

**FANUC Robot S-10/S-700
Maintenance and Troubleshooting
Reference Manual**

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Div [17][19] \rightarrow usat 5 \rightarrow 19 slot 3
usat 6 \rightarrow 2

0001

Div [1] \rightarrow usat 17
usat 18

00010100 = 20

slot 4

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810-377-7159

For all other Troubleshooting and Technical Support
contact your local distributor or call the Hotline
Monday – Friday, 8:00 A.M. – 5:00 P.M. Eastern Time

BEFORE YOU CALL please have your Maintenance and Troubleshooting manual, and the following information, ready.

INFORMATION	DETAILS
Customer Information	Include <ul style="list-style-type: none">• your company's name• caller's name• phone number where caller can be reached, including area code and extension
Robot type (A, L, M, P, or S, & 3-digit number)	On the arm of the robot.
Controller style (RA, RB, RC, RF, RG, RG2, RH, RJ, RJ2)	Ask your supervisor.
F Number	On the identification tag on the robot and controller, near the cable connection.
Robot serial number (if no F Number is available)	On the identification tag located near the cable connection.
Controller serial number (if no F Number is available)	On the controller tag located on the doors.
Software edition and revision numbers	Shown on the CRT or teach pendant status screen during the power-up sequence.
List of error messages	Include <ul style="list-style-type: none">• error message number• message following error message number• any numbers following error message
List of diagnostic LEDs	Note the PCB where the LED is located and the LED name or designation.
History of problem	Description of events leading up to the problem.
Application software	List <ul style="list-style-type: none">• any application software running the system• the line number where the program halted• a description of what is happening on that line

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I. OVERVIEW AND CONTROLLER MAINTENANCE

1. INTRODUCTION

This manual presents a description of the S-10 and S-700 robots and also a description of the R-H controllers (S-10: A05B-2066-B001/A05B-2067-B001; S-700: A05B-2061-B001) and each of their components, including component setting, adjustment and replacement procedures. Preventive maintenance and troubleshooting methods are also described.

WARNING) Turn off the power or press the EMERGENCY STOP button on the teach pendant or operator's panel before entering the robot motion area.

1.1 Structure

Fig. 1.1 shows the configuration of the controller and mechanical unit for both the S-10 and S-700 robots.

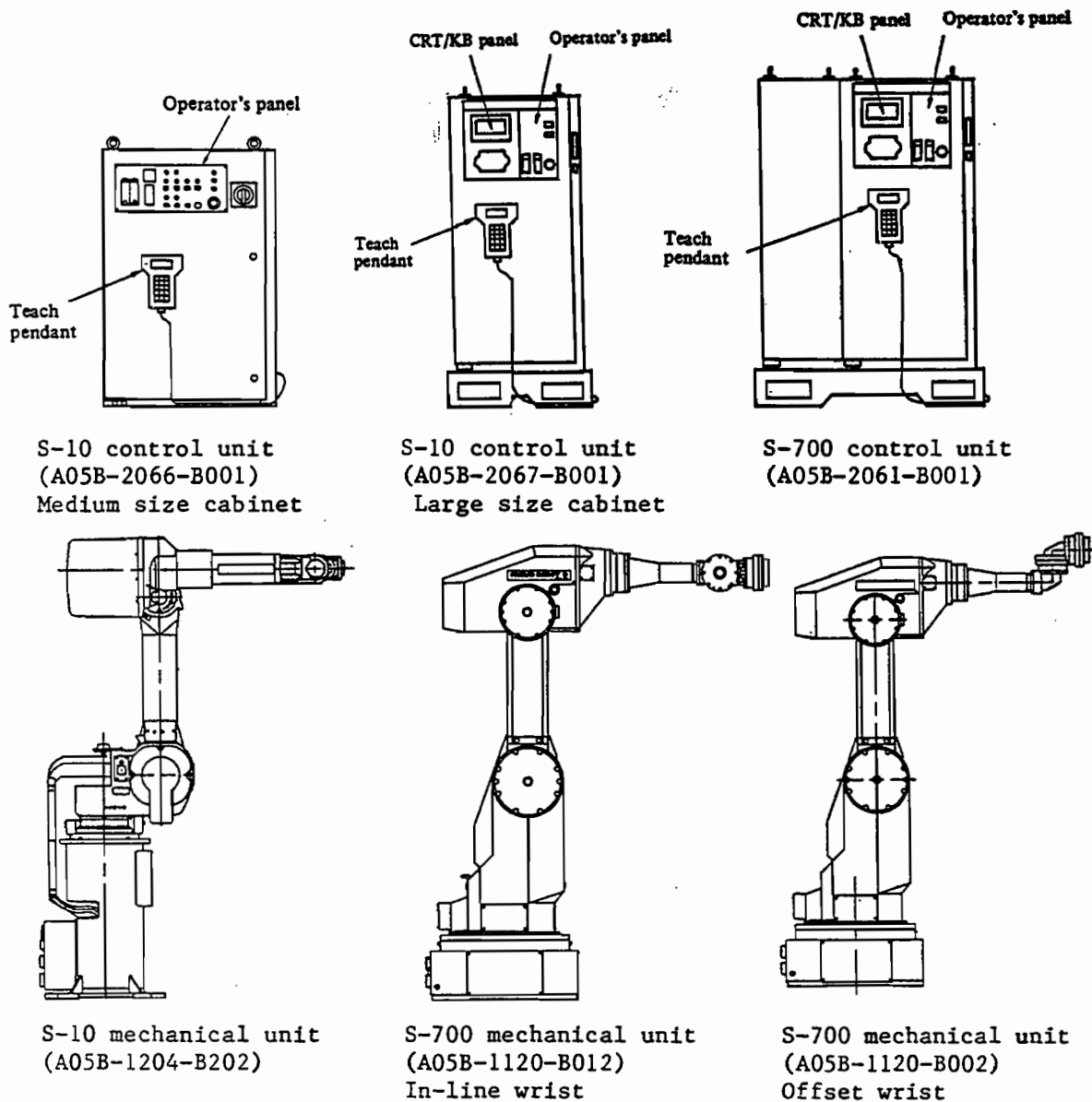


Fig. 1.1 Configuration of the S-10 and S-700 controllers and mechanical units

The S-10 and S-700 robots are articulated robots with six axes. The medium size control unit for the S-10 is comprised of the operator's panel and the teach pendant. The large size cabinet also includes a built-in CRT/KB. The control unit for the S-10 or S-700 is comprised of the operator's panel, CRT/KB and teach pendant. The control unit for the S-700 is also comprised of a side cabinet.

1.2 Problem Conditions and Determining Causes

To correctly identify the cause of a problem, it is necessary to analyze the problem conditions accurately. To minimize the downtime caused by these problems, perform the following checks: First make a preliminary check of items (a) thru (c). Second, make sure that the problem has not been caused by incorrect operation or errors in programming. Third, find out whether the malfunction is in the control unit or the mechanical unit.

1.2.1 Making preliminary check

- a) Is the robot being operated normally?
(Check emergency stop, teach pendant ENABLE ON/OFF switch, hold.)
- b) Is an error message displayed?
- c) When and in what location did the problem occur? What is its frequency?

Note the following:

- . Mechanical position where the problem occurred
- . Error message displayed
- . Problem frequency
- . Amount of positioning error
- . Display of the program position where the problem occurred
- . Software series and edition number displayed on the CRT when the power is turned on.
- . System variables
Compare the values set in system variables to the standard values for system variables set in the control unit.
- . Results of interface signal check by using the diagnostic system.
- . In what part of program did the problem occur? (program name, line number, etc.) Is the problem related to the movement of a controlled axis?

1.2.2 Locating the cause of the problem

Identify an abnormal symptom by using the analysis of the above items, and determine a probable cause of the problem from the following:

- a) Error in operation or programming
Operate the robot correctly and note any difference.
- b) A problem in a peripheral device, remote control panel, or another externally connected unit. Check the interface signals between the system and error messages. If necessary, change the externally connected unit to agree with the interface diagram.
- c) Control unit check
Check to see if any of the LEDs on the PCBs in the control unit are lighted indicating the cause of an alarm.
If an alarm related to the servo system has occurred, check the LEDs in the servo amplifier to determine the axis which is the cause of the problem. Check whether this LED is lighted before turning off the power supply.

1.2.3 Checking the mechanical unit

Check the following:

a) External damage

Check the mechanical unit for damage due to foreign substances in the unit or contact with peripheral devices or other external equipment.

b) Excessive load or external force

Is the force required for the movement of the workpiece within the limit conditions set for the robot?

Has excessive external force been applied?

c) Cables and hose

Are cable connectors securely connected?

Are moving cables and internal cables free of damages, sharp bends, or other defects?

Are there any air leaks?

d) Smooth movement

Is the servo amplifier functioning normally?

Do the axes decelerate smoothly without any shock when the robot stops?

Are there any abnormal noises or vibrations during movement?

2. SAFETY

GMFanuc Robotics Corporation (hereafter referred to as GMF Robotics or GMF) is concerned with the safety and welfare of its customers, their employees, and their equipment. However GMF does not design or install safety related equipment and consequently cannot be responsible for ensuring the safety of the various user personnel. GMF expressly disclaims any such responsibility. Safety should, however, be given the highest priority in designing and using a robot system.

Although the user must comply with all federal, state, and municipal laws, regulations, or guidelines pertaining to safety, the user must also take such steps as may be necessary to ensure the safety of all personnel.

2.1 Personnel Safety Considerations

2.1.1 General precautions

While GMF cannot be responsible for the safety of the robot system design, GMF strongly recommends that the following steps be taken to promote the safety of user personnel. These suggestions are intended to supplement and not replace any federal, state, or local laws, regulations, or guidelines.

- . Train all individuals associated with the robot system in an approved GMF training course.
- . Equip the system with a flashing light or other visual or audible warning device to indicate when the robot is operating (i.e. power is applied to the robot's servo drive units).
- . Provide an interlocked barrier guard, such as that shown in Fig. 2.1.1, which cuts drive power to the servos when a barrier gate is opened.

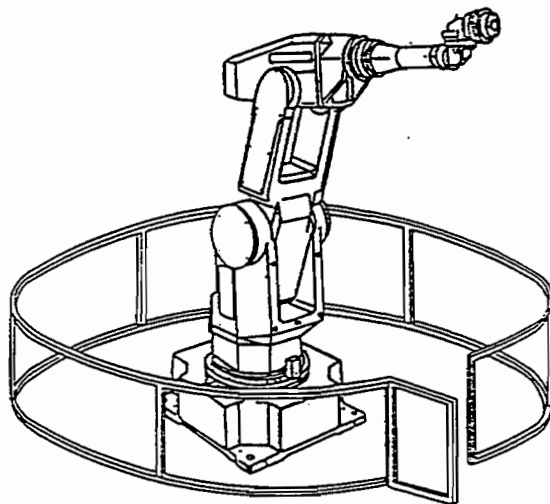


Fig. 2.1.1 Use of a fence to secure work area

- . Ensure that all peripheral devices are properly grounded to minimize the effects of electromagnetic interference (EMI) and radio-frequency interference (RFI).
- . Locate all controls outside the robot mechanical unit's work envelope.
- . Clearly identify the work envelope of the robot with signs, lines on the floor, and special barriers.
- . Use presence-sensing devices such as light curtains, mats, capacitance systems, proximity-sensing devices, and vision systems to enhance safety.
- . Make provisions for power lockout/tagout.

2.1.2 Operator safety precautions

Implement the following measures to safeguard the operator.

- . Use anti-tie-down logic to prevent the operator from bypassing safety measures.
- . Install a lockout device using an "access code" to prevent unauthorized persons from operating the robot.
- . Mount EMERGENCY STOP switches within easy reach of the operator and at critical points in and around the work cell.
- . Where possible, install safety fences, shown in Fig. 2.1.1, to protect against unauthorized entry into the work envelope.
- . Install special guarding to prevent the operator from reaching into restricted areas of the work envelope.

2.1.3 Teacher safety precautions

Implement the following safety measures to safeguard the program teacher.

- . Before teaching, make a visual inspection of the robot and work envelope to ensure no potentially hazardous conditions exist.
- . Before entering the work envelope, confirm that all safeguards are in place.
- . When teaching positional data, the teacher must have sole control of the robot.
- . When data is being taught, isolate the robot from all remote control signals that can cause motion.
- . Any program being run for the first time should be tested in the following manner:

WARNING: The user should remain clear of the robot's work envelope at all times when a program is being run.

1. Using a low motion speed, test run the program in the single step mode for at least one full cycle.
 2. Using a low motion speed, test run the program in the continuous mode for at least one full cycle.
 3. Using a higher motion speed, test run the program in the continuous mode for at least one full cycle.
 4. If the program operates correctly for each of the above tests, install all safety measures and run the program in automatic mode.
- . Do not begin an automatic mode of operation until the teacher is clear of the work envelope.

2.1.4 Maintenance personnel safety considerations

Implement the following safety measures to safeguard maintenance personnel.

- . Where possible, perform maintenance with the power off. Implement lockout/tagout procedures and release or block all stored energy (air, etc.).
- . Before entering the work envelope, make a visual inspection of the robot system to ensure that no potentially hazardous conditions or malfunctions exist. Functionally test the teach pendant for proper operation before entering the work envelope.
- . When maintenance must be performed inside the work envelope with power applied, those inside the work envelope must have sole control of the robot. Isolate the robot from all remote control signals.
- . Do not place the robot into automatic mode unless all personnel are clear of the work envelope.
- . Place the robot arm in a location that will ensure that personnel will not be exposed to a trap point. An escape path should always be provided.

- . Use devices such as blocks, mechanical stops, and pins to prevent hazardous movement of the robot. Care must be taken to ensure that such devices do not generate trap points for personnel.
- . For some procedures, a second person should be positioned at the operator's panel. This person must have proper understanding of the robot system and knowledge of the associated potential hazards.

2.2 Machine Tool and Peripheral Device Safety Considerations

2.2.1 Programming precautions

Implement the following programming safety measures to prevent damage to the machine tool and other peripheral devices.

- . Back-check any limit switches used in the work cell to identify failure before any component of the work cell can be damaged.
- . Implement "failure routines" in robot programs that are designed to provide appropriate robot actions in the event that a peripheral device or another robot in the work cell fails.
- . Use "handshaking" protocol to ensure that the operations of the robot and the peripheral device are synchronized.
- . Program the robot to check the condition of all peripheral devices during an operating cycle.

2.2.2 Mechanical precautions

Implement the following mechanical safety measures to prevent damage to the machine tool and other peripheral devices.

- . Ensure that the work cell is clean and free of oil, water, or debris of any kind.
- . Limit the work envelope of the robot through the use of limit switches (software limits) and mechanical stops to avoid unnecessary movement of the robot into the work area of the machine tool and peripheral devices.

2.3 Robot Safety Considerations

2.3.1 Operating precautions

Implement the following operating safety measures to prevent damage to the robot.

- . When jogging the robot, use a low speed override to obtain greater control of the mechanical unit.
- . Before pressing any of the manual jog keys on the teach pendant, think of the robot motions that will result.

2.3.2 Programming precautions

Implement the following programming safety measures to prevent damage to the robot.

- . When two or more robots must share the same work area, establish "interference zones" to provide other robot controllers and peripheral devices with information regarding the location of the robot mechanical unit during operation.
- . Ensure that the robot program ends with the mechanical unit near the calibration point.

2.3.3 Mechanical precautions

Implement the following safety measures to prevent damage to the robot.

- . Ensure that the work envelope of the robot is clean and free of oil, water, or debris of any kind.
- . Use circuit breakers to guard against electrical overload.

2.4 End Effector Safety Considerations

2.4.1 Programming precautions

The following programming safety measures should be implemented to prevent damage to the end effector.

- . Provide an "open-gripper" command just prior to picking up the workpiece.
- . Provide a time delay to allow any actuator (pneumatic, hydraulic, or electrical) sufficient time to operate after the appropriate input/output command has been given.
- . Use output signals from limit switches in the end effector to verify that the end effector is operating properly (i.e. a part-in-gripper limit switch).
- . Program a reduced deceleration rate as the robot approaches a "pick-up point" or workpiece to prevent an overshoot of the programmed point.

2.4.2 Mechanical precautions

Implement the following mechanical safety measures to prevent damage to the end effector.

- . Use a safety joint to protect and end-of-arm tooling.
- . Design sufficient compliance into the end effector to allow for small variations in the orientation of the workpiece.
- . Install sensors on the end effector (i.e., photoelectric, cats-whisker limit switch) to detect when the end-of-arm tooling is approaching an obstruction.
- . Use a vision system to ensure that the robot mechanical unit and end effector are oriented properly to pick up the workpiece.
- . Use additional hardware to ensure that the workpiece is oriented properly so that the robot mechanical unit end effector picks up the part correctly.

3. CONTROLLER DESCRIPTIONS

3.1 General Description

The controller controls servo motors provided for each axis of the robot. It also controls the end effector and interface signals between the controller and associated peripheral devices.

S-10 and S-700 robots are controlled by one of the following controllers.

- 1) A05B-2066-B001 S-10/R-H controller (Medium size cabinet)
- 2) A05B-2067-B001 S-10/R-H controller (Large size cabinet)
- 3) A05B-2061-B001 S-700/R-H controller (Large size cabinet)

The controller contains the following components:

- 1) Basic control unit (including backplane, power supply unit and control PCBs)
- 2) I/O unit
- 3) Battery unit
- 4) Circuit breaker
- 5) Power input unit
- 6) Servo amplifiers
- 7) Operator's panel
- 8) Remote CRT/KB unit or Built-in CRT/KB panel
- 9) Teach pendant
- 10) Transformers
- 11) Fan units
- 12) Outlet unit
- 13) Servo-on relay unit

Built-in CRT/KB panel, Outlet unit and Servo-on relay unit are options only for controllers with large size cabinets.

The connection of each unit is shown in Fig. 3.1 (a) - (j).

The function of each unit is shown in Table 3.1.

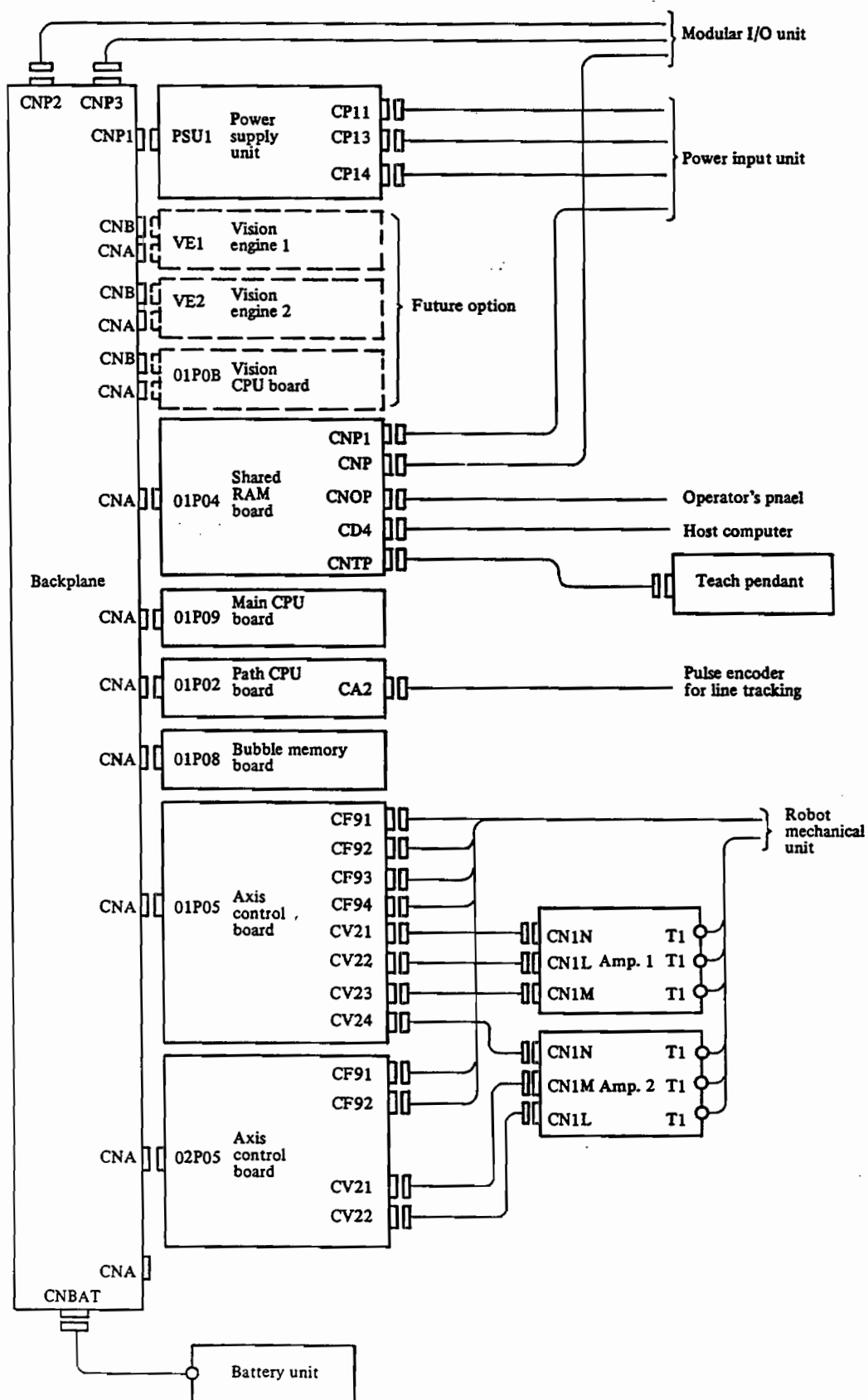


Fig. 3.1 (a) Connection diagram of 6-axis controller (S-10)
(with the modular I/O unit)

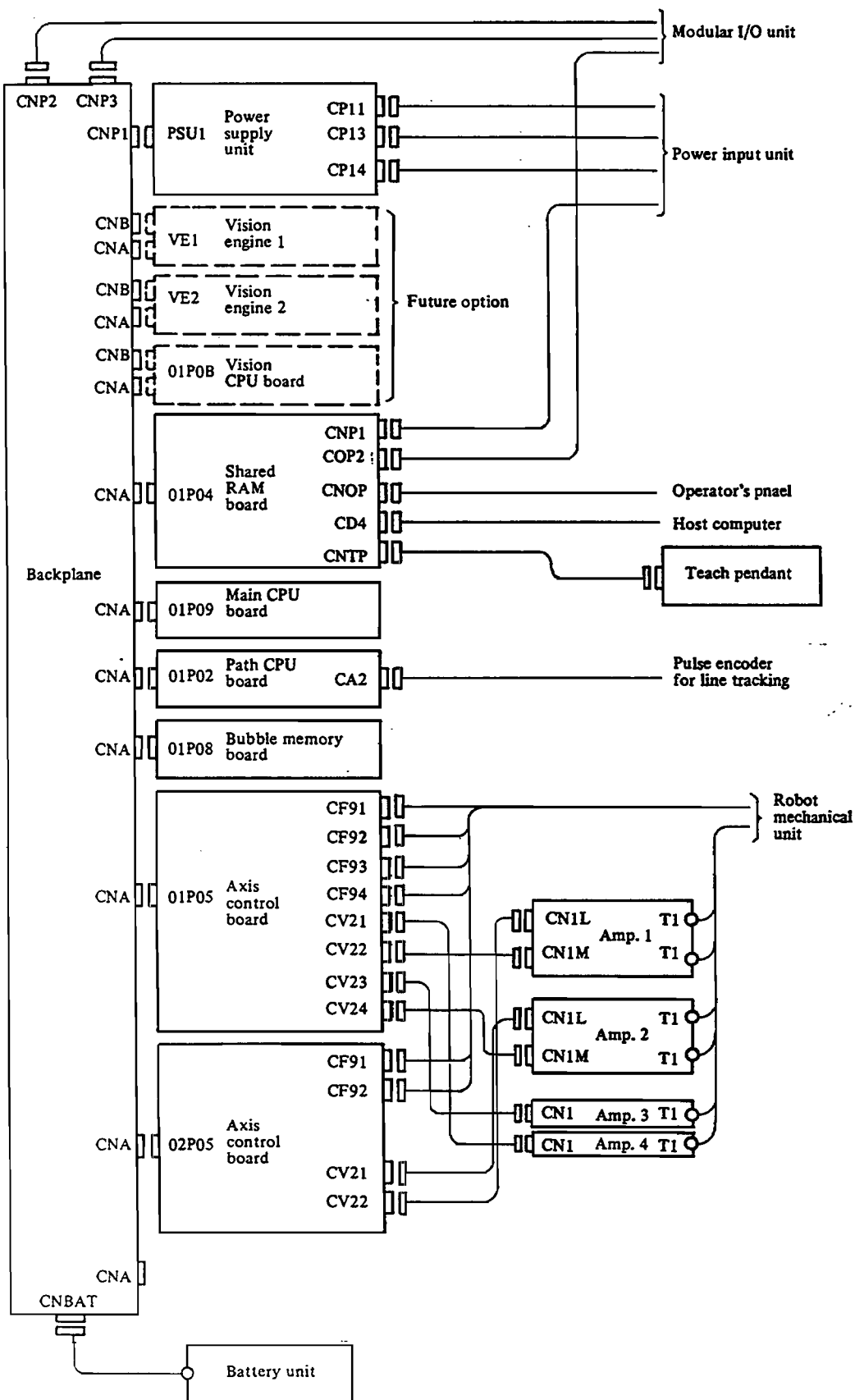


Fig. 3.1 (b) Connection diagram of 6-axis controller (S-700)
(with the modular I/O unit)

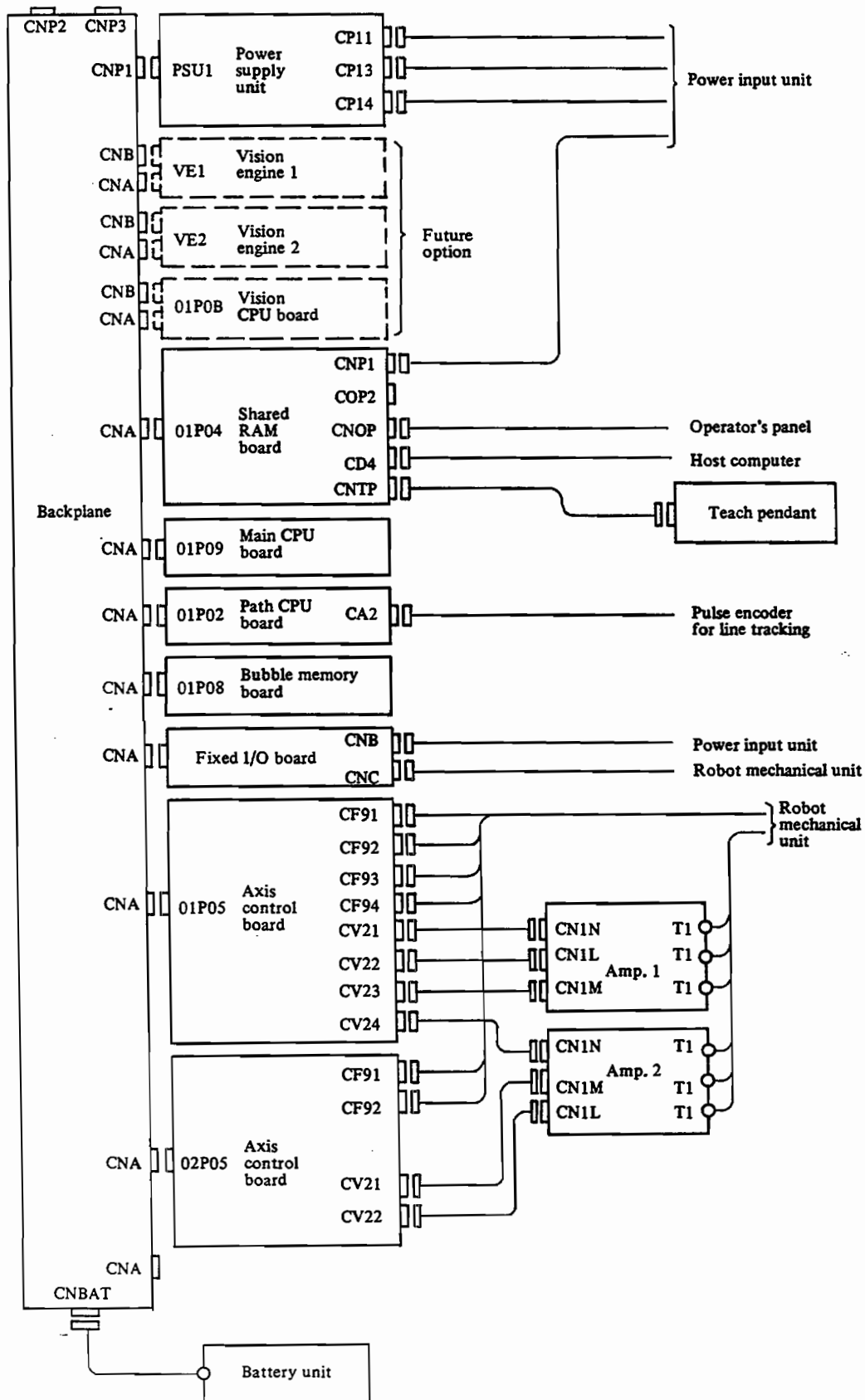


Fig. 3.1 (c) Connection diagram of 6-axis controller (S-10)
(with the fixed I/O board)

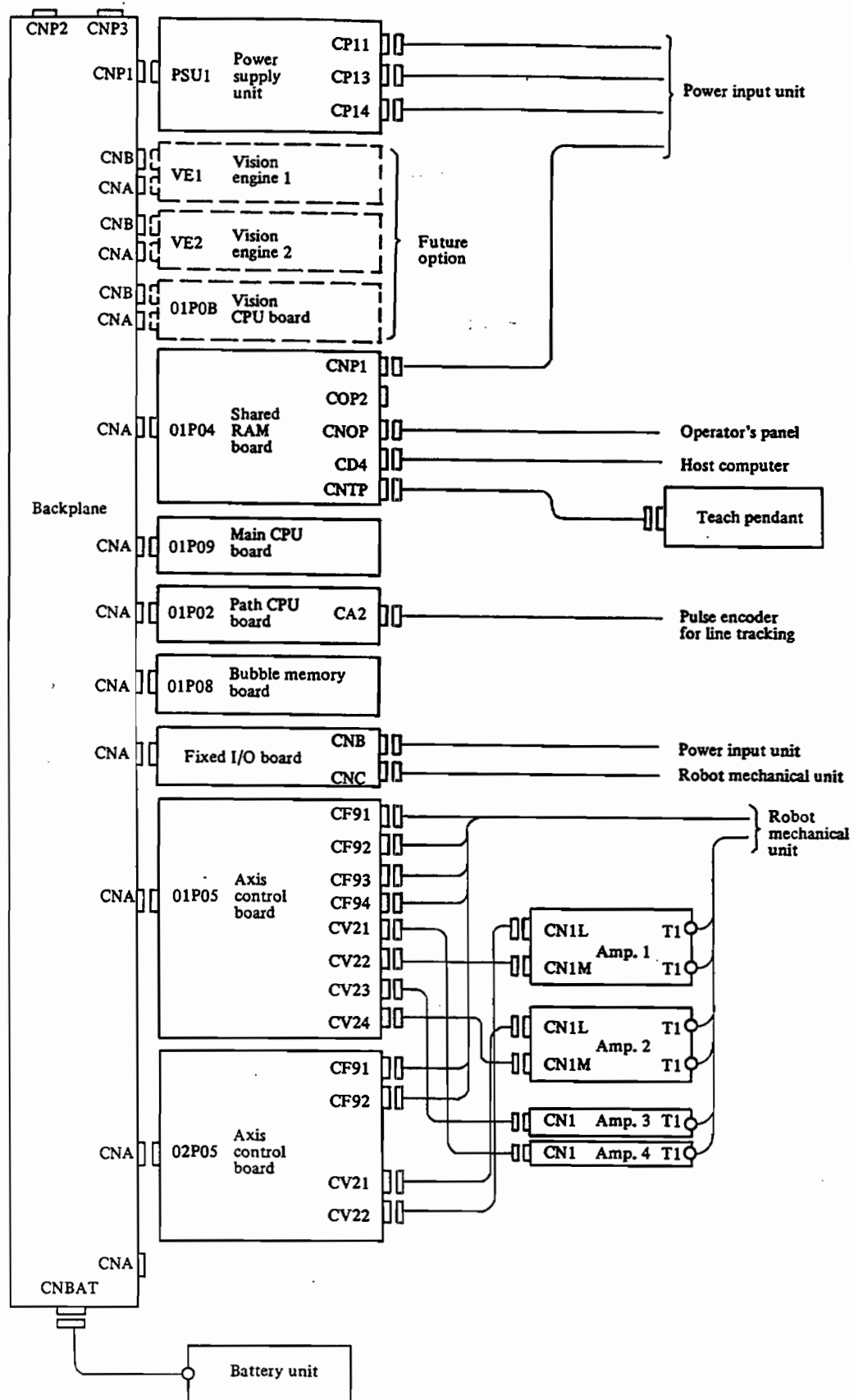


Fig. 3.1 (d) Connection diagram of 6-axis controller (S-700)
(with the fixed I/O board)

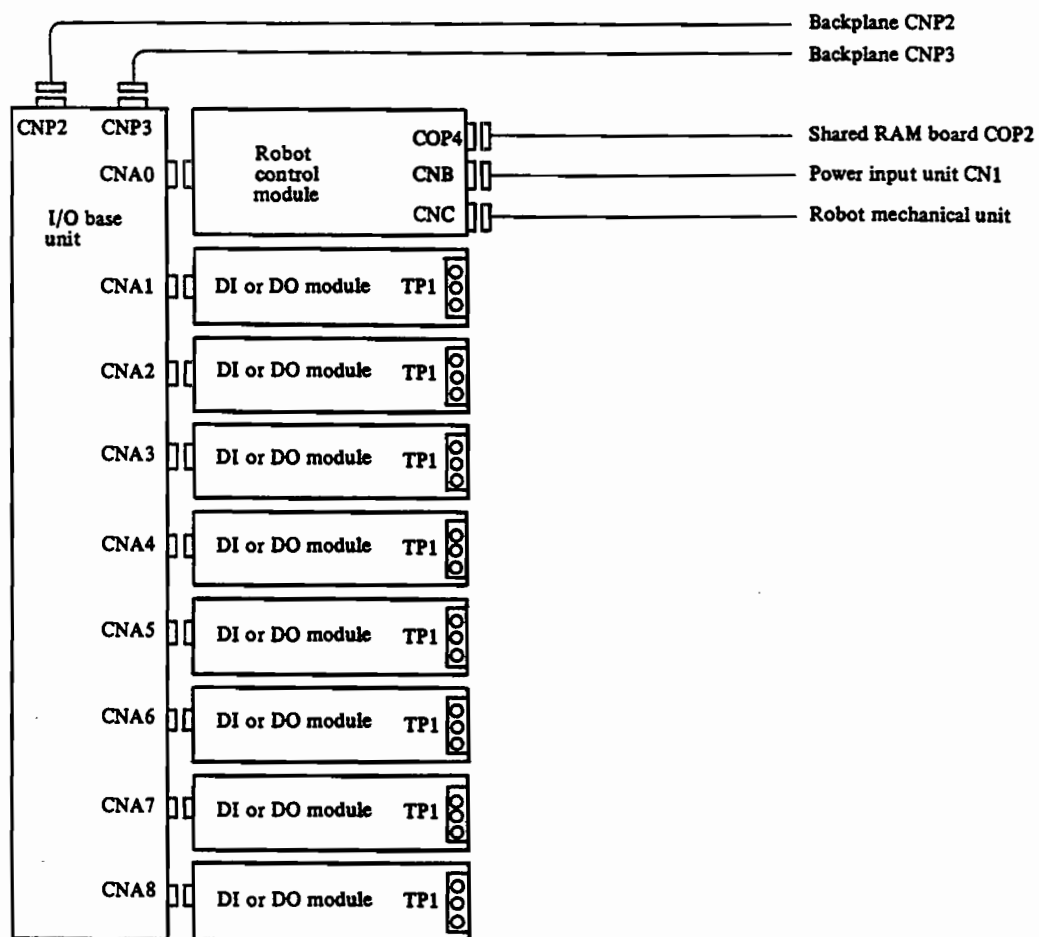


Fig. 3.1 (e) Connection diagram of modular I/O unit

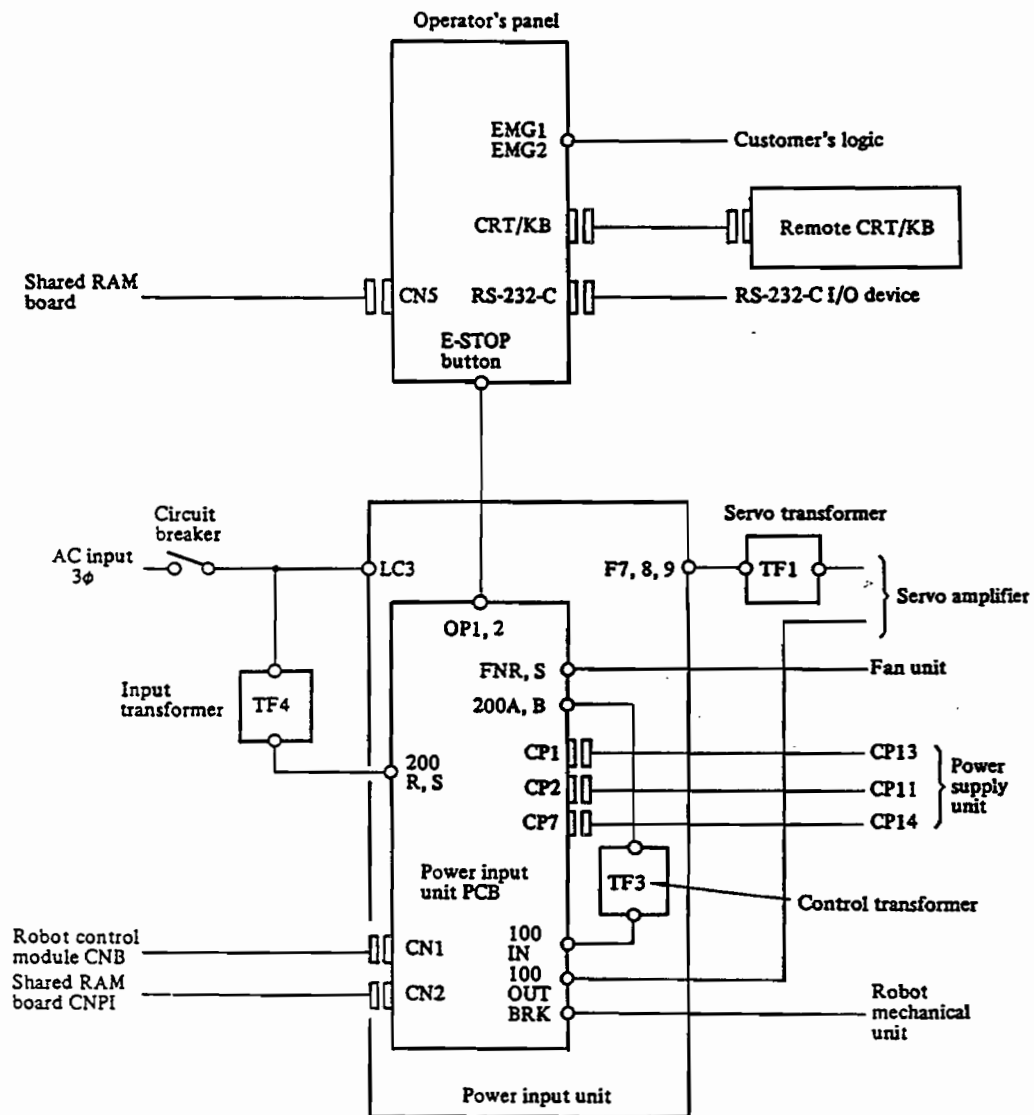


Fig. 3.1 (f) Connection diagram of the controller (Remote CRT/KB, operator's panel, power input unit of medium size cabinet)

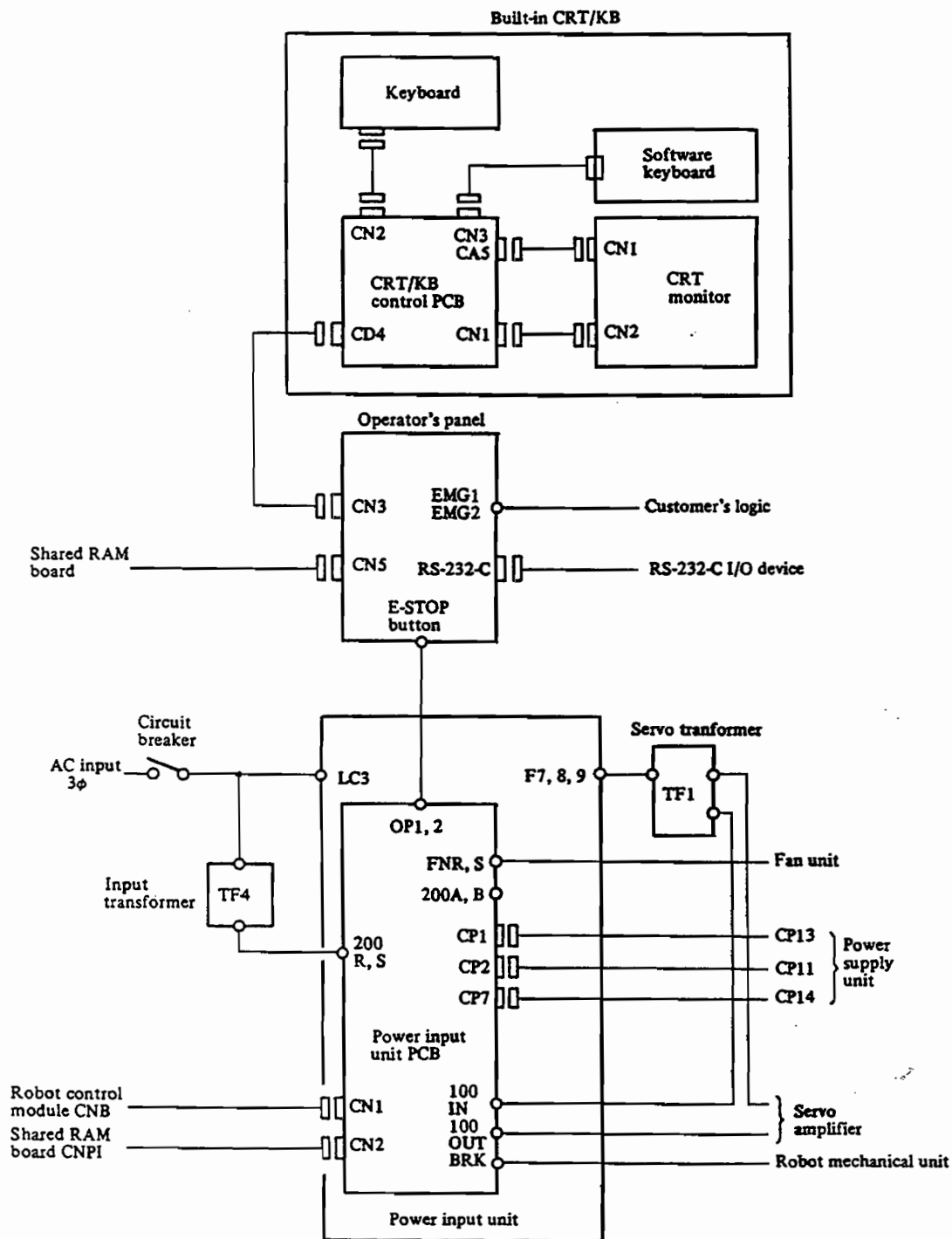


Fig. 3.1 (g) Connection diagram of the S-10 controller (Built-in CRT/KB, operator's panel, power input unit, circuit breaker of large size cabinet)

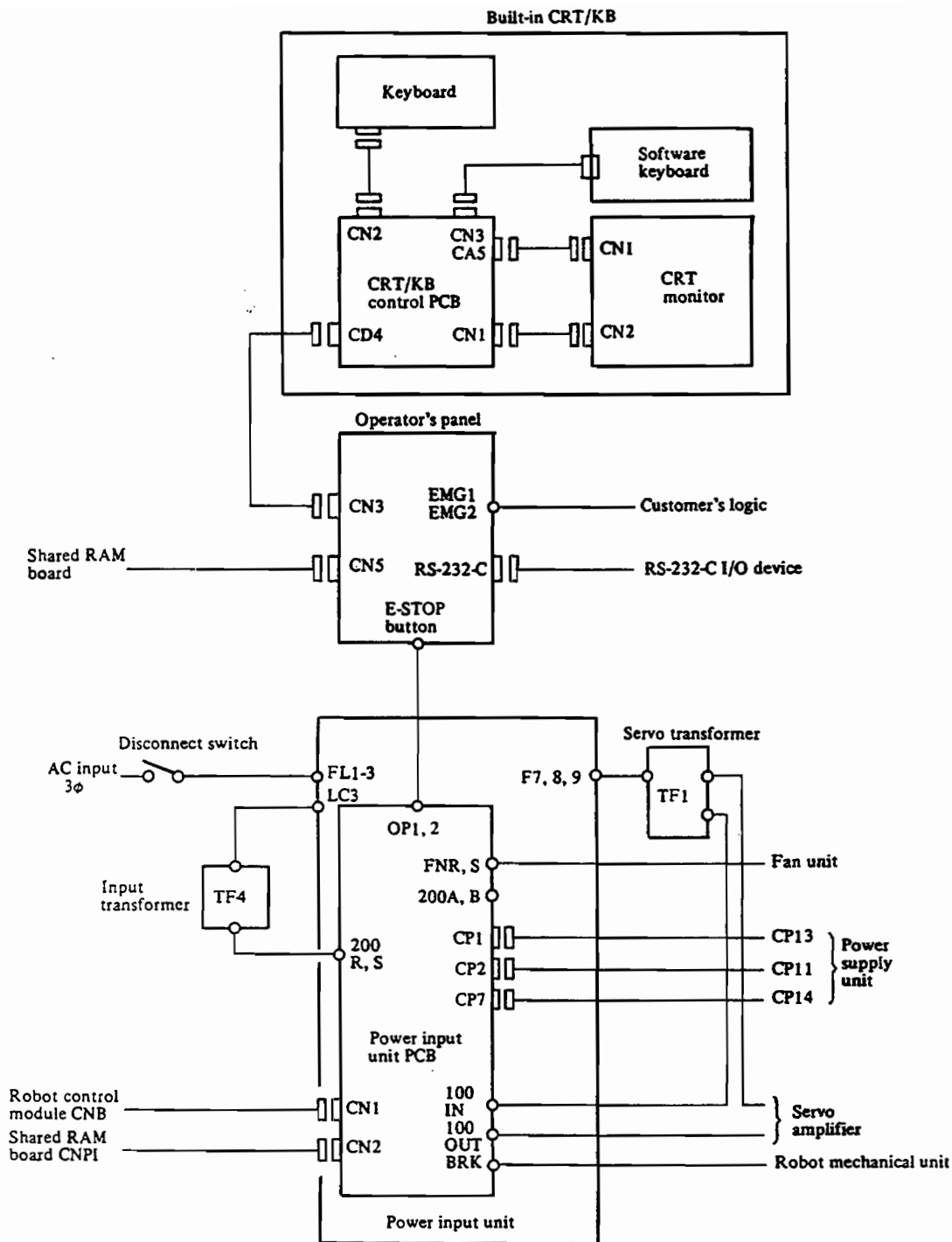


Fig. 3.1 (h) Connection diagram of the S-10 controller (Built-in CRT/KB, operator's panel, power input unit, disconnect switch of large size cabinet)

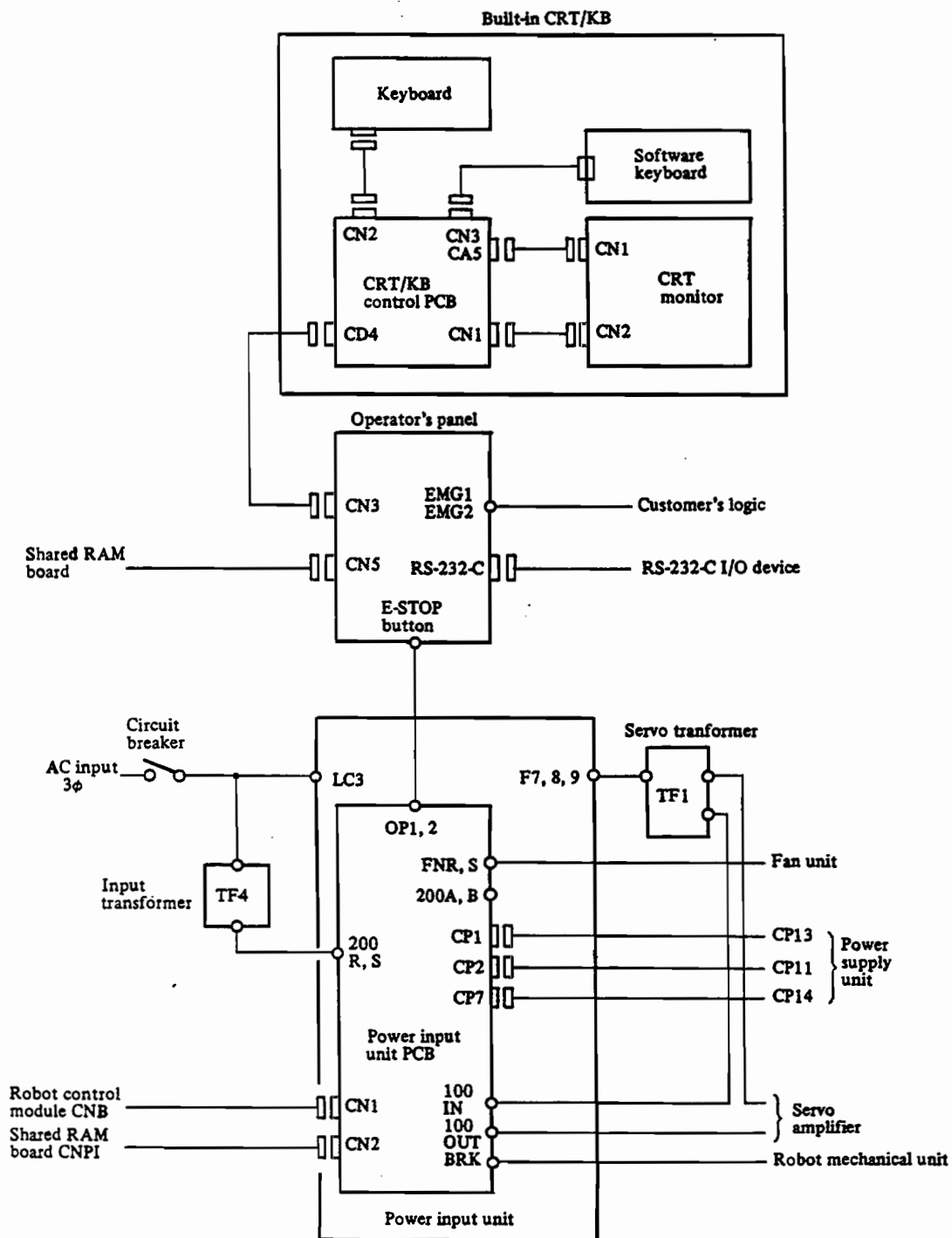


Fig. 3.1 (i) Connection diagram of the S-700 controller (Built-in CRT/KB, operator's panel, power input unit, circuit breaker of large size cabinet)

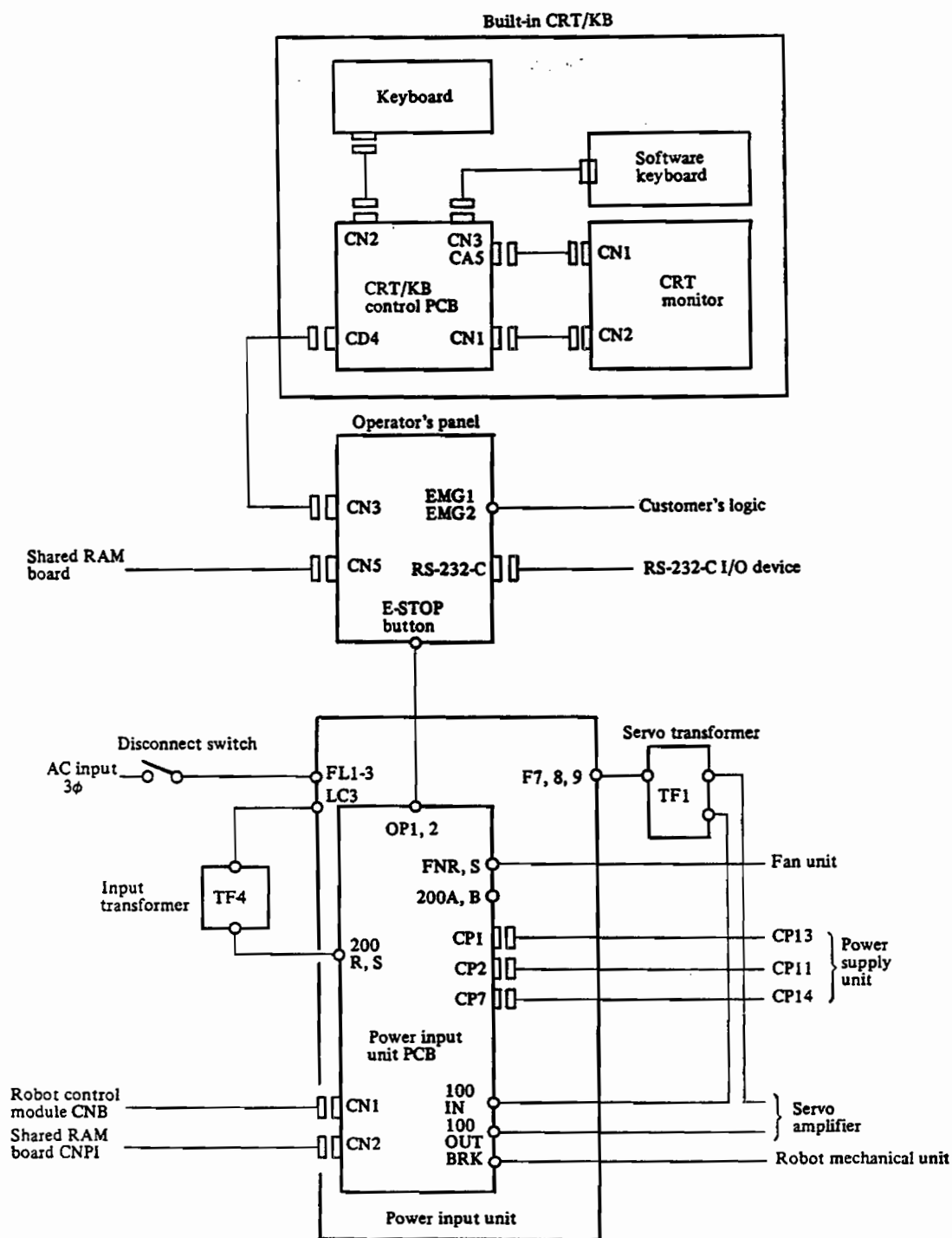


Fig. 3.1 (j) Connection diagram of the S-700 controller (Built-in CRT/KB, operator's panel, power input unit, disconnect switch of large size cabinet)

Table 3.1 Component function for the S-10/S-700

Name		Function	Slot No. or mod- ule No.	Remarks
Backplane		Provides the bus connection for the control PCBs.		
PCBs mounted on the backplane	Power supply unit	Supplies the DC voltage to basic control unit and the I/O unit	PSU1	
	Main CPU board	<ul style="list-style-type: none"> . Main CPU . Co-processor interface . DRAM, 1 MB or 2 MB . Battery-backed RAM, 64 kB 	01P09	
	Path CPU board	<ul style="list-style-type: none"> . Path CPU . Co-processor interface . DRAM, 256 kB . Calendar clock . Tracking counter 	01P02	
	Shared RAM board	<ul style="list-style-type: none"> . RAM, 64 kB . Optical link . RS-422 for teach pendant . RS-232-C for host computer . RS-232-C for CRT/KB . RS-232-C for I/O devices . Operator's panel interface 	01P04	
	Bubble memory board	<ul style="list-style-type: none"> . Stores system software, system variables and KAREL application programs . 1 MB, 1.5 MB or 2 MB 	01P08	
	Axis control board	<ul style="list-style-type: none"> . Digital servo control (4 axes) . Digital servo control (2 axes) 	01P05 02P05	6-axis controller
I/O unit	I/O base unit	Bus connection between the various I/O modules including the robot control module, DI/DO modules, and analog I/O modules		

Name		Function	Slot No. or mod- ule No.	Remarks
PCB mounted in I/O base unit	Robot control module	. Interface between basic control unit and I/O unit . Robot mechanical unit interface . Power input unit interface	RC01C	
	DI module	Input for peripheral device control (Various types are prepared for input control. Details are described in section 17.)	ID08C, ID16C, ID08D, ID16D, IA08E or IA16E	
	DO module	Output for peripheral device control (Various types are prepared for output control. Details are described in section 18.)	OD08B, OD16B, OD08C, OD16C, OD08G, OD16G, OA08D, OA16D, OA08E or OA16E	
	Analog input module	Analog input for peripheral device control (Details are described in section 19.)	AD04A	
	Analog output module	Analog outputs for peripheral device control (Details are described in section 20.)	DA02A	
Fixed I/O board		. Robot mechanical unit interface . Power input unit interface		
Battery unit		Batteries for RAM are mounted.		
Power input unit		. Power ON/OFF control circuit . Magnetic contactor . Fuses . Control transformer (S-10, medium size)		
PCB mounted in power input unit	Input unit PCB	. ON/OFF control . Relay circuit for emergency stop control . Motor brake control circuit		

Name		Function	Slot No. or mod- ule No.	Remarks
Servo amplifier		Unit to amplify the PWM signals and drive the servo motors		
Operator's panel		<ul style="list-style-type: none"> . Lamps and switches to operate the robot . Connector panel for RS-232-C . Connector panel for the CRT/KB . Hour meter (option on vertical operator's panel, large size cabinet) 		
Teach pendant		<ul style="list-style-type: none"> . 40 x 8 characters LCD . 40 keys and DEADMAN switch . EMERGENCY STOP button 		
Trans- former	Servo transformer	<ul style="list-style-type: none"> . AC power drive source for the servo amplifiers . Provides 100 VAC to power input unit (S-700) 		TF1
	Input transformer	<ul style="list-style-type: none"> . 200 VAC for the power unit 		TF4
Fan units		<ul style="list-style-type: none"> . Fans are provided to cool inside the main or connecting cabinet. . Fans are provided to circulate air inside the main cabinet. 		

3.2 External Components

Various external components are provided for the R-H controller. They are the teach pendant, operator's panel and CRT/KB.

There are two types of controller cabinets -- the medium size and the large size. Either size cabinet is available for the S-10. Only the large size is used for the S-700. The built-in CRT/KB and the disconnect handle are options that are available only for the large size controller.

The external views of the cabinet and the external components are the same for the three types of controllers.

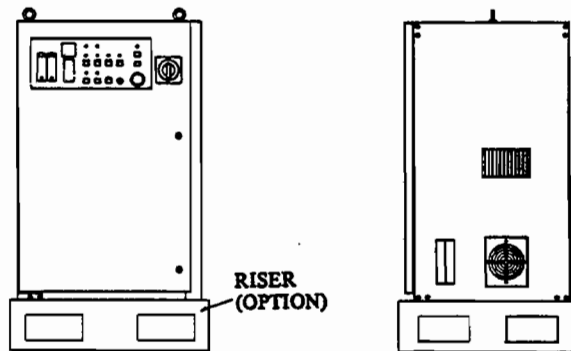
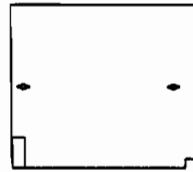


Fig. 3.2 (a) External view of controller (S-10, medium size cabinet)

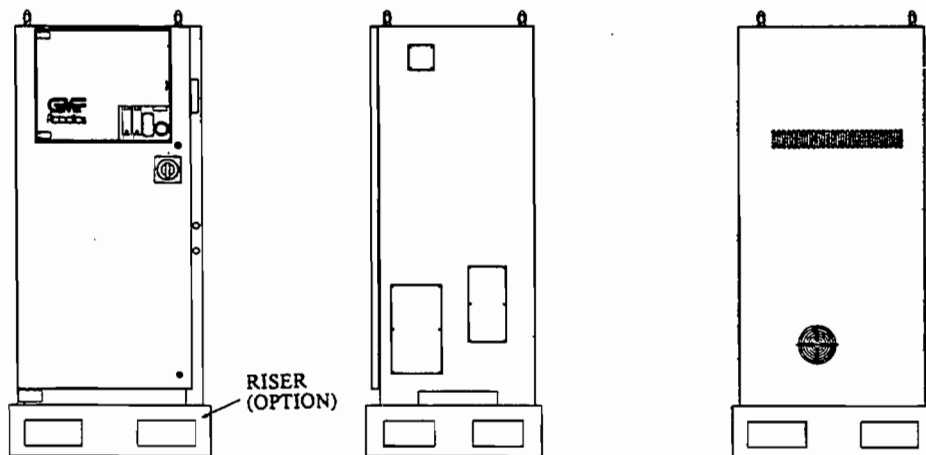
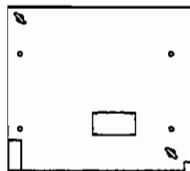


Fig. 3.2 (b) External view of controller (S-10, large size cabinet, circuit breaker handle)

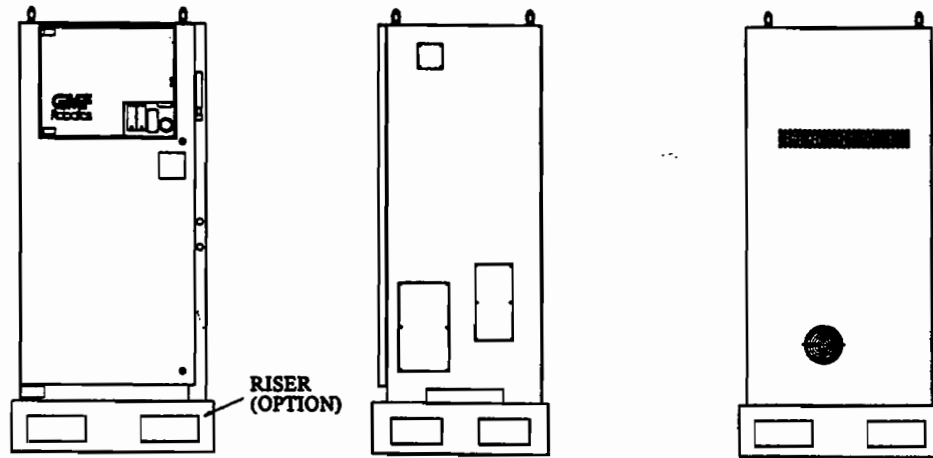
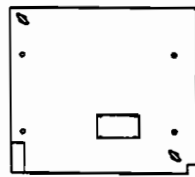


Fig. 3.2 (c) External view of controller (S-10, large size cabinet, power disconnect handle)

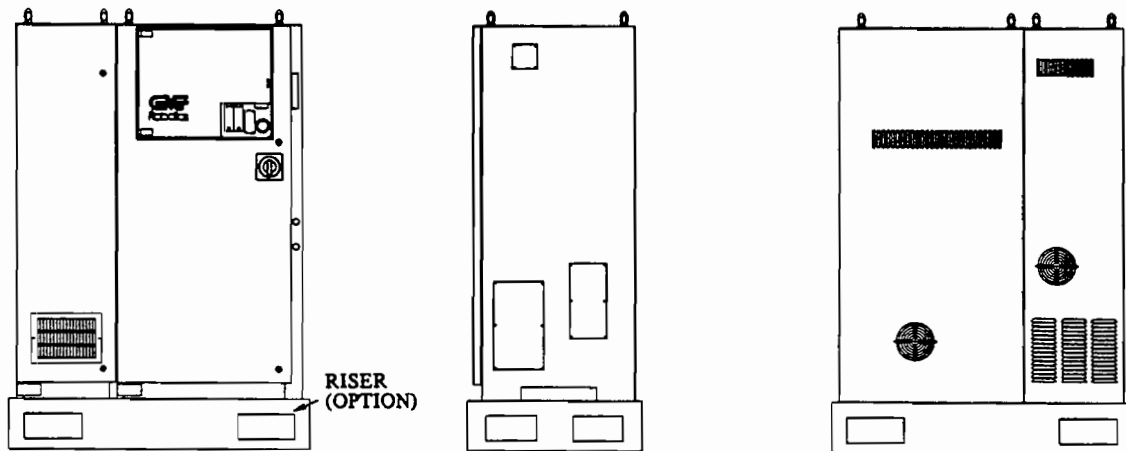
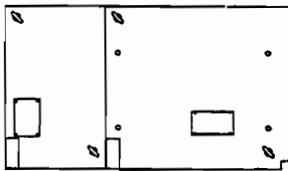


Fig. 3.2 (d) External view of controller (S-700, large size cabinet with side cabinet, circuit breaker handle)

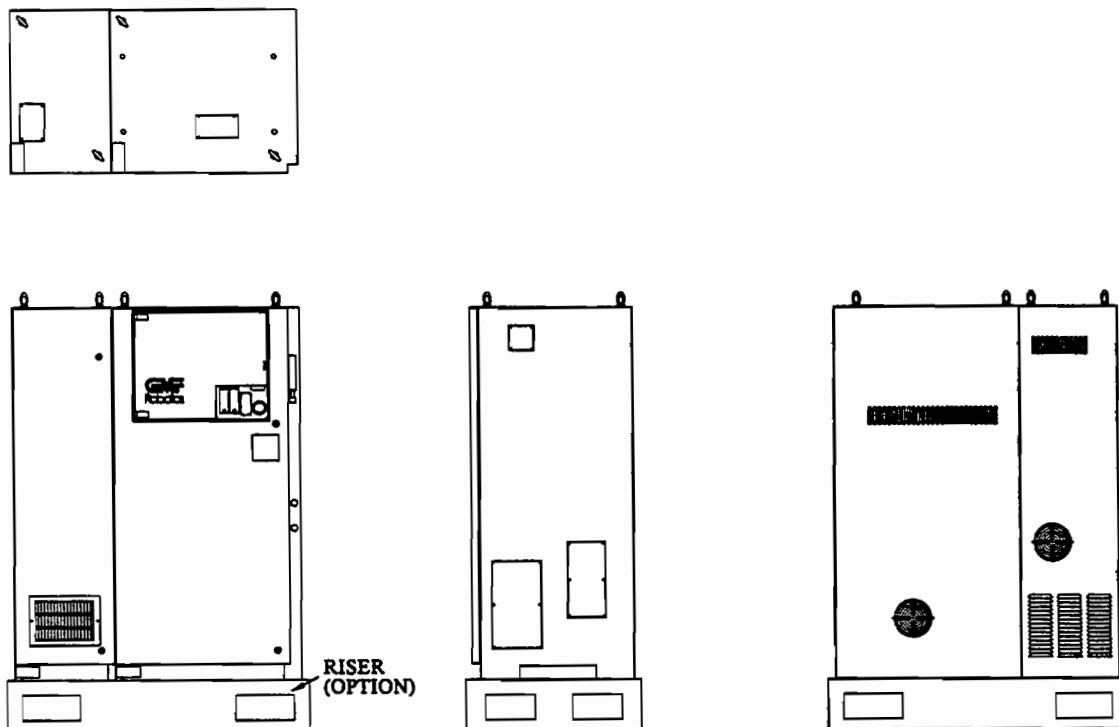


Fig. 3.2 (e) External view of controller (S-700, large size cabinet with side cabinet, power disconnect handle)

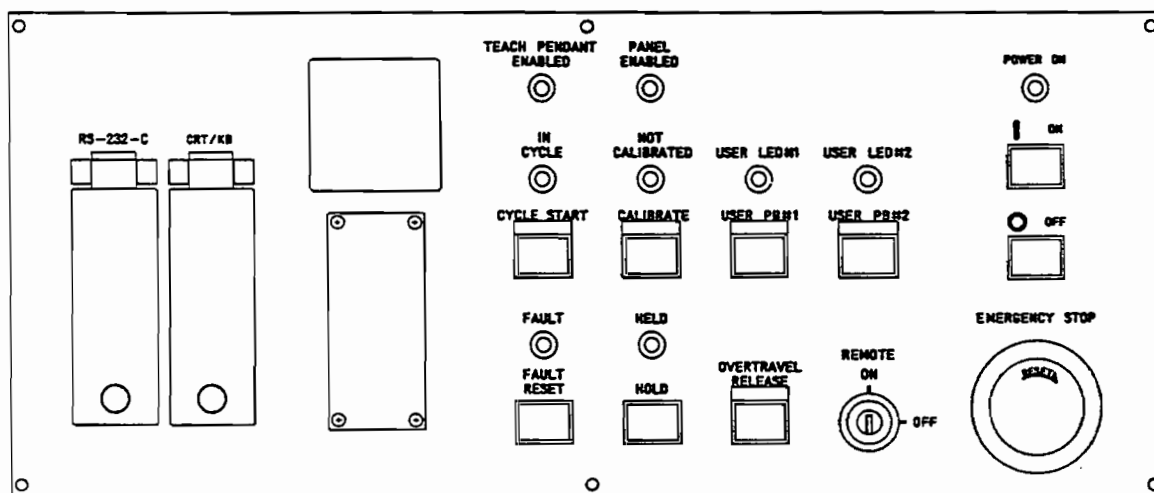
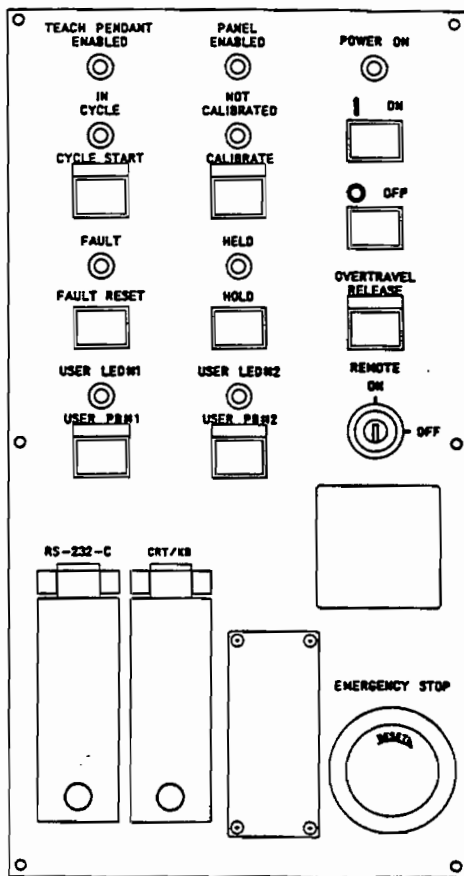
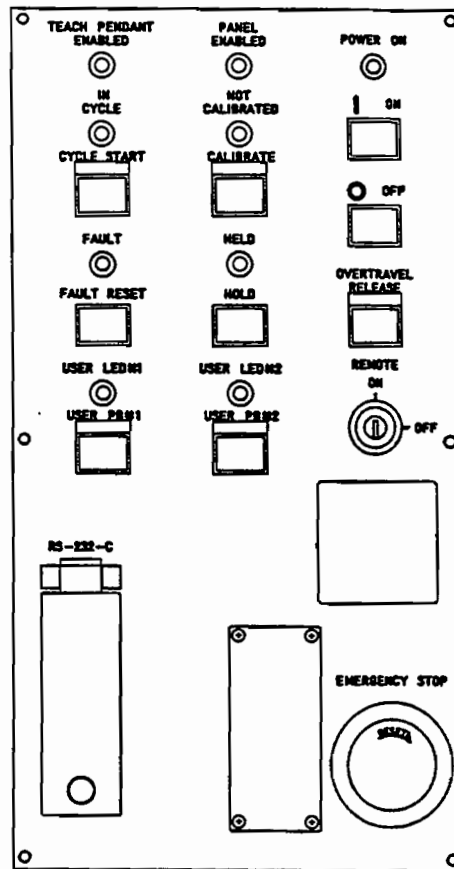


Fig. 3.2 (f) External view of horizontal type operator's panel (S-10 controller) (Medium size cabinet)



(For remote CRT/KB)



(For built-in CRT/KB)

Fig. 3.2 (g) External view of vertical type operator's panel
(S-10, S-700 controller with large size cabinet)

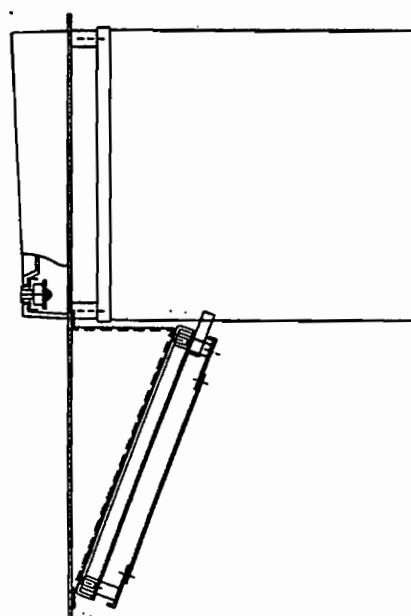
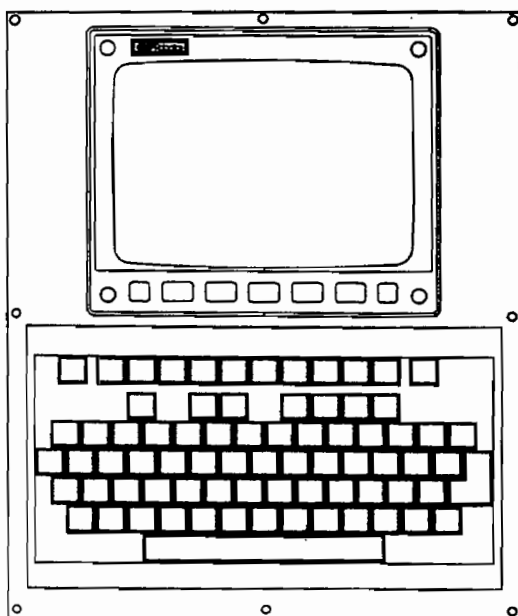


Fig. 3.2 (h) External view of built-in CRT/KB (20° angled)

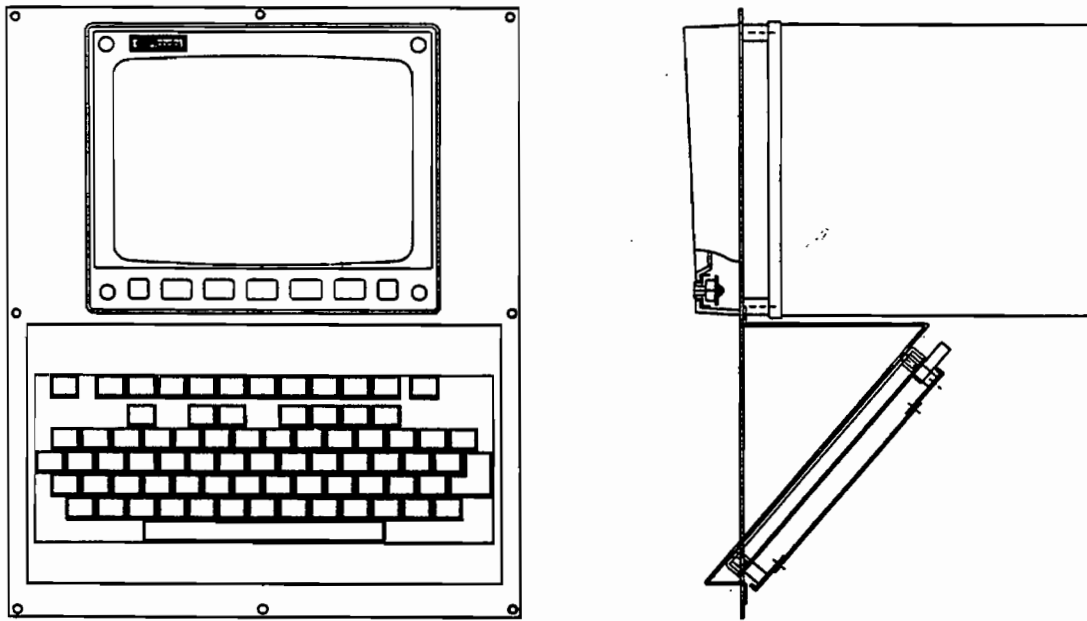


Fig. 3.2 (i) External view of built-in CRT/KB (40° angled)

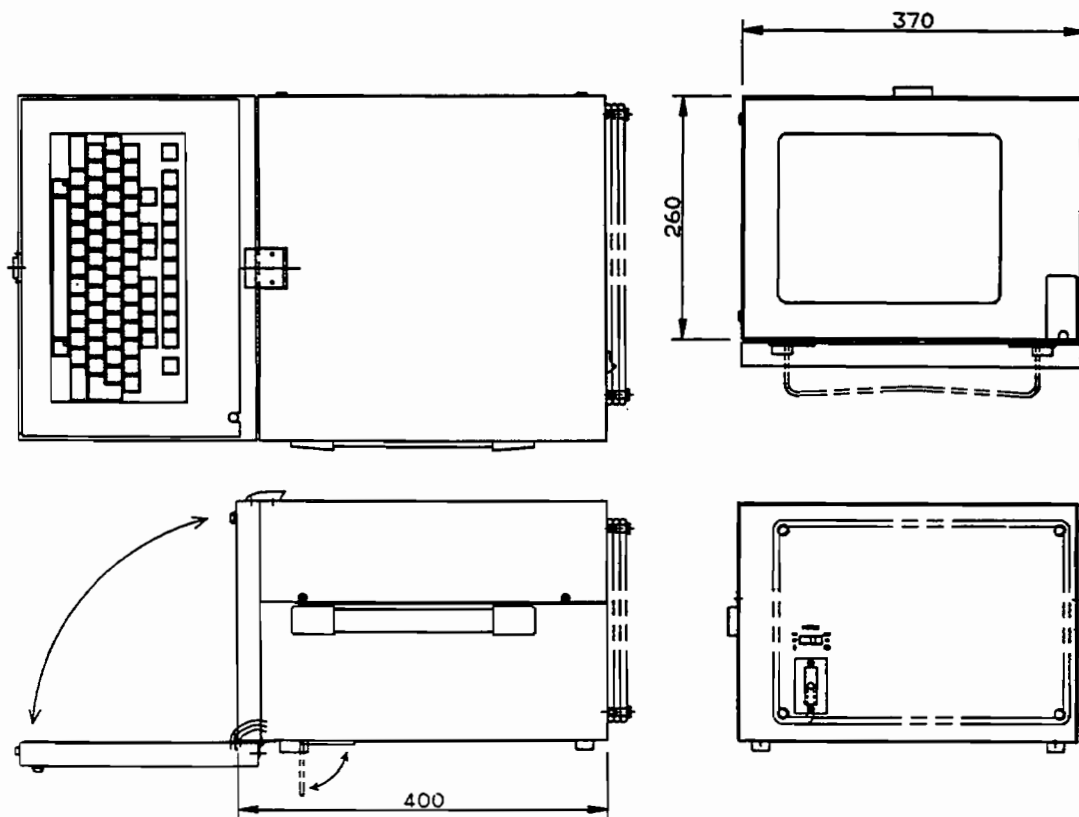


Fig. 3.2 (j) External view of remote CRT/KB

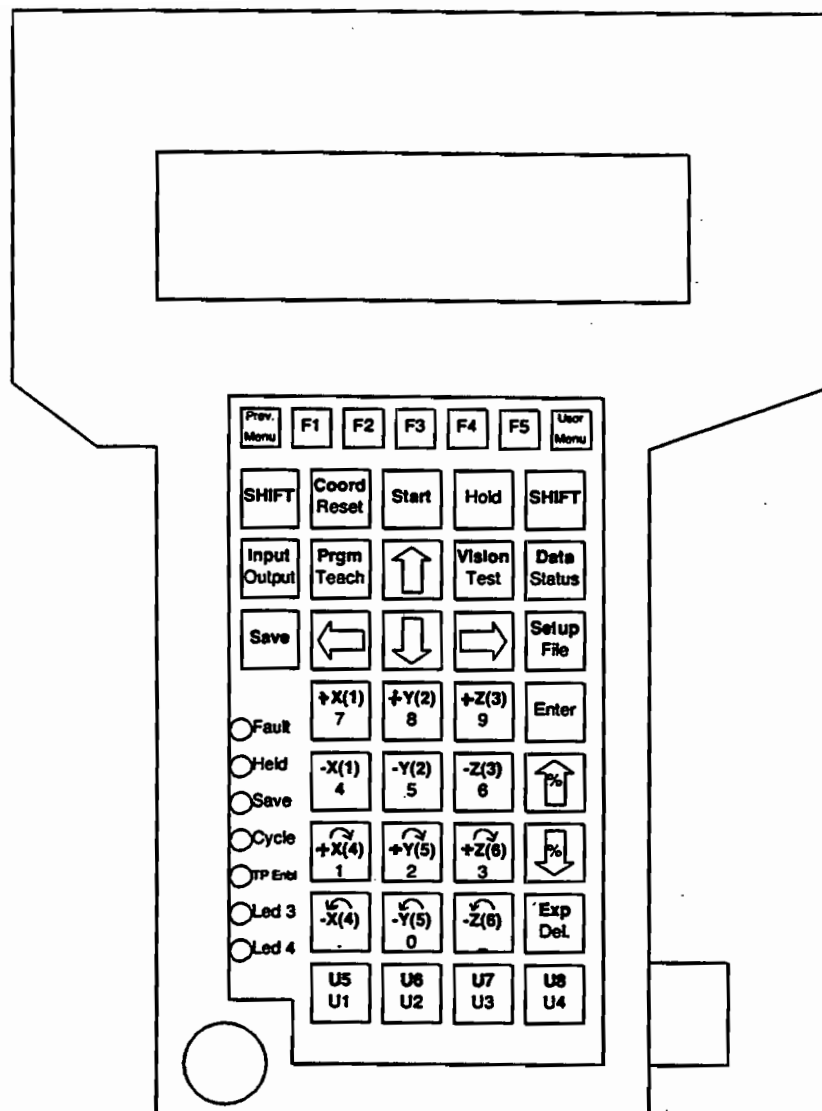


Fig. 3.2 (k) External view of the teach pendant

3.3 Internal Components

Various components are mounted in the controller. They are the basic control unit, I/O unit, servo amplifiers and so on.

For the internal components location diagram, refer to Fig. 3.3.

