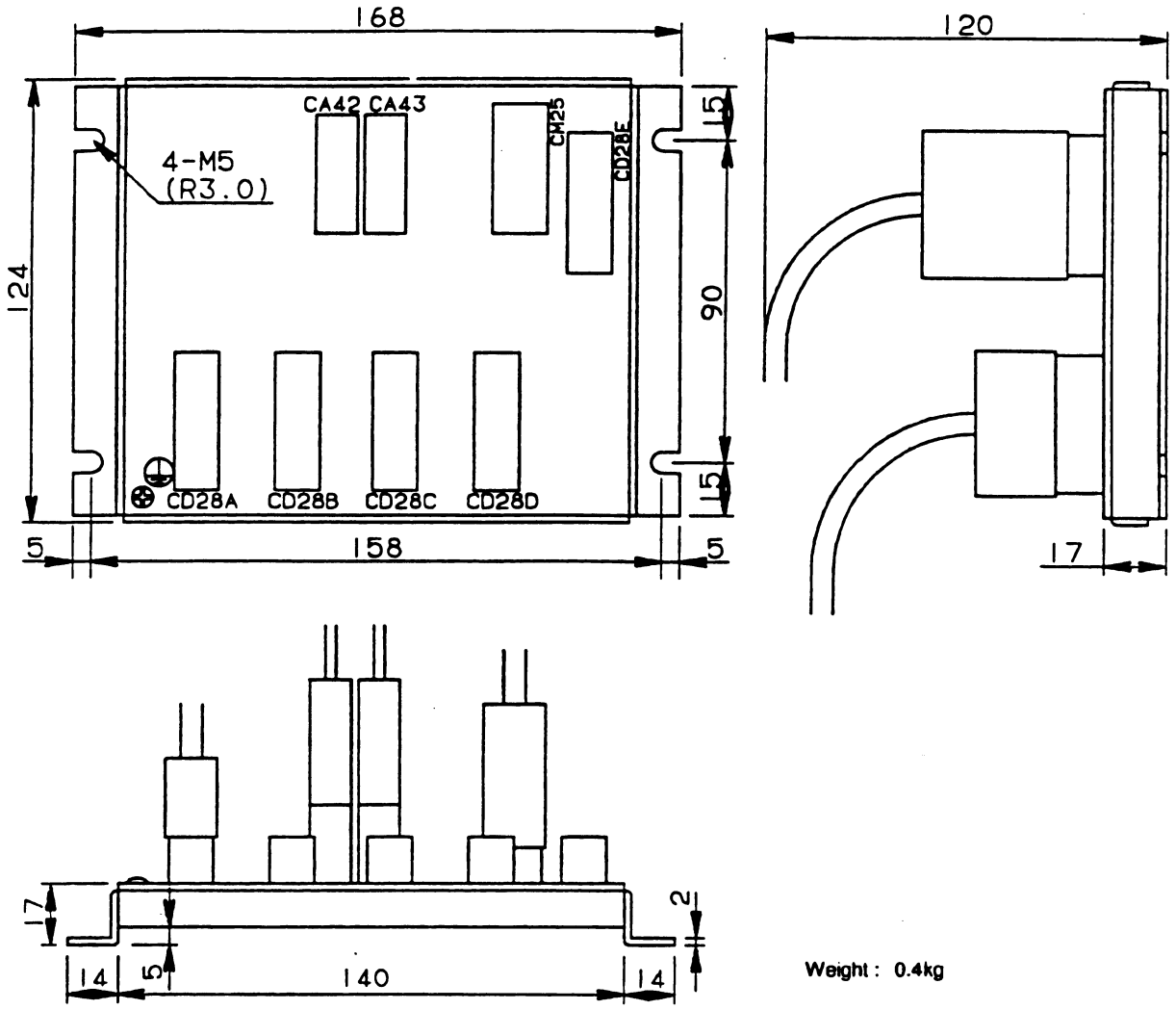


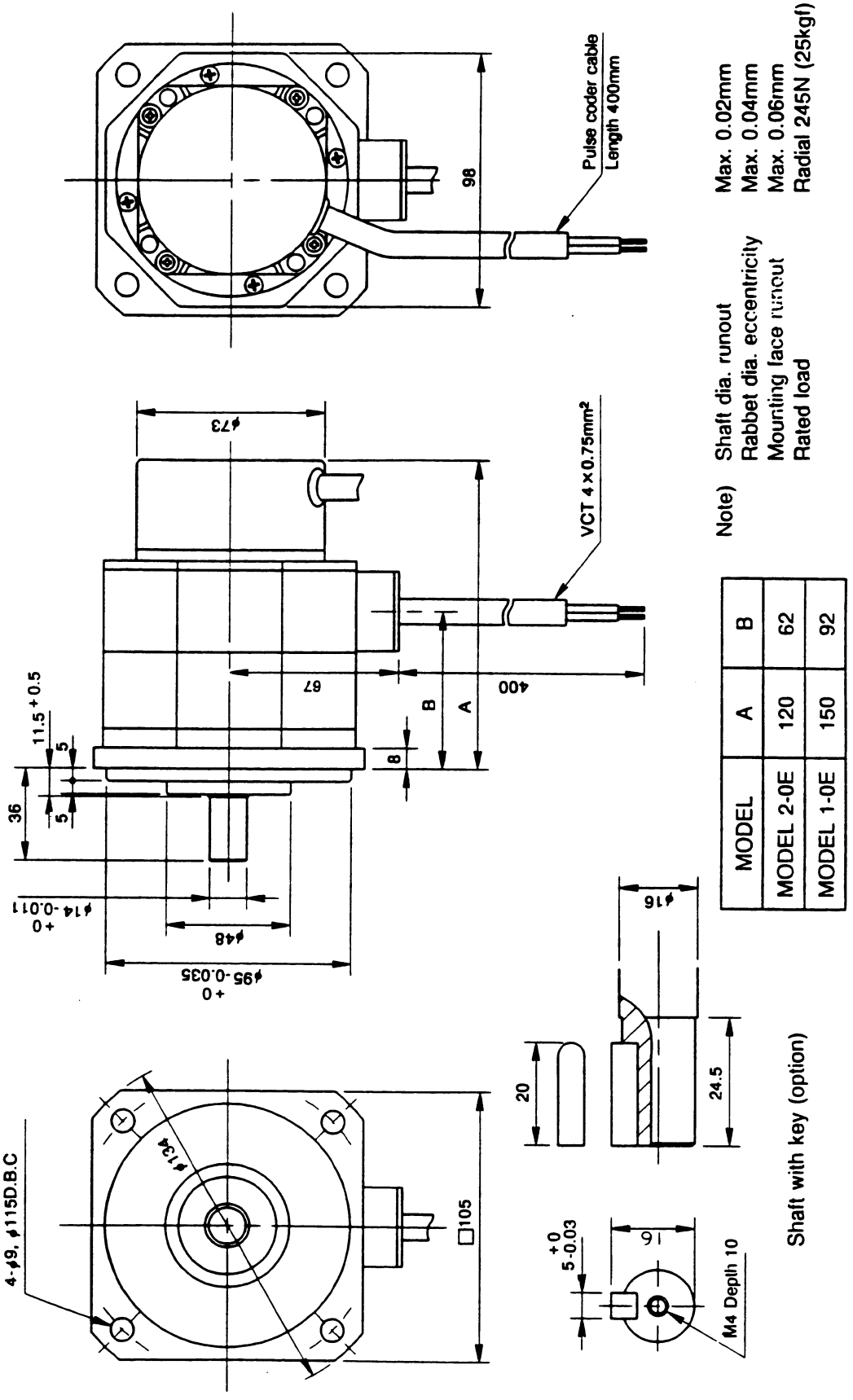
Fig. 16 FANUC FA Card Adapter (built-in type)