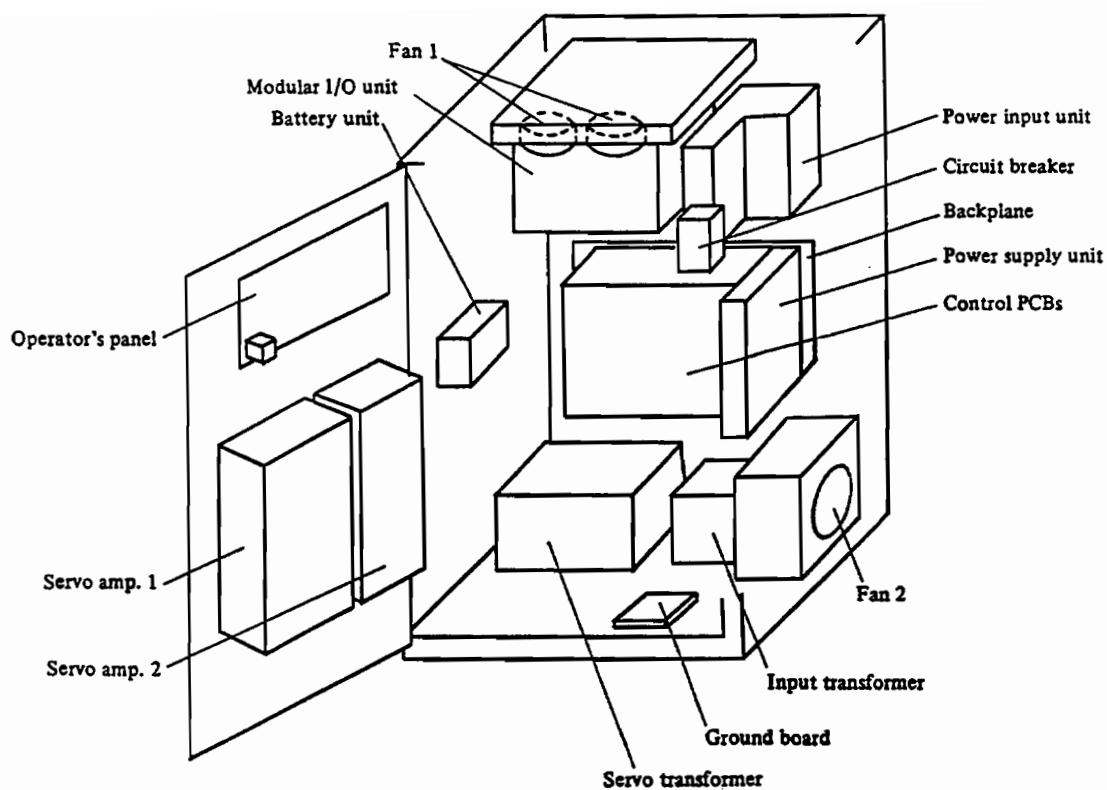


Fig. 3.3 (a) Internal component location (S-10, medium size cabinet)

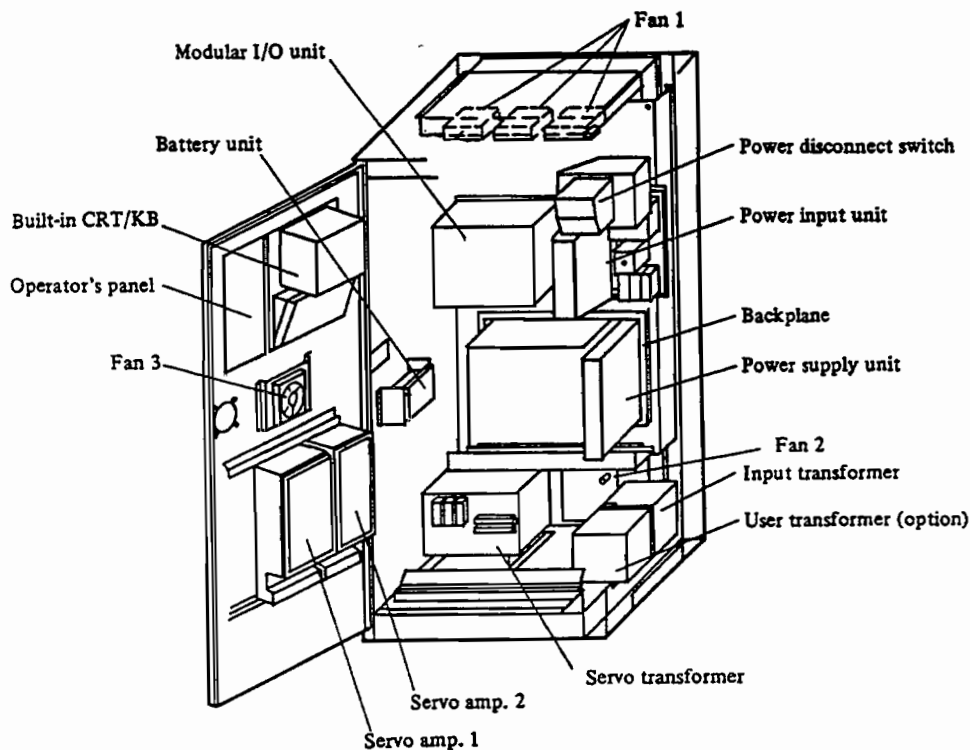


Fig. 3.3 (b) Internal component location (S-10, large size cabinet)

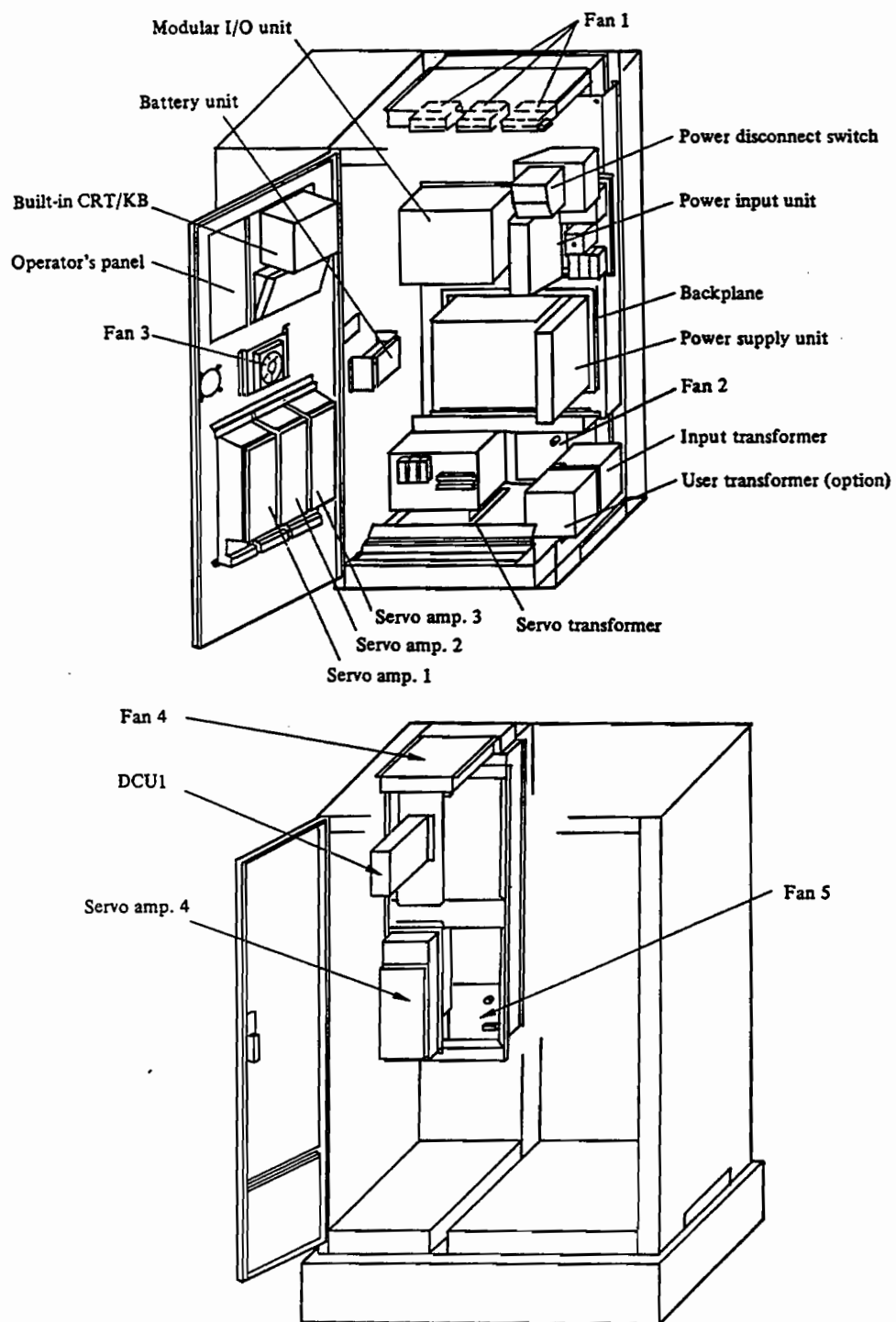


Fig. 3.3 (c) Internal components location (S-700, large size cabinet and side cabinet)

3.4 Controller Components Specifications

1) Common components for S-10 and S-700

Unit	Part number	Slot or module No.	Size
Basic control unit			
— Backplane	A20B-1002-0860		
— Power supply unit	A20B-1000-0770		
— Main CPU board	A16B-1211-0040	..... 01P09	2MB DRAM
	A16B-1211-0041	..... 01009	1MB DRAM
— Path CPU board	A16B-1211-0030	..... 01P02	
— Shared RAM board	A16B-1211-0860	..... 01P04	
— Bubble memory board	A16B-1211-0090	..... 01P08	2MB
	A16B-1211-0091	..... 01P08	1.5MB
	A16B-1211-0092	..... 01P08	1MB
— Fixed I/O board	A16B-1211-0750		
— Axis control board	A16B-1211-0060	..... 01P05	
	A16B-1211-0062	..... 02P05	
Modular I/O unit			
— I/O base unit	A03B-0801-C012		
— I/O backplane PCB	A20B-1002-0450		
— Robot control module	A03B-0801-C462	..... RC01C	
— Analog input module	A03B-0801-C410	..... AD04A	
— Analog output module	A03B-0801-C411	..... DA02A	
— DI module	A03B-0801-C420	..... ID08C	
	A03B-0801-C421	..... ID16C	
	A03B-0801-C422	..... ID08D	
	A03B-0801-C423	..... ID16D	
	A03B-0801-C424	..... IA08E	
	A03B-0801-C425	..... IA16E	
— DO module	A03B-0801-C440	..... OD08B	
	A03B-0801-C441	..... OD16B	
	A03B-0801-C442	..... OD08C	
	A03B-0801-C443	..... OD16C	
	A03B-0801-C444	..... OA08D	
	A03B-0801-C445	..... OA16D	
	A03B-0801-C446	..... OA08E	
	A03B-0801-C447	..... OA16E	
	A03B-0801-C448	..... OD08H	
	A03B-0801-C449	..... OD16H	
Built-in CRT/KB unit (Large size cabinet)			
(20 degree angled)	A05B-2051-C101		
(40 degree angled)	A05B-2051-C102		
— CRT monitor	A13B-0056-C001		
— Control PCB	A20B-1003-0340		
— Keyboard PCB	A86L-0001-0149		
— Software keyboard PCB	A20B-1000-0840		

Unit	Part number
Remote CRT/KB unit	A13B-0144-B001
— CRT monitor	A61L-0001-0088
— Control PCB	A16B-1211-0760
— Keyboard PCB	A86L-0001-0149
— Fan unit	A13B-0144-C001
Battery unit	
— Battery case	A98L-0004-0096
— Battery	A98L-0031-0005 (3 units are necessary)
Operator's panel	
(Horizontal type)	A05B-2045-C122
(Vertical type)	A05B-2051-C122 (for Remote CRT/KB)
(Vertical type)	A05B-2051-C121 (for Built-in CRT/KB)
Outlet unit	A05B-2051-C021
Servo-on lamp	
— Servo-on relay	A05B-2051-C051
— Lamp switch	A55L-0001-0124#LR22H
— Lamp	A49L-0001-0028#AHX-135
Teach pendant	A05B-2051-C142
— Control PCB	A20B-1002-0980
— Keyboard PCB	A20B-1002-0970
— LCD module	A61L-0001-0109
— LCD control board	A61L-0001-0100#CB1053RP

2) S-10 specific components

Unit	Part number
Controller	
(Medium size cabinet)	A05B-2066-B001
(Large size cabinet)	A05B-2067-B001
Transformer (Medium size cabinet)	
— Servo transformer TF1	A80L-0024-0002
— Input transformer TF4	A80L-0012-0010
Transformer (Large size cabinet)	
— Servo transformer TF1	A80L-0024-0004
— Input transformer TF4	A80L-0012-0010
— User transformer TF5	A80L-0001-0520
Servo amplifier	
— L: U axis (1-0)	
— M: θ axis (5RF)	
— N: W axis (5RF)	A06B-6058-H327
— L: α axis (3-OF)	
— M: β axis (3-OF)	
— N: γ axis (2-OF)	A06B-6058-H325
Note) The numbers in parentheses show the motor type.	
Fan units (Medium size cabinet)	
— Fan 1 (2 units)	A05B-2045-C901
— Fan 2	A05B-2045-C902
Fan units (Large size cabinet)	
— Fan 1 (3 units)	A05B-2051-C901
— Fan 2	A05B-2051-C902
— Fan 3	A05B-2051-C905
Circuit breaker (Medium size cabinet)	
(220/240 VAC input)	A60L-0001-0098#3/30A
(380-550 VAC input)	A60L-0001-0098#3/15A
(575 VAC input)	A60L-0001-0258#SA53H-15
Circuit breaker (Large size cabinet)	
(220/240 VAC input)	A60L-0001-0188#N
(380-550 VAC input)	A60L-0001-0098#3/20A
(575 VAC input)	A60L-0001-0258#SA53H-15
Circuit breaker with leak detector	
(220/240 VAC input)	A60L-0001-0116#CA
(380-550 VAC input)	A60L-0001-0116#AA

Unit	Part number
Power disconnect switch	A60L-0001-0181#175
Power input unit (220/240 VAC input, Medium size cabinet)	A14B-0076-B321
— Power input unit PCB	A16B-1310-0530
— Fuse	A60L-0001-0042#JG1-30
— Contactor	A58L-0001-0094#200V1A1B
Power input unit (380-550 VAC input, Medium size cabinet)	A14B-0076-B320
— Power input unit PCB	A16B-1310-0530
— Fuse	A60L-0001-0042#JG1-15
— Contactor	A58L-0001-0094#200V1A1B
Power input unit (220/240 VAC input, Large size cabinet)	A14B-0076-B323
— Power input unit PCB	A16B-1310-0530
— Fuse	A60L-0001-0042#JG1-30
— Contactor	A58L-0001-0094#200V1A1B
Power input unit (380-550 VAC input, Large size cabinet)	A14B-0076-B322
— Power input unit PCB	A16B-1310-0530
— Fuse	A60L-0001-0042#JG1-15
— Contactor	A58L-0001-0094#200V1A1B
Power input unit (200/240 VAC input, Power disconnect switch, Large cabinet)	A14B-0076-B325
— Power input unit PCB	A16B-1310-0530
— Fuse (FL1-3)	A60L-0001-0042#JG2-40
— Fuse (F7-9)	A60L-0001-0042#JG1-30
— Contactor	A58L-0001-0094#200V1A1B
Power input unit (380-575 VAC input, Power disconnect switch, Large cabinet)	A14B-0076-B324
— Power input unit PCB	A16B-1310-0530
— Fuse (FL1-3)	A60L-0001-0042#JG1-20
— Fuse (F7-9)	A60L-0001-0042#JG1-15
— Contactor	A58L-0001-0094#200V1A1B

3) S-700 specific components

Unit	Part number
Controller (Large size cabinet)	A05B-2061-B001
Transformer (Large size cabinet)	
— Servo transformer TF1	A80L-0024-0004
— Input transformer TF4	A80L-0012-0010
— User transformer TF5	A80L-0001-0520
Servo amplifier	
— L: α axis (1-0B)	A06B-6058-H222
— M: U axis (5RF)	
— L: β axis (1-0B)	A06B-6058-H221
— M: γ axis (1-0B)	
— θ axis (5RF)	A06B-6058-H012
— W axis (20F)	A06B-6058-H006
Note) The numbers in parentheses show the motor type.	
Discharge unit	A06B-6050-H050
Fan units (Large size cabinet)	
— Fan 1	A05B-2051-C901
— Fan 2	A05B-2051-C902
— Fan 3	A05B-2051-C905
— Fan 4	A05B-2051-C903
— Fan 5	A05B-2051-C902
Circuit breaker	
(220/240 VAC input)	A60L-0001-0188#J
(380-550 VAC input)	A60L-0001-0098#3/30A
(575 VAC input)	A60L-0001-0258#SA53H-20
Circuit breaker with leak detector	
(220/240 VAC input)	A60L-0001-0116#DA
(380-550 VAC input)	A60L-0001-0116#BA
Power disconnect switch	A60L-0001-0181#175
Power input unit (220/240 VAC input)	A14B-0076-B323
— Power input unit PCB	A16B-1310-0530
— Fuse	A60L-0001-0042#JG1-30
— Contactor	A58L-0001-0094#200V1A1B
Power input unit (380-575 VAC input)	A14B-0076-B322
— Power input unit PCB	A16B-1310-0530
— Fuse	A60L-0001-0042#JG1-15
— Contactor	A58L-0001-0094#200V1A1B

Unit	Part number
Power input unit (220/240 VAC input, Power disconnect switch)	A14B-0076-B325
— Power input unit PCB	A16B-1310-0530
— Fuse (FL1-3)	A60L-0001-0042#JG2-40
— Fuse (F7-9)	A60L-0001-0042#JG1-30
— Contactor	A58L-0001-0094#200V1A1B
Power input unit (380-575 VAC input, Power disconnect switch)	A14B-0076-B324
— Power input unit PCB	A16B-1310-0530
— Fuse (FL1-3)	A60L-0001-0042#JG1-20
— Fuse (F7-9)	A60L-0001-0042#JG1-15
— Contactor	A58L-0001-0094#200V1A1B

4. PREVENTIVE MAINTENANCE

Preventive maintenance is based upon the amount of hours of operation of the robot. Some applications require a robot to be operational for 24 hours a day, while others require less on-time. If the robot is to operate continually, all check items should be maintained accordingly. The following chart should be used as a quick reference guide for preventive maintenance. This chart is based upon hours of operation and not calendar time. Some items should be checked as a daily routine by the operator. Quality of the work accomplished by the robot should be checked to determine the need for maintenance. Use the chart to indicate minimum preventive maintenance requirements. Hot, dusty, dirty or other poor environment will accelerate the frequency of maintenance.

Note) Appendix 3 contains a reference matrix of preventive maintenance schedules and a maintenance check list.

4.1 Daily Checks

Clean each part, and visually check the overall system and component parts for damage before daily system operation. Check the following items as the occasion demands.

- 1) Before automatic operation check items one through eight, listed in Table 4.1
- 2) After automatic operation, return the robot to the zero position and turn off the power. Continue the maintenance checks by checking items nine through 10 in Table 4.1.

Table 4.1 Daily preventive maintenance checks

Item	Check items		Check points
1	When air control set is combined	Air pressure	Check air pressure using the pressure gauge on the air regulator. If it does not meet the specified pressure of 5-7 kg/cm ² (standard 5 kg/cm ²), adjust it using the regulator pressure setting handle. See Fig. 4.1.
2		Oiler oil mist quantity	Check the drop quantity during wrist or hand motion. If it does not meet the specified value (1 drop/10-20 sec), adjust it using the oiler control knob. Under normal usage the oiler becomes empty in about 10 to 20 days under normal operation.
3		Oiler oil level	Check to see that the oiler level is within the specified level shown in Fig. 4.1.
4		Leakage from hose	Check the joints, hoses, etc. for leaks. Repair leaks, or replace parts, as required.
5	Visual check of cables		Refer to II-6.4 (S-10) and III-6.4 (S-700).

Item	Check items	Check points
6	Vibration, abnormal noises, and motor heating	Check to see that each axis moves smoothly.
7	Changing repeatability	Check to see that the stop position of the robot has not deviated from previous stop positions.
8	Peripheral devices for proper operation	Check whether the peripheral devices operate properly according to commands from robot.
9	Cleaning and checking of each part	Clean each part (remove chips, etc.) and check component parts for cracks and flaws.
10	Ventilation portion of control unit	If the ventilation portion of the control unit is dusty, turn off power and clean the unit.
11	U/W-axis brake	Refer to II-3.2 (S-10) and III-3.2 (S-700).

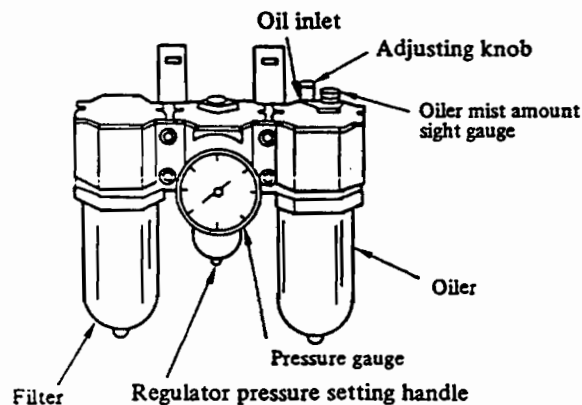


Fig. 4.1 Air control set

4.2 Monthly Checks (Determined by hours of operation)

Check the following items monthly. Additional inspection areas and times should be added to the table according to the robot's working conditions, environment, etc.

Table 4.2 Monthly preventive maintenance checks (or 500 hours)

Item	Check items	Check points
1	Check lubrication	Refer to II-2 (S-10) and III-2 (S-700).
2	Check each part for play and looseness	
3	Check connectors for looseness	Push-in connector assembly and retighten lock ring.

4.3 Quarterly Checks

Check the following items once every three months (or 1000 hours).

Table 4.3 Quarterly preventive maintenance checks

Item	Check items	Check points
1	Grease	Refer to II-2 (S-10) and III-2 (S-700).

4.4 Semiannual Checks

Check the following items once every 6 months (or 2000 hours).

Table 4.4 Semiannual periodic maintenance checks

Item	Check items	Check points
1	DC power voltage check	Check the +5 V, +15 V, +24 V, and -15 V power supplies of the power unit and the +24 V, +15 V, and -15 V power supplies of the servo unit for the specified values.

4.5 3-year Checks

Check the following items once every 3 years.

Item	Check items	Check points
1	Grease	Refer to II-2 (S-10) and III-2 (S-700).

4.6 Periodic Replacement

Replace the following parts when needed.

Item	Replaced parts	Replace
1	Filter cover on control unit	Replace once every two years if needed.

4.7 Maintenance Tools

The following instruments and tools are required for the maintenance procedures contained in this manual.

1) Measuring instruments

Instruments	Accuracy/Tolerance	Applications
AC voltmeter	AC power voltage measurement. Tolerance: Less than <u>+2%</u>	AC power voltage measurement
DC voltmeter	Maximum scale 10 V, 30 V Tolerance: Less than <u>+2%</u> (A digital voltmeter is required 20,000 ohm/volt)	DC power voltage measurement
Oscilloscope	Frequency bandwidth: DC to greater than 5 MHz, 2 channels	

Item	Check items	Check points
Dial gauge	1/100 mm	Measurement of positioning and backlash.
Slide calipers	150 mm	

2) Tools

Tool	Size
Cross-point (+) screwdrivers	Large, medium, and small sizes
Conventional (-) screwdrivers	Large, medium, and small sizes
Hexagonal wrench key sets (metric)	M3 - M16
Adjustable wrenches	Medium and small sizes
Pliers	Adjustable, long nose
Cutting pliers	Diagonal
Grease gun	With output pipe and fitting
Pliers for C-retaining ring	Internal and external
Dial indicator and stand	0-10 mm range

5. TROUBLESHOOTING

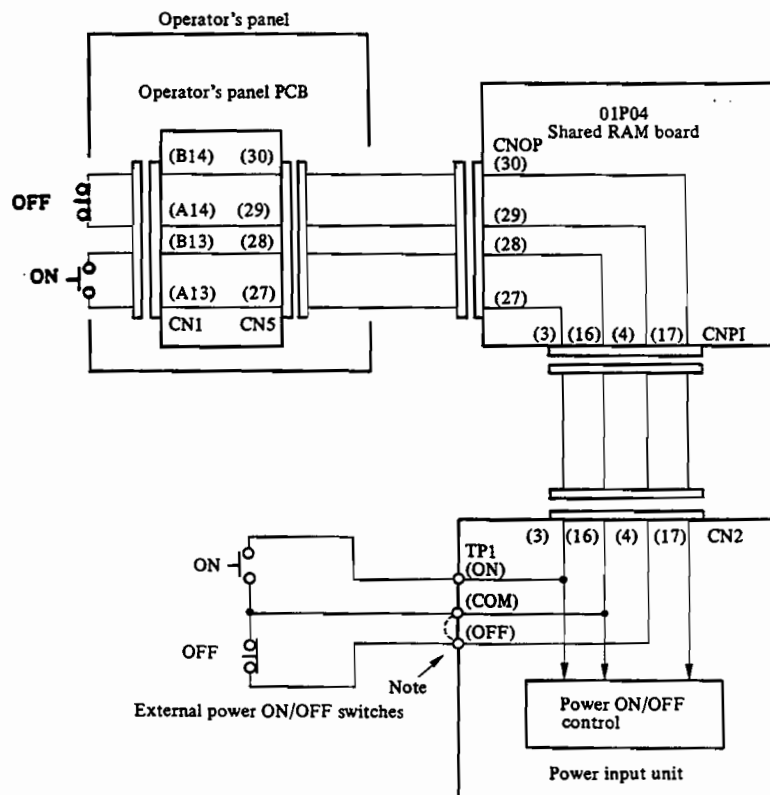
5.1 Introduction

This section contains information for troubleshooting the system. The material included here describes the alarms that are involved with hardwired circuits. Refer to the KAREL System Reference Manual for a description of all of the error codes.

5.2 Power Cannot be Turned On

Item	Cause of trouble	Checking procedure	Corrective action
1	Input power supply is not connected	1) Check whether the circuit breaker or disconnect switch is turned on.	
		2) Check to see that the pilot lamp PIL (green LED) is lit in the power input unit. (Refer to 23.4.3)	
		3) When PIL is OFF, make sure that input power is supplied at the connection terminal for 200R and 200S on the power input unit.	
		4) When power is not supplied to the power input unit at 200R and 200S, fuse F1 on the input transformer TF4 may be blown. (Refer to 24.1)	Remove causes of blown fuse and replace the fuse.
		5) When power is supplied to power input unit and PIL is OFF, refer to 23.4.4. Fuse F1, F2, or F3, on the power input unit may be blown.	Remove causes of blown fuses and replace fuses.
2	Alarm lamp is ON	1) Refer to 23.4.3. Make sure that lamp ALM (red LED) is OFF. If it is ON, remove the cause. Press POWER OFF button once, and then press POWER ON button to turn power on.	
3	Cable connection	1) Make sure that the cables are correctly connected as shown in Fig. 5.2.	
4	POWER OFF switch on operator's panel is faulty	1) Verify that the POWER OFF button contact is closed.	Replace POWER OFF switch.

Item	Cause of trouble	Checking procedure	Corrective action
4	POWER OFF switch on operator's panel is faulty	2) Verify that two pins "OFF" on the power input unit PCB of the power input unit are shorted. (Refer to 23.4.1)	
5	POWER OFF contact of external power supply ON/OFF	1) Make sure that OFF and COM are shorted at TP1 terminal on the power input unit PCB of the power input unit. (Refer to 23.4.2)	If not shorted, short them by using a shorting strip.
6	POWER ON switch on operator's panel is faulty	1) Verify that the contact is closed when the POWER ON button is pressed.	Replace POWER ON switch.
		2) Make sure that two pins "ON" on CN2 on the power input unit PCB of the power input unit are shorted when the POWER ON button is pressed. (Refer to 23.4.2)	



Note) A jumper wire is necessary between OFF and COM when external power ON/OFF switches are not available.

Fig. 5.2 Power ON/OFF control

5.3 Troubleshooting Using Error Codes

The 4000 error codes indicate problems in servo control. The number included with the error message is interpreted as follows:

008: error on 1st axis
004: error on 2nd axis
002: error on 3rd axis
001: error on 4th axis
080: error on 5th axis
040: error on 6th axis

5.3.1 Error code 4001 DEADMAN switch

This signal indicates that the teach pendant is enabled and the DEADMAN switch is not being held. Its function is to indicate a breakage in the circuit string between the teach pendant and controller. When the switch is held in, the signal is not active. Releasing the switch, or breaking the cable, will result in the alarm being displayed. Power to the servo amplifier is removed, and the robot is placed in an emergency stop condition.

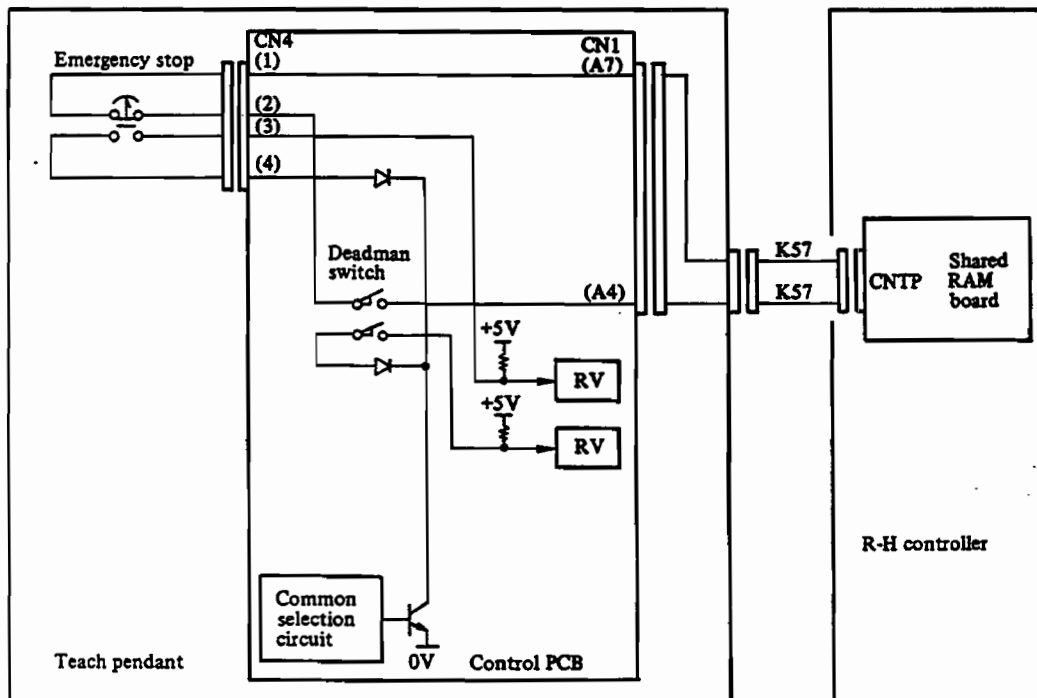


Fig. 5.3.1 Error code 4001 DEADMAN switch

5.3.2 Error code 4002 emergency stop

The emergency stop alarm indicated that one of the E-stop buttons has been pressed or that the E-stop wiring is defective. EMERGENCY STOP buttons are located on the teach pendant and on the operator's panel. Additional buttons may be connected to the external emergency stop circuit.

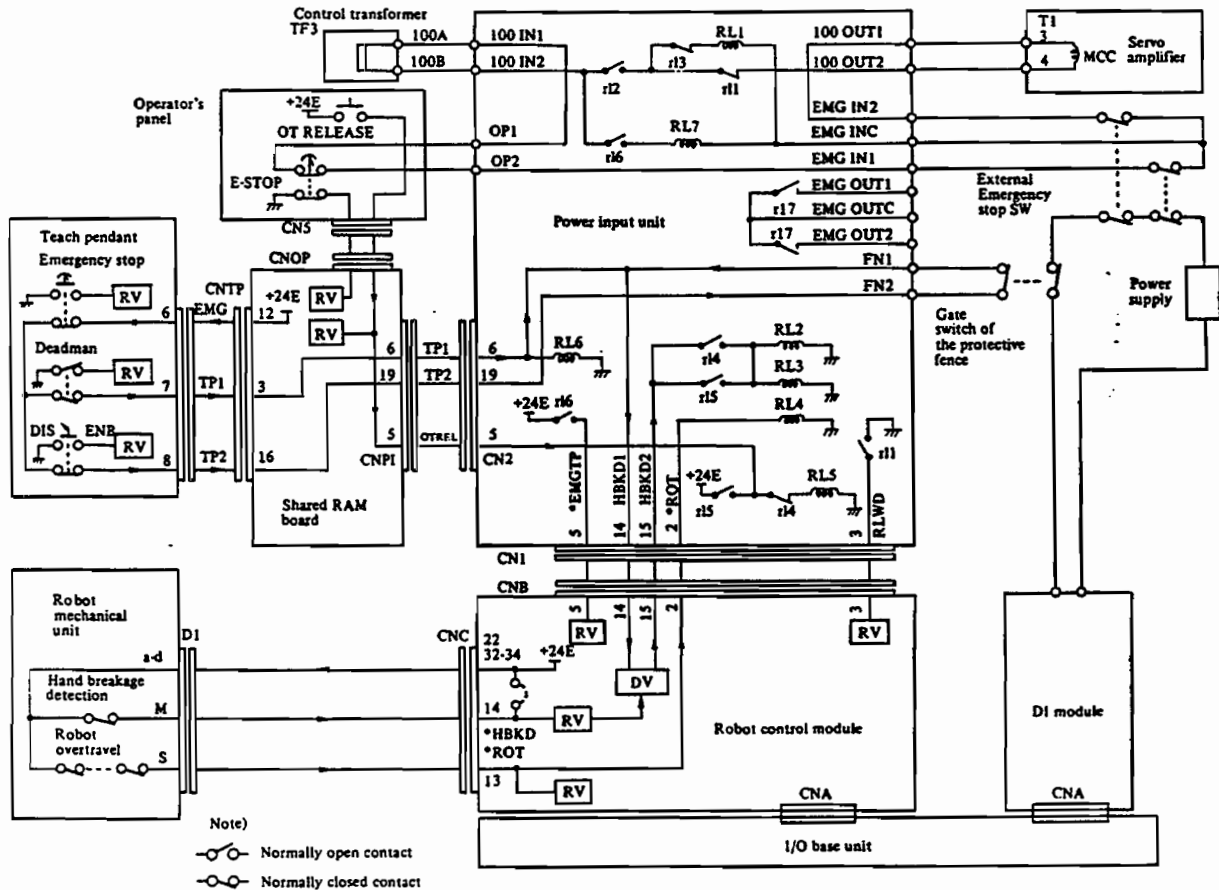
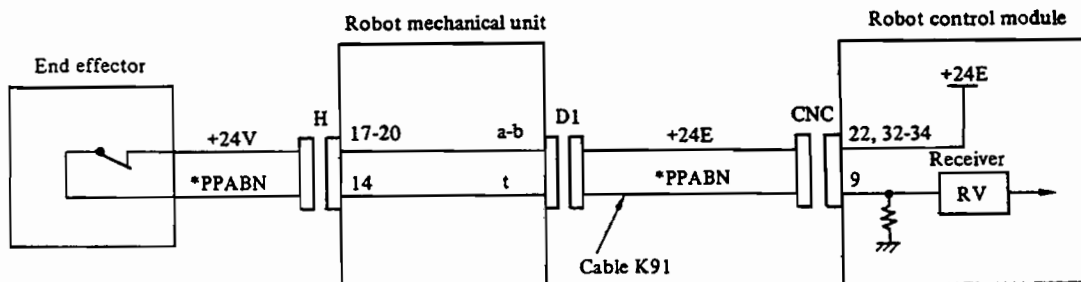


Fig. 5.3.2 Error code 4002 emergency stop

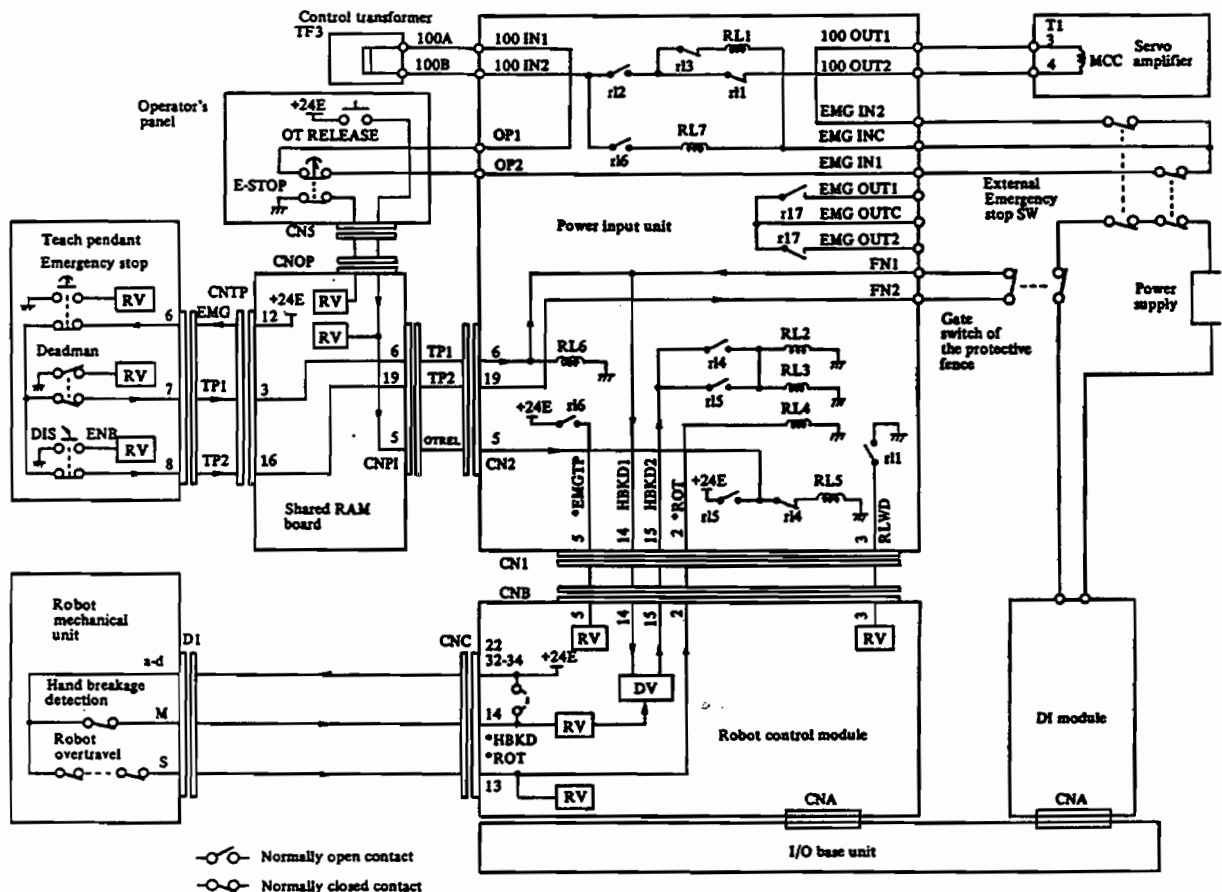
5.3.3 Error code 4003 pneumatic pressure alarm

This alarm indicates that the pneumatic pressure used in the end effector is abnormal. Check the pneumatic pressure and/or pneumatic pressure input *PPABN to the controller. The contact *PPABN is normally closed. See section IV-4.2 for the connection of this contact.



5.3.4 Error code 4004 hand breakage detection

The hand-break-detect circuit monitors the operating condition of the safety switch on the end effector. This normally closed switch opens when a crash occurs and places the robot into a stop condition. This stop resembles an emergency stop or other major alarm which removes power from the servo amplifier and applies the brakes.



Note) Refer to the mechanical unit internal connection diagram in Appendix 1 for circuit wiring in the mechanical unit.

Fig. 5.3.4 Error code 4004/4005 hand breakage detection and robot overtravel

5.3.5 Error code 4005 robot overtravel

Robot overtravel indicates that an axis has exceeded its limits and has activated a limit switch. All axes employ limit switches that are mounted at the positive and negative extremes of the motion range and are wired in series. Robot overtravel alarms indicate that an opening in the series string has occurred. When this alarm occurs, the power is removed from the drives and brakes are applied. The robot axis must be moved, until the switch releases, before resetting is possible. Refer to Fig. 5.3.4.

5.3.6 Error code 4006 relay welding detection

This error indicates the contacts of the emergency stop relay (RL2) on the power input unit PCB are welded together. If this alarm cannot be reset, replace RL2.

5.3.7 Error code 4008 TGLS alarm

The function of the TGLS alarm is to indicate a problem in the feedback system. Each axis pulse encoder's information is monitored in the controller. If a signal is lost, the alarm is sent, and the robot motion is terminated. Refer to the following figures.

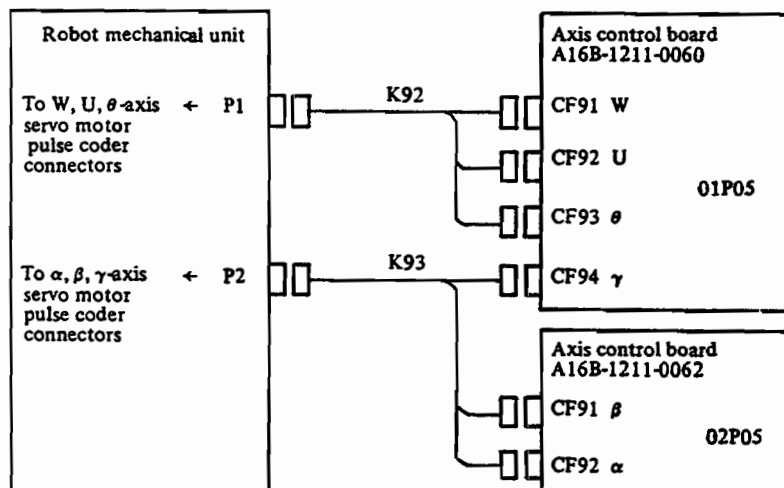


Fig. 5.3.7 (a) Error code 4008 TGLS alarm, S-10

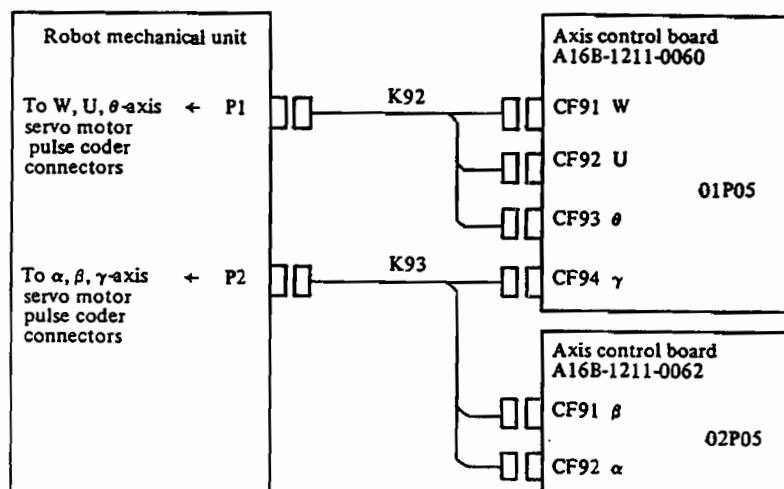


Fig. 5.3.7 (b) Error code 4008 TGLS alarm, S-700

CF91 of 01P05 (W)	1	0 V	8	OH1A	14	PCZA1
	2	0 V	9	OH2A	15	*PCZA1
	3	0 V	10	C8A1	16	PCAA1
	4	+5 V	11	C4A1	17	*PCAA1
	5	+5 V	12	C2A1	18	PCBA1
	6	+5 V	13	C1A1	19	*PCBA1
	7				20	REQA1

CF94 of 01P05 (Y)	1	0 V	8	OH1B	14	PCZA4
	2	0 V	9	OH2B	15	*PCZA4
	3	0 V	10	C8A4	16	PCAA4
	4	+5 V	11	C4A4	17	*PCAA4
	5	+5 V	12	C2A4	18	PCBA4
	6	+5 V	13	C1A4	19	*PCBA4
	7				20	REQA4

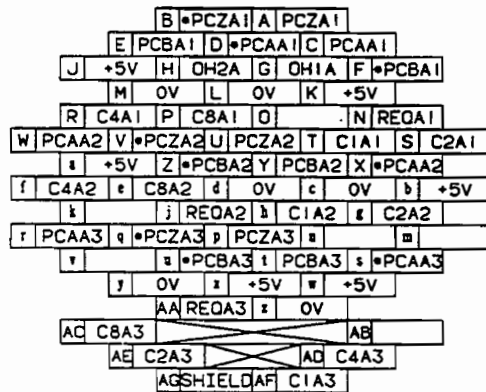
CF92 of 01P05 (U)	1	0 V	8	OHA2	14	PCZA2
	2	0 V	9	OHA2	15	*PCZA2
	3	0 V	10	C8A2	16	PCAA2
	4	+5 V	11	C4A2	17	*PCAA2
	5	+5 V	12	C2A2	18	PCBA2
	6	+5 V	13	C1A2	19	*PCBA2
	7				20	REQA2

CF91 of 02P05 (S)	1	0 V	8	OHA5	14	PCZA5
	2	0 V	9	OHA5	15	*PCZA5
	3	0 V	10	C8A5	16	PCAA5
	4	+5 V	11	C4A5	17	*PCAA5
	5	+5 V	12	C2A5	18	PCBA5
	6	+5 V	13	C1A5	19	*PCBA5
	7				20	REQA5

CF93 of 01P05 (Θ)	1	0 V	8	OHA3	14	PCZA3
	2	0 V	9	OHA3	15	*PCZA3
	3	0 V	10	C8A3	16	PCAA3
	4	+5 V	11	C4A3	17	*PCAA3
	5	+5 V	12	C2A3	18	PCBA3
	6	+5 V	13	C1A3	19	*PCBA3
	7				20	REQA3

CF92 of 02P05 (α)	1	0 V	8	OHA6	14	PCZA6
	2	0 V	9	OHA6	15	*PCZA6
	3	0 V	10	C8A6	16	PCAA6
	4	+5 V	11	C4A6	17	*PCAA6
	5	+5 V	12	C2A6	18	PCBA6
	6	+5 V	13	C1A6	19	*PCBA6
	7				20	REQA6

P1(MS3106B 32A10S)



P2(MS3106B 32A10S2)

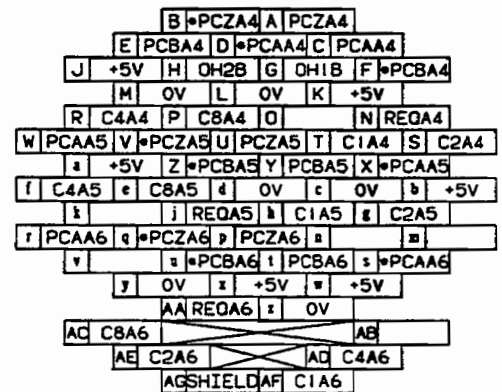


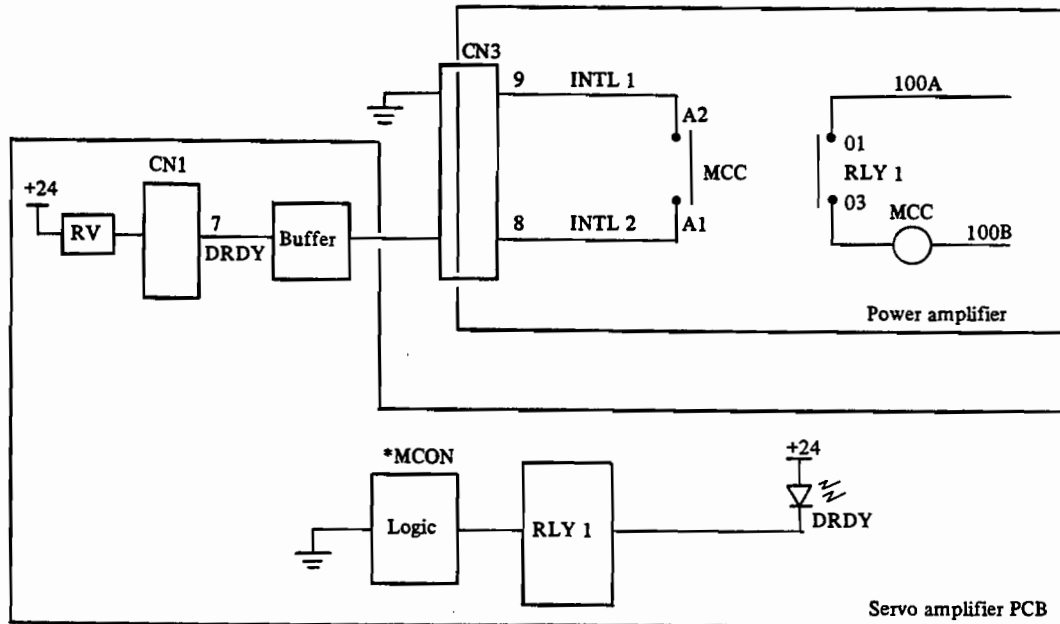
Fig. 5.3.7 (c) Error code 4008 TGLS alarm

5.3.8 Error codes 4009 - 4014

Error codes 4009 - 4014 indicate a problem on the servo amplifier. Refer to section 5.4 "Troubleshooting Servo Amplifier".

5.3.9 Error code 4020 velocity ready is off

The *DRDY signal, indicating the servo amplifier is on, has not been received after *MCON signal is sent to the servo amplifier PCB. Verify that RYL1 is operating properly and that 100 V (wire number 100A) is present.



5.3.10 Error code 4007 Motor Overheat

An overload alarm indicates that a thermal sensor in the controller has detected an overload. Sensors are located in the servo amplifiers, servo transformer and the motors. This condition is usually caused by an axis exceeding its capacity or duty cycle. All of the sensors are self-resetting after they cool sufficiently. When the alarm occurs, power is removed from the servo drives, and robot motion is stopped.

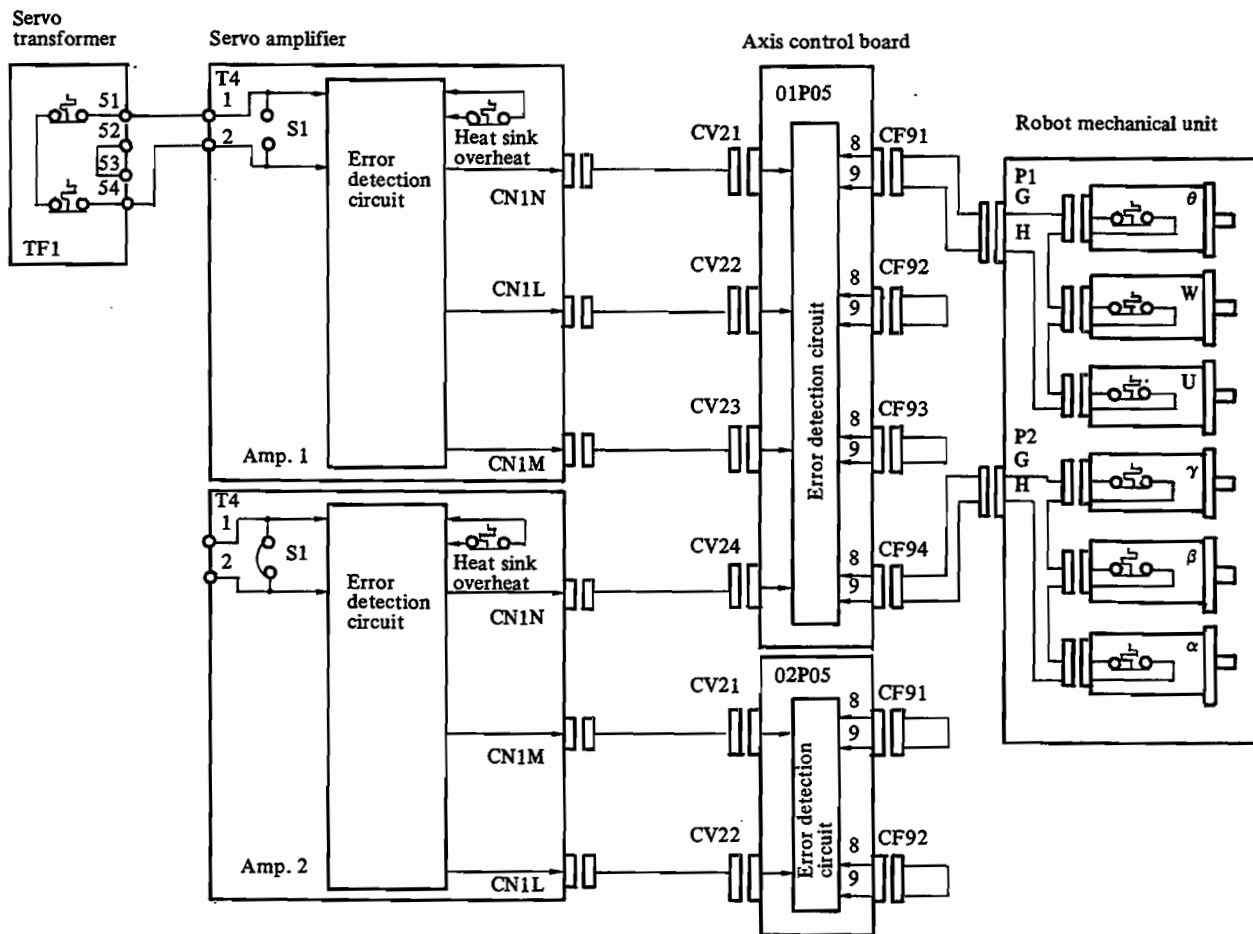


Fig. 5.3.10 (a) Error code 4007 Motor Overheat (S-10)

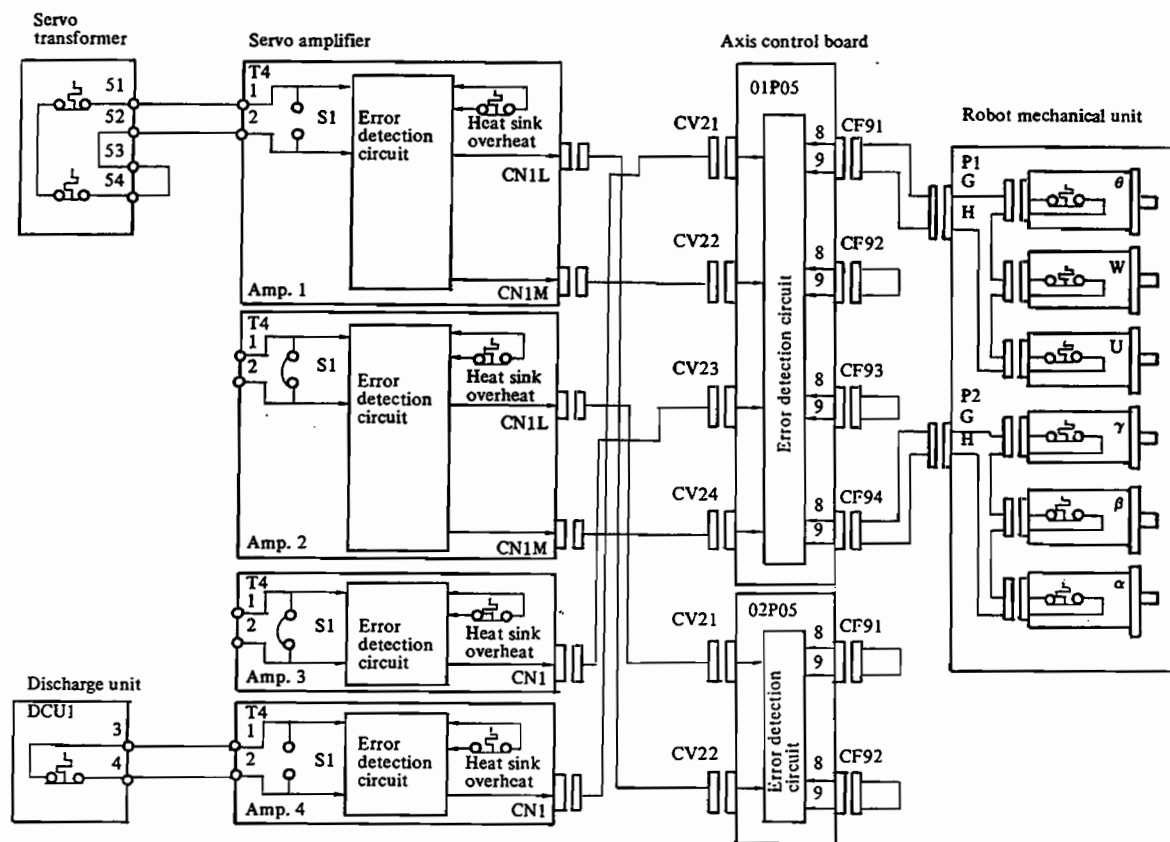


Fig. 5.3.10 (b) Error code 4007 Motor Overheat (S-700)

5.3.11 Error code 4024 fuse alarm in brake circuits

The fuse alarm indicates that one or more fuses on the power input unit PCB has blown. Each fuse contains an internal switch which triggers the alarm when the fuse blows. A blown fuse might have been caused by an overload condition or a short circuit in the brake wiring. By observing which fuse is blown, the problem area may be narrowed to a group of drives.

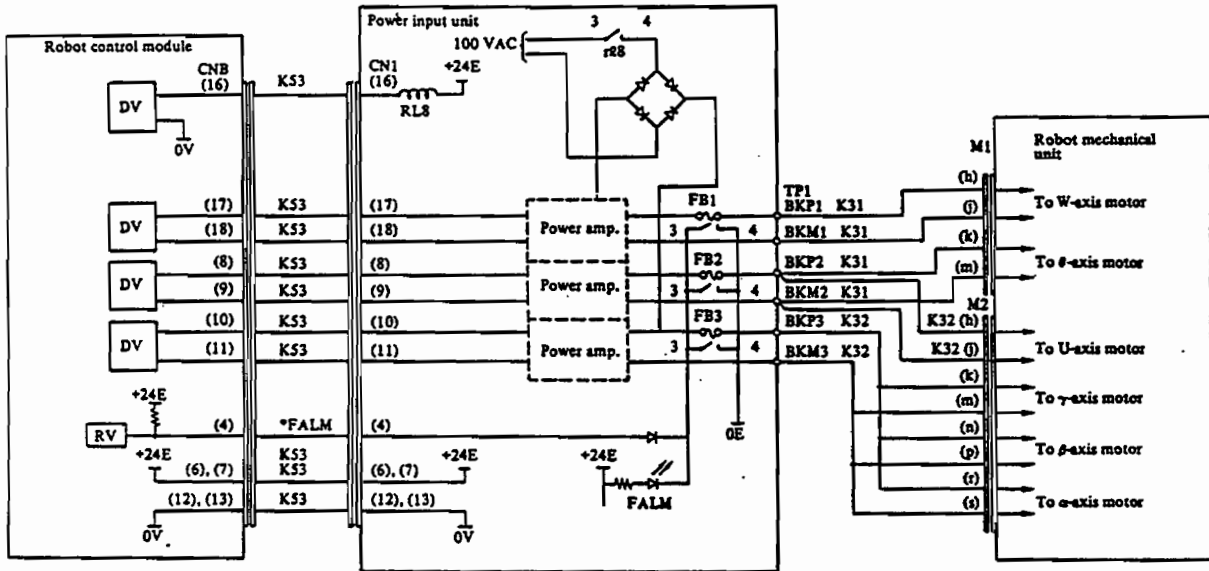


Fig. 5.3.11 (a) Error code 4024 fuse alarm on power input unit PCB (S-10)

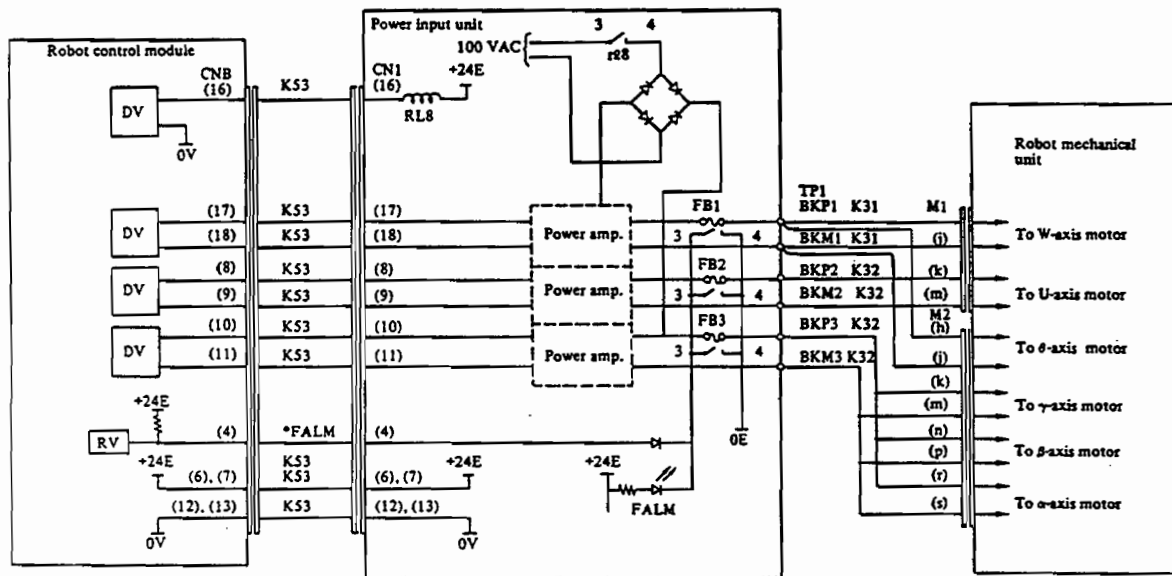


Fig. 5.3.11 (b) Error code 4024 fuse alarm on power input unit PCB (S-700)

5.4 Troubleshooting Servo Amplifier

1) Protection and error detection functions

The servo amplifier has the following functions designed to protect the motor from overload and to detect an error in servo loop circuits.

No.	Kinds of functions	Indications	Description
1	Overload	Overload alarm is indicated for the control unit	If the temperature of the radiation fin on the servo amplifier or of the servo transformer exceeds a set value, this overload alarm is generated.
2	Circuit breaker (No-fuse breaker)	Circuit breaker is tripped	If an abnormal current exceeding the rated limit of the breaker is applied to the motor, this NFB operates, causing the motor to be stopped by dynamic braking.
3	High voltage alarm	LED HV lights	If the DC voltage of the main power supply is abnormally high, the motor is stopped by dynamic braking and the HV lamp lights.
4	Low voltage alarm	LED LV lights	If control voltage is abnormally low, the motor is stopped by dynamic braking and the LV lamp lights.
5	Circuit fault detection	LED HC lights	If an abnormally high current flows to the main circuit, the motor is stopped by dynamic braking and the HC lamp lights.
		LED DC lights	If the regenerative discharge circuit malfunctions, or if the acceleration/deceleration rate is too high, the motor is stopped by dynamic braking and the DC lamp lights.

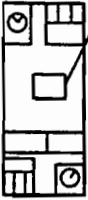
2) Troubleshooting

Troubleshooting and fault recovery are discussed in this section.

a) Overload alarm

Item	Causes of problems	Check procedures	Corrective action
1	PCB setting failure	Check if S1 of PCB is set as specified.	Set S1 properly.
2	Thermostat of the servo transformer is open.	Remove the wires connected to transformer terminals 51 and 54 and measure the resistance across them. The normal value is 10 ohms or less, if the circuit is open (more than 100 kilo-ohms), the thermostat is open. If the thermostat is open and the surface temperature of the transformer is 80 to 90°C, check the motor current. If the surface temperature is 60° or less, the transformer is defective.	Check the friction torque. Replace the transformer.
3	Radiation fins of the unit are overheated.	Check the motor current.	Reduce the load.
4	Thermostat of the servo motor is open.	Check the motor current. Check to see if the friction in the robot mechanical part is excessively large.	Reduce the load on the motor.
5	Thermostat of the discharge unit is open.	Verify the acceleration/deceleration time of the motor.	Adjust the acceleration/deceleration rate.

b) Circuit breaker is tripped

Item	Causes of problems	Check procedures	Corrective action
1	Circuit breaker is tripped.	<p>The operating condition of the breaker is as illustrated below.</p>  <p>This button pops out when the circuit breaker is tripped. Depress this button after turning off the power supply to reset the circuit breaker.</p>	Reset the breaker after turning off the power supply. (If the breaker cannot be reset immediately, wait for about 10 minutes before resetting it.)
2	Diode module DS or other parts are defective in servo amplifier.	The circuit breaker is tripped just when turning on the power supply after the corrective action in Item 1 is taken.	Replace diode module DS or servo amplifier.
3	Mechanical unit malfunctions.	Observe the servo amplifier PCB using an oscilloscope to determine if the load current of the motor exceeds the rated current during rapid movement. Refer to section 26.	Remove the overload.

c) HV alarm

Item	Causes of problems	Check procedures	Corrective action
1	Input AC power voltage is higher than specified.	Check if the servo transformer taps are properly connected.	Repair tap connection.
2	Servo motor is defective.	Check if the insulation resistance is normal between the motor armature (power line) and the body.	Replace motor.
3	Load inertia is excessive.		Increase the acceleration/ deceleration time constant.
4	PCB is defective.	If HV alarm occurs without any defect in items 1, 2, 3, the PCB is defective.	Replace the PCB.

Item	Causes of problems	Check procedures	Corrective action
5	The regenerative discharge unit is defective.	Determine if the regenerative discharge circuit is defective and that the wiring is properly connected.	Replace the PCB, discharge transistor, or discharge unit.

d) LV alarm

Item	Causes of problems	Check procedures	Corrective action
1	Input AC power voltage is lower than specified.	Check if the input AC power voltage and tap connection of servo transformer are correct.	Correct the tap connection.
2	+5 V supply circuit is defective.	Check if +5 V is normal.	Replace the PCB.
3	PCB is defective.	If LV alarm occurs and items 1 and 2 are not defective, the PCB is defective.	Replace the PCB.

e) HC alarm

Item	Causes of problems	Check procedures	Corrective action
1	Wrong connection of motor power line	HC alarm does not occur when the power supply is turned on after the motor power line has been disconnected. (Since the gravity axis may drop in this case, support it or disconnect the drive cable of gravity axis brake.)	Reconnect the motor power line correctly.

Item	Causes of problems	Check procedures	Corrective action
2	Transistor module is defective.	Check if HC alarm occurs when the power supply is turned on after disconnecting the power line according to item 1. Turn off the power supply, remove PCB, and check the right terminal of the transistors module with a circuit tester. The transistor module is defective if the resistance between terminals is several ohms (within 10 ohms).	Replace transistor module. Check resistance between C_i-E_i ($i=1, 2, \dots, 6$)
3	Internal short-circuit failure of motor windings	Check motor windings for normal insulation.	Replace motor.
4	PCB is defective.	If HC alarm occurs and items 1, 2, 3 are not defective, the PCB is defective.	Replace PCB.

f) Machine vibrates

Item	Causes of problems	Check procedures	Corrective action
1	Position loop gain is not set correctly.	Check the related system variable.	Set the system variable properly.
2	Pulse coder signal is defective.	Check whether the pulse coder signal cable (C1, C2, C4 and C8) is disconnected.	Replace the pulse coder signal cable.

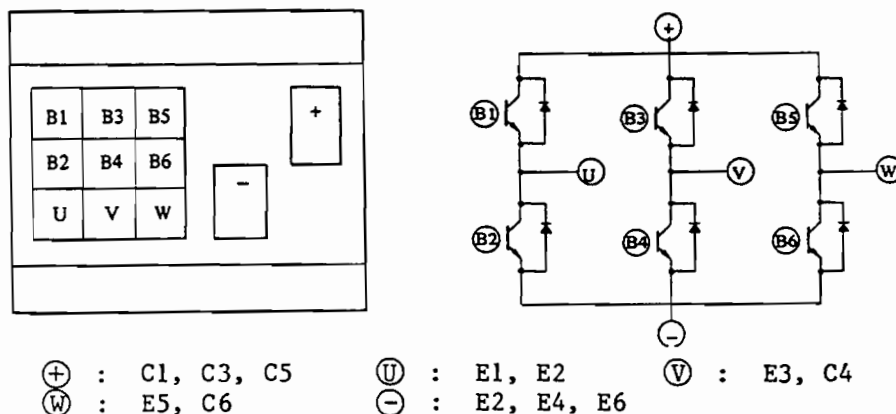


Fig. 5.4 Layout and circuit diagram of transistor module

6. BACKPLANE PCB (A20B-1002-0860)

6.1 Theory of Operation

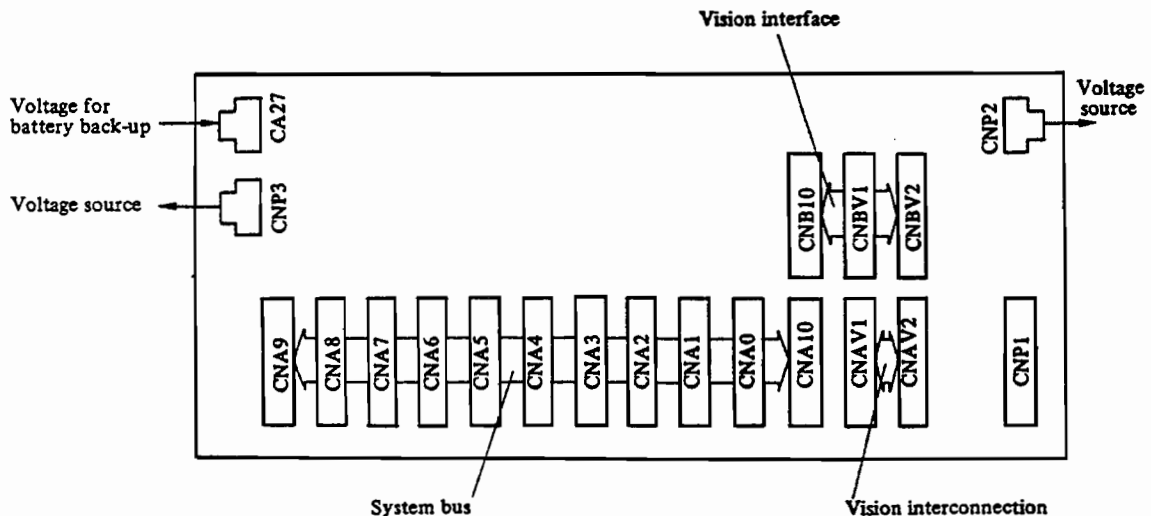
The backplane PCB is used to interconnect the power supply unit and the control PCBs by means of the backplane bus. Connector CNP1 is dedicated for the power supply unit; the others are for control PCBs.

Control PCBs are connected by means of electrical buses on the backplane PCB. The three types of buses and their use are as follows:

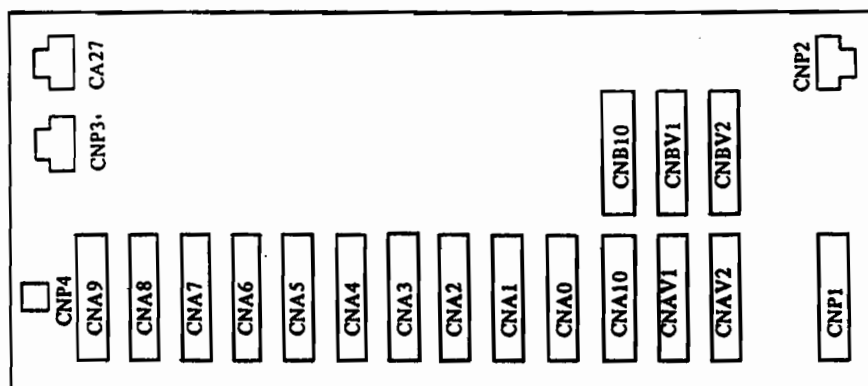
Bus	Connector	Use
- System bus	CNA0-CNA10	For the main system PCBs such as Main CPU, Path CPU, Axis control and others
- Vision engine interface	CNB10 CNBV1-CNBV2	Interface for vision CPU and Vision engine 1 and 2
- Vision engine interconnection	CNAV1-CNAV2	Local bus for Vision engine 1 and 2

The backplane PCB has several connectors other than the 96-pin connectors. The connectors CNP2 and CNP3 are used to provide voltage to peripheral units such as the modular I/O unit. Connector CA27 is used for the battery input. Connector CNP4 and the test points (TEST, HIGH, LOW) are used only at production test. The backplane PCB also has resistors and resistor modules. The resistors are used within the circuitry for clocks and serial data transfer. The resistor modules are used to pull up the tri-state signals on each bus.

6.2 Block Diagram



6.3 Connector/Signal Identification



CNA0 (System-bus, CCU*)

	a	b	c
32	SYSClk1	+5 V	SUBCLK1
31	SYSClk2	+5 V	0 V
30	GA13	+5 V	AM2
29	GA12	+5 V	AM1
28	GA11	0 V	AM0
27	GA10	0 V	GA23
26	GA09	+5 V	GA22
25	GA08	+5 V	GA21
24	GA07	+5 V	GA20
23	GA06	0 V	GA19
22	GA05	0 V	GA18
21	GA04	+15 V	GA17
20	GA03	+15 V	GA16
19	GA02	0 V	GA15
18	GA01	0 V	GA14
17	*GAS	-15 V	*GDTACK
16	*GUDS	-15 V	*GBERR
15	*GLDS	0 V	*EN
14	R/W	0 V	*SYSCLR
13	*SYSEMG	+24 V	*SYSFAIL
12	*GBR	+24 V	*SYSTEMR
11	*BGIN	0 V	*ITP
10	*BGOUT	0 V	*ITPL
09	*GBBSY	*PF	EN
08	GD07	*IDSTB	GD15
07	GD06	0 V	GD14
06	GD05	0 V	GD13
05	GD04	SDO	GD12
04	GD03	SDI	GD11
03	GD02	0 V	GD10
02	GD01	0 V	GD09
01	GD00	VBAT	GD08

*CCU: Central Control Unit

AM0 - 2 : Address modifier #0 - #2
 GA01 - 23: Global address bus #1 - #23
 GD00 - 15: Global data bus #0 - #15
 *GAS : Global address strobe
 R/W : Read/Write
 *GUDS : Global data strobe high byte
 *GLDS : Global data strobe low byte
 *GDTACK : Global data acknowledge
 *GBR : Global bus request
 *BGIN : Bus ground in
 *BGOUT : Bus ground out
 *GBERR : Global bus error
 *GBBSY : Global bus busy
 *SYSTEMR : System timer
 *ITP : Interpolation start
 *ITPL : Interpolation lock
 *IDSTB : ID strobe
 SYSClk1 : System clock (16.384 MHz)
 SYSClk2 }
 SUBCLK1 } : Subsidiary clock #1
 *SYSCLR : System clear
 *SYSFAIL : System fail
 *SYSEMG : System emergency
 SDO : Serial data out
 SDI : Serial data in
 *PF : Power off interrupt
 VBAT : Battery power
 EN }
 *EN } : Power enabled
 "*EN" is a reverse logic signal of "EN".
 0 V : Reference for supply voltage
 +5 V : +5 VDC power supply for digital logic circuit
 +24 V : +24 VDC power supply for I/O interface
 +15 V }
 -15 V } : +15 VDC power supply for memory backup

CNA1 - 10 (System bus)

	a	b	c
32	SYSCLK	+5 V	SUBCLK
31	0 V	+5 V	0 V
30	GA13	+5 V	AM2
29	GA12	+5 V	AM1
28	GA11	0 V	AM0
27	GA10	0 V	GA23
26	GA09	+5 V	GA22
25	GA08	+5 V	GA21
24	GA07	+5 V	GA20
23	GA06	0 V	GA19
22	GA05	0 V	GA18
21	GA04	+15 V	GA17
20	GA03	+15 V	GA16
19	GA02	0 V	GA15
18	GA01	0 V	GA14
17	*GAS	-15 V	*GDTACK
16	*GUDS	-15 V	*GBERR
15	*GLDS	0 V	*EN
14	R/W	0 V	*SYSCLR
13	*SYSEMG	+24 V	*SYSFAIL
12	*GBR	+24 V	*SYSTM
11	*BGIN	0 V	*ITP
10	*BGOUT	0 V	*ITPL
09	*GBBSY	SDI	SDO
08	GD07	*IDSTB	GD15
07	GD06	0 V	GD14
06	GD05	0 V	GD13
05	GD04	*USED	GD12
04	GD03		GD11
03	GD02	0 V	GD10
02	GD01	0 V	GD09
01	GD00	VBAT	GD08

AM0 - 2 : Address modifier #0 - #2
 GA01 - 23: Global address bus #1 - #23
 GD00 - 15: Global data bus #0 - #15
 *GAS : Global address strobe
 R/W : Read/Write
 *GUDS : Global data strobe high byte
 *GLDS : Global data strobe low byte
 *GDTACK : Global data acknowledge
 *GBR : Global bus request
 *BGIN : Bus ground in
 *BGOUT : Bus ground out
 *GBERR : Global bus error
 *GBBSY : Global bus busy
 *SYSTM : System timer
 *ITP : Interpolation start
 *ITPL : Interpolation lock
 *IDSTB : ID strobe
 *USED : Slot used
 SYSCLK : System clock (16.384 MHz)
 SUBCLK1 : Subsidiary clock #1
 *SYSCLR : System clear
 *SYSFAIL : System fail
 *SYSEMG : System emergency
 SDO : Serial data out
 SDI : Serial data in
 VBAT : Battery power
 *EN : Power enabled
 0 V : Reference for supply voltage
 +5 V : +5 VDC power supply for digital logic circuit
 +24 V : +24 VDC power supply for I/O interface
 +15 V } : +15 VDC power supply for
 -15 V } : memory backup

CNAV1, 2 (Vision engine interconnection)

	A	B	C
32	6MCLK	+5 V	*QADC
31	0 V	+5 V	0 V
30	(NC)	+5 V	QA
29	BMWD	+5 V	(NC)
28	EXDISP	0 V	D7
27	EXVSYN	0 V	D6
26	EXHSYN	+5 V	D5
25	*DSPTM	+5 V	D4
24	VSYNC	+5 V	D3
23	HSYNC	0 V	D2
22	CHRD	0 V	D1
21	OUTWD	(+15 V)	D0
20	RUNLNG	(+15 V)	*MCD2
19	(NC)	0 V	*MCD3
18	*XAOVR	0 V	*STRB
17	*YAOVR	(-15 V)	MSABE
16	BNRC	(-15 V)	*RUNLE
15	(NC)	0 V	*RLWD
14	*LDXDCT	0 V	ISSYN
13	XDCTDN	(+24 V)	ISASL
12	RDBRAM	(+24 V)	*MCD5
11	WTBRAM	0 V	ISACO
10	ACNTBF	0 V	ISAC1
09	APSBF	*WD08	ISPCKE
08	IDB7A	*WD02	IDB7B
07	IDB6A	0 V	IDB6B
06	IDB5A	0 V	IDB5B
05	IDB4A	*CTEY0	IDB4B
04	IDB3A	*BLOE	IDB3B
03	IDB2A	0 V	IDB2B
02	IDB1A	0 V	IDB1B
01	IDB0A	(—)	IDB0B

Signals in parentheses are not used.

6MCLK : Clock (6 MHz)
 BMWD : Bit map window
 (EXDISP): (External display timing)
 (EXVSYN): (External V sync.)
 (EXHSYN): (External H sync.)
 *DSPTM : Display timing
 VSYNC : V sync.
 HSYNC : H sync.
 CHRD : Character overlay
 OUTWD : Output window
 RUNLNG : Runlength
 *XAOVR : X address over
 *YAOVR : Y address over
 BNRC : Binary output
 *LDXDCT : Load X down counter
 *DCTDN : Count down X
 RDBRAM : Read Buffer RAM (BRAM)
 WTBRAM : Write BRAM
 ACNTBF : Address count enable for BRAM
 APSBF : Address preset for BRAM
 *WD08 : Write D0 8
 *WD02 : Write D0 2
 *CTEY0 : Count enable Y0
 *BLOE : BRAM output latch enable
 *QADC : Clock (12 MHz)
 QA : Clock (12 MHz)
 D0 - 7 : 8-bit data bus for inter engine
 *MCD2 } : Modal command strobe 2-3
 *MCD3 }
 (*STRB) : (Strobe for future option)
 MSABE : Master access enable
 *RUNLE : Runlength enable
 *RLWD : Runlength window
 ISSYN : ISP sync.
 ISASL : ISP address select
 *MCD5 : Modal command strobe 5
 ISACO : ISP address control 0
 ISAC1 : ISP address control 1
 ISPCKE : ISP clock enable
 IDB0A-7A: Image data bus A
 IDB0B-7B: Image data bus B
 +5 V : +5 V power
 0 V : 0 V

CNBV1, 2; CNB10 (Vision engine interface)

	A	B	C
32	*C12MM	+5 V	*C24MM
31	0 V	+5 V	0 V
30	MAB13	+5 V	(NC)
29	MAB12	+5 V	(NC)
28	MAB11	0 V	(NC)
27	MAB10	0 V	(NC)
26	MAB9	+5 V	(NC)
25	MAB8	+5 V	IOSEL
24	MAB7	+5 V	(NC)
23	MAB6	0 V	CRTR/W
22	MAB5	0 V	RS
21	MAB4	(+15 V)	MAB17
20	MAB3	(+15 V)	MAB16
19	MAB2	0 V	MAB15
18	MAB1	0 V	MAB14
17	READ	(-15 V)	*DTDRAW
16	MPUDS	(-15 V)	*FMRDY
15	MPLDS	0 V	*INHM
14	*FMRDU	0 V	*PORM
13	*FMRDL	(+24 V)	*CSCRT
12	*FMWU	(+24 V)	*WEDO
11	*FMWL	0 V	RFREQ
10	*IRDRAW	0 V	(NC)
09	(NC)	*SDBE	(NC)
08	MDB7	(NC)	MDB15
07	MDB6	0 V	MDB14
06	MDB5	0 V	MDB13
05	MDB4	(NC)	MDB12
04	MDB3	(NC)	MDB11
03	MDB2	0 V	MDB10
02	MDB1	0 V	MDB9
01	MDB0	(—)	MDB8

*C12MM : Clock (12 MHz)
 *C24MM : Clock (24 MHz)
 MAB1 - 17: Address bus
 READ : Read/Write
 MPUDS : Upper byte data strobe
 MPLDS : Lower byte data strobe
 *FMRDU : Read frame memory upper byte
 *FMRDL : Read frame memory lower byte
 *FMWU : Write frame memory upper byte
 *FMWL : Write frame memory lower byte
 *IRDRAW : Interrupt from ACRTC
 *SDBE : System data bus enable for ACRTC
 IOSEL : Input/output select
 CRTR/W : Read/Write for ACRTC
 RS : Register select for ACRTC
 *DTDRAW : DATAACK from ACRTC
 *FMRDY : Ready from frame memory
 *INHM : Access inhibit to MPU
 *PORM : Power on reset
 *CSCRT : Chip select for ACRTC
 *WEDO : Write enable for DO
 REREQ : Refresh request to frame memory
 MDB0 - 15: 16-bit data bus

CNP1

	A	B	C
32	TH	COM	TL
31		*PF	EN
30	+15 V		
29	+5 V	+15 V	+15 V
28	+5 V	+5 V	-15 V
27	+5 V	+5 V	+5 V
26	+5 V	+5 V	+5 V
25	+5 V	+5 V	+5 V
24	+5 V	+5 V	+5 V
23	+5 V	+5 V	+5 V
22	+5 V	+5 V	+5 V
21	+5 V	+5 V	+5 V
20	+5 V	+5 V	+5 V
19	+5 V	+5 V	+5 V
18	+5 V	+5 V	+5 V
17	+5 V	+5 V	+5 V
16	0 V	0 V	+5 V
15	0 V	0 V	0 V
14	0 V	0 V	0 V
13	0 V	0 V	0 V
12	0 V	0 V	0 V
11	0 V	0 V	0 V
10	0 V	0 V	0 V
09	0 V	0 V	0 V
08	0 V	0 V	0 V
07	0 V	0 V	0 V
06	0 V	0 V	0 V
05	0 V	0 V	0 V
04	0 V	0 V	0 V
03	0 V	0 V	0 V
02	0 V	0 V	0 V
01	+24 V	+24 V	+24 V

+5 V
 +15 V
 -15 V : DC output
 +24 V
 0 V
 TH }
 TL } : For test (for variation of
 COM } : +10% in +5 V)
 *PF : Power failure
 EN : Enable

CNP2

01	+15 V
02	0 V
03	*PF
04	EN
05	0 V
06	-15 V

*PF: Power off interrupt
EN : Power enabled

CNP3

01	+5 V
02	+5 V
03	0 V
04	0 V
05	+24 E
06	+24 E

+5 V : +5 VDC power source
0 V : 0 V (Ground)
+24 E: +24 VDC power source

CNP4

01	HI
02	TEST
03	LO




























HI
TEST } : For test (for variation of ±10% in +5 V)
LO }

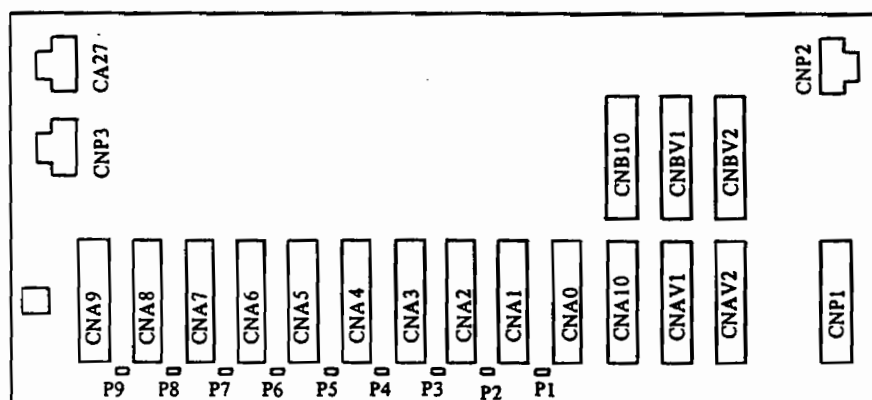
CA27

01	VBAT
02	0 V
03	0 V

VBAT: Battery power

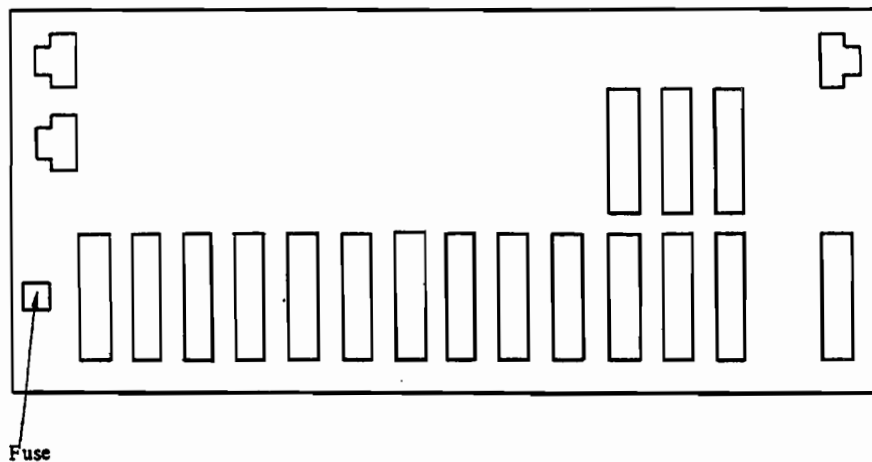
6.4 Jumper Settings

Jumpers	Standard setting	Uses																																				
P1		<p>Jumpers P1 - P9 correspond to CNA1 - 9. If a PCB is in the slot n, the jumper Pn is set to 0 side, if not it is set to V side. (n = 1 - 9) (0 is Occupied and V is Vacant.)</p> <p>For example, there are PCBs on CNA0, 1, 2, 3, 8 and 9. The jumper settings are as follows:</p> <table><tr><td>P1</td><td>0</td><td></td><td>V</td></tr><tr><td>P2</td><td>0</td><td></td><td>V</td></tr><tr><td>P3</td><td>0</td><td></td><td>V</td></tr><tr><td>P4</td><td>0</td><td></td><td>V</td></tr><tr><td>P5</td><td>0</td><td></td><td>V</td></tr><tr><td>P6</td><td>0</td><td></td><td>V</td></tr><tr><td>P7</td><td>0</td><td></td><td>V</td></tr><tr><td>P8</td><td>0</td><td></td><td>V</td></tr><tr><td>P9</td><td>0</td><td></td><td>V</td></tr></table>	P1	0		V	P2	0		V	P3	0		V	P4	0		V	P5	0		V	P6	0		V	P7	0		V	P8	0		V	P9	0		V
P1			0		V																																	
P2			0		V																																	
P3			0		V																																	
P4			0		V																																	
P5			0		V																																	
P6			0		V																																	
P7			0		V																																	
P8			0		V																																	
P9			0		V																																	
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P7																																						
P8																																						
P9																																						



Location of jumpers

6.5 Fuse

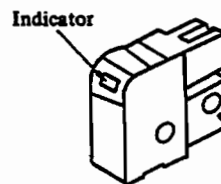


Causes and corrective actions for blown fuses.

The basic control unit is provided with a fuse at the battery input end as shown in Fig. 6.5. The following description covers the causes of a blown fuse.

The blown fuse shows a white failure display in the indicator as shown in the figure at the right.

- a) A part inside the Backplane PCB may be shorted.
- b) A part inside the Main CPU PCB may be shorted.
- c) A part inside the Path CPU PCB may be shorted.



Specification number of fuse: A60L-0001-0046#0.32

Replace the fuse with one having the same specification number.

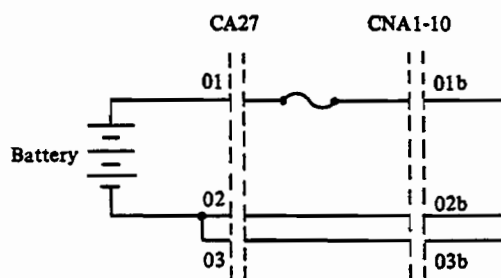
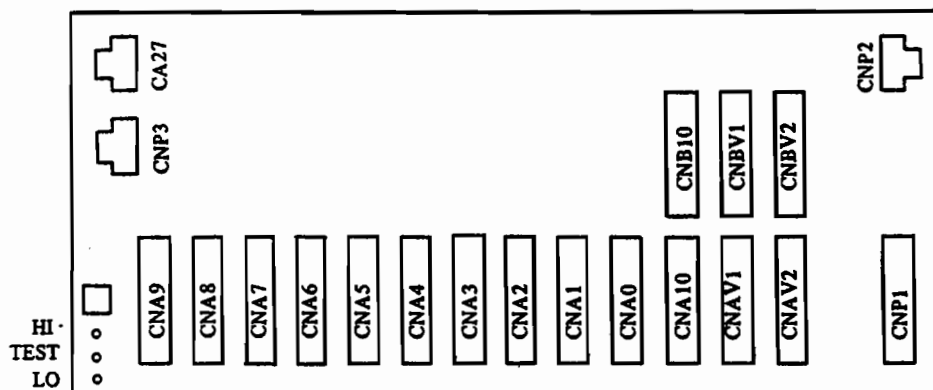


Fig. 6.5 Fuse at battery input

6.6 Test Points

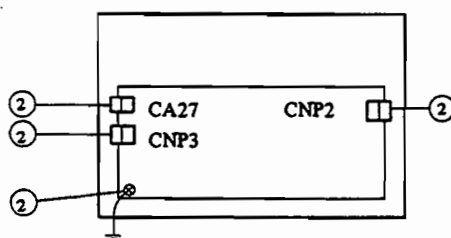
Test points	Contents
HI	For variation of $\pm 10\%$ in +5 V.
TEST	TEST <u>short</u> HI : +10% TEST ——— LO : -10%
LO	Note) These are used only at production test.



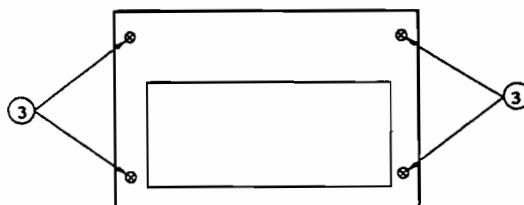
6.7 Removal/Replacement

1) Procedure

- ① Remove all boards on the backplane.
- ② Detach the cables.



- ③ Remove the backplane by loosening four screws.



- ④ For mounting a new backplane, reverse the above procedure.

7. POWER SUPPLY UNIT (A20B-1000-0770)

7.1 Theory of Operation

The power supply unit produces DC voltages for distribution and use throughout the controller. All DC voltages for the basic control unit and the modular I/O unit are supplied from this unit. Additional DC voltages are supplied by other PCBs for specific purposes.

An input voltage of 200 VAC is rectified, filtered, and regulated for the DC voltage levels of +5 V, +15 V, -15 V, and +24 V.

The power supply unit is protected from an overcurrent of AC input by two fuses located on the unit. These fuses have an internal switch that trips to flag the alarm to the input unit when the device is blown.

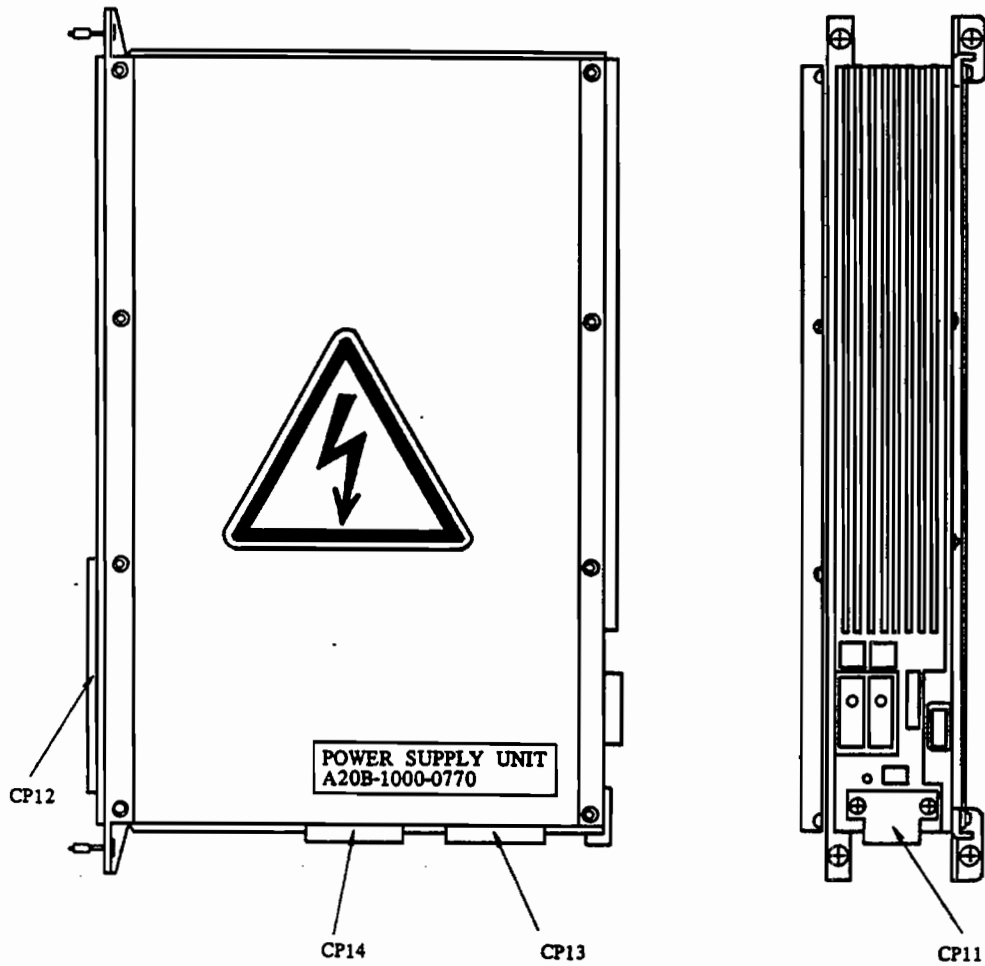
One other fuse exists on the power supply unit. This fuse is connected to the +24 volt line labelled +24 E that supplies the following circuits:

- . I/O
- . overtravel
- . emergency stop
- . hand breakage
- . other +24 volt circuits

Overcurrent limiting characteristics of the regulator protect the power supply from overload or short circuit. When the voltage monitor on the power supply detects a drop in output voltage, excluding +24 E, it flags an alarm to the controller. There are no LEDs or variable resistors for the user to monitor or adjust. All voltage levels are passed through smoothing circuits that ensure outputs are of the proper level for logic circuits.

[illegible]

7.3 Connector/Signal Identification



CP12

	A	B	C
32	TH	COM	TL
31		*PF	EN
30	+15 V	NR2	VNR
29	+5 V	+15 V	+15 V
28	+5 V	+5 V	-15 V
27	+5 V	+5 V	+5 V
26	+5 V	+5 V	+5 V
25	+5 V	+5 V	+5 V
24	+5 V	+5 V	+5 V
23	+5 V	+5 V	+5 V
22	+5 V	+5 V	+5 V
21	+5 V	+5 V	+5 V
20	+5 V	+5 V	+5 V
19	+5 V	+5 V	+5 V
18	+5 V	+5 V	+5 V
17	+5 V	+5 V	+5 V
16	0 V	0 V	+5 V
15	0 V	0 V	0 V
14	0 V	0 V	0 V
13	0 V	0 V	0 V
12	0 V	0 V	0 V
11	0 V	0 V	0 V
10	0 V	0 V	0 V
09	0 V	0 V	0 V
08	0 V	0 V	0 V
07	0 V	0 V	0 V
06	0 V	0 V	0 V
05	0 V	0 V	0 V
04	0 V	0 V	0 V
03	0 V	0 V	0 V
02	0 V	0 V	0 V
01	+24 V	+24 V	+24 V

+5 V, +15 V, -15 V, +24 E, 0 V: DC output

TH }
 TL } : For test (for variation of $\pm 10\%$ in +5 V)
 COM }
 *PF : Power failure
 EN : Enable
 NR2 }
 VNR } : Not used

7.4 Variable Resistors

This power supply unit contains no adjusting or setting points that require adjusting routinely. The reference voltage A10 (=10.00 V) has already been adjusted during tests of this unit. Always check reference voltage A10 whenever the power supply unit is replaced. The location of VR11 and A10 is shown in Fig. 7.4. If A10 voltage is deviated, adjust it to 10.00 V by turning VR11. (Use a digital voltmeter.) The voltage increases when turning VR11 clockwise.

CP13 (Input unit PCB)

06	ALD
05	ALC
04	
03	PF
02	PFH
01	PFL

ALD }
 ALC } : Alarm output
 PF }
 PFH } : Power failure
 PFL }

CP14 (I/O unit)

06	+24 E
05	+24 V
04	0 V
03	0 V
02	+5 V
01	+5 V

CP11 (Input unit PCB)

03	G
02	200S
01	200R

G : Ground
 200S }
 200R } : 200 VAC input

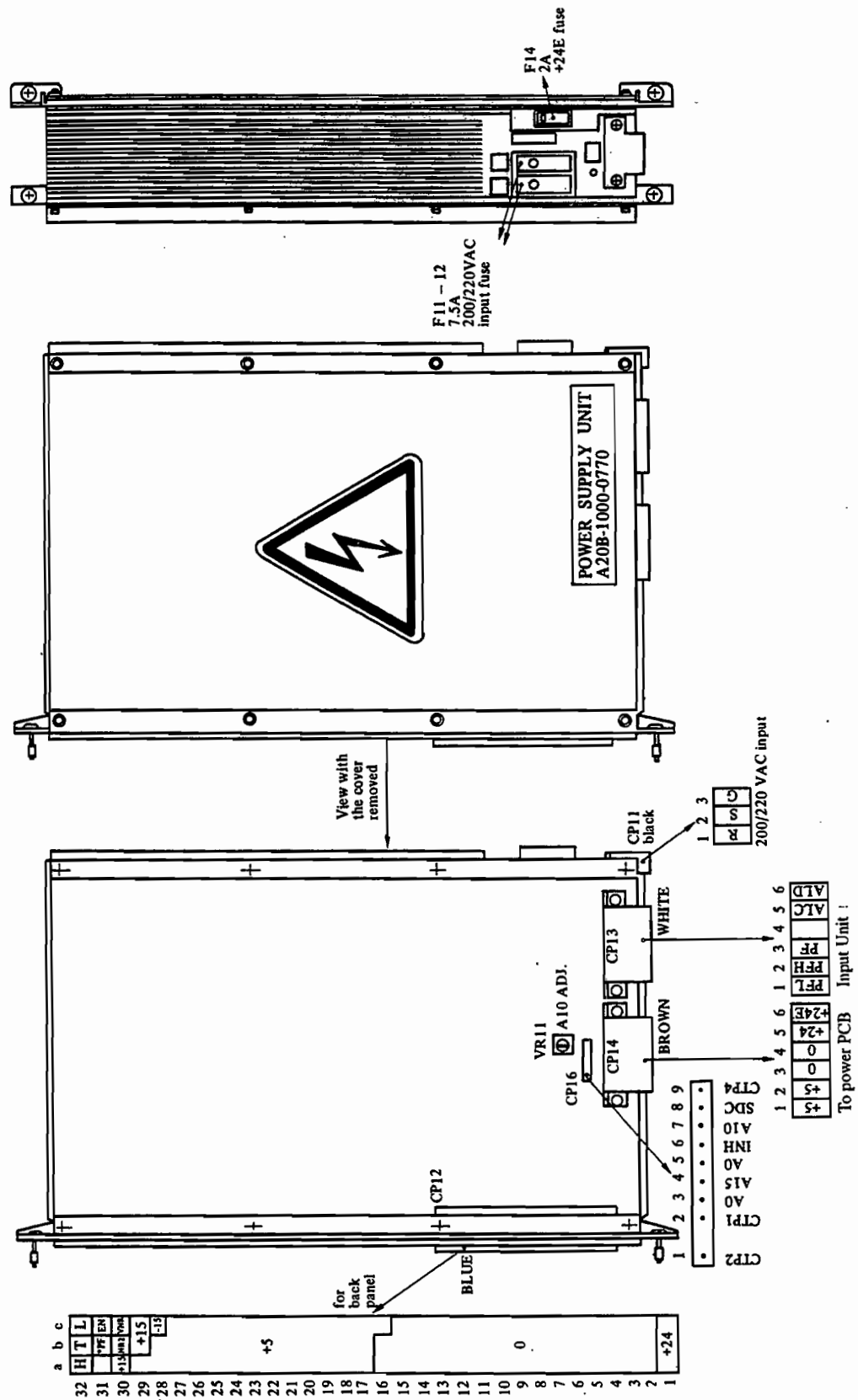


Fig. 7.4 Power supply unit external view

7.5 Fuses

Refer to Fig. 7.4 for the position of the fuses.

The power supply unit is provided with fuses F11 to F12 at the input end, and F14 at +24 E output terminal. The following description covers causes and actions to be taken when these fuses are blown.

① Cause and remedies of a blown F11 or F12 fuse

- a) Short-circuit of diode stack DS11
- b) Short-circuit between C-E of switching transistors Q14, Q15
- c) Short-circuit of diodes D24, D25
- d) Short-circuit between C-E of transistor in auxiliary power supply circuit M11

Replace with the spare power supply unit, if the parts described in (a) - (d) are found to be shorted.

Specification number of F11 to F12: A60L-0001-0101#P475H

Replace with fuses having the same specification number.

② Causes and remedies of a blown F14 fuse.

- a) The +24 E power cable to I/O base unit or a part inside the I/O unit may be shorted.
- b) The +24 E power line may be in contact with the other power line or cause a ground fault by the robot mechanical unit side wiring. Remove CP14, and check them carefully.

Specification number of F14: A60L-0001-0046#2.0

Replace with a fuse having the same specification number.

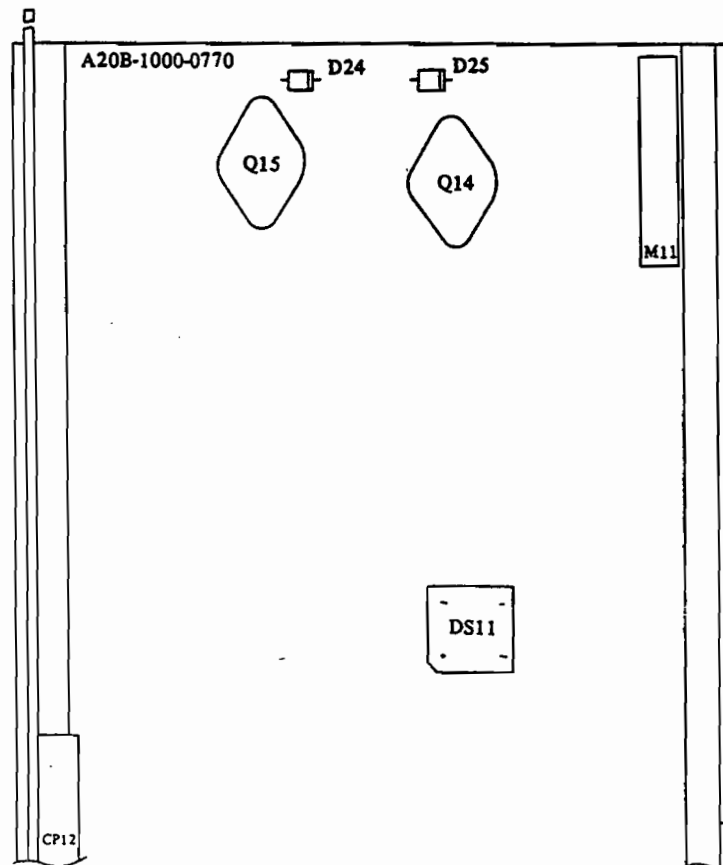
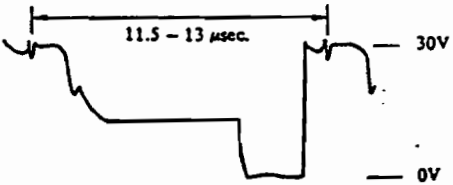
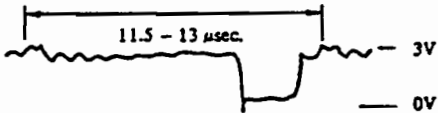
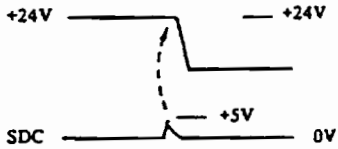
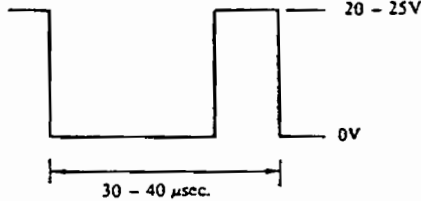
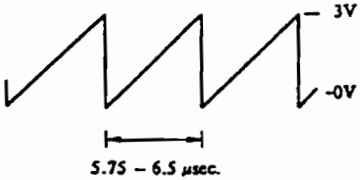
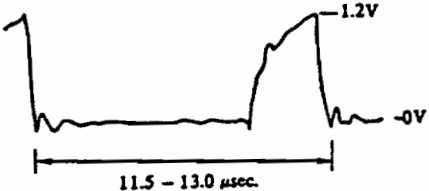
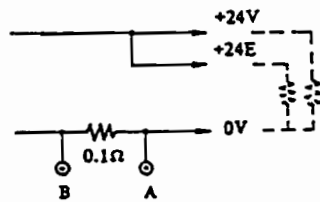
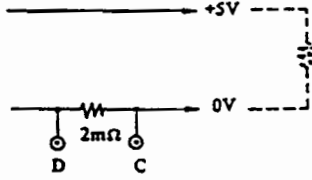


Fig. 7.5 Position of components on the power supply unit
(The unit cover is removed in the above figure)

7.6 Test Points

The meanings of the test points on the power supply unit are as follows. (See Fig. 7.6)

Test points	Symbol	Contents	Waveform
CP16	CTP2	Pre-driver signal of +5 V regulator	
CP16	CTP1	+5 V control	
CP16	A0		0 V
CP16	A15		14.5 - 15.5 VDC
CP16	INH	When "INH" is shorted to 0 V, overcurrent alarm of +5 VDC output is neglected. This terminal is used for testing only.	
CP16	A10	Reference voltage adjustable by variable resistor VR11.	10.000 - 10.007 VDC
CP16	SDC	Shut down control signal. When the power is turned off, +24 V output is cut off by this signal.	
CP16	CTP4	+15 V control	

Test points	Symbol	Contents	Waveform
F	-	Triangle wave	
PC	-	+5 V control	
A, B	-	Terminals for the current measurement of +24 V and +24 E output.	
C, D	-	Terminals for the current measurement of +5 V output.	

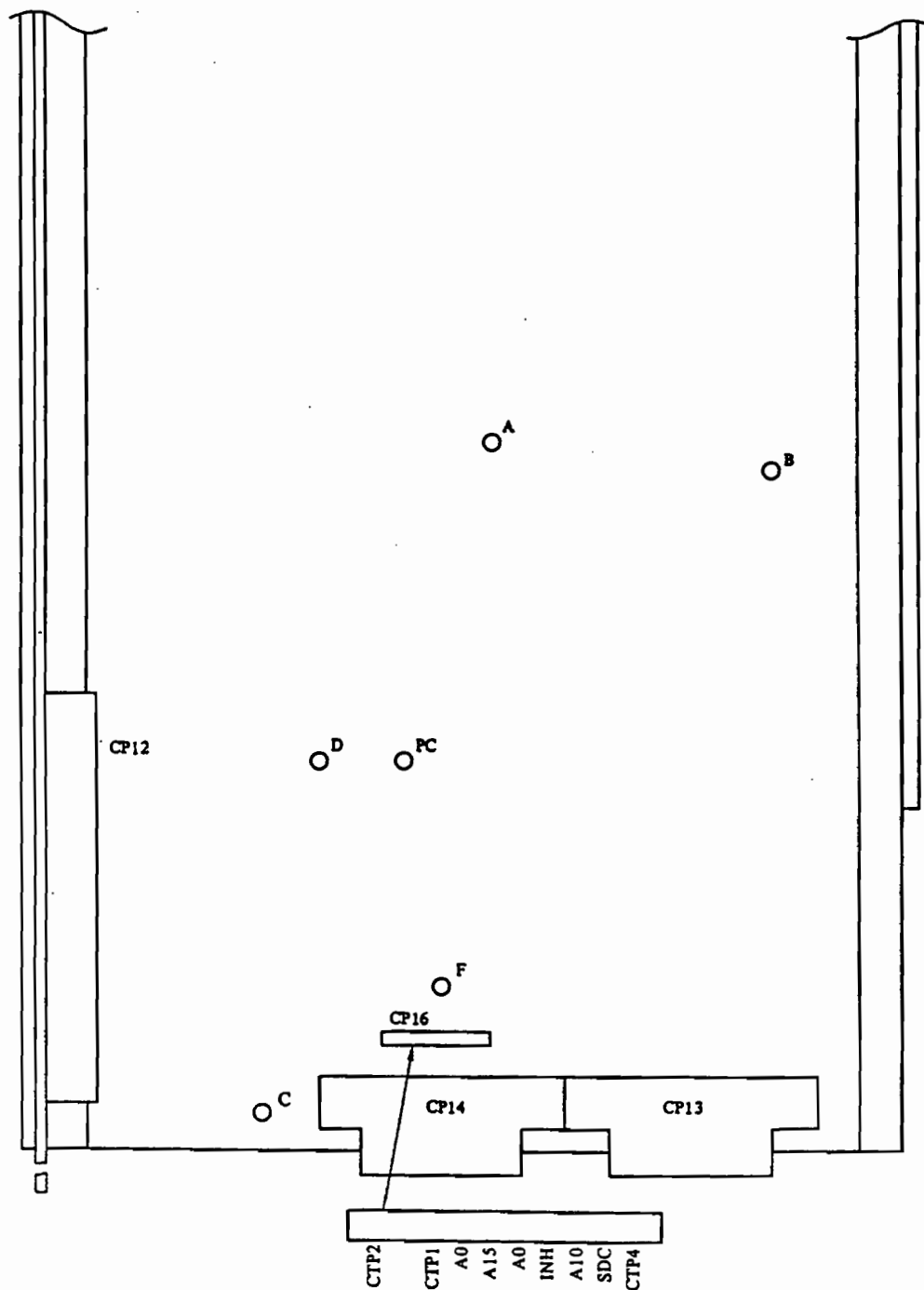
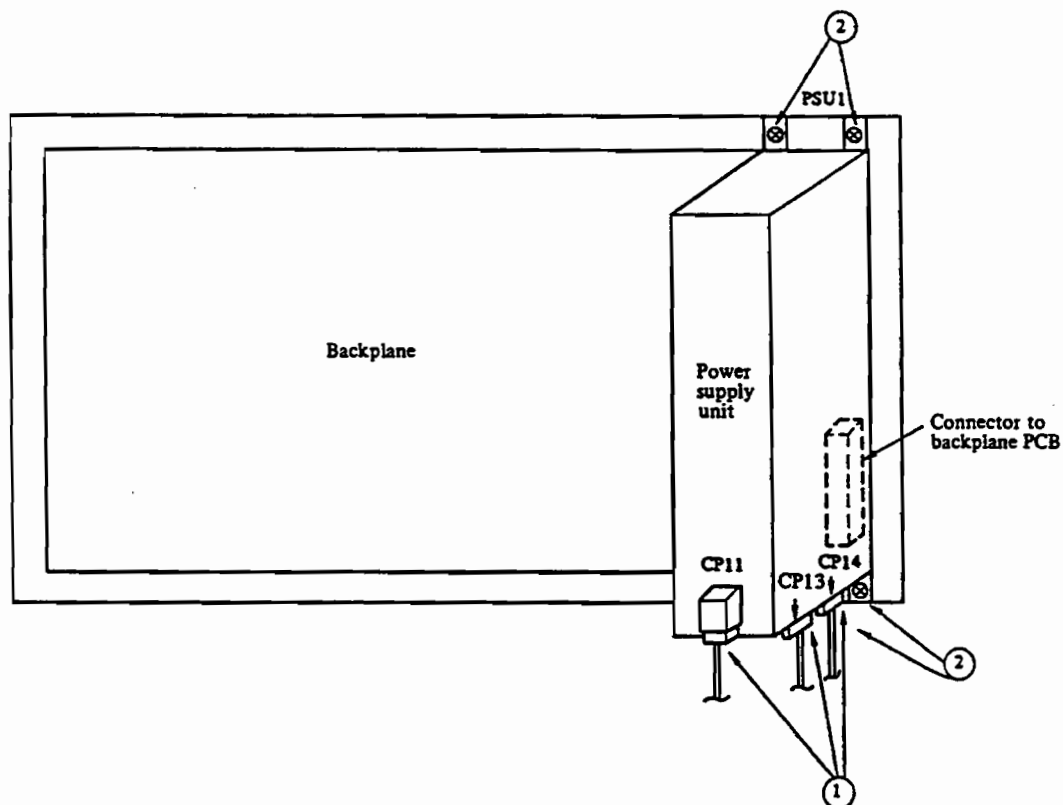


Fig. 7.6 Location of test points on the power supply unit
(The unit cover is removed in the above figure)

7.7 Removal/Replacement



1) Procedure

- ① Disconnect cables of connectors CP11, CP13 and CP14.
- ② Detach the power supply unit by removing four screws. The power supply unit is connected to the backplane PCB of the basic control unit by the connector shown by a dotted line in the figure.
- ③ For mounting new power supply unit, reverse the above procedure.

Caution) Always check reference voltage A10 whenever the power supply unit is replaced.

8. MAIN CPU BOARD (A16B-1211-0040, 0041)

8.1 Theory of Operation

The main CPU board processes the KAREL language system, file operations, and system I/O.

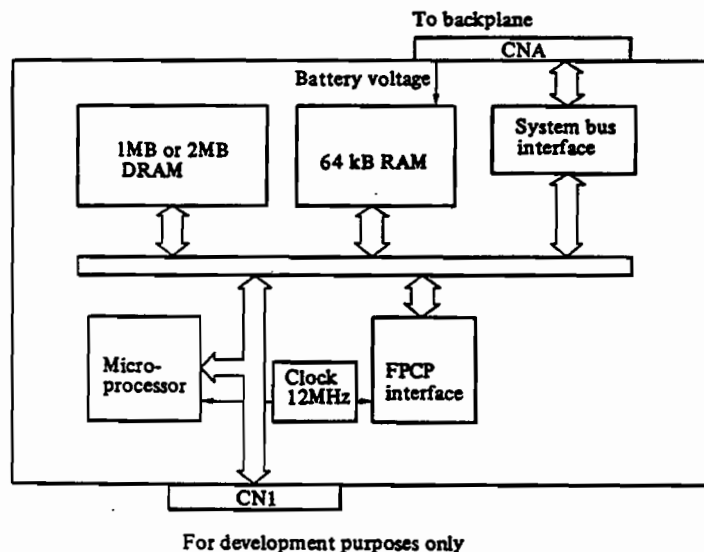
The board contains the local memory for a microprocessor. The memory is organized by four (-0041) or eight (-0040) DRAM modules, the total capacity is 1 MB (-0041) or 2 MB (-0040).

The system software is loaded into the DRAM from bubble memory.

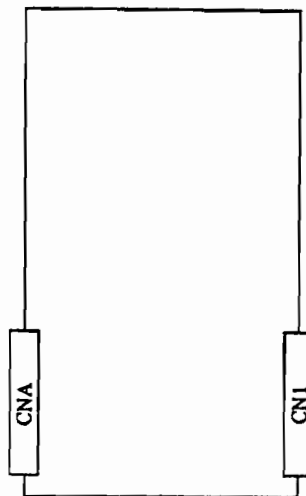
In addition to the DRAM, there is a 64 kB battery-backed RAM. The board can be equipped with a floating-point coprocessor chip as an optional feature.

The system bus interface allows when the microprocessor to access the shared resources on the system bus.

8.2 Block Diagram



8.3 Connector/Signal Identification



CNA (Main CPU)

	a	b	c
32	SYSCLK	+5 V	SUBCLK
31	0 V	+5 V	0 V
30	GA13	+5 V	AM2
29	GA12	+5 V	AM1
28	GA11	0 V	AM0
27	GA10	0 V	GA23
26	GA09	+5 V	GA22
25	GA08	+5 V	GA21
24	GA07	+5 V	GA20
23	GA06	0 V	GA19
22	GA05	0 V	GA18
21	GA04	+15 V	GA17
20	GA03	+15 V	GA16
19	GA02	0 V	GA15
18	GA01	0 V	GA14
17	*GAS	-15 V	*GDTACK
16	*GUDS	-15 V	*GBERR
15	*GLDS	0 V	*EN
14	R/W	0 V	*SYSCLR
13	*SYSEMG	+24 V	*SYSFAIL
12	*GBR	+24 V	*SYSTMTR
11	*BGIN	0 V	*ITP
10	*BGOUT	0 V	*ITPL
09	*GBBSY	SDI	SDO
08	GD07	*IDSTB	GD15
07	GD06	0 V	GD14
06	GD05	0 V	GD13
05	GD04	*USED	GD12
04	GD03		GD11
03	GD02	0 V	GD10
02	GD01	0 V	GD09
01	GD00	VBAT	GD08

AM0 - 2 : Address modifier #0 - #2
 GA01 - 23: Global address bus #1 - #23
 GD00 - 15: Global data bus #0 - #15
 *GAS : Global address strobe
 R/W : Read/Write
 *GUDS : Global data strobe high byte
 *GLDS : Global data strobe low byte
 *GDTACK : Global data acknowledge
 *GBR : Global bus request
 *BGIN : Bus ground in
 *BGOUT : Bus ground out
 *GBERR : Global bus error
 *GBBSY : Global bus busy
 *SYSTMTR : System timer
 *ITP : Interpolation start
 *ITPL : Interpolation lock
 *IDSTB : ID strobe
 *USED : Slot used
 SYSCLK : System clock (16.384 MHz)
 SUBCLK1 : Subsidiary clock #1
 *SYSCLR : System clear
 *SYSFAIL : System fail
 *SYSEMG : System emergency
 SDO : Serial data out
 SDI : Serial data in
 VBAT : Battery power
 *EN : Power enabled
 0 V : Reference for supply voltage
 +5 V : +5 VDC power supply for digital logic circuit
 +24 V : +24 VDC power supply for I/O interface
 +15 V } : +15 VDC power supply for
 -15 V } : memory backup

CN1 (Test PCB)

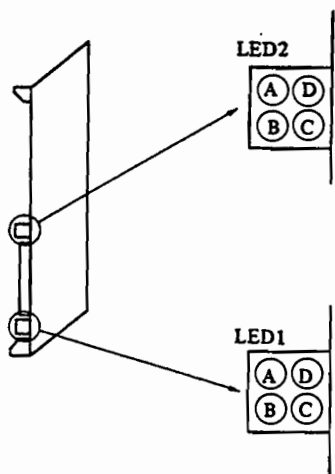
	C	B	A
32	*IPL2	+5 V	*IPL1
31	*IPL0	+5 V	A23
30	A22	+5 V	A21
29	A20	+5 V	A19
28	A18	0 V	A17
27	A16	0 V	A15
26	A14	+5 V	A13
25	A12	+5 V	A11
24	A10	+5 V	A09
23	A08	0 V	A07
22	A06	0 V	A05
21	A04		A03
20	A02	+15 V	A01
19	*EPEX	0 V	*AS
18	*VMA	0 V	*UDS
17	E		*LDS
16	*VPA	-15 V	R/W
15	*RES	0 V	*NMIE
14	*BERR	0 V	FC0
13	*HALT		FC1
12	*RST	+24 V	FC2
11	*INH	0 V	D15
10	D14	0 V	D13
09	D12	TH	D11
08	D10	*DTKI	D09
07	D08	TL	D07
06	D06	CO	D05
05	D04	*PF	EN
04	D03	*BR	*DTAK
03	D02		*BGC
02	D01	0 V	*BGAK
01	D00	*BGI	*CLK

This connector is not used.

8.4 LEDs

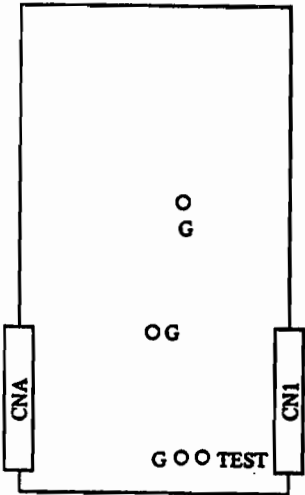
LED 1	Meanings	Status
A (Yellow)	Not used	
B (Yellow)	Not used	
C (Yellow)	Not used	
D	Not used	

LED 2	Meanings	Status
A (Red)	DRAM parity alarm	Parity alarm occurs, accessing dynamic-RAM on main CPU PCB.
B (Red)	SRAM parity alarm	Parity alarm occurs, accessing static-RAM main CPU PCB.
C	Not used	
D		

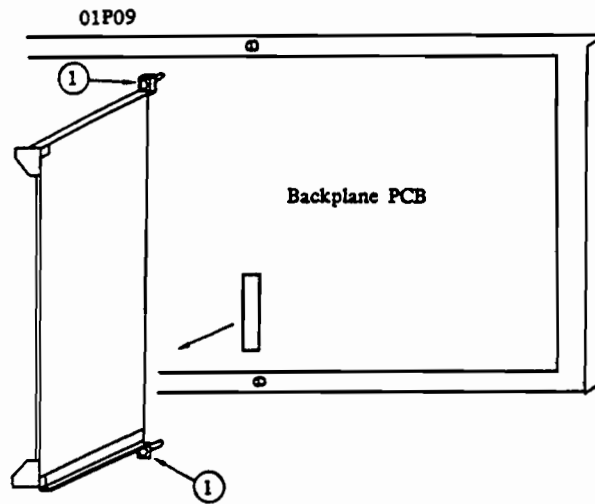


8.5 Test Points

Test points	Contents
G	0 V (ground)
TEST	This terminal is used in software debugging



8.6 Removal/Replacement

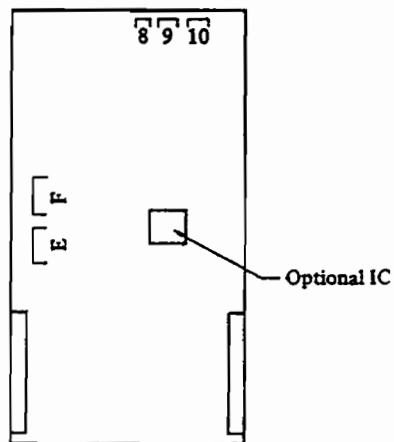


1) Procedure

- ① Detach PCB by loosening the screws ①.
- ② Mount new PCB.

2) Caution

If the PCB being replaced has the optional IC, check that the IC mounted on the new PCB has the same specification.



9. PATH CPU BOARD (A16B-1211-0030)

9.1 Theory of Operation

The path CPU board calculates path information and provides it to the servo system.

The board contains the local memory for a microprocessor. The memory size is 256 kB, organized by DRAMs.

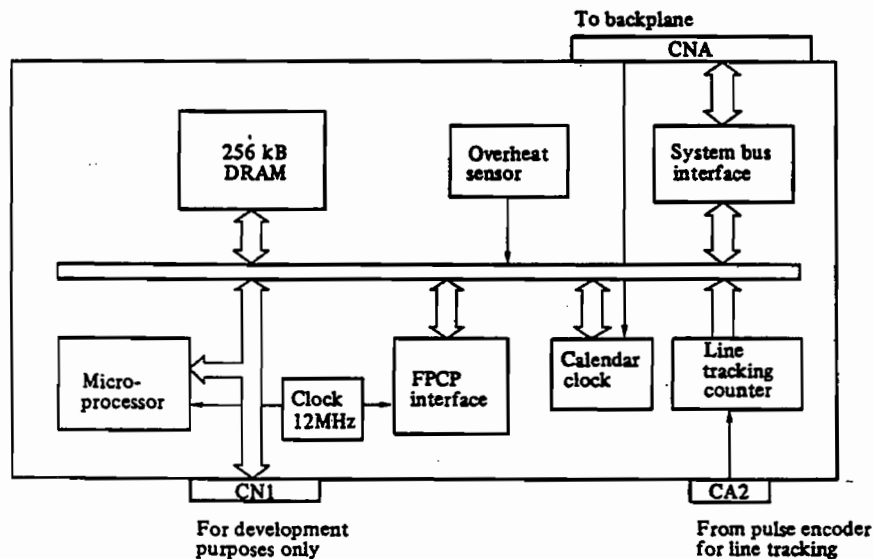
The executive software is loaded into the DRAM from bubble memory after power up.

The board can be equipped with a floating-point coprocessor chip and a line tracking counter as optional features.

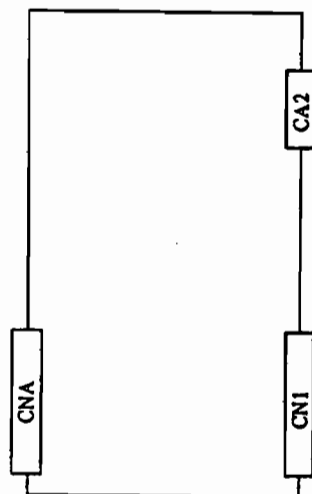
The board has an overheat sensor and a battery-operated calendar clock, which provides the R-H controller with an absolute date and time base. The overheat sensor detects abnormal temperature rise and signals it to the path CPU via a digital input.

The critical temperature is 65°C. The global bus interface allows the microprocessor to access the shared resources on the system bus.

9.2 Block Diagram



9.3 Connector/Signal Identification



CNA (Path CPU)

	a	b	c
32	SYCLK	+5 V	SUBCLK
31	0 V	+5 V	0 V
30	GA13	+5 V	AM2
29	GA12	+5 V	AM1
28	GA11	0 V	AM0
27	GA10	0 V	GA23
26	GA09	+5 V	GA22
25	GA08	+5 V	GA21
24	GA07	+5 V	GA20
23	GA06	0 V	GA19
22	GA05	0 V	GA18
21	GA04	+15 V	GA17
20	GA03	+15 V	GA16
19	GA02	0 V	GA15
18	GA01	0 V	GA14
17	*GAS	-15 V	*GDTACK
16	*GUDS	-15 V	*GBERR
15	*GLDS	0 V	*EN
14	R/W	0 V	*SYSCLR
13	*SYSEMG	+24 V	*SYSFAIL
12	*GBR	+24 V	*SYSTMTR
11	*BGIN	0 V	*ITP
10	*BGOUT	0 V	*ITPL
09	*GBBSY	SDI	SDO
08	GD07	*IDSTB	GD15
07	GD06	0 V	GD14
06	GD05	0 V	GD13
05	GD04	*USED	GD12
04	GD03		GD11
03	GD02	0 V	GD10
02	GD01	0 V	GD09
01	GD00	VBAT	GD08

AM0 - 2 : Address modifier #0 - #2
 GA01 - 23: Global address bus #1 - #23
 GD00 - 15: Global data bus #0 - #15
 *GAS : Global address strobe
 R/W : Read/Write
 *GUDS : Global data strobe high byte
 *GLDS : Global data strobe low byte
 *GDTACK : Global data acknowledge
 *GBR : Global bus request
 *BGIN : Bus ground in
 *BGOUT : Bus ground out
 *GBERR : Global bus error
 *GBBSY : Global bus busy
 *SYSTMTR : System timer
 *ITP : Interpolation start
 *ITPL : Interpolation lock
 *IDSTB : ID strobe
 USED : Slot used
 SYCLK : System clock (16.384 MHz)
 SUBCLK1 : Subsidiary clock #1
 *SYSCLR : System clear
 *SYSFAIL : System fail
 *SYSEMG : System emergency
 SDO : Serial data out
 SDI : Serial data in
 VBAT : Battery power
 *EN : Power enabled
 0 V : Reference for supply voltage
 +5 V : +5 VDC power supply for digital logic circuit
 +24 V : +24 VDC power supply for I/O interface
 +15 V } : +15 VDC power supply for
 -15 V } : memory backup

CA2 (Position coder)

14	PCZ		01	0 V
15	*PCZ	08	02	0 V
16	PCA	09	03	0 V
17	*PCA	10	04	+5 V
18	PCB	11	05	+5 V
19	*PCB	12	06	+5 V
20	SG	13	07	

PCZ } : Z-phase of Position Coder
 *PCZ }
 PCA } : A-phase of Position Coder
 *PCA }
 PCB } : B-phase of Position Coder
 *PCB }

CN1 (Test PCB)

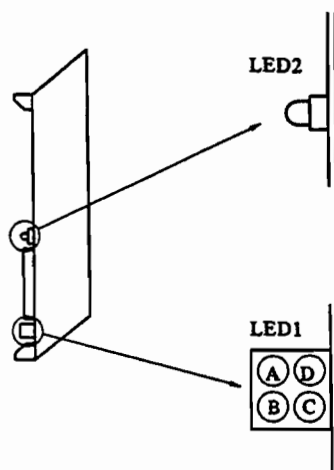
	C	B	A
32	*IPL2	+5 V	*IPL1
31	*IPL0	+5 V	A23
30	A22	+5 V	A21
29	A20	+5 V	A19
28	A18	0 V	A17
27	A16	0 V	A15
26	A14	+5 V	A13
25	A12	+5 V	A11
24	A10	+5 V	A09
23	A08	0 V	A07
22	A06	0 V	A05
21	A04		A03
20	A02	+15 V	A01
19	*EPEX	0 V	*AS
18	*VMA	0 V	*UDS
17	E		*LDS
16	*VPA	-15 V	R/W
15	*RES	0 V	*NMIE
14	*BERR	0 V	FC0
13	*HALT		FC1
12	*RST	+24 V	FC2
11	*INH	0 V	D15
10	D14	0 V	D13
09	D12	TH	D11
08	D10	*DTKI	D09
07	D08	TL	D07
06	D06	CO	D05
05	D04	*PF	EN
04	D03	*BR	*DTAK
03	D02		*BGC
02	D01	0 V	*BGAK
01	D00	*BGI	*CLK

This connector is not used.

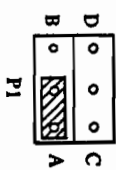
9.4 LEDs

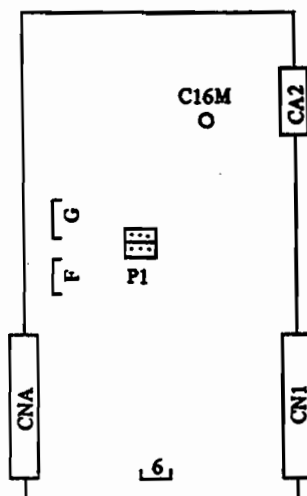
LED 1	Meaning	Status
A (Yellow)	Not used	
B (Yellow)	Not used	
C (Yellow)	Not used	
D	Not used	

LED	Meaning	Status
LED2 (Red)	DRAM parity alarm	Parity alarm occurs, accessing dynamic-RAM on path CPU PCB.



9.5 Jumper Settings

Jumper	Standard setting	Uses
P1		Pulse width adjustment of the 16.384 MHz clock. Change the setting so that the waveform at test point C16 is as shown in section 9.7. (The setting P1 was adjusted before shipping.)

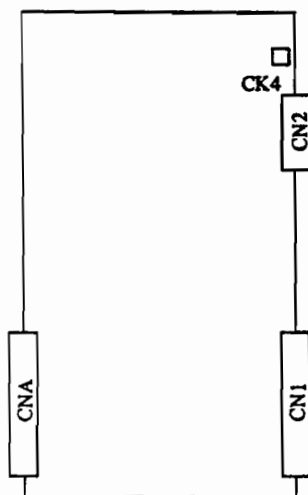


9.6 Variable Capacitor


The variable capacitor CK4 is used for minute adjustment of the frequency for RTC (Real Time Controller; M6242). The frequency is measured at 64 Hz using a frequency counter. CK4 was adjusted before shipping. (Refer to section 9.7 for the location of the RTC test point).

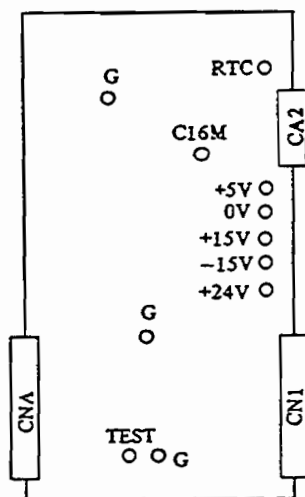
If CK4 requires adjustment:

- ① Connect frequency counter to test point RTC.
- ② Adjust CK4 until frequency equals 64 Hz.



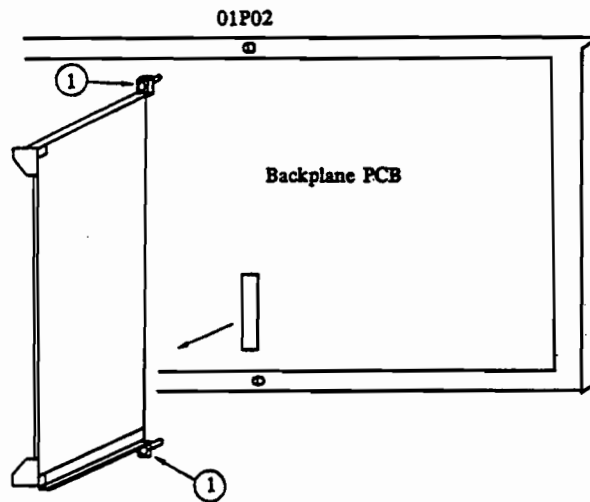
9.7 Test Points

Test points	Contents	Waveform
G	0 V (ground)	
0 V	0 V (ground)	
+5 V	Supply voltage for logic	+5 VDC
+15 V	Supply voltage	+15 VDC
-15 V	Supply voltage	-15 VDC
+24 V	Supply voltage	+24 VDC
C16M	Clock for main system (16.384 MHz)	
TEST	This terminal is used in software debugging.	
RTC	Real Time Control This terminal is used in minute adjustment of the frequency for RTC (M6242).	



Location of test points

9.8 Removal/Replacement

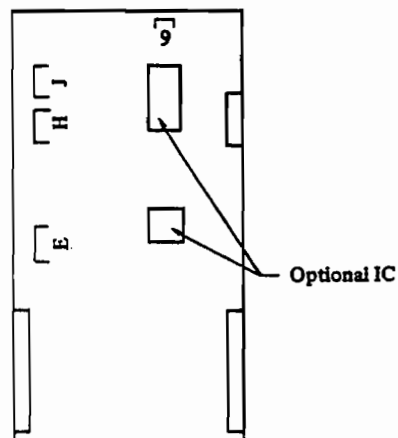


1) Procedure

- ① Detach PCB by loosening the screws ①.
- ② Mount new PCB.

2) Caution

If the PCB being replaced has the optional IC, check that the IC mounted on the new PCB has the same specification.



10. SHARED RAM BOARD (A16B-1211-0860)

10.1 Theory of Operation

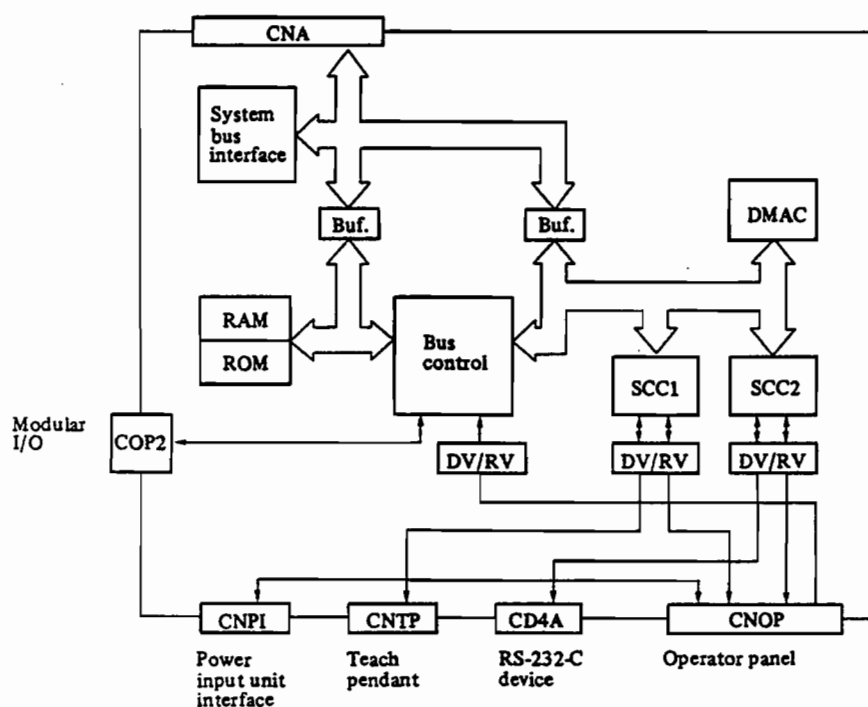
The shared RAM board is an essential module in the R-H controller, functioning as a central control module for the System BUS.

It provides a system clock, clear, timer, and other important signals. Four serial ports are available; Direct Memory Access (DMA) data transfer capability is supported for some. The shared RAM is used not only by the processors on the bus but also by an optical link for the I/O unit. The shared ROM contains a diagnostic program and an initial program loader. Processors are designed to run with this ROM first after power up. The board also contains drivers and receivers to drive LED displays and to receive push button status signals from the operator panel and to send and receive signals from the teach pendant, RS-232-C interface and the power input unit interface.

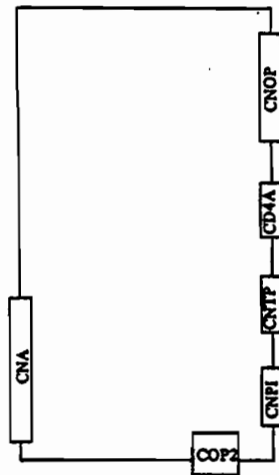
Four LEDs are located on the shared RAM PCB. The LEDs indicate system errors.

Note) The system can be operated without the teach pendant by plugging a teach pendant bypass plug into CNTP.

10.2 Block Diagram



10.3 Connector/Signal Identification



CNA

	a	b	c
32	SYSCLK1	+5 V	SUBCLK1
31	SYSCLK2	+5 V	0 V
30	GA13	+5 V	AM2
29	GA12	+5 V	AM1
28	GA11	0 V	AM0
27	GA10	0 V	GA23
26	GA09	+5 V	GA22
25	GA08	+5 V	GA21
24	GA07	+5 V	GA20
23	GA06	0 V	GA19
22	GA05	0 V	GA18
21	GA04	+15 V	GA17
20	GA03	+15 V	GA16
19	GA02	0 V	GA15
18	GA01	0 V	GA14
17	*GAS	-15 V	*GDTACK
16	*GUDS	-15 V	*GBERR
15	*GLDS	0 V	*EN
14	R/W	0 V	*SYSCLR
13	*SYSEMG	+24 V	*SYSFAIL
12	*GBR	+24 V	*SYSTMTR
11	*BGIN	0 V	*ITP
10	*BGOUT	0 V	*ITPL
09	*GBBSY	*PF	EN
08	GD07	*IDSTB	GD15
07	GD06	0 V	GD14
06	GD05	0 V	GD13
05	GD04	SDO	GD12
04	GD03	SDI	GD11
03	GD02	0 V	GD10
02	GD01	0 V	GD09
01	GD00	VBAT	GD08

AM0 - 2 : Address modifier #0 - #2
 GA01 - 23: Global address bus #1 - #23
 GD00 - 15: Global data bus #0 - #15
 *GAS : Global address strobe
 R/W : Read/Write
 *GUDS : Global data strobe high byte
 *GLDS : Global data strobe low byte
 *GDTACK : Global data acknowledge
 *GBR : Global bus request
 *BGIN : Bus ground in
 *BGOUT : Bus ground out
 *GBERR : Global bus error
 *GBBSY : Global bus busy
 *SYSTMTR : System timer
 *ITP : Interpolation start
 *ITPL : Interpolation lock
 *IDSTB : ID strobe
 SYSCLK1 } : System clock (16.384 MHz)
 SYSCLK2 }
 SUBCLK1 : Subsidiary clock #1
 *SYSCLR : System clear
 *SYSFAIL : System fail
 *SYSEMG : System emergency
 SDO : Serial data out
 SDI : Serial data in
 *PF : Power off interrupt
 VBAT : Battery power
 EN } : Power enabled
 *EN }
 "EN" is a reverse logic signal of "EN".
 0 V : Reference for supply voltage
 +5 V : +5 VDC power supply for digital logic circuit
 +24 V : +24 VDC power supply for I/O interface
 +15 V } : +15 VDC power supply for memory backup
 -15 V }

CD4A

RS-232-C port A

14	+24 VR	08	RDA	01	
15		09	SDA	02	
16		10		03	
17	0 V	11		04	
18	DRA	12		05	ERA
19	CSA	13		06	
20	RSA			07	

RDA : Receiving data
 SDA : Sending data
 RSA : Request to send
 CSA : Clear to send
 DRA : Data set ready
 ERA : Data terminal ready
 +24 VR : +24 VDC power supply for
 RS-232-C port
 0 V : 0 V

CNTP

RS-422 for teach pendant

14	*RDTP	08		01	RDTP
15	*SDTP	09		02	SDTP
16	TP2	10	TP3	03	TP1
17	0 V	11	TP4	04	
18	0 V	12	EMG	05	
19	0 V	13		06	
20				07	+24F

RDTP } : Receiving data from teach
 *RDTP } pendant
 "*RDTP" is a reverse logic signal of
 "RDTP".
 SDTP } : Sending data to teach pendant
 *SDTP }
 TP1 : Status signal of EMERGENCY
 STOP button and deadman switch
 TP2 : Status signal of EMERGENCY
 STOP button and DISABLE/ENABLE
 switch
 EMG : Common line signal for TP1 and
 TP2
 TP3 } : Extra E-stop contact output
 TP4 }
 +24 F : +24 VDC power supply for teach
 pendant
 0 V : 0 V

CNOP

RS-232-C ports and DI/DO for operator's panel

01	RSB			33	RSC
02	0 V	19	RDB	34	0 V
03	ERB	20	0 V	35	ERC
04	DRB	21	SDB	36	DRC
05	CSB	22	0 V	37	CSC
06	TP3	23	RDC	38	0 V
07	CSTART	24	0 V	39	PENBL
08	CALIB	25	SDC	40	TPENBL
09	FRESET	26	0 V	41	INCYC
10	HOLD	27	ON1	42	NOTCAL
11	OTREL	28	ON2	43	FAULT
12	REMOTE	29	OFF1	44	HELD
13	UPB1	30	OFF2	45	ULED1
14	UPB2	31	0 V	46	ULED2
15	ESTOP	32	0 V	47	+24 V
16	+24 F			48	+24 V
17	+24 F			49	+24 V
18	TP4			50	

TPENBL: Teach pendant enabled LED
 PENBL : Panel enabled LED
 INCYC : In cycle LED
 NOTCAL: Not calibrated LED
 ULED1 : User LED #1
 ULED2 : User LED #2
 FAULT : Fault LED
 HELD : Held LED
 CSTART: Cycle start button
 CALIB : Calibrate button
 UPB1 : User panel button #1
 UPB2 : User panel button #2
 FRESET: Fault reset button
 HOLD : Hold button
 OTREL : Overtravel release button
 ON1 } : Contact of the Power ON button
 ON2 } : (normally open)
 OFF1 } : Contact of the Power OFF button
 OFF2 } : (normally closed)
 REMOTE: Remote switch
 ESTOP : Emergency stop switch
 RDB : Receiving data
 SDB : Sending data
 RSB : Request to send
 CSB : Clear to send
 DRB : Data set ready
 ERB : Data terminal ready
 The six signals listed above are for the RS-232-C interface.
 RDC : Receiving data
 SDC : Sending data
 RSC : Request to send
 CSC : Clear to send
 DRC : Data set ready
 ERC : Data terminal ready
 Above 6 signals are contact of CRT/KB interface.
 TP3 } : Extra E-stop contact output
 TP4 } :
 +24 F : +24 VDC power connection for RS-232-C interface
 +24 V } : +24 VDC power connection for operator's panel
 0 V } :

CNPI

Input unit interface

1	+24 F	8		14	0 V
2	+24 F	9		15	0 V
3	ON1	10		16	ON2
4	OFF1	11		17	OFF2
5	OTREL	12		18	
6	TP1	13		19	TP2
7	+24 F			20	0 V

OTREL : OVERTRAVEL RELEASE button
 ON1 } : Contact of the POWER ON button
 ON2 } : (normally open)
 OFF1 } : Contact of the POWER OFF button
 OFF2 } : (normally closed)
 TP1 : Status signal of EMERGENCY STOP
 button and DEADMAN switch
 TP2 : Status signal of EMERGENCY STOP
 button and DISABLE/ENABLE
 switch
 +24 F : +24 VDC power connection for
 0 V : power input unit interface

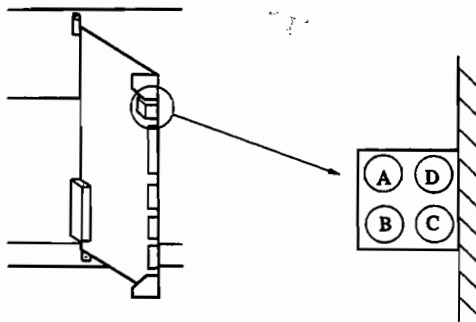
COP2

OPTIN
OPTOUT

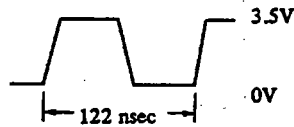
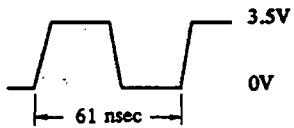
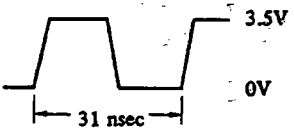
OPTIN : Optical input signal from
 modular I/O unit
 OPTOUT : Optical output signal to
 modular I/O unit

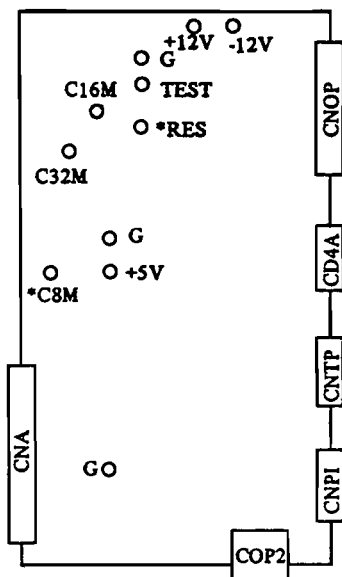
10.4 LEDs

LEDs	Meanings	Status
A (Red)	System fail	This indicates that at least one module is malfunctioning. This signal is asserted illuminating the LED when the main CPU PCB or path CPU PCB is malfunctioning.
B (Red)	System emergency	This indicates a system emergency. The causes are as follows: <ul style="list-style-type: none"> . AC power failure . The watch-dog timer timeout . Error in serial data communication
C	Not used	One of the following battery problems.
D (Red)	Battery alarm	This indicates the following battery problems: <ul style="list-style-type: none"> . The battery unit is not connected. . Fuse on the backplane PCB is blown. . The voltage of the battery becomes less than 3.6 VDC.

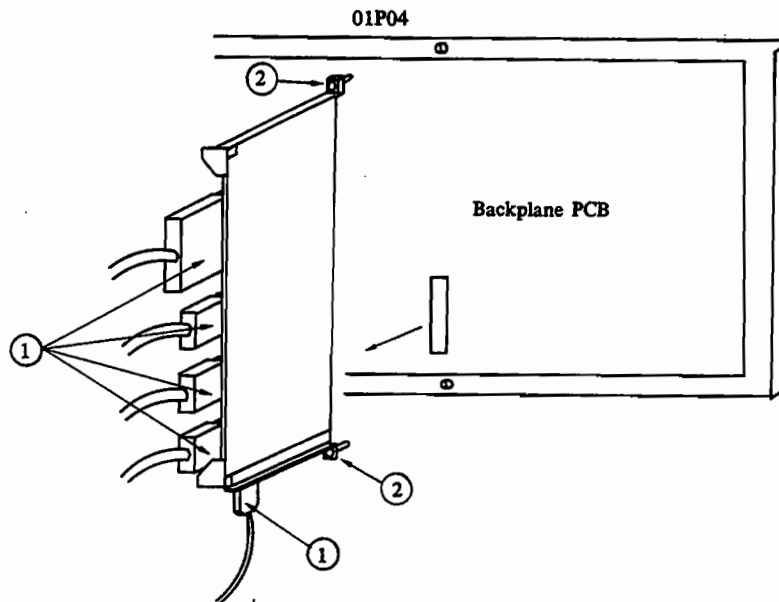


10.5 Test Points

Test points	Contents	Waveform
G	0 V (ground)	
+5 V	Supply voltage for logic	+5 VDC
+12 V	Supply voltage for RS-232-C and RS-422 driver	+12 VDC
-12 V	Supply voltage for RS-232-C and RS-422 driver	-12 VDC
*C8M	Clock for bus controller (8.192 MHz)	
C16M	Clock for main system (16.384 MHz)	
C32M	Clock source for C8M and C16M (32.768 Mhz)	
TEST	This terminal is used in software debugging	
*RES	This terminal is used in software debugging.	



10.6 Removal/Replacement



1) Procedure

- ① Disconnect cables from the PCB.
- ② Detach PCB by loosening the screws ②.
- ③ For mounting new PCB, reverse the above procedure.

CAUTION

Make sure the teach pendant cable is plugged into the teach pendant connector (CNTF) not the serial port connector (CD4A). Otherwise, damage to equipment could occur.

11. BUBBLE MEMORY BOARD (A16B-1211-0090, 0091, 0092)

11.1 Theory of Operation

The bubble memory board is a non volatile mass-storage device used for storing the system software, system variables, and KAREL application programs.

There are three types of bubble memory boards.

A16B-1211-0090: 2 MB

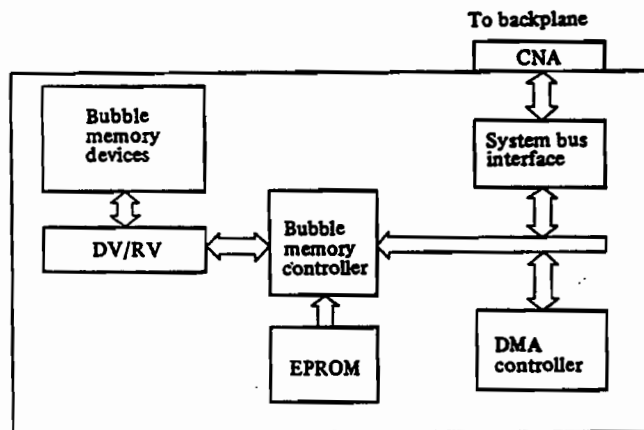
A16B-1211-0091: 1.5 MB

A16B-1211-0092: 1 MB

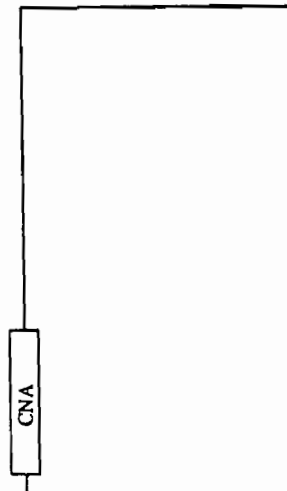
The bubble memory devices are controlled by the controller LSI circuit on the board; data is transferred between the bubble memory board and the other boards by the system bus. Since the DMA (Direct Memory Access) function is supported, the data transfer operation is done by hardware once it has been initiated by software.

A factory-programmed EPROM stores the defective loop information for all bubble memory devices on the board.

11.2 Block Diagram



11.3 Connector/Signal Identification








CNA (Bubble memory)

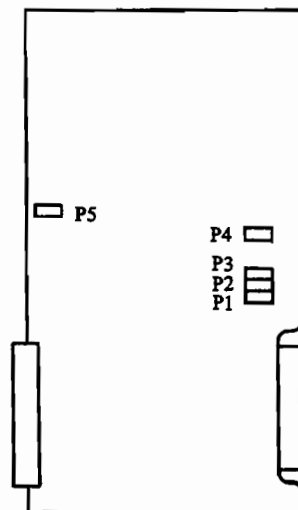
	a	b	c
32	SYSCLK	+5 V	SUBCLK
31	0 V	+5 V	0 V
30	GA13	+5 V	AM2
29	GA12	+5 V	AM1
28	GA11	0 V	AM0
27	GA10	0 V	GA23
26	GA09	+5 V	GA22
25	GA08	+5 V	GA21
24	GA07	+5 V	GA20
23	GA06	0 V	GA19
22	GA05	0 V	GA18
21	GA04	+15 V	GA17
20	GA03	+15 V	GA16
19	GA02	0 V	GA15
18	GA01	0 V	GA14
17	*GAS	-15 V	*GDTACK
16	*GUDS	-15 V	*GBERR
15	*GLDS	0 V	*EN
14	R/W	0 V	*SYSCLR
13	*SYSEMG	+24 V	*SYSFAIL
12	*GBR	+24 V	*SYSTMTR
11	*BGIN	0 V	*ITP
10	*BGOUT	0 V	*ITPL
09	*GBBSY	SDI	SDO
08	GD07	*IDSTB	GD15
07	GD06	0 V	GD14
06	GD05	0 V	GD13
05	GD04	*USED	GD12
04	GD03		GD11
03	GD02	0 V	GD10
02	GD01	0 V	GD09
01	GD00	VBAT	GD08

AM0 - 2 : Address modifier #0 - #2
 GA01 - 23: Global address bus #1 - #23
 GD00 - 15: Global data bus #0 - #15
 *GAS : Global address strobe
 R/W : Read/Write
 *GUDS : Global data strobe high byte
 *GLDS : Global data strobe low byte
 *GDTACK : Global data acknowledge
 *GBR : Global bus request
 *BGIN : Bus ground in
 *BGOUT : Bus ground out
 *GBERR : Global bus error
 *GBBSY : Global bus busy
 *SYSTMTR : System timer
 *ITP : Interpolation start
 *ITPL : Interpolation lock
 *IDSTB : ID strobe
 USED : Slot used
 SYSCLK : System clock (16.384 MHz)
 SUBCLK1 : Subsidiary clock #1
 *SYSCLR : System clear
 *SYSFAIL : System fail
 *SYSEMG : System emergency
 SDO : Serial data out
 SDI : Serial data in
 VBAT : Battery power
 *EN : Power enabled
 0 V : Reference for supply voltage
 +5 V : +5 VDC power supply for digital logic circuit
 +24 V : +24 VDC power supply for I/O interface
 +15 V } : +15 VDC power supply for
 -15 V } : memory backup

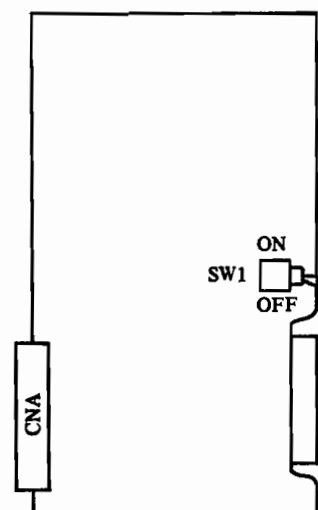
11.4 Jumper and Switch Settings

Jumpers	Standard setting	Uses
P1	B  A	B side setting is selected in software debugging only. In normal use, all must be set to A side.
P2	B  A	
P3	B  A	
P4	B  A	
P5	B  A	

Switch	Standard setting	Uses
SW1	OFF	ON : NOT USED OFF: Normal mode



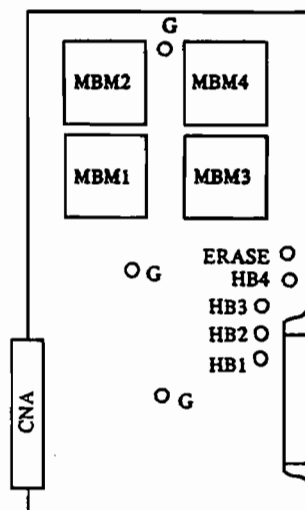
Location of jumpers



Location of switch

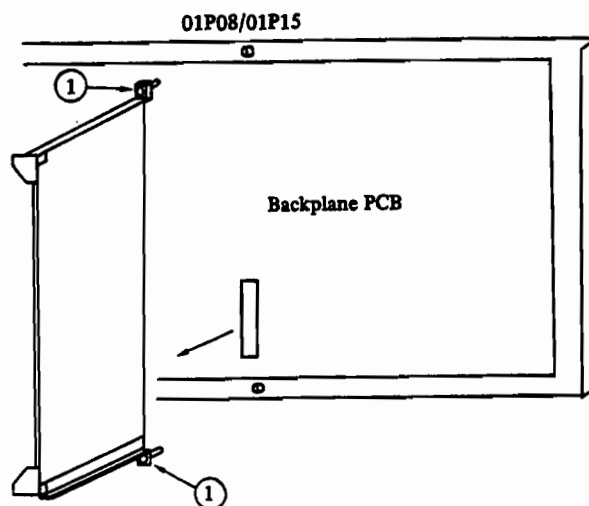
11.5 Test Points

Test points	Contents	Waveform
G	0 V	
HB1	These test points are used for erasing the bubble memory devices. If "ERASE" and "HBn" are short-circuited, the corresponding device MBMn will be erased. (n = 1 - 4) Test point Device ERASE — HB1 : MBM1 ERASE — HB2 : MBM2 ERASE — HB3 : MBM3 ERASE — HB4 : MBM4	
HB2		
HB3		
HB4		
ERASE		



Location of test points

11.6 Removal/Replacement



1) Procedure

- ① Detach PCB by loosening the screws ①.
- ② Mount new PCB.

NOTE Refer to the R-H Controller System Software Installation Kit documentation for information on reloading system software.

12. AXIS CONTROL BOARD (A16B-1211-0060, 0062)

12.1 Theory of Operation

The axis control board receives the motion commands from the path CPU and moves the robot's axes.

There are two types of axis control boards.

A16B-1211-0060: 4-axis control

A16B-1211-0062: 2-axis control

For every two axes, one high-speed microprocessor provides full digital servo control based on modern digital control theory.

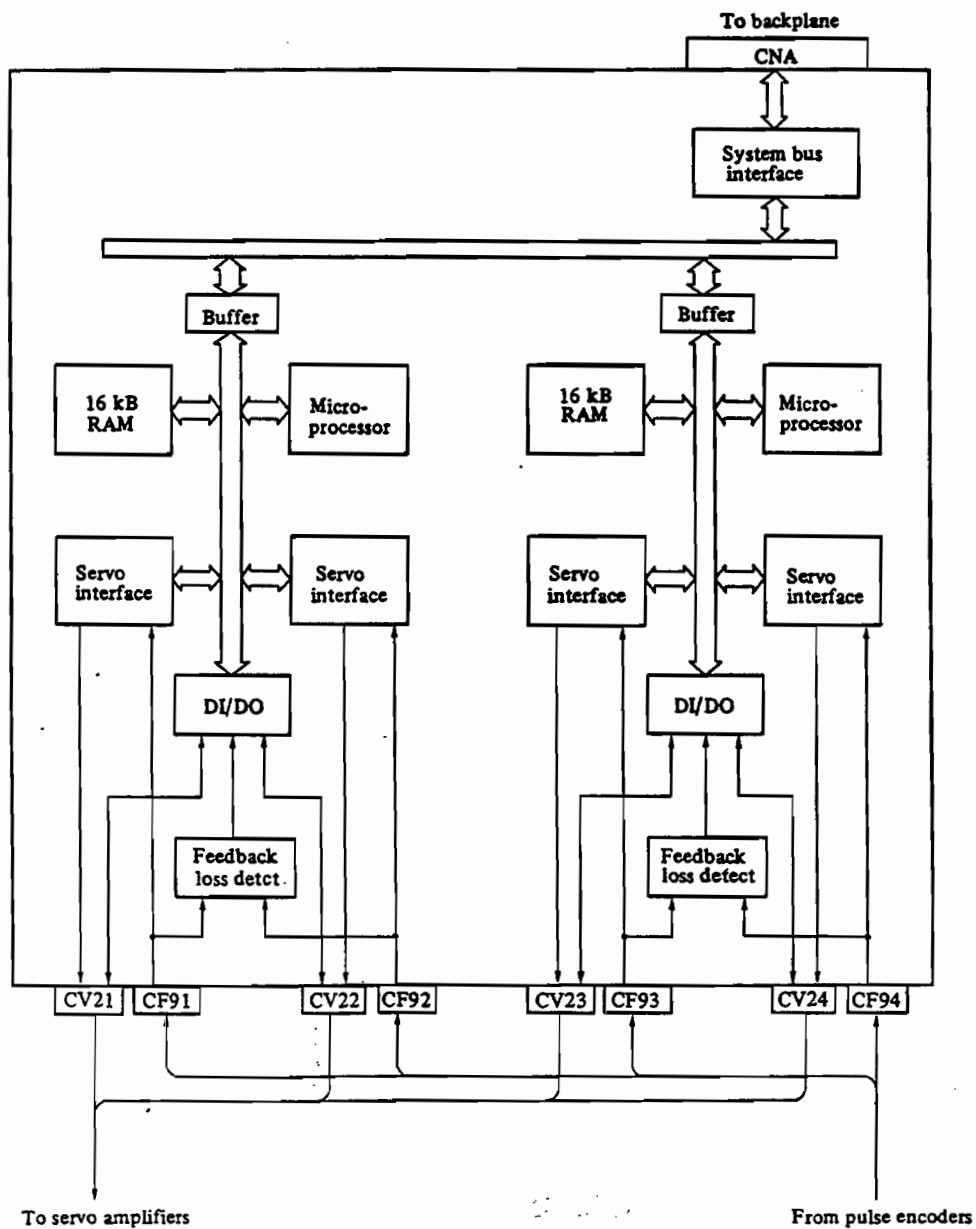
The microprocessor has 16 kB RAM. The software is loaded into RAM by the main CPU via the system bus.

The servo interface contains a custom LSI circuit, A/D converter and some glue (miscellaneous) logic.

For each axis, two connectors are located on the front end of the board. One is a position feedback from the pulse encoder on the motor. The other is a connector to the servo amplifier, which generates the motor power proportional to the torque command from the axis control board.

The board has a feedback loss detect circuit that indicates an error when the pulse encoder cable is disconnected. If the servo amplifier detects an error, the board receives the information via a digital input.

12.2 Block Diagram



12.3 Connector/Signal Identification

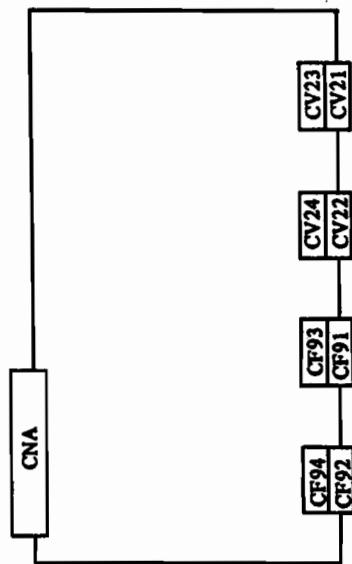
The relationship between the axis numbers, axis names, and the connectors on the axis control PCB, robot mechanical unit, and servo amplifiers is shown in Table 12.3 (a) and (b).

Table 12.3 (a) S-10

Axis Software No.	Axis Hardware No.	Axis	Axis control PCB	Feedback connector	Connector on robot	Axis control PCB	Velocity connector	Servo Amp. No.	Connector
2	1	W	1	CF91	P1	1	CV21	1	CN1N
3	2	U		CF92	P1		CV22		CN1L
1	3	θ		CF93	P1		CV23		CN1M
4	4	γ		CF94	P2		CV24	2	CN1N
5	5	β	2	CF91	P2	2	CV21		CN1M
6	6	α		CF92	P2		CV22		CN1L

Table 12.3 (b) S-700

Axis Software No.	Axis Hardware No.	Axis	Axis control PCB	Feedback connector	Connector on robot	Axis control PCB	Velocity connector	Servo Amp. No.	Connector
2	1	W	1	CF91	P1	1	CV21	4	CN1
3	2	U		CF92	P1		CV22	1	CN1M
1	3	θ		CF93	P1		CV23	3	CN1
4	4	γ		CF94	P2		CV24	2	CN1M
5	5	β	2	CF91	P2	2	CV21	2	CN1L
6	6	α		CF92	P2		CV22	1	CN1L

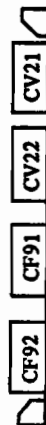


Connector position (Side view of PCB)



A16B-1211

-0060



-0062

CNA (Axis control)

	a	b	c
32	SYSCLK	+5 V	SUBCLK
31	0 V	+5 V	0 V
30	GA13	+5 V	AM2
29	GA12	+5 V	AM1
28	GA11	0 V	AM0
27	GA10	0 V	GA23
26	GA09	+5 V	GA22
25	GA08	+5 V	GA21
24	GA07	+5 V	GA20
23	GA06	0 V	GA19
22	GA05	0 V	GA18
21	GA04	+15 V	GA17
20	GA03	+15 V	GA16
19	GA02	0 V	GA15
18	GA01	0 V	GA14
17	*GAS	-15 V	*GDTACK
16	*GUDS	-15 V	*GBERR
15	*GLDS	0 V	*EN
14	R/W	0 V	*SYSCLR
13	*SYSEMG	+24 V	*SYSFAIL
12	*GBR	+24 V	*SYSTMTR
11	*BGIN	0 V	*ITP
10	*BGOUT	0 V	*ITPL
09	*GBBSY	SDI	SDO
08	GD07	*IDSTB	GD15
07	GD06	0 V	GD14
06	GD05	0 V	GD13
05	GD04	*USED	GD12
04	GD03		GD11
03	GD02	0 V	GD10
02	GD01	0 V	GD09
01	GD00	VBAT	GD08

AM0 - 2 : Address modifier #0 - #2
 GA01 - 23: Global address bus #1 - #23
 GD00 - 15: Global data bus #0 - #15
 *GAS : Global address strobe
 R/W : Read/Write
 *GUDS : Global data strobe high byte
 *GLDS : Global data strobe low byte
 *GDTACK : Global data acknowledge
 *GBR : Global bus request
 *BGIN : Bus ground in
 *BGOUT : Bus ground out
 *GBERR : Global bus error
 *GBBSY : Global bus busy
 *SYSTMTR : System timer
 *ITP : Interpolation start
 *ITPL : Interpolation lock
 *IDSTB : ID strobe
 USED : Slot used
 SYSCLK : System clock (16.384 MHz)
 SUBCLK1 : Subsidiary clock #1
 *SYSCLR : System clear
 *SYSFAIL : System fail
 *SYSEMG : System emergency
 SDO : Serial data out
 SDI : Serial data in
 VBAT : Battery power
 *EN : Power enabled
 0 V : Reference for supply voltage
 +5 V : +5 VDC power supply for
 digital logic circuit
 +24 V : +24 VDC power supply for I/O
 interface
 +15 V } : +15 VDC power supply for
 -15 V } : memory backup

For 1st axis CF91

1	0 V	8	OH1A1	14	PCZA1
2	0 V	9	OH2A1	15	*PCZA1
3	0 V	10	C8A1	16	PCAA1
4	+5 V	11	C4A1	17	*PCAA1
5	+5 V	12	C2A1	18	PCBA1
6	+5 V	13	C1A1	19	*PCBA1
7				20	REQA1

For 2nd axis CF92

1	0 V	8	OH1A2	14	PCZA2
2	0 V	9	OH2A2	15	*PCZA2
3	0 V	10	C8A2	16	PCAA2
4	+5 V	11	C4A2	17	*PCAA2
5	+5 V	12	C2A2	18	PCBA2
6	+5 V	13	C1A2	19	*PCBA2
7				20	REQA2

For 3rd axis CF93

1	0 V	8	OH1A3	14	PCZA3
2	0 V	9	OH2A3	15	*PCZA3
3	0 V	10	C8A3	16	PCAA3
4	+5 V	11	C4A3	17	*PCAA3
5	+5 V	12	C2A3	18	PCBA3
6	+5 V	13	C1A3	19	*PCBA3
7				20	REQA2

For 4th axis CF94

1	0 V	8	OH1A4	14	PCZA4
2	0 V	9	OH2A4	15	*PCZA4
3	0 V	10	C8A4	16	PCAA4
4	+5 V	11	C4A4	17	*PCAA4
5	+5 V	12	C2A4	18	PCBA4
6	+5 V	13	C1A4	19	*PCBA4
7				20	REQA4

For 5th axis CF91

1	0 V	8	OH1A5	14	PCZA5
2	0 V	9	OH2A5	15	*PCZA5
3	0 V	10	C8A5	16	PCAA5
4	+5 V	11	C4A5	17	*PCAA5
5	+5 V	12	C2A5	18	PCBA5
6	+5 V	13	C1A5	19	*PCBA5
7				20	REQA5

For 6th axis CF92

1	0 V	8	OH1A6	14	PCZA6
2	0 V	9	OH1A6	15	*PCZA6
3	0 V	10	C8A6	16	PCAA6
4	+5 V	11	C4A6	17	*PCAA6
5	+5 V	12	C2A6	18	PCBA6
6	+5 V	13	C1A6	19	*PCBA6
7				20	REQA6

CF91 - CF94

OH1 } : Motor overheat
OH2 }
C8 } : Gray code from pulse coder
C4 }
C2 }
C1 }
PCZ } : Z-phase of pulse coder
*PCZ }
PCA } : A-phase of pulse coder
*PCA }
PCB } : B-phase of pulse coder
*PCB }
REQ } : Request signal for absolute pulse coder

Suffix A1 - A6 represents the axis number 1 - 6.

(CF91 of the second axis control board 02P05)

(CF92 of the second axis control board 02P05)

For 1st axis CV21

01	*PWMAA1 (*ALM1)			14	*PWMDA1 (*ALM8)
02	COMAA1	08	IRA1	15	COMDA1
03	*PWMAA1 (*ALM2)	09	GDRA1	16	*PWMEA1
04	COMBA1	10	ISA1	17	COME1
05	*PWMCA1 (*ALM4)	11	GDSA1	18	*PWMFA1
06	COMCA1	12	*MCONA1	19	COMFA1
07	*DRDYA1	13	GND	20	

CV21 - CV24

*PWMA
 *PWMB
 *PWMC
 *PWMD
 *PWME
 *PWMF
 COMA
 COMB
 COMC
 COMD
 COME
 COMF
 GDR

: Pulse width modulator
 : (Note 2)

: Common signals for PWM

: Feedback current of
 R-phase

: Feedback current of
 S-phase

: Ground for feedback
 current

For 2nd axis CV22

01	*PWMAA2 (*ALM1)			14	*PWMDA2 (*ALM8)
02	COMAA2	08	IRA2	15	COMDA2
03	*PWMAA2 (*ALM2)	09	GDRA2	16	*PWMEA2
04	COMBA2	10	ISA2	17	COME2
05	*PWMCA2 (*ALM4)	11	GDSA2	18	*PWMFA2
06	COMCA2	12	*MCONA2	19	COMFA2
07	*DRDYA2	13	GND	20	

Note 1) Suffix A1 - A6 represents the axis number 1 - 6.

Note 2) PWM signal pins are used bidirectionally. Normally they are outputs. When the servo amplifier is alarming, they become inputs. Names in parentheses are alarm signals in such a case.

For 3rd axis CV23

01	*PWMAA3 (*ALM1)			14	*PWMDA3 (*ALM8)
02	COMAA3	08	IRA3	15	COMDA3
03	*PWMAA3 (*ALM2)	09	GDRA3	16	*PWMEA3
04	COMBA3	10	ISA3	17	COME3
05	*PWMCA3 (*ALM4)	11	GDSA3	18	*PWMFA3
06	COMCA3	12	*MCONA3	19	COMFA3
07	*DRDYA3	13	GND	20	

For 4th axis CV24

01	*PWMAA4 (*ALM1)	08	IRA4	14	*PWMDA4 (*ALM8)
02	COMAA4	09	GDRA4	15	COMDA4
03	*PWMB44 (*ALM2)	10	ISA4	16	*PWMEA4
04	COMBA4	11	GDSA4	17	COME44
05	*PWMCA4 (*ALM4)	12	*MCONA4	18	*PWMFA4
06	COMCA4	13	GND	19	COMFA4
07	*DRDYA4			20	

For 5th axis CV21

01	*PWMAA5 (*ALM1)	08	IRA5	14	*PWMDA5 (*ALM8)
02	COMAA5	09	GDRA5	15	COMDA5
03	*PWMB45 (*ALM2)	10	ISA5	16	*PWMEA5
04	COMBA5	11	GDSA5	17	COME45
05	*PWMCA5 (*ALM4)	12	*MCONA5	18	*PWMFA5
06	COMCA5	13	GND	19	COMFA5
07	*DRDYA5			20	

(CV21 of the second axis control
board 02P05)

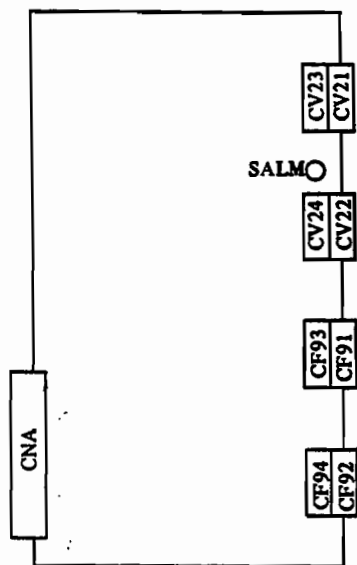
For 5th axis CV22

01	*PWMAA6 (*ALM1)	08	IRA6	14	*PWMDA6 (*ALM8)
02	COMAA6	09	GDRA6	15	COMDA6
03	*PWMB46 (*ALM2)	10	ISA6	16	*PWMEA6
04	COMBA6	11	GDSA6	17	COME46
05	*PWMCA6 (*ALM4)	12	*MCONA6	18	*PWMFA6
06	COMCA6	13	GND	19	COMFA6
07	*DRDYA6			20	

(CV22 of the second axis control
board 02P05)

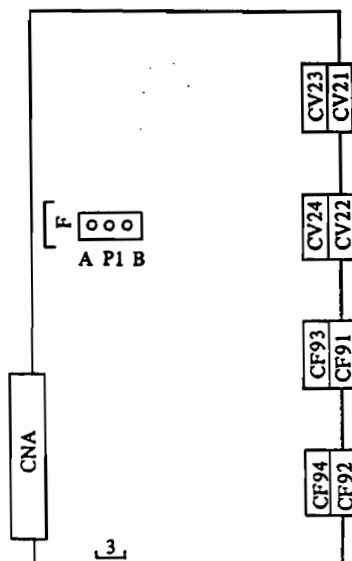
12.4 LEDs

LED	Meanings	Status
SALM	Servo alarm	<ol style="list-style-type: none"> 1. Parity alarm occurs, accessing static-RAM on the axis control PCB. 2. Watch dog time out.



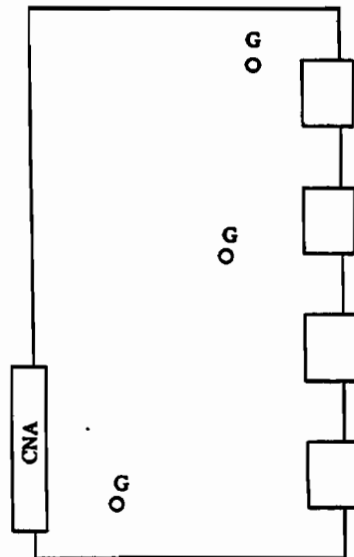
12.5 Jumper Settings

Jumper	Standard setting	Uses
P1	<div style="display: flex; align-items: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg);">A P1 B</div> <div style="border: 1px solid black; padding: 2px; margin: 0 5px;"> <div style="background: repeating-linear-gradient(45deg, transparent, transparent 2px, black 2px, black 4px); width: 10px; height: 10px; margin: 0 auto;"></div> <div style="width: 10px; height: 10px; border: 1px solid black; border-radius: 50%; margin: 0 auto;"></div> </div> </div>	<p>A: This PCB is used in "R-H" system.</p> <p>B: This PCB is used in "R-G" system.</p> <p>In this system, it must be set to A side.</p>



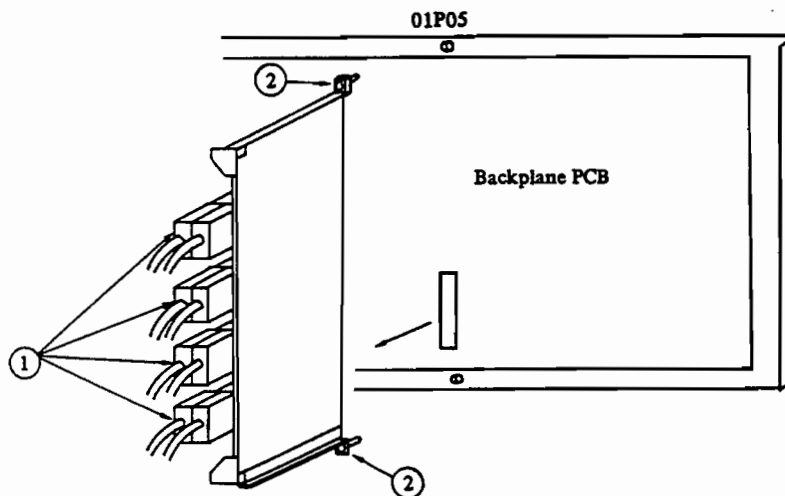
12.6 Test Points

Test points	Contents
G	0 V (ground)



Location of test points

12.7 Removal/Replacement



1) Procedure

- ① Disconnect cables from the PCB.
- ② Detach PCB by loosening the screws ②.
- ③ For mounting new PCB, reverse the above procedure.

2) Caution

When connecting cables, be careful to the match cables and connectors on PCB.

13. REMOTE CRT/KB (A13B-0144-B001)

13.1 Theory of Operation

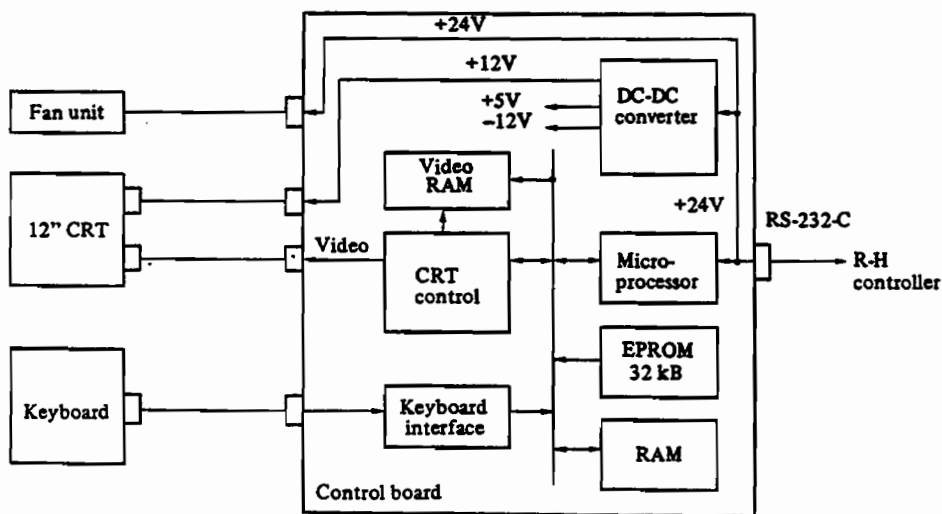
The remote CRT/KB is a portable terminal which contains a 12" CRT display and a full ASCII keyboard.

The remote CRT/KB is connected to the R-H controller at its RS-232-C port and is used as a user interface.

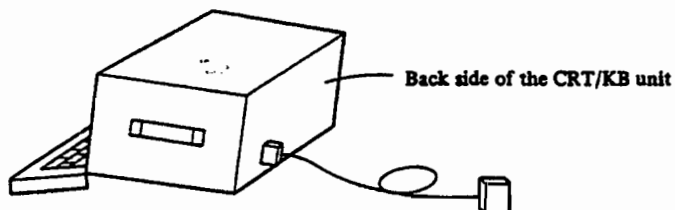
The unit is composed of a 12" monochrome CRT, a membrane keyboard, a fan unit and a control board. The control board has a microprocessor that processes serial communication, key-scanning and CRT display information. The CRT control circuit generates a video signal based on the data in the video RAM.

All DC power used in the unit is supplied from the R-H controller. The +24 V provided via RS-232-C cable is a source for the DC-DC converter.

13.2 Block Diagram



13.3 Connector/Signal Identification



Remote CRT/KB side

1				14	+24 V
2		8	RD	15	
3		9	SD	16	CD
4		10		17	SG
5	ER	11		18	DR
6		12		19	CS
7		13		20	RS

Controller side

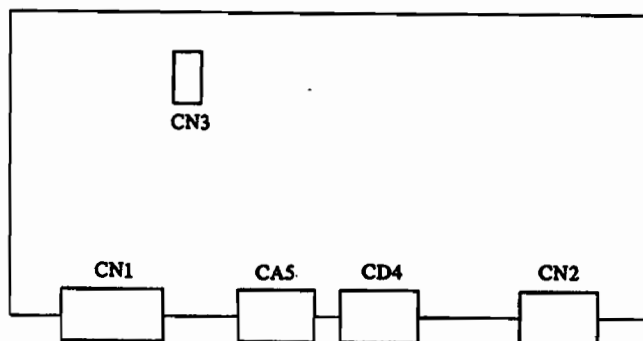
1	FG	14	
2	SD	15	
3	RD	16	
4	RS	17	
5	CS	18	
6	DR	19	
7	SG	20	ER
8	CD	21	
9		22	
10		23	
11		24	
12		25	+24 V
13			

FG : Frame ground
 RD : Received data
 SD : Transmitted data
 RS : Request to send
 ER : Data terminal ready
 SG : Signal ground
 +24 V: +24 VDC power source for the remote CRT/KB

} RS-232-C data signal
 } RS-232-C control signal

13.4 CRT/KB Control PCB (A16B-1211-0760)

13.4.1 Connector/signal identification



Front view of the CRT/KB control PCB

CN1

1	
2	
3	0 V
4	0 V
5	+12 V
6	+12 V

0 V } : +12 VDC power source for the
+12 V } : CRT unit

CA5

1		8		14	
2		9	0 V	15	
3		10	0 V	16	
4	*INCINT	11	0 V	17	
5	VSUNC	12	0 V	18	
6	HSUNC	13	0 V	19	
7	*VIDEO			20	

*VIDEO : Video signal for CRT
*INCINT: Increased intensity
HSUNC : Horizontal synchronous control signal
VSUNC : Vertical synchronous control signal
0 V : 0 V (ground level)

} CRT control signal

CD4

1		8		14	RS
2		9		15	
3	ER	10		16	
4		11		17	SG
5		12	SD	18	
6		13	RD	19	
7				20	+24 V

ER
SD
RD
RS
SG
+24 V

} : Refer to Sec. 13.3

CN2

1	*KEY1	8	*COM7	14	*COM0
2	*KEY2	9	*COM8	15	*COM1
3	*KEY3	10	*COM9	16	*COM2
4	*KEY4	11	*LED2	17	*COM3
5	*KEY5	12	*LED1	18	*COM4
6	*KEY6	13	*KEY0	19	*COM5
7	*KEY7			20	*COM6

*COM0 - 9: Common of the key switch
(from the CRT/KB control PCB)

*KEY0 - 7: Input signal of key switch
status (to the CRT/KB control
PCB)

*LED1 } : Input signal of LED status
*LED2 } : (from the CRT/KB control PCB)

CN3

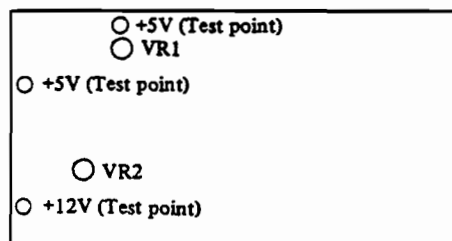
1	+24 V
2	GND

+24 V : +24 VDC power source for
the fan unit

GND : 0 V



13.4.2 Variable resistors

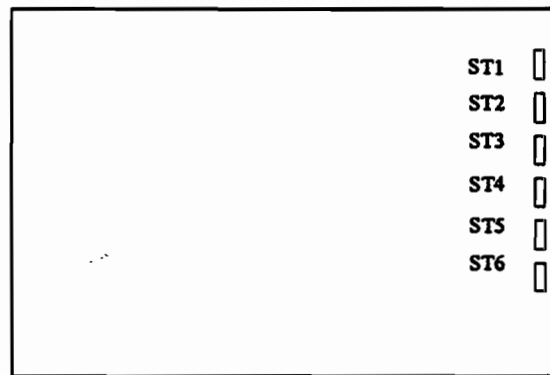
Name	Function	Adjustment
VR1	Adjustment of the +5 V voltage	Adjust the VR1 so that the voltage at "+5 V" is within a range of $5\text{ V} \pm 0.1\text{ V}$.
VR2	Adjustment of the +12 V voltage	Adjust the VR2 so that the voltage at "+12 V" is within a range of $12\text{ V} \pm 0.1\text{ V}$.