Weight : 0.4kg

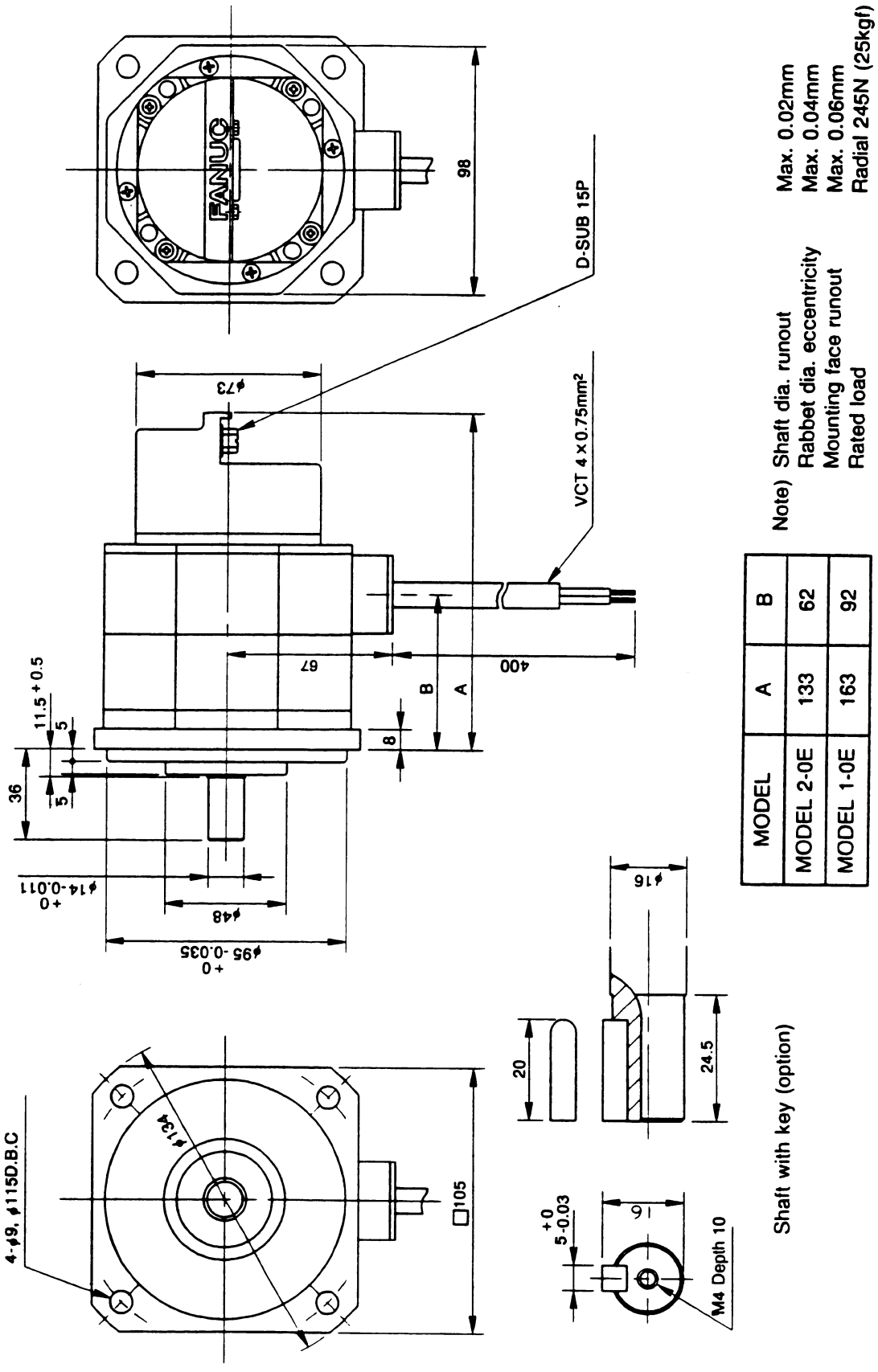
Specification : A16B-2600-0080

Fig. 17 DPL/MDI Switching Circuit



MODEL	A	B
MODEL 2-0E	120	62
MODEL 1-0E	150	92

Fig. 18 (a) AC Servo Motor 2-0E, 1-0E External View
(with incremental pulse coder, lead wire)



MODEL	A	B
MODEL 2-0E	133	62
MODEL 1-0E	163	92

Fig. 18 (b) AC Servo Motor 2-0E, 1-0E External View
(with incremental pulse coder, connector)