Location of variable resistors


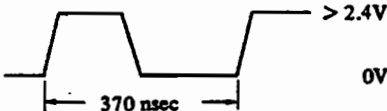
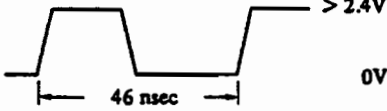
13.4.3 Jumper settings

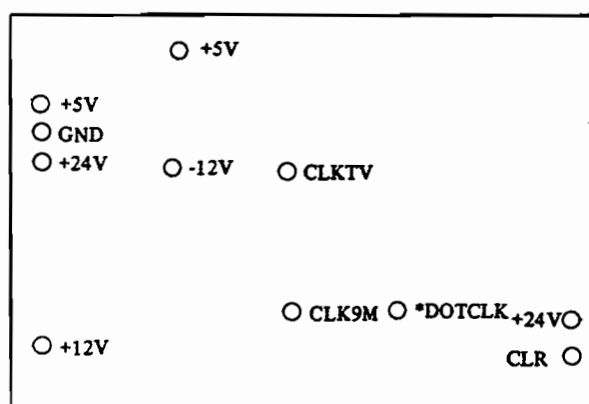
Jumpers	Standard setting	Uses
ST1	A  B	Character generator selection: Select A side: KANA + ALPHA NUMERIC Select B side: ALPHA NUMERIC
ST2 to ST6	A  B	Not used (all B side)



Location of jumpers

13.4.4 Test points

Test points	Symbol	Contents	Waveform
CLK9M	-	System clock for the CRT/KB control PCB	
CLKTV	-	Character clock for the CRT/KB control PCB	
*DOTCLK	-	Dot clock for the CRT/KB control PCB	
*CLR	-	Power on signal for the CRT/KB control PCB	>2.4 VDC
+24 V	-	Power source for this unit	+22 - +24 VDC
+12 V	-	Supply voltage for CRT unit and RS-232-C driver	+12 VDC \pm 0.1 V
-12 V	-	Supply voltage for RS-232-C driver	-12 VDC \pm 0.1 V
+5 V	-	Supply voltage for the control circuit	+5 VDC \pm 0.1 V
GND	-		0 V

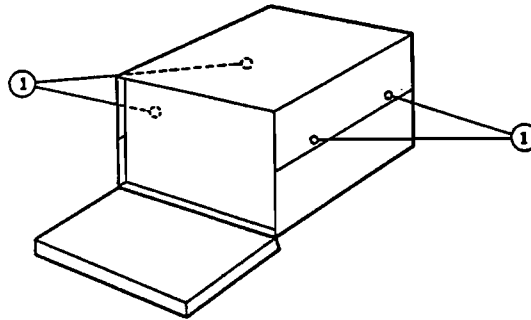


Location of test points

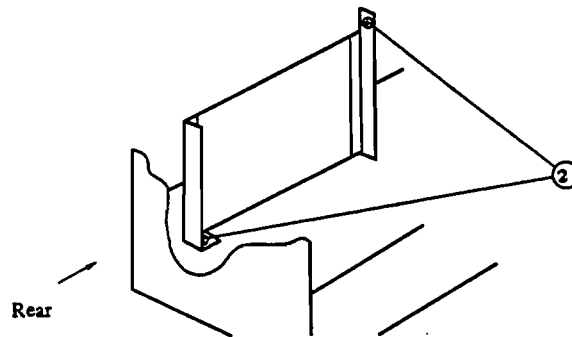
13.4.5 Removal/replacement

1) Procedure

- ① Remove the top cover by loosening four screws.



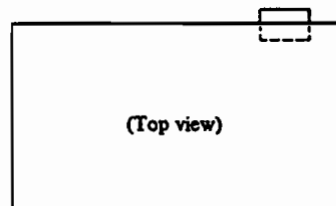
- ② Remove the PCB by loosening two screws.



- ③ Disconnect cables from the PCB.
- ④ For mounting a new PCB, reverse the above procedure.

13.5 Keyboard PCB (A86L-0001-0149)

13.5.1 Connector/signal identification



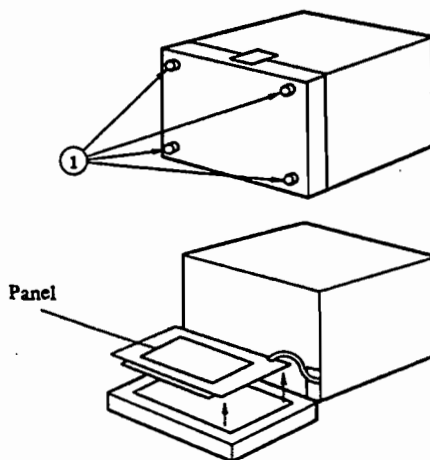
A1	*KEY0	B1	*KEY1
A2	*KEY2	B2	*KEY3
A3	*KEY4	B3	*KEY5
A4	*KEY6	B4	*KEY7
A5	*LED1	B5	*LED2
A6	*COM0	B6	*COM1
A7	*COM2	B7	*COM3
A8	*COM4	B8	*COM5
A9	*COM6	B9	*COM7
A10	*COM8	B10	*COM9

*KEY0 - 7
*LED1
*LED2
*COM0 - 9 } : Refer to Sec. 13.4.1

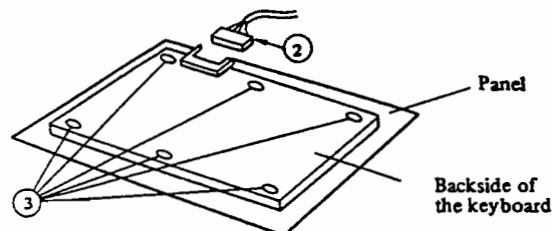
13.5.2 Removal/replacement

1) Procedure

- ① Remove the keyboard panel by loosening four screws.



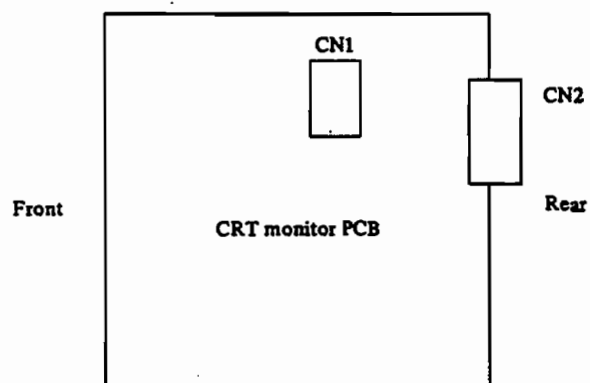
- ② Disconnect the connector.
- ③ Remove the keyboard by loosening six nuts.



- ④ For mounting a new keyboard, reverse the above procedure.

13.6 CRT Monitor (A61L-0001-0088)

13.6.1 Connector/signal identification



View of the part-mounting side

CN1

1	*VIDEO	8	0 V	14	
2	HSYNC	9	0 V	15	
3	VSYNC	10	0 V	16	
4	*INCINT	11	0 V	17	
5		12	0 V	18	
6		13		19	
7				20	

*VIDEO
 HSYNC
 VSYNC
 *INCINT
 0 V

} : Refer to 13.4.1

CN2

1	
2	
3	0 V
4	0 V
5	+12 V
6	+12 V

0 V
 +12 V

} : Refer to Sec. 13.4.1

14. BUILT-IN CRT/KB (A05B-2051-J101, J102)

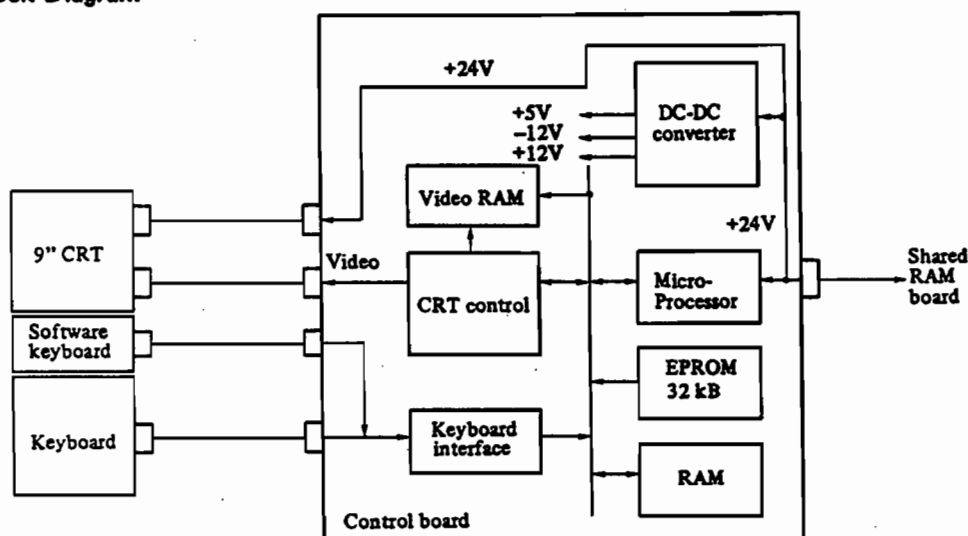
14.1 Theory of Operation

The built-in CRT/KB is a console which contains a 9" CRT display and a full ASCII keyboard.

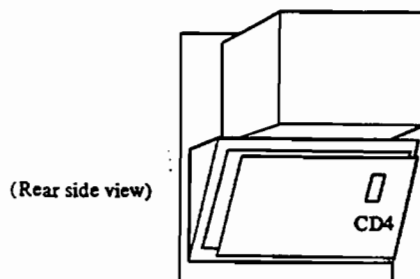
The built-in CRT/KB is connected to the shared RAM board at its RS-232-C port and is used as a user interface.

The unit is composed of a 9" monochrome CRT, a membrane keyboard, a software keyboard and a control board. The control board has a microprocessor that processes serial communication, key-scanning and CRT display information. The CRT control circuit generates a video signal based on the data in the video RAM. All DC power used in the unit is converted from the +24 V provided via RS-232-C cable.

14.2 Block Diagram



14.3 Connector/Signal Identification



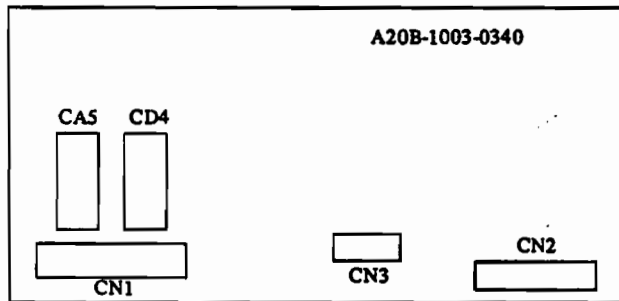
CD4

1				14	+24 V
2		8	SD	15	
3		9	RD	16	
4		10		17	SG
5		11		18	ER
6		12		19	RS
7		13		20	

RD : Received data } RS-232-C data
SD : Transmitted data } signal
RS : Request to send } RS-232-C
ER : Data terminal } control signal
ready
SG : Signal ground
+24 V: +24 VDC power source for the
remote CRT/KB

14.4 CRT/KB Control PCB (A20B-1003-0340)

14.4.1 Connector/signal identification



Front view of the CRT/KB control PCB

CN1

1	
2	
3	0 V
4	0 V
5	+24 V
6	+24 V

0 V } : +24 VDC power source for
+24 V } : the CRT unit

CA5

1	*VIDEO	8	0 V	14	
2	HSYNC	9	0 V	15	
3	VSNC	10	0 V	16	
4	*INCINT	11	0 V	17	
5		12	0 V	18	
6		13		19	
7				20	

*VIDEO : Video signal for CRT
*INCINT: Increased intensity
HSYNC : Horizontal synchronous } CRT
 control signal } control
VSNC : Vertical synchronous } signal
 control signal }
0 V : 0 V (ground level)

CD4

1		8	SD	14	+24 V
2		9	RD	15	
3		10		16	
4		11		17	SG
5		12		18	ER
6		13		19	RS
7				20	

SD : Transmitted data } RS-232-C
RD : Received data } data signal
RS : Request to send } RS-232-C
ER : Data terminal } control signal
 ready }
SG : Signal ground
+24 V: +24 VDC power source for the
 remote CRT/KB

CN2

A1	*KEY0	B1	*KEY1
A2	*KEY2	B2	*KEY3
A3	*KEY4	B3	*KEY5
A4	*KEY6	B4	*KEY7
A5	*LED1	B5	*LED2
A6	*COM0	B6	*COM1
A7	*COM2	B7	*COM3
A8	*COM4	B8	*COM5
A9	*COM6	B9	*COM7
A10	*COM8	B10	*COM9

*COM0 - 7: Common of the key switch
(from the CRT/KB control PCB)
*KEY0 - 9: Input signal of key switch
status (to the CRT/KB control
PCB)
LED1 } : Input signal of LED status
LED2 } : (from the CRT/KB control PCB)

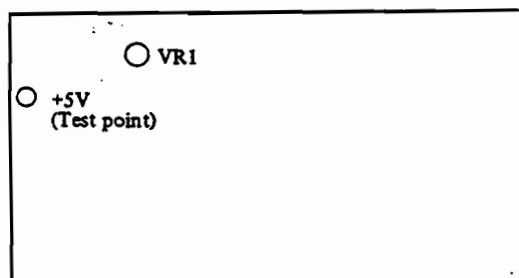
CN3

A1	*KY1	B1	*SCOM
A2	*KY2	B2	
A3	*KY3	B3	
A4	*KY4	B4	*KY7
A5	*KY5	B5	*KY6

*SCOM : Common of the softkey switch
*KY1 - 7 : Input signal of softkey
switch status
(from the CRT/KB control PCB)

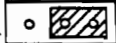
14.4.2 Variable resistors

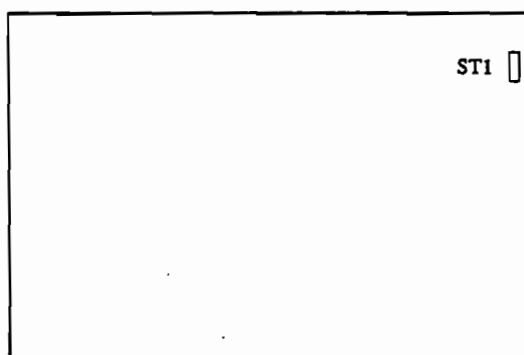
Name	Function	Adjustment
VR1	Adjustment of the +5 V voltage	Adjust the VR1 so that the voltage at "+5 V" is within a range of $5\text{ V} \pm 0.1\text{ V}$.



Location of variable resistors

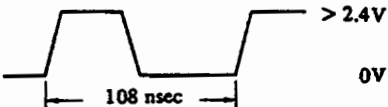
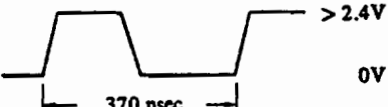

14.4.3 Jumper setting

Jumper	Standard setting	Uses
ST1	A  B	Character generator selection: Select A side: KANA + ALPHA NUMERIC Select B side: ALPHA NUMERIC

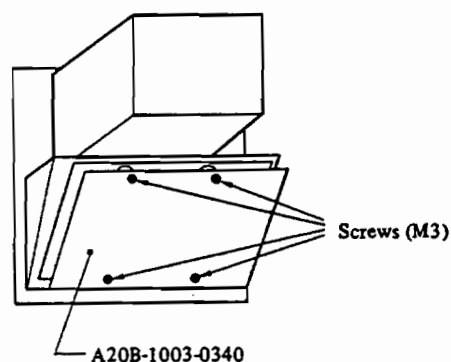


Location of jumpers

14.4.4 Test points

Test points	Symbol	Contents	Waveform
CLK9M	-	System clock for the CRT/KB control PCB	
CLKTV	-	Character clock for the CRT/KB control PCB	
*DOTCLK	-	Dot clock for the CRT/KB control PCB	
*CLR	-	Power on signal for the CRT/KB control PCB	>2.4 VDC
+24 V	-	Power source for this unit	+22 - +24 VDC
+12 V	-	Supply voltage for CRT unit and RS-232-C driver	+12 VDC \pm 0.1 V
-12 V	-	Supply voltage for RS-232-C driver	-12 VDC \pm 0.1 V
+5 V	-	Supply voltage for the control circuit	+5 VDC \pm 0.1 V
GND	-		0 V

14.4.5 Removal/replacement

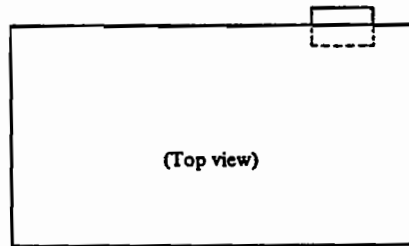


1) Procedure

- ① Disconnect cables from the CRT/KB control PCB.
- ② Detach the CRT/KB control PCB by loosening the four screws.
- ③ For mounting the PCB, reverse the above procedure.

14.5 Keyboard PCB (A86L-0001-0149)

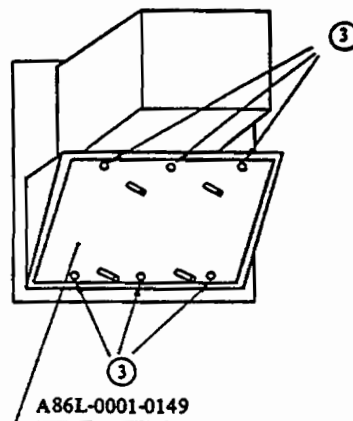
14.5.1 Connector/signal identification



A1	*KEY0	B1	*KEY1
A2	*KEY2	B2	*KEY3
A3	*KEY4	B3	*KEY5
A4	*KEY6	B4	*KEY7
A5	*LED1	B5	*LED2
A6	*COM0	B6	*COM1
A7	*COM2	B7	*COM3
A8	*COM4	B8	*COM5
A9	*COM6	B9	*COM7
A10	*COM8	B10	*COM9

*KEY0 - 7
*LED1
*LED2
*COM0 - 9 } : Refer to Sec. 13.4.1

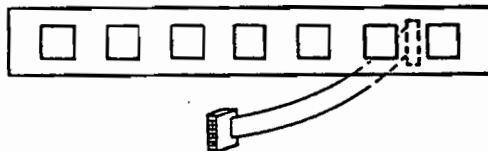
14.5.2 Removal/replacement



- ① Remove the CRT/KB control PCB, according to Sec. 14.4.5.
- ② Disconnect cables from the keyboard PCB.
- ③ Remove the nuts ③ from the keyboard mounting plate, and detach the keyboard PCB along with the mounting plate. (The mounting plate and PCB are attached.)
- ④ Remove the key sheet from the keyboard mounting plate. (The key sheet adheres to the keyboard mounting plate.)
- ⑤ For mounting the PCB, reverse the above procedure.

14.6 Software Keyboard PCB (A20B-1000-0844)

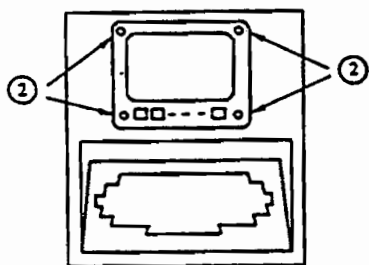
14.6.1 Connector/signal identification



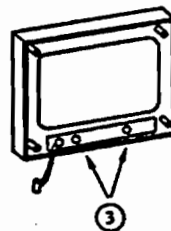
A1	*KYD1	B1	*COM00
A2	*KYD2	B2	
A3	*KYD3	B3	
A4	*KYD4	B4	*KYD7
A5	*KYD5	B5	*KYD6

*COM00 : Common of key switch
*KYD1 - 7: Input signal of key switch status

14.6.2 Removal/replacement



Front view of CRT/KB panel

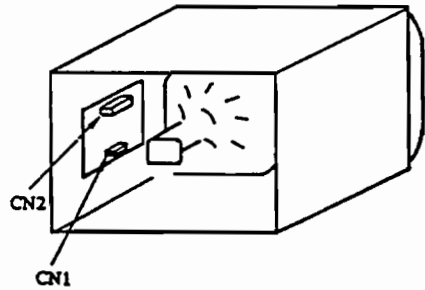


Rear view of the CRT escutcheon

- ① Disconnect the flat cable for software keyboard from the PCB.
- ② Remove four screws ② fixing the CRT escutcheon, and detach the software keyboard PCB along with the CRT escutcheon.
- ③ Detach the software keyboard PCB by loosening the two screws ③.
- ④ For mounting the PCB, reverse the above procedure.

14.7 CRT Monitor (A13B-0056-0001)

14.7.1 Connector/signal identification



Rear view of the CRT monitor

CN2

1	2	3	4	5	6
		0 V	0 V	+24 V	+24 V

+24 V } : Supply voltage for CRT monitor
0 V }

CN1

14			01	VIDEO
15		08 0 V	02	H SYNC
16		09 0 V	03	V SYNC
17		10 0 V	04	HIGH VIDEO
18		11 H VIDEO RET.	05	
19		12 0 V	06	
20		13	07	

VIDEO : Video signal
HSYNC : Horizontal sync. signal
VSYNC : Vertical sync. signal
HIGH VIDEO : High brightness video signal
H VIDEO RET.: 0 V for "HIGH VIDEO"
0 V : 0 V

14.7.2 Adjustment routine

The CRT character display controls are set at the factory and generally will not require major adjustment. To adjust brightness (B) and contrast (C), turn the corresponding variable resistors mounted on the side of the CRT display unit (Fig. 14.7.2).

Caution) Keep fingers and tools away from the display unit when first turning the power on, because an extremely high initial voltage, between 10 and 11 kV, is present.

Note) If a signal cable is disconnected, the entire CRT screen will go blank.

1) Adjusting Brightness (variable resistor B)

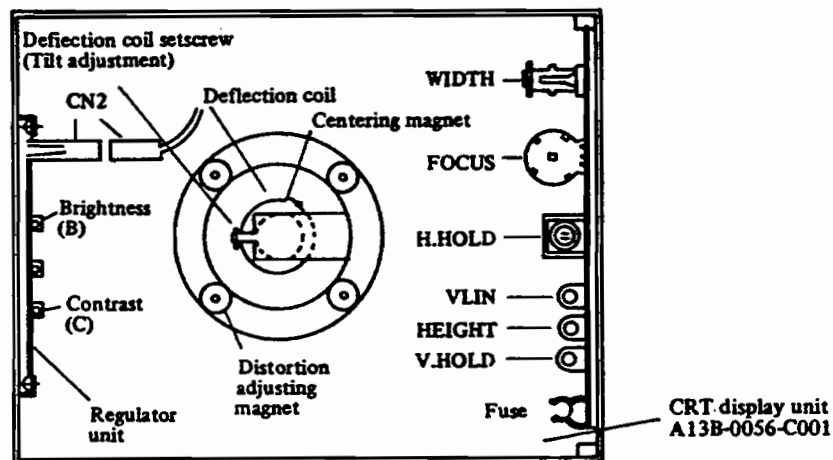
This control knob (variable resistor B) controls the overall brightness of the CRT screen.

- a) Adjust the brightness control knob (variable resistor B) to the brightest level possible before the raster (scanning line) appears on the screen.
- b) If the raster appears during the contrast (variable resistor C) or other screen adjustment, use the brightness control (variable resistor B) to eliminate it.

2) Adjusting Contrast (variable resistor C)

The contrast knob controls the difference between the brightest and darkest picture elements.

- a) Adjust the contrast control knob (variable resistor C) until display characters achieve an easy-to-read brightness level.
- b) Do not apply too much contrast, as this can distort the characters and make them difficult to read.



Note) The CRT display unit includes the regulator unit.

Fig. 14.7.2 Adjustment position (Rear view of display unit)

14.7.3 Special adjustment

If the CRT picture is distorted or tilted, the adjusting magnets located on the CRT display unit (Fig. 14.7.3 (a)) will correct these problems.

Bringing the magnets closer to or farther from the cathode ray deflects the scanning beam to the desired result.

Generally, adjustments are not required unless a CRT component, such as a CRT deflection coil, has been newly installed.

- 1) Picture distortion and position adjustments are made using the deflection coil distortion adjusting magnets, centering magnet, and deflection coil set screw. To avoid an electric shock, adjust them after turning the power off.

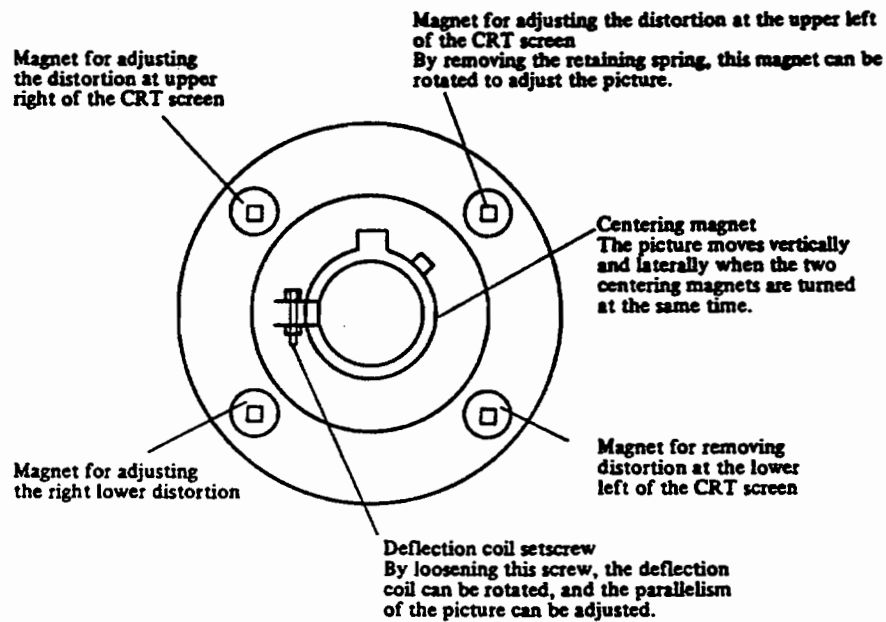


Fig. 14.7.3 (a) Adjustment position (Rear view of CRT)

- 2) Adjustments for synchronization (vertical and horizontal), focus, linearity, width and height are made by using the variable resistors and adjustable coil located on the PCB in the CRT display unit.

WIDTH Changes the horizontal picture size

FOCUS Sharpens characters

H.HOLD Stops the picture from shifting horizontally
(Horizontal synchronization)

V.LIN Equalizes character sizes vertically in
the upper and lower parts of the screen
(Vertical amplitude)

HEIGHT Changes vertical picture size
(Vertical amplitude)

V.HOLD Stops the picture from rolling vertically
(Vertical synchronization)

- 3) Fuse
CRT display unit power fuse 1.6 A, 125 V.
(Surge protection type)

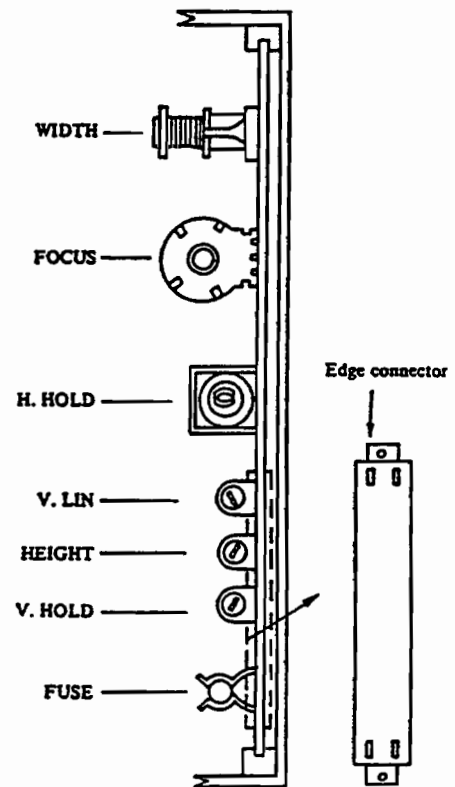


Fig. 14.7.3 (b) Adjusting devices

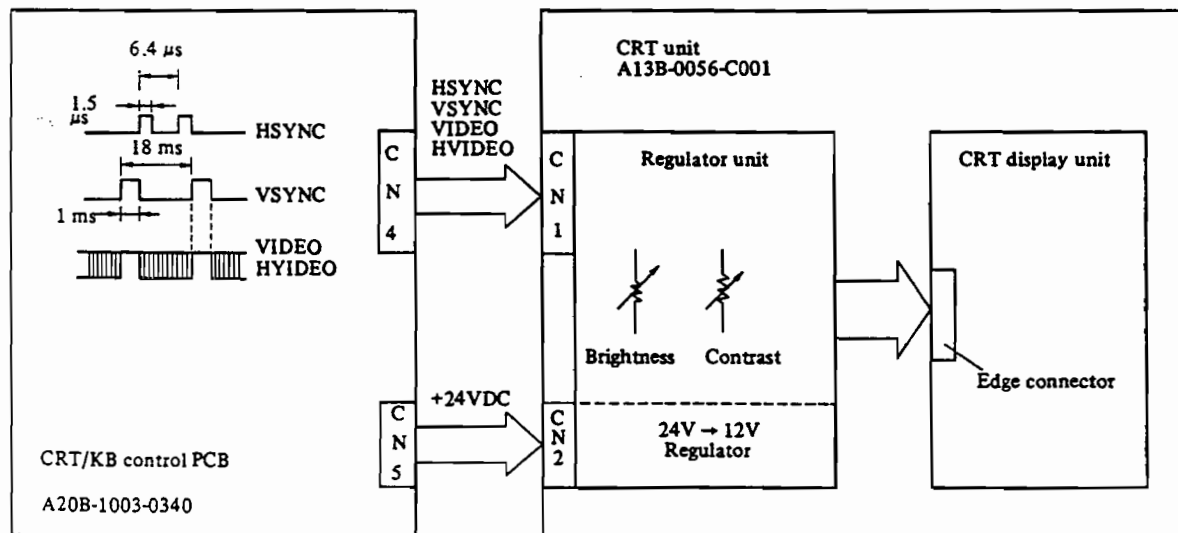
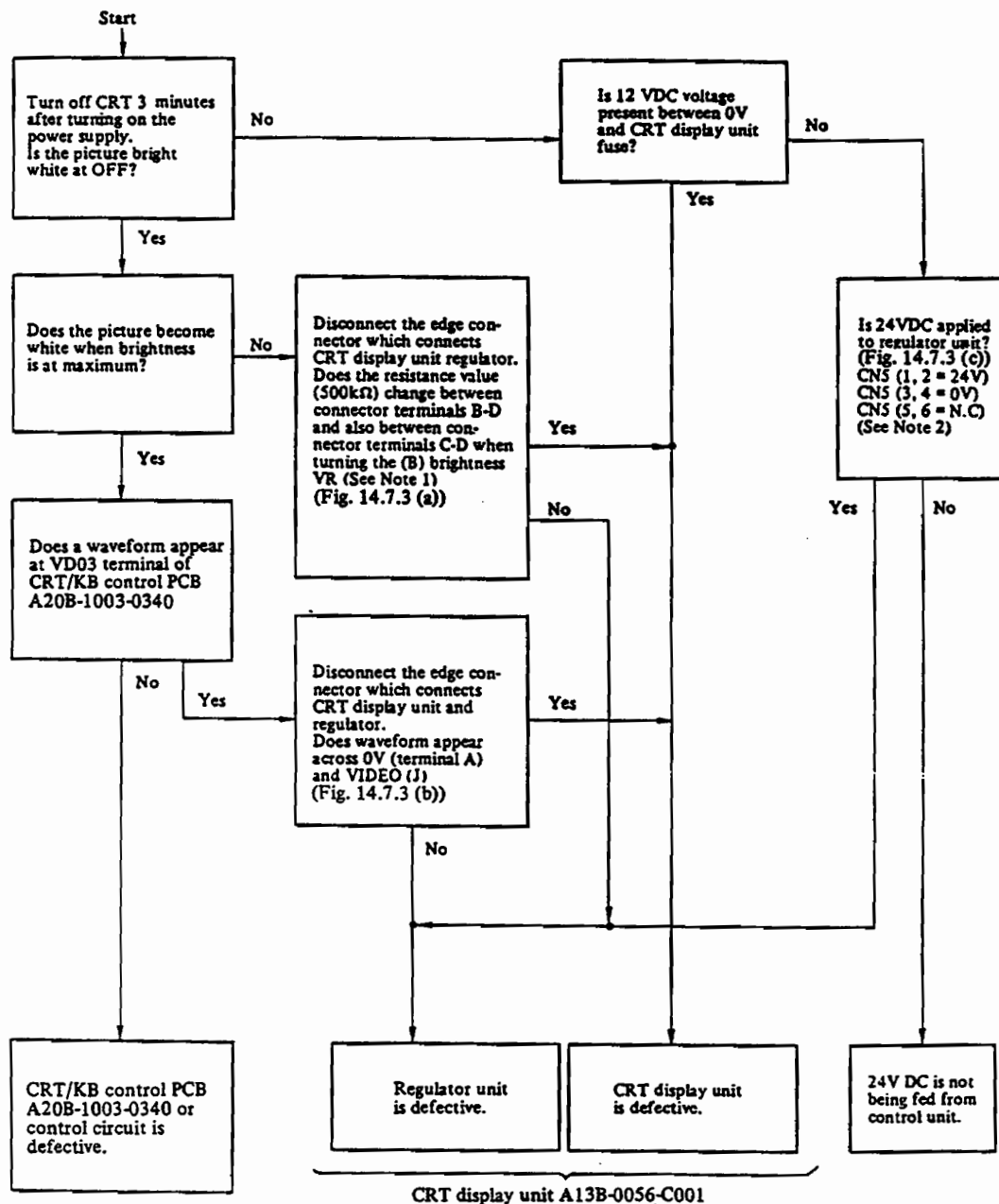


Fig. 14.7.3 (c) CRT unit block diagram

14.7.4 Troubleshooting flow chart

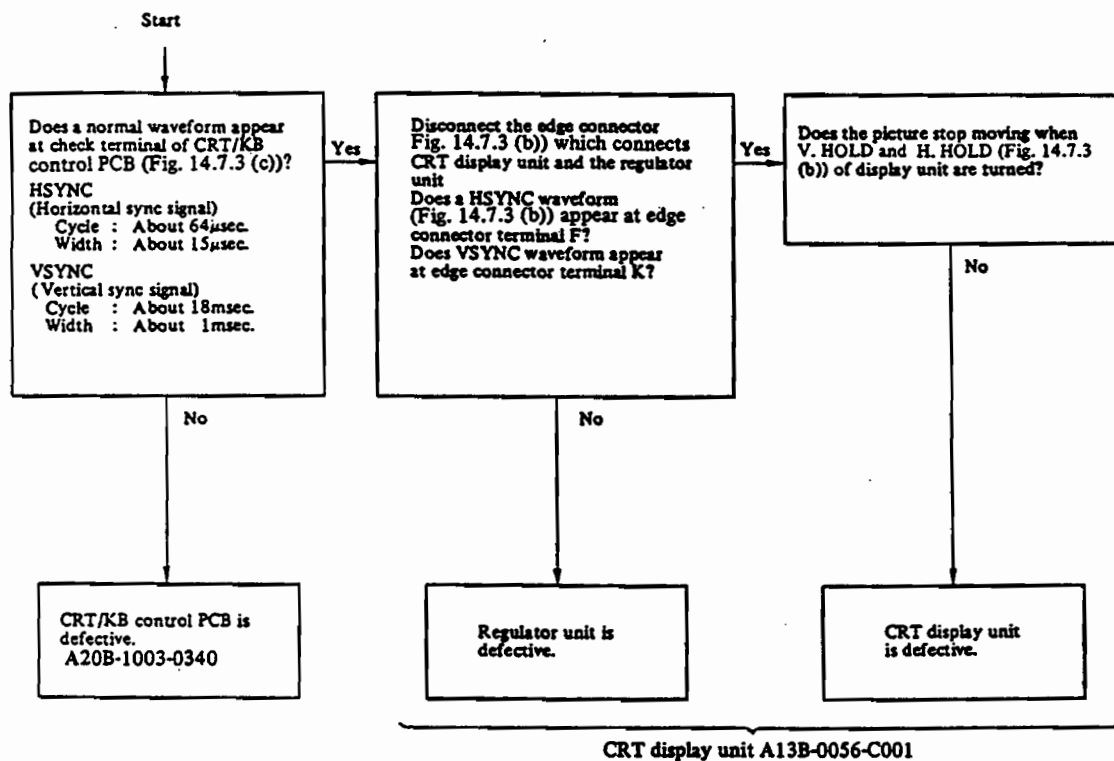
1) No display



Note 1) VR: Variable resistor

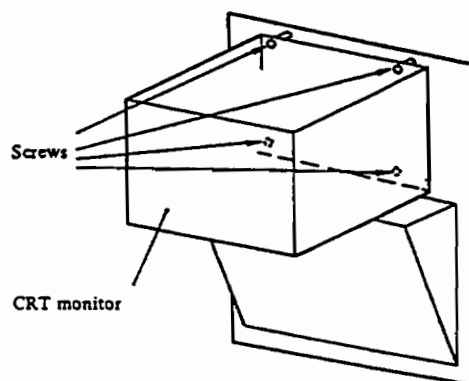
Note 2) Check cable connector pins after disconnecting the connector.

2) Picture shifts



14.7.5 Removal/replacement

Remove four screws holding the CRT monitor, and detach the CRT monitor.

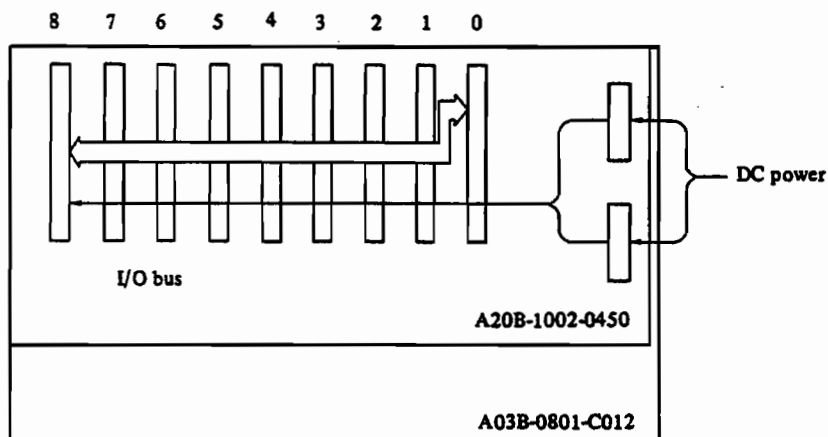


15. I/O BASE UNIT (A03B-0801-C012)

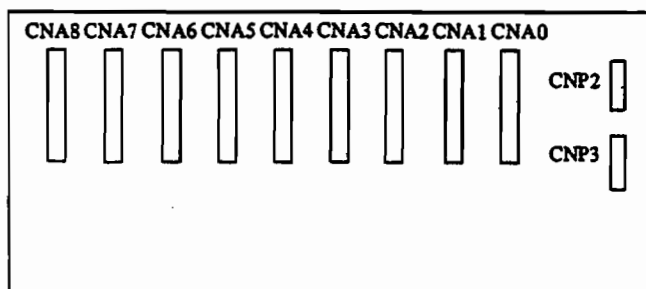
15.1 Theory of Operation

The I/O base unit serves as the bus connection between the various I/O modules including the robot control module, the DI module, the DO module, the analog input module, and the analog output module.

15.2 Block Diagram



15.3 Connector/Signal Identification



CNP2

01	+15 V
02	GND
03	N.C
04	EN
05	GND
06	-15 V

+15 V } : DC power supply from the basic
 -15 V } control unit
 GND }
 EN : DC voltage output enable
 signal
 N.C : No connection

CNP3

01	+5 V
02	+5 V
03	GND
04	GND
05	+24 V
06	+24 E

+5 V } : DC power supply from the power
 +24 V } unit
 +24 E }
 GND }
 +24 E is +24 VDC for robot control
 module.

CNA0

	C	B	A
32	A0	+5 V	
31	A2	+5 V	A1
30	D1	+5 V	D0
29	D3	+5 V	D2
28	D5	GND	D4
27	D7	GND	D6
26	R/W	GND	DP
25	*BE	GND	*DS
24	*POR	GND	RDY
23	*ERRO	GND	*ERRI
22	ITPS	GND	*RID
21	+24 V	GND	ST
20	+24 V	-15 V	+15 V
19	+24 E	-15 V	+15 V
18		*CS2	*CS1
17		*CS4	*CS3
16		*CS6	*CS5
15		*CS8	*CS7
14		*CS10	*CS9
13		*SA0	*SA1
12		*SA2	*SA3
11		A0R	A1R
10		A2R	*D0R
09		*D1R	*D2R
08		*D3R	*D4R
07		*D5R	*D6R
06		*D7R	*DPR
05		RCK1	RCK2
04	*EXRDY	RCK3	RWR
03	*IOCRDY	*ERROR	*DSR
02	*EXRCK	*ERRIR	*BER
01	EN	RDYR	*RIDR

A0-2 : Address bus for the I/O modules
 D0-7 : Data bus for the I/O modules
 DP : parity bit of the data bus
 R/W : Read/write control signal for the I/O modules
 *DS : Data strobe signal for the I/O modules
 *BE : Bus enable signal for the I/O modules
 *POR : Power-on reset signal
 RDY : Ready signal from the I/O modules
 *ERRO : Error signal detected in the robot control module
 *ERRI : Error signal detected in the I/O modules
 ITPS : Signal to synchronize the interpolation
 *RID : Read strobe for ID code of the I/O modules
 ST : Start signal
 *CS1-10 : Card select for the I/O module (slot 1-10)
 *SA0-3 : Slot address for external I/O bus
 A0R-A2R : Address bus for external I/O bus
 *D0R-D7R : Data bus for external I/O bus
 *DPR : Parity bit of the external data bus
 RCK1-3 : Selecting signal of additional I/O base unit (not used)
 RWR : Read/write signal for external I/O bus

*EXRDY : Ready signal from additional I/O base unit (not used)
 *DSR : Data strobe signal for external I/O bus
 *ERROR : Error signal detected in the robot control module
 *IOCRDY : Interface module ready for external I/O bus
 *BER : Bus enable signal for external I/O bus
 *ERRIR : Error signal detected in additional I/O base unit (not used)
 *EXRCK : Additional I/O base unit existing signal
 *RIDR : Read strobe for ID code of I/O modules on additional I/O base unit (not used)
 RDYR : Ready signal from additional I/O base unit (not used)
 EN : DC voltage output enable signal from the power unit

+24 V
 +24 E
 +15 V
 -15 V
 +5 V
 GND

: DC voltage inputs

CNA1-8

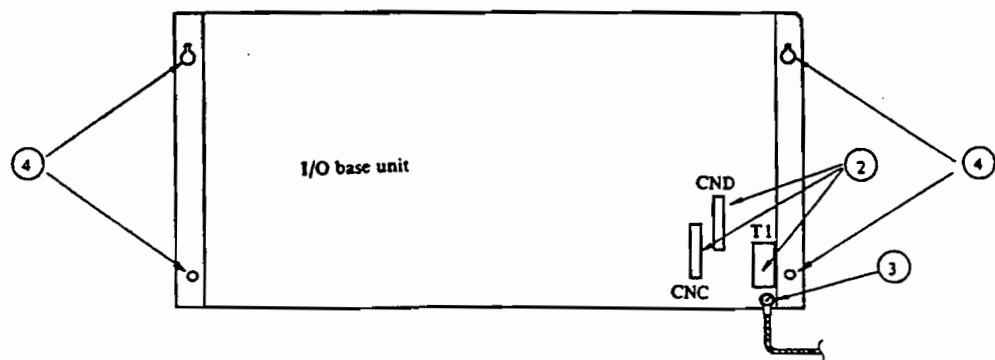
	C	B	A
32	A0	+5 V	*CS
31	A2	+5 V	A1
30	D1	+5 V	D0
29	D3	+5 V	D2
28	D5	GND	D4
27	D7	GND	D6
26	R/W	GND	DP
25	*BE	GND	*DS
24	*POR	GND	RDY
23	*ERRO	GND	*ERRI
22	ITPS	GND	*RID
21	+24 V	GND	ST
20	+24 V	-15 V	+15 V
19	+24 E	-15 V	+15 V
18			
17			
16			
15			
14			
13			
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11			
10			
09			
08			
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06			
05			
04			
03			
02			
01			

Connector CNA1-8 are used for the connection with I/O modules. "CNA1" corresponds with slot 1 and "CNA2" with slot 2, and so on. The signal meanings are described in the "CNA0" explanation.

15.4 Removal/Replacement

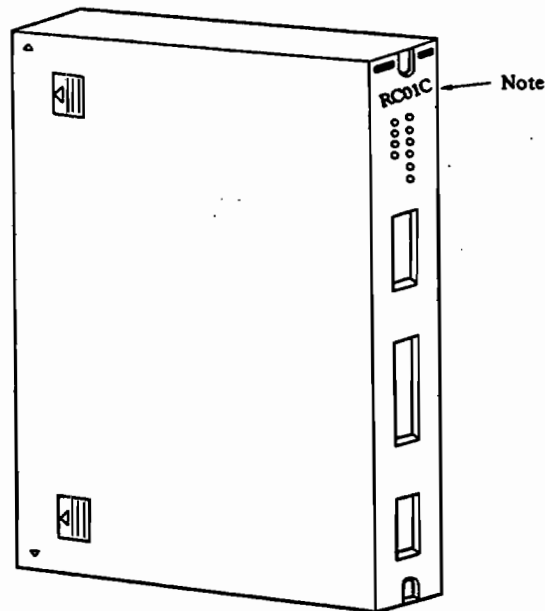
1) Procedure

- ① Remove the I/O modules in the I/O base unit according to Sec. 16-20.
- ② Disconnect all cables ② from the I/O base unit.
- ③ Disconnect the ground wire ③.
- ④ The I/O base unit can be removed by loosening four screws ④.
- ⑤ For mounting new I/O base unit, reverse the above procedure.



16. ROBOT CONTROL MODULE (A03B-0801-C462)

The external view of the robot control module is shown in the following figure.



Note) "RC01C" means the robot control module.

16.1 Theory of Operation

The robot control module is connected to the I/O base unit. The robot control module serves as an interface between the shared RAM board and the I/O base unit through fiber optic communications. Information is received from and transmitted to the cables, other I/O modules, or circuitry. LEDs indicate circuit performance.

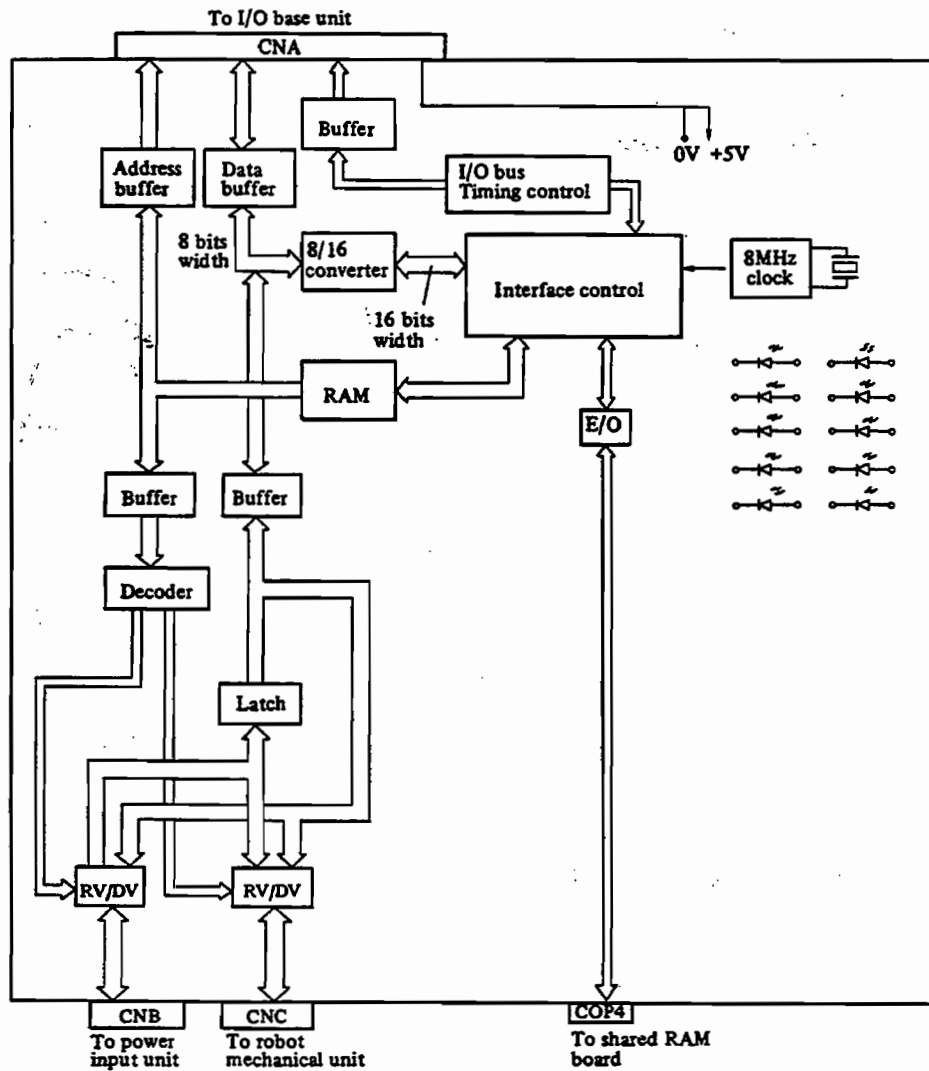
A section of 8/16 converter converts 16 bits data bus width of shared RAM PCB to 8 bits data bus width. RAM is used on this module to store address translation data.

I/O modules are mapped on the memory area of the main processor according to the contents of the RAM. The mapping arrangement is independent of the physical arrangement of the modules.

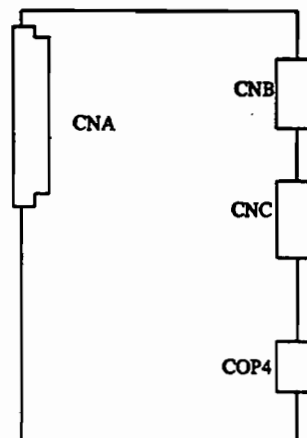
Robot control module also serves as an interface for data transfer from the robot and the operator's panel. Eight input and eight output lines are wired to the robot for customer selected interfacing. Along with these lines on the CNC connector are lines for signals such as hand breakage, overtravel, near zero, and other robot indicators.

Connector CNB is the internal connection of the controller. A voltage of +24 VDC for the input or output signals of this module is connected to the power input unit through CNB. Information from relays such as the fuse alarm, relay welding, and other inputs is fed to this module. The robot control module also drives the brake on/off control signals.

16.2 Block Diagram



16.3 Connector/Signal Identification



CNA

	A	B	C
32		+5 V	A0
31	A1	+5 V	A2
30	D0	+5 V	D1
29	D2	+5 V	D3
28	D4	GND	D5
27	D6	GND	D7
26	DP	GND	R/W
25	*DS	GND	*BE
24	*RDY	GND	*POR
23	*ERRI	GND	*ERRO
22	*RID	GND	ITPS
21	ST	GND	
20			
19			
18	*CS1	*CS2	*CS11
17	*CS3	*CS4	*CS12
16	*CS5	*CS6	*CS13
15	*CS7	*CS8	*CS14
14	*CS9	*CS10	*CS15
13	*SA1	*SA0	SDOUT
12	*SA3	*SA2	SDIN
11	A1R	A0R	*OPTOFF
10	*D0R	A2R	*IOCON
09	*D2R	*D1R	
08	*D4R	*D3R	
07	*D6R	*D5R	
06	*DPR	*D7R	
05	RCK2	RCK1	
04	RWR	RCK3	*EXRDY
03	*DSR	*ERROR	*IOCRDY
02	*BER	*ERRIR	*EXRCK
01	*RIDR	RDYR	EN

*DPR : Parity bit of the external data bus
 RCK1-3 : Selecting signal of additional I/O base unit (not used)
 RWR : Read/write signal for external I/O bus
 *EXRDY : Ready signal from additional I/O base unit (not used)
 *DSR : Data strobe signal for external I/O bus
 *ERROR : Error signal detected in the robot control module
 *IOCRDY : Interface module ready for external I/O bus
 *BER : Bus enable signal for external I/O bus
 *ERRIR : Error signal detected in additional I/O base unit (not used)
 *EXRCK : Additional I/O base unit existing signal
 *RIDR : Read strobe for ID code of I/O modules on additional I/O base unit (not used)
 RDYR : Ready signal from additional I/O base unit (not used)
 EN : DC voltage output enable signal from the power input unit
 +5 V } : DC voltage
 GND }

A0-2 : Address bus for the I/O modules
 D0-7 : Data bus for the I/O modules
 DP : Parity bit of the data bus
 R/W : Read/write control signal for the I/O modules
 *DS : Data strobe signal for the I/O modules
 *BE : Bus enable signal for the I/O modules
 *POR : Power-on reset signal
 RDY : Ready signal from the I/O modules
 *ERRO : Error signal detected in the robot control module
 *ERRI : Error signal detected in the I/O modules
 ITPS : Signal to synchronize the interpolation
 *RID : Read strobe for ID code of the I/O modules
 ST : Start signal
 *CS1-10 : Card select for the I/O module (slot 1-10)
 *CS11-15 } : Not used
 SDOUT }
 SDIN }
 *OPTOFF }
 *IOCON }
 *SA0-3 : Slot address for external I/O bus
 A0R-A2R : Address bus for external I/O bus
 *D0R-D7R : Data bus for external I/O bus

CNB

14	HBKD1			01	
15	HBKD2	08	BKR21	02	*ROT
16	*BKRE	09	BKR22	03	RLWD
17	BKR11	10	BKR31	04	*FALM
18	BKR12	11	BKR32	05	*EMGTP
19		12	0 E	06	+24 E
20		13	0 E	07	+24 E

*ROT : Robot overtravel signal
 RLWD : Relay welding signal detected in the power input unit
 *FALM : Fuse alarm of the brake control circuit
 *EMGTP : Emergency stop signal from the teach pendant
 BKR21 } : Contact signal of the 2nd
 BKR22 } : brake release
 BKR31 } : Contact signal of the 3rd
 BKR32 } : brake release
 HBKD1 } : Contact signal of the hand
 HBKD2 } : breakage detection
 *BKRE : Brake release enable
 BKR11 } : Contact signal of the 1st
 BKR12 } : brake release
 +24 E } : DC voltage
 0 E }

CNC

23	RD01			01	RD11
24	RD02	13	*ROT	02	RD12
25	RD03	14	*HBKD	03	RD13
26	RD04	15	NZ1	04	RD14
27	RD05	16	NZ2	05	RD15
28	RD06	17	NZ3	06	RD16
29	RD07	18	NZ4	07	RD17
30	RD08	19	NZ5	08	RD18
31	OPRL	20	NZ6	09	*PPABN
32	+24 E	21	ALML	10	0 E
33	+24 E	22	+24 E	11	0 E
34	+24 E			12	0 E

The connector "CNC" is used for the interface with the mechanical unit.
 RD11-8 : General purpose DIs
 RD01-8 : General purpose DOs
 *ROT : Robot overtravel signal
 *HBKD : Hand breakage detection
 ALML : DO for the alarm lamp
 OPRL : DO for the operation lamp
 *PPABN } : Not used
 NZ6 }
 NZ1-5 : Near zero signals
 +24 E } : DC voltage for DI & DO's
 0 E }

COP4

OPTIN
OPTOUT

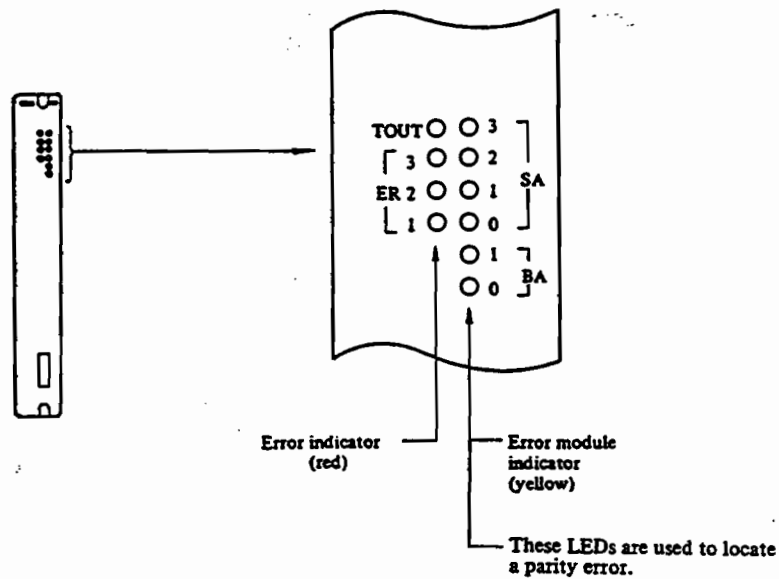
OPTIN : Optical input signal from the shared RAM PCB
 OPTOUT : Optical output signal to the shared RAM PCB

16.4 LEDs

Error indicator LEDs are mounted on the front panel of the robot control module (RC01C) to indicate an error which may occur during data transfer between basic control unit and RC01C or between RC01C and I/O module.

I/O module means robot control module, DI module, DO module, analog input module or analog output module.

Error indicator LEDs









Error contents

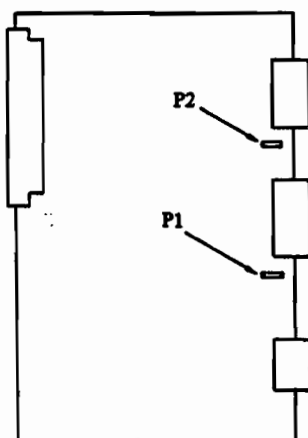
Error display				Name of error	Error contents	Causes
TOUT	ER3	ER2	ER1			
-	-	-	-	Normal operation	————	————
-	o	o	o	CLOCK STOP	An error occurred during data transfer between RC01C and the shared RAM board.	1. Optical cable is disconnected. 2. Optical connector is not sufficiently connected. 3. Optical connector tip is dirty. 4. RC01C is defective. 5. Shared RAM board is defective.
-	o	o	-	CARRIER STOP		
-	o	-	o	SIGNAL FORM ERROR		
-	o	-	-	FORMAT ERROR		
-	-	o	o	OVERRUN ERROR		
-	-	o	-	ERROR WORD		
o	-	-	o	TIME OUT ERROR		
-	-	-	o	PARITY ERROR	A parity error was detected during data transfer between RC01C and I/O module, or a parity error occurred in RAM of RC01C. In this case, the mounting base number of the data transfer module in trouble and the slot number are displayed in SA3-SA0 and BA1-0. SA3-SA0: Slot number (binary display) BA1, BA0: Base number (binary display) Example) Base #1, slot #5 SA3 SA2 SA1 SA0 BA1 BA0 0 1 0 1 0 1 Slot #5 Base #1 0: Goes out 1: Lights If both slot number and base number are "0", there is a parity error of RAM in RC01C.	1. I/O module is defective. 2. RC01C is defective.

o: Lamp lights

-: Lamp goes out

16.5 Jumper Settings

Jumpers	Standard setting	Uses
P1		Selecting common voltage for RDI: When P1 is set to A side, a pneumatic pressure alarm will occur. <div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div style="text-align: center;">  0V common </div> <div style="text-align: center;">  +24V common </div> </div>
P2		Short-circuit *HBKD input. <div style="display: flex; justify-content: space-around; align-items: flex-end;"> <div style="text-align: center;">  *HBKD is effective </div> <div style="text-align: center;">  *HBKD is short-circuited </div> </div>

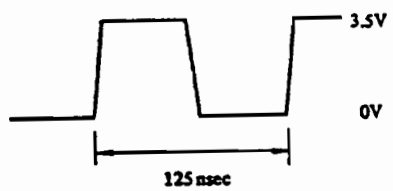


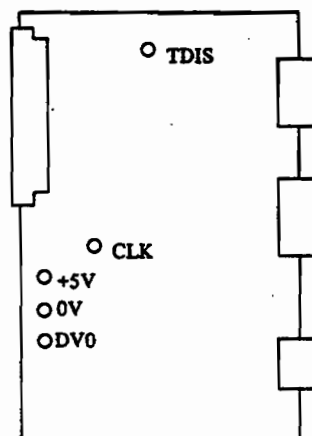
Location of jumpers
(The plastic cover is removed in the above figure)

Refer to Sec. 16.7 for the plastic case disassembly method.

16.6 Test Points

The meanings of the test points on the robot control module are as follows.

Test points	Contents	Waveform
TDIS	When TP3 is connected to GND, the time out error detected in robot control module is disabled. This test point is used for development.	
+5 V		+5 VDC
CLK	8 MHz clock	
DVO	DVO indicates that the reset is initiated by the software.	
GND		0 V

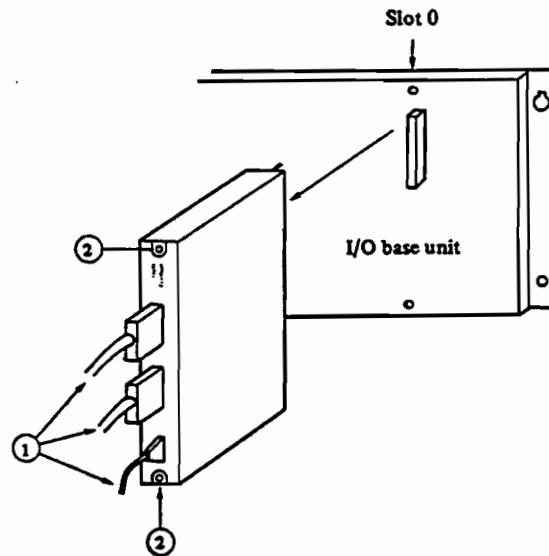


Location of test points

Note) In the above figure, the plastic cover is removed. Refer to Sec. 16.7 for the plastic case disassembly method.

16.7 Removal/Replacement

1) Removing robot control module from I/O base unit



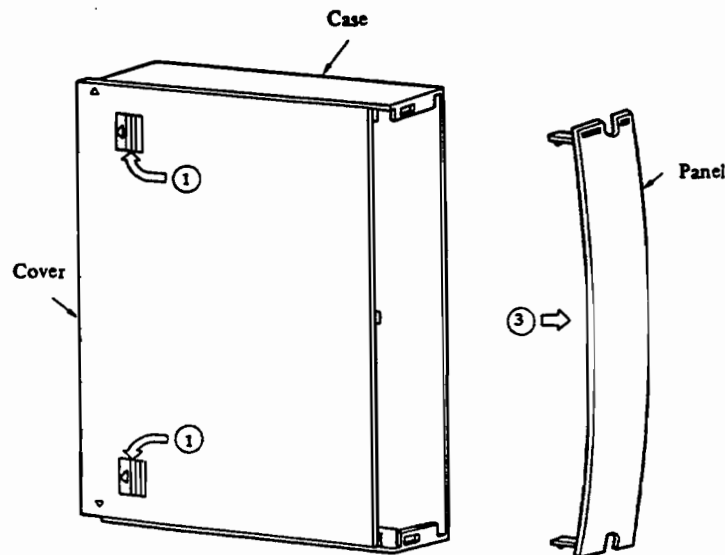
a) Procedure

- ① Disconnect the cable from the robot control module (RC01C).
- ② Detach RC01C by loosening two screws ②.
- ③ For mounting the new RC01C, reverse the above procedure.

b) Setting

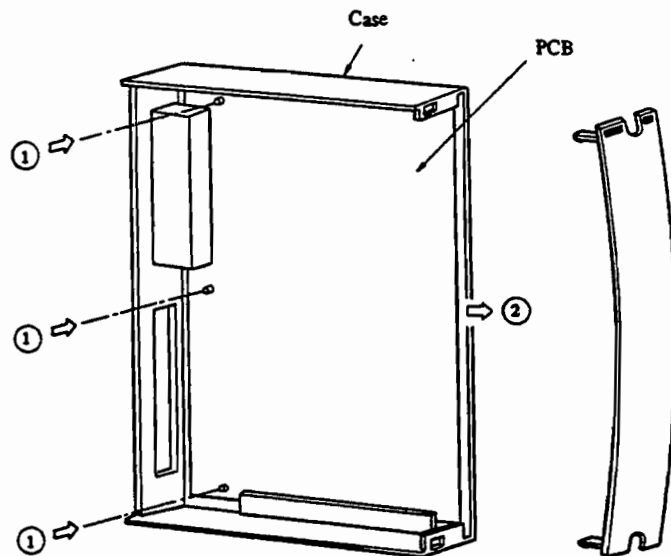
Set the new RC01C correctly using the original RC01C as a reference.

2) Plastic case disassembly method



- ① Using both thumbs push the positions ① on the cover in the direction of the arrows.
- ② Slide the cover off.
- ③ The panel can be detached by pushing the center of the panel from direction ③ until it is curved.

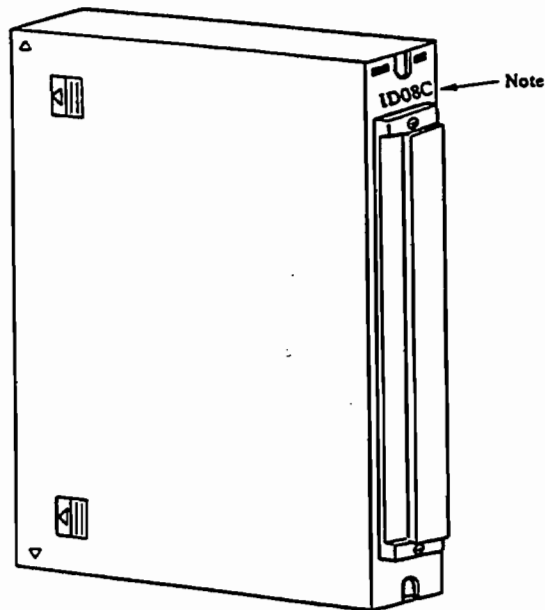
3) Detaching the PCB from the plastic case



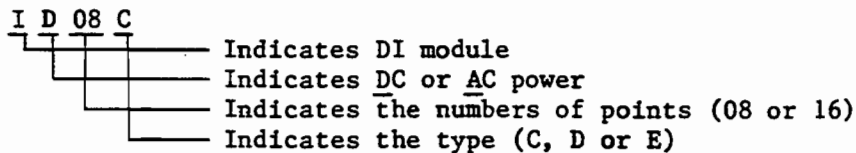
- ① Remove PCB mounting screws ①.
- ② Draw the PCB out of the case in the direction ②.

17. DI MODULE

The external view of the DI module is shown in the following figure.



Note) The code marked on the upper side of the front panel indicates the type of DI module.



The DI module has the following specification numbers:

ID08C	.....	A03B-0801-C420
ID16C	.....	A03B-0801-C421
ID08D	.....	A03B-0801-C422
ID16D	.....	A03B-0801-C423
IA08E	.....	A03B-0801-C424
IA16E	.....	A03B-0801-C425

17.1 Theory of Operation

The DI module provides the user with the means of interfacing peripheral equipment inputs to the controller. AC or DC type modules are available for this purpose.

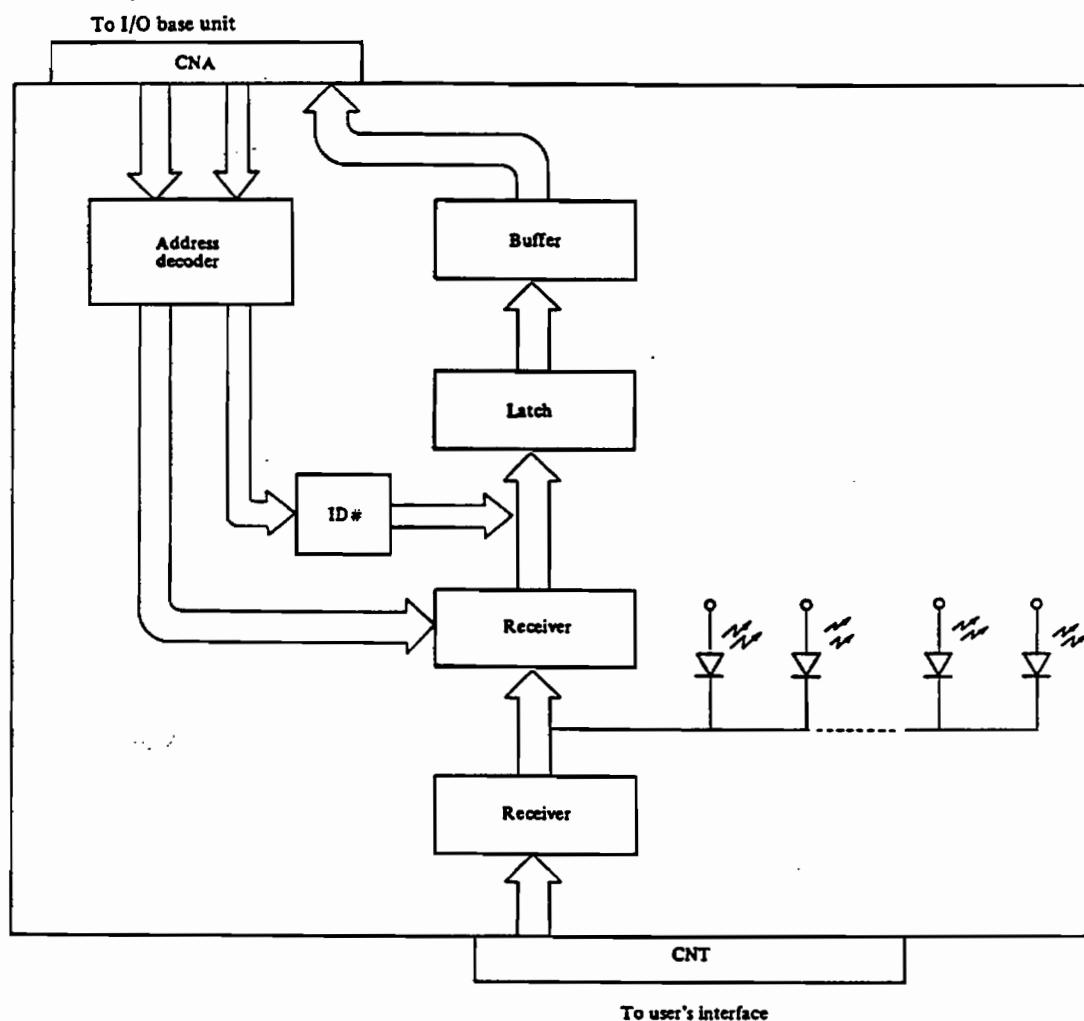
The DI module connects to the I/O base unit through the CNA connector. Interfacing is completed by connecting input lines to the CNT terminal strips. Eight and sixteen channel input modules can be selected for interfacing.

The DI module also acts as a level converter because AC and DC inputs may be accessing the controller.

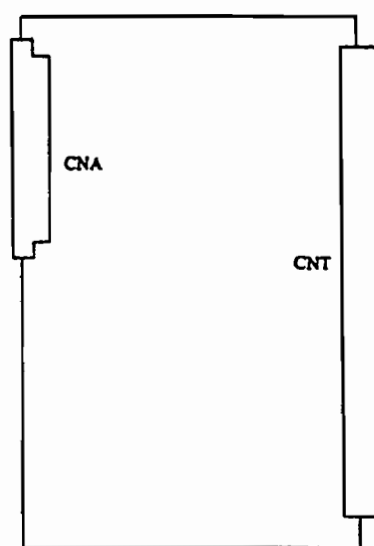
All interface signals are converted to logic-level +5 volts before being placed on the I/O bus.

LEDs are mounted on the module to monitor each input line. These LEDs light when an input is fired to the controller.

17.2 Block Diagram



17.3 Connector/Signal Identification



CNA

	a	b	c
32	*CS	+5 V	A0
31		+5 V	
30	D0	+5 V	D1
29	D2	+5 V	D3
28	D4	0 V	D5
27	D6	0 V	D7
26	DP	0 V	R/W
25	*DS	0 V	*BE
24		0 V	
23	*ERRI	0 V	
22	*RID	0 V	
21		0 V	
20			
19			
18			
17			
16			
15			
14			
13			
12			
11			
10			
09			
08			
07			
06			
05			
04			
03			
02			
01			

*CS : Card select
 A0 : Address signal
 D0-7 : Data bus
 DP : Parity bit of the data bus
 R/W : Read/write control signal
 *DS : Data strobe signal
 *BE : Bus enable signal
 *ERRI : Error signal detected in the DI module
 *RID : Read strobe for ID code
 +5 V } : DC voltage
 0 V }

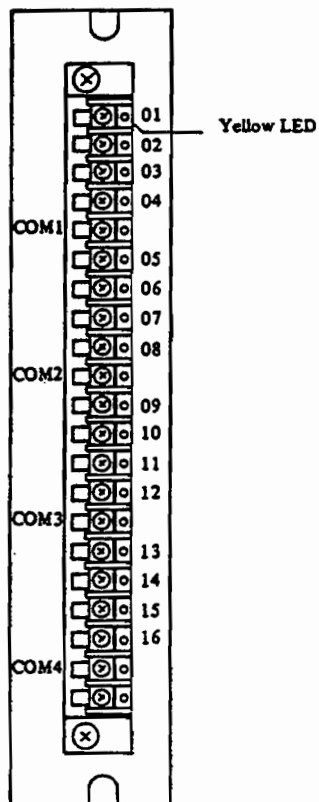
CNT

Refer to IV-3.2.5 for terminal CNT.

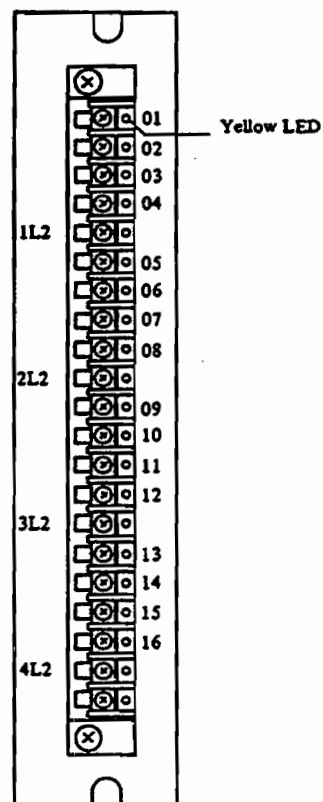
17.4 LEDs

The DI module is provided with LEDs for indicating the on/off conditions of each input signal.

ID08C, ID16C
ID08D, ID16D

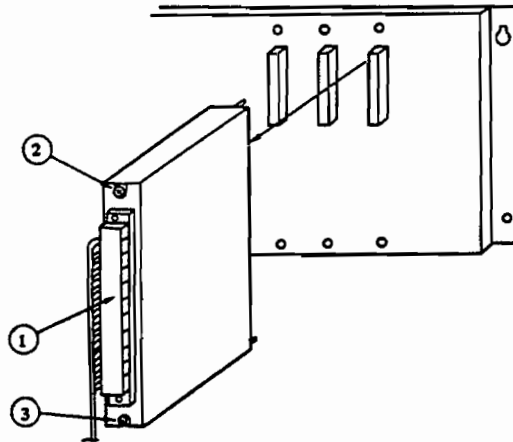


IA08E, IA16E



LED : Lights Input turns on.
Goes out turns off Input turns off.

17.5 Removal/Replacement



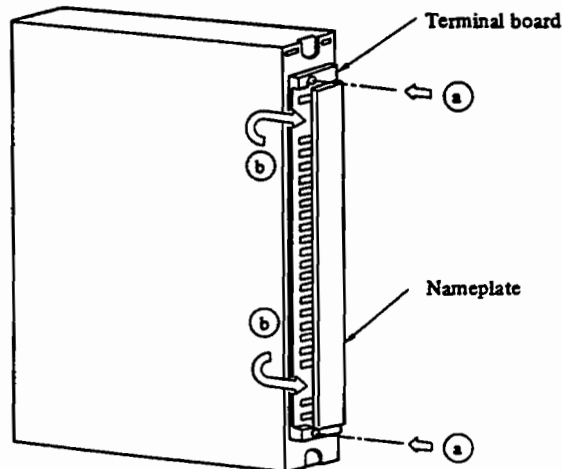
1) Procedure

- ① Disconnect cables from DI module.

Disconnect the terminal board by loosening the two screws (a) shown in the following figure and, while holding its upper and lower ends, pulling out the entire terminal board.

For disconnecting the wiring, open the nameplate.

The nameplate is opened by pulling it out, while holding it at (b) shown in the following figure.



- ② Detach DI module by loosening the screws (2).

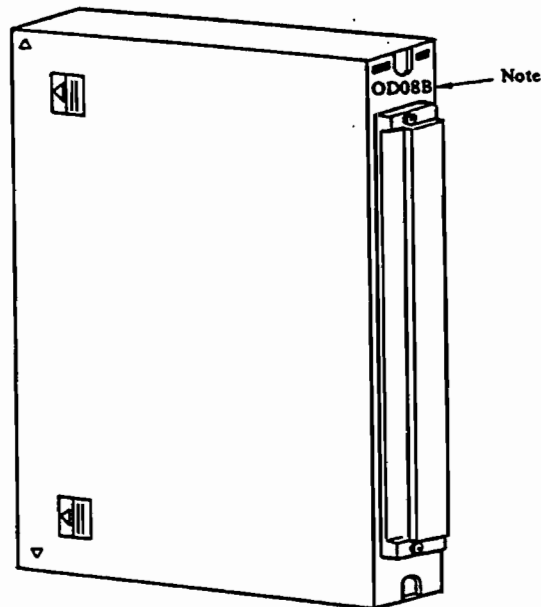
- ③ For mounting new DI module, reverse the above procedure, replacing the terminal board on the new DI module with the original terminal board.

2) Cautions

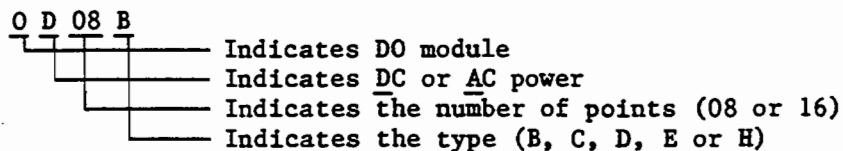
Mount the terminal board removed from the replacement DI module on the old DI module before returning the module for repair.

18. DO MODULE

The external view of the DO module is shown in the following figure.



Note) The code marked on the upper side of the front panel indicates the type of DO module.



The DO module has the following specification numbers:

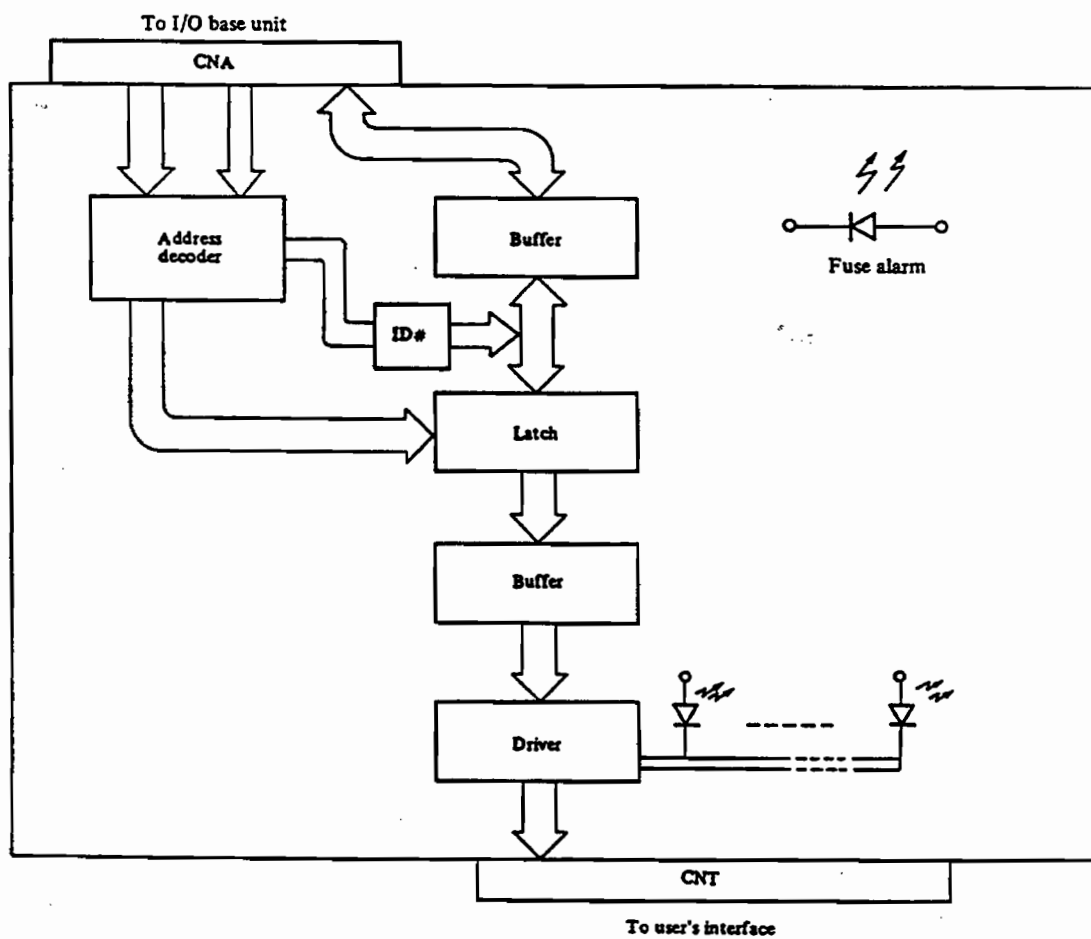
OD08B	.....	A03B-0801-C440
OD16B	.....	A03B-0801-C441
OD08C	.....	A03B-0801-C442
OD16C	.....	A03B-0801-C443
OA08D	.....	A03B-0801-C444
OA16D	.....	A03B-0801-C445
OA08E	.....	A03B-0801-C446
OA16E	.....	A03B-0801-C447
OA08H	.....	A03B-0801-C448
OA16H	.....	A03B-0801-C449

18.1 Theory of Operation

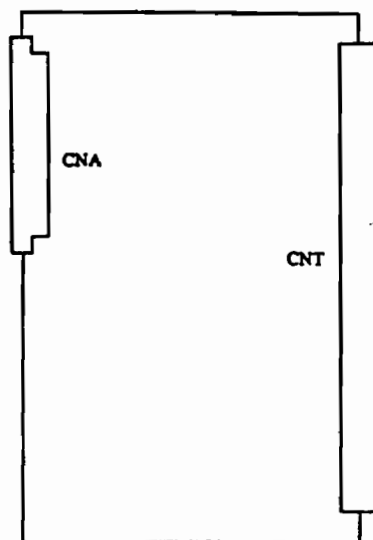
The DO module provides outputs to the user for interfacing. AC or DC type outputs are available and cover a range of output current capacities. Eight and sixteen channel output modules are available.

Data is taken from the I/O base unit through the CNA connector and conditioned to be output by means of the CNT terminal strips. The DO module provides the level conversion from logic level to the signal level specified by the module. LEDs monitor each output as the output is fired by the controller. Fuses on each module protect the equipment from overcurrent conditions.

18.2 Block Diagram



18.3 Connector/Signal Identification



CNA

	a	b	c
32	*CS	+5 V	A0
31		+5 V	
30	D0	+5 V	D1
29	D2	+5 V	D3
28	D4	0 V	D5
27	D6	0 V	D7
26	DP	0 V	R/W
25	*DS	0 V	*BE
24		0 V	*POR
23	*ERRI	0 V	*ERRO
22	*RID	0 V	
21		0 V	
20			
19			
18			
17			
16			
15			
14			
13			
12			
11			
10			
09			
08			
07			
06			
05			
04			
03			
02			
01			

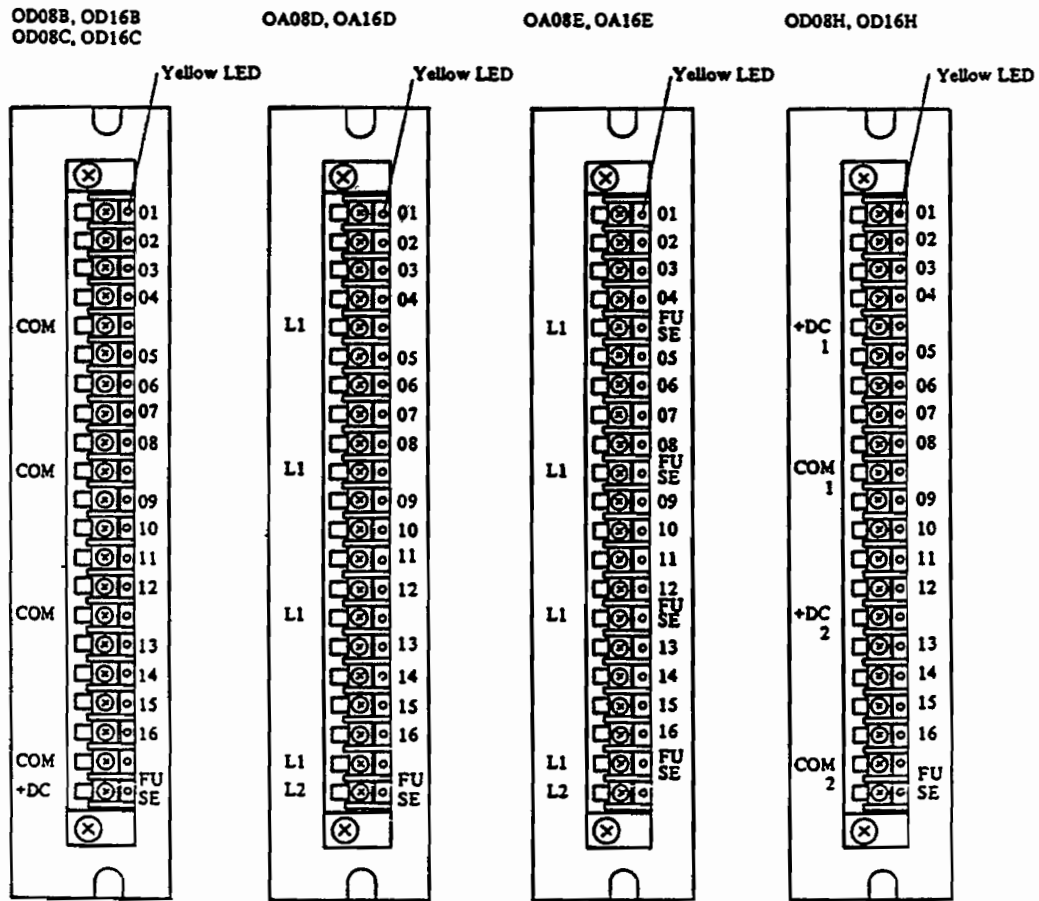
*CS : Card select
 A0 : Address signal
 D0-7 : Data bus
 DP : Parity bit of the data bus
 R/W : Read/write control signal
 *DS : Data strobe signal
 *BE : Bus enable signal
 *POR : Power-on reset
 *ERRO : Error signal detected in the I/O interface module
 *ERRI : Error signal detected in the DI module
 *RID : Read strobe for ID code
 +5 V } : DC voltage
 0 V }

CNT

Refer to IV-3.2.5 for terminal CNT.

18.4 LEDs

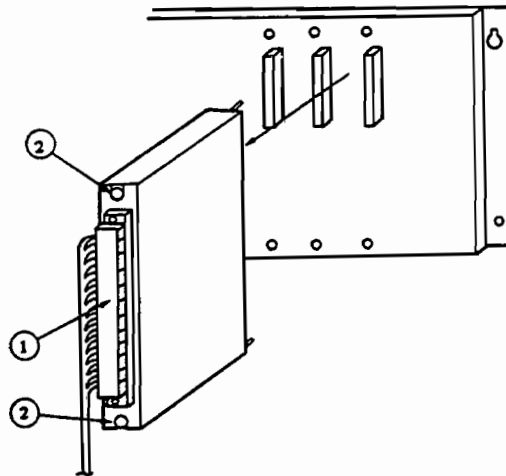
The DO module is provided with LEDs for indicating the on/off conditions of each output signal.



LED : Lights Output turns on.
Goes out Output turns off.

Module name	ODO8H, OD16H
Mounting positions of fuse-alarm indicator LEDs and mounting positions of fuses	<div><div><div><div><div>01</div><div>02</div><div>03</div><div>04</div><div>+DC 1</div><div>05</div><div>06</div><div>07</div><div>08</div><div>COM 1</div><div>09</div><div>10</div><div>11</div><div>12</div><div>+DC 2</div><div>13</div><div>14</div><div>15</div><div>16</div><div>COM 2</div><div>FUSE</div></div><div><div>×</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div><div>○</div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18.6 Removal/Replacement



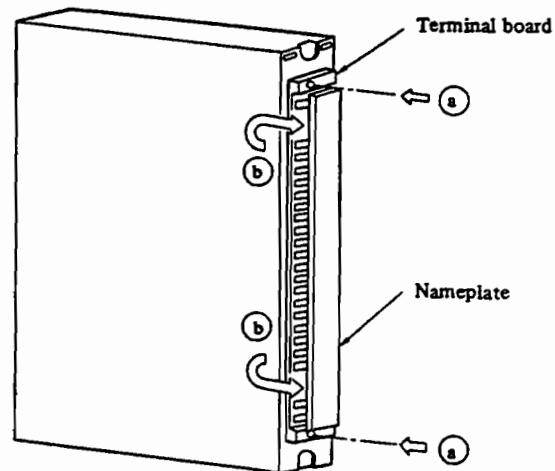
1) Procedure

① Disconnect cables from D0 module.

Disconnect the terminal board by loosening the two screws (a) shown in the following figure and, while holding its upper and lower ends, pulling out the entire terminal board.

For disconnecting the wiring, open the nameplate.