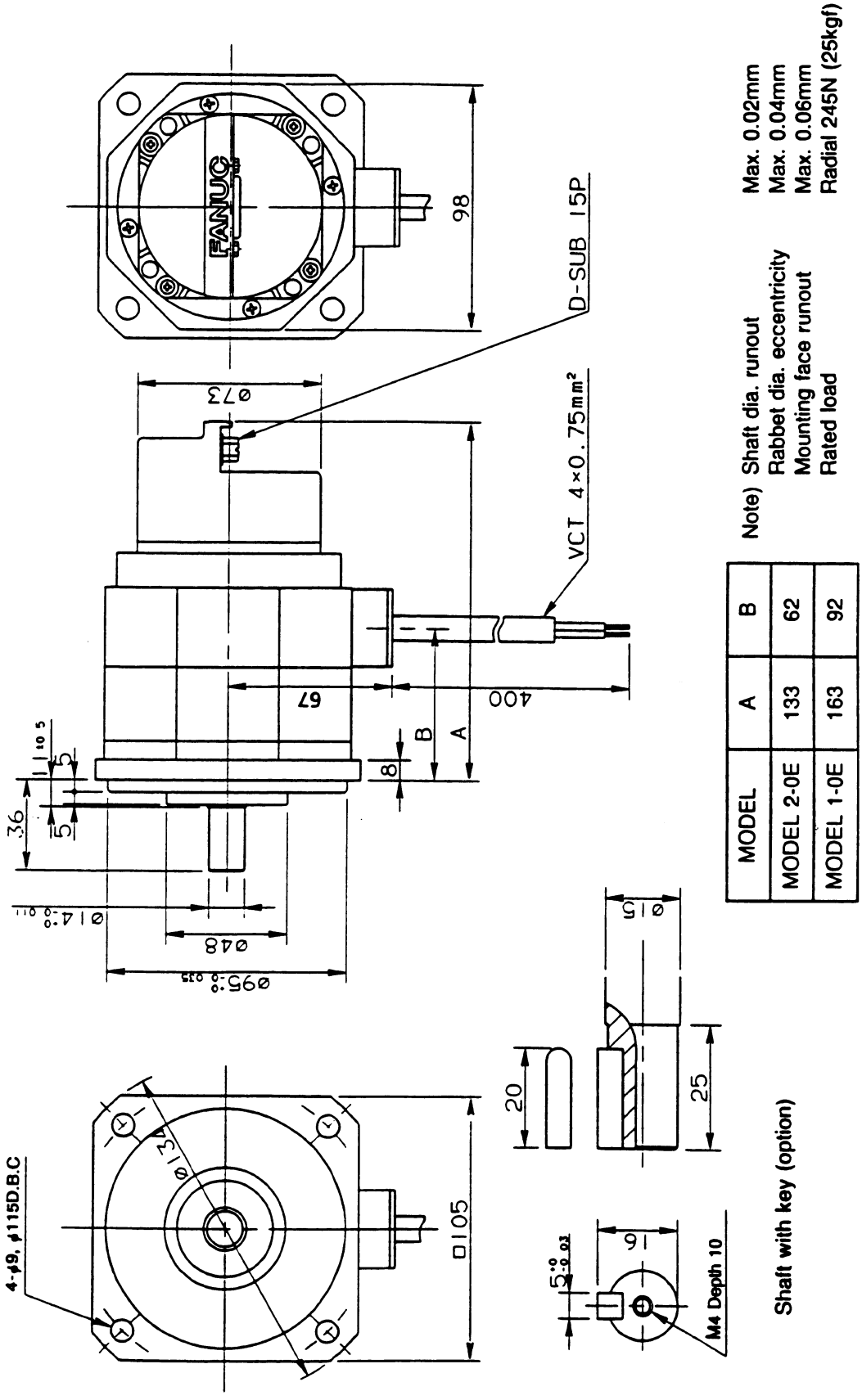
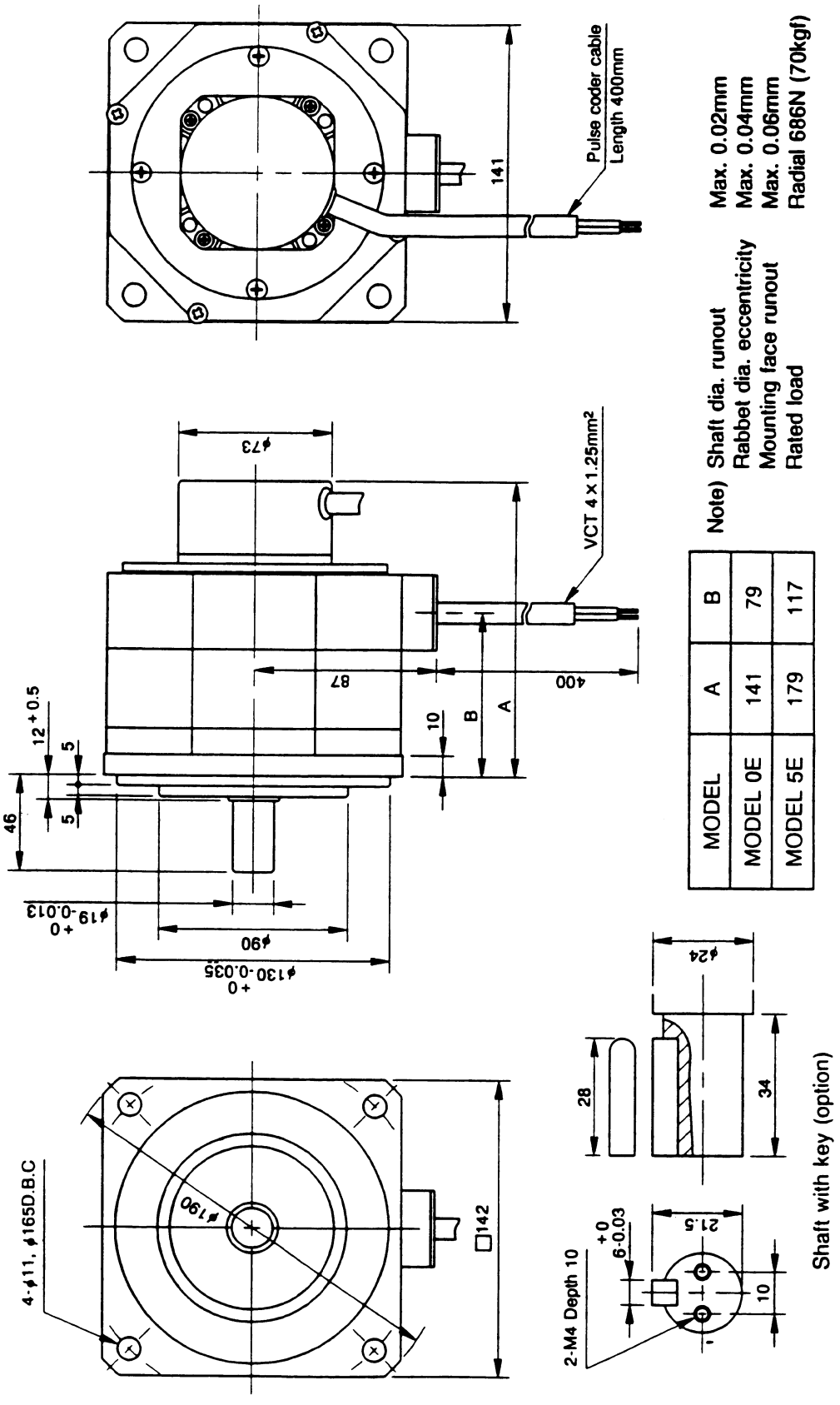