The nameplate is opened by pulling it out, while holding it at (b) shown in the following figure.



② Detach D0 module by loosening the screws ②.

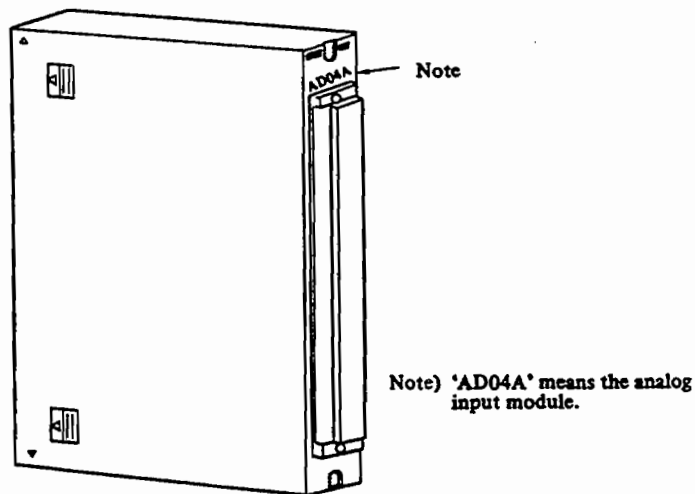
③ For mounting new D0 module, reverse the above procedure replacing the terminal board on the new D0 module by the original terminal board.

2) Cautions

Mount the terminal board removed from the replacement D0 module on the old D0 module before returning the module for repair.

19. ANALOG INPUT MODULE (A03B-0801-C410)

The external view of the analog input module is shown in the following figure.

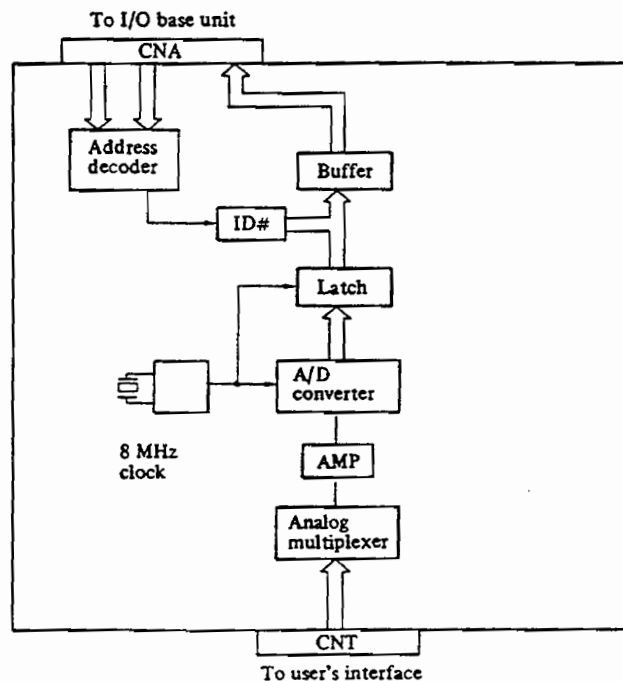


19.1 Theory of Operation

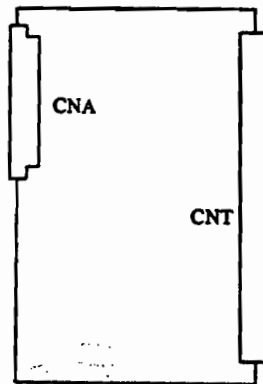
The analog input module provides the user with a means for interfacing peripheral equipment analog inputs to the controller. This device connects to the I/O base unit through the CNA connector. Interfacing is completed by connecting input lines to the CNT terminal strips. A four channel input module is available.

For interfacing, the analog input module also acts as an A/D converter because analog inputs may be accessing the controller. All interface signals are converted to the digital value before being placed on the I/O bus.

19.2 Block Diagram



19.3 Connector/Signal Identification



CNA

	a	b	c
32	*CS	+5 V	A0
31	A1	+5 V	A2
30	D0	+5 V	D1
29	D2	+5 V	D3
28	D4	0 V	D5
27	D6	0 V	D7
26	DP	0 V	R/W
25		0 V	*BE
24		0 V	*POR
23	*ERRI	0 V	
22	*RID	0 V	
21		0 V	
20	+15 V	-15 V	
19	+15 V	-15 V	
18			
17			
16			
15			
14			
13			
12			
11			
10			
09			
08			
07			
06			
05			
04			
03			
02			
01			

*CS : Card select
 A0-3 : Address signal
 D0-7 : Data bus
 DP : Parity bit of the data bus
 R/W : Read/write control signal
 *BE : Bus enable signal
 *POR : Power-on reset
 *ERRI : Error signal detected in
 the analog input module
 *RID : Read strobe for ID code
 +15 V }
 -15 V } : DC voltage
 +5 V }
 0 V }

CNT

Refer to IV-3.2.5 for terminal CNT.

19.4 Variable Resistors

Ten variable resistors are located on the analog input module (AD04A). Refer to Sec. 19.7 for the adjusting method.

The variable resistors VR3 and VR4 are used for the gain adjustment of the operation-amplifiers.

The variable resistor VR5 is used for the balance adjustment between two operation-amplifiers.

The variable resistor VR6 is used for the gain adjustment of the operation-amplifiers.

The variable resistor VR12 is used for the offset adjustment of the A/D converter.

The variable resistor VR11 is used for the gain adjustment of the A/D converter.

The variable resistors VR7, VR8, VR9 and VR10 are used for the adjustment of the input resistance.

19.5 Test Points

The meanings of the test points on the analog input module are as follows.

Test points	Symbol	Contents	Waveform (voltage)
TP1	-	Used for test. Input common selected by multiplexer.	Common for TP3
TP2	-	Output of the operation-amplifiers whose input is "TP1".	Common for TP4
TP3	-	Used for test. Analog input selected by multiplexer.	-10 V - +10 V (Reference is TP1)
TP4	-	Output of the operation-amplifiers whose input is "TP3".	-10 V - +10 V (Reference is TP2)
TP5	-	Differential voltage between TP4 and TP2.	-10 V - +10 V
TP6	-	Input to the A/D converter.	-10 V - +10 V
TP7	+15 V	+15 VDC power	+15 VDC
TP8	-15 V	-15 VDC power	-15 VDC
TP10	+5 V	+5 VDC power	+5 VDC
TP9 TP11	GND		0 V

Test points	Symbol	Contents	Waveform (voltage)
TP12	INH	Used for test. By connecting TP12 to TP11 (GND), all the analog input is neglected (disconnected) to the A/D converter input.	

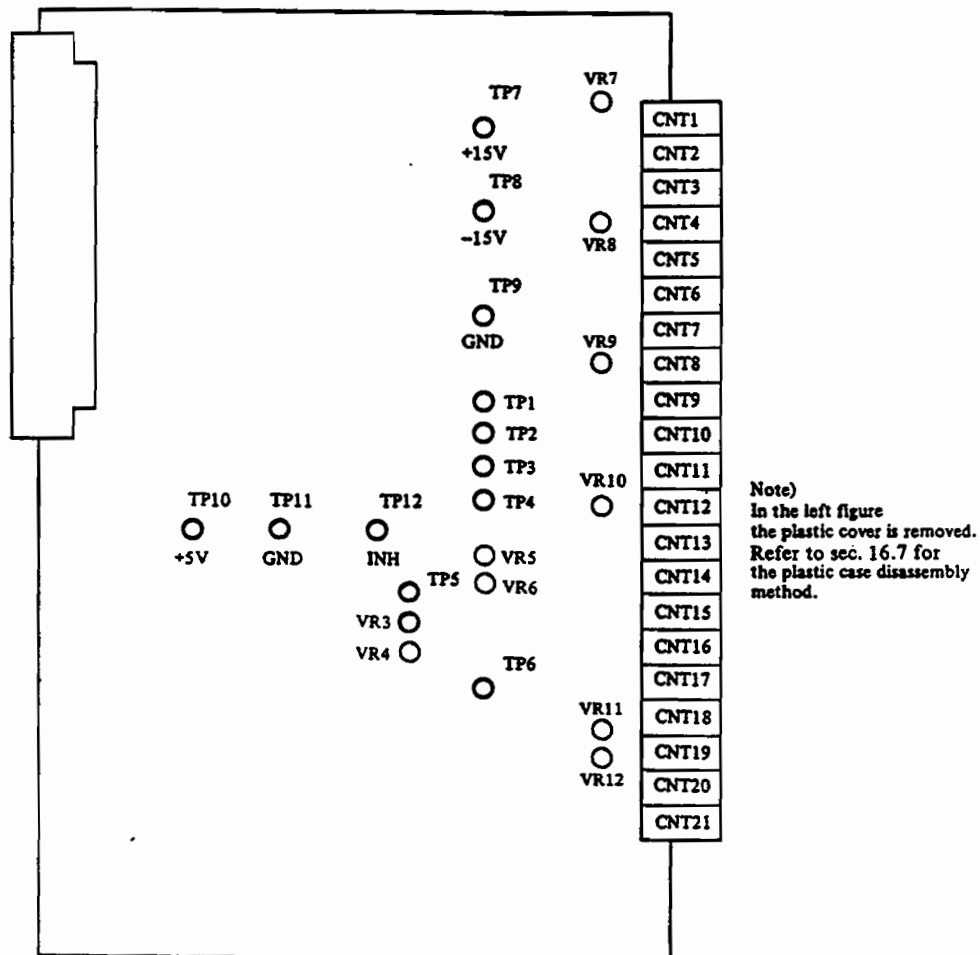
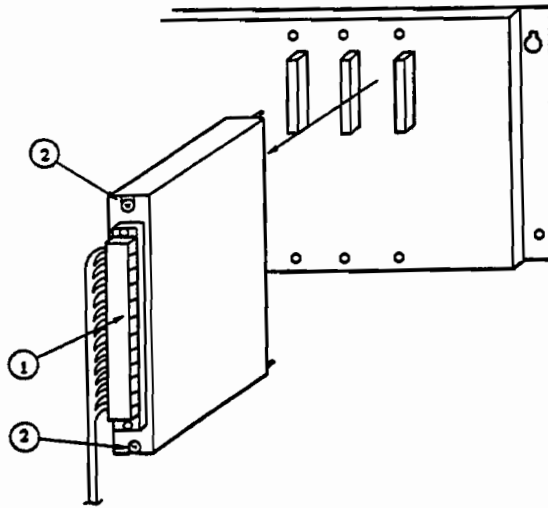


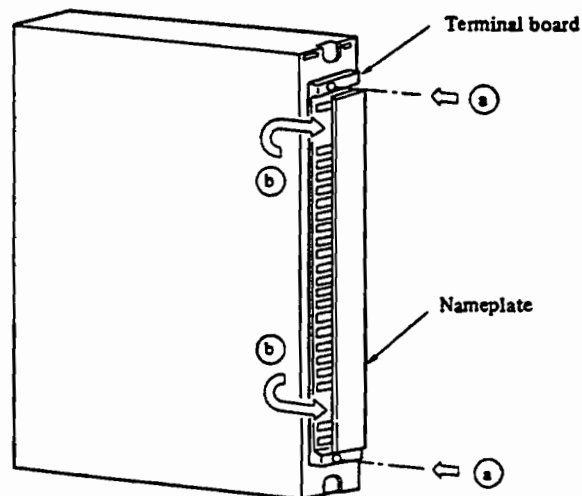
Fig. 19.5 Location of test points and variable resistors on the analog input module

19.6 Removal/Replacement



1) Procedure

- ① Disconnect cables from the analog input module.
Disconnect the terminal board by loosening the two screws (a) shown in the following figure and; while holding its upper and lower ends, pulling out the entire terminal board.
For disconnecting the wiring, open the nameplate.
The nameplate is opened by pulling it out, while holding it at (b) shown in the following figure.



- ② Detach analog input module by loosening the screws (2).
 - ③ For mounting new analog input module, reverse the above procedure.
- 2) Adjusting
 - 3) Cautions
Mount the terminal board removed from the replacement module on the old module before returning the module for repair.

19.7 Calibration Procedure

Obtain the following equipment:

- . Voltage source (resolution 1 mV)
- . Voltage meter (resolution 0.1 mV)
- . Resistance meter (resolution 0.01 ohm)

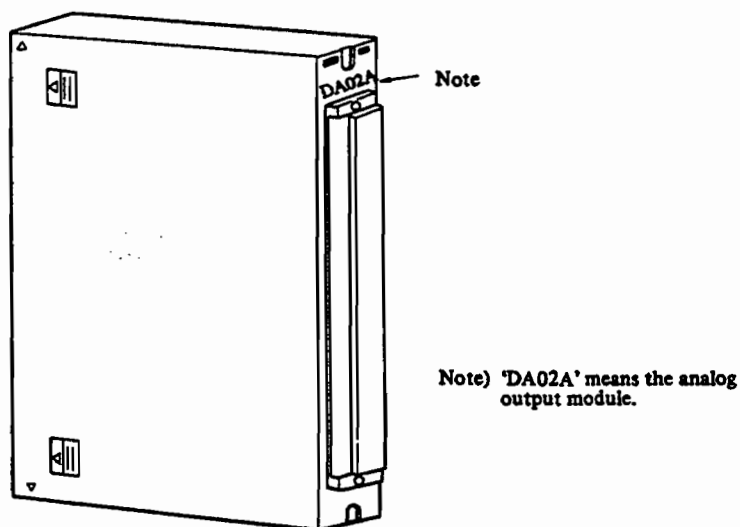
Calibrate as follows.

1. Input 0.000 V to TP1 and TP3.
2. Adjust VR3 until the voltage at TP5 becomes 0.0 mV.
3. Adjust VR4 until the voltage at TP6 becomes 0.0 mV.
4. Input +5 V to TP1 and TP3.
5. Adjust VR5 until the voltage at TP5 becomes 0.0 mV.
6. Input 0.000 V to TP1 and input +10.000 V to TP3.
7. Adjust VR6 until the voltage at TP6 becomes +9.768 V.
8. Input 0.000 V to TP1 and input -10.000 V to TP3.
9. Adjust VR12 until the display for analog inputs on the KAREL controller AIO screen (Note) becomes F830 (hex).
10. Input 0.000 V to TP1 and input +10.000 V to TP3.
11. Adjust VR11 until the display for analog inputs on the KAREL controller AIO screen becomes 07D0 (hex).
12. Input 0.000 V to TP1 and TP3.
13. Confirm that the display for analog inputs on the KAREL controller AIO screen is 0000.
14. Repeat steps 8 through 13 until all conditions are met.
15. Adjust VR7 until the resistance between CNT(2) and CNT(3) becomes 250.0 ohms.
16. Adjust VR8 until the resistance between CNT(6) and CNT(7) becomes 250.0 ohms.
17. Adjust VR9 until the resistance between CNT(10) and CNT(11) becomes 250.0 ohms.
18. Adjust VR10 until the resistance between CNT(14) and CNT(15) becomes 250.0 ohms.

Note) The KAREL controller AIO screen can be displayed on the CRT/KB by pressing STATUS (F2) on the POWER UP screen, followed by I/O (F3) on the STATUS screen, and AIO (F4) on the I/O screen.

20. ANALOG OUTPUT MODULE (A03B-0801-C411)

The external view of the analog output module is shown in the following figure.

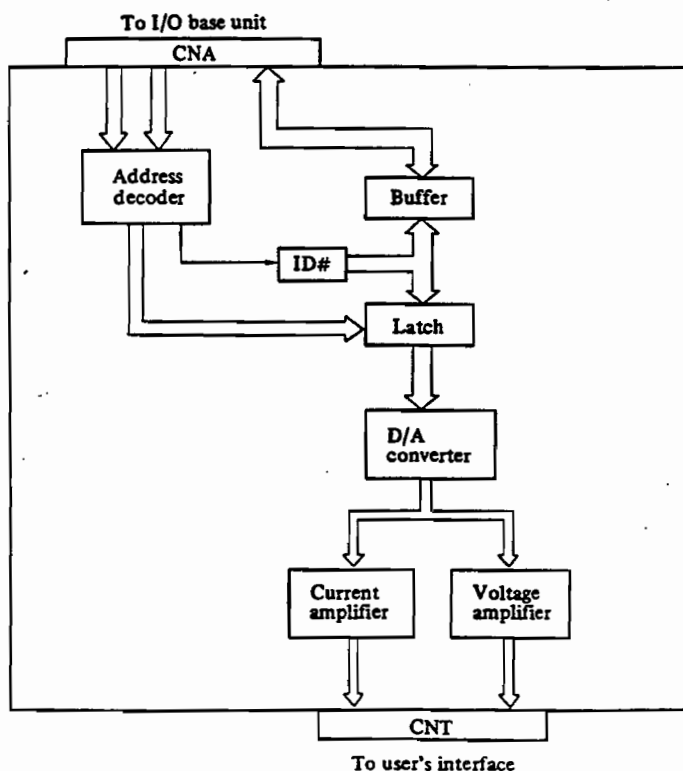


20.1 Theory of Operation

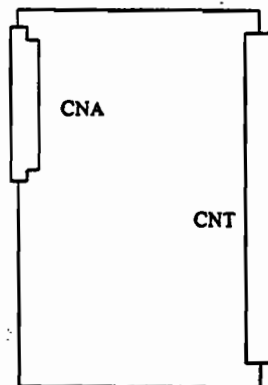
The analog output module provides analog outputs to the user for interfacing. A two channel output module is available.

Data is taken from the I/O base unit through the CNA connector and conditioned to be output through the CNT terminal strips. This module also provides D/A conversion from the digital value.

20.2 Block Diagram



20.3 Connector/Signal Identification



CNA

	a	b	c
32	*CS	+5 V	A0
31	A1	+5 V	A2
30	D0	+5 V	D1
29	D2	+5 V	D3
28	D4	0 V	D5
27	D6	0 V	D7
26	DP	0 V	R/W
25	*DS	0 V	*BE
24		0 V	*POR
23	*ERRI	0 V	*ERRO
22	*RID	0 V	
21		0 V	+24 V
20	+15 V	-15 V	+24 V
19	+15 V	-15 V	
18			
17			
16			
15			
14			
13			
12			
11			
10			
09			
08			
07			
06			
05			
04			
03			
02			
01			

*CS : Card select
 A0-2 : Address signal
 D0-7 : Data bus
 DP : Parity bit of the data bus
 R/W : Read/write control signal
 *BE : Bus enable signal
 *DS : Data strobe signal
 *BE : Bus enable signal
 *POR : Power-on reset
 *ERRO : Error signal detected in the I/O interface module
 *ERRI : Error signal detected in the analog output module
 *RID : Read strobe for ID code
 +24 V }
 +15 V } : DC voltage
 -15 V }
 0 V }

CNT

Refer to IV-3.2.5 for terminal CNT.

20.4 Variable Resistors

Twelve variable resistors are located on the analog output module (DA02A). Refer to Sec. 20.8 for the adjusting method.

The variable resistors VRA1 and VRB1 are used for the offset adjustment of the D/A converter. VRA1 is provided for channel 1 output and VRB1 is for channel 2 output.

The variable resistors VRA2 and VRB2 are used for the offset adjustment of the voltage amplifiers. VRA2 is provided for channel 1 output and VRB2 is for channel 2 output.

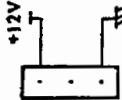
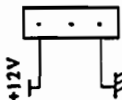
The variable resistors VRA5 and VRB5 are used for the gain adjustment of the voltage amplifiers. VRA5 is for channel 1 and VRB5 is for channel 2.

The variable resistors VRA3 and VRB3 are used for the offset adjustment of the V/I conversion circuit. VRA3 is for channel 1 and VRB3 is for channel 2.

The variable resistors, VRA4 and VRB4 are used for the balance adjustment of the V/I conversion circuit. VRA4 is for channel 1 and VRB4 is for channel 2.

The variable resistors VRA6 and VRB6 are used for the gain adjustment of the V/I conversion circuit. VRA6 is for channel 1 and VRB6 is for channel 2.

20.5 Jumper Settings

Jumpers	Standard setting	Uses
S1		This jumper is used only for the offset and balance adjustment of the V/I conversion circuit for channel 1. Refer to Sec. 20.8 for the setting method. The standard setting is always open.
S2		This jumper is used only for the offset and balance adjustment of the V/I conversion circuit for channel 2. Refer to Sec. 20.8 for the setting method. The standard setting is always open.

20.6 Test Points

The meanings of the test points on the analog output module are as follows.

Test points	Symbol	Contents	Waveform (voltage)
PA1		Output of the D/A converter of channel 1	-10 V - +10 V
PA2		Output of the voltage amplifier of channel 1	-10 V - +10 V
PA3 PA4		Used for the offset and balance adjustment of the V/I conversion circuit of channel 1. Refer to Sec. 20.8 for details.	
PB1		Output of the D/A converter of channel 2	-10 V - +10 V
PB2		Output of the voltage amplifier of channel 2	-10 - +10 V
PB3 PB4		Used for the offset and balance adjustment of the V/I conversion circuit of channel 1. Refer to Sec. 20.8 for details.	
+15 V		+15 VDC power	+15 VDC
-15 V		-15 VDC power	-15 VDC
GND		0 V	
+5 V		+5 VDC power	+5 VDC
+24 V		+24 VDC power	+24 VDC
+12 V		+12 VDC power	+12 VDC
-12 V		-12 VDC power	-12 VDC
-5 V		-5 VDC power	-5 VDC

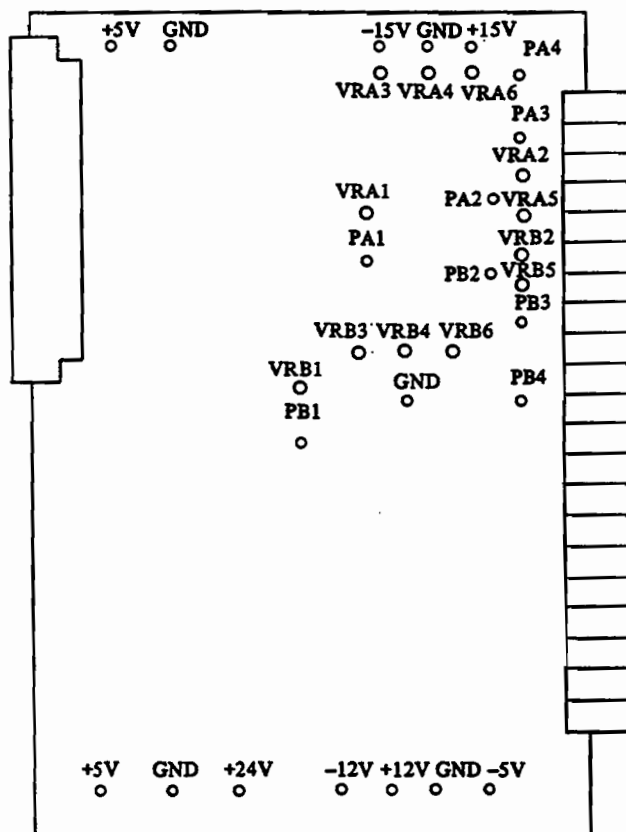
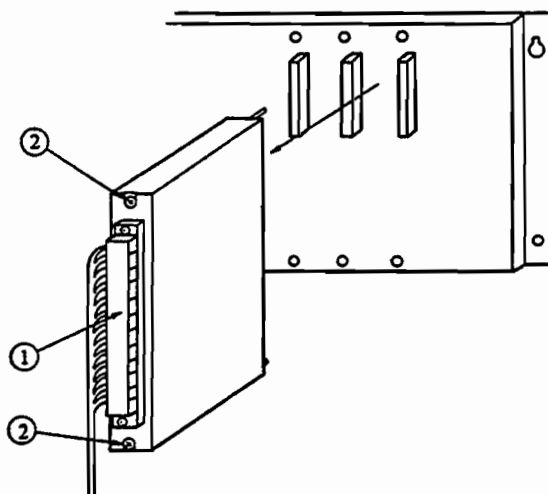


Fig. 20.6 Location of test points and variable resistors on the analog output module

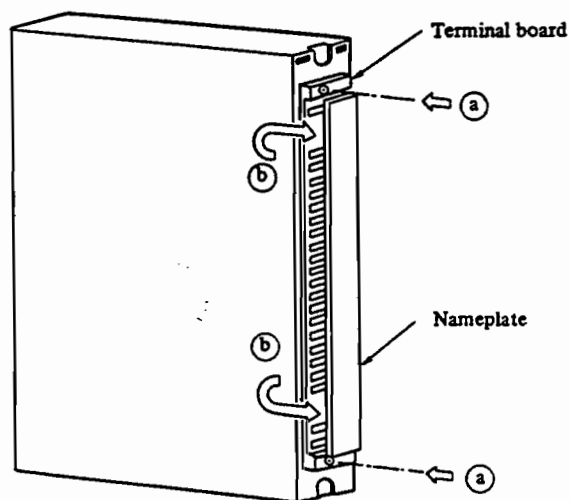
The plastic cover is removed in the above figure. Refer to Sec. 16.7 for the plastic case disassembly method.

20.7 Removal/Replacement



1) Procedure

- ① Disconnect cables from above analog output module (DA02A).
Disconnect the terminal board by loosening the two screws (a) shown in the following figure and, while holding its upper and lower ends, pulling out the entire terminal board.
For disconnecting the wiring, open the nameplate.
The nameplate is opened by pulling it out, while holding it at (b) shown in the following figure.



- ② Detach analog input module by loosening the screws (2).
- ③ For mounting new DA02A, reverse the above procedure.
- 2) Adjusting
Adjust the PCB correctly after replacement.
- 3) Setting
Set new DA02A correctly using the original DA02A as a reference.
- 4) Cautions
Mount the terminal board removed from the replacement module on the old module before returning it for repair.

20.8 Calibration Procedure

Obtain the following equipment:

- . Voltage meter (resolution 0.1 mV)
- . Current meter (resolution 1 uA)

Calibrate the Analog output channel 1 as follows:

1. From the KCL> prompt, type in the following:
 SET PORT AOUT[n] = 0 where n is the port number.
 This command will force a 0 V output.
2. Adjust VRA1 until 0 V is measured at PA1.
3. Adjust VRA2 until 0 V is measured at PA2.
4. From the KCL> prompt, type in the following:
 SET PORT AOUT[n] = 2000 where n is the port number.
 This command will force a +10 V output.
5. Adjust VRA5 until 10 V is measured at PA2.
6. From the KCL> prompt, type in the following:
 SET PORT AOUT[n] = -2000 where n is the port number.
 This command will force a -10 V output.
7. Confirm that -10 V is measured at PA2.
8. From the KCL> prompt, type in the following:
 SET PORT AOUT[n] = 0 where n is the port number.
9. Set the jumper S1 to 0 V side (or connect PA4 to 0 V).
10. Turn VRA3 clockwise until it stops: then turn it again counterclockwise until 0 V is measured at PA2. Stop immediately when the voltage at PA2 reaches 0 V, otherwise the offset of the V/I converter cannot be adjusted correctly.
11. Set the jumper S1 to +12 V side (or connect PA4 to +12 V).
12. Adjust VRA4 until the voltage between PA3 and PA4 becomes 0 V.
13. Remove the jumper S1 (PA4 should be open).
14. Connect a current meter between CNT(3) and CNT(4).
15. From the KCL> prompt, type in the following:
 SET PORT AOUT [n] = 1000 where n is the port number.
 This command will force a 20 mA output.
16. Adjust VRA6 until 20 mA is measured.

Calibrate the Analog output channel 2 as follows:

1. From the KCL> prompt, type in the following:
 SET PORT AOUT[n] = 0 where n is the port number.
 This command will force a 0 V output.
2. Adjust VRB1 until 0 V is measured at PB1.
3. Adjust VRB2 until 0 V is measured at PB2.
4. From the KCL> prompt, type in the following:
 SET PORT AOUT[n] = 2000 where n is the port number.
 This command will force a +10 V output.
5. Adjust VRB5 until 10 V is measured at PB2.
6. From the KCL> prompt, type in the following:
 SET PORT AOUT[n] = -2000 where n is the port number.
 This command will force a -10 V output.
7. Confirm that -10 V is measured at PB2.
8. From the KCL> prompt, type in the following:
 SET PORT AOUT[n] = 0 where n is the port number.
9. Set the jumper S1 to 0 V side (or connect PB4 to 0 V).
10. Turn VRB3 clockwise until it stops, then turn it again counterclockwise until 0 V is measured at PB2. Stop immediately when the voltage at PB2 reaches 0 V, otherwise the offset of the V/I converter cannot be adjusted correctly.
11. Set the jumper S1 to +12 V side (or connect PB4 to +12 V).
12. Adjust VRB4 until the voltage between PB3 and PB4 becomes 0 V.
13. Remove the jumper S1 (PB4 should be open).
14. Connect a current meter between CNT(3) and CNT(4).
15. From the KCL> prompt, type in the following:
 SET PORT AOUT[n] = 1000 where n is the port number.
 This command will force a 20 mA output.
16. Adjust VRB6 until 20 mA is measured.

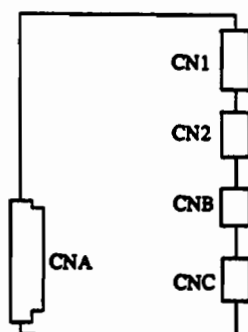
21.1 Theory of Operation

Signal lines are connected to the appropriate connector from the fixed I/O board. CNC is used for connection to the mechanical unit, and CNB is used for connection to the power input unit. CN1 and CN2 are used for user I/O.

21.2 Block Diagram



21.3 Connector/Signal Identification



CNA

	a	b	c
32		+5 V	
31	0 V	+5 V	0 V
30		+5 V	
29		+5 V	
28		0 V	
27		0 V	
26		+5 V	
25		+5 V	
24		+5 V	
23		0 V	
22		0 V	
21		+15 V	
20		+15 V	
19		0 V	
18		0 V	
17		-15 V	
16		-15 V	
15		0 V	*EN
14		0 V	*SYSCLR
13		+24 V	
12		+24 V	
11	*BGIN	0 V	
10	*BGOUT	0 V	
09		SDI	SDO
08			
07		0 V	
06		0 V	
05			
04			
03		0 V	
02		0 V	
01			

*BGIN : Bus ground in } Wired together
 *BGOUT : Bus ground out } in the board
 SDI : Serial data in
 SDO : Serial data out
 *EN : Reverse logic signal of power enable
 *SYSCLR: System clear
 0 V
 +5 V
 +24 V } : DC voltage
 +15 V
 -15 V

CN1

33	UD01	19	0 E	01	UDI1
34	UD02	20	0 E	02	UDI2
35	UD03	21	0 E	03	UDI3
36	UD04	22		04	UDI4
37	UD05	23		05	UDI5
38	UD06	24	UDI17	06	UDI6
39	UD07	25	UDI18	07	UDI7
40	UD08	26	UDI19	08	UDI8
41	UD09	27	UDI20	09	UDI9
42	UD010	28	UDI21	10	UDI10
43	UD011	29	UDI22	11	UDI11
44	UD012	30	UDI23	12	UDI12
45	UD013	31	UDI24	13	UDI13
46	UD014	32		14	UDI14
47	UD015			15	UDI15
48	UD016			16	UDI16
49	0 E			17	0 E
50	0 E			18	

UDI1 - 32: User DI
 UD01 - 24: User DO
 0 E : Common of UDIs and UD0s

CN2

14	UD017	08	UDI31	01	UDI25
15	UD018	09	UDI32	02	UDI26
16	UD019	10	0 E	03	UDI27
17	UD020	11	0 E	04	UDI28
18	UD021	12	UD024	05	UDI29
19	UD022	13	0 E	06	UDI30
20	UD023			07	

CNB

14	HBKD1			01	
15	HBKD2	08	BKR21	02	*ROT
16	*BKRE	09	BKR22	03	RLWD
17	BKR11	10	BKR31	04	*FALM
18	BKR12	11	BKR32	05	*EMGTP
19		12	0 E	06	+24 E
20		13	0 E	07	+24 E

*ROT : Robot overtravel signal
 RLWD : Relay welding signal detected
 in the input unit
 *FALM : Fuse alarm of the brake
 control circuit
 *EMGTP : Emergency stop signal from
 the teach pendant
 BKR21 } : Contact signal of the 2nd
 BKR22 } : brake release
 BKR31 } : Contact signal of the 3rd
 BKR32 } : brake release
 HBKD1 } : Contact signal of the hand
 HBKD2 } : breakage detection
 *BKRE : Brake release enable
 BKR11 } : Contact signal of the 1st
 BKR12 } : brake release
 +24 V } : DC voltage
 0 V }

CNC

23	RD01			01	RDI1
24	RD02	13	*ROT	02	RDI2
25	RD03	14	*HBKD	03	RDI3
26	RD04	15	NZ1	04	RDI4
27	RD05	16	NZ2	05	RDI5
28	RD06	17	NZ3	06	RDI6
29	RD07	18	NZ4	07	RDI7
30	RD08	19	NZ5	08	RDI8
31	OPRL	20	NZ6	09	*PPABN
32	+24 E	21	ALML	10	0 E
33	+24 E	22	+24 E	11	0 E
34	+24 E			12	0 E

The connector "CNC" is used for the interface with the mechanical unit.

RDI1 - 8: General purpose DIs

RD01 - 8: General purpose DOs

*ROT : Robot overtravel signal

*HBKD : Hand breakage detection

ALML : DO for the alarm lamp

OPRL : DO for the operation lamp

*PPABN } : Not used







NZ6 }

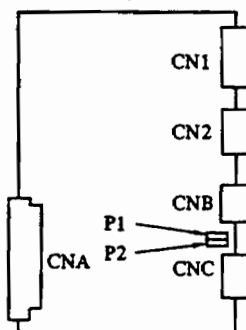
NZ1 - 5 : Near zero signals

+24 E } : DC voltage for DI and DO's

0 V }

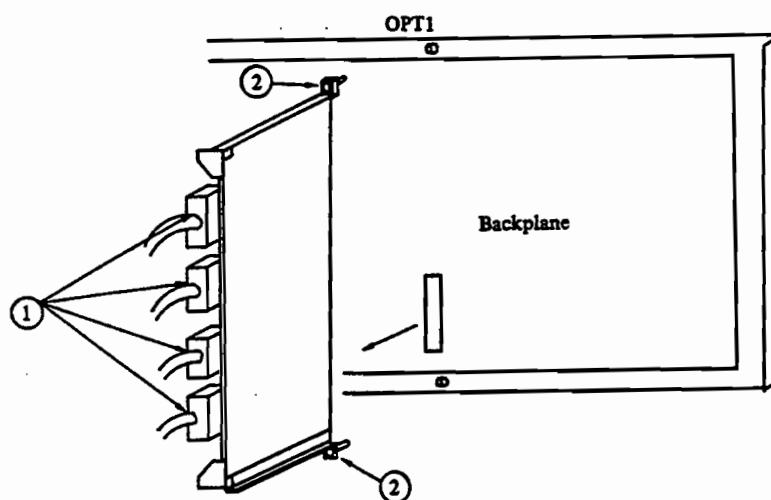
21.4 Jumper Settings

Jumpers	Standard setting	Uses
P1		<p>Selecting common voltage for RDI: When P1 is set to A side, a pneumatic pressure alarm will occur.</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  0V common </div> <div style="text-align: center;">  +24V common </div> </div>
P2		<p>Short-circuit *HBKD input.</p> <div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  *HBKD is effective </div> <div style="text-align: center;">  *HBKD is short-circuited </div> </div>



Location of jumpers

21.5 Removal/Replacement

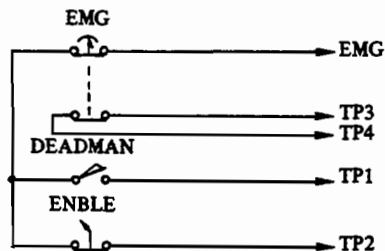
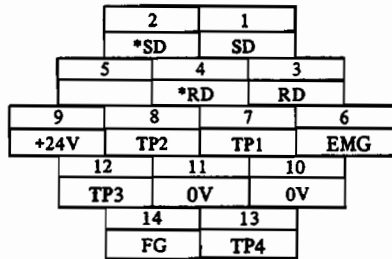
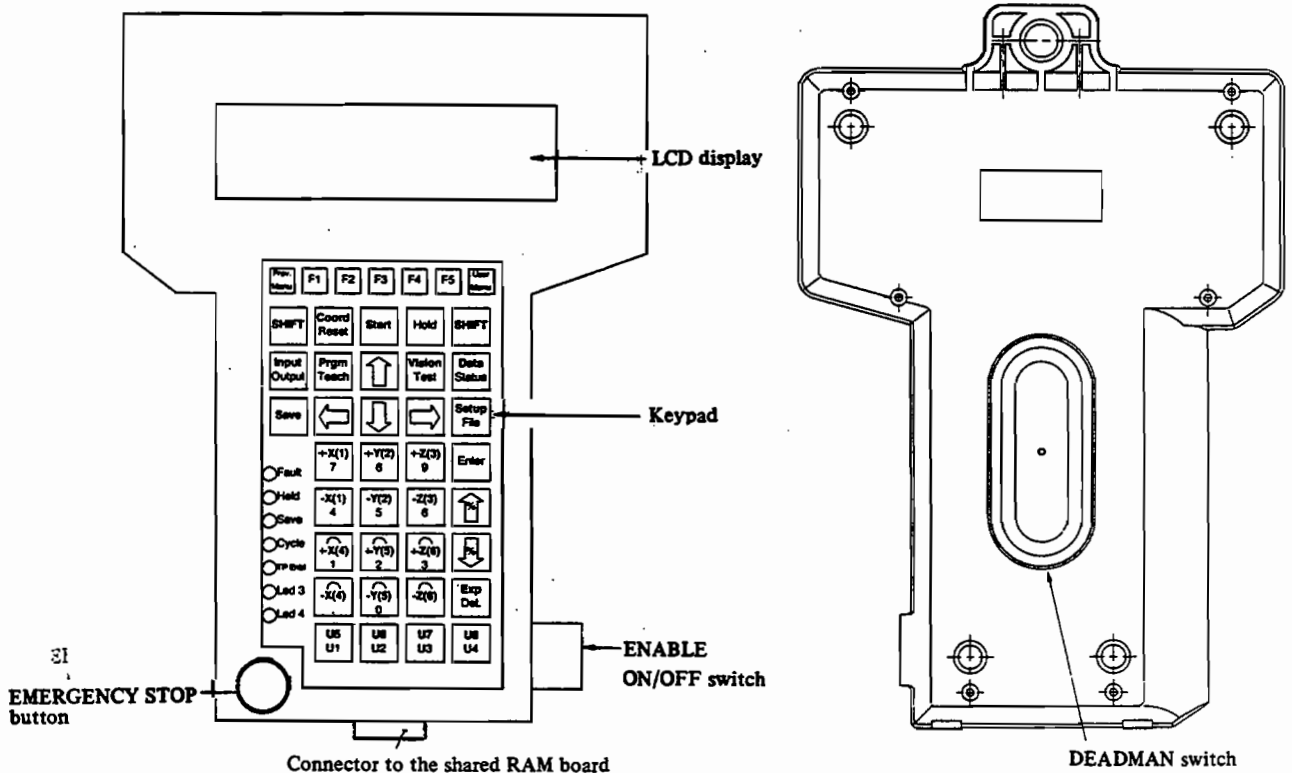


1) Procedure

- ① Disconnect cables from the fixed I/O board.
- ② Detach PCB by loosening two screws ②.
- ③ For mounting new PCB, reverse the above procedure.

22.3 Teach Pendant (A05B-2051-C142)

22.3.1 Connector/signal identification



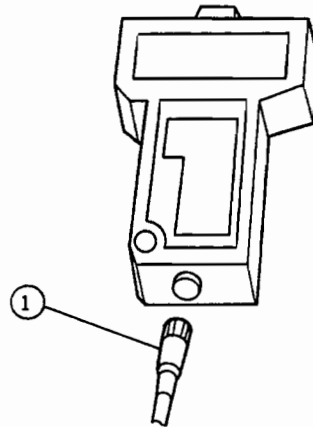
SD } : Sending data
 *SD }
 "SD" is a reverse logic signal of "SD".
 RD } : Receiving data
 *RD }
 "RD" is a reverse logic signal of "RD".
 Note) Above signals are RS-422 interface.
 EMG : EMERGENCY STOP +24 VDC which comes from the controller
 TP1 : Status signal of EMERGENCY STOP button and DEADMAN switch
 TP2 : Status signal of EMERGENCY STOP button and ENABLE ON/OFF switch
 TP3,TP4: Extra contact output of EMERGENCY STOP button
 +24 V : +24 VDC for logic circuit
 0 V : Signal ground
 FG : Frame ground

22.3.2 Removal/replacement of teach pendant and components

1) Unit (Teach pendant)

a) Procedure

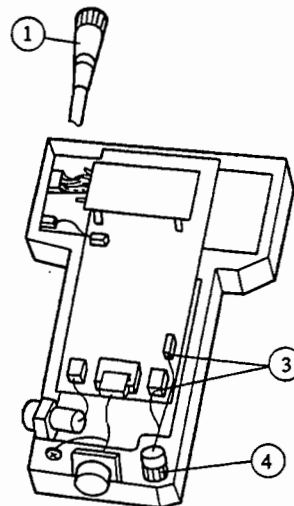
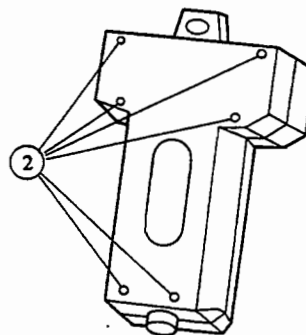
- ① Disconnect the cable.
- ② Replace the teach pendant with a new one, and connect the cable.



2) Component (EMERGENCY STOP button)

a) Procedure

- ① Disconnect the cable.
- ② Remove the back-cover by loosening six screws ②.
- ③ Disconnect the cable ③.
- ④ Remove the EMERGENCY STOP button by loosening part ④.
- ⑤ For mounting a new button, reverse the above procedure.



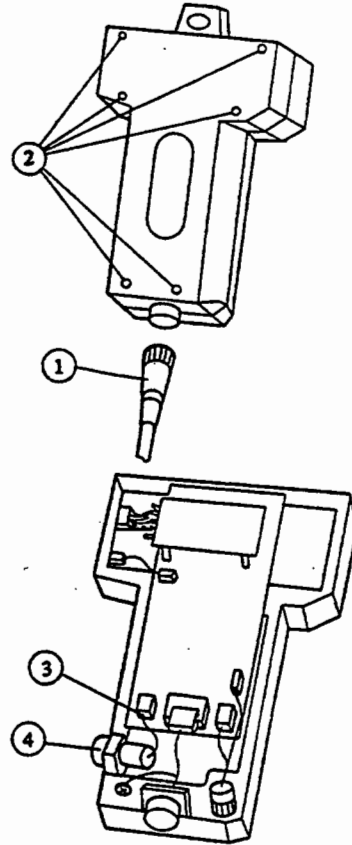
CAUTION

Make sure the teach pendant cable is plugged into the teach pendant connector (CNTP) not the serial port connector (CD4A). Otherwise, damage to equipment could occur.

3) Component (ENABLE ON/OFF switch)

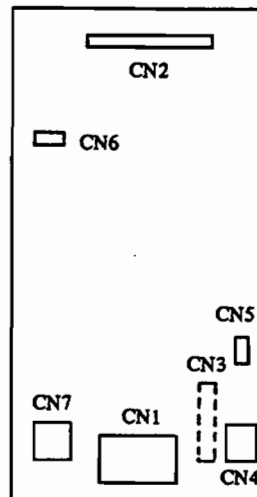
a) Procedure

- ① Disconnect the cable.
- ② Remove the back cover by loosening six screws ②.
- ③ Disconnect cable ③.
- ④ Remove the ENABLE ON/OFF switch.
- ⑤ For mounting a new switch, reverse the above procedure.



22.4 Teach Pendant Control PCB (A20B-1002-0980)

22.4.1 Connector/signal identification



CN1

	a	b
10		
09	TP3	TP4
08		
07	0 V	EMG
06	0 V	0 V
05	0 V	+24 V
04	TP2	TP1
03		
02	*RD	RD
01	*SD	SD

Refer to Sec. 22.3.1 for the signal names.

CN2

01	VSS(0V)
02	VDD(+5V)
03	VO(+3.4V)
04	RS
05	RW
06	E
07	DB0
08	DB1
09	DB2
10	DB3
11	DB4
12	DB5
13	DB6
14	DB7
15	*CS
16	*RES
17	VEE(-5V)
18	
19	
20	

VSS(0 V) : 0 V
 VDD(+5 V) : +5 VDC power supply
 VO(+3.4 V): Power source to drive LCD
 RS : Resistor select to LCD controller
 RW : Read/write control to LCD controller
 E : Read enable to LCD controller
 DB0 - 7 : Data bus to/from LCD controller
 *CS : Chip select to LCD controller
 *RES : Reset signal to LCD controller
 VEE(-5 V) : Power source to drive LCD

CN3

	a	b
01	*KEY00	*KEY01
02	*KEY02	*KEY03
03	*KEY04	*KEY05
04	*KEY06	*KEY07
05	*KCOM0	*KCOM1
06	*KCOM2	*KCOM3
07	*KCOM4	*KCOM5
08	*LED1	*LED2
09	*LED3	*LED4
10	*LED5	*LED6
11	*LED7	
12	+5 V	

*KEY00 - 07: Output signal of keyswitch status to the teach pendant control PCB
 *KCOM0 - 5 : Common of the keyswitch from the teach pendant control PCB
 *LED1 - 7 : Drive signal of LED display
 +5 V : Common of LEDs

CN4

01	EMG1
02	EMG2
03	EMG3
04	EMG4

EMG1, 2: The status of the EMERGENCY STOP button (normally closed)
 EMG3, 4: The status of the EMERGENCY STOP button (normally open)

CN5

01	EMG5
02	EMG6

EMG5, 6: The status of the EMERGENCY STOP button (normally closed) used for TP3/TP4

CN6

01	+24 V
02	0 V

+24 V } : Power source for LCD back light
 0 V }

CN7

01	ENB1
02	ENB2
03	ENB3
04	ENB4

ENB1, 2: The status of the ENABLE ON/OFF switch (closed in "ENABLE")
 ENB3, 4: The status of the ENABLE ON/OFF switch (open in "ENABLE")

22.4.2 Variable resistors

Symbol	Function	Adjustment
VR1	+5 V adjustment	Adjust VR1 until +5 V is observed at test point +5 V.
VR2	V0 adjustment	Adjust VR2 until +3.4 V is observed at test point V0.

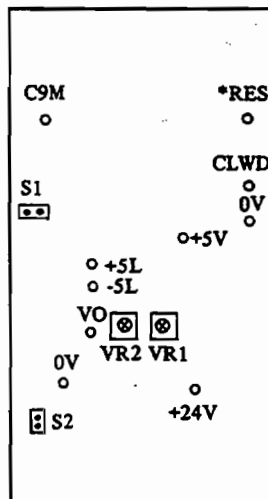




Fig. 22.4.2 Location of variable resistors, jumpers and test points

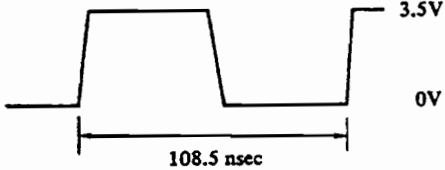
22.4.3 Jumper settings

Jumpers	Standard setting	Uses
S1	 Short	Used for production testing only
S2	 Open	Not used

See Fig. 22.4.2 for location of S1 and S2.

22.4.4 Test points

The meanings of the test points on the teach pendant control PCB are as follows.

Test points	Symbol	Contents	Waveform
*RES	-	Used for emulation of power on reset: When *RES is connected to G terminal, the circuit is reset as though it were powered up. This is used for software debugging only.	
CLWD	-	Short-circuit of watch dog alarm detection: When CLWD is connected to G terminal, the watch dog alarm detection is disabled. This is used for software debugging only.	
C9M	-	Clock for MPU of the teach pendant.	
+24 V	-	+24 VDC voltage	+22.0 - +24.4 VDC
+5 V	-	+5 VDC voltage	+4.85 - +5.15 VDC

Test points	Symbol	Contents	Waveform
+5 L	-	Voltage supplied to the LCD module	+4.85 - +5.15 VDC (Equals +5 V)
-5 L	-		-4.85 - -5.15 VDC
V0	-		+3.4 VDC

See Fig. 22.4.2 for location of test points.

22.4.5 Removal/replacement of teach pendant control PCB

1) Procedure

- ① Disconnect the cable.
- ② Remove the back cover by loosening six screws ②.
- ③ Disconnect the cables from the teach pendant control PCB.
- ④ Detach the teach pendant control PCB by loosening six screws ④.
- ⑤ Detach the LCD control PCB according to Sec. 22.7.2.
- ⑥ For mounting the new teach pendant control PCB, reverse the above procedure.

2) Setting

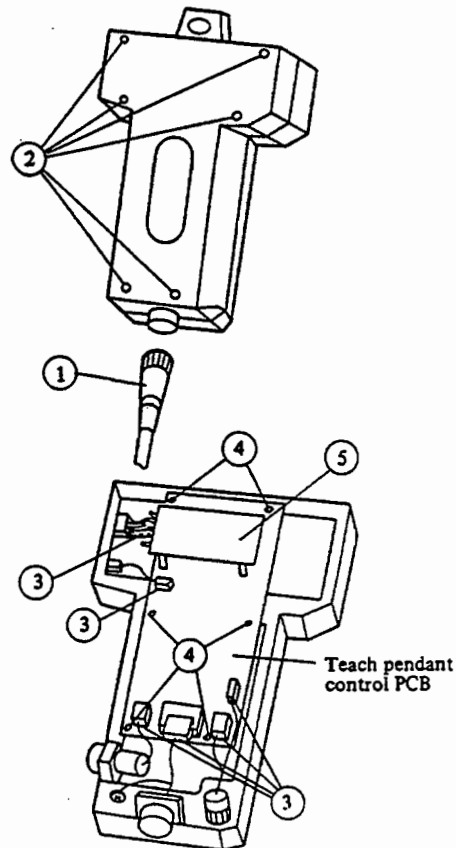
Set the new teach pendant control PCB correctly using the original PCB as a reference.

3) Adjustment

Adjust the teach pendant control PCB correctly after replacement.

4) Cautions

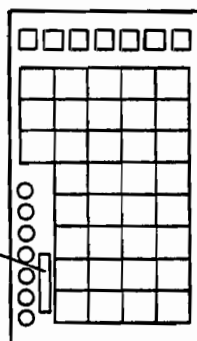
Check the ROM No. and edition number between the old and the new PCBs.



22.5 Keyboard PCB (A20B-1002-0970)

22.5.1 Connector/signal identification

Connector to the
teach pendant
control PCB CN3
(mounted on the
back side)



Top view

	A	B
01	*KEY00	*KEY01
02	*KEY02	*KEY03
03	*KEY04	*KEY05
04	*KEY06	*KEY07
05	*KCOM0	*KCOM1
06	*KCOM2	*KCOM3
07	*KCOM4	*KCOM5
08	*LED1	*LED2
09	*LED3	*LED4
10	*LED5	*LED6
11	*LED7	
12	+5 V	

*KEY00 - 07: Output signal of keyswitch
status to the teach pendant
control PCB

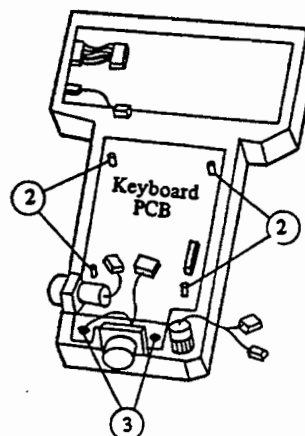
*KCOM0 - 5 : Common of the keyswitch
from the teach pendant
control PCB

*LED1 - 7 : Drive signal of LED display
+5 V : Common of LEDs

22.5.2 Removal/replacement of keyboard PCB

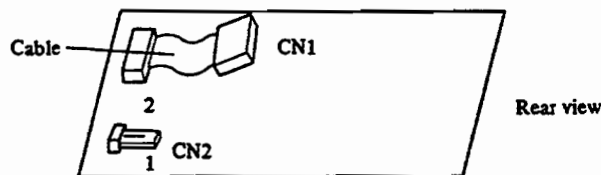
1) Procedure

- ① Remove the cover and the teach pendant control PCB according to Sec. 22.4.5.
- ② Remove the screws and spacers ②.
- ③ Detach the keyboard PCB by loosening two screws ③.
- ④ For mounting a new PCB, reverse the above procedure.



22.6 LCD Module (A61L-0001-0109)

22.6.1 Connector/signal identification



CN1

01	D1	02	FLM
03	M	04	CL1
05	CL2	06	D2
07	VDD(+5V)	08	VSS(0V)
09	VEE(-5V)	09	V0(+3.4V)

D1, D2 }
 CL1, CL2 } : Control signals to drive
 FLM } LCD
 M }
 VDD(+5 V) }
 VSS(0 V) } : Power source to drive LCD
 VEE(-5 V) }
 V0(+3.4 V) }

CN2

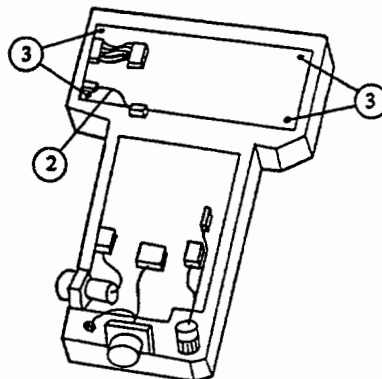
01	+24 V
02	0 V

+24 V }
 0 V } : Power source to drive
 the LCD back light

22.6.2 Removal/replacement of LCD module

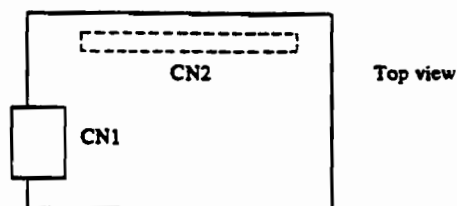
1) Procedure

- ① Remove the cover and the teach pendant control PCB according to Sec. 22.4.5.
- ② Disconnect cable ②.
- ③ Detach the LCD module by loosening four screws ③.
- ④ For mounting a new module, reverse the above procedure.



22.7 LCD Control PCB (A61L-0001-0100 #CB1053RP)

22.7.1 Connector/signal identification



CN1

01	D1	02	FLM
03	M	04	CL1
05	CL2	06	D2
07	VDD(+5V)	08	VSS(0V)
09	VEE(-5V)	10	V0(+3.4V)

D1, D2
 CL1, CL 2
 FLM
 M

} : Control signals to drive LCD

VDD(+5 V)
 VSS(0 V)
 VEE(-5 V)
 V0(+3.4 V)

} : Power source to drive LCD

CN2

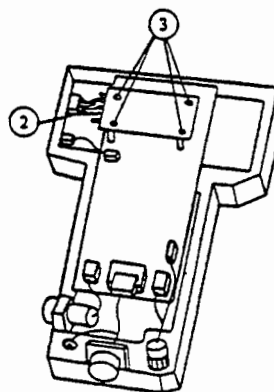
01	VSS(0V)
02	VDD(+5V)
03	V0(+3.4V)
04	RS
05	RW
06	E
07	DB0
08	DB1
09	DB2
10	DB3
11	DB4
12	DB5
13	DB6
14	DB7
15	*CS
16	*RES
17	VEE(-5V)
18	
19	
20	

VSS(0 V) : 0 V
 VDD(+5 V) : +5 VDC power supply
 V0(+3.4 V) : Power source to drive LCD
 RS : Resistor select to LCD controller
 RW : Read/write control to LCD controller
 E : Read enable to LCD controller
 DB0 - 7 : Data bus to/from LCD controller
 *CS : Chip select to LCD controller
 *RES : Reset signal to LCD controller
 VEE(-5 V) : Power source to drive LCD

22.7.2 Removal/replacement of LCD control PCB

1) Procedure

- ① Remove the cover and the teach pendant control PCB according to Sec. 22.4.5.
- ② Disconnect the cable ②.
- ③ Detach the LCD control PCB by loosening four screws ③.
- ④ For mounting a new PCB, reverse the above procedure.



23. POWER INPUT UNIT

Described in this section are:

- The theory of operation of AC power control (23.1)
- The block diagram of AC power control (23.2)
- The power input unit excluding PCB (23.3)
- The power input unit PCB (23.4)

23.1 Theory of Operation

AC power is supplied to the controller by the power input unit. The power input unit brings in three phase power from the main supply through the circuit breaker or the disconnect switch with fuses and distributes the power to the servo transformer and the power input unit PCB.

The power input unit consists of the line contactor (LC3), fuses F7 - F9, the control transformer (TF3), and the power input unit PCB. Three phase AC inputs are connected to the circuit breaker. Their outputs are connected to the servo transformer through the line contactor (LC3) and fuses F7 - F9. LC3 is energized from the power input unit PCB (A16B-1311-0530) start up circuitry. This supplies three phase power to the servo transformer. The servo transformer outputs 200 VAC for servo drive power. The power input unit PCB also supplies 200 VAC to the control transformer (TF3), which supplies 100 VAC back to the power input unit PCB.

In the case that the controller is equipped with a disconnect switch instead of a circuit breaker, the fuses FL1 - FL3 are mounted on the power input unit. Three phase AC inputs are connected to the disconnect switch and its outputs are connected to the servo transformer through the fuses FL1 - FL3, the line contactor (LC3) and fuses F7 - F9. Other part is as described above.

The power input unit PCB receives 200 VAC from the input transformer (TF4). Primary power for TF4 comes from the circuit breaker through fuse F1. The power input unit PCB controls the start up sequence. Once the start sequence has completed, the power input unit PCB controls 100 VAC for the overtravel and emergency stop circuitry, the brake circuits, the optional hour meter and the magnetic circuit contactor (MCC) on the servo amplifier. The power input unit PCB also controls the 200 VAC that supplies power to the fan, the DC power supply unit and the control transformer (TF3).

Eight LEDs PIL, ALM, BK1, BK2, BK3, S.ON, FALM and FALM2 are on the power input unit PCB. PIL indicates that power is supplied. ALM indicates that an alarm signal has been received. BK1, BK2 and BK3 indicate brake ON/OFF status. S.ON indicates 100 VAC ON/OFF status to the servos. FALM and FALM2 indicate a fuse blown alarm.

23.2 Block Diagram

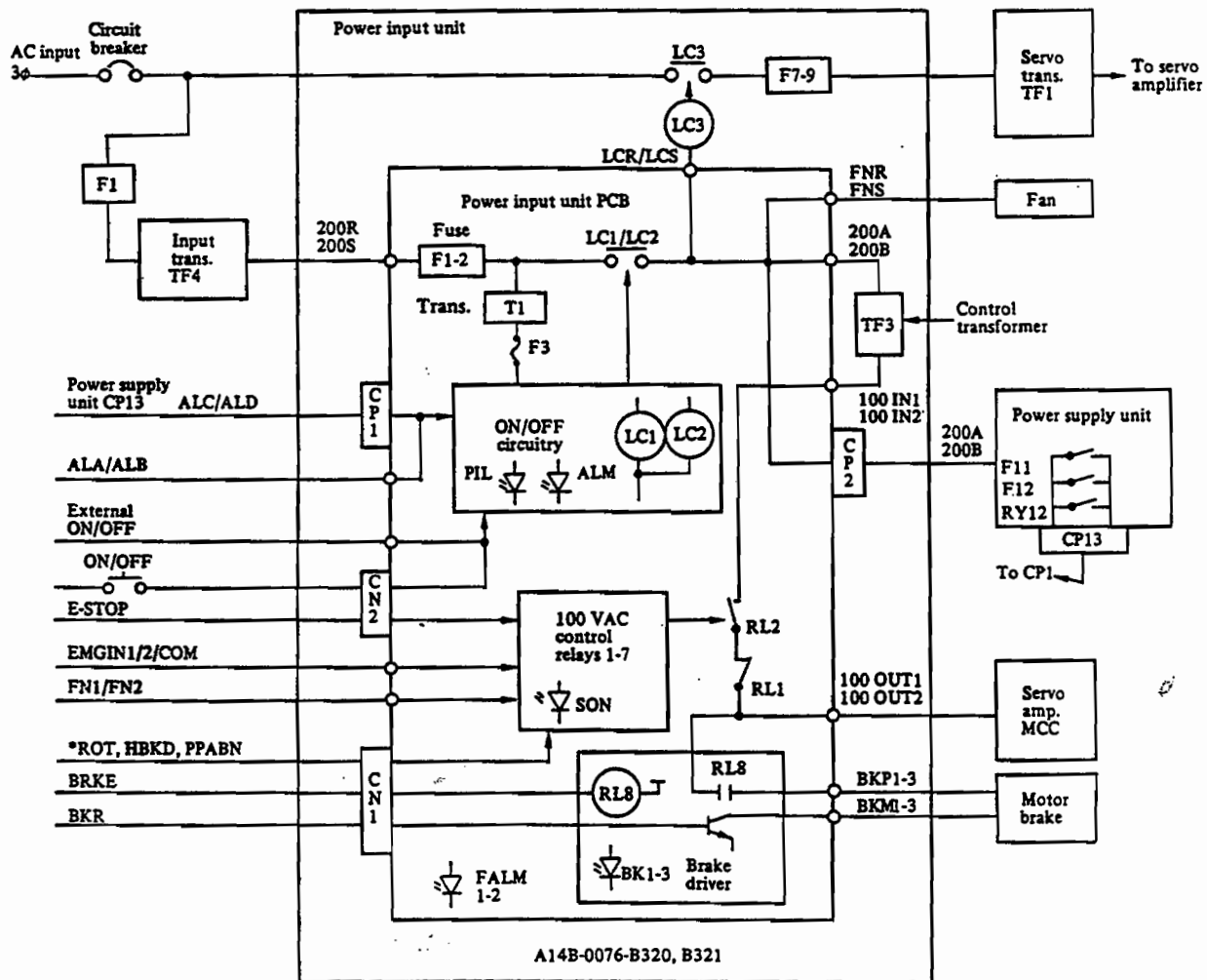


Fig. 23.2 (a) Block diagram of power input unit, S-10
(Medium size cabinet)

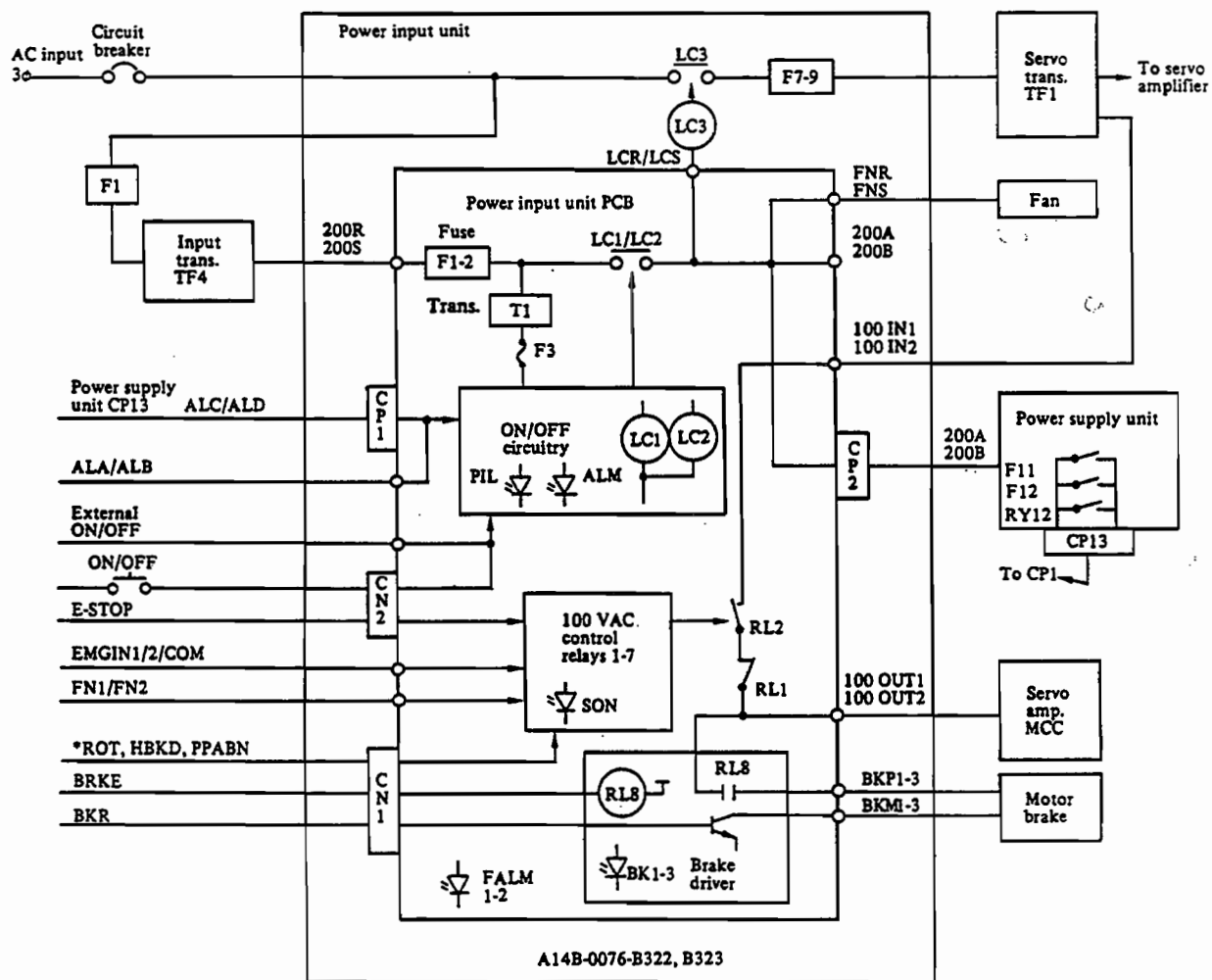


Fig. 23.2 (b) Block diagram of power input unit, S-10/S-700
(Large size cabinet, circuit breaker)

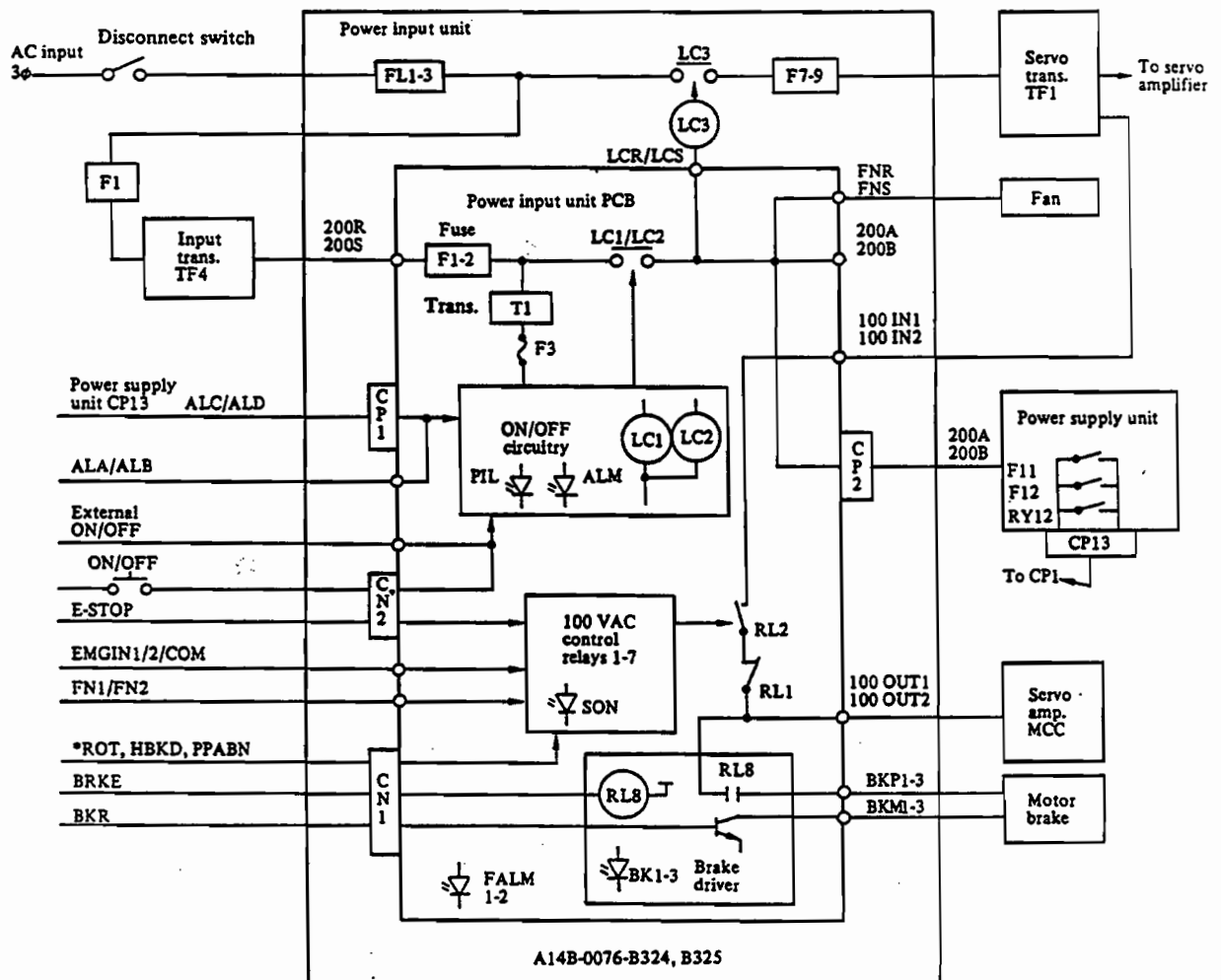


Fig. 23.2 (c) Block diagram of power input unit, S-10/S-700
(Large size cabinet, disconnect switch)

23.3 Power Input Unit

There are six types of power input units and one of them is used being based on the cabinet types, the AC input voltage, and the power disconnection device.

Specification

			AC input voltage	
			220/240 VAC	380/415/460/480 500/550/575 VAC
Medium size cabinet	Power disconnect device	Circuit breaker including leakage breaker	A14B-0076-B321	A14B-0076-B320
Large size cabinet		Disconnect switch	A14B-0076-B323	A14B-0076-B322
			A14B-0076-B325	A14B-0076-B324

Differences in internal configurations among those units are shown in the block diagrams Fig. 23.2 (a) through (c). Differences by the AC input voltage are the wire color of AC lines and capacity of fuses. Location of components is shown in Fig. 23.3 (a). Main components are:

PCB : Power input unit PCB

LC3 : Line contactor

F7 - 9 : Fuses for servo transformer

FL1 - 3: Fuses for AC input power

TF3 : Control transformer

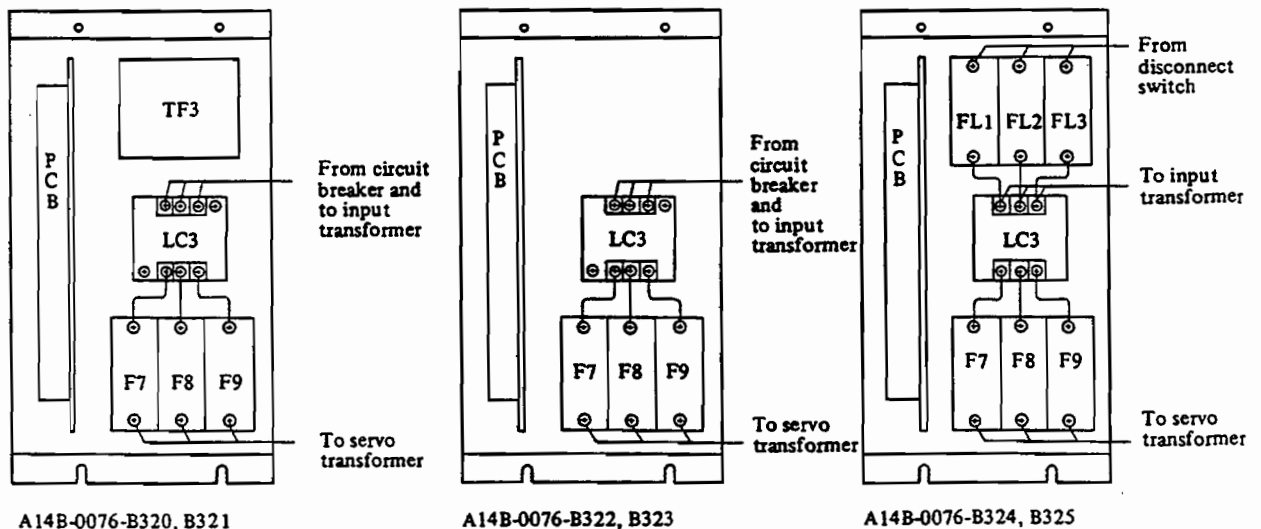


Fig. 23.3 (a) Location of power input unit components

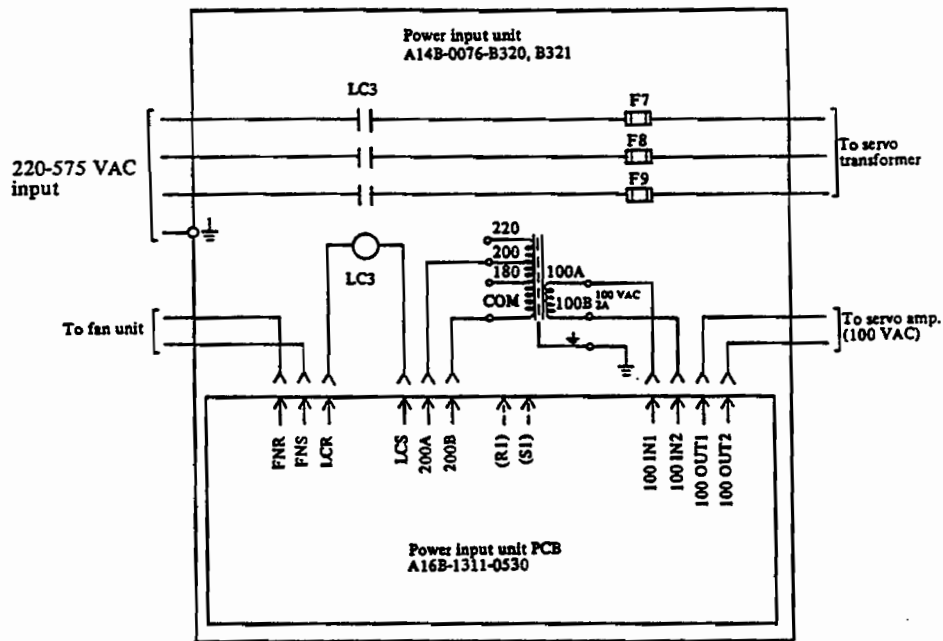


Fig. 23.3 (b) Power input unit circuitry (Medium size cabinet)

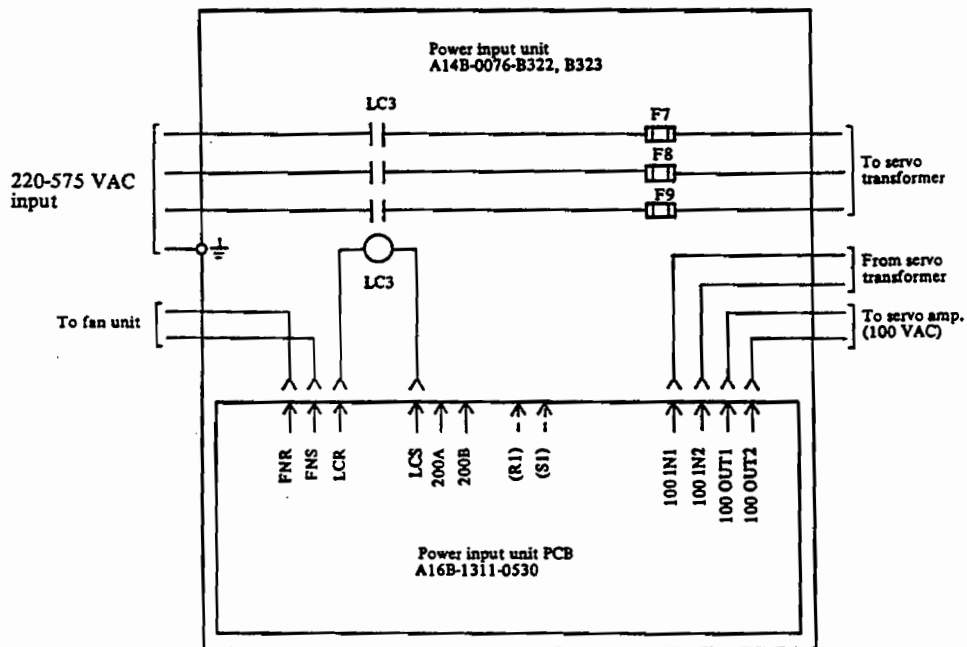


Fig. 23.3 (c) Power input unit circuitry (Large size cabinet, breaker)

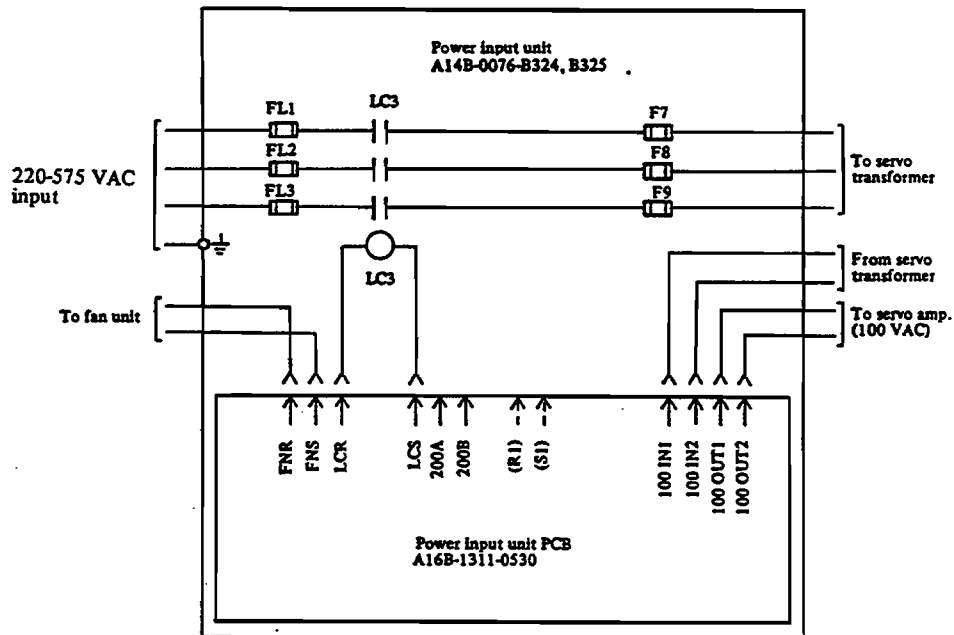


Fig. 23.3 (d) Power input unit circuitry (Large size cabinet, disconnect switch)

23.3.1 Fuses

Fuse specification is shown below.

S-10 and S-700 controllers

		Power input unit specification A14B-0076- <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>			
		B321, B323	B325	B320, B322	B324
AC input voltage		220/240 VAC		380/415/460/480/500/550/575 VAC	
Fuse	F7-9	A60L-0001-0042 #JG1-30	A60L-0001-0042 #JG1-30	A60L-0001-0042 #JG1-15	A60L-0001-0042 #JG1-15
	FL1-3	—	A60L-0001-0042 #JG2-40	—	A60L-0001-0042 #JG1-20

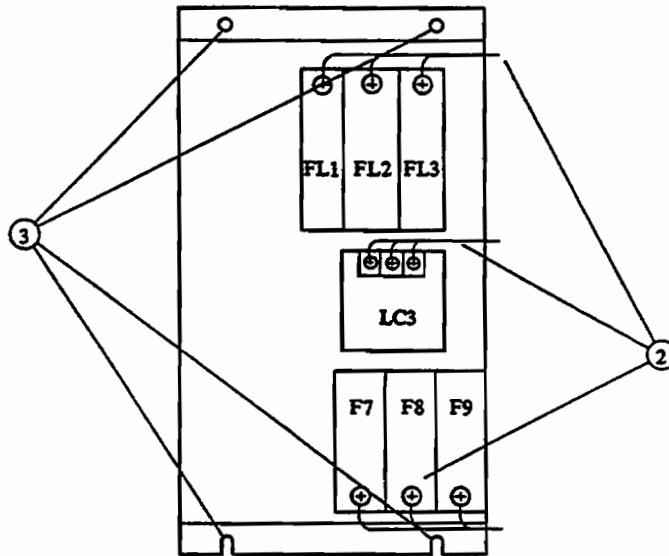
Refer to Fig. 23.3 (a) for location of fuses.

23.3.2 Removal/replacement

1) Power input unit

a) Procedure

- ① Disconnect all cables from the power input unit PCB.
- ② Disconnect all cables ② from the power input unit.
- ③ The power input unit can be removed by loosening four screws ③.
- ④ For mounting new power input unit, reverse the above procedure.

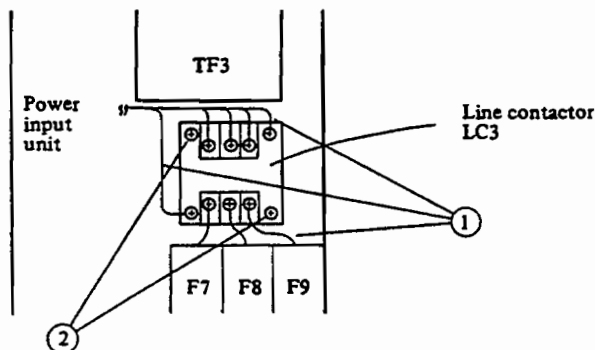


Front view of power input unit

2) Line contactor (LC3)

a) Procedure

- ① Disconnect all cables ① from the line contactor.
- ② The line contactor can be removed by loosening two screws ②.
- ③ For mounting new line contactor, reverse the above procedure.

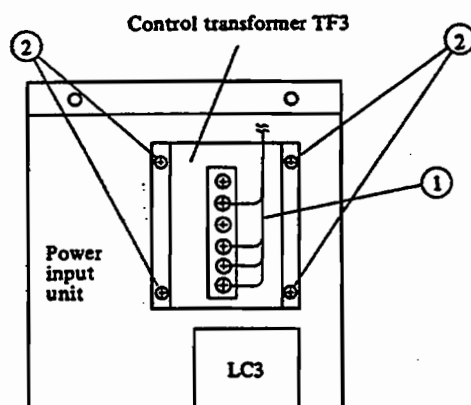


Front view of the power input unit

3) Control transformer (TF3)

a) Procedure

- ① Disconnect all cables ① from the transformer.
- ② The transformer can be removed by loosening four screws ②.
- ③ For mounting new transformer, reverse the above procedure.



Front view of power input unit

23.4 Power Input Unit PCB (A16B-1310-0530)

23.4.1 Connector/signal identification

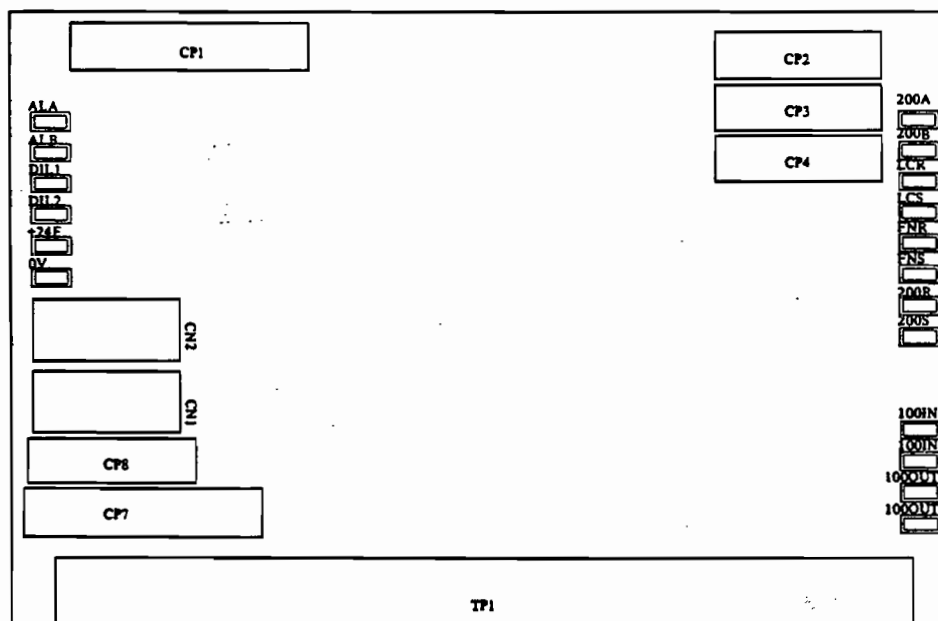
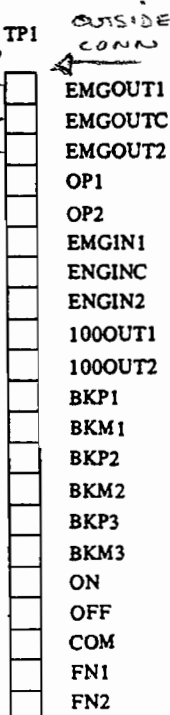


Fig. 23.4.1 Location of terminals and connectors on the power input unit PCB

THE EMGOUT RELAY
CONTACT
CLOSED WITH NORMAL
CONDITION (CAN RUN)
SEE LOGIC
TABLE
NEXT
PAGE



EMGIN1	}	: Emergency stop control inputs from external equipment
EMGINC		
EMGIN2		
EMGOUT1	}	: Emergency stop control outputs for external equipment
EMGOUTC		
EMGOUT2		
BKP1	}	: 1st brake control output
BKM1		
BKP2	}	: 2nd brake control output
BPM2		
BKP3	}	: 3rd brake control output
BKM3		
BKP is a positive side output, and BKM is a negative side output.		
OP1	}	: Input of the emergency stop on the operator's panel
OP2		
FN1	}	: Input of the gate switch of the protective fence
FN2		
ON	}	: Connection terminals for external ON/OFF control switches (Note)
OFF		
COM	}	: 100 VDC power output (for servo amp.)
100 OUT1		
100 OUT2		

Note) Refer to Sec. 23.4.2 for the connection information.

The relationship between the signals is as follows.

Status	100 VAC output for the servo amplifiers	100 VDC output for the motor brake	Contact between EMGOUT1 and EMGOUTC	Contact between EMGOUTC and EMGOUT2
Normal (Note*) (Robot can be operated)	100 VAC ON	100 VDC ON	Closed	Open
EMGIN1-EMGINC (open)	OFF	OFF	Open	Closed
EMGINC-EMGIN2 (open)	OFF	OFF	Closed	Open
Other emergency stop status (includes "ROT" or "EMG" of TP...) E-STOP button is pressed	OFF	OFF	Open	Closed
E-STOP button is released but RESET has not been pressed	ON	OFF	Closed	Open

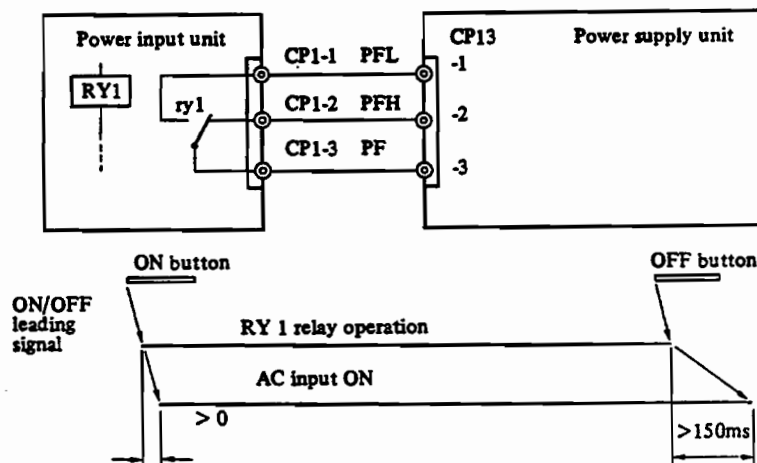
* Note) Normal status means that "EMGIN1" and "EMGINC" are shorted, "EMGINC" and "EMGIN2" are shorted, and any other emergency stop conditions have not occurred.

CP1

01	PFL
02	PFH
03	PF
04	
05	ALC
06	ALD

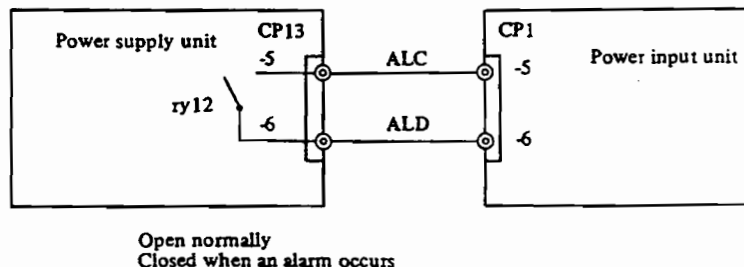
PFL }
PFH } : Power ON/OFF leading signal
PF }

These contact signals are output to the power supply unit before power is normally turned on or normally turned off by the ON/OFF button provided on the operator's panel or an external ON/OFF button. As shown in the diagram, PFL/PF are connected prior to the AC input unit coming on after the ON button has been pressed. PF/PFH are connected at least 150 ms after the OFF button is pressed. Loss of the PFL signal indicates to the power supply unit that power is going off.



ALC }
ALD } : Alarm signal detected by the power supply unit

This contact signal is given from the power supply unit when the EN signal of the power supply unit goes low. The EN signal goes low when the DC output voltages, being monitored by a voltage monitoring circuit on the power supply unit, fall outside of the specified range. When this signal is given, the AL relay in the power input unit energizes and latches in to turn off the AC input power.



The alarm LED lights. The power off button must be pressed to release the latched AL relay in order to recover from this alarm.

CP2 - CP4

01	200A
02	200B
03	GND

200A } : 200 VAC power source for the power supply unit
 200B }
 GND : 0 V (ground)

CP3 and CP4: These connectors are not used.

CP7

01	
02	
03	0 V
04	0 V
05	+24 V
06	+24 E

+24 E: +24 V (External use from power supply unit)
 0 V: Ground
 +24 V: +24 V from power supply unit

CP8

01	+24 F
02	0 V
03	

+24 F: +24 V (via fuse F10)
 0 V: Ground

CN1

14	HBKD1	08	BKR21	01	OTREL
15	HBKD2	09	BKR22	02	*ROT
16	*BKRE	10	BKR31	03	RLWD
17	BKR11	11	BKR32	04	*FALM
18	BKR12	12	0 V	05	*EMGTP
19		13	0 V	06	+24 E
20				07	+24 E

OTREL : Overtravel release signal from the operator's panel through the robot control module
 *ROT : Robot overtravel signal from the mechanical unit through the robot control module
 RLWD : Relay welding signal to the robot control module
 *FALM : Fuse alarm of the brake control circuit
 *EMGTP : Emergency stop signal of the teach pendant
 +24 E : +24 VDC to the robot control module
 BKR11 } : Contact signal of the 1st
 BKR12 } : brake release
 BKR21 } : Contact signal of the 2nd
 BKR22 } : brake release
 BKR31 } : Contact signal of the 3rd
 BKR32 } : brake release
 HBKD1 } : Contact signal of the hand
 HBKD2 } : breakage detection
 *BKRE : Brake release enable

CN2

01	+24 F			14	0 V
02	+24 F	08		15	0 V
03	ON1	09		16	ON2
04	OFF1	10		17	OFF2
05	OTREL	11		18	
06	TP1	12		19	TP2
07	+24 F	13		20	0 V

CN2 is connected to CNPI on the shared RAM board.

+24 F: +24 V to CNPI on shared RAM board

OTREL: Overtravel release signal from the operator panel through CNPI on the shared RAM board

TP1 : Status signal of EMERGENCY STOP button and DEADMAN switch on the teach pendant

TP2 : Status signal of EMERGENCY STOP button and DISABLE/ENABLE switch on the teach pendant

ON1 }
ON2 } : Connection with ON/OFF switch
OFF1 } : provided on the operator's panel
OFF2 }
0 V : Ground

CONNECTION TERMINALS

200A }
200B } : 200 VAC power output to the control transformer

LCR }
LCS } : Control signal output of the line contactor (LC3) for the servo transformer

FNR }
FNS } : 200 VAC power output for fan units

200R }
200S } : 200 VAC power input for the power input unit PCB

100IN1 }
100IN2 } : 100 VAC power (output of control transformer)

100OUT1 }
100OUT2 } : 100 VAC power output (same as TP1, 9 and 10)

ALA }
ALB } : Connection terminals for an external alarm

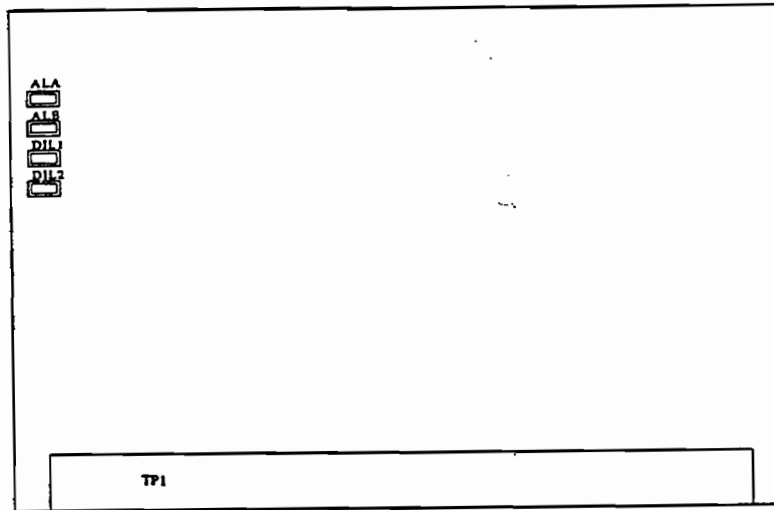
DIL1 }
DIL2 } : Connection terminals of the door interlock switch

+24 F : +24 V fuse line

0 V : Ground

: These terminals are not used. When these are not used, these should be shorted.

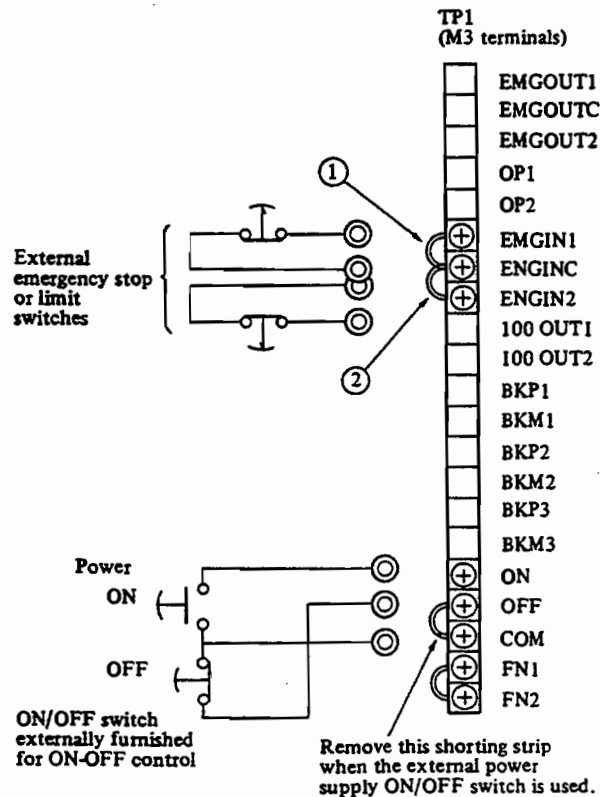
23.4.2 Jumper/shorting strip settings

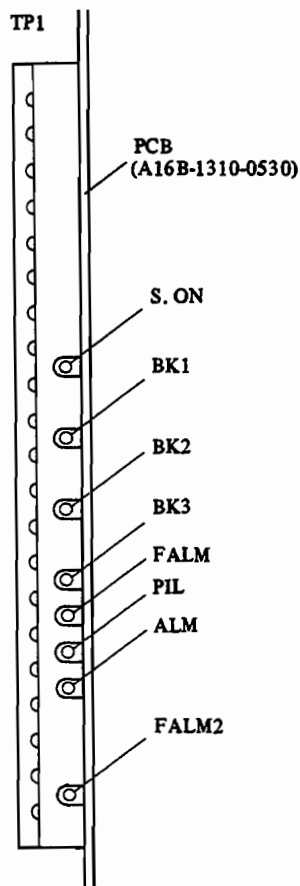


When the terminals "EMGIN1", "EMGINC", and "EMGIN2" on TP1 are not used, the terminals should be shorted. The setting method is as follows. When the terminals "EMGIN1" and "EMGINC" are used, remove the shorting strip ①. And when "EMGINC" and "EMGIN2" are used, remove ②.

"OFF" and "COM" of terminal TP1 should be shorted when the external ON/OFF control is not used. When the external ON/OFF control is used, the connection is shown below.

"FN1" and "FN2" of terminal TP1 should be shorted when the gate switch of the protective fence is not used. When the gate switch of the protective fence is not used, the connection is shown below.



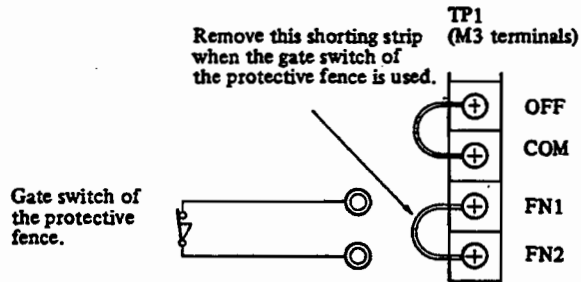


LED	Meaning	Status
S.ON (amber)	Servo on	100 VAC is supplied to the servo amplifier, when this LED lights.
BK1 (amber)	1st brake is released	When this LED lights, the brake on axis 1 on the S-10 is released. Axes 2 and 3 on the S-700 is released.
BK2 (amber)	2nd brake is released	When this LED lights, the brakes on axes 2 and 3 on the S-10 is released. Axis 1 on the S-700 is released.
BK3 (amber)	3rd brake is released	When this LED lights, the brakes on axes 4, 5, and 6 on both the S-10 and S-700 are released.
FALM (red)	Fuse alarm of the brake circuit	If one of three fuses F4 - F6 is blown, this LED lights.
PIL (amber)	Pilot lamp	PIL lights while the power is supplied to the terminal TP1 "200R" and "200S" if F3 is not blown.
ALM (red)	Alarm lamp	ALM lights when the power input unit PCB receives an alarm signal from the power unit. (Note)
FALM2 (red)	Fuse alarm of the +24 F supply	If fuse F10 is blown, this LED lights.

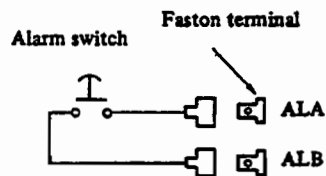
Note) When ALM lights, the line contactors LC1, LC2 and LC3 turn off.

LC1 and LC2 are installed on the power input unit PCB, and LC3 is on the power input unit. The controller power cannot be turned on under this condition, to reset this condition, the power supply must be turned off, or the POWER OFF button (either the controller POWER OFF button or external POWER OFF button) must be pressed.

Caution) Even when the controller power has been turned off, power is still applied to the input unit and the amber PIL LED will be lit. Before touching any part of the input unit be sure that the PIL is off and the circuit breaker/disconnect switch is off.



ALA and ALB terminals should be left open when an external alarm is not used. When an external alarm is used, the connection is as follows.



"DIL1" and "DIL2" terminals are not used in the power input unit PCB. When these terminals are open, the controller cannot be turned on.

23.4.3 LEDs

Eight LEDs, S.ON, BK1, BK2, BK3, FALM, PIL, ALM and FALM2 are provided with the power input unit PCB.

23.4.4 Fuses

Seven fuses are installed in the power input unit PCB.

F1, F2 Input fuses of 200 VAC line

F3 Input fuse of the control circuit

F4, F5, F6 Fuses of the brake control line

F10 Input fuse of 24 VDC line

Each fuse specification is as follows.

Fuse number	Specification
F1, F2	A60L-0001-0101#P4100H
F3	A60L-0001-0172#DM03
F4, F5, F6	A60L-0001-0046#2.0
F10	A60L-0001-0046#5.0

If one of the three fuses F4 - F6 is blown the FALM LED lights. If F10 is blown the FALM2 LED lights. The blown fuse shows a white failure display in the indicator shown below.

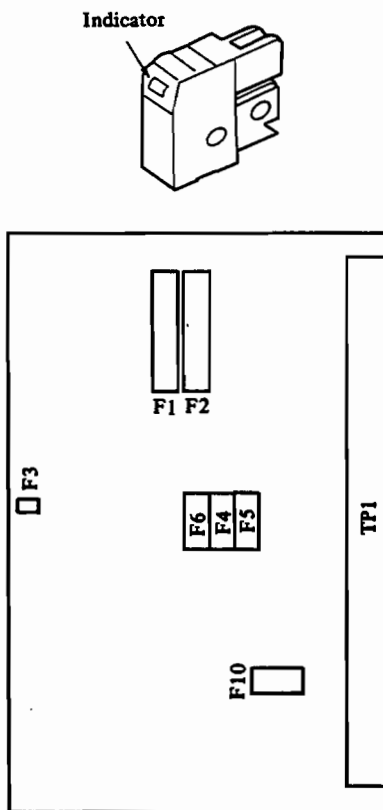


Fig. 23.4.4 Location of fuses on power input unit PCB

23.4.5 Test points

Test points	Symbol	Contents	Waveform (voltage)
C	-	Output of the diode bridge to convert AC to DC voltage	about 25 VDC
B	-	Cathode of the Zener diode (ZD1)	about 22 VDC
E	-	DC power voltage of the input unit PCB circuit	21 to 22 VDC
0 V	-	0 V reference for output of bridge	0 V

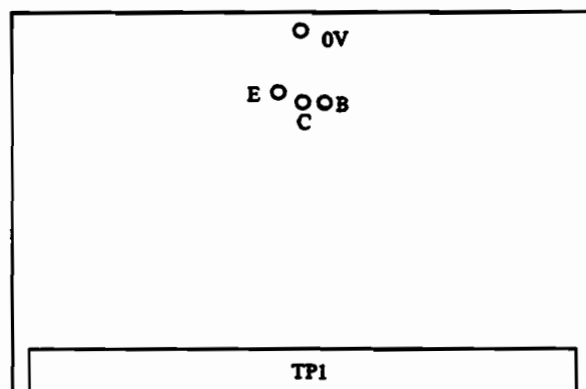


Fig. 23.4.5 Location of test points on power input unit PCB

23.4.6 Removal/replacement

1) Power input unit PCB

a) Procedure

- ① Disconnect cables from the power input unit PCB.
- ② Detach the PCB by loosening the five screws ②.
- ③ For mounting the PCB, reverse the above procedure.

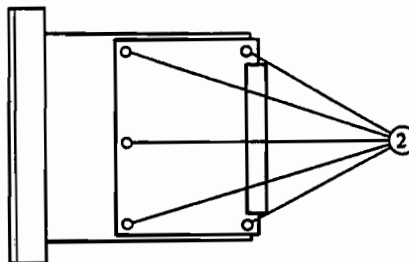


Fig. 23.4.6 (a) Left side view of power input unit PCB

2) Component (relay)

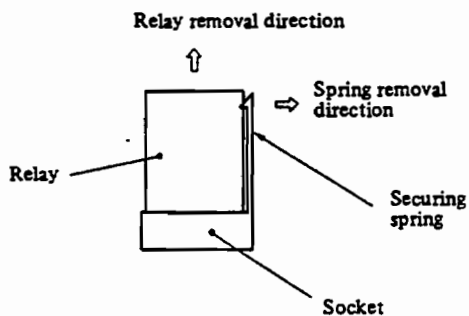


Fig. 23.4.6 (b) Relays LC1, LC2, RL1, RL2, RL7, RL8, RS2

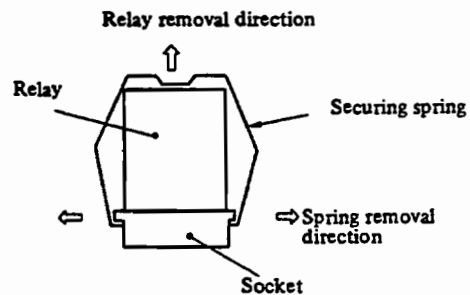


Fig. 23.4.6 (c) Relay RS1

Remove the spring that clamps the relay to its socket by pulling it in the direction indicated by the arrow (⇒) shown above. Then remove the relay by pulling it in the direction (↑) shown above.

24. TRANSFORMERS

Four transformers (servo, input, control and user) are installed in the controller.

Servo transformer : Provides power for servo amplifiers

Input transformer : Provides 200 VAC for power supply unit, fan units, control transformer and power input unit.

Control transformer: Provides 100 VAC for servo amplifiers and motor brakes.

User transformer : Provides 115 VAC for user (option).

Specifications of transformers are as follows.

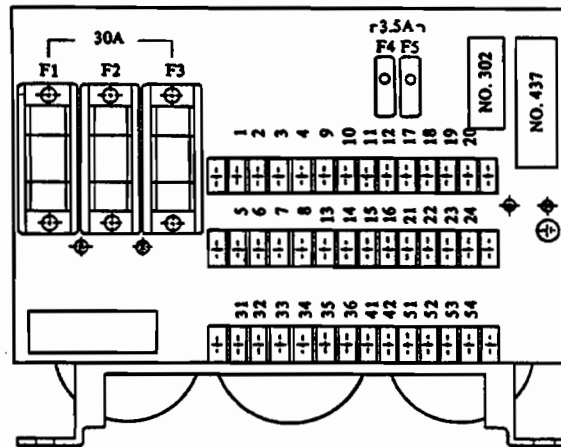
	S-10		S-700
	Medium size cabinet	Large size cabinet	Large size cabinet
Servo transformer TF1	A80L-0024-0002	A80L-0024-0004	A80L-0024-0004
Input transformer TF4	A80L-0012-0010	A80L-0012-0010	A80L-0012-0010
Control transformer TF3	A80L-0001-0342 (an integral part of power input unit)	Not available (100 VAC is provided by servo transformer)	Not available (100 VAC is provided by servo transformer)
User transformer TF5	Not available	A80L-0001-0520	A80L-0001-0520

24.1 Fuses

1) Servo transformer TF1

F1 - F3: Fuses for 200 VAC output (30 A)
A60L-0001-0042#JG1-30

F4 - F5: Fuses for 100 VAC output (3.5 A)
A60L-0001-0101#P435H

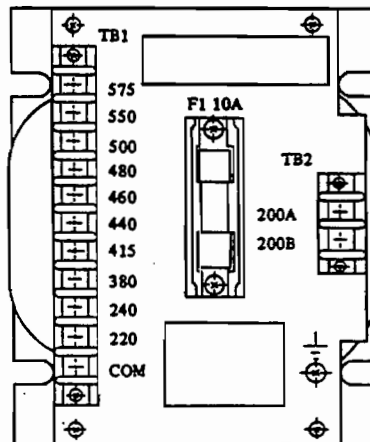


Front view

Note) Fuses on the servo transformer are provided only for the large size cabinet.

2) Input transformer TF4

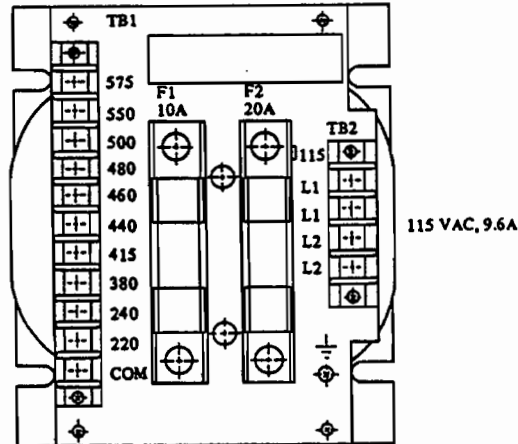
F1: Input fuse
A60L-0001-0193#FH-32F



3) User transformer

F1: Input fuse of user transformer TF5
A60L-0001-0042#JG1-10

F2: Output fuse of user transformer TF5
A60L-0001-0042#JG1-20



24.2 Settings

1) Servo transformer TF1

Connect the jumpers as follows.

Power supply voltage	Connection of primary tap						Connecting style
	U	V	W	Jumper			
220	7	15	23	8-15	16-23	24-7	Delta
240	6	14	22	8-14	16-22	24-6	
380	7	15	23	8-16	16-24	Star	
415	6	14	22				
440							
460	5	13	21				
480	4	12	20				
500	3	11	19				
550	2	10	18				
575	1	9	17				

2) Input transformer TF4

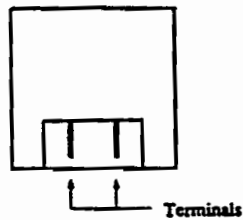
Select the correct tap so that the power supply voltage is within +10% to -15% of the tap voltage.

3) User transformer

Select the correct tap so that the power supply voltage is within +10% to -15% of the tap voltage.

25. HOUR METER

25.1 Connector/Signal identification



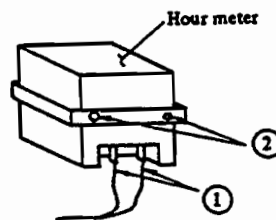
Terminals: 100 VAC input
'terminals for
hour meter

(Rear view of the hour meter)

25.2 Removal/Replacement

1) Procedure

- ① Disconnect cables ① from the hour meter.
- ② The hour meter can be removed by loosening two nuts ②.
- ③ For mounting new hour meter, reverse the above procedure.



(Rear side of the operator's panel)

26. SERVO AMPLIFIER

In the S-10 R-H controller, two three-axis servo amplifiers are used.

In the S-700 R-H controller, two one-axis servo amplifiers and two two-axis servo amplifiers are used to drive each axis.

The relationship between the axes numbers, axes names, and the connectors on the axis control PCB, robot mechanical unit, and servo amplifiers is shown in Table 26 (a) and (b).

Table 26 (a) S-10

Axis Software No.	Axis Hardware No.	Axis	Axis control PCB	Feedback connector	Connector on robot	Axis control PCB	Velocity connector	Servo Amp. No.	Connector
2	1	W	1	CF91	P1	1	CV21	1	CN1N
3	2	U		CF92	P1		CV22		CN1L
1	3	θ		CF93	P1		CV23		CN1M
4	4	γ		CF94	P2		CV24		CN1N
5	5	β	2	CF91	P2	2	CV21	2	CN1M
6	6	α		CF92	P2		CV22		CN1L

Table 26 (b) S-700

Axis Software No.	Axis Hardware No.	Axis	Axis control PCB	Feedback connector	Connector on robot	Axis control PCB	Velocity connector	Servo Amp. No.	Connector
2	1	W	1	CF91	P1	1	CV21	4	CN1
3	2	U		CF92	P1		CV22	1	CN1M
1	3	θ		CF93	P1		CV23	3	CN1
4	4	γ		CF94	P2		CV24	2	CN1M
5	5	β	2	CF91	P2	2	CV21	2	CN1L
6	6	α		CF92	P2		CV22	1	CN1L

26.1 One-axis Servo Amplifier

This type of amplifier is used in the S-700 controller. The part numbers are as follows.

S-700
A06B-6058-H006 (W) A06B-6058-H012 (θ)

26.1.1 Theory of operation

The servo amplifier drives an AC servo motor. It consists of two parts, the power amplifier (unit base) and the servo amplifier PCB.

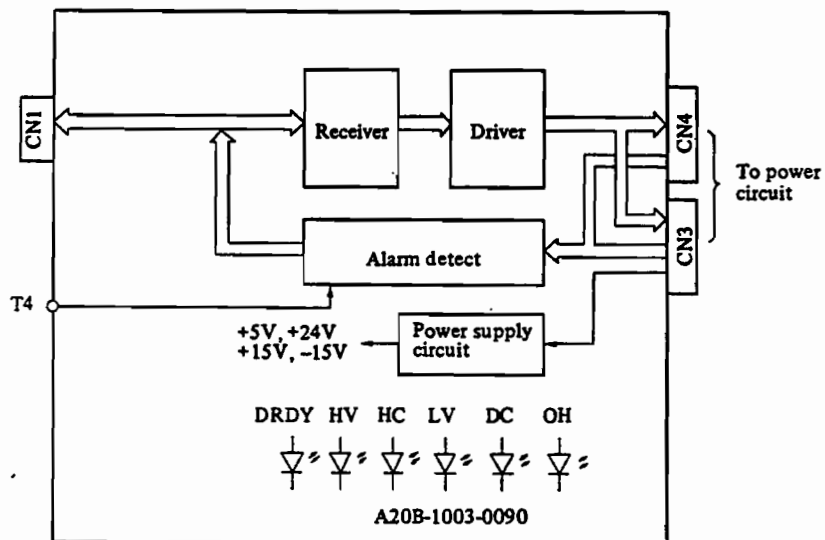
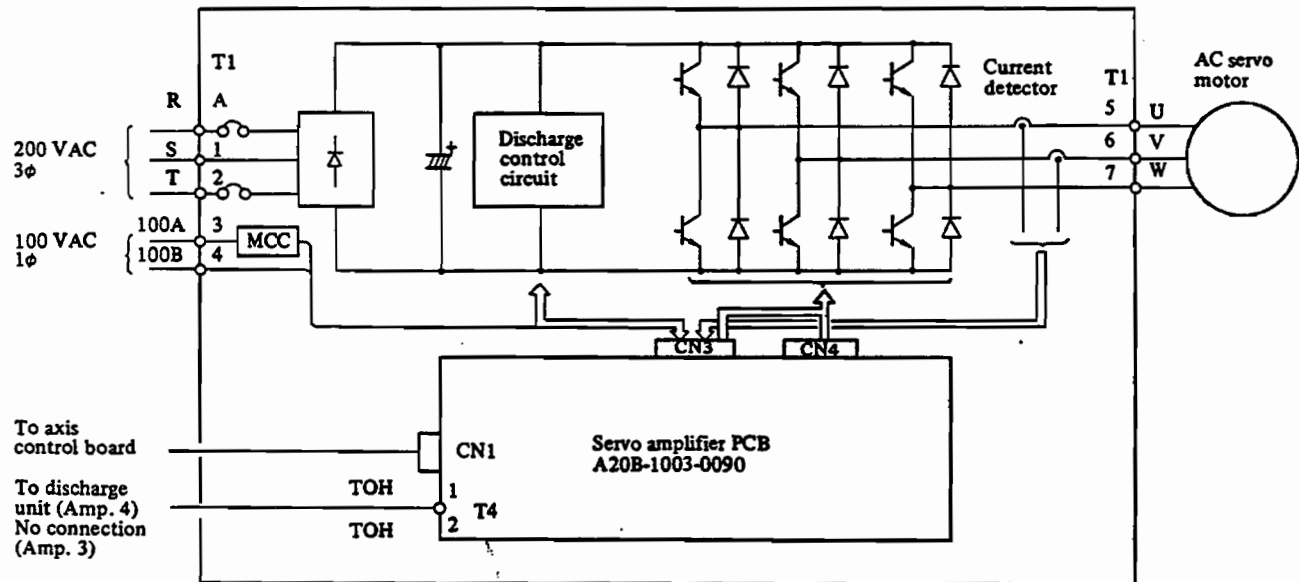
The power amplifier employs three-phase power supply for the main circuit and single phase 100 VAC for the braking contact. An input voltage of three-phase power is rectified and filtered by the diode bridge and the capacitor for the DC voltage power supply. The DC voltage is converted to three-phase current by the three-phase transistor bridge which is driven by the pulse width modulation (PWM) signals from the servo amplifier PCB through CN3 and CN4.

The current of the motor is detected by the current detecting resistors and transmitted to the servo amplifier PCB through CN3. Then it is sent to the axis control board via CN1. The regenerative discharge circuit is in the power amplifier to absorb the energy from the motor.

The servo amplifier PCB also has the alarm circuit for the protection of the servo control system.

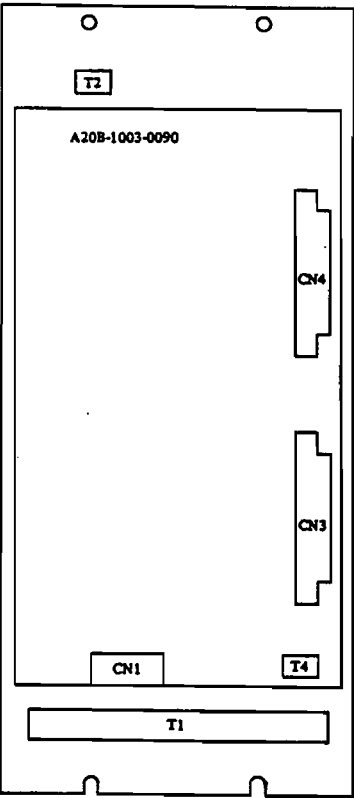
The LEDs on the servo amplifier PCB indicate the alarm condition when the alarm circuit operates.

26.1.2 Block diagram



Block diagram of the servo amplifier PCB

26.1.3 Connector/signal identification



T1

A	R
1	S
2	T
3	100A
4	100B
5	U
6	V
7	W
8	

R, S, T : 200 VAC three phase
 100A, 100B: 100 VAC single phase
 U, V, W : Three phase output for motor
 $\underline{\quad}$: Ground terminal

○ \neg
 ○ \neg

T2

4	LCG
5	
6	HCA

LCG : Collector of transistor Q1
 HCA : DC main power supply

T4

1	TOH1
2	TOH2

TOH1, TOH2: Transformer overheat input

CN1

01	*PWMA (*ALM1)	08	IR	14	*PWMD (ALM8)
02	COMA	09	GDR	15	COMD
03	*PWMB (*ALM2)	10	IS	16	*PWME
04	COMB	11	GDS	17	COME
05	*PWMC (*ALM4)	12	*MCON	18	*PWMF
06	COMC	13	GND	19	COMF
07	*DRDY			20	

IR, GDR : Phase-R current
 IS, GDS : Phase-S current
 *MCON : MCC control
 *DRDY : Servo ready
 GND : Ground
 *PWMA(*ALM1), COMA : PWM signals and
 *PWMB(*ALM2), COMB their commons
 *PWMC(*ALM4), COMC *PWMA, *PWMB, *PWMC
 *PWMD(ALM8), COMD and *PWMD are bidi-
 *PWME, COME rectional. When an
 *PWMF, COMF alarm is signalled
 to the axis control
 board, these lines
 become outputs and
 they are referred
 to as *ALM1, *ALM2,
 *ALM4 and *ALM8,
 respectively.

CN3

01	DB
02	FB
03	VL
04	TH1
05	TH2
06	RLY
07	20V
08	ITLK
09	100A
10	100B
11	MCC
12	CDU1
13	CDU2
14	CDV1
15	CDV2

DB : Base signal for transistor D
 FB : Base signal for transistor F
 VL : Emitter signal for transistor B, D, F, G
 TH1, TH2 : Overheat of heatsink
 RLY : Precharge control relay
 20V : 20 VDC for precharge control relay
 ITLK : Interlock of contactor
 100A, 100B: 100 VAC
 MCC : Magnetic contactor control
 CDU1, CDU2: Current detect of U phase
 CDV1, CDV2: Current detect of V phase

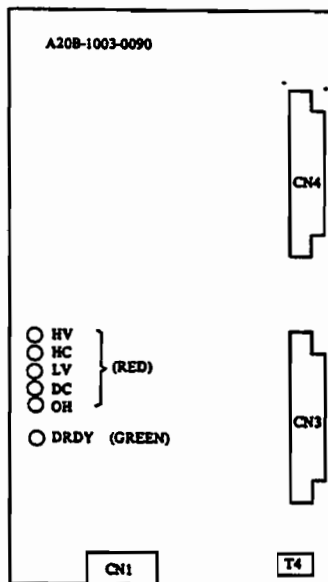
CN4

01	GC
02	GB
03	VDR
04	VDS
05	VDT
06	FG
07	VH1
08	VH2
09	AB
10	AE
11	CB
12	CE
13	EB
14	EE
15	BB

GC : Collector signal for transistor G
 GB : Base signal for transistor G
 VDR, VDS, VDT: 200 VAC for DC power supply
 FG : Frame ground
 VH1 : Current detect of DC link
 VH2 : Positive voltage of DC link
 AB : Base signal for transistor A
 AE : Emitter signal for transistor A
 CB : Base signal for transistor C
 CE : Emitter signal for transistor C
 EB : Base signal for transistor E
 EE : Emitter signal for transistor E
 BB : Base signal for transistor B

26.1.4 LEDs

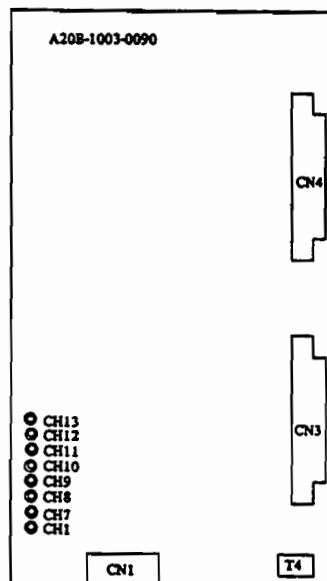
LED	Function	Conditions
HV (R)	High voltage alarm	<p>The DC voltage of the main power supply is higher than 450 V.</p> <ul style="list-style-type: none"> a. AC power supply is higher than the specified range. b. The regenerative energy discharge circuit becomes defective, which includes the PCB, the transistor Q1, and discharge resistor or the separately mounted discharge unit. c. Servo motor or the power cable for motor insulation is defective. d. Load inertia is excessive.
HC (R)	High current alarm	<p>The DC current through the main DC power supply is too high.</p> <ul style="list-style-type: none"> a. Transistor module is defective. b. Short-circuit failure in the motor or the cable. c. PCB is defective.
LV (R)	Low voltage alarm	<p>Regulated power supply +15 V or +5 V on PCB is abnormally low.</p> <ul style="list-style-type: none"> a. AC input power supply is lower than specified. b. PCB is defective.
DC (R)	Discharge circuit alarm	<p>On time of the discharge transistor Q1 is too long (over several seconds) or its capacity to discharge is overloaded.</p> <ul style="list-style-type: none"> a. Transistor Q1 or PCB is defective. b. Acceleration/deceleration frequency is too high. c. The setting of jumper S2 is improper. <p>Refer to 26.1.6 for proper settings.</p>
OH (R)	Overheat alarm	<p>Some thermostat in the controller has operated.</p> <ul style="list-style-type: none"> a. The thermostat at the heat-sink on servo amplifier. b. The thermostat in the servo transformer. c. The thermostat in the regenerative discharge unit.
DRDY (G)	Servo amp. ready	MCC turns on and motor is energized.



Location of LEDs on A20B-1003-0090

26.1.5 Test points

Test points	Symbol	Contents	Waveform
CH1	*PWMA	A-phase PWM signal	
CH7	IR	R-phase current	
CH8	IS	S-phase current	
CH9	0 V	0 V (Ground)	
CH10	+5 V	+5 VDC	
CH11	+15 V	+15 VDC	
CH12	-15 V	-15 VDC	
CH13	+24 V	+24 VDC	



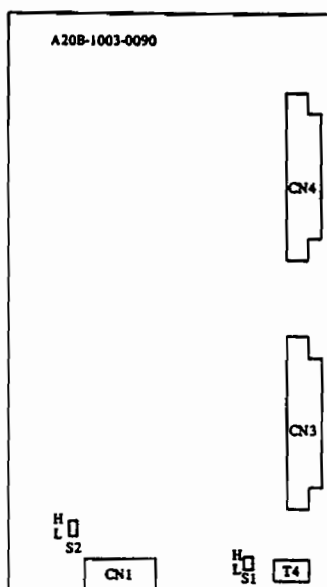
Location of test points on A20B-1003-0090

26.1.6 Jumper settings

S-700

Jumper No.	Axis						Meaning
	#1		#2		#3	#4	
	U	α	β	γ	θ	W	
S1					H	L	TOH setting When the overheat signal is not provided. to T4, the S1 setting should be H side.
S2					L	H	DC alarm setting When the discharge unit is not added, the S2 setting should be L side.

Symbols #1 - #4 show the servo amp. No.



Location of jumper settings

26.1.7 Removal/replacement

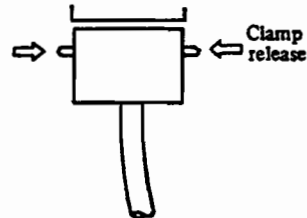
1) Unit

- a) Remove the cables connected to the connector CN1 and terminals T1, T2 and T4.

Unclamp connectors are follows:

. CN1

- ① Squeeze the clamp release to remove the connector.



- b) Loosen two mounting screws at the bottom.
- c) Remove two mounting screws at the top and remove the unit.

Mounting screws, top

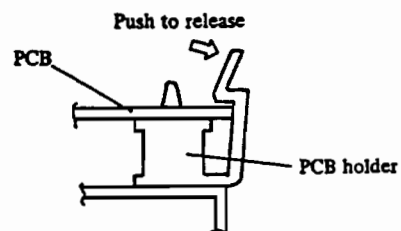


Mounting screws, bottom

2) Component

a) PCB

- ① Release six PCB holders.
- ② Pull up PCB from connectors CN3, CN4.



26.2 Two-axis Servo Amplifier

This type of amplifier is used in the S-700 controller. The part numbers are as follows.

S-700
A06B-6058-H221 (β, γ)
A06B-6058-H222 (U, α)

26.2.1 Theory of operation

The servo amplifier drives an AC servo motor. It consists of two parts, the power amplifier (unit base) and the servo amplifier PCB.

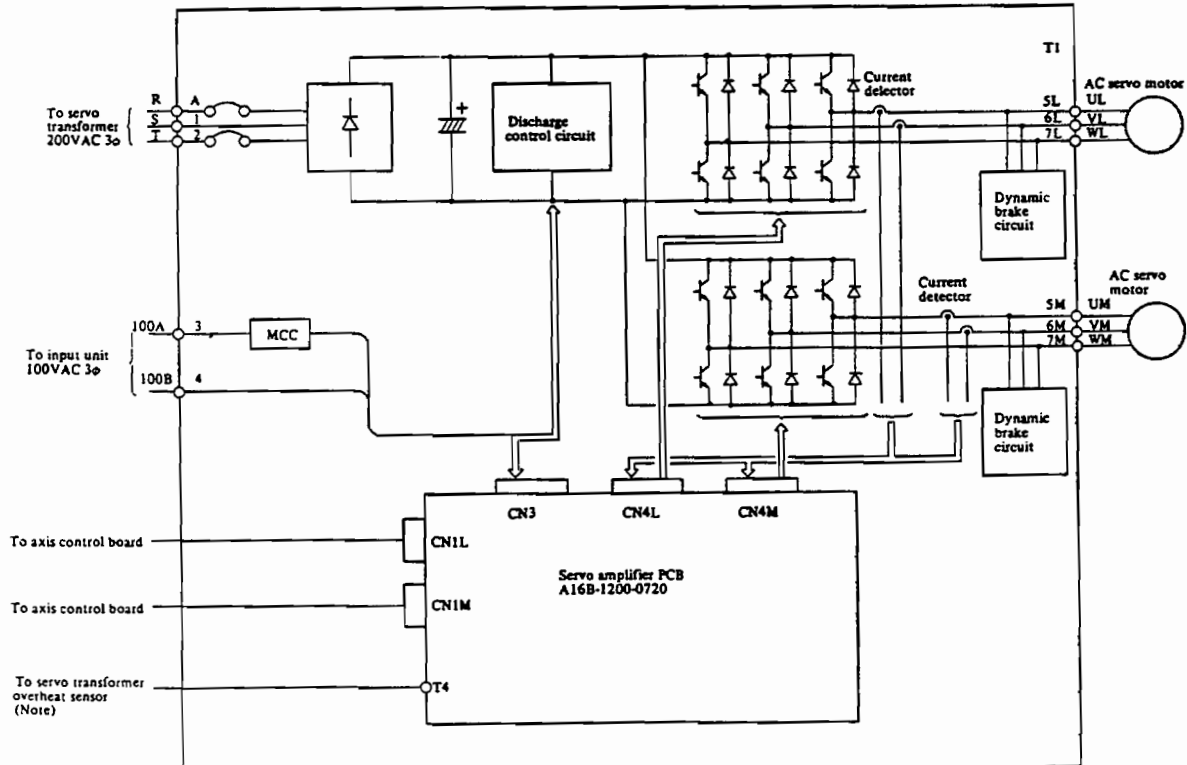
The power amplifier employs three-phase power supply for the main circuit and single phase 100 VAC for the braking contact. An input voltage of three-phase power is rectified and filtered by the diode bridge and the capacitor for the DC voltage power supply. The DC voltage is converted to three-phase current by the three-phase transistor bridge which is driven by the pulse width modulation (PWM) signals from the servo amplifier PCB through CN3, CN4L and CN4M.

The current of the motor is detected by the current detecting resistors and transmitted to the servo amplifier PCB through CN3. Then it is sent to the axis control board via CN1L and CN1M. The regenerative discharge circuit is in the power amplifier to absorb the energy from the motor.

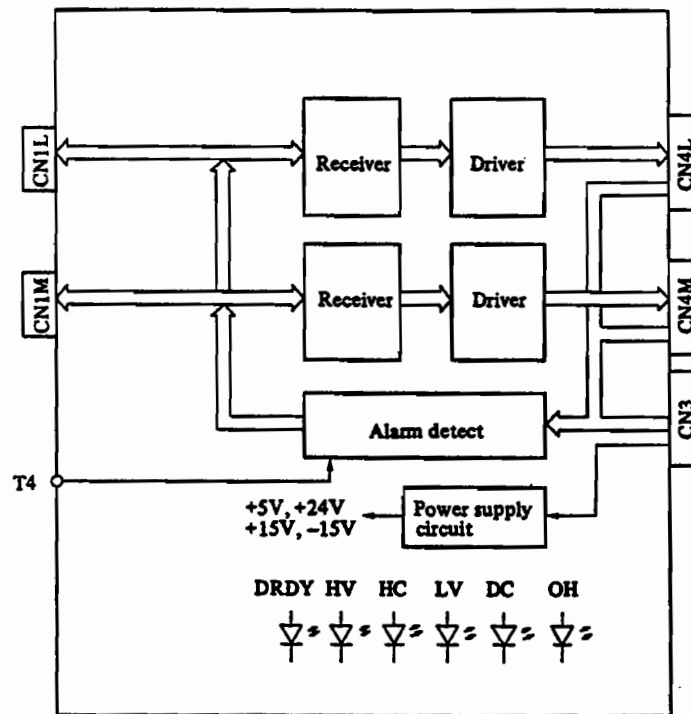
The servo amplifier PCB also has the alarm circuit for the protection of the servo control system.

The LEDs on the servo amplifier PCB indicate the alarm condition when the alarm circuit operates.

26.2.2 Block diagram

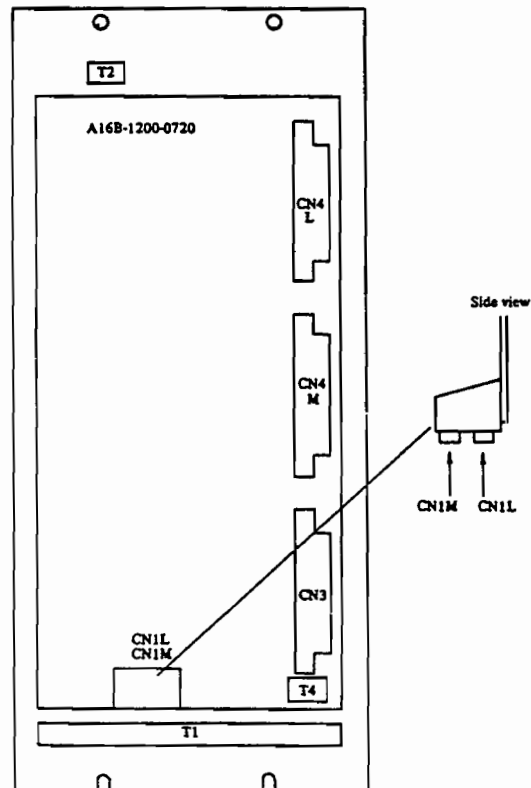


Note) Connected on Amp. 1, U and α. Not used on Amp. 2, β and γ.



Block diagram of the servo amplifier PCB (Two-axis type)

26.2.3 Connector/signal identification



T1

A	R
1	S
2	T
3	100A
4	100B
5L	UL
6L	VL
7L	WL
5M	UM
6M	VM
7M	WM

R, S, T : 200 VAC three phase
 100A, 100B : 100 VAC single phase
 UL, VL, WL : Three phase output for motor
 UM, VM, WM : Ground terminal

○ $\frac{1}{2}$ "
 ○ $\frac{1}{2}$ "

T2

4	LCG
5	
6	HCA

LCG : Collector of transistor Q1
 HCA : DC main power supply

T4

1	TOH1
2	TOH2

TOH1, TOH2: Transformer overheat input

CN3

01	VH
02	VHV
03	VDR
04	VDS
05	VDT
06	NFG
07	LCG
08	LBG
09	LEG
10	100A
11	MCC
12	INTL1
13	INTL2
14	TH1
15	TH2

VH : Detect signal for HC alarm
 VHV,VDR,VDS,VDT: Detect signal for discharge circuit
 (200 VAC for DC power supply)
 NFG : Ground for noise filter
 LCG : Collector signal for discharge circuit
 LBG : Base signal for discharge circuit
 LEG : Emitter signal for discharge circuit
 100A : 100 VAC
 MCC : Contactor control
 INTL1, INTL2 : Interlock of contactor
 TH1, TH2 : Overheat of heat sink

CN4L

01	VHL
02	LBAL
03	LBBL
04	LEAL
05	LBCL
06	LBDL
07	LECL
08	LBEL
09	LBFL
10	LEEL
11	LEL
12	CDU1L
13	CDU2L
14	CDV1L
15	CDV2L

VHL : Collector signal for transistor of L-axis
 LBAL : Base signal for transistor A of L-axis
 LEAL : Emitter signal for transistor A of L-axis
 LBBL : Base signal for transistor B of L-axis
 LBCL : Base signal for transistor C of L-axis
 LBDL : Emitter signal for transistor C of L-axis
 LECL : Base signal for transistor D of L-axis
 LBEL : Base signal for transistor E of L-axis
 LEEL : Emitter signal for transistor E of L-axis
 LBFL : Base signal for transistor F of L-axis
 LEL : Emitter signal for transistor of L-axis
 CDU1L, CDU2L: Current detect of U phase of L-axis
 CDV1L, CDV2L: Current detect of V phase of L-axis

CN4M

01	VHM
02	LBAM
03	LBBM
04	LEAM
05	LBCM
06	LBDM
07	LECM
08	LBEM
09	LBFM
10	LEEM
11	LEM
12	CDU1M
13	CDU2M
14	CDV1M
15	CDV2M

VHM : Collector signal for transistor of M-axis
 LBAM : Base signal for transistor A of M-axis
 LEAM : Emitter signal for transistor A of M-axis
 LBBM : Base signal for transistor B of M-axis
 LBCM : Base signal for transistor C of M-axis
 LBDM : Emitter signal for transistor C of M-axis
 LECM : Base signal for transistor D of M-axis
 LBEM : Base signal for transistor E of M-axis
 LEEM : Emitter signal for transistor E of M-axis
 LBFM : Base signal for transistor F of M-axis
 LEM : Emitter signal for transistor of M-axis
 CDU1M, CDU2M: Current detect of U phase of M-axis
 CDV1M, CDV2M: Current detect of V phase of M-axis

CN1L L-axis servo interface signals

01	*PWMAL (*ALM1)	08	IRL	14	*PWMDL (*ALM8)
02	COMAL	09	GDRL	15	COMDL
03	*PWMBL (*ALM2)	10	ISL	16	*PWMEL
04	COMBL	11	GDSL	17	COMEL
05	*PWMCL (*ALM4)	12	*MCONL	18	*PWMFL
06	COMCL	13	GND	19	COMFL
07	*DRDYL			20	

*PWMAL(*ALM1), COMAL
 *PWMBL(*ALM2), COMBL
 *PWMCL(*ALM4), COMCL
 *PWMDL(*ALM8), COMDL
 *PWMEL, COMEL
 *PWMFL, COMFL
 IRL, GDRL
 ISL, GDSL
 *MCONL
 *DRDYL
 GND

PWM signals and
 their commons
 PWMA through PWMD
 are also used to
 send an alarm
 code.
 : Phase-R current
 : Phase-S current
 : MCC control
 : Servo amp. ready
 : Ground

CN1M M-axis servo interface signals

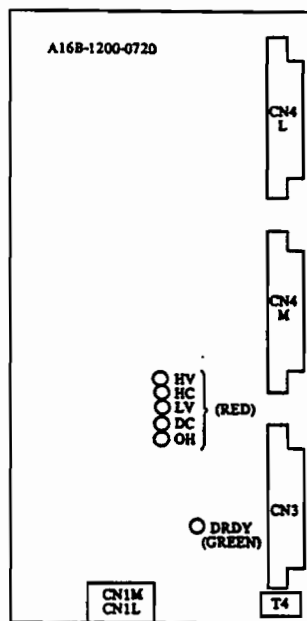
01	*PWMAM (*ALM1)	08	IRM	14	*PWMDM (*ALM8)
02	COMAM	09	GDRM	15	COMDM
03	*PWMBM (*ALM2)	10	ISM	16	*PWMEM
04	COMBM	11	GDSM	17	COMEM
05	*PWMCM (*ALM4)	12	*MCONM	18	*PWMFM
06	COMCM	13	GND	19	COMFM
07	*DRDYM			20	

*PWMAM(*ALM1), COMAM
 *PWMBM(*ALM2), COMBM
 *PWMCM(*ALM4), COMCM
 *PWMDM(*ALM8), COMDM
 *PWMEM, COMEM
 *PWMFM, COMFM
 IRM, GDRM
 ISM, GDSM
 *MCONM
 *DRDYM
 GND

PWM signals and
 their commons
 PWMA through PWMD
 are also used to
 send an alarm
 code.
 : Phase-R current
 : Phase-S current
 : MCC control
 : Servo amp. ready
 : Ground

26.2.4 LEDs

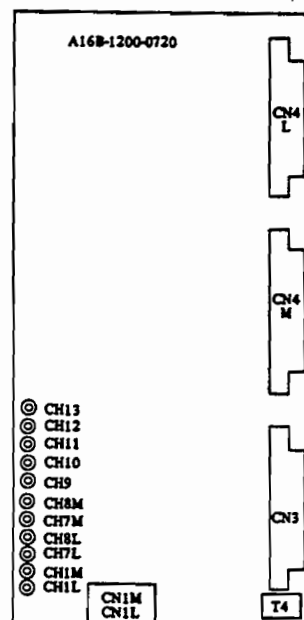
LED	Function	Conditions
HV (R)	High voltage alarm	<p>The DC voltage of the main power supply is higher than 450 V.</p> <ul style="list-style-type: none"> a. AC power supply is higher than the specified range. b. The regenerative energy discharge circuit becomes defective, which includes the PCB, the transistor Q1, and discharge resistor or the separately mounted discharge unit. c. Servo motor or the power cable for motor insulation is defective. d. Load inertia is excessive.
HC (R)	High current alarm	<p>The DC current through the main DC power supply is too high.</p> <ul style="list-style-type: none"> a. Transistor module is defective. b. Short-circuit failure in the motor or the cable. c. PCB is defective.
LV (R)	Low voltage alarm	<p>Regulated power supply +15 V or +5 V on PCB is abnormally low.</p> <ul style="list-style-type: none"> a. AC input power supply is lower than specified. b. PCB is defective.
DC (R)	Discharge circuit alarm	<p>On time of the discharge transistor Q1 is too long (over several seconds) or its capacity to discharge is overloaded.</p> <ul style="list-style-type: none"> a. Transistor Q1 or PCB is defective. b. Acceleration/deceleration frequency is too high. c. The setting of jumper S2 is improper. <p>Refer to 26.2.6 for proper settings.</p>
OH (R)	Overheat alarm	<p>Some thermostat in the controller has operated.</p> <ul style="list-style-type: none"> a. The thermostat at the heat-sink on servo amplifier. b. The thermostat in the servo transformer. c. The thermostat in the regenerative discharge unit.
DRDY (G)	Servo amp. ready	MCC turns on and motor is energized.



Location of LEDs

26.2.5 Test points

Test points	Symbol	Contents
CH1L, M	*PWMA	A-phase PWM signal
CH7L, M	IR	R-phase current
CH8L, M	IS	S-phase current
CH9	0 V	0 V (Ground)
CH10	+5 V	+5 VDC
CH11	+15 V	+15 VDC
CH12	-15 V	-15 VDC
CH13	+24 V	+24 VDC

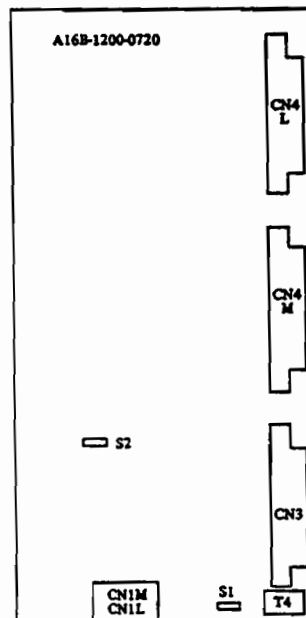


Location of test points on A16B-1200-0720

26.2.6 Jumper settings

Jumper No.	Axis						Meaning
	#1		#2		#3	#4	
	U	α	β	γ	θ	W	
S1	L		H		/	/	TOH setting When the overheat signal is not provided to T4, the S1 setting should be H side.
S2	L		L		/	/	DC alarm setting When the discharge unit is not added, the S2 setting should be L side.

Symbols #1 - #4 show the servo amp. No.



Location of the jumpers

26.2.7 Removal/replacement

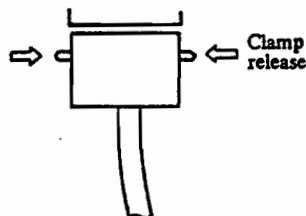
1) Unit

- a) Remove the cables connected to the connector CN1L, CN1M and terminals T1, T2 and T4.

Unclamp connectors are follows:

. CN1L, CN1M

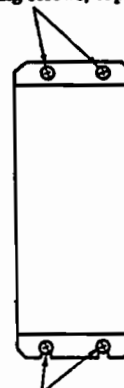
- ① Squeeze the clamp release to remove the connector.



- b) Loosen two mounting screws at the bottom.

- c) Remove two mounting screws at the top and remove the unit.

Mounting screws, top

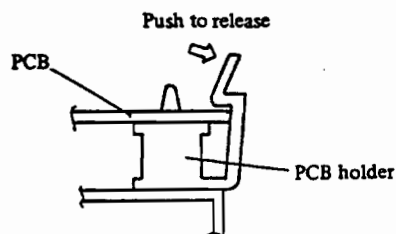
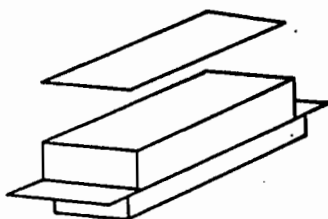


Mounting screws, bottom

2) Component

a) PCB

- ① Release six PCB holders.
- ② Pull up PCB from connectors CN3, CN4L, CN4M.



26.3 Three-axis Servo Amplifier

This type of amplifier is used in the S-10 controller. The part numbers are as follows. The NEW amplifier replaces the CURRENT amplifier.

ROBOT	BASIC SPECIFICATION	CURRENT AMPLIFIER	NEW AMPLIFIER
S-10 Medium	A05B-2066-H021	A06B-6058-H327 A06B-6058-H325	A06B-6058-H333 A06B-6058-H331
S-10 Large	A05B-2067-H021	A06B-6058-H327 A06B-6058-H325	A06B-6058-H333 A06B-6058-H331

26.3.1 Theory of operation

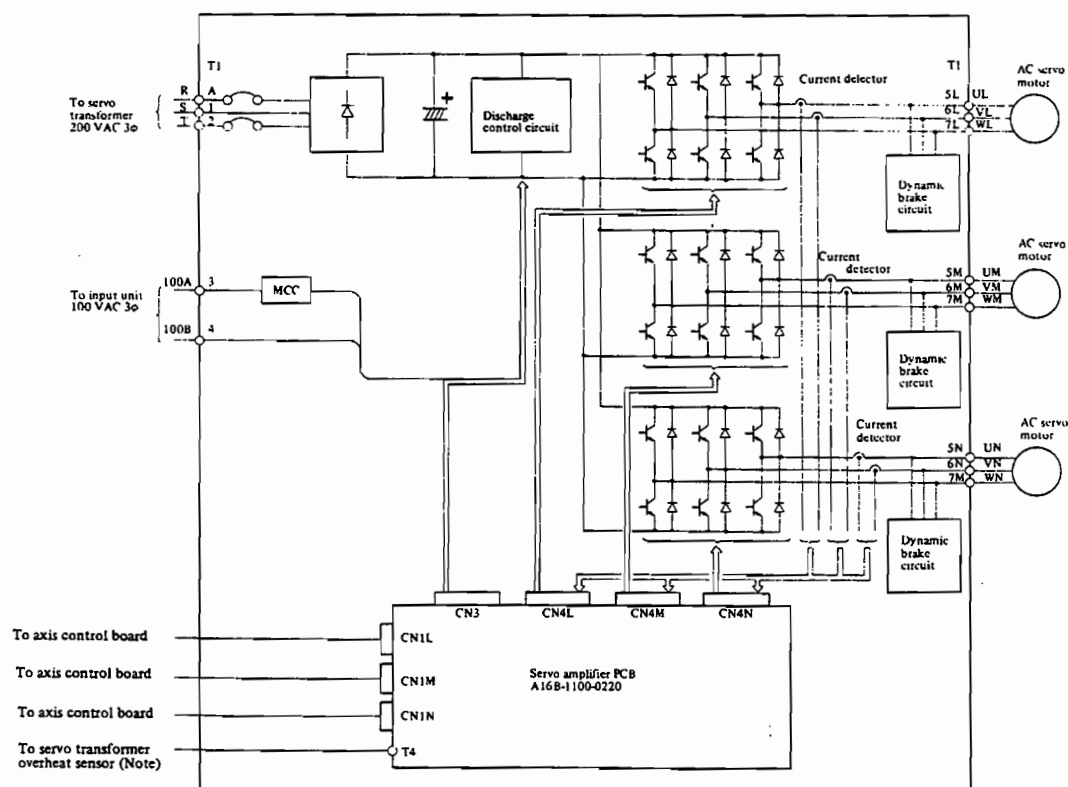
The servo amplifier drives an AC servo motor. It consists of two parts, the power amplifier (unit base) and the servo amplifier PCB.

The power amplifier employs three-phase power supply for the main circuit and single phase 100 VAC for the braking contact. An input voltage of three-phase power is rectified and filtered by the diode bridge and the capacitor for the DC voltage power supply. The DC voltage is converted to three-phase current by the three-phase transistor bridge which is driven by the pulse width modulation (PWM) signals from the servo amplifier PCB through CN4L, CN4M and CN4N.

The current of the motor is detected by the current detecting resistors and transmitted to the servo amplifier PCB through CN4L, CN4M and CN4N. Then it is sent to the axis control board via CN1L, CN1M and CN1N. The regenerative discharge circuit is in the power amplifier to absorb the energy from the motor. The servo amplifier PCB also has the alarm circuit for the protection of the servo control system.

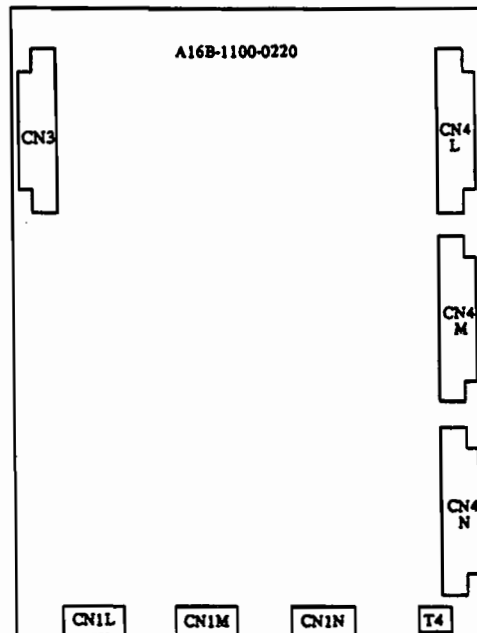
The LEDs on the servo amplifier PCB indicate the alarm condition when the alarm circuit operates.

26.3.2 Block diagram



Note) Connected on Amp. 1 (W, U, θ). Not used on Amp. 2 (α , β , γ).

26.3.3 Connector/signal identification



T1

A	R
1	S
2	T
3	100A
4	100B
5L	UL
6L	VL
7L	WL
5M	UM
6M	VM
7M	WM
5N	UN
6N	VN
7N	WN

R, S, T : 200 VAC three phase
 100A, 100B : 100 VAC single phase
 UL, VL, WL }
 UM, VM, WM } : Three phase output for motor
 UN, VN, WN }
 ≡ : Ground terminal

○ ≡
 ○ ≡

T2

4	LCG
5	
6	HCA

LCG : Collector of transistor Q1
HCA : DC main power supply

T4

1	TOH1
2	TOH2

TOH1, TOH2: Transformer overheat input

CN1L L-axis servo interface signals

01	*PWMAL (*ALM1)	08	IRL	14	*PWMDL (*ALM8)
02	COMAL	09	GDRL	15	COMDL
03	*PWMBL (*ALM2)	10	ISL	16	*PWML
04	COMBL	11	GDSL	17	COMEL
05	*PWMCL (*ALM4)	12	*MCONL	18	*PWMFL
06	COMCL	13	GND	19	COMFL
07	*DRDYL			20	

*PWMAL(*ALM1),COMAL } : PWM signals and
*PWMBL(*ALM2),COMBL } their commons
*PWMCL(*ALM4),COMCL } PWMA through PWMD
*PWMDL(*ALM8),COMDL } are also used to
*PWML, COMEL } send an alarm
*PWMFL, COMFL } code.
IRL, GDRL : Phase-R current
ISL, GDSL : Phase-S current
*MCONL : MCC control
*DRDYL : Servo amp. ready
GND : Ground

CN1M M-axis servo interface signals

01	*PWMAM (*ALM1)	08	IRM	14	*PWMDM (*ALM8)
02	COMAM	09	GDRM	15	COMDM
03	*PWMBM (*ALM2)	10	ISM	16	*PWMM
04	COMBM	11	GDSM	17	COMEM
05	*PWMCM (*ALM4)	12	*MCONM	18	*PWMFM
06	COMCM	13	GND	19	COMFM
07	*DRDYM			20	

*PWMAM(*ALM1),COMAM } : PWM signals and
*PWMBM(*ALM2),COMBM } their commons
*PWMCM(*ALM4),COMCM } PWMA through PWMD
*PWMDM(*ALM8),COMDM } are also used to
*PWMM, COMEM } send an alarm
*PWMFM, COMFM } code.
IRM, GDRM : Phase-R current
ISM, GDSM : Phase-S current
*MCONM : MCC control
*DRDYM : Servo amp. ready
GND : Ground

CN1N N-axis servo interface signals

01	*PWMAN (*ALM1)	08	IRN	14	*PWMDN (*ALM8)
02	COMAN	09	GDRN	15	COMDN
03	*PWMBN (*ALM2)	10	ISN	16	*PWMDN
04	COMBN	11	GDSN	17	COMEN
05	*PWMCN (*ALM4)	12	*MCONN	18	*PWMFN
06	COMCN	13	GND	19	COMFN
07	*DRDYN			20	

*PWMAN(*ALM1),COMAN } : PWM signals and
 *PWMBN(*ALM2),COMBN } their commons
 *PWMCN(*ALM4),COMCN } PWMA through PWM
 *PWMDN(*ALM8),COMDN } are also used to
 *PWMDN, COMEN } send an alarm
 *PWMFN, COMFN } code.
 IRN, GDRN } : Phase-R current
 ISN, GDSN } : Phase-S current
 *MCONN } : MCC control
 *DRDYN } : Servo amp. ready
 GND } : Ground

CN3

01	TH2
02	TH1
03	INTL2
04	INTL1
05	MCC
06	100A
07	LEG
08	LBG
09	LCG
10	NFG
11	VDT
12	VDS
13	VDR
14	VHV
15	VH

VH : Detect signal for HC alarm
 VHV,VDR,VDS,VDT: Detect signal for discharge circuit
 (200 VAC for DC power supply)
 NFG : Ground for noise filter
 LCG : Collector signal for discharge circuit
 LBG : Base signal for discharge circuit
 LEG : Emitter signal for discharge circuit
 100A : 100 VAC
 MCC : Contactor control
 INTL1, INTL2 : Interlock of contactor
 TH1, TH2 : Overheat of heat sink

CN4L

01	VHL
02	LBAL
03	LBBL
04	LEAL
05	LBCL
06	LBCL
07	LECL
08	LBEL
09	LBFL
10	LEEL
11	LEL
12	CDU1L
13	CDU2L
14	CDV1L
15	CDV2L

VHL : Collector signal for transistor of L-axis
 LBAL : Base signal for transistor A of L-axis
 LEAL : Emitter signal for transistor A of L-axis
 LBBL : Base signal for transistor B of L-axis
 LBCL : Base signal for transistor C of L-axis
 LECL : Emitter signal for transistor C of L-axis
 LBCL : Base signal for transistor D of L-axis
 LBEL : Base signal for transistor E of L-axis
 LEEL : Emitter signal for transistor E of L-axis
 LBFL : Base signal for transistor F of L-axis
 LEL : Emitter signal for transistor of L-axis
 CDU1L, CDU2L: Current detect of U phase of L-axis
 CDV1L, CDV2L: Current detect of V phase of L-axis

CN4M

01	VHM
02	LBAM
03	LBBM
04	LEAM
05	LBCM
06	LBDM
07	LECM
08	LBEM
09	LBFM
10	LEEM
11	LEM
12	CDU1M
13	CDU2M
14	CDV1M
15	CDV2M

VHM : Collector signal for transistor of M-axis
 LBAM : Base signal for transistor A of M-axis
 LEAM : Emitter signal for transistor A of M-axis
 LBBM : Base signal for transistor B of M-axis
 LBCM : Base signal for transistor C of M-axis
 LECM : Emitter signal for transistor C of M-axis
 LBDM : Base signal for transistor D of M-axis
 LBEM : Base signal for transistor E of M-axis
 LEEM : Emitter signal for transistor E of M-axis
 LBFM : Base signal for transistor F of M-axis
 LEM : Emitter signal for transistor of M-axis
 CDU1M, CDU2M: Current detect of U phase of M-axis
 CDV1M, CDV2M: Current detect of V phase of M-axis

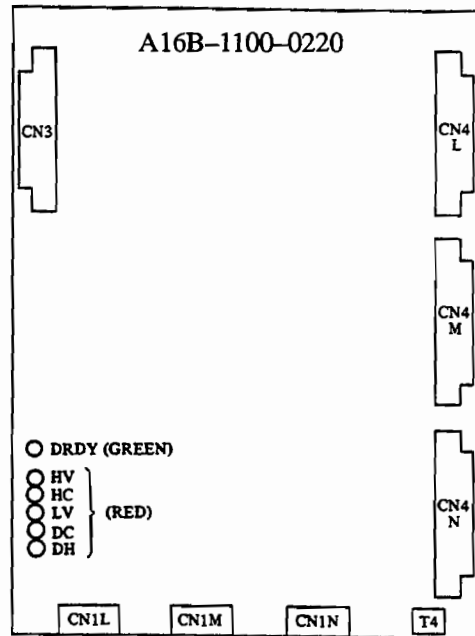
CN4N

01	VHN
02	LBAN
03	LBBN
04	LEAN
05	LBCN
06	LBDN
07	LECN
08	LBEN
09	LBFN
10	LEEN
11	LEN
12	CDU1N
13	CDU2N
14	CDV1N
15	CDV2N

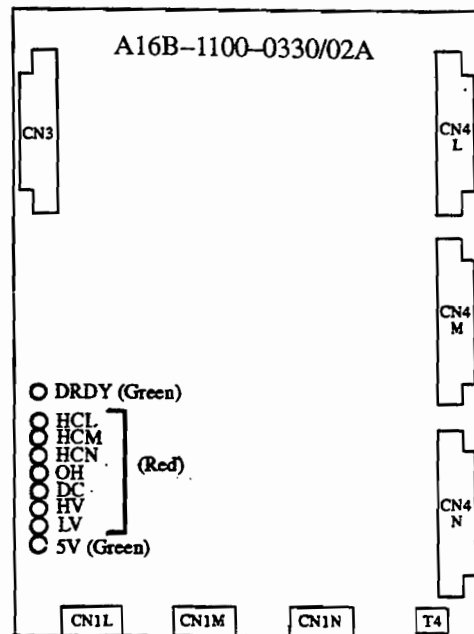
VHN : Collector signal for transistor of N-axis
 LBAN : Base signal for transistor A of N-axis
 LEAN : Emitter signal for transistor A of N-axis
 LBBN : Base signal for transistor B of N-axis
 LBCN : Base signal for transistor C of N-axis
 LECN : Emitter signal for transistor C of N-axis
 LBDN : Base signal for transistor D of N-axis
 LBEN : Base signal for transistor E of N-axis
 LEEN : Emitter signal for transistor E of N-axis
 LBFN : Base signal for transistor F of N-axis
 LEN : Emitter signal for transistor of N-axis
 CDU1N, CDU2N: Current detect of U phase of N-axis
 CDV1N, CDV2N: Current detect of V phase of N-axis

26.3.4 LEDs

LED	Function	Conditions
HV (R)	High voltage alarm	<p>The DC voltage of the main power supply is higher than 450 V.</p> <ul style="list-style-type: none"> a AC power supply is higher than the specified range. b The generative energy discharge circuit becomes defective, which includes the PCB, the transistor Q1, and discharge resistor or the separately mounted discharge unit. c Servo motor or the power cable for the motor is defective. d Load inertia is excessive. e Discharge unit is being used too much.
HC (R)	High current alarm	<p>The DC current through the main DC power supply is too high.</p> <ul style="list-style-type: none"> a Transistor module is defective b Short circuit failure in the motor or the cable c PCB is defective d "CAUTION – with this alarm, swapping boards can cause the new board to blow"
LV (R)	Low voltage alarm	<p>Regulated power supply for +15 V or +5 V on PCB is abnormally low.</p> <ul style="list-style-type: none"> a. AC input power supply is lower than specified. b. PCB is defective.
DC (R)	Discharge circuit alarm	<p>On time of the discharge transistor Q1 is too long (over several seconds) or its capacity to discharge is overloaded.</p> <ul style="list-style-type: none"> a. Transistor Q1 or PCB is defective. b. Acceleration/deceleration frequency is too high. c. The setting of jumper S2 is improper. <p>Refer to 26.3.6 for proper setting.</p>
OH (R)	Overheat alarm	<p>Some thermostat in the controller has operated.</p> <ul style="list-style-type: none"> a. The thermostat at the heat-sink on servo amplifier. b. The thermostat in the servo transformer. c. The thermostat in the regenerative discharge unit.
DRDY (G)	Servo amp. ready	MCC turns on and motor is energized.







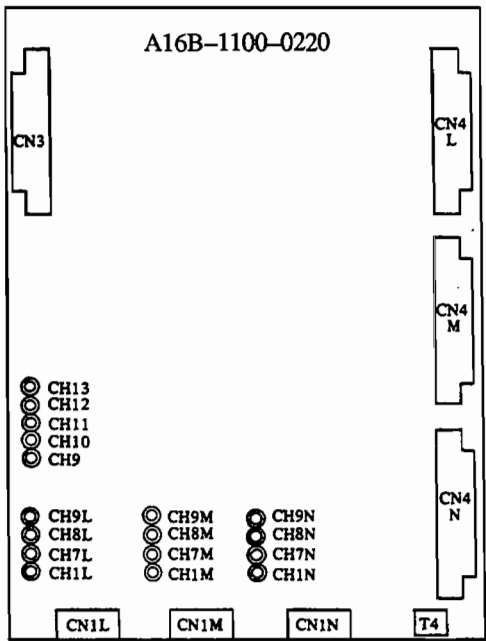
Location of LEDs on A16B-1100-0220



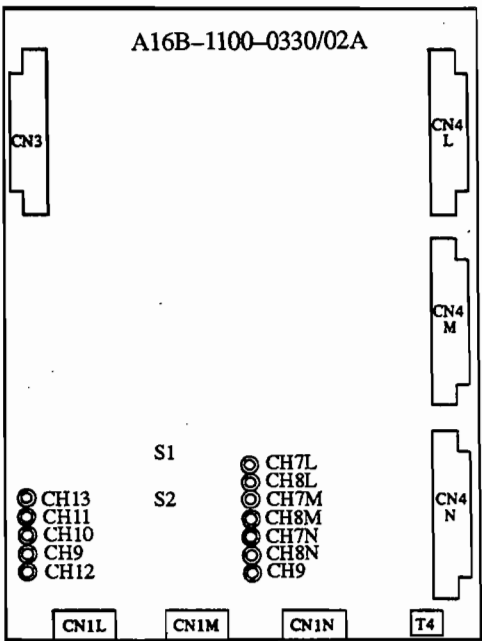
Location of LEDs on A16B-1100-0330/02A

26.3.5 Test points

Test points	Symbol	Contents
CH1L, M, N		A-phase PWM signal
CH7L, M, N		R-phase current
CH8L, M, N		S-phase current
CH9, 9L, M, N		0 V (Ground)
CH10	+5 V	+5 VDC
CH11	+15 V	+15 VDC
CH12	-15 V	-15 VDC
CH13	+24 V	+24 VDC



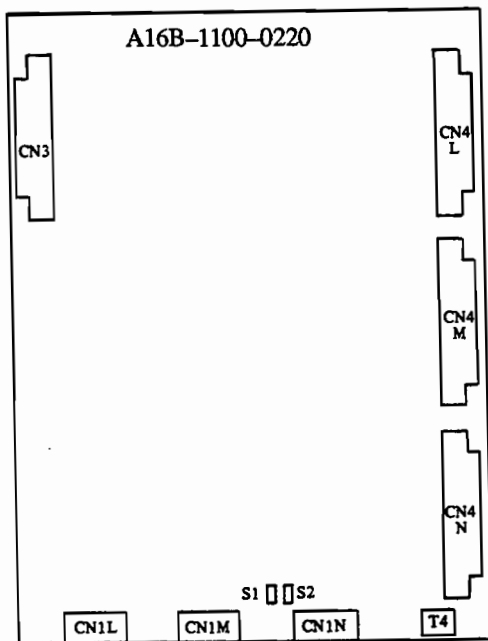
Location of test points on
A16B-1100-0220



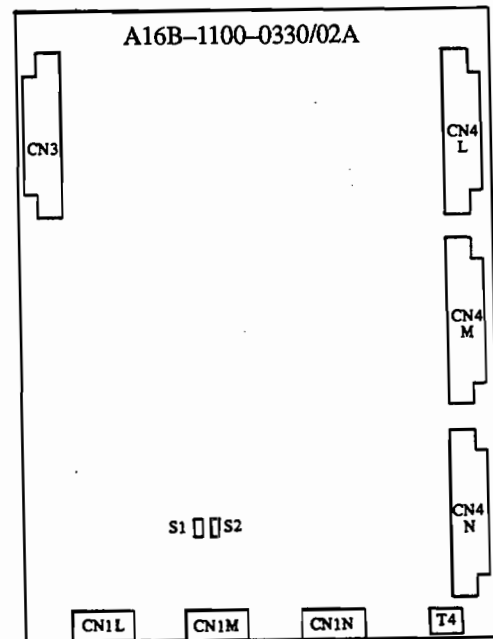
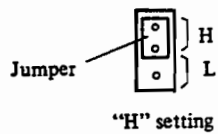
Location of test points on
A16B-1100-0330/02A

26.3.6 Jumper settings

Jumper No.	Axis						Meaning
	Amp. 1			Amp. 2			
	W	U	θ	γ	β	α	
S1	L			H			TOH setting When the overheat signal is not provided to T4, the S1 setting should be H side.
S2	L			L			DC alarm setting When the discharge unit is not added, the S2 setting should be L side.



Location of jumpers A16B-1100-0220



Location of jumpers A16B-1100-0330/02A

26.3.7 Removal/replacement

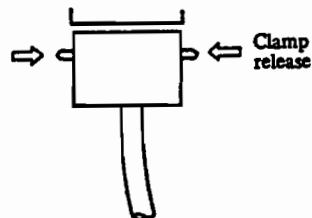
1) Unit

- a) Remove the cables connected to the connector CN1L, CN1M, CN1N and terminals T1, T2 and T4.

Unclamp connectors are follows:

. CN1L, CN1M, CN1N

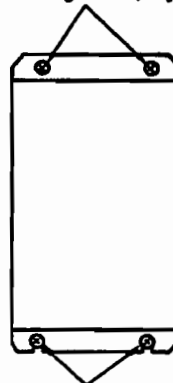
- ① Squeeze the clamp release to remove the connector.



- b) Loosen two mounting screws at the bottom.

- c) Remove two mounting screws at the top and remove the unit.

Mounting screws, top

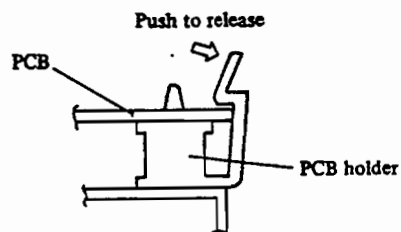
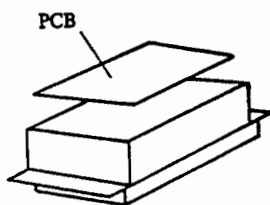


Mounting screws, bottom

2) Component

a) PCB

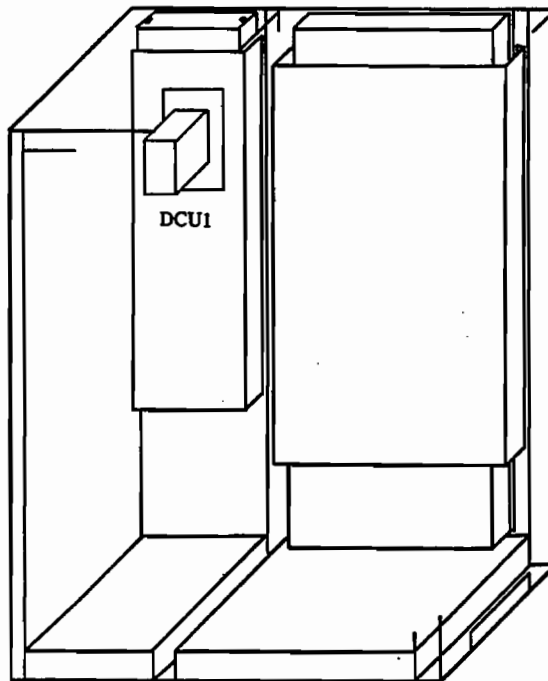
- ① Release six PCB holders.
② Pull up PCB from connectors CN3, CN4L, CN4M, CN4N.



26.4 Discharge Unit

26.4.1 Location of discharge unit

S-700

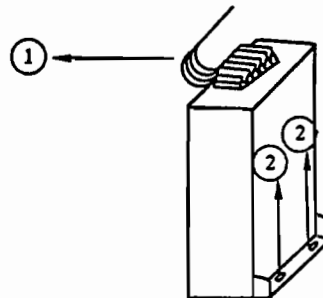


26.4.2 Removal/replacement

1) Specification
A06B-6050-H050

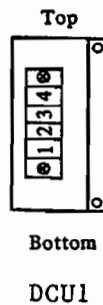
2) Procedure

- ① Disconnect cables from the discharge unit.
- ② Remove the unit by loosening two screws ②.



3) Caution

When discharge units have been replaced, check that units are correctly oriented.



27. OPERATOR'S PANEL

There are three types of operator's panels.

- Horizontal type operator's panel

This type is used in the S-10 controllers with medium size cabinet. See Fig. 3.2 (f).

- Vertical type operator's panel for remote CRT/KB

This type is used in the S-10 and S-700 controllers with large size cabinets. An RS-232-C serial port connector named CRT/KB is on the panel and is used to connect the remote CRT/KB unit. See Fig. 3.2 (g).

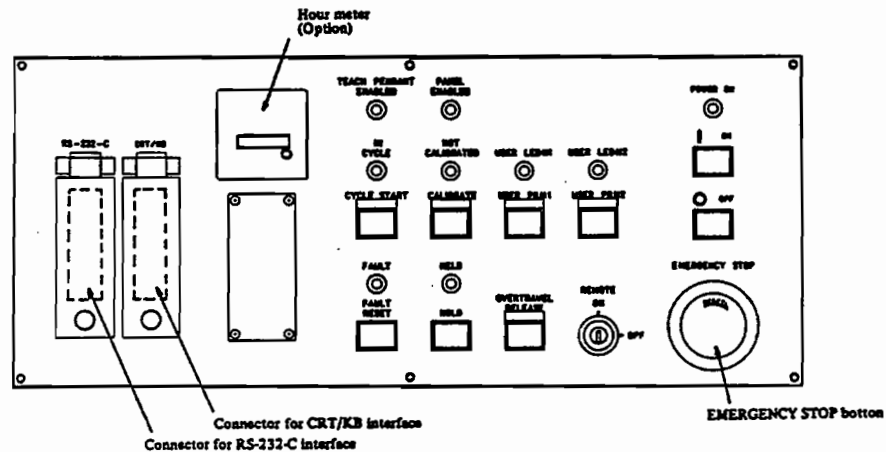
- Vertical type operator's panel for built-in CRT/KB

This type is used in the S-10 and S-700 controllers with large size cabinets. Since the RS-232-C port cable is routed inside the cabinet, the connector for CRT/KB is not available on the panel. See Fig. 3.2 (g).

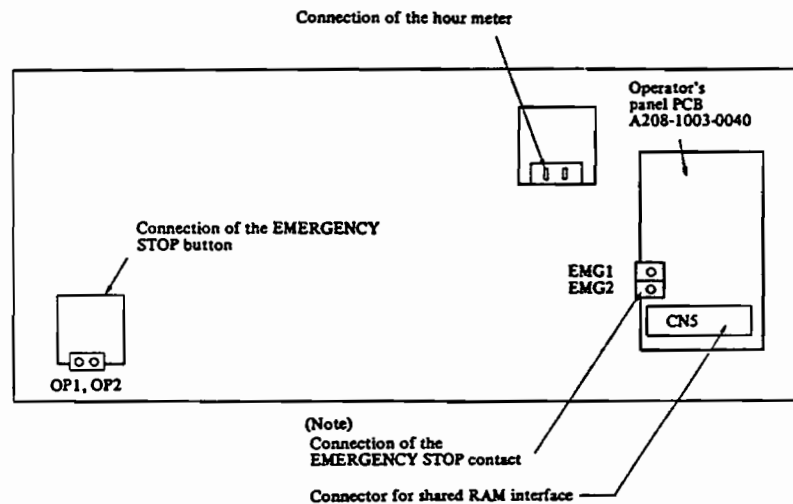
27.1 Connector/Signal Identification

1) Horizontal type operator's panel (A05B-2045-C122)

(Front view)



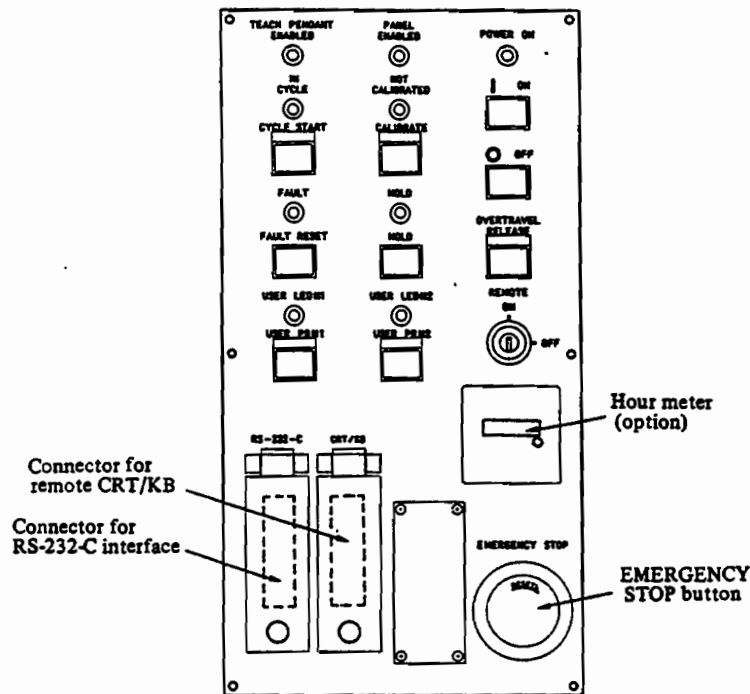
(Rear view)



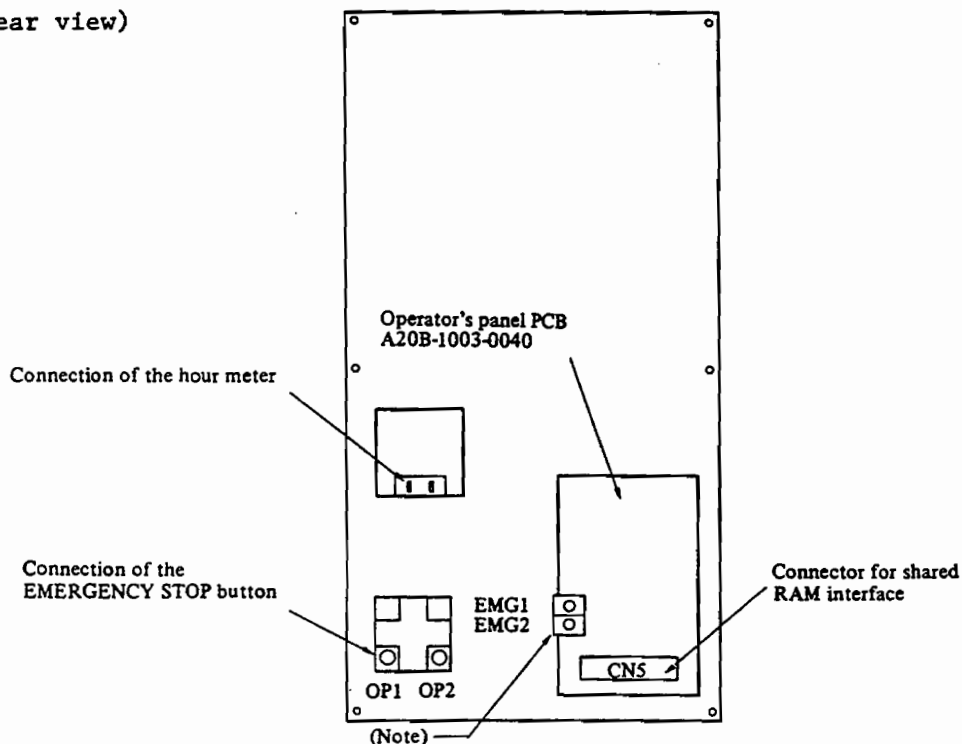
Note) For customer use, a contact output is available at this terminal. Contacts of EMERGENCY STOP buttons on the operator's panel and the teach pendant are connected in series and appear at this terminal.

2) Vertical type operator's panel for remote CRT/KB (A05B-2051-C122)

(Front view)



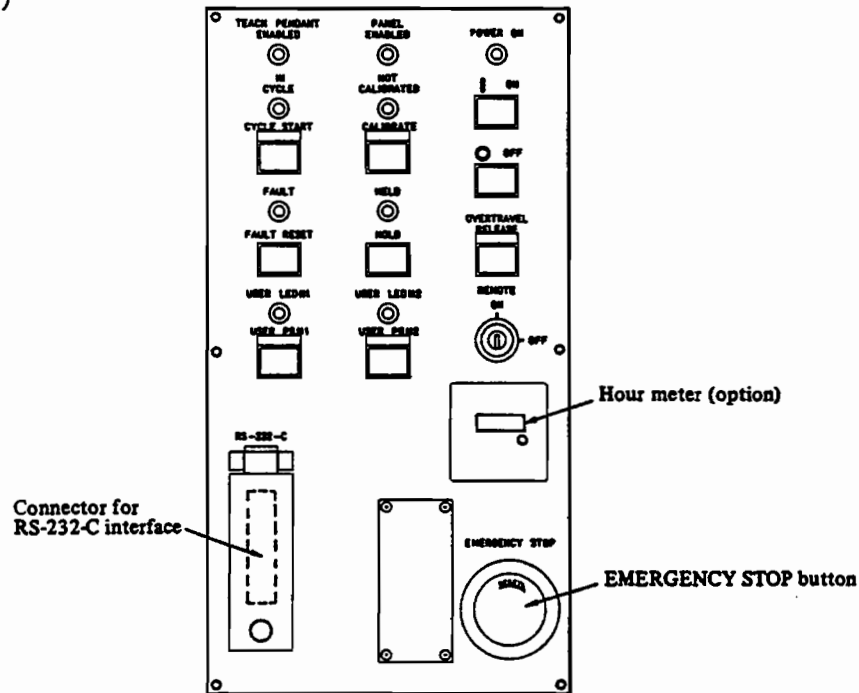
(Rear view)



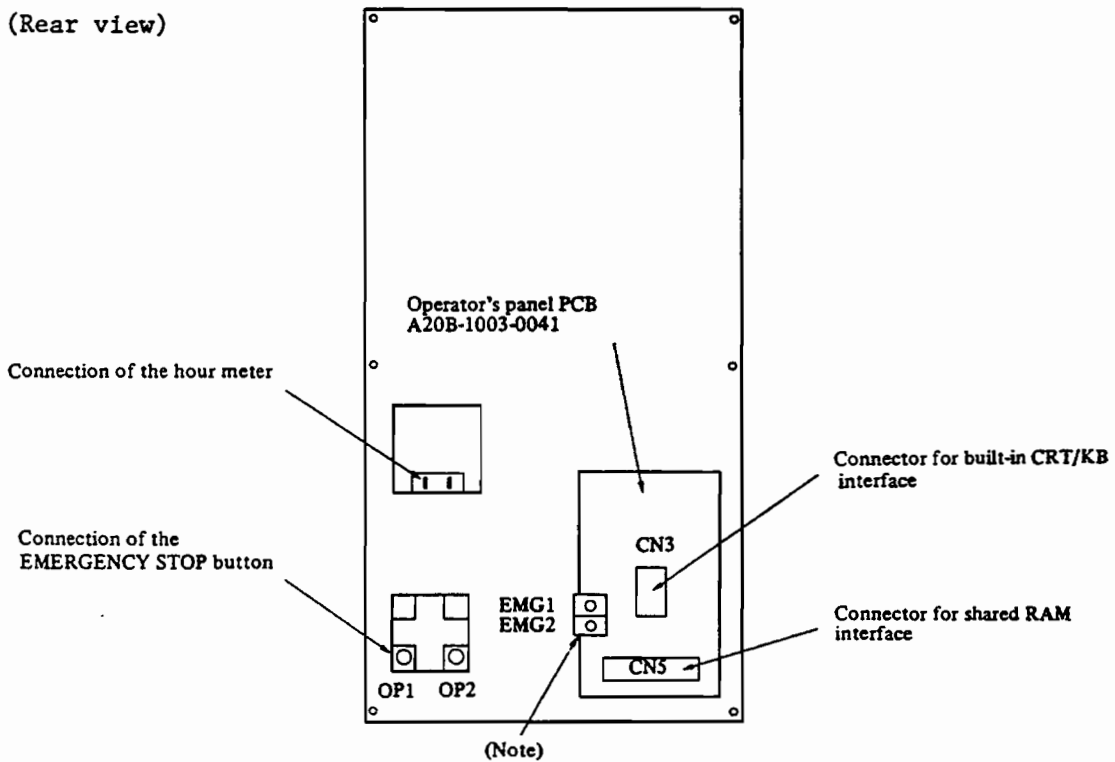
Note) For customer use, a contact output is available at this terminal. Contacts of EMERGENCY STOP buttons on the operator's panel and the teach pendant are connected in series and appear at this terminal.