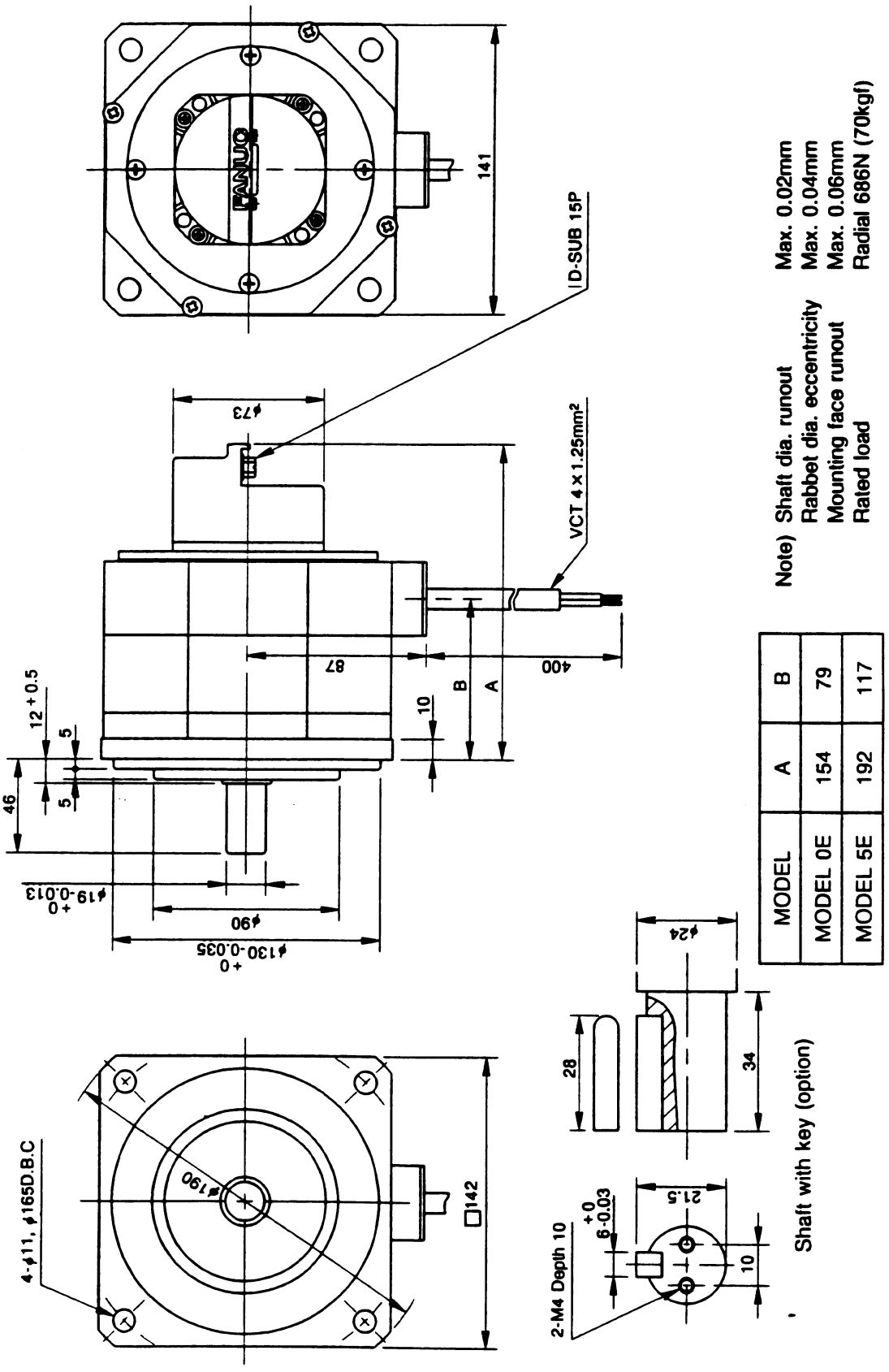