3) Vertical type operator's panel for built-in CRT/KB (A05B-2051-C121)

(Front view)



(Rear view)



Note) For customer use, a contact output is available at this terminal. Contacts of EMERGENCY STOP buttons on the operator's panel and the teach pendant are connected in series and appear at this terminal.

CN5 (connector for shared RAM interface)

33	RSC	19	RDB	1	RSB
34	0 V	20	0 V	2	0 V
35	ERC	21	SDB	3	ERB
36	DRC	22	0 V	4	DRB
37	CSC	23	RDC	5	CSB
38	0 V	24	0 V	6	TP3
39	PENBL	25	SDC	7	CSTART
40	TPENBL	26	0 V	8	CALIB
41	INCYC	27	ON1	9	FRESET
42	NOTCAL	28	ON2	10	HOLD
43	FAULT	29	OFF1	11	OTREL
44	HELD	30	OFF2	12	REMOTE
45	ULED1	31	0 V	13	UPB1
46	ULED2	32	0 V	14	UPB2
47	+24 V			15	ESTOP
48	+24 V			16	+24 F
49	+24 V			17	+24 F
50				18	TP4

CN3 (built-in CRT/KB interface)

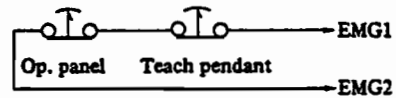
1		8	RDC	14	+24 V
2		9	SDC	15	
3		10		16	
4		11		17	0 V
5	ERC	12		18	DRC
6		13		19	CSC
7				20	RSC

TPENBL : TEACH PENDANT ENABLED LED
 PENBL : PANEL ENABLED LED
 INCYC : IN CYCLE LED
 NOTCAL : NOT CALIBRATED LED
 ULED1 : USER LED #1
 ULED2 : USER LED #2
 Fault : FAULT LED
 HELD : HELD LED
 CSTART : CYCLE START button
 CALIB : CALIBRATE button
 UPB1 : USER PB #1
 UPB2 : USER PB #2
 FRESET : FAULT RESET button
 HOLD : HOLD button
 OTREL : OVERTRAVEL RELEASE button
 ON1 } : Contact of the POWER ON button
 ON2 } : (normally open)
 OFF1 } : Contact of the POWER OFF button
 OFF2 } : (normally closed)
 REMOTE : REMOTE switch
 ESTOP : EMERGENCY STOP switch
 RDB : Receiving data
 SDB : Sending data
 RSB : Request to send
 CSB : Clear to send
 DRB : Data set ready
 ERB : Data terminal ready
 The six signals listed above are for the RS-232-C interface
 RDC : Receiving data
 SDC : Sending data
 RSC : Request to send
 CSC : Clear to send
 DRC : Data set ready
 ERC : Data terminal ready
 The six signals listed above are for the CRT/KB interface
 TP3 } : Extra emergency stop output
 TP4 } :
 +24 F } : +24 VDC power connection for
 0 V } : RS-232-C interface
 +24 V } : +24 VDC power connection for
 0 V } : operator's panel

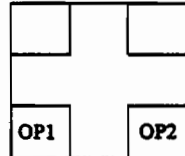
Contact output of emergency stop

1	EMG1
2	EMG2

EMG1 } : Contact output of emergency
EMG2 } stop buttons

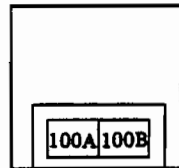


Connection of emergency stop



OP1 } : Emergency stop contact which is
OP2 } used to interrupt 100 VAC for
servo amp's.

Connection of the hour meter



100A } : 100 VAC which is available when
100B } there are no emergency stop
conditions.

Connector for RS-232-C interface

1	FG	14	
2	SDB	15	
3	RDB	16	
4	RSB	17	
5	CSB	18	
6	DRB	19	
7	0 E	20	ERB
8		21	
9		22	
10		23	
11		24	
12		25	+24 R
13			

RDB : Receiving data
SDB : Sending data
RSB : Request to send
CSB : Clear to send
DRB : Data set ready
ERB : Data terminal ready
FG : Frame ground
+24 R : +24 V power supply for RS-232-C
drive
0 E : 0 V

Connector for CRT/KB interface

1	FG	14	
2	SDC	15	
3	RDC	16	
4	RSC	17	
5	CSC	18	
6	DRC	19	
7	0 V	20	ERC
8		21	
9		22	
10		23	
11		24	
12		25	+24 V
13			

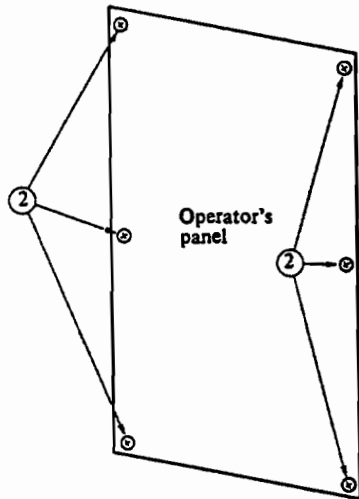
RDC : Receiving data
SDC : Sending data
RSC : Request to send
CSC : Clear to send
DRC : Data set ready
ERC : Data terminal ready
FG : Frame ground
+24 V : +24 V power supply for CRT/KB
drive
0 V : 0 V

27.2 Removal/Replacement

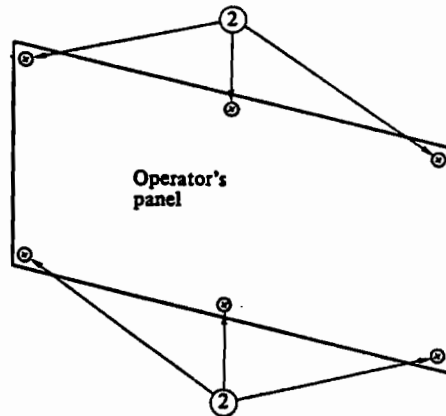
1) Unit

a) Procedure

- ① Disconnect all cables from the operator's panel.
- ② Remove the operator's panel by loosening six screws ②.
- ③ For mounting new unit, reverse the above procedure.



Vertical type



Horizontal type

2) Component (lamps and switches)

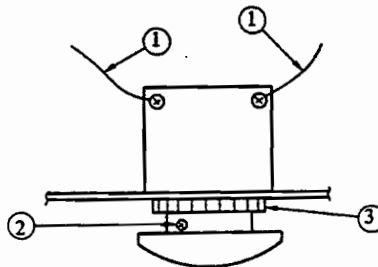
a) Procedure

- ① Disconnect the soldered wire from lamp or switch.
- ② Remove the lamp or switch by loosening the nuts.
- ③ For mounting new lamp or switch, reverse the above procedure.

3) Component (EMERGENCY STOP button)

a) Procedure

- ① Disconnect all cables ① from the EMERGENCY STOP button.
- ② Remove the top of button by loosening a screw ②.
- ③ Remove the button by loosening a ring ③.
- ④ For mounting new button, reverse the above procedure.



28. BATTERY UNIT

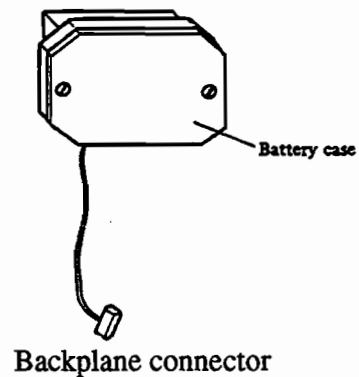
28.1 Connector/Signal Identification

Backplane connector

1	VB
2	OV
3	

VB: Battery (+ side)

OV: Battery (- side)

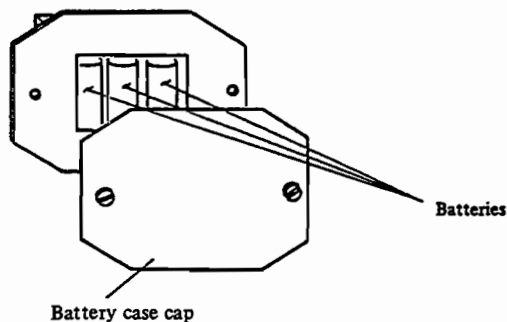


28.2 Removal/Replacement

Various data of the user program is saved in the RAM by back-up batteries. These batteries should be replaced with new ones annually. When the voltage of the batteries becomes too low, CRT and teach pendant display shows: "10017 Backup Battery Low Voltage." Change them according to following procedure:

1) Procedure

- ① Keep the controller power on.
- ② Open the front door of the controller.
- ③ Remove the battery case cap.
- ④ Take out old batteries from the battery case.
- ⑤ Set the new batteries into the battery case. Pay attention to the direction of batteries.
- ⑥ Put the case cap on the battery case.



29. OUTLET UNIT AND GROUND CONNECTED LAMP

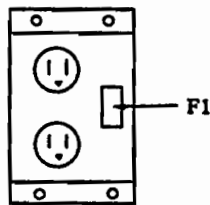
29.1 Lamp

A lamp called Ground Connected Lamp is installed under the handle of the main cabinet. Its lighting indicates that the one terminal (L2) of the outlet is connected to the ground and 115 VAC is output to the secondary side of the user transformer. When this lamp is pressed in halfway, it goes out. When it is pressed in all the way, the lamp lights again. Its lighting indicates that 115 VAC is output to the secondary side of user transformer.

29.2 Fuse

One fuse is installed in the outlet unit. This fuse is provided for the output of the outlet terminals.

Fuse specification A60L-0001-0101#PL475L



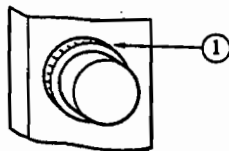
Location of fuse on the outlet unit

29.3 Removal/Replacement

1) Unit (Ground Connected lamp)

a) Procedure

- ① Remove the ring ① from the Ground Connected lamp.
- ② The Ground Connected lamp can be removed with connection cables attached.
- ③ Disconnect all cables from the lamp.
- ④ For mounting new lamp, reverse the above procedure.

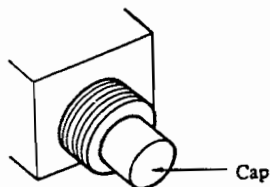


Front view of the lamp

2) Component (lamp)

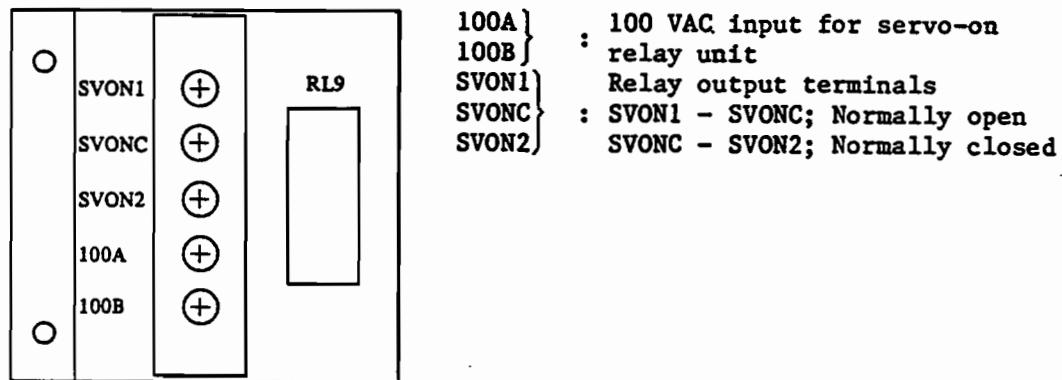
a) Procedure

- ① Remove the Ground Connected lamp, according to the above procedure ①, ②.
- ② Remove the cap of the lamp.
- ③ For mounting new lamp, reverse the above procedure.



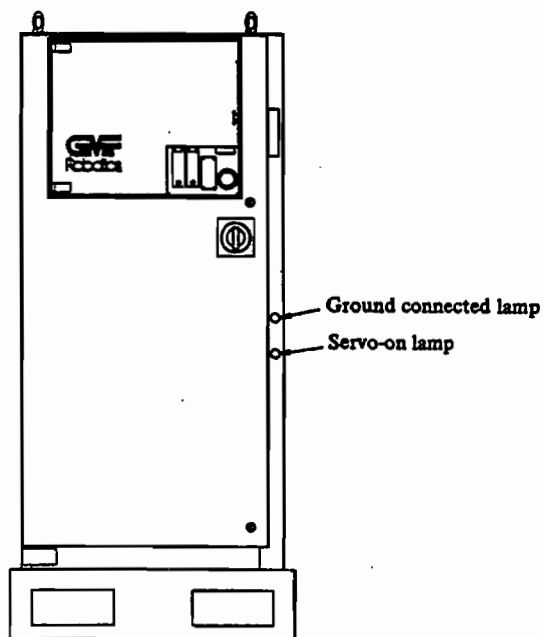
30. SERVO-ON RELAY UNIT AND SERVO-ON LAMP

30.1 Connector/Signal Identification



30.2 Lamp

A lamp called servo-on lamp is installed under the ground connected lamp of the main cabinet. Its lighting indicates that 100 VAC is supplied to the servo amplifiers. When this lamp is pressed in halfway, it goes out. When it is pressed in all the way, the lamp lights again. Its lighting indicates that 100 VAC is available in the controller.

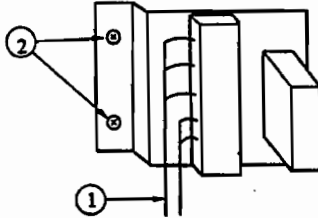


30.3 Removal/Replacement

1) Unit (servo-on relay unit)

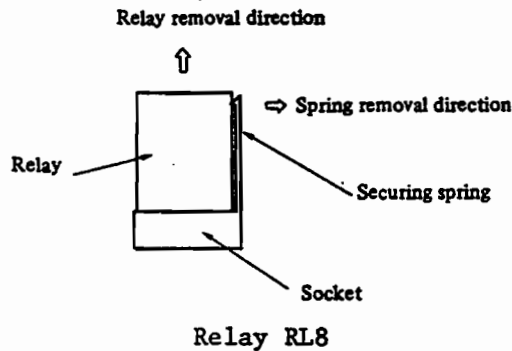
a) Procedure

- ① Disconnect all cables ① from the servo-on relay unit.
- ② The servo-on relay unit can be removed by loosening two screws ②.
- ③ For mounting new unit, reverse the above procedure.



2) Component (relay)

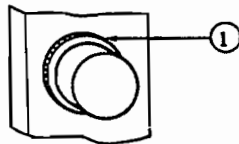
Remove the spring that clamps the relay to its socket by pulling it in the direction indicated by the arrow (⇒) shown above. Then remove the relay by pulling it in the direction (↑) shown above.



3) Unit (servo-on lamp)

a) Procedure

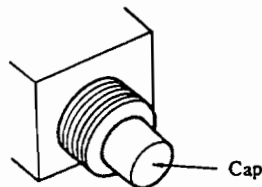
- ① Remove the ring ① from the servo-on lamp.
- ② The servo-on lamp can be removed with connection cables attached.
- ③ Disconnect all cables from the lamp.
- ④ For mounting new lamp, reverse the above procedure.



4) Component (lamp)

a) Procedure

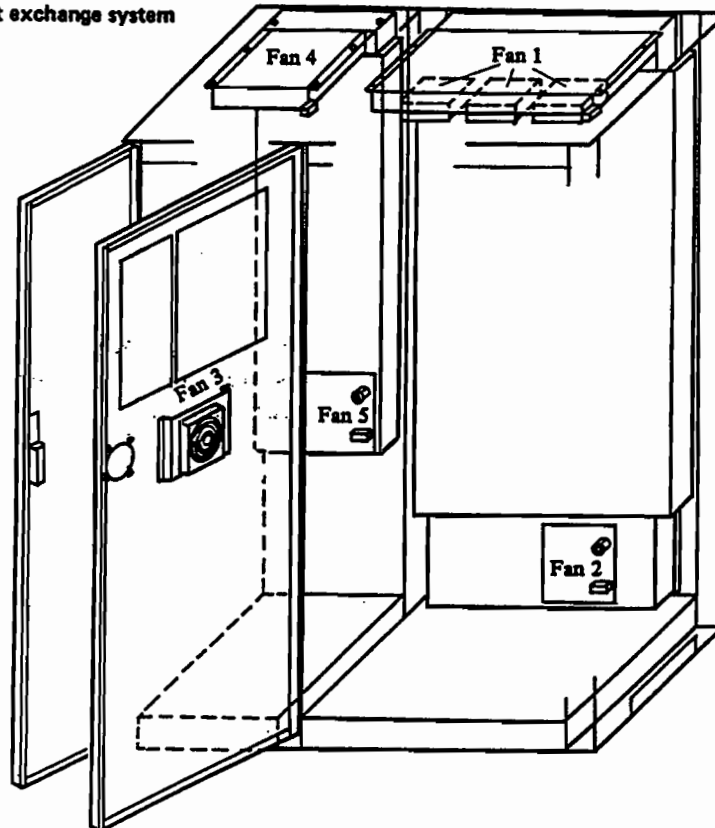
- ① Remove the servo-on lamp, according to the above procedure ①, ②.
- ② Remove the cap of the lamp.
- ③ For mounting new lamp, reverse the above procedure.



31. FAN UNIT

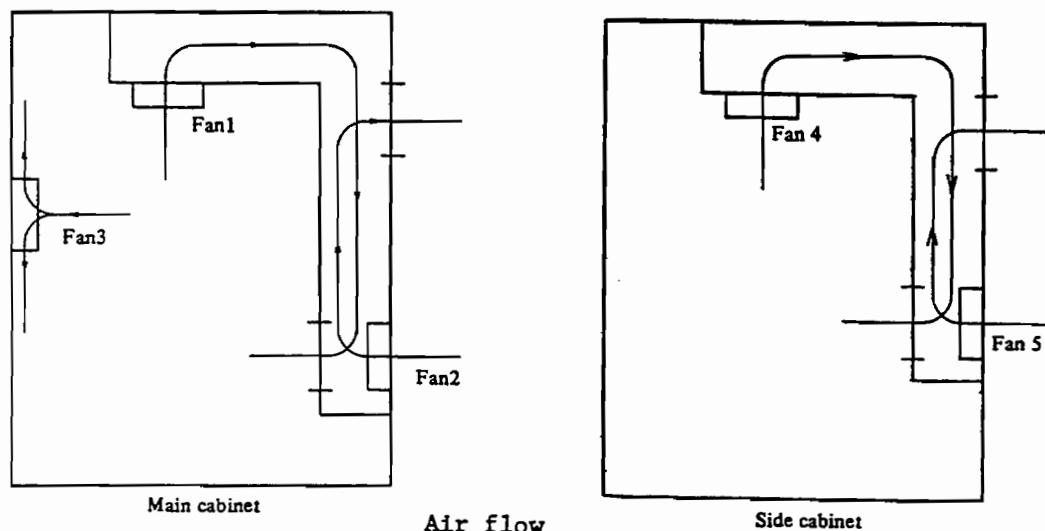
31.1 Fan Unit for Large Size Cabinet

31.1.1 Operation of heat exchange system



Location of fan units

The controller incorporates an air-to-air heat exchange system. The electric components of the controller are isolated from outside air except for the bottom segment of the side cabinet where the servo transformer and discharge units are installed. Air flow direction is as shown below.



31.1.2 Removal/replacement

1) Fan 1

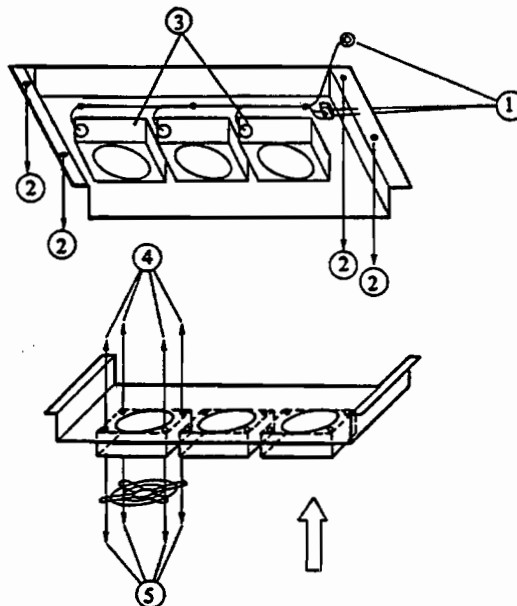
a) Specification

A05B-2051-C901 (fan unit)

A90L-0001-0043 (fan motor)

b) Procedure

- ① Disconnect the cables from the fan unit.
- ② Remove the unit by loosening four screws ②.
- ③ Disconnect the cables from the fan motors.
- ④ Remove the fan motor from the plate by loosening four screws ④.
- ⑤ Remove the finger guard from the fan motor by loosening four screws ⑤. For mounting a new fan motor, reverse the above procedure.



2) Fan 2

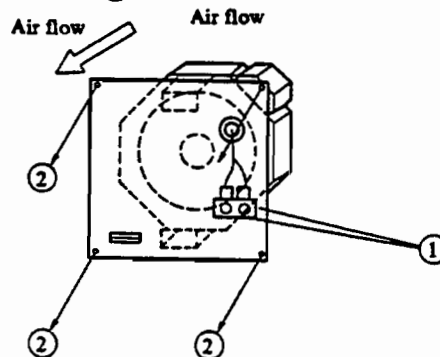
a) Specification

A05B-2051-C902 (fan unit)

A90L-0001-0213#A (fan motor)

b) Procedure

- ① Disconnect the cables from the fan unit.
- ② Remove the unit by loosening four screws ②. For mounting a new fan unit, reverse the above procedure.



3) Fan 3

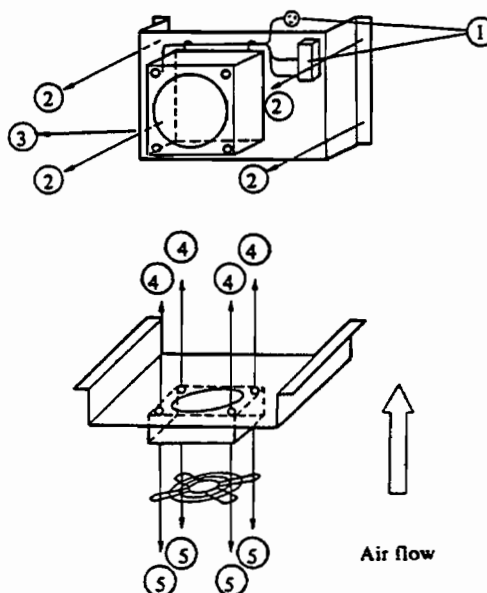
a) Specification

A05B-2051-C905 (fan unit)

A90L-0001-0043 (fan motor)

b) Procedure

- ① Disconnect the cables from the fan unit.
- ② Remove the unit by loosening four screws ②.
- ③ Disconnect the cable from the fan motor.
- ④ Remove the fan motor from the plate by loosening four screws ④.
- ⑤ Remove the finger guard from the fan motor by loosening four screws ⑤. For mounting a new fan motor, reverse the above procedure.



4) Fan 4

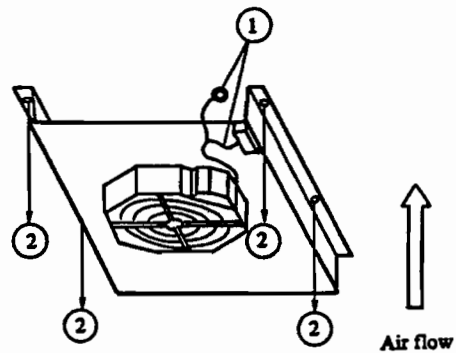
a) Specification

A05B-2051-C903 (fan unit)

A90L-0001-0213#A (fan motor)

b) Procedure

- ① Disconnect the cables from the fan unit.
- ② Remove the unit by loosening four screws ②. For mounting a new fan unit, reverse the above procedure.



5) Fan 5

a) Specification

A05B-2051-C902 (fan unit)

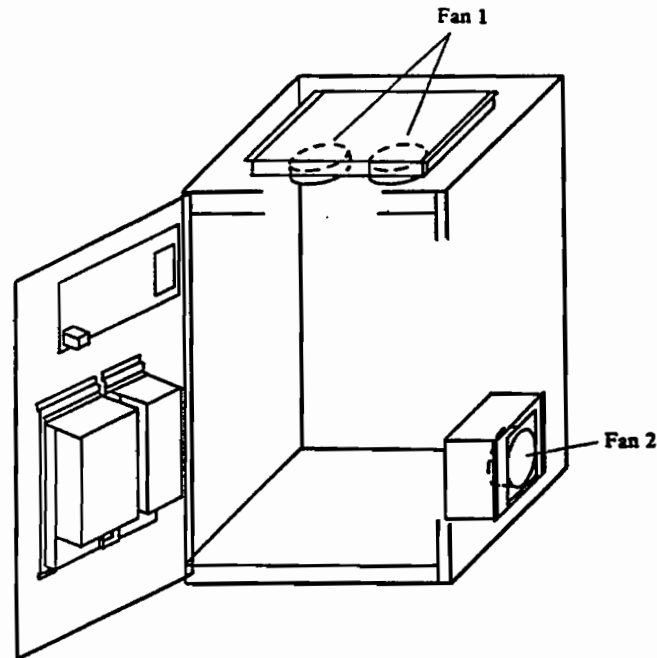
A90L-0001-0213#A (fan motor)

b) Procedure

Same as the Fan 2.

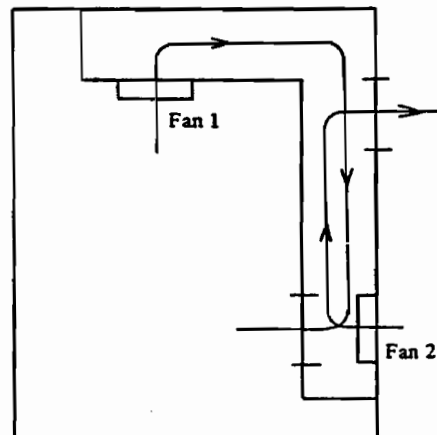
31.2 Fan Unit for Medium Size Cabinet

31.2.1 Operation of heat exchange system



Location of fan units

The controller incorporates an air-to-air heat exchange system. The electric components of the controller are isolated with outside air. Air flow direction is as shown below.



Air flow

31.2.2 Removal/replacement

1) Fan 1

a) Specification

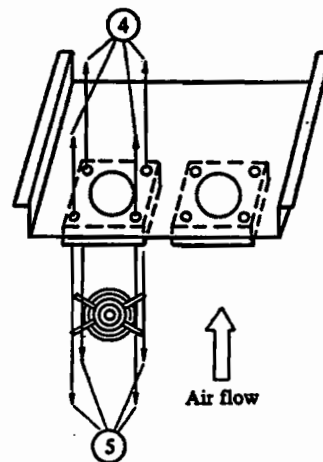
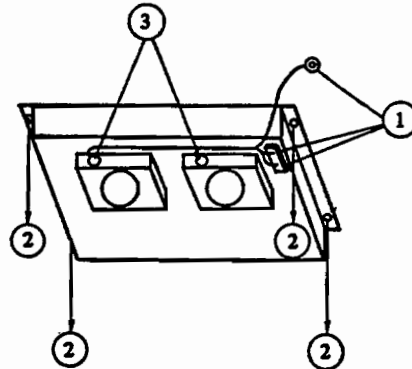
A05B-2045-C901 (fan unit)

A90L-0001-0099#A (fan motor)

b) Procedure

- ① Disconnect cables from the fan unit.
- ② Remove the unit by loosening four screws ②.
- ③ Disconnect cables from fan motors.
- ④ Remove the fan motor from the plate by loosening four screws ④.
- ⑤ Remove the finger guard from the fan motor by loosening four screws ⑤.

For mounting a new fan motor, reverse the above procedure.



2) Fan 2

a) Specification

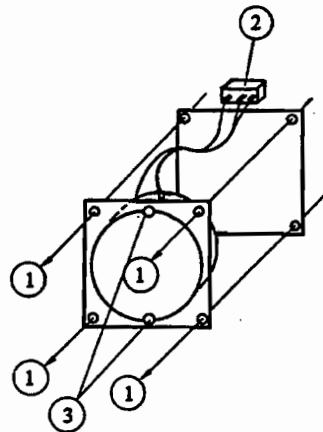
A05B-2045-C902 (fan unit)

A90L-0001-0049 (fan motor)

b) Procedure

- ① Remove the fan unit by loosening four screws ①.
- ② Disconnect the cables from the unit.
- ③ Remove the fan motor from the plate by loosening two screws ③.

For mounting a new fan motor, reverse the above procedure.



32. ABSOLUTE PULSE CODER

32.1 Theory of Operation

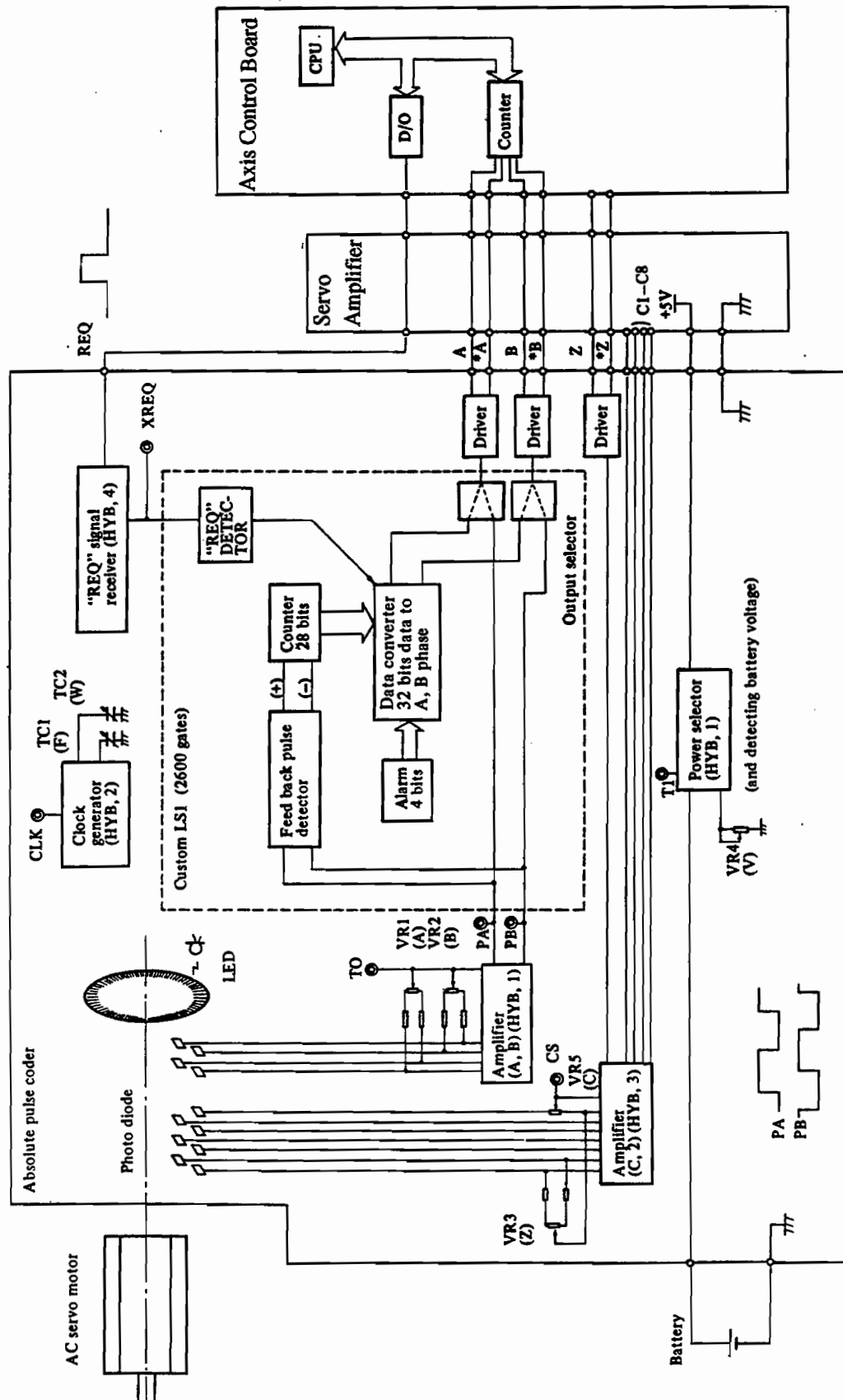
The Absolute Pulse Coder is made up of a rotating mechanism, an LED, a code disk, photo cells, and a signal processing circuit. The code disk contains several slits. As the disk rotates on a shaft the slits in the disk alternately block and permit light to the photo cells.

The photo cells receive the interrupted light beams which the signal processing circuit converts to digital electrical signals. The signals are amplified and transformed into a square wave-form of C-MOS level as PA and PB in Hybrid IC 1. Signals PA and PB are applied to the Feedback Pulse Detector and the Output Selector contained in the LSI chip. The Feedback Pulse Detector generates plus and minus pulses according to the rotary direction of the code disk. A 28-bit counter increments the plus pulses and decrements the minus pulses.

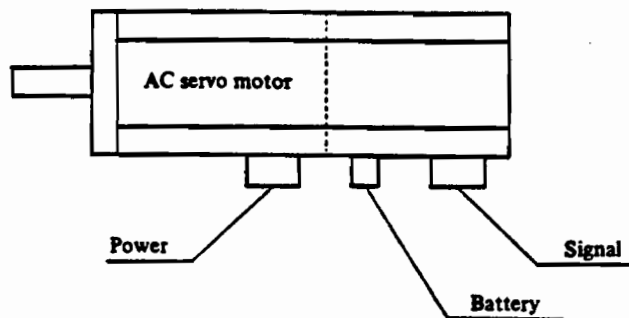
The REQ Signal Receiver is a level converter to C-MOS level. The absolute pulse coder receives the data request signal, REQ. The Data Converter translates the 32 bits of data, 28 bits of counter data and 4 bits of alarm data into serial data. At the same time, the Output Selector selects signals from the Data Converter, and the serial data is transmitted to the controller through two pairs of phase signals as A, *A, B, and *B. Following the data transmission, the Output Selector selects signals PA and PB and position control operation is available.

The Absolute Pulse Coder also has a Power Selector in Hybrid IC 1. When +5 volts is not applied to the pulse coder from the power supply, the power select circuit obtains power from the battery unit.

32.2 Block Diagram



32.3 Connector/Signal Identification



Standard type

Signal (MS3102A 22-14P)

A	A	L	+5V
B	*A	M	0V
C	B	N	SHIELD
D	*B	P	OH1
E	Z	R	OH2
F	*Z	S	REQ
G	C1	T	+6A
H	C2	U	OVA
J	C4	V	-
K	C8		

A, *A, B, *B : Count signal
 Z, *Z : Reference signal
 C1, C2, C4, C8: Phase control signal for AC servo motor
 +5V, 0V : Power supply from controller
 OH1, OH2 : Over heat signal of servo motor
 REQ : Data request signal
 +6V, OVA : Power supply from battery unit

Battery (MS3102A 10SL-4P)

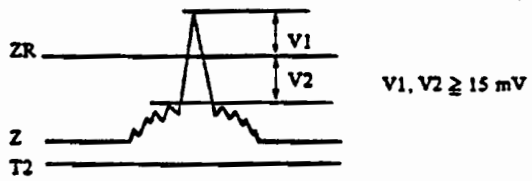
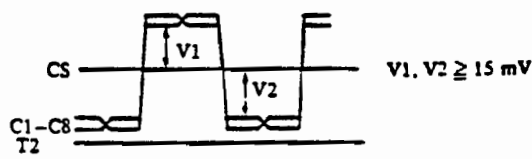
A	+6VB	B	0VB
---	------	---	-----

+6VB, 0VB : Power supply from battery unit

Signal

Wire color	Signal	Wire color	Signal
Black	*A	Gray	0V
Blue	*B	Orange	REQ
Green	*Z	Red/White	+6A
Orange/White	C2	Gray/White	OVA
Brown/White	C4	Red (thick)	+6B
Purple/White	C8	Gray (thick)	0VB
Red	+5		

32.4 Variable Resistors

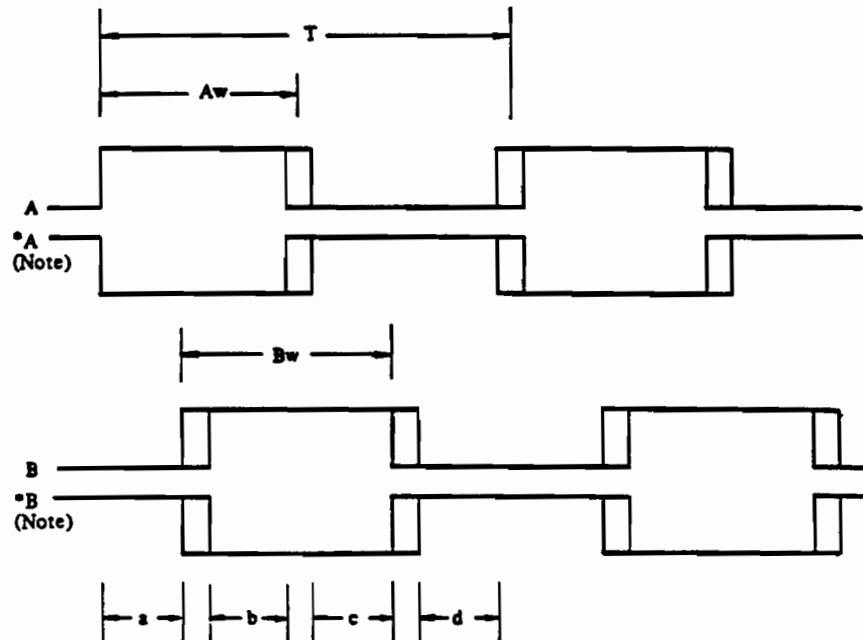
V.R.	Standard setting	Remarks
VR1 (A)	-	Adjustment of the duty of A or *A (Pulse coder outputs) Duty = 50:50
VR2 (B)	-	Adjustment of the duty of B or *B (Pulse coder outputs) Duty = 50:50
VR3 (Z) Note	-	Adjustment of the level of Z and ZR (Photo diodes outputs) 
VR4 (V)	-	Adjustment of the voltage of T1 T1 voltage = $4 \pm 0.04V$ (When +6A or +6B are supplied 6V, and +5V is off)
VR5 (C)	-	Adjustment of CS level which is the comparison level of C1, C2, C4, C8 (Photo diode outputs). 

Note) VR3 is used for the adjustment of the both *Z and C2, C4, C8 signals.

Trimmer capacitors

V.R.	Standard setting	Remarks
TC1 (F)	-	Adjustment of the frequency of CLK $F = 10 \text{ kHz}$ (When +6A or +6B are supplied 6V, and +5V is off)
TC2 (W)	-	Adjustment of the low level width of CLK Low level width = 600 ns (When +6A or +6B are supplied 6V, and +5V is off)

3) Output waveform
a) Count signal

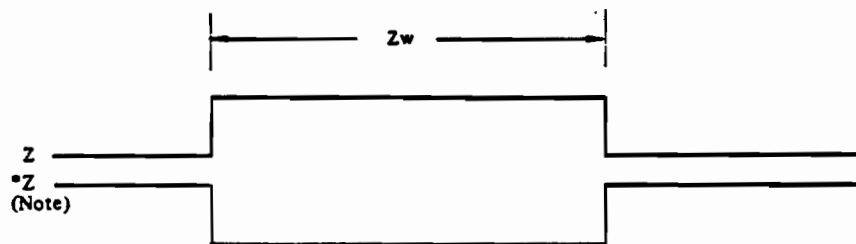


$$0.45 \cdot T \leq A_w, B_w \leq 0.55 T \quad 'H' \geq 2.4 \text{ volt}$$

$$0.14 \cdot T \leq a, b, c, d \quad 'L' \geq 0.4 \text{ volt}$$

Upper drawing shows the waveform with CW rotation. When the shaft is rotated in CCW direction (viewed from shaft end), signals "A" and "*A" are interchanged with B and *B respectively.

b) Reference signal

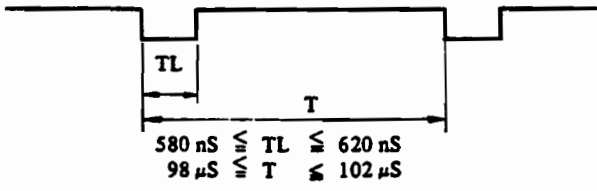


$$1 \cdot T \leq Z_w \leq 3 \cdot T \quad 'H' \geq 2.4 \text{ volt}$$

$$'L' \leq 0.4 \text{ volt}$$

32.5 Test Points

1) When "+6A" or "+6B" are supplied 6 V, and "+5V" is off.

Test points	Specifications
T1	Voltage 3.96 V - 4.04 V
T0	Voltage 1.5 V - 2.5 V
ON	Voltage ≥ 3.93 V
BT	Voltage ≥ 3.93 V
CT	Voltage ≤ 0.05 V
CLK	Waveform <div style="text-align: center;">  <p> $580 \text{ nS} \leq TL \leq 620 \text{ nS}$ $98 \mu\text{S} \leq T \leq 102 \mu\text{S}$ </p> </div>
AM	Waveform Inverse waveform of "CLK"

2) When "+5" is supplied 5V, and "+6A" and "+6B" are off.

Test points	Specifications
T1	Voltage ≥ 4.7 V
T0	Voltage 1.5 V - 2.5 V
ON	Voltage ≥ 4.7 V
BT	Voltage ≤ 0.05 V
CT	Voltage ≥ 4.7 V
CLK	Frequency 1.1 MHz - 1.9 MHz
AM	Voltage ≥ 4.7 V
XREQ	Duty ≥ 4.5 V (When "REQ" is supplied 0 V.) ≤ 0.4 V (When "REQ" is supplied 10 V.)
PA	Duty 45:55 - 55:45 (When the shaft is rotating.)
PB	Duty 45:55 - 55:45 (When the shaft is rotating.)

c) Phase control signal for AC servo motor



'H' \geq 2.4 volt
'L' \leq 0.4 volt

The drawing above shows the waveform with CW rotation. When the shaft is rotated in CCW direction, signal "C8" has an inverted waveform.

32.6 Removal/Replacement

32.6.1 Replacing pulse coder

1) Replacing pulse coder

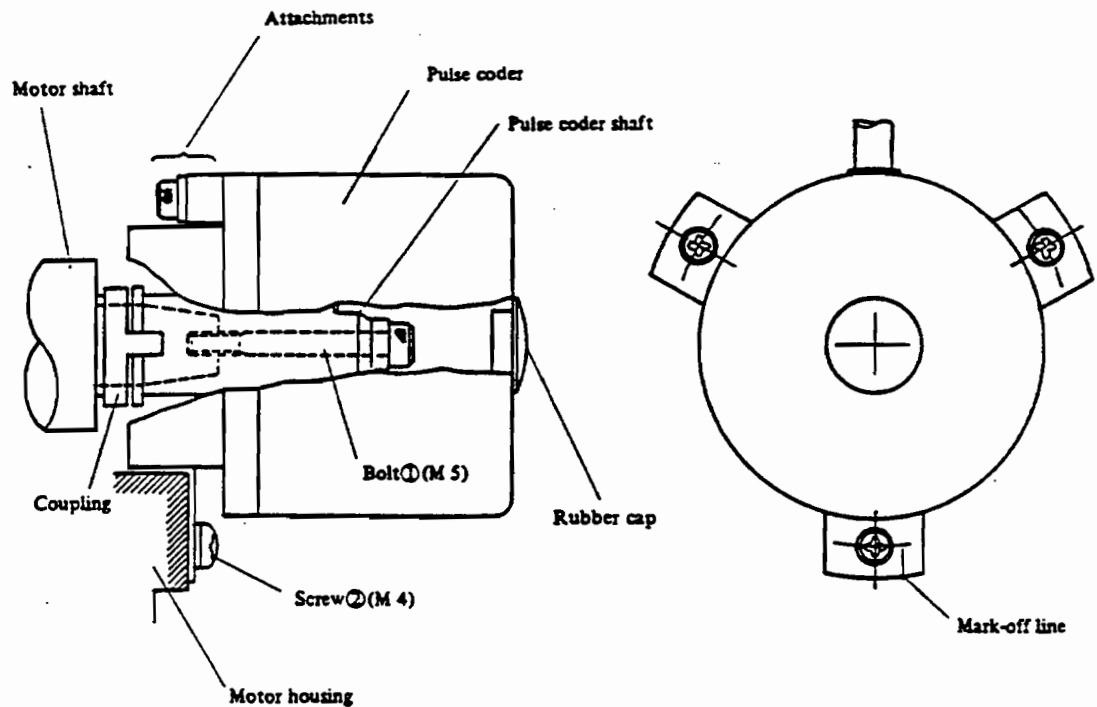
The method written here is applicable to AC servo motor models 0, 5, 10, 20, 30 and 30R. It is impossible to remove the pulse coder from the other motor models (2-0, 1-0, 3-0, 4-0, 5-0), because, for those types, the pulse coder itself is directly assembled onto the motor shaft.

a) Remove the defective pulse coder.

- ① Remove rubber cap.
- ② Unfasten bolt ①.
- ③ Unfasten screw ②.
- ④ Remove pulse coder (+attachments) from the motor shaft.

b) Mount new (good) pulse coder.

- ① Mount pulse coder (+attachments) on the motor shaft. Notice that both a tooth (of coupling) and a groove (of pulse coder) are just fitted together. Care should be taken, for fitting length is short.
- ② Connect both shafts by bolt ①.
- ③ Adjust marking-off line between attachments of pulse coder and motor housing.
- ④ Fasten screw ②.



2) Checking the phase-relationship

The method written here is applicable to all models of FANUC AC servo motors.

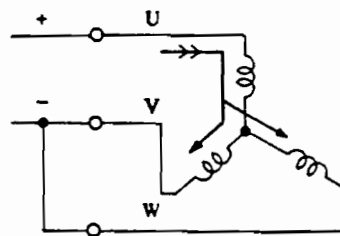
- ① Connect V and W of motor power line.
- ② Excite motor at rated DC current from U to V and W. (U: +, V and W: -)
- ③ Supply 5 VDC to the pulse coder, and check signals of C1 - C8. Correct pattern is as follows.

C1	C2	C4	C8
1	1	1	1
or 1	1	1	0 (Note)

(1: HIGH, 0: LOW)

Note) C8 is "0" for CCW rotation.

Rated DC current at the check of phase relationship is as follows:



MOTOR MODEL	3-0, 4-0:	1.2 A
	1-0, 2-0:	4 A
	0.5 :	9 A
	10 :	15 A
	20, 30 :	30 A
	30R :	40 A

32.6.2 Replacing batteries

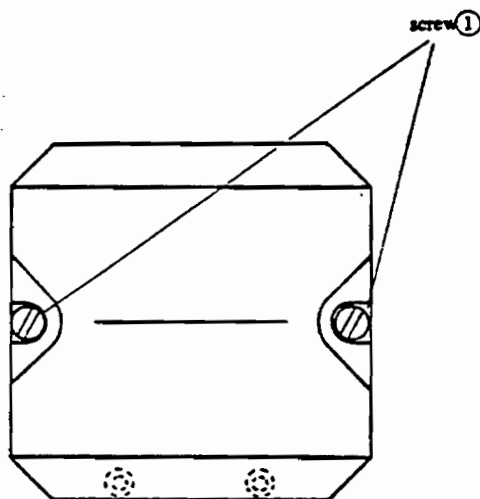
Caution) Be sure that the power source from the controller is on before removing or replacing batteries. If there is no power to the absolute pulse coders, remastering of the mechanical unit will be required.

1) Removing dead batteries

- ① Unfasten two screws ① and remove the lid.
- ② Remove dead batteries.

2) Mounting new batteries

- ① Mount four new alkaline manganese dioxide batteries. Check their polarity to ensure they are installed correctly.
- ② Fasten two screws ① to attach the lid.



Battery case for absolute pulse coder

II. S-10 MECHANICAL UNIT MAINTENANCE

1. CONFIGURATION

Fig. 1 shows the configuration of the mechanical unit.

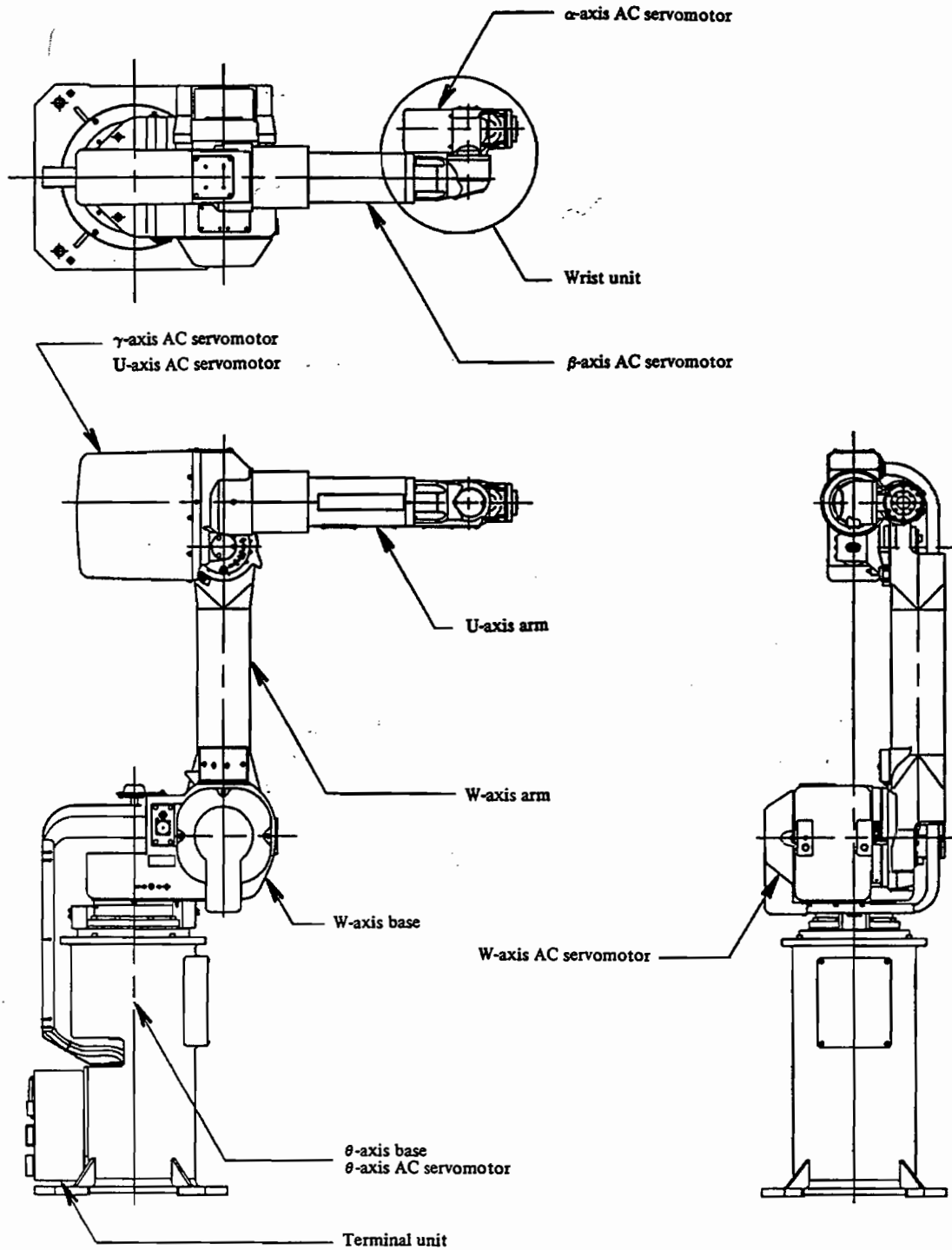


Fig. 1 Mechanical unit configuration (S-10)

1.1 θ -axis Drive Mechanism

Fig. 1.1 shows the θ -axis drive mechanism.

The rotation of the AC servomotor is decelerated by the RV reducer. The θ -axis drive is responsible for rotating the entire robot assembly.

Note) For manual movement, the θ -axis moves in the rotary direction of the manual crank.

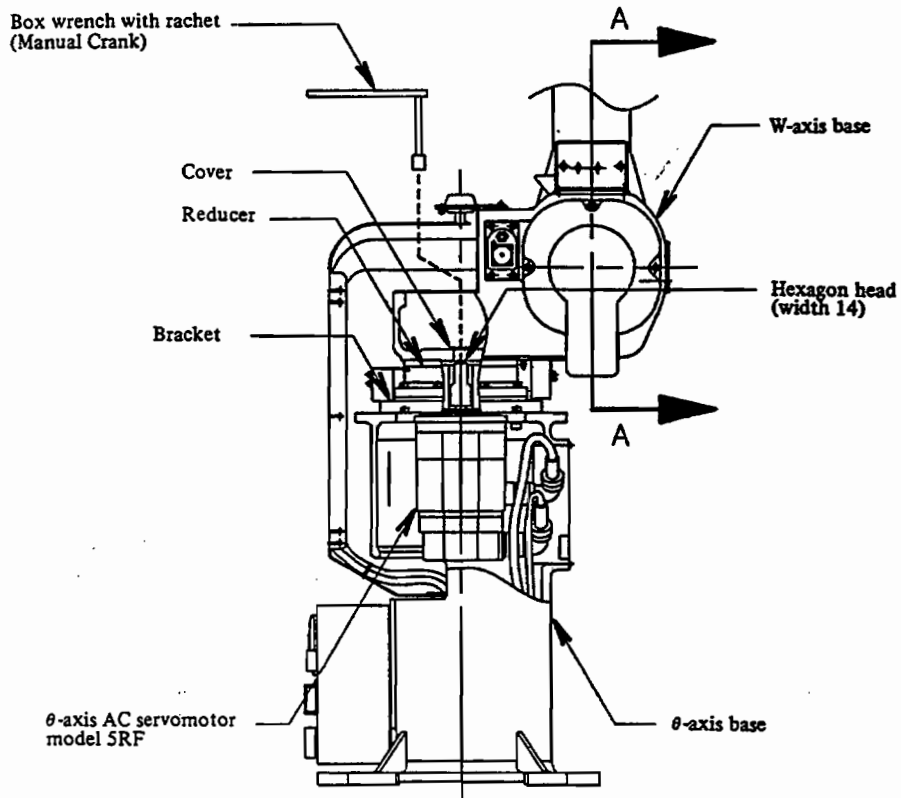
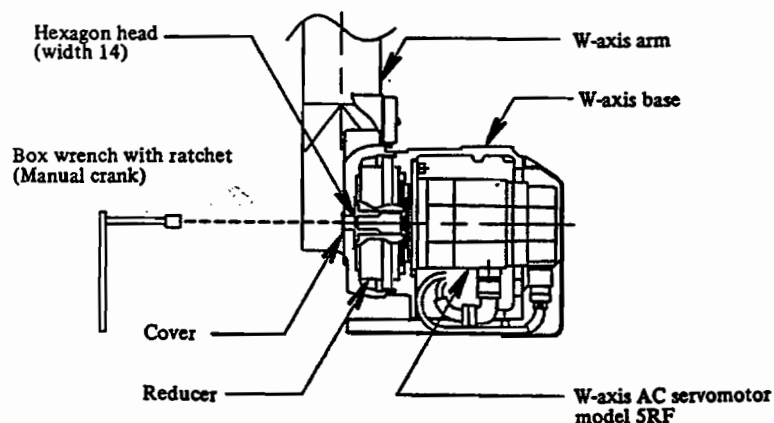


Fig. 1.1 θ -axis drive mechanism (S-10)

1.2 W-axis Drive Mechanism

Fig. 1.2 shows W-axis drive mechanism. The rotation of the AC servomotor is decelerated by the reducer and rotates the W-axis. The RV reducer supports the W-axis arm.

Note) For manual movement, the W-axis moves in the rotary direction of the manual crank.



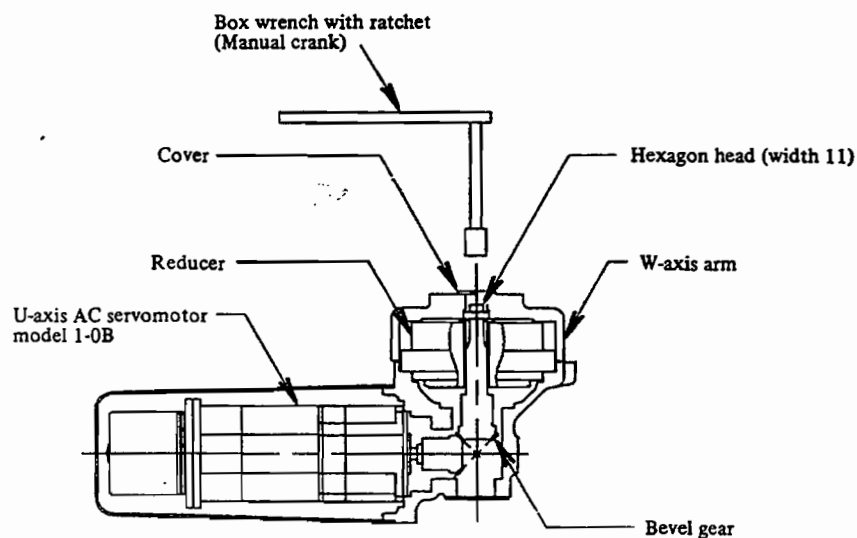
Section A-A (Refer to Fig. 1.1)

Fig. 1.2 W-axis drive mechanism (S-10)

1.3 U-axis Drive Mechanism

Fig. 1.3 shows the U-axis mechanism. The rotation of the AC servomotor is decelerated by the reducer and rotates the U-axis unit. The U-axis unit is supported by the U-axis RV reducer.

Note) For manual movement, the U-axis moves in the direction opposite to the rotary direction of the manual crank.



Section A-A (Refer to Fig. 1.4)

Fig. 1.3 U-axis drive mechanism (S-10)

1.4 γ -axis Drive Mechanism

Fig. 1.4 shows the γ -axis drive mechanism. The rotation of the AC servomotor is decelerated by the harmonic drive and rotates the U-axis arm. The U-axis arm is supported by the U-axis housing via the reducer and cross roller bearing.

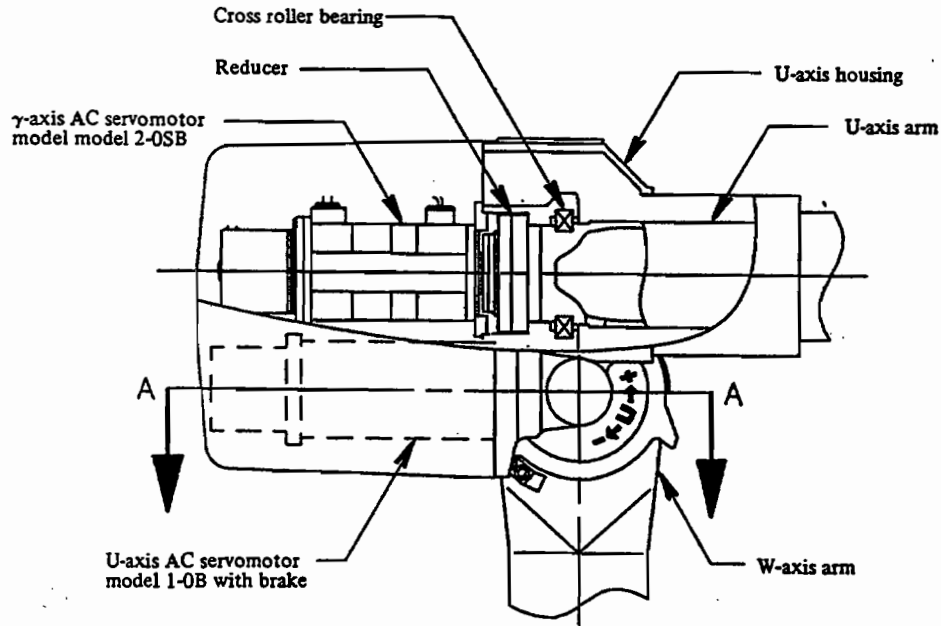


Fig. 1.4 γ -axis drive mechanism (S-10)

1.5 β -axis Drive Mechanism

Fig. 1.5 shows the β -axis drive mechanism. The rotation of the AC servomotor is decelerated by the harmonic drive and rotates the α -axis unit via the bevel gear.

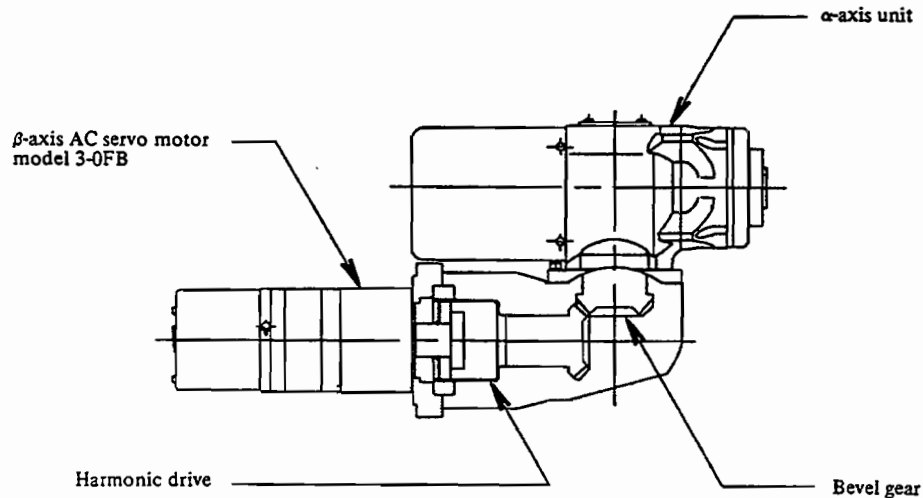


Fig. 1.5 β -axis drive mechanism (S-10)

1.6 α -axis Drive Mechanism

Fig. 1.6 shows the α -axis drive mechanism. The rotation of the AC servomotor is decelerated by the harmonic drive and rotates the output flange.

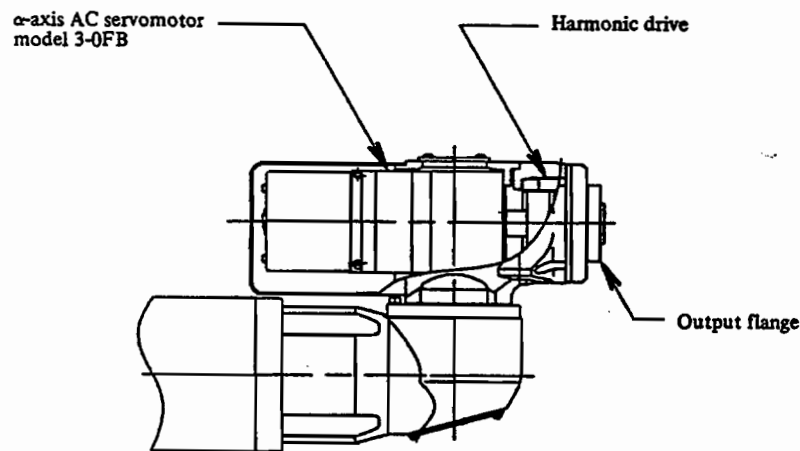


Fig. 1.6 α -axis drive mechanism (S-10)

1.7 Major Component Specifications

1) Motor

Specification	Axis	Remarks
A06B-0345-B231	θ	AC 5RF with brake
A06B-0345-B231	W	AC 5RF with brake
A06B-0522-B351	U	AC 1-0 with brake
A06B-0310-B351	γ	AC 2-OS with brake
A06B-0368-B231 (A05B-1204-J091)	β	AC 3-OF with brake (Connector remodeling specification)
A06B-0368-B231 (A05B-1204-J091)	α	AC 3-OF with brake (Connector remodeling specification)

2) Reducer

Specification	Axis
A97L-0118-0801#121	θ
A97L-0118-0801#153	W
A97L-0118-0802#105	U
A97L-0118-0803#53.5	γ
A97L-0118-0804	β
A97L-0118-0805	α

3) Unit

Specification	Remarks
A290-7204-V201	θ cable guide unit
A290-7204-V202	θ terminal unit
A290-7204-V501	Wrist unit
A290-7204-V512	α -axis unit

4) Gear

Specification	Axis
A290-7204-X411	U
A290-7204-X412	U
A290-7204-X511	β
A290-7204-X512	β

5) Shim

Specification	Remarks		
A290-7204-X421 A290-7204-X422 A290-7204-X430	0.3t 0.1t 0.15t	X411, X412	For adjusting U-axis bevel gear
A290-7204-X521 A290-7204-X522 A290-7204-X523 A290-7204-X529	0.5t 0.1t 0.03t 0.15t	X511	Wrist unit For adjusting S-axis bevel gear
A290-7204-X524 A290-7204-X525 A290-7204-X526 A290-7204-X530	0.5t 0.1t 0.03t 0.15t	X512	

6) Cover

Specification	Remarks
A290-7204-X305	W-axis motor cover
A290-7204-X410	U-axis motor cover
A290-7204-X323	W-axis cable cover
A290-7204-X324	U-axis cable cover
A290-7204-X325	θ -axis cable cover

7) Cross roller bearing

Specification	Axis
A97L-0001-0907#8016CS	γ
A97L-0118-0513#5013CS	β
A97L-0118-0513#4010CS	α

2. LUBRICATING CONDITION CHECKS

1) Monthly check

Check the following once a month.

Item	Check item	Checking procedure
1	Lubrication of β -axis wrist gear box	Remove the cover and check the gear surface for presence of oil, damage, smut and foreign substances.

2) Grease check

Never perform greasing procedures before turning off power. Oil is used in the air route. Grease is used in other portions.

a) Applying grease

- i) Apply grease normally every 3 months.
- ii) For the greasing points and the greasing procedure, see Fig. 2 and Table 2 (a).
- iii) Parts not specified in Table 2 (a) need not be greased, since they are grease-sealed bearings or oilless bearings.

Table 2 (a) Greasing Points

Item	Greasing point	Grease	Qty	Method of greasing
1	α -axis harmonic drive	Harmonic grease SK-1	10 cc	Pull out the plug for air vent, replace it with the grease nipple which is attached and apply grease to it. (If the grease nipple interferes with the welding wire, etc., replace it again with the plug after greasing.)
2	β -axis harmonic drive	Harmonic grease SK-1	10 cc	
3	β -axis gear box	Molynoc grease 2	10 cc	Remove the cover and supply grease about 1/2 of gear box capacity.

Table 2 (b) Recommended Lubricants

	Oil (Air control set)
Mobil Oil	DTE Oil Light
Esso Standard	Tellesso 32
Shell Oil	Shell Turbo Oil T32
Mitsubishi Oil	Diamond Turbine Oil 32
Nippon Oil	FBK Turbine 32
Idemitsu Kosan	Daphne Turbine Oil 32
Maruzen Oil	Special A Turbine Oil 32

3) 3-year check

Change grease for reducers of θ , W, U, and γ axes and U-axis gear box every 3 years or 20,000 hours. Use the following procedure:

- Remove the θ (W, U, γ) grease nipple and the θ (W, U) plug shown in Fig. 2 (b).
- Blow in air through the hole from which the θ (W, U, γ) plug has been removed to remove grease completely through the other hole.
- Fit the θ (W, U, γ) grease nipple and apply the grease specified in Table 2 (c).
- Remount the θ (W, U, γ) plug.

4) Cross Roller Bearing

Insert 5 cc of grease into the Gamma-axis cross roller bearing grease nipple. Rotate the axis to achieve even disbursement of lubricant.

Table 2 (c) Locations Requiring 3-year Lubrication

	Grease		Qty (cc)
	Nippon Oil	Shell Oil	
θ -axis reducer	EPNOC GREASE NO. 0	SHELL ALVANIA EP GREASE RO	150
W-axis reducer			130
U-axis reducer			130
U-axis gear box			130
γ -axis reducer			100
Cross-roller bearing	MOLYNOC GREASE	SHELL ALVANIA #2	5

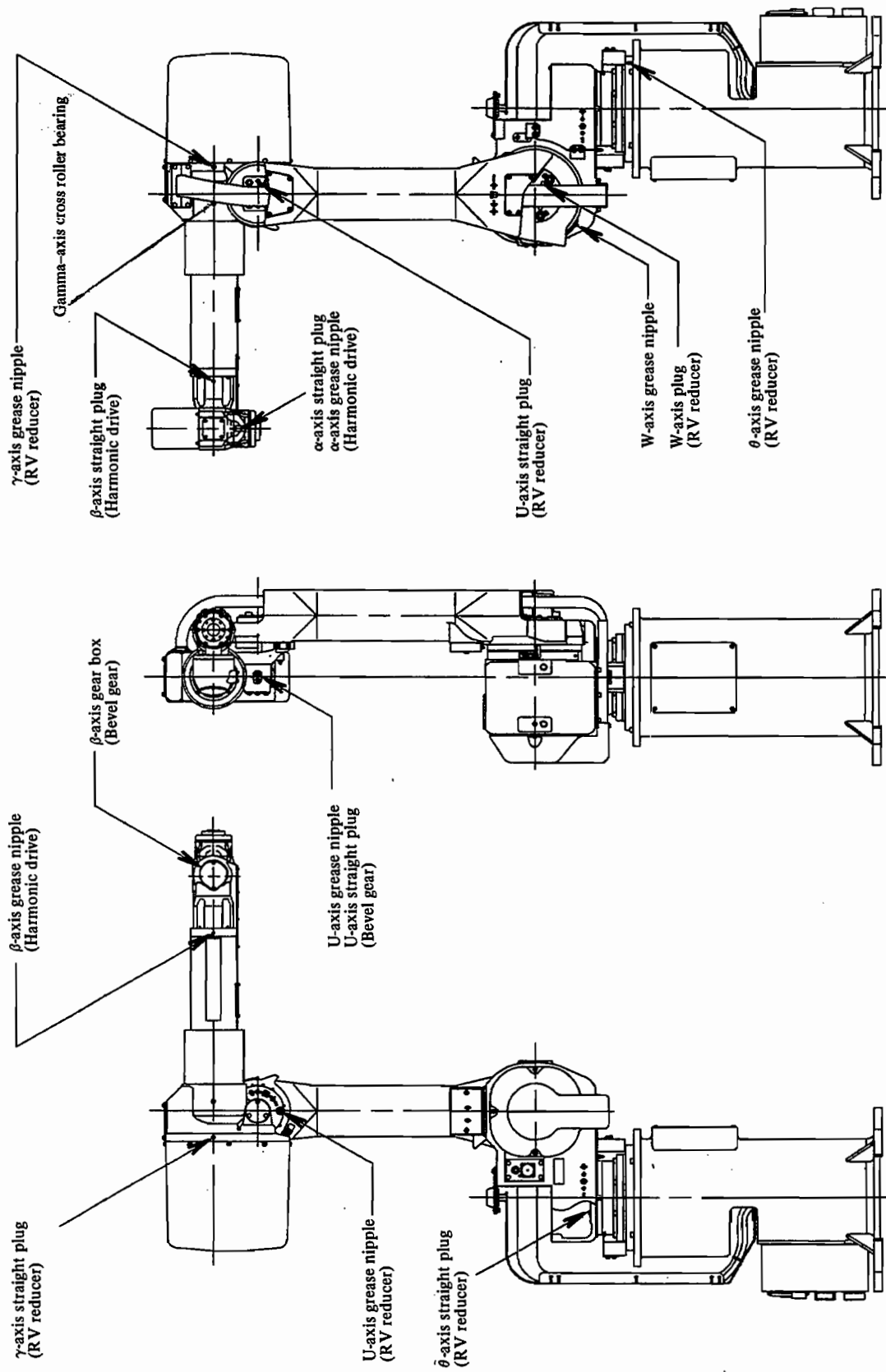


Fig. 2 Greasing Point

3. TROUBLESHOOTING

3.1 General

The source of mechanical unit problems may be difficult to find because of overlapping causes. Problems may become further complicated, if they are not corrected properly. Therefore, it is necessary to keep an accurate record of problems and to take proper corrective actions.

3.2 Problems and Causes

Major problems in mechanical unit and their probable causes are listed below:

1) Robot will not calibrate.

- a) (Cause) Voltage of the memory backup battery is low.
(Measure) Replace battery. (Refer to 5.10)

2) Position error

- a) (Cause) Robot struck an obstacle.
(Measure) Revise the teaching points.
- b) (Cause) Robot or peripheral machine is not firmly mounted.
(Measure) Mount firmly.
- c) (Cause) Excessive Load.
(Measure) Reduce the load or speed.
- d) (Cause) System variables are not standard.
(Measure) Change the system variables to standard settings.
- e) (Cause) A cable is disconnected or broken.
(Measure) Replace the cable. (Refer to 7.2)
- f) (Cause) APC abnormal.
(Measure) Replace the motor. (Refer to 5.1 - 5.9)
- g) (Cause) Excessive backlash.
(Measure) See below.

3) The robot vibrates.

- a) (Cause) The robot is not bolted securely on the floor.
(Measure) Tighten the bolts firmly.
- b) (Cause) The floor itself vibrates.
(Especially when the robot is installed on the second floor and higher.)
(Measure) Change the robot mounting place.
- c) (Cause) Excessive Load.
(Measure) Reduce load or speed.
- d) (Cause) The adjustment of the servo is faulty.
(Measure) Adjust the servo. (Consult GMFanuc)
- e) (Cause) A cable is broken.
(Measure) Replace the cable. (Refer to 7.2)
- f) (Cause) Not grounded.
(Measure) Ground the robot.
- g) (Cause) The motor or reducer is faulty.
(Measure) Replace the motor or reducer. (Refer to 5.1 - 5.9)
- h) (Cause) The axis control board PCB is faulty.
(Measure) Replace the axis control board PCB.
- i) (Cause) The time constant is faulty.
(Measure) Revise time constant. (Refer to the KAREL System Reference Manual.)
- j) (Cause) Excessive backlash.
(Measure) See below.

4) Excessive backlash

- a) (Cause) Screws and pins are loose.
(Measure) Tighten screws. Coat the specified area with LOCTITE.
- b) (Cause) The reducer is faulty.
(Measure) Replace the reducer. (Refer to 5.1 - 5.9)
- c) (Cause) The adjustment of the gear backlash is faulty.
(Measure) Adjust the gear backlash. (Refer to 4.6 - 4.7)
- d) (Cause) A gear is worn.
(Measure) Replace the gear. (Consult GMFanuc)
- e) (Cause) A bearing is worn.
(Measure) Replace the bearing. (Consult GMFanuc)
- f) (Cause) A casing is broken.
(Measure) Replace the broken parts. (Consult GMFanuc)

5) Abnormal noise

- a) (Cause) Grease/oil to the gear or reducer is insufficient.
(Measure) Grease. (Refer to 5.1 - 5.9)
- b) (Cause) Dust is in the gear or reducer.
(Measure) Flash and then grease. (Refer to 5.1 - 5.9)
- c) (Cause) The adjustment of the gear backlash is faulty.
(Measure) Adjust the backlash. (Refer to 4.4 - 4.5)
- d) (Cause) A gear is worn.
(Measure) Replace the gear. (Consult GMFanuc)
- e) (Cause) A bearing is worn.
(Measure) Replace the bearing. (Consult GMFanuc)
- f) (Cause) The adjustment of servo constants is faulty.
(Measure) Adjust servo constants correctly. (Consult GMFanuc)

6) Abnormal heat

- a) (Cause) Grease/oil to the gear or reducer is insufficient.
(Measure) Grease. (Refer to 2)
- b) (Cause) Nonspecified grease/oil is used.
(Measure) Replace the grease/oil. (Refer to 2)
- c) (Cause) Overload.
(Measure) Decrease the load or speed.
- d) (Cause) The adjustment of the gear backlash is faulty.
(Measure) Adjust the backlash. (Refer to 4.4 - 4.5)
- e) (Cause) The time constant is faulty.
(Measure) Revise time constant. (Consult GMFanuc)

7) Drop of an axis when the power is turned off.

- a) (Cause) Brake gap is noticeable.
(Measure) Replace the motor. (Refer to 5.1 - 5.9)
- b) (Cause) Brake drive relay is defective.
(Measure) Replace the relay. (Refer to I, 23.4.6)

A 5 mm drop of the W or U axis is normal when power is interrupted while the robot was not moving or when an emergency stop is made.

8) Leakage of grease/oil

- a) (Cause) O-ring 2, oil seal 2, or packing is broken.
(Measure) Replace the broken parts. (Consult GMFanuc)
- b) (Cause) Casing is broken.
(Measure) Replace the broken parts. (Consult GMFanuc)
- c) (Cause) Screws are loose.
(Measure) Tighten screws.

Backlash less than the amounts shown in the table is not abnormal.

Table 3.2 (b) Axis backlash

	θ	W	U	γ	β	α
Angle conversion (min.)	1.5	1.5	1.5	3	8	3
Displacement conversion (mm)	0.67 (1529)	0.31 (700)	0.26 (600)	0.26 (300)	0.70 (300)	0.26 (300)

Note) The values of displacement conversion values shows backlash in the rotating direction at the distance from the axis center, shown in parentheses.

Table 3.2 (c) Allowable falling value

At power off	5.0 mm
At emergency stop	5.0 mm

3.3 Replacing Parts and Performing Adjustments

Adjustment is necessary whenever a part was replaced.

The table below shows the parts that require replacing and the items that require adjustment.

Part to be replaced or function to be changed	Adjustment
Replacement of cable	(a) Forming of cable (b) Limit switch (c) Mastering
Replacement of limit switch	(a) Limit switch and dog
θ -axis stroke change	(a) Dog mounting position, limit switch (b) Stop mounting position (c) System variable
Replacement of batteries (Replace every year)	Replace them keeping power unit on. No adjustment is necessary.

4. ADJUSTMENTS

Mechanical parts have been adjusted to the optimum condition at the time of shipment from our company. Therefore, they normally need not be adjusted by the customer at the time of delivery.

Adjustments should be made as specified in this section after a long period of use or after replacing a part.

4.1 Adjusting Limit Switches and Dogs

1) Zero position and working limit

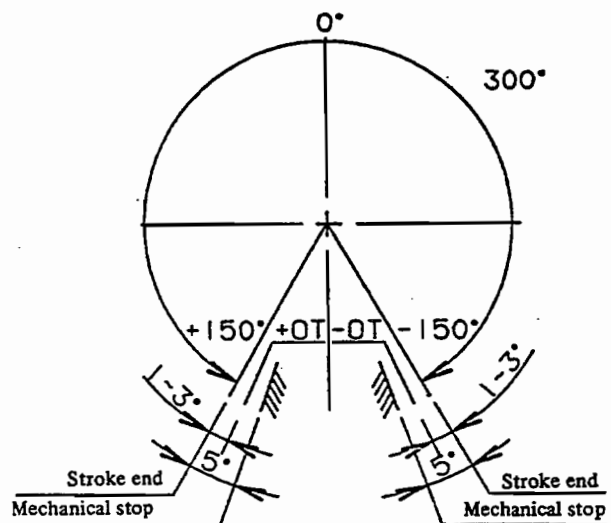
Each controlled axis has its own home position and working limit area (stroke).

The robot is controlled not to move beyond its working limit unless the servo system fails or a system error in which the zero position is lost occurs.

When the controlled axis reaches its working limit, it is called overtravel (OT). Overtravel for basic three axes (θ -, W-, and U-axis) is detected by a mechanical dog and a limit switch. If an alarm is generated, the robot stops. Mechanical stops are provided at either end of each axis.

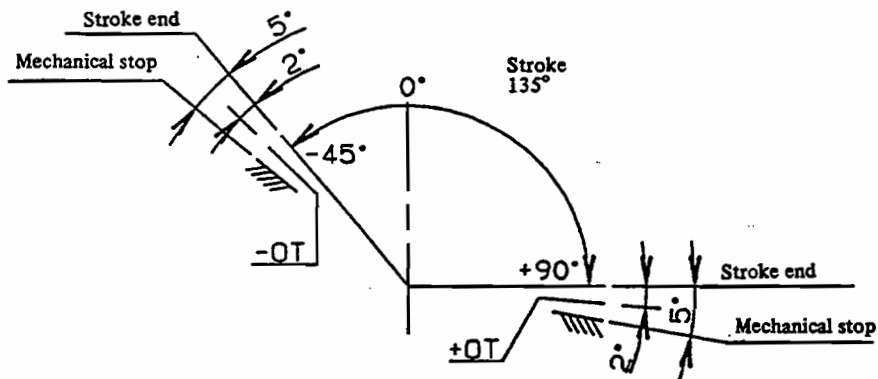
Fig. 4.1 (a) - (g) show the zero positions of OT detection dogs, the mechanical stops, and the motion limits (stroke) of each axis.

Adjust the limit switch and the dog so that the OT alarm is generated at the position shown below:



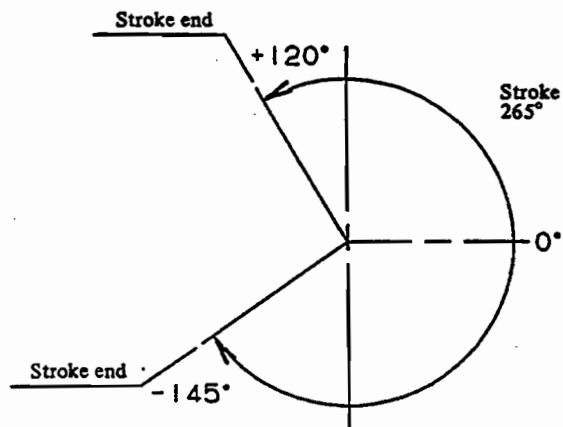
Note) The stroke can be changed.

Fig. 4.1 (a) θ -axis rotation (300°) (S-10)



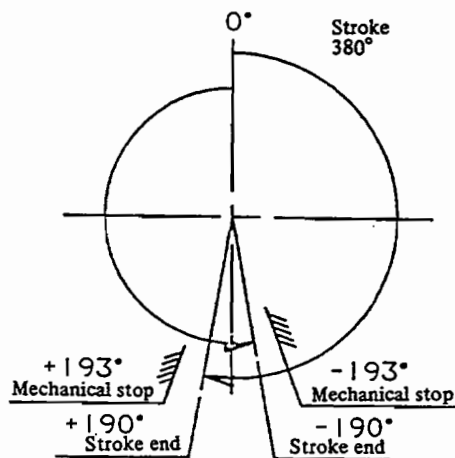
Note) The motion range is limited by the U-axis position.

Fig. 4.1 (b) W-axis rotation (S-10)



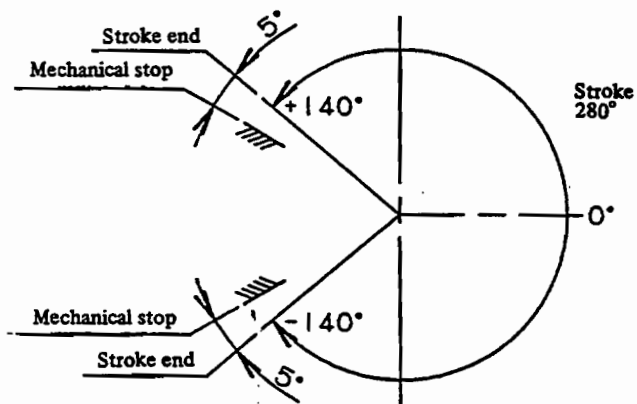
Note) The motion range is limited by the W-axis position.

Fig. 4.1 (c) U-axis rotation (S-10)



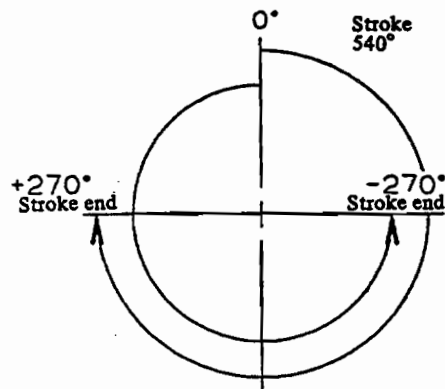
Note) OT limit switches are not used in the γ-axis.

Fig. 4.1 (d) γ-axis wrist rotation (S-10)



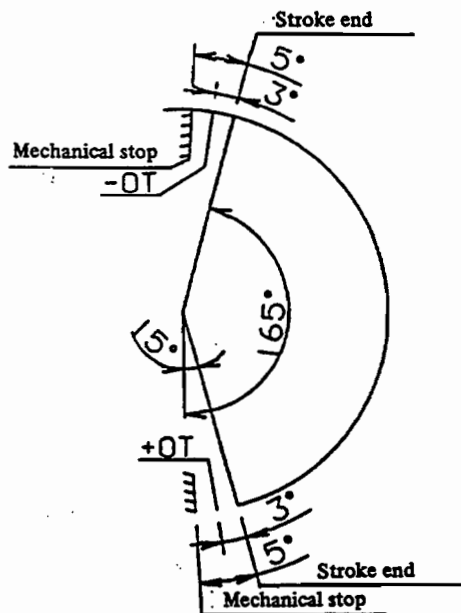
Note) OT limit switches are not used in the β -axis.

Fig. 4.1 (e) β -axis rotation (S-10)



Note) The OT limit switch and mechanical stop are not used in the α -axis.

Fig. 4.1 (f) α -axis wrist rotation (S-10)



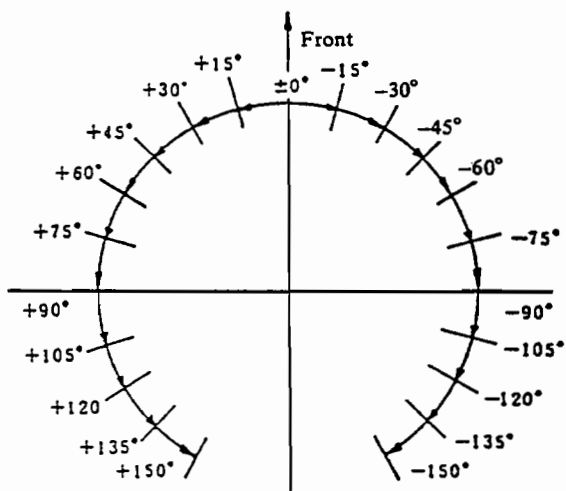
Note) The allowable range for the relative angle between the W-axis and U-axis arms is a minimum of 15° and a maximum of 165°.

Fig. 4.1 (g) W/U limit interference angles (S-10)

4.2 θ -axis Stroke Modification

It is possible to limit the θ -axis stroke as required by the surroundings for the robot. The stroke can be changed as shown in Fig. 4.2 (a) by changing the dog position or the mechanical stop.

Include the position where the mastering jig is used (either one of $\theta = 0^\circ$, $+90^\circ$, -90°), select the + and - OT limits from the following:



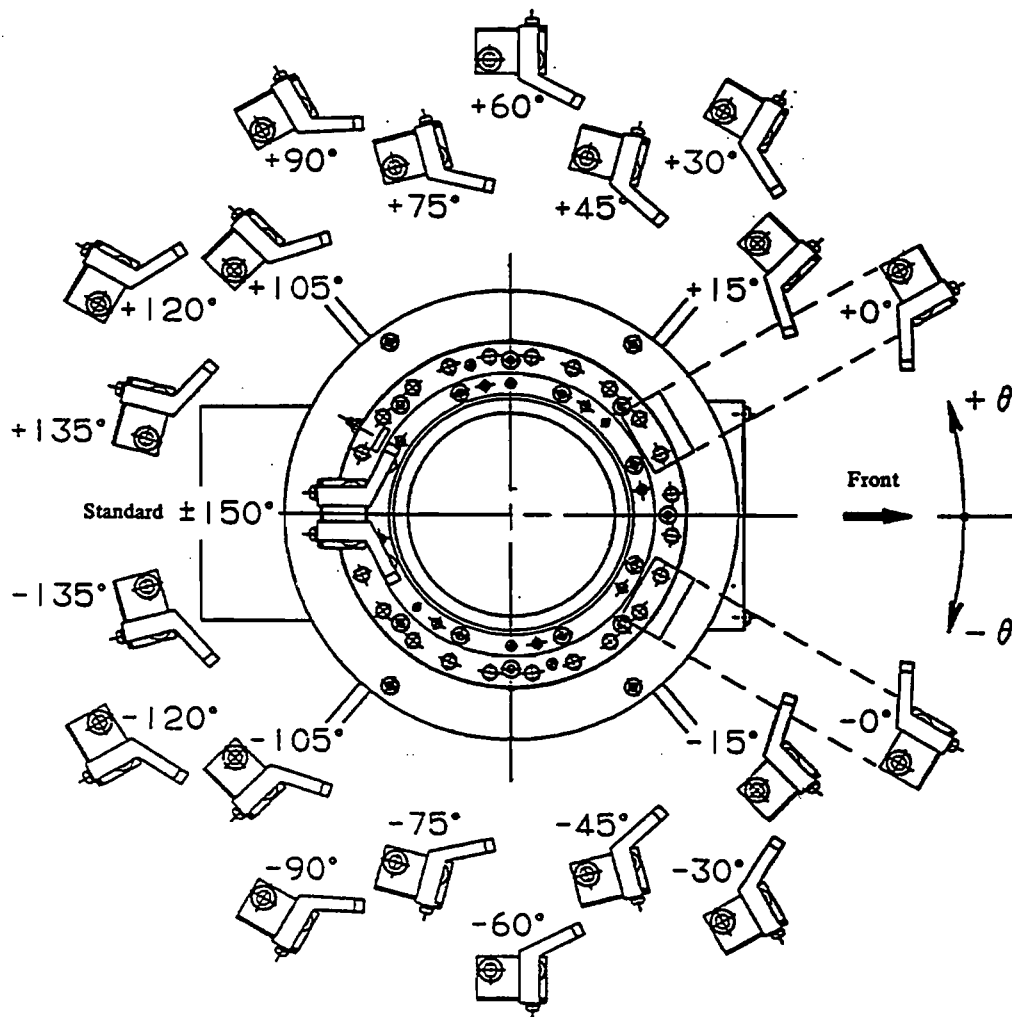
Note) Standard stroke
-150° to +150°

+0°	}	—	}	-0°
+15°				-15°
+30°				-30°
+45°				-45°
+60°				-60°
+75°				-75°
+90°				-90°
+105°				-105°
+120°				-120°
+135°				-135°
+150°				-150°

Fig. 4.2 (a) Changing the θ -axis stroke (S-10)

1) Changing the dog and mechanical stop positions

Change the dog and mechanical stop positions according to the desired stroke position as shown in Fig. 4.2 (b).