Fig. 18 (c) AC Servo Motor 2-0E, 1-0E External View
(with absolute pulse coder (serial A), connector)



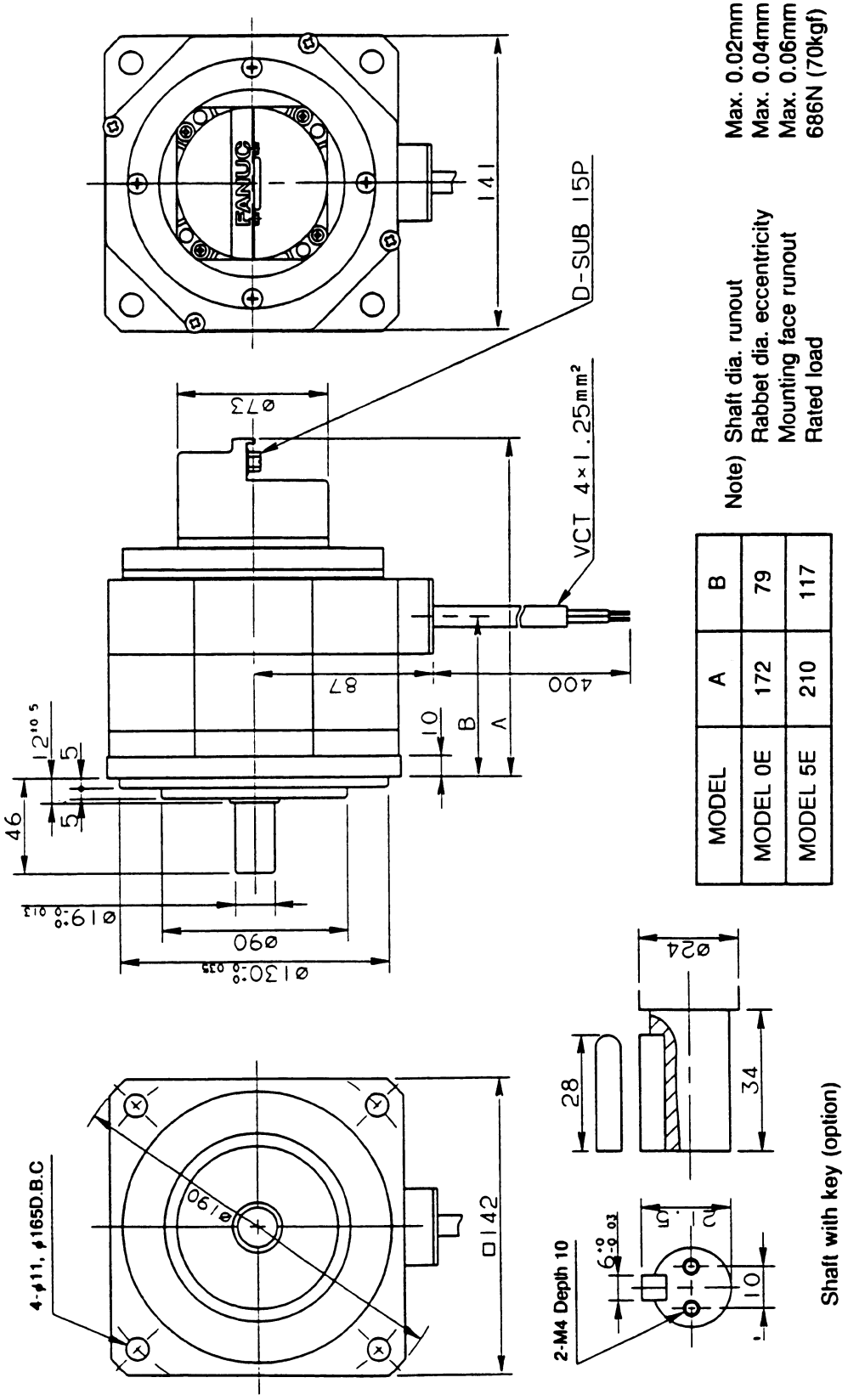
MODEL	A	B
MODEL 0E	141	79
MODEL 5E	179	117

Fig. 18 (d) AC Servo Motor 0E, 5E External View
(with incremental pulse coder, lead wire)



MODEL	A	B
MODEL 0E	154	79
MODEL 5E	192	117

Fig. 18 (e) AC Servo Motor 0E, 5E External View
(with incremental pulse coder, connector)



MODEL	A	B
MODEL 0E	172	79
MODEL 5E	210	117

Fig. 18 (f) AC Servo Motor 0E, 5E External View
(with absolute pulse coder (serial A), connector)

APPENDIX 5. SPECIFICATION OF AC SERVO MOTOR E series

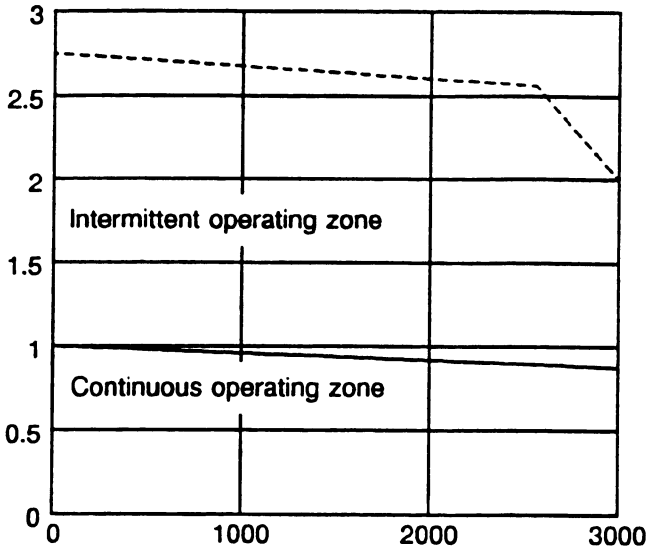
(1) Specifications

Item \ Model	Unit	2-0E	1-0E	0E	5E
Output power	kW (HP)	0.27 (0.36)	0.50 (0.68)	0.8 (1.0)	0.9 (1.2)
Cont. stall torque	Nm (kgfcm)	1 (10)	2 (20)	3 (31)	6 (61)
Max. speed	min^{-1}	3000	3000	3000	2000
Rotor inertia	kgm^2 ($kgfcms^2$)	0.00033 (0.0034)	0.00065 (0.0067)	0.002 (0.02)	0.004 (0.04)
Weight	kg	2.5	4	6	10

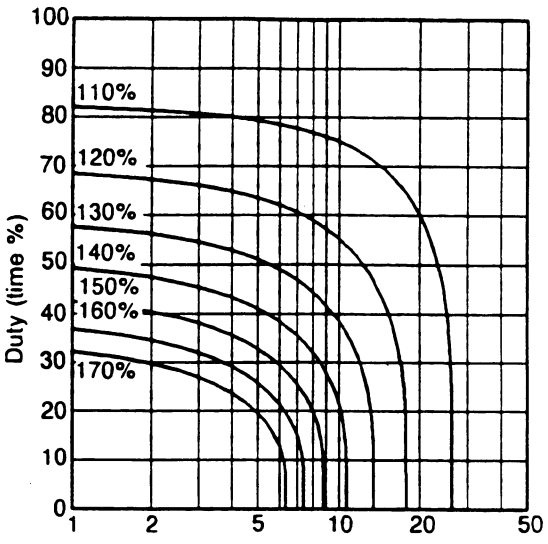
The values are the standard values at 20°C.

(2) MODEL 2-0E

Speed-Torque characteristics (digital)



Overload duty characteristics



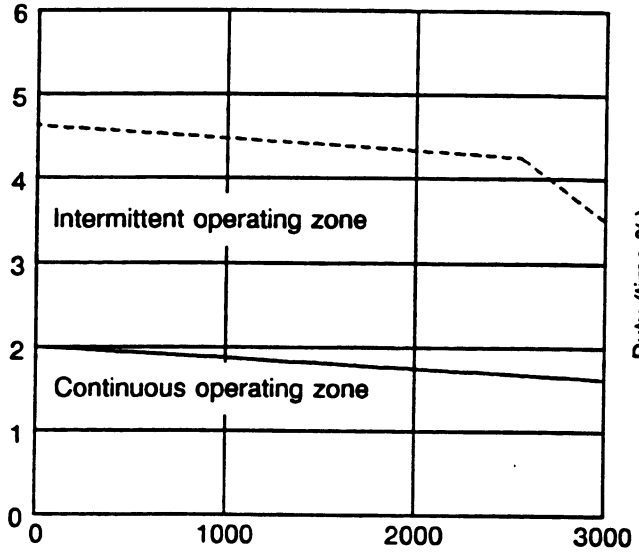
Data sheet

Parameters	Symbol	Value		Unit
Max. speed	Nmax	3000		min^{-1}
Cont. stall torque *	Ts	1 10.2		Nm kgfcm
Rotor inertia	Jm	0.00033 0.0034		kgm^2 $kgfcms^2$
Cont. RMS current	Is	2.2		A(rms)
Torque const. *	Kt	0.45 4.6		Nm/A(rms) kgfcm/A(rms)
Back EMF const. * (RMS voltage per phase) *	Ke Kv	16 0.15		$V/1000min^{-1}$ Vsec/rad
Armature resistance *	Ra	2.3		Ω
Mechanical time const. *	tm	0.011		sec
Thermal time const.	tt	15		min
Static torque	Tf	0.1 1		Nm kgfcm
Max. allowable current	Im	12		A(peak)
Max. torque	Tm	3.8 39		Nm kgfcm
Max. acceleration		11500		rad/sec^2
Max. winding temperature rise	θm	125		°C
Weight		2.5		kg

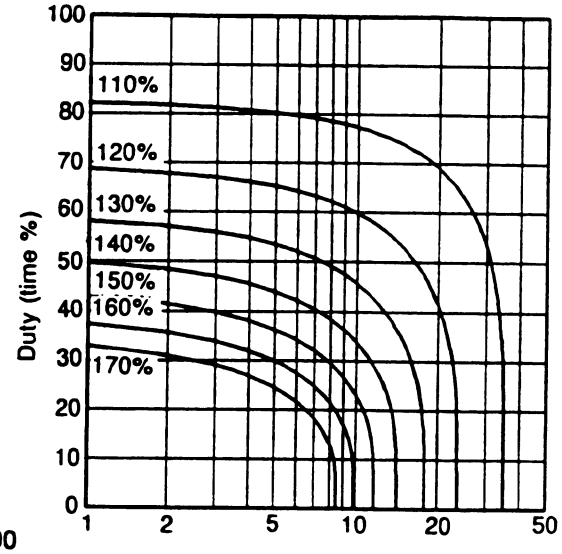
* The values are the standard values at 20°C and their errors are ±10%.
The speed-torque characteristics vary depending on the type of software, parameter setting and input voltage of the digital servo system.
These values may be changed without prior notice.

(3) MODEL 1-0E

Speed-Torque characteristics (digital)



Overload duty characteristics



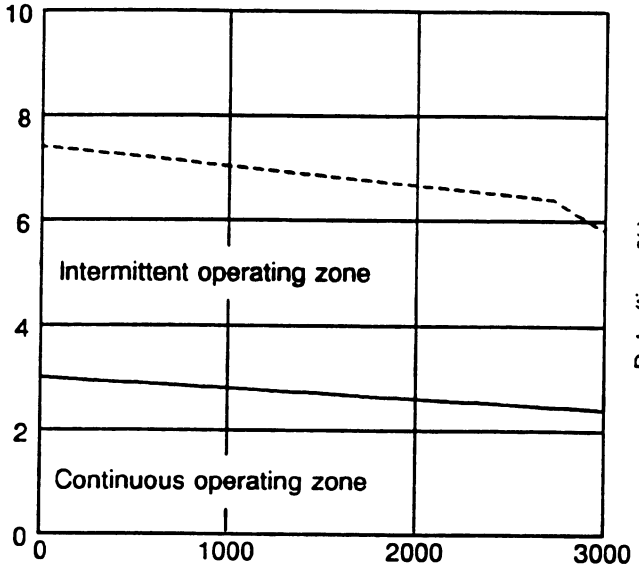
Data sheet

Parameters	Symbol	Value		Unit
Max. speed	Nmax	3000		min^{-1}
Cont. stall torque *	Ts	2 20.4		Nm kgfcm
Rotor inertia	Jm	0.00065 0.0067		kgm^2 $kgfcms^2$
Cont. RMS current	Is	2.6		A(rms)
Torque const. *	Kt	0.72 7.3		Nm/A(rms) kgfcm/A(rms)
Back EMF const. * (RMS voltage per phase) *	Ke Kv	25 0.24		$V/1000min^{-1}$ Vsec/rad
Armature resistance *	Ra	2.1		Ω
Mechanical time const. *	tm	0.008		sec
Thermal time const.	tt	20		min
Static torque	Tf	0.15 1.5		Nm kgfcm
Max. allowable current	Im	19		A(peak)
Max. torque	Tm	9.7 98		Nm kgfcm
Max. acceleration		14600		rad/sec^2
Max. winding temperature rise	θm	125		°C
Weight		4		kg

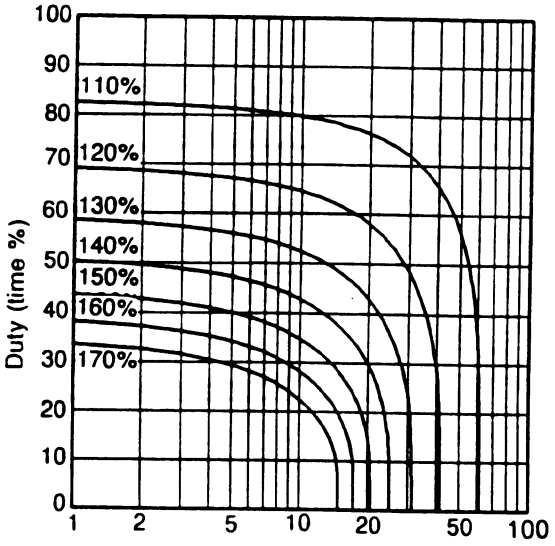
- The values are the standard values at 20°C and their errors are ±10%.
  The speed-torque characteristics vary depending on the type of software, parameter setting and input voltage of the digital servo system.
  These values may be changed without prior notice.

(4) MODEL 0E

Speed-Torque characteristics (digital)



Overload duty characteristics



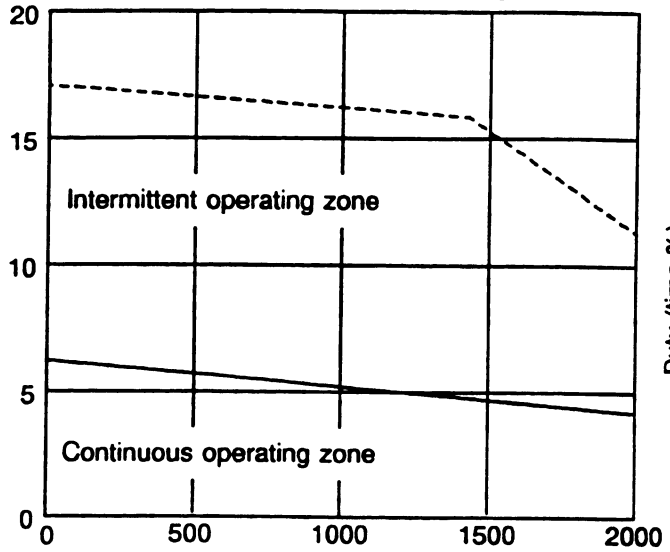
Data sheet

Parameters	Symbol	Value		Unit
Max. speed	Nmax	3000		min^{-1}
Cont. stall torque *	Ts	3 30.6		Nm kgfcm
Rotor inertia	Jm	0.002 0.02		kgm^2 $kgfcms^2$
Cont. RMS current	Is	5.2		A(rms)
Torque const. *	Kt	0.58 5.9		Nm/A(rms) kgfcm/A(rms)
Back EMF const. * (RMS voltage per phase) *	Ke Kv	20 0.19		$V/1000min^{-1}$ Vsec/rad
Armature resistance *	Ra	0.68		Ω
Mechanical time const. *	tm	0.012		sec
Thermal time const.	tt	35		min
Static torque	Tf	0.29 3		Nm kgfcm
Max. allowable current	Im	30		A(peak)
Max. torque	Tm	12 125		Nm kgfcm
Max. acceleration		6000		rad/sec^2
Max. winding temperature rise	θm	125		°C
Weight		6		kg

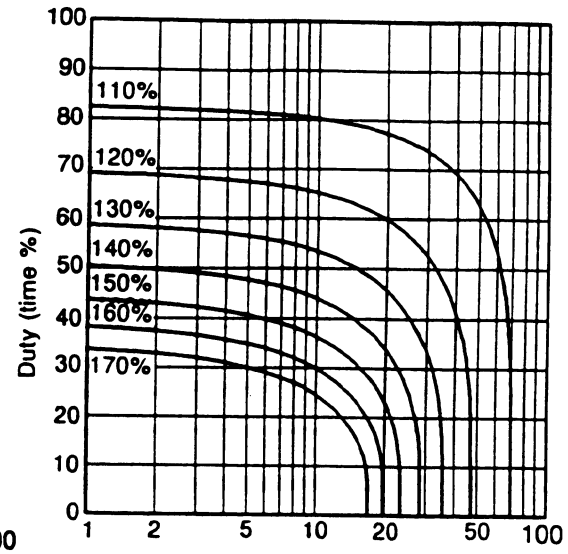
- The values are the standard values at 20°C and their errors are ±10%.
  The speed-torque characteristics vary depending on the type of software, parameter setting and input voltage of the digital servo system.
  These values may be changed without prior notice.

(5) MODEL 5E

Speed-Torque characteristics (digital)



Overload duty characteristics



Data sheet

Parameters	Symbol	Value		Unit
Max. speed	Nmax	2000		min^{-1}
Cont. stall torque *	Ts	6 61.2		Nm kgfcm
Rotor inertia	Jm	0.0039 0.040		kgm^2 $kgfcms^2$
Cont. RMS current	Is	5.4		A(rms)
Torque const. *	Kt	1.11 11.3		Nm/A(rms) kgfcm/A(rms)
Back EMF const. * (RMS voltage per phase) *	Ke Kv	40 0.38		$V/1000min^{-1}$ Vsec/rad
Armature resistance *	Ra	1.0		Ω
Mechanical time const. *	tm	0.0093		sec
Thermal time const.	tt	40		min
Static torque	Tf	0.3 3		Nm kgfcm
Max. allowable current	Im	30		A(peak)
Max. torque	Tm	24 240		Nm kgfcm
Max. acceleration		6000		rad/sec^2
Max. winding temperature rise	θm	125		°C
Weight		10		kg

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

APPENDIX 6. REQUIRED POWER FOR UNITS

No.		Unit name	Power voltage	Power current	Supplied from
1	1	Power Mate-E 3-phase power supply	200 VAC to 230V +10% to −15% 50/60 Hz ± 2 Hz	0.45 to 1.5 kVA (By motor model)	Supplied from external power source
	2	Power Mate-E single phase power supply for control	200 VAC to 230V +10% to −15% 50/60 Hz ± 2 Hz	50 VA	Supplied from external power source
2	1	I/O card	24 VDC	1.5 A	External power supply
3	1	DPL/MDI	5 VDC	0.2 A	Power Mate
	2	Remote DPL/MDI	5 VDC	0.3 A	Power Mate
4	1	Position indicator	24 VDC	0.6 A	External power supply
5	1	DPL/MDI switching circuit	24 VDC	0.2 A	External power supply
6	1	Battery	3 VDC	——	Lithium dry cells (3V)
	2	Battery for an absolute pulse coder	6 VDC	——	Lithium dry cells (6V)
7	1	Servo motor (+built-in pulse coder)	5 VDC	0.35 A	Power Mate
8	1	Separate pulse coder	5 VDC	0.35 A	Power Mate
9	1	Manual pulse coder	5 VDC	0.1 A	Power Mate

(Note) The Power Mate controller is supplied with a power of 200 VAC, 50 VA of single phase and generates a power of 5 VDC for the DPL/MDI, pulse coder, and manual pulse generator.

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Revision Record

FANUC Power Mate-MODEL E DESCRIPTIONS (B-62112E)

01	May '93	———			
Edition	**Date**	**Contents**	**Edition**	**Date**	**Contents**

EUROPEAN HEADQUARTERS
GRAND-DUCHE DE LUXEMBOURG
GE Fanuc Automation Europe S.A.
Zone Industrielle
L-6468 Echternach
☎ (+352) 727979 - 1
🖷 **(+352) 727979 – 214**
www.gefanuc-europe.com

BELGIUM / NETHERLANDS
GE Fanuc Automation Europe S.A.
- Netherlands Branch -
Postbus 7230 - NL-4800 GE Breda
Minervum 1603A - **NL-4817 ZL**
Breda
☎ (+31) 76-5783 201 (CNC)
☎ (+31) 76-5783 212 (PLC)
🖷 (+31) 76-5870 181
www.gefanuc.nl

CZECH REPUBLIC
GE Fanuc Automation CR s.r.o.
U studanky 3
CZ-170 00 Praha 7
☎ (+420) 2 333 72 502 (CNC)
☎ (+420) 2 333 72 503 (PLC)
🖷 (+420) 2 333 70 821
www.gefanuc.cz

FRANCE
GE Fanuc Automation France S.A.
39, rue du Saule Trapu, BP 219
F-91882 Massy Cedex
☎ (+33) 1 69 75 86 39 (CNC)
☎ (+33) 1 69 75 86 20 (PLC)
🖷 (+33) 1 69 75 86 49
www.gefanuc.fr

GERMANY
GE Fanuc Automation GmbH
Bernhäuser Straße 22
D-73765 Neuhausen a.d.F
☎ (+49) 7158 187 400
🖷 (+49) 7158 187 455 (CNC)
🖷 (+49) 7158 187 466 (PLC)
www.gefanuc.de

GERMANY
GE Fanuc Eberle Automation GmbH
Südwestpark 48
D-90449 Nürnberg
☎ (+49) 911 9672 100 (PLC)
🖷 (+49) 911 9672 200 (PLC)
www.gefanuc.de

GERMANY
GE Fanuc Automation GmbH
Elberfelderstr. 45
D-40724 Hilden
☎ (+49) 2103 247410 (Laser/CNC)
🖷 (+49) 2103 247420 (Laser/CNC)
www.gefanuc.de

GERMANY
GE Fanuc Automation Deutschland GmbH
Bensheimer Str. 61
D-65428 Rüsselsheim
☎ (+49) 6142 357600
🖷 (+49) 6142 357611
www.gefanuc.de

GERMANY
GE Fanuc Automation GmbH
Obere Hauptstr. 72
D-09244 Lichtenau
☎ (+49) 37208 695 20(CNC)
☎ (+49) 37208 695 30 (PLC)
🖷 (+49) 37208 695 55
www.gefanuc.de

ITALY
GE Fanuc Automation Italia S.r.l.
Largo Brugnatelli 15 – Via Volta 4
I-20090 Buccinasco (MI)
☎ (+39) 02 45795 1 (CNC)
🖷 (+39) 02 45795 250 (CNC)
www.gefanuc.it

ITALY
GE Power Controls Italia S.p.a
Via Tortona 27
I-20144 Milano
☎ (+39) 02 4242 280 (PLC)
🖷 (+39) 02 4242 511 (PLC)
www.gefanuc.it

POLAND
GE Fanuc Automation
Polska Sp. z o.o.
ul. Czerwińskiego 6
40-123 Katowice - Poland
☎ (+48) 32 258 5077
🖷 (+48) 32 258 5077

SPAIN
GE Fanuc Automation España S.A.
Polígono Industrial Olaso
Calle Olaso, 57 - Locales 10 y 11
E-20870 Elgoibar
☎ (+34) 943 74 82 90 (CNC)
🖷 (+34) 943 74 44 21 (CNC)
www.gefanuc.es

SPAIN
GE Power Controls Ibérica S.L.
Calle Marqués de Comillas, 1
E-08225 Terrassa (Barcelona)
☎ (+34) 93 736 58 28 (PLC)
🖷 (+34) 93 788 24 03 (PLC)
www.gefanuc.es

SWEDEN
GE Fanuc Automation Nordic AB
Hammarbacken 4B
S-19149 Sollentuna
☎ (+46) 8 444 5520
🖷 (+46) 8 444 5521
www.gefanuc.se

SWITZERLAND
GE Fanuc Automation Europe S.A.
Zweigniederlassung Brügg –
Swiss Branch
Erlenstrasse 35a
P.O. Box CH-2555 Brügg BE
☎ (+41) 32 366 63 63 (CNC)
☎ (+41) 32 366 63 33 (PLC)
🖷 (+41) 32 366 63 64 (CNC)
🖷 (+41) 32 366 63 34 (PLC)
www.gefanuc.ch

UNITED KINGDOM
GE Fanuc Automation (UK) Ltd.
Unit 1 - Mill Square
Featherstone Road
Wolverton Mill South
Milton Keynes MK12 5BZ
☎ (+44) 1908 84 4000
🖷 (+44) 1908 84 4001
www.gefanuceur.co.uk

The export of this product is subject to the authorization of the government of the country from where the product is exported.

In this manual we have tried as much as possible to describe all the various matters.
However, we cannot describe all the matters which must not be done, or which cannot be done, because there are so many possibilities.
Therefore, matters which are not especially described as possible in this manual should be regarded as "impossible".