Note) The figure shows the top view of the θ -axis base.

Fig. 4.2 (b) Changing the dog and mechanical stop positions (S-10)

a) Changing the minimum and maximum command pulses

\$LOWERLIMS[1]: θ -axis stroke lower limit in radians

\$UPPERLIMS[1]: θ -axis stroke upper limit in radians

Set a numeral so that upper pulse should always be greater than lower pulse.

Position	\$LOWERLIMS[1] (θ -axis stroke lower limit in radians)	\$UPPERLIMS[1] (θ -axis stroke upper limit in radians)
-150°	-2.617993878	-
-135°	-2.356194490	-2.356194490
-120°	-2.094395102	-2.094395102
-105°	-1.832595714	-1.832595714
-90°	-1.570796326	-1.570796326
-75°	-1.308996939	-1.308996939
-60°	-1.047197551	-1.047197551
-45°	-0.785398163	-0.785398163
-30°	-0.523598775	-0.523598775
-15°	-0.261799387	-0.261799387
0°	0.0	0.0
+15°	0.261799387	0.261799387
+30°	0.523598775	0.523598775
+45°	0.785398163	0.785398163
+60°	1.047197551	1.047197551
+75°	1.308996939	1.308996939
+90°	1.570796326	1.570796326
+105°	1.832595714	1.832595714
+120°	2.094395102	2.094395102
+135°	2.356194490	2.356194490
+150°	-	2.617993878

4.3 Mastering Procedure

4.3.1 Introduction

This procedure describes the mastering procedure for a robot with an absolute pulse coder system. No operation is required for calibration with this system. The robot is automatically calibrated when power is turned on and the system becomes ready. Mastering is the establishment of an absolute reference point (or known location) as the mastering position of the robot. The known location can be the zero position (determined by aligning the zero witness marks on a particular axis or by making precise measurements according to specified distances) or a location determined by moving the axis into a mastering fixture. The method used for determining the known location is dependent on the robot model and is described in detail in Sections 4.3.3 and 4.3.4.

Using a mastering fixture is the most accurate and recommended mastering procedure. Note that the same mastering fixture should be used for all robots in a system.

Mastering is done at the factory and generally is not required as part of the daily operation. Mastering will need to be done when a mechanical part has been replaced or altered, if the system variables dealing with mastering have been lost or changed, or if the positional information from the absolute pulse coders has been lost.

4.3.2 Mastering procedure

1. Power up the controller.
2. Turn REMOTE ON/OFF switch ON. *(Clear fault on controller)*
3. Using the CRT/KB, call up the KCL display screen.
4. Using the teach pendant, jog the mechanical unit to the mastering position described in Section 4.3.3.

5. Using the CRT/KB (with REMOTE switch turned to ON) enter UTIL in response to the KCL> prompt.
6. In response to the UTIL> prompt enter MASTER.
7. Enter Y in response to the displayed question "Are you sure?"
8. At the prompt "Mastering at 0 degrees Y/N?" enter:
Y if you are mastering at the zero-degree position or
N if you are mastering using a mastering fixture.
9. Press ENTER twice.
10. Power down and up.

4.3.3 Zero-degree position

The zero-degree position of the S-10 robot is shown i Fig. 4.3.3.

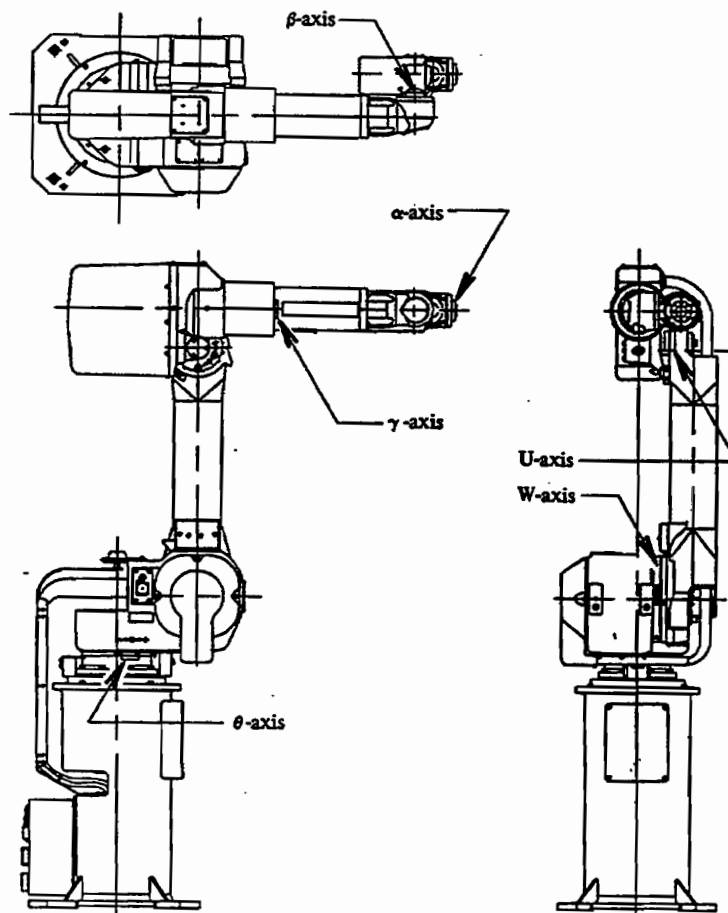


Fig. 4.3.3 Zero degree position marks of each axis (S-10)

4.3.4 Mastering using a mastering fixture

The robot has been mastered at the time of shipment. If the present value stored via the APC (Absolute Pulse Coder) differs from the actual position of each axis after a major component of the robot mechanical unit has been replaced, mastering is to be carried out to set the robot geometric position. Select one of $\theta = 0^\circ$, -90° or $+90^\circ$ according to the working area.

The robot should be calibrated to satisfy the following conditions.

- . Make the robot's base level. (1 mm/base)
- . Remove the wrist hand and related parts.
- . Do not allow an external force to be applied to the robot.

Note) The axis stroke is not checked during mastering. Be especially careful, therefore, regarding the robot axes movement.

1) Mastering procedure

If it is necessary to change the mastering point of the θ axis, change the system variable \$MASTER_POS[1] before mastering according to the following procedure:

1. Using the CRT/KB, call up the KCL display screen.
2. At the KCL> prompt, enter SET VAR\$MASTER_POS[1] =
-1.570796326: $\theta = -90^\circ$
1.570796326: $\theta = 90^\circ$
0: $\theta = 0^\circ$
3. When the KCL> prompt reappears, enter SSAVE SYS_STANDARD.

a) Assemble the mastering fixture

i) Assembly of fixture base

Assemble the fixture base as shown in Fig. 4.3.4 (a)

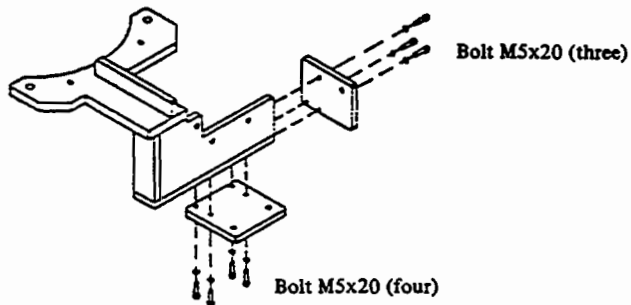


Fig. 4.3.4 (a) Assembly of fixture base (S-10)

ii) Mounting on robot body

After selecting the mastering position from among $\theta = 0^\circ$, -90° or 90° , mount the fixture on the θ -axis base using bolts and pins.

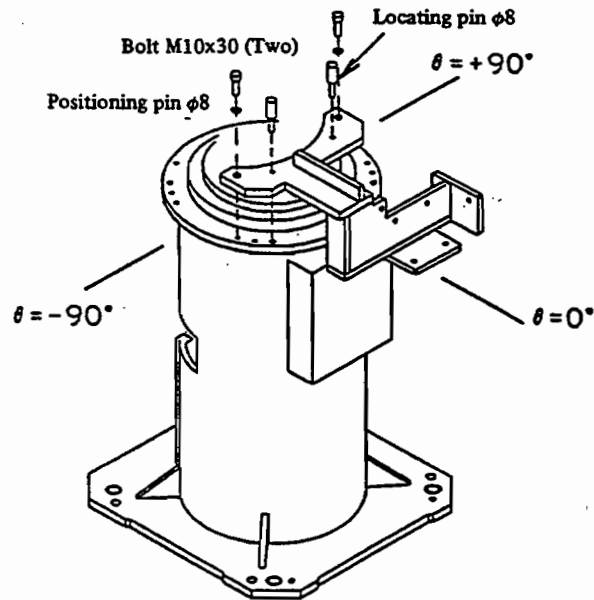


Fig. 4.3.4 (b) Mounting on robot body (S-10)

iii) Mounting of dial indicators

Mount six dial indicators on the base as shown in Fig. 4.3.4 (c) and set all the indicators to 3.00 mm using a calibration block. (Note that the dial indicator may break if the bolts are tightened too much).

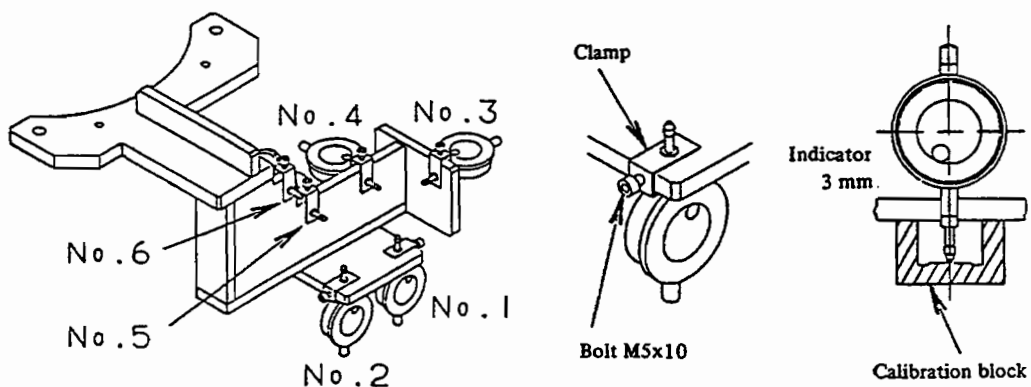


Fig. 4.3.4 (c) Mounting dial indicators (S-10)

iv) Mounting fixture on wrist

Jog the robot to the position where $\alpha = \beta = \gamma = 0^\circ$ and mount the fixture on the α -axis as shown in Fig. 4.4 (d). At this time, if it touches a mechanical stop at -190° and $+190^\circ$ position of γ -axis, set the γ -axis to 0° rotating it in the opposite direction.

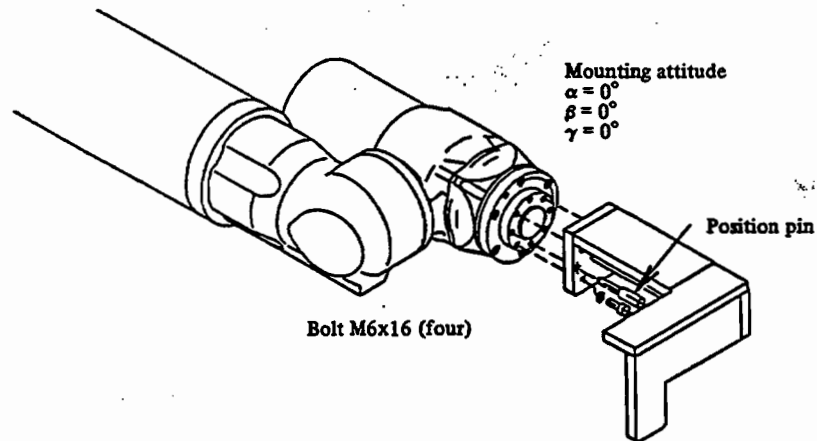


Fig. 4.3.4 (d) Mounting fixture on wrist (S-10)

b) Mastering procedure

Align each axis with the mastering fixture by jogging. To prevent an error due to the axis backlash at this time, turn the dial indicator so that it reads a higher value to reach the specified position. If the dial indicator was turned in the opposite direction by mistake, repeat the procedure from the beginning.

- 1) Move the robot slowly so that the dial indicator comes to the center of the marking line on the fixture mounted on the wrist.

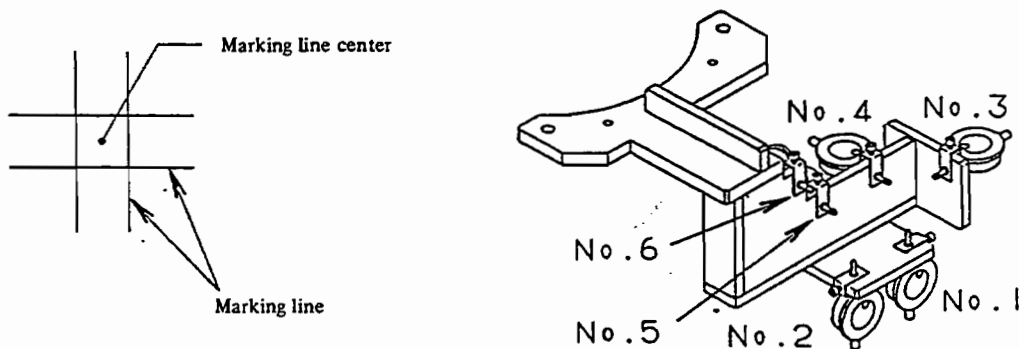


Fig. 4.3.4 (e) Dial indicator positioning (S-10)

- ii) Move the α axis so that the readings of dial indicators No.1 and No.5 are identical.
- iii) Jog the θ and γ axes so that the readings of dial indicators No.4 and No.5 are identical and that the reading of dial indicator No.3 is 3.00 mm. If the readings of dial indicators No.1 and No.2 are not the same at this time, make a correction so that they are identical.
- iv) Jog the W, U and β axes so that the readings of dial indicators No.2, No.5 and No.6 are 3.00 mm.
- v) Check that the readings of all dial indicators are 3.00 mm after the above operation.
- vi) Perform the mastering procedure described in Section 4.3.2.

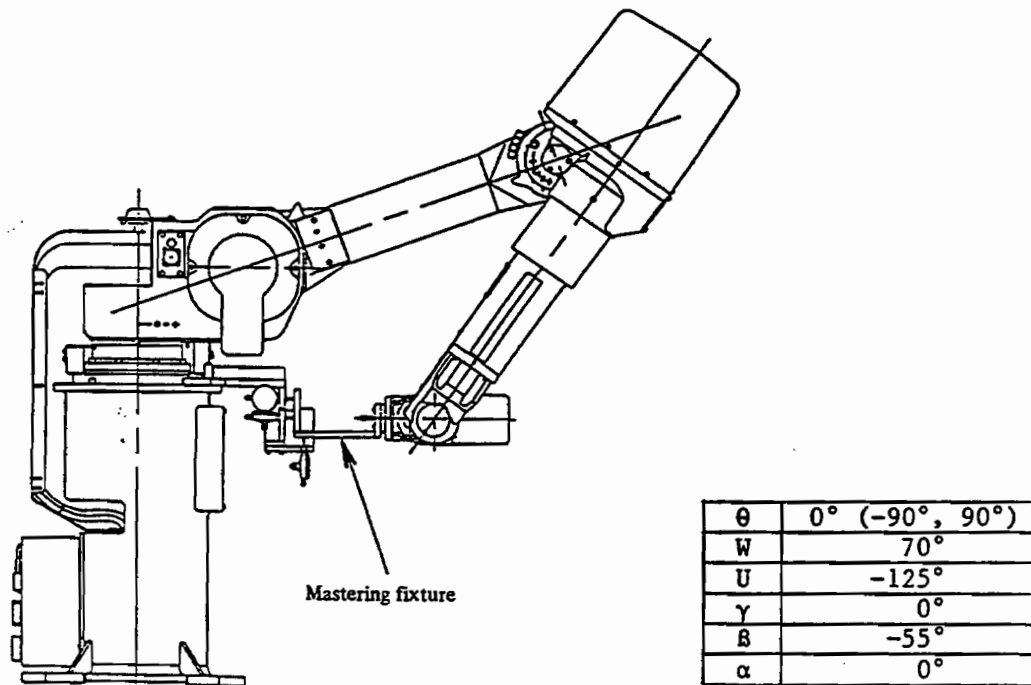


Fig. 4.3.4 (f) Mastering position

4.4 Adjusting U-axis Bevel Gear Backlash

- ① Remove the U-axis motor (Refer to 5.5)
- ② Remove the U-axis reducer (Refer to 5.6)
- ③ Remove the four M5 x 16 bolts, holder and gear D unit.
- ④ Remove the four M5 x 16 bolts, holder and gear C unit.
- ⑤ Adjust the backlash within 0.05 - 0.15 mm using shims (A290-7204-X421/X422/X430).
- ⑥ Reassemble reversing the above procedure. Coat the bolts and pins removed in steps ① - ④ lightly with LOCTITE and tighten the bolts with the specified torque. (See Fig. 4.6, 5.5 and 5.6)
- ⑦ After adjustment, apply grease according to Section 2 "LUBRICATING CONDITION CHECKS."

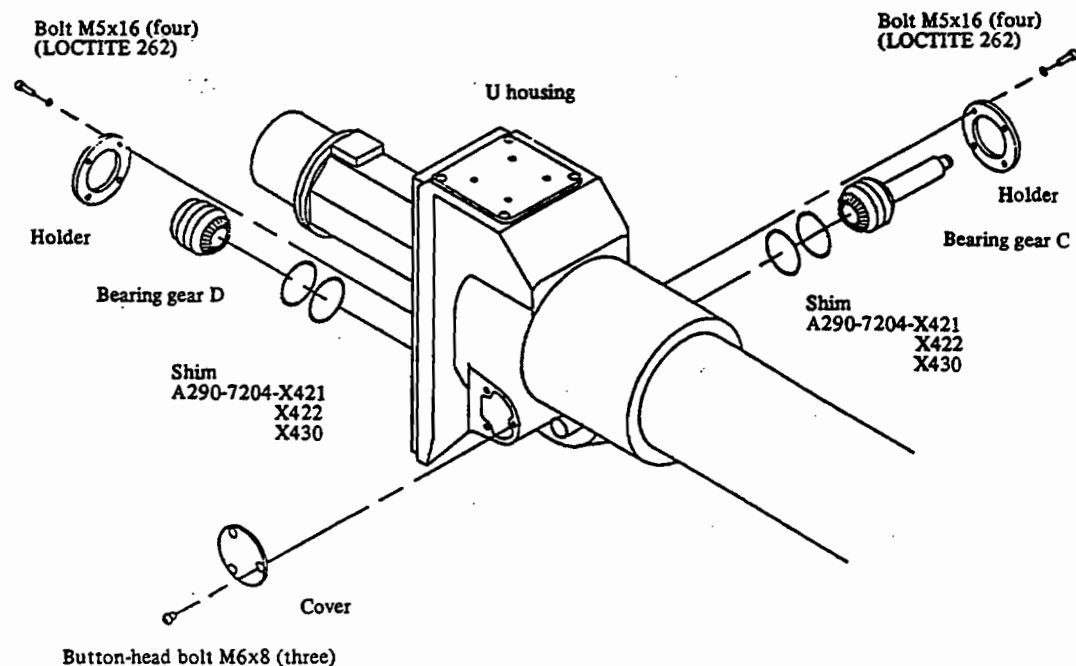


Fig. 4.4 Adjusting U-axis bevel gear backlash (S-10)

4.5 Adjusting β -axis Bevel Gear Backlash

- ① Remove the α -axis motor cover and then the α -axis unit from the bracket. (Refer to 5.7 ①, ②)
- ② Remove the wrist unit from the U-axis arm. (Refer to 5.8 ①, ②)
- ③ Remove the β -axis motor and the harmonic drive. (Refer to 5.8 ③ - ⑥)
- ④ Remove six M4x12 bolts, holder, and gear A unit.
- ⑤ Remove four M5x20 bolts, two $\phi 4 \times 16$ taper pins, and then the bracket.
- ⑥ Remove eight M5x12 bolts, holder, and gear B unit.
- ⑦ Adjust the backlash to a maximum of 0.02 mm at a distance of 300 mm measured from the center of rotation. Use shims (A290-7204-X521 - X526/X529/X530).
- ⑧ Reassemble reversing the above procedure. When assembling the holder removed in step ⑥, the position of the bolt for the stop should be at the base of U-axis arm.

Coat the bolts and pins removed in steps ① - ⑥ lightly with LOCTITE, and tighten the bolts with a specified torque. (See Fig. 4.7, 5.7 (a), 5.8 (a) and (b)).

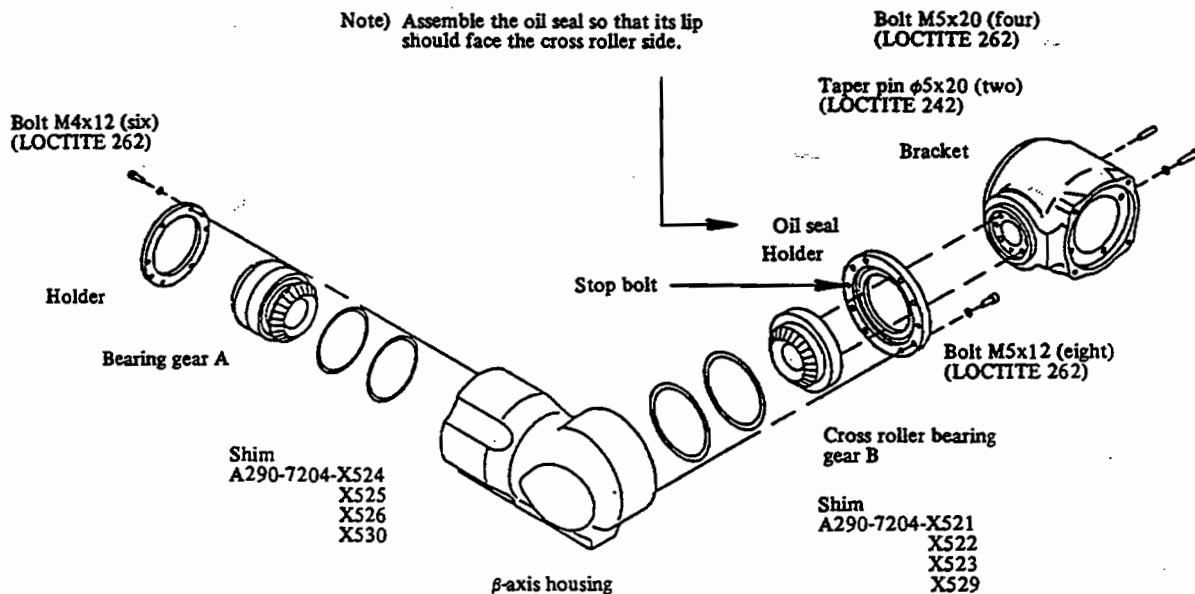


Fig. 4.5 Adjusting β -axis bevel gear backlash

5. REPLACING AND ADJUSTING PARTS

When a part is replaced, certain adjustments are required.

Parts requiring replacing and the items that require adjustment are listed below.

Replacement parts	Adjustment item
θ -axis motor	(a) Mastering (b) Dog adjustment
W- and U-axis motor	(a) Mastering
α -, β - and γ -axis motor	(a) Mastering
θ -, W- and U-axis reducer	(a) Mastering (b) Dog adjustment
γ -axis reducer, α -, and β -axis harmonic drive	(a) Mastering

5.1 Replacing θ -axis Motor

- ① Remove two bolts mounting the upper part of the cable guide to the W-axis base.
- ② Remove the stop and the dog from the bracket.
- ③ Remove the connector box and remove the connector of the θ -axis motor.
- ④ Remove eight M8x25 bolts and two $\phi 8$ x30 spring pins mounting the bracket to the θ -axis base, and lift the mechanical unit. At this time, take care not to apply excessive force to the cable, cable guide, and connector box.
- ⑤ Remove four M10x25 motor mounting bolts, and pull out the motor downward.
- ⑥ Remove the C-ring, washer, input gear, coupling, and the draw bolt, and then pull out the input spline.
- ⑦ Replace the motor and reassemble reversing the above procedure. Apply LOCTITE lightly to the bolts and the draw bolt pins removed in steps ④ - ⑥. Tighten bolts and draw bolts with the specified torque. (Refer to Fig. 5.1)

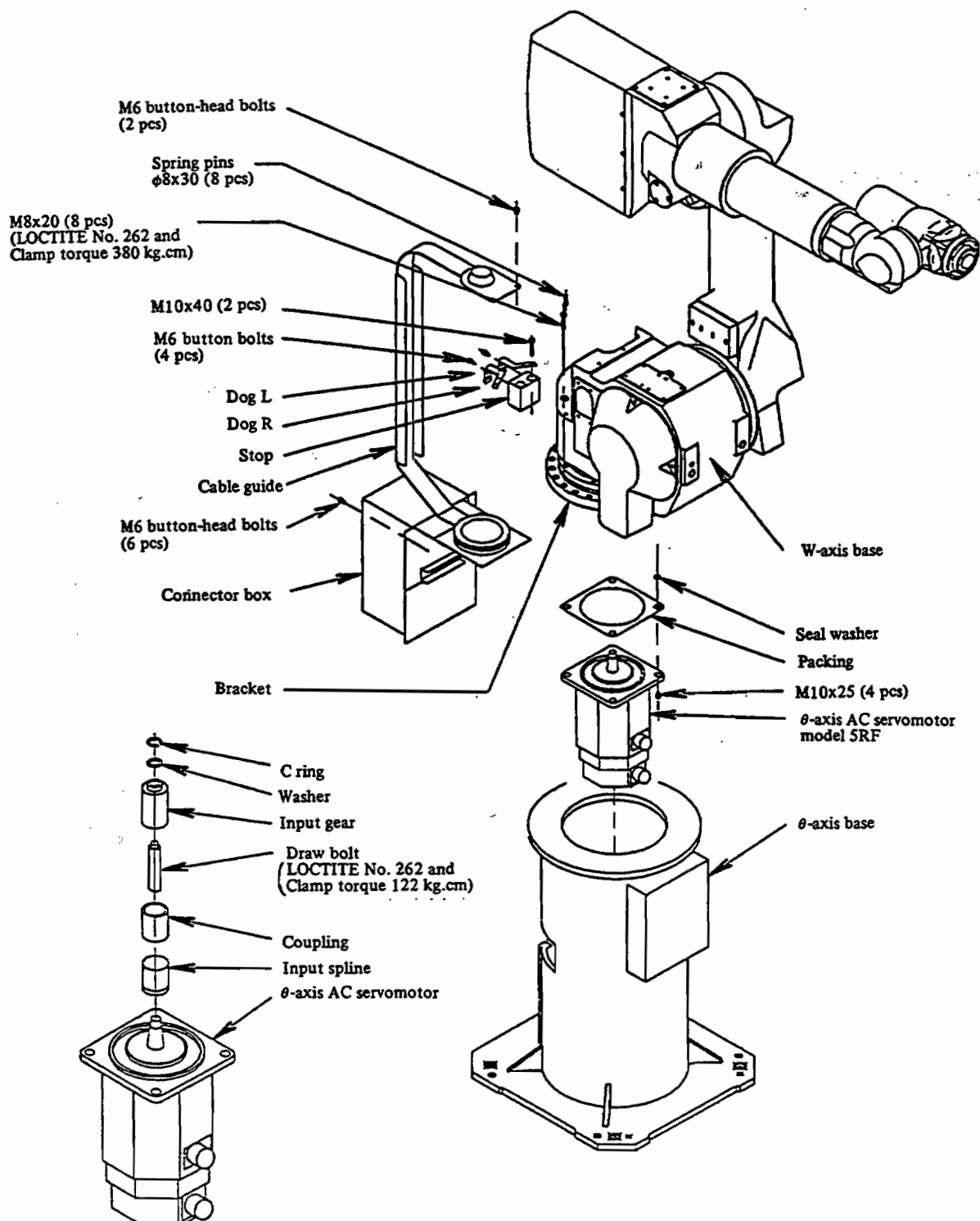


Fig. 5.1 (a) Replacing θ -axis motor (S-10)

5.2 Replacing θ -axis Reducer

- ① Remove two M6 button-head bolts mounting the upper part of the cable guide to W-axis base.
- ② Remove the stop and the dog from the bracket.
- ③ Remove the rear cover from the W-axis.
- ④ Remove three M12x40 bolts and two $\phi 10 \times 30$ taper pins mounting the W base to the θ -axis reducer, and lift the mechanical unit. At this time, take care not to apply excessive force to the cable, cable guide, and connector box.
- ⑤ Remove eight M6x30 bolts and two $\phi 5 \times 20$ taper pins mounting the θ -axis reducer to the bracket, and replace the reducer.
- ⑥ Reassemble reversing the above procedure. Apply a thin coat of LOCTITE to the bolts and pins removed in steps ④ and ⑤. Tighten the bolts with the specified torque. See Fig. 5.2.
- ⑦ Grease each part, referring to section 2.

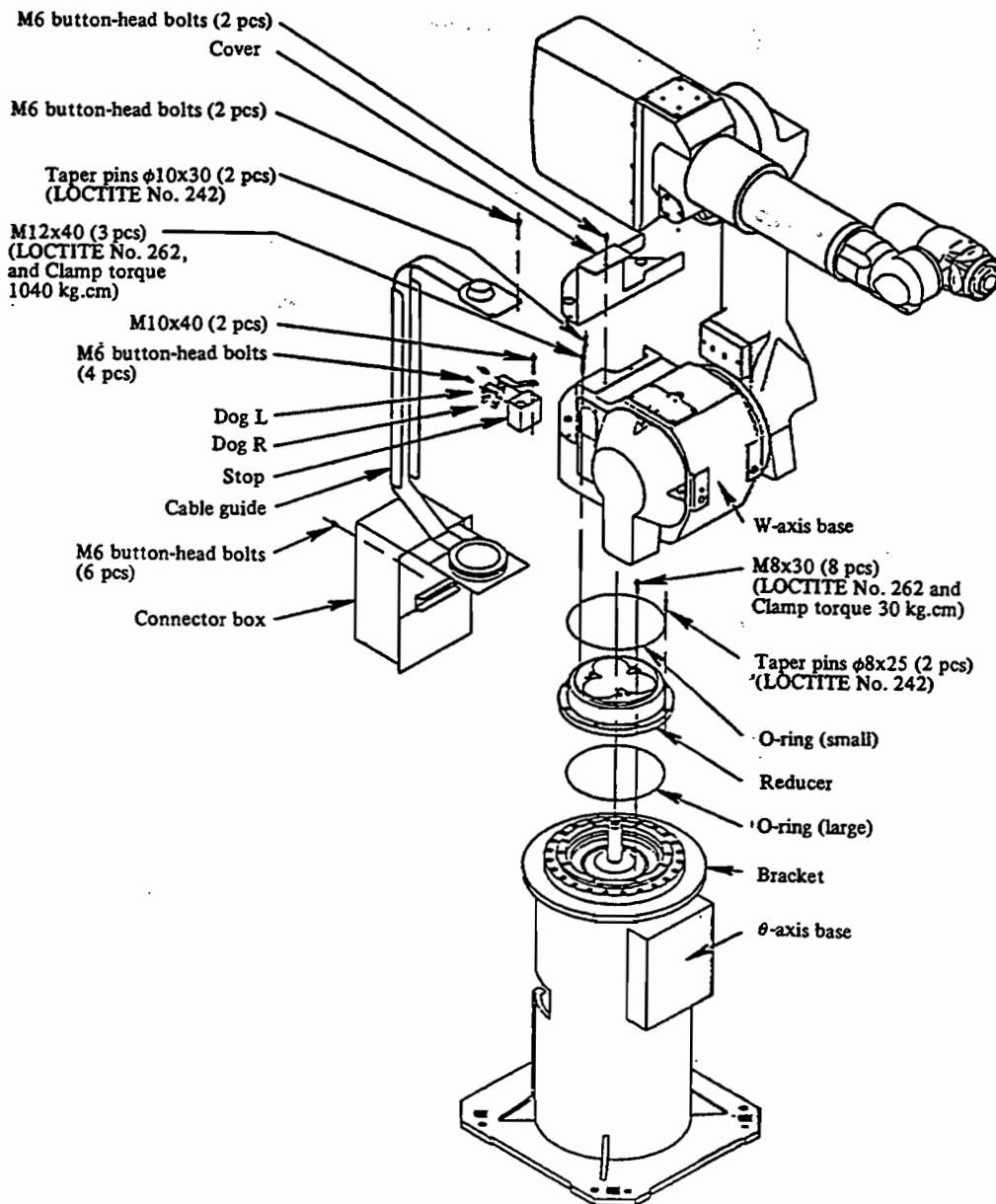


Fig. 5.2 Replacing θ -axis reducer (S-10)

5.3 Replacing W-axis Motor

- ① Press the W-axis against the mechanical stop or support the axis so it cannot move.
- ② Remove the side cover from the W-axis base and then the W-axis motor connector.
- ③ Remove four M10x25 bolts and the motor.
- ④ Remove the C-ring and pull out the input gear and the coupling. Remove the draw bolt and pull out the input spline. (See Fig. 5.1.)
- ⑤ After replacing the motor, reassemble reversing the above procedure. Apply LOCTITE lightly to the bolts, the draw bolt, and pins removed in steps ③ and ④. Tighten bolts with specified torque (See Fig. 5.1/5.3).

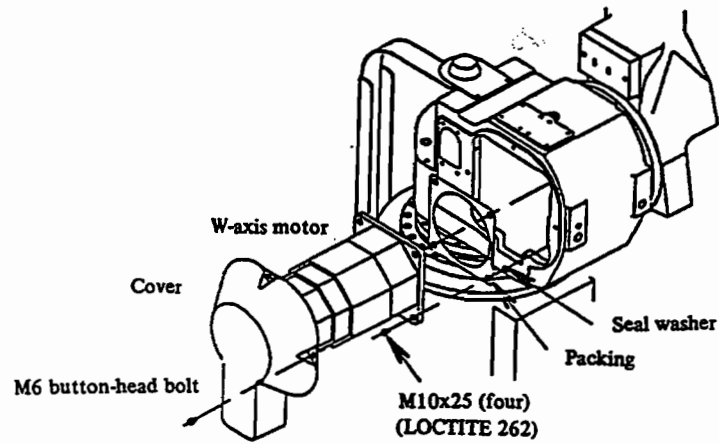


Fig. 5.3 Replacing W-axis motor (S-10)

5.4 Replacing W-axis Reducer

- ① Press the W-axis against the rear mechanical stop or support the axis so it cannot move.
- ② Remove clamps from below the W-axis base and side of W-axis arm in order to pull a cable out. If the cable can not be pulled enough, remove the connector of upper U-axis. (Refer to 7.2 ① and Fig. (a) - (c).)
- ③ Remove three M12x40 bolts, two $\phi 10 \times 30$ taper pins, and then the W-axis arm from the W-axis base.
- ④ Remove eight M8x30 bolts, two $\phi 8 \times 30$ taper pins mounting the W-axis reducer to the W-axis base, and then the reducer.
- ⑤ Replace the reducer, and reassemble reversing the above procedure. Lightly apply LOCTITE to the bolts and pins removed in steps ③ and ④. Tighten bolts with the specified torque.
- ⑥ After replacement, apply grease according to Section ② "LUBRICATING CONDITION CHECKS."

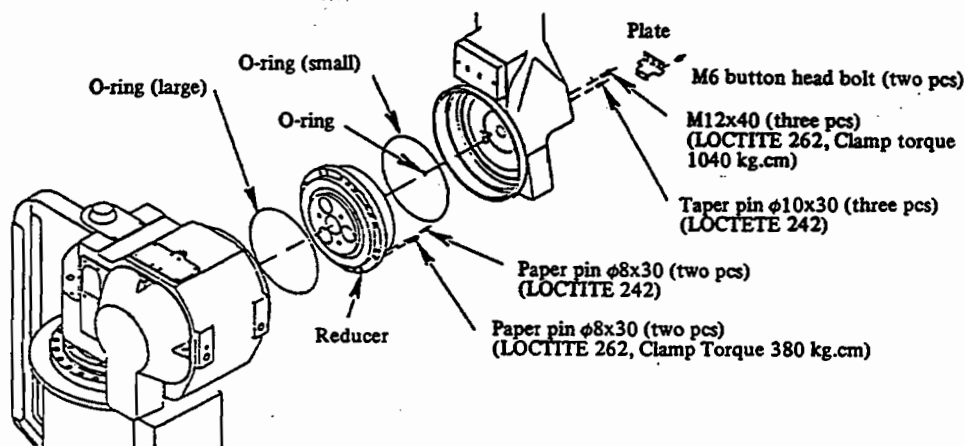


Fig. 5.4 Replacing W-axis reducer (S-10)

5.5 Replacing U-axis Motor

- ① Press the U-axis against the mechanical stop or support the axis so it cannot move.
- ② Remove the U-axis motor cover, U-axis cover, and then the U-axis motor connector.
- ③ Remove four M6x16 bolts and the motor.
- ④ Remove the hexagonal bolts from the motor shaft, and pull out the input spline.
- ⑤ After replacing the motor, reassemble reversing the above procedure. Apply LOCTITE lightly to bolts, nuts and pins removed in steps ③ and ④. Tighten bolts with the specified torque. (See Fig. 5.5)

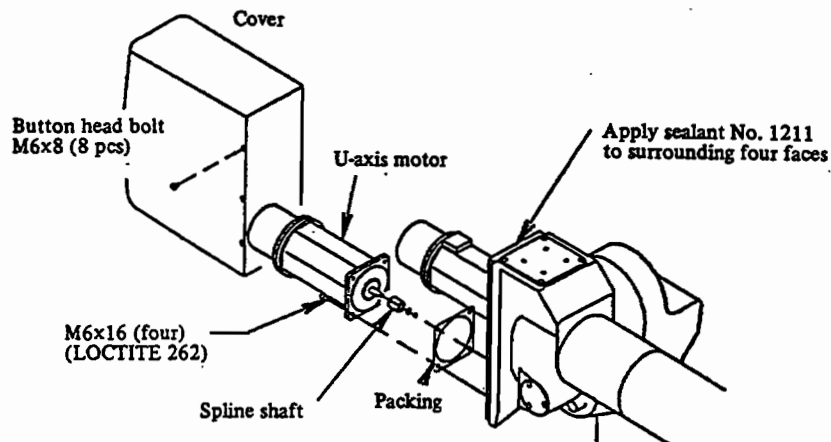


Fig. 5.5 Replacing U-axis motor (S-10)

5.6 Replacing U-axis Reducer

- ① Press the U-axis against the mechanical stop or support the axis so it cannot move.
- ② Remove the cable connected from W-axis arm to the U-axis. (Refer to 7.2 ① and Fig. (a) and (b).)
- ③ Remove four M10x40 bolts, two $\phi 8 \times 25$ taper pins, and then the U-axis unit from the W-axis arm.
- ④ Remove eight M6x30 bolts, two $\phi 5 \times 20$ taper pins, mounting the U-axis reducer to the U-axis unit and then the reducer.
- ⑤ Replace the reducer and reassemble reversing the above procedure. Lightly apply LOCTITE to the bolts and pins removed in steps ③ and ④. Tighten bolts with the specified torque.
- ⑥ After replacement, apply grease according to Section ② "LUBRICATING CONDITION CHECKS."

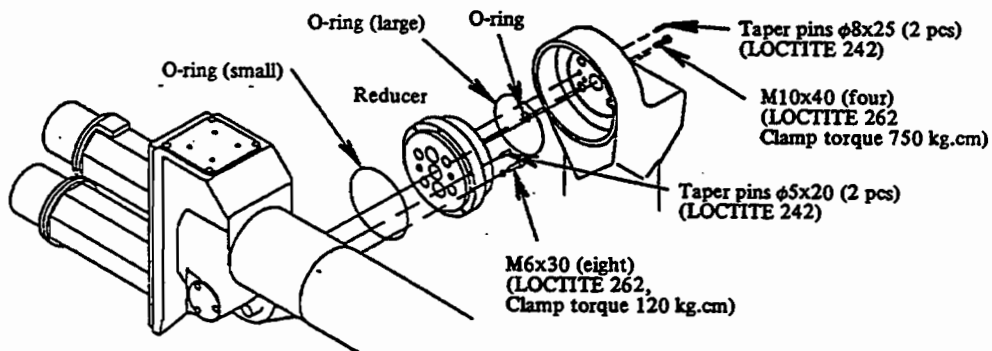
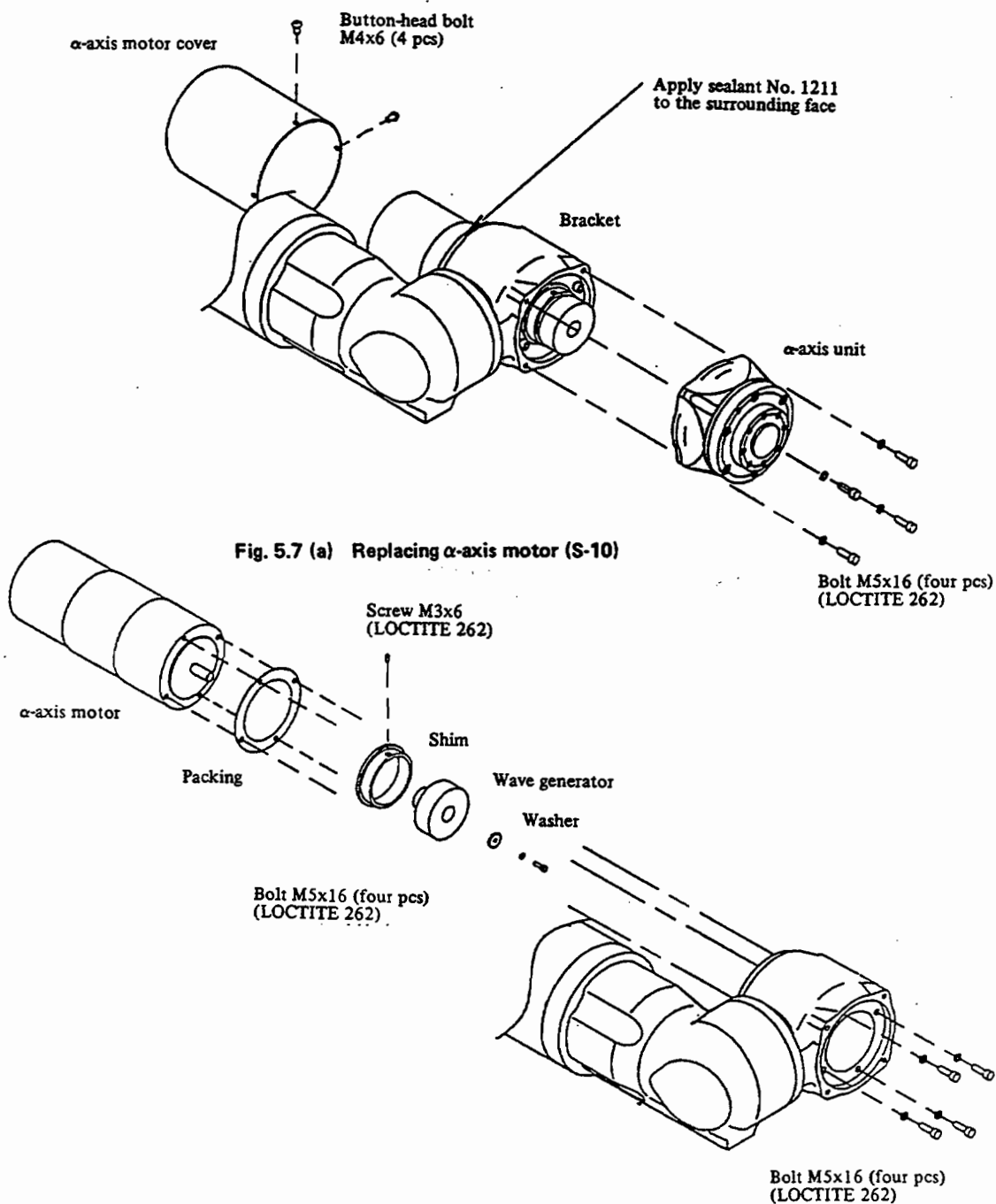


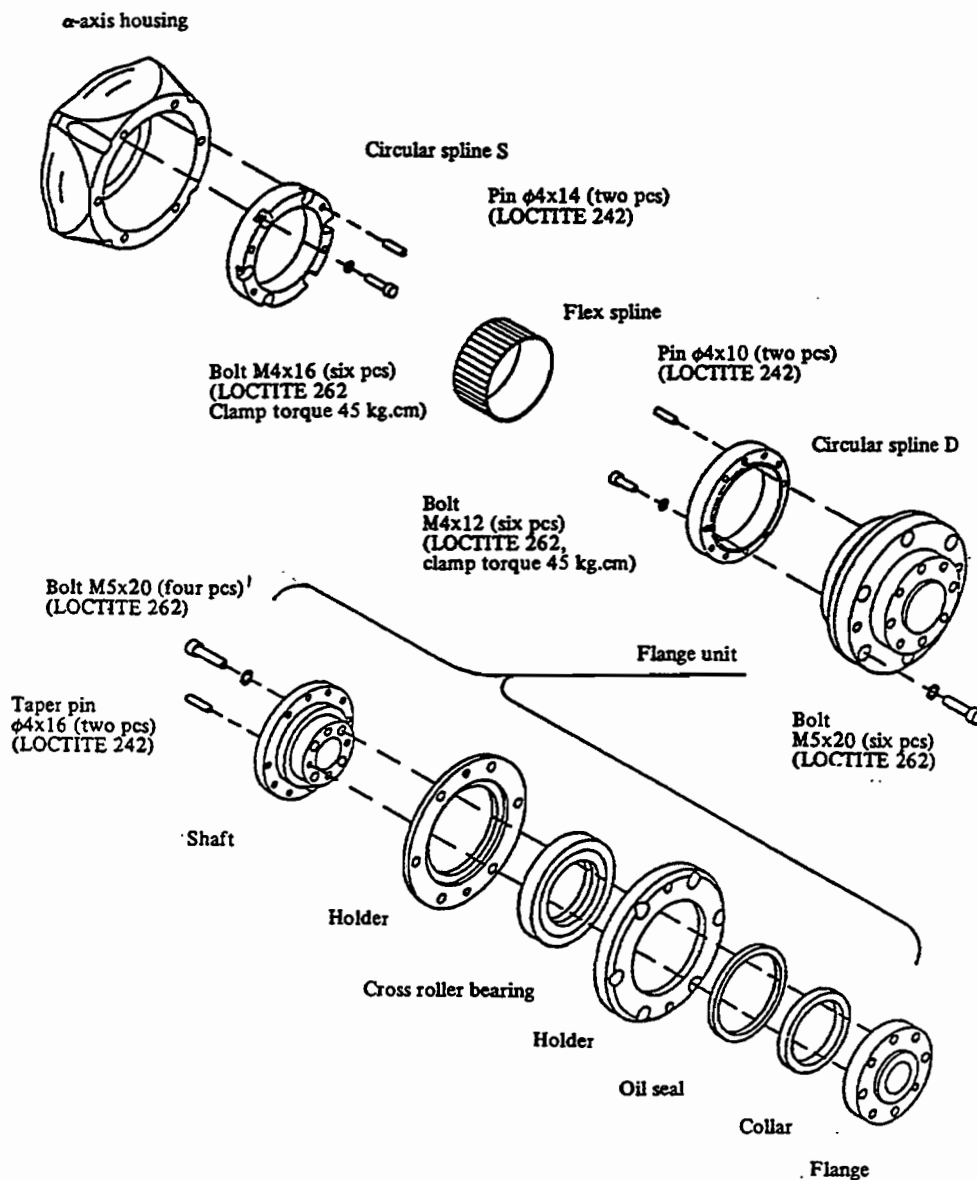
Fig. 5.6 Replacing U-axis reducer (S-10)

5.7 Replacing α -axis Motor and Harmonic Drive

- ① Remove the α -axis motor cover and the α -axis motor connector.
- ② Remove four M5x16 bolts and then the α -axis unit from the bracket.
- ③ Remove six M5x16 bolts and then the α -axis motor from the bracket.
- ④ Remove a screw M3x6, a bolt M3x10, and then the wave generator from the motor shaft.
- ⑤ If only the motor is replaced, reassemble reversing above procedure after replacing the motor. Apply LOCTITE lightly to bolts removed at ② - ④. (See Fig. 5.7 (a) and (b))



- ⑥ Remove six M5x20 bolts and the flange unit from α -axis housing.
- ⑦ Remove six M4x16 bolts, two $\phi 4 \times 14$ pins, and the circular spline S.
- ⑧ Remove six M4x12 bolts and two $\phi 4 \times 14$ pins and the circular spline D.
- ⑨ Remove eight M5x20 bolts and two $\phi 4 \times 16$ taper pins from the flange unit removed in step ⑥, and remove the flange, the holder, and the cross roller bearing. (The cross roller bearing must be replaced.)
- ⑩ Replace the flex spline, the circular splines S and D, and the wave generator, and reassemble reversing above procedure. At this time, lightly apply LOCTITE to the bolts and pins removed in steps ② - ⑨. Tighten bolts with specified torque.
- ⑪ After replacement, apply grease according to Section 2.



Note) Assemble oil seal so that the lip faces the cross roller side.

Fig. 5.7 (c) Replacing α -axis harmonic drive (S-10)

5.8 Replacing β -axis Motor and Harmonic Drive

- ① Remove the cable cover from the U-axis arm and then the β -axis motor connector. (Refer to 7.2 ② and Fig. 7.2 (a) to (f).)
- ② Remove four M5x30 bolts and a $\phi 5$ x30 spring pin, and remove the wrist unit from the U-axis arm.
- ③ Remove four M4x12 bolts and then the motor.
- ④ Remove the plate and pull out the wave generator.
- ⑤ If only the motor is replaced, reassemble reversing above procedure after replacing the motor. Apply LOCTITE lightly to the bolts and pins removed in steps ② - ④. (See Fig. 5.8 (a))

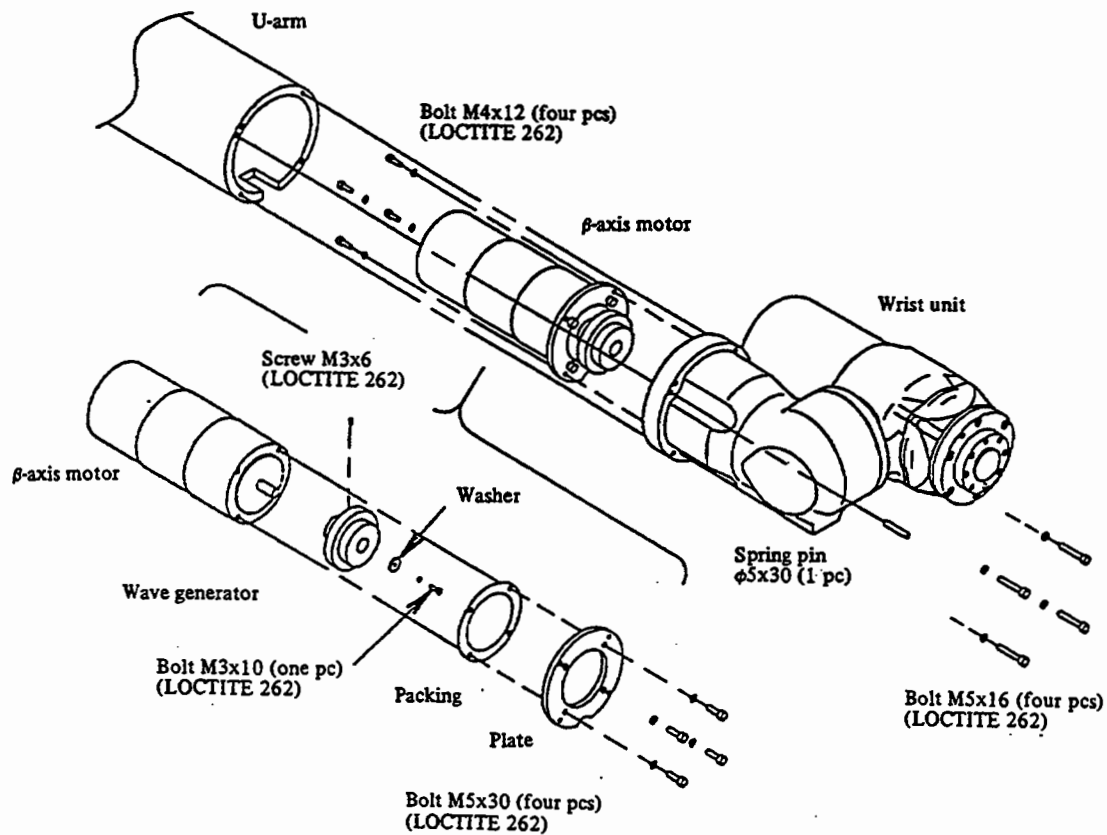


Fig. 5.8 (a) Replacing β -axis motor (S-10)

- ⑥ Remove six M5x20 bolts and the two $\phi 4 \times 20$ spring pins, and remove the holder from the β -axis housing.
- ⑦ Remove six M5x16 bolts, two $\phi 5 \times 20$ taper pins, the flex spline and the holder.
- ⑧ Remove six M5x25 bolts, two $\phi 4 \times 20$ taper pins, and then the circular spline from the holder.
- ⑨ Replace the flex spline, the circular spline, and the wave generator, and reassemble reversing above procedure. At this time, lightly apply LOCTITE to all the the bolts and pins removed in steps ② - ⑧. Tighten bolts with the specified torque. (See Fig. 5.8 (a) and (b))
- ⑩ After replacement, apply grease according to Section 2.

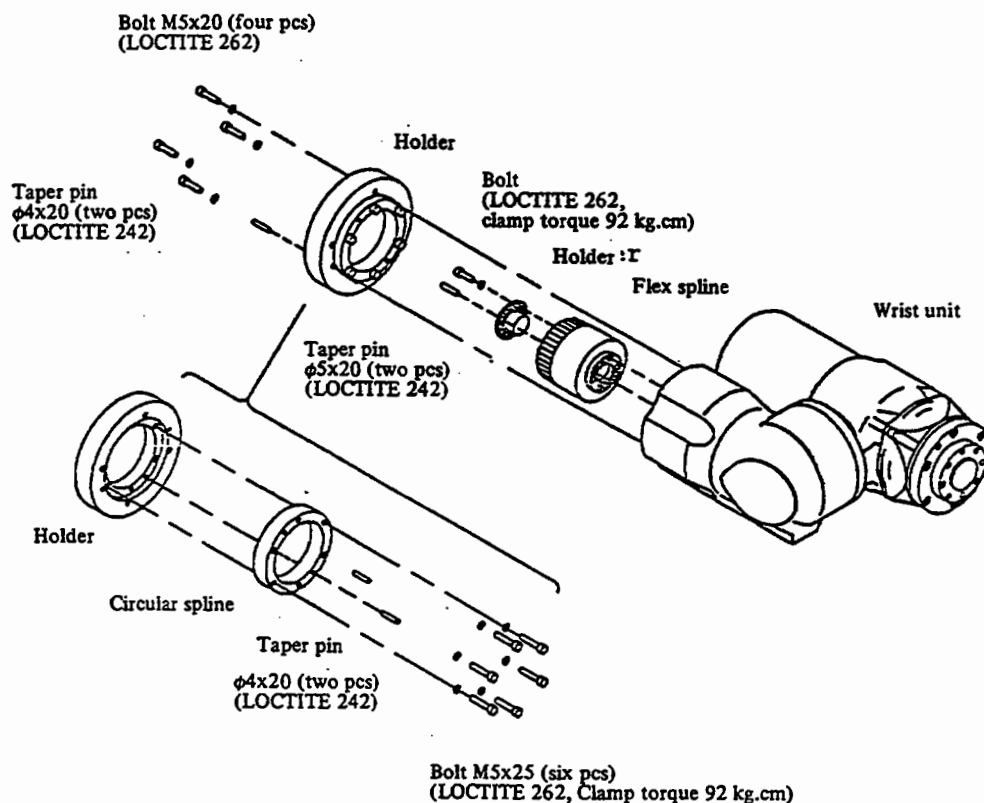


Fig. 5.8 (b) Replacing β -axis harmonic drive (S-10)

5.9 Replacing γ -axis Motor and Reducer

- ① Remove the U-axis cover and U-axis motor connector.
- ② Remove the four M6x20 bolts mounting the motor and then the motor.
- ③ Remove the hexagonal nuts and the draw bolts.
- ④ If only the motor is replaced, reassemble reversing above procedure after replacing the motor. Apply LOCTITE lightly to the bolts and nuts removed in steps ② and ③. Apply a thin coat of LOCTITE on the hexagonal nut of the motor shaft and tighten to the specified torque. (See Fig. 5.9 (a).)

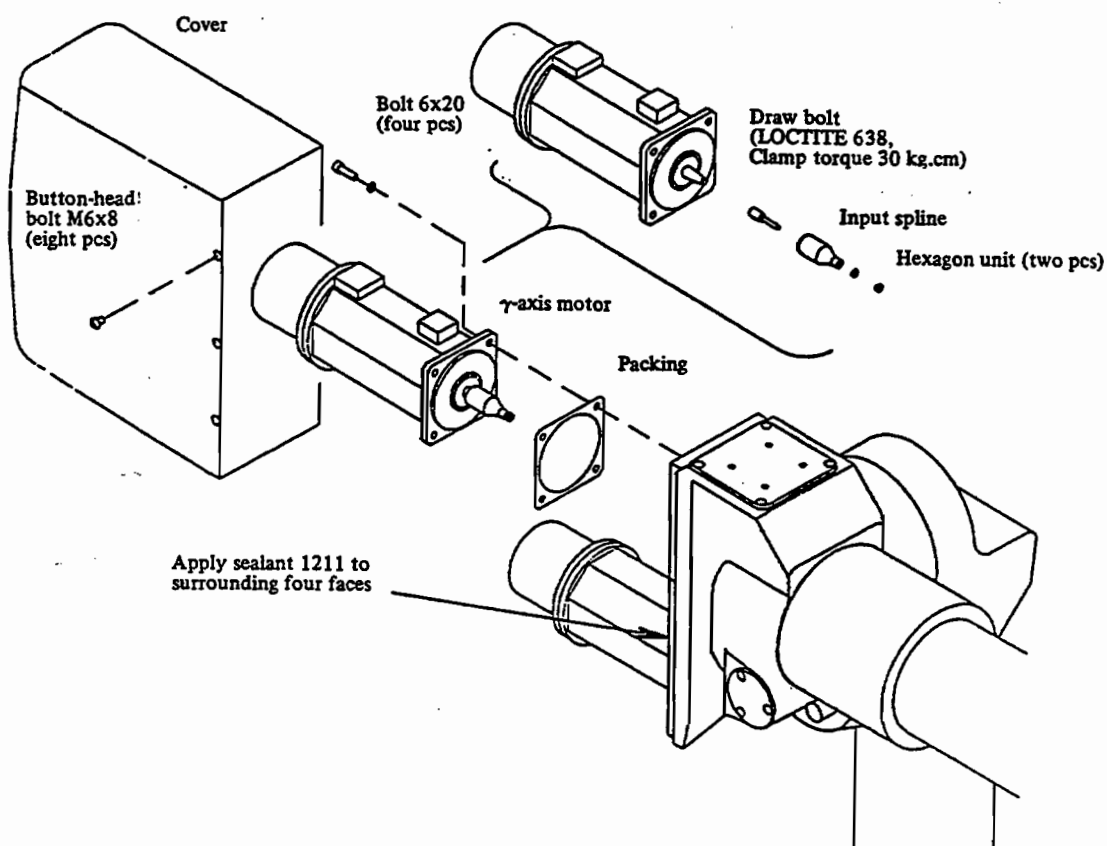


Fig. 5.9 (a) Replacing γ -axis motor (S-10)

- ⑥ Remove four M6x16 bolts, and then the holder.
- ⑦ Remove four M6x55 bolts.
- ⑧ Remove eight M5x35 bolts, and then the reducer from the U-axis housing.
- ⑨ Replace the reducer and reassemble reversing the above procedure. At this time, lightly apply LOCTITE to bolts and nuts removed in steps ② - ⑦. Tighten nuts with specified torque. (Refer to 5.9 ② and Fig. (b).)
- ⑩ After replacement, apply grease according to Section 2.

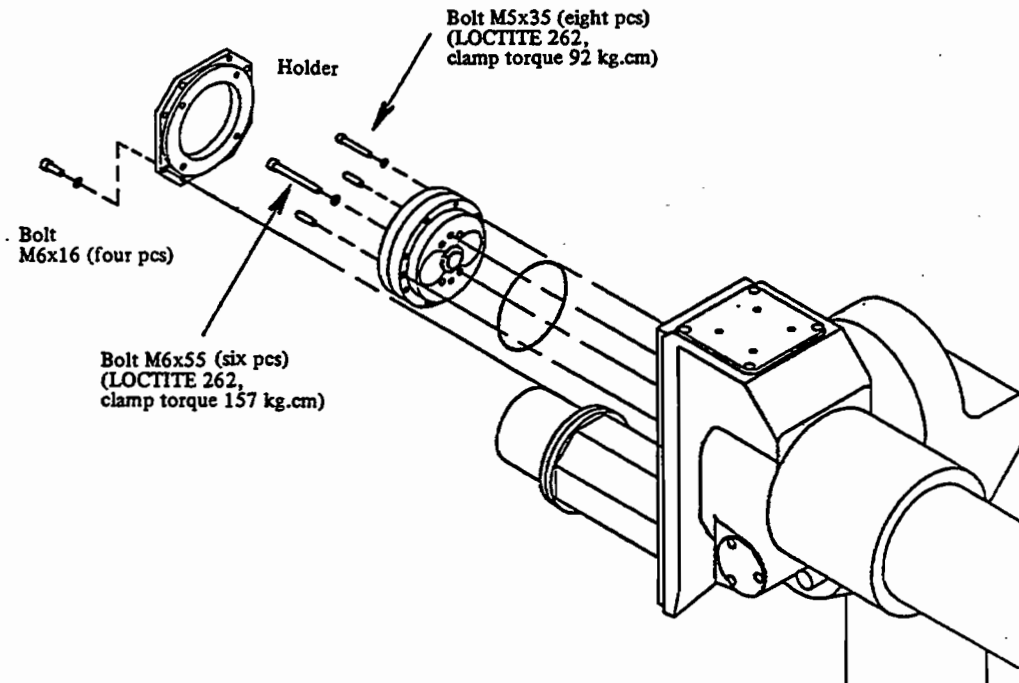
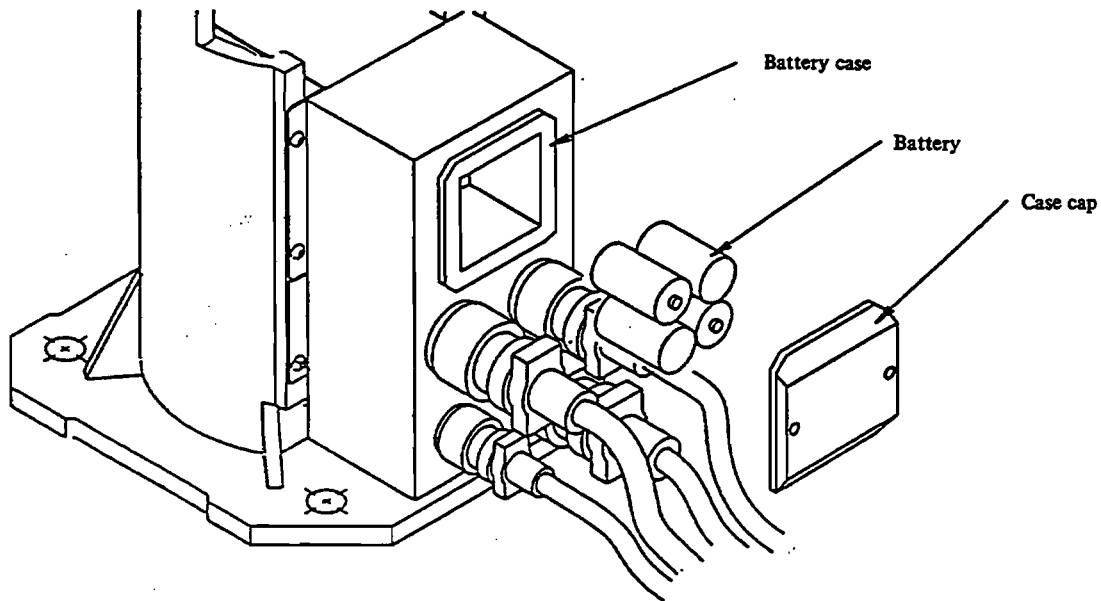


Fig. 5.9 (b) Replacing γ -axis reducer (S-10)

5.10 Replacing Battery (APC BATTERY)

The data of the home position of each of the robot axes is stored by the Absolute Pulse Coder, which is powered by the backup batteries. The batteries must be replaced every year. They should be replaced as follows.

- 1) Turn the power on.
Press the EMERGENCY STOP button to prohibit the robot operation.
- 2) Remove the battery case cap.
- 3) Remove the old batteries from the battery case.
- 4) Set the new batteries in the battery case. Pay careful attention to the direction of each battery.
- 5) Remount the battery case cap.



Battery specifications: A98L-0031-0005, 4 batteries, 1.5 V, size D

Fig. 5.10 Replacing batteries (S-10)

6. WIRING AND PIPING

6.1 Piping Diagram

Fig. 6.1 shows the internal piping diagram of the mechanical unit.

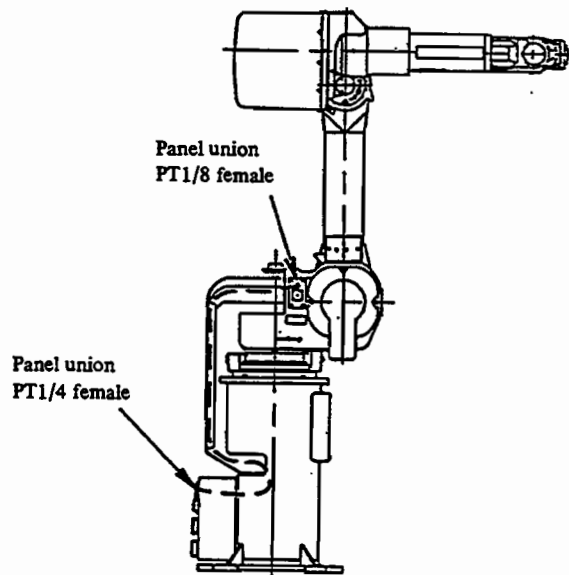


Fig. 6.1 Piping diagram (S-10)

6.2 Wiring Diagram

Fig. 6.2 shows mechanical unit wiring diagram.

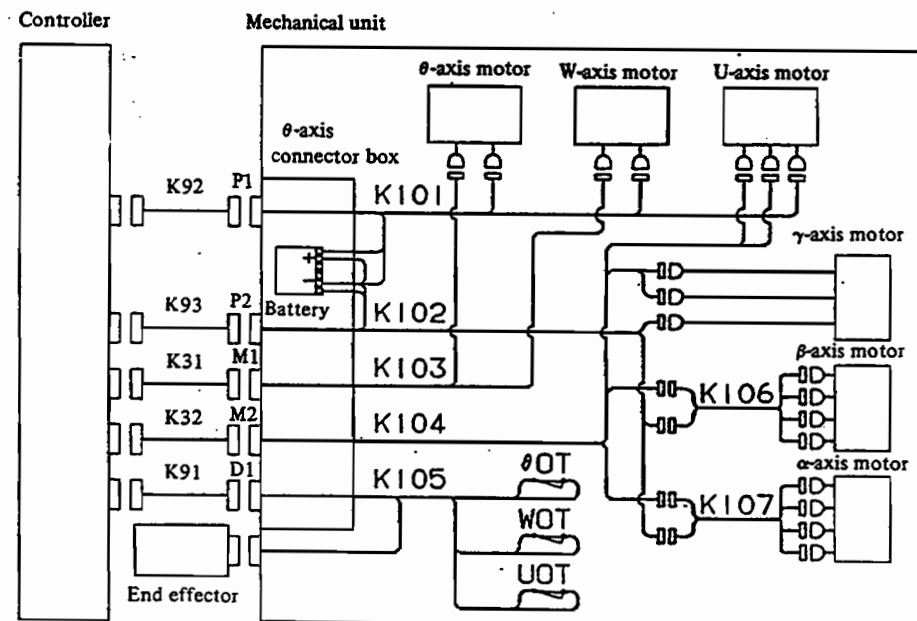


Fig. 6.2 Mechanical unit wiring diagram (S-10)

6.3 Limit Switch Installation Diagram

Fig. 6.3 shows the installation diagram for the limit switches.

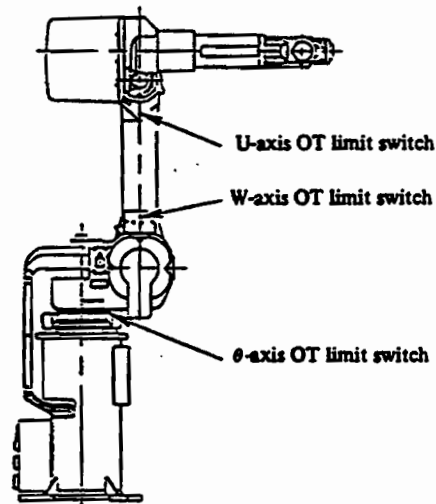


Fig. 6.3 Limit switch installation diagram (S-10)

6.4 Cable Installation Diagram

Visually check the following:

- 1) Check the whether connecting cables in the robot rotational part are distorted or bent by the robot rotation.
- 2) Check whether the routing of the cables connected to the W- and U-axes is distorted or bent by the elbow motion.
- 3) Check whether the routing of the cables connected to the end effector is suitable to the wrist motion or the service motion of the robot.

In Fig. 6.4 the installation diagram for the cables in the mechanical unit is shown.

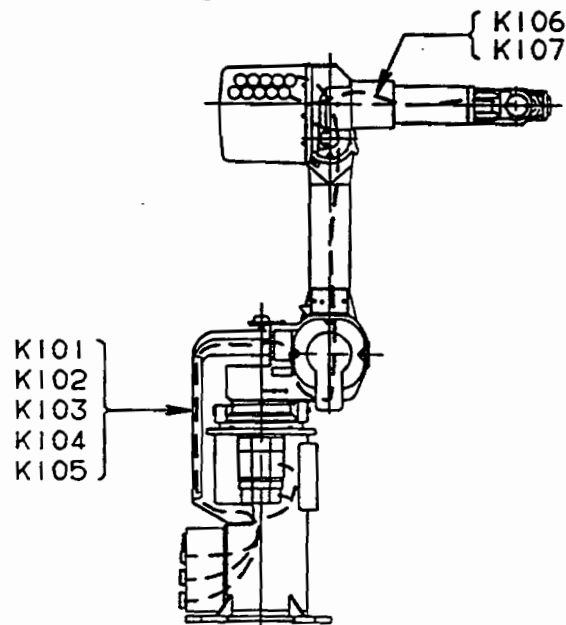


Fig. 6.4 Mechanical unit cable installation diagram (S-10)

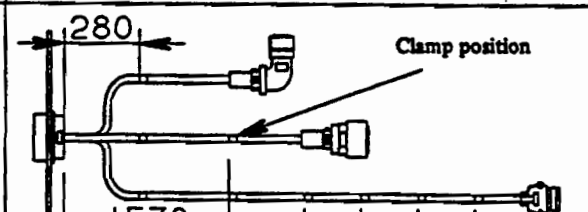
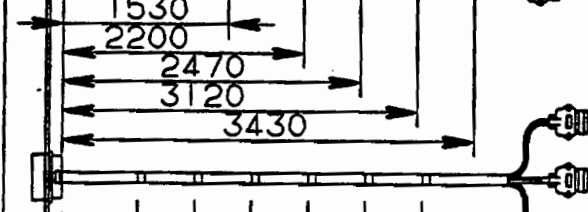
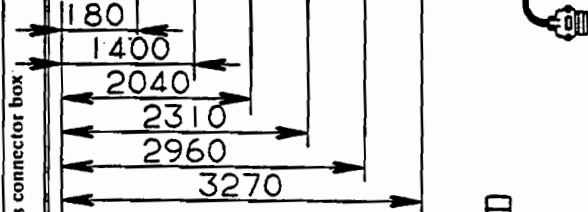
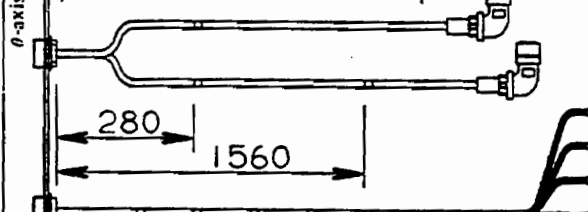
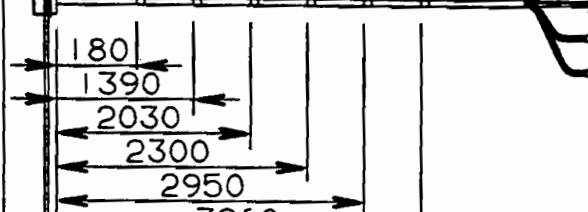
7. REPLACING CABLES

A broken or damaged cable should be replaced as specified in this section. If the pulse coder cable (K101, K102, K106, K107) connector is disconnected the motor loses its absolute position. When the motor loses its absolute position, mastering must be carried out.

7.1 Cable Forming

When mounting the replaced cable with clamps and tie wraps, clamp it at the positions specified in Table 7.1. Unless the cable is clamped at the specified positions, the cable may be broken due to excessive sagging or tension.

Table 7.1 Cable clamping positions (S-10)

Stamp	Cable clamping position	Stamp	Cable No.
P1		θ P	K101
		WP	
		UP	
P2		γ P	K102
		β P	
		α P	
M1		θ M	K103
		WM	
		UM	
M2		UBK	K104
		γ M	
		γ BK	
		β M	
		α M	
P21		EE	K105

7.2 Replacing Cables

1) Replacing cables K101, K102, K103, K104

- ① After removing the U-axis cover, cut the tie wrap to remove the connector and two clamps. (Fig. 7.2 (a))
- ② Remove the U-axis and W-axis cable covers and the W-axis arm clamps (2 clamps), cut the tie wrap, and pull out the cable from under the W-axis arm. (Fig. 7.2 (b))
- ③ Remove the W-axis motor cover and disconnect the connector. Remove the W-axis base clamps (2 clamps) and cut the tie wrap. (Fig. 7.2 (c))
- ④ Disconnect the end effector connector and air hose. (Fig. 7.2 (d))
- ⑤ Remove the θ -axis cable cover and the cable guide from the W-axis base.
- ⑥ Remove the θ -axis connector box from the θ -axis base and pull it out toward you together with the cable guide.
- ⑦ Disconnect the θ -axis motor connector.
- ⑧ Cut the cable guide tie wrap.
- ⑨ Remove the θ -axis connector box cover A, cut the tie wrap, and then remove the cover B.
- ⑩ Replace the cable and mount the new cable reversing the above procedure.
- ⑪ Remaster the robot (Refer to 4.3.)

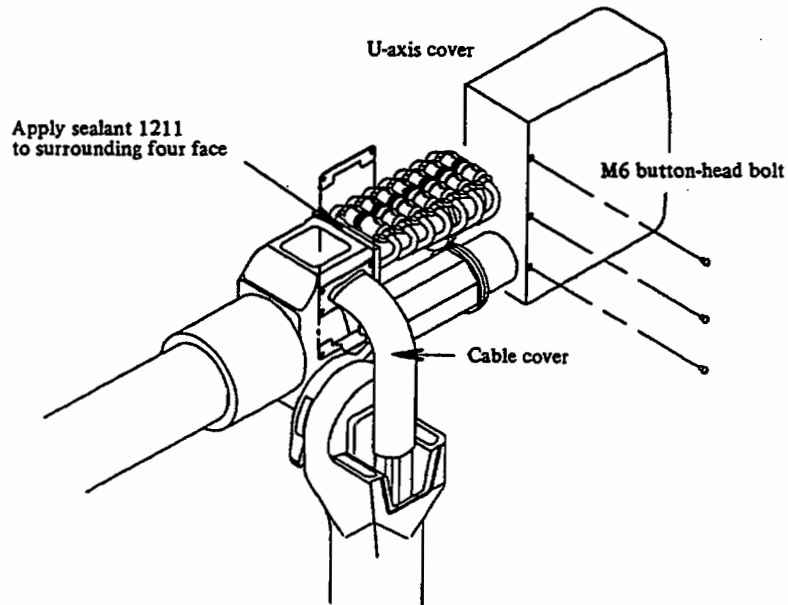


Fig. 7.2 (a) Replacing cables K101, K102, K103, K104, K105 (S-10)

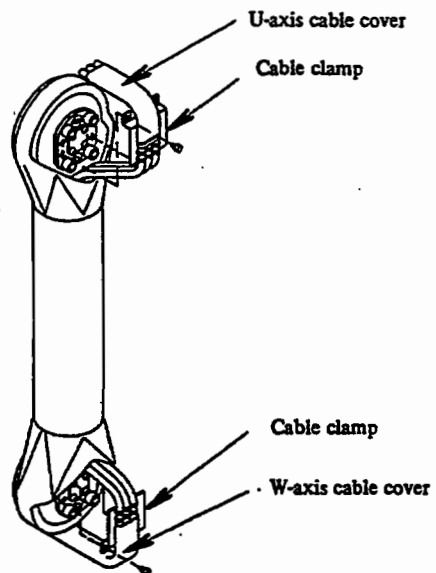


Fig. 7.2 (b) Replacing cables K101, K102, K103, K104, K105 (S-10)

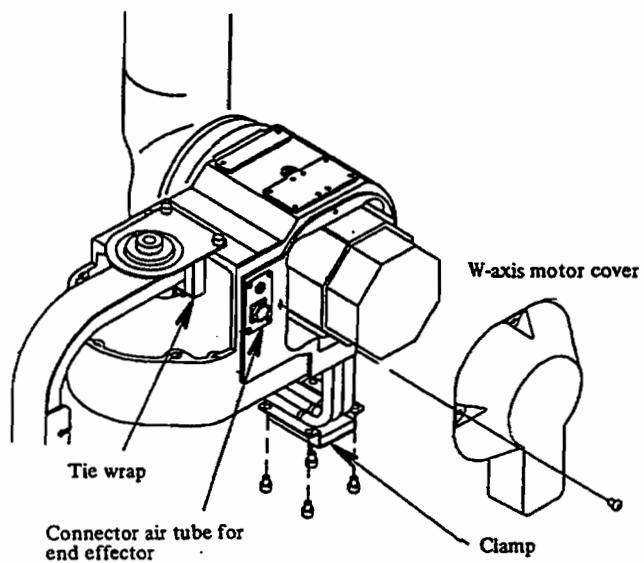


Fig. 7.2 (c) Replacing cables K101, K102, K103, K104, K105 (S-10)

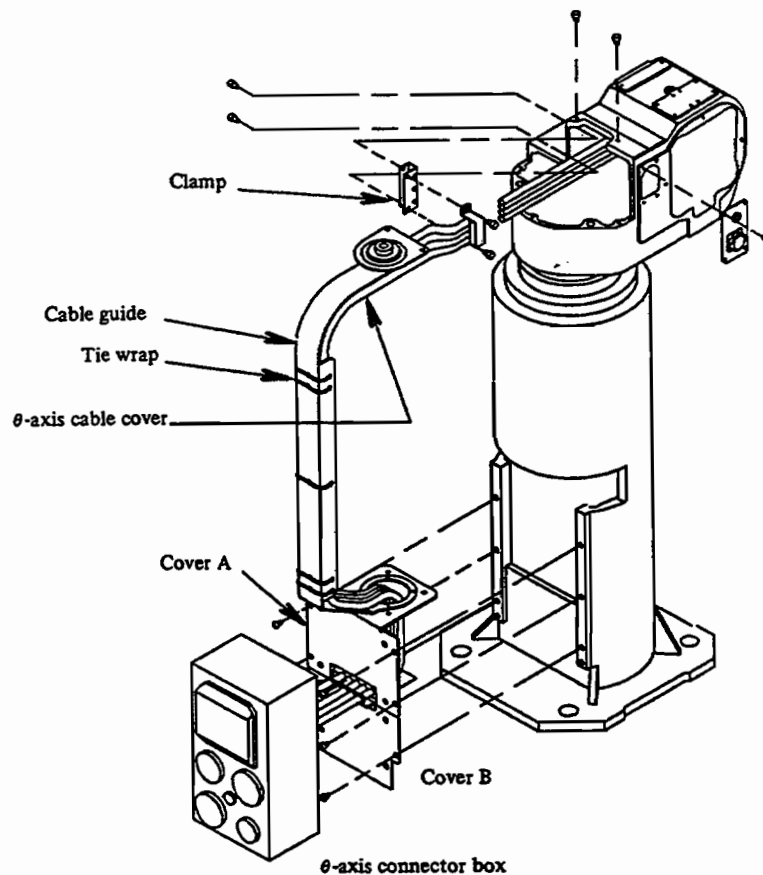


Fig. 7.2 (d) Replacing cables K101, K102, K103, K104, K105 (S-10)

2) Replacing cables K106 and K107

- ① Remove the U-axis cover and the connector marked with P2, M2 SP and SM (Fig. 7.2 (e)) (Remove the connector marked with SP and SM if only K106 is replaced)
- ② Remove the U-axis arm cover and remove two M6 button head bolts mounting the cable cover and slide the cover forward.
- ③ Remove the clamp and draw out the cable together with the connector. (Fig. 7.2 (f))
- ④ Cut the tie-wrap and disconnect the connector.
- ⑤ Replace cable K106.
- ⑥ Remove the α-axis motor cover and the connector. (Fig. 7.2 (f))
- ⑦ Remove β-axis covers A and B, and the clamp. Cut the tie wrap.
- ⑧ Pull out the tube together with the cable and draw out the end connector via the gear box.
- ⑨ Replace the cable after removing it from behind the U-axis arm. Reassemble reversing the above procedure. (Apply sealant No. 1211 to the β-housing groove)
- ⑩ Reassemble the clamp and the cover just as before, connecting each connector.
- ⑪ Remaster the robot. (Refer to 4.3.)

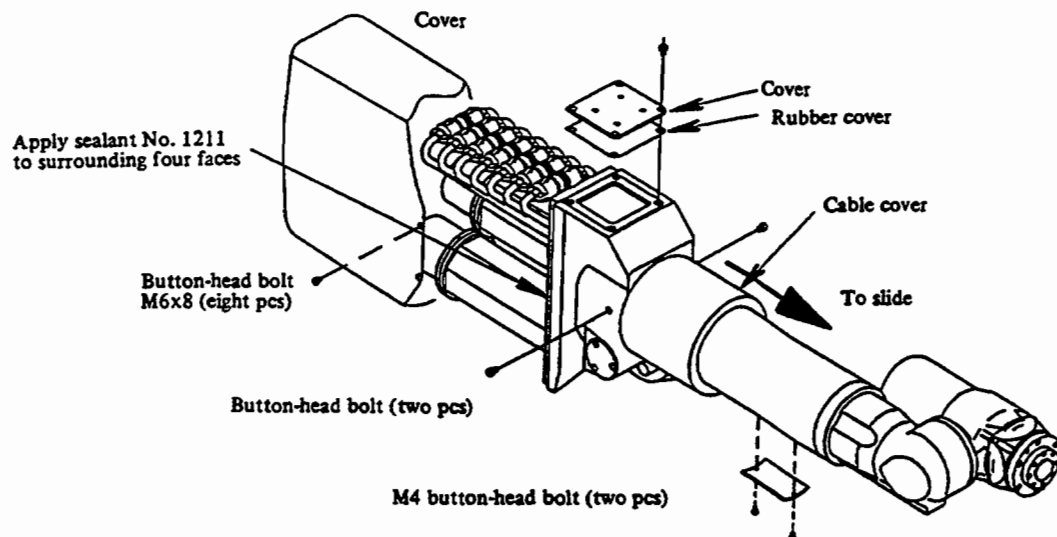


Fig. 7.2 (e) Replacing cables K106, K107 (S-10)

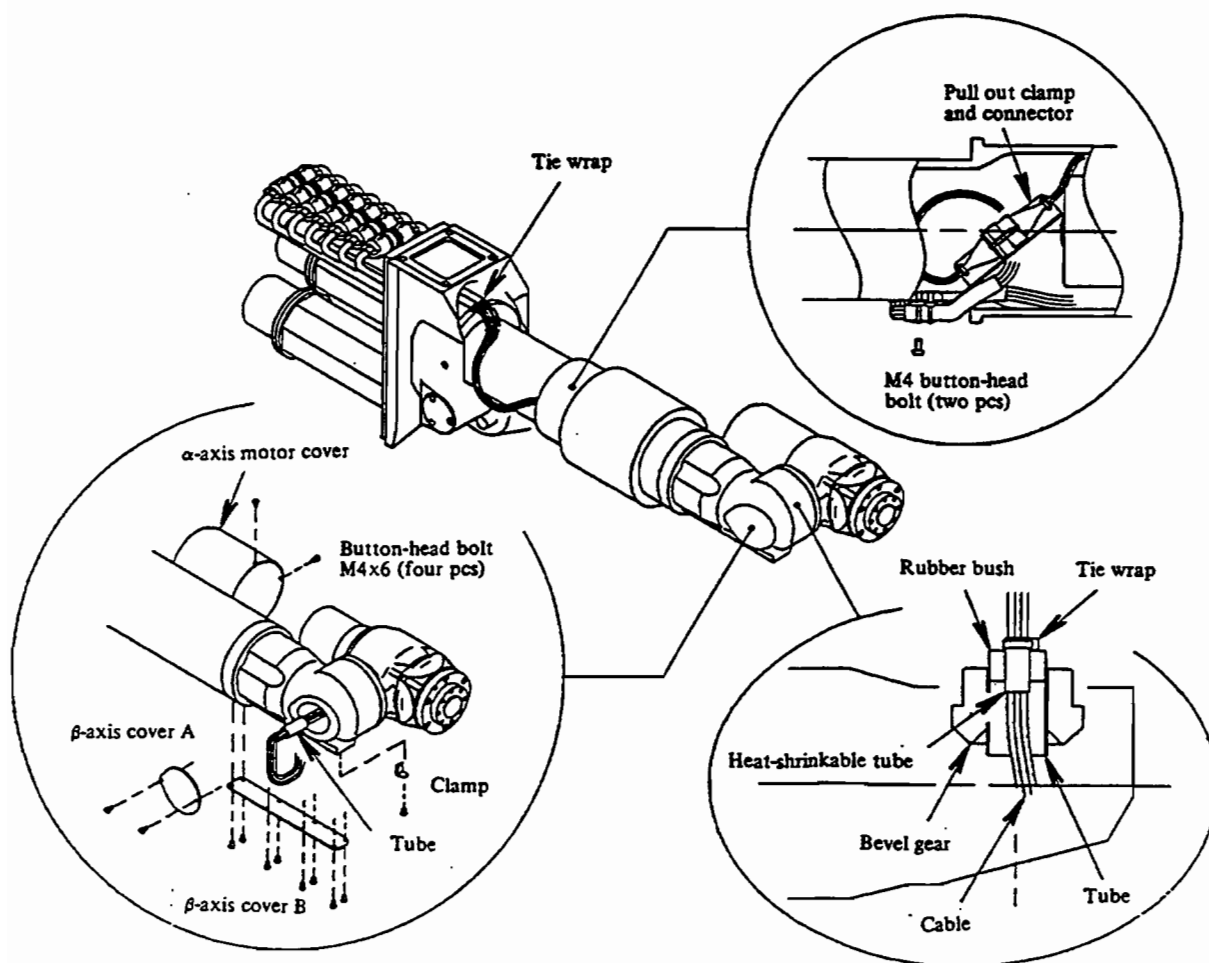


Fig. 7.2 (f) Replacing cables K106, K107 (S-10)

7.3 Replacing Limit Switch

1) θ -axis OT limit switch (cable K105)

- ① Remove the rear cover of the W axis
- ② Remove the limit switch mounting plate from the stop.
- ③ Remove the limit switch from the plate.
- ④ Remove the cover below the switch and disconnect the cable crimp terminal. Replace the limit switch.
- ⑤ Mount the new limit switch reversing the above procedure.
- ⑥ Check that the limit switch operates accurately at the overtravel position.
- ⑦ Check that the limit switch does not operate in the θ -axis motion range.

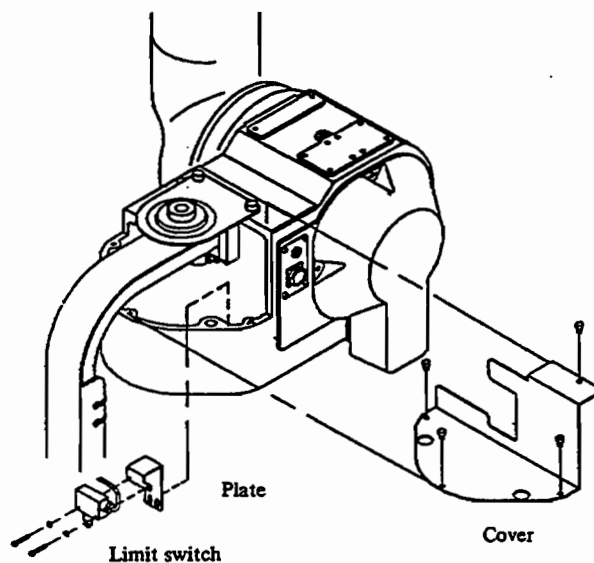


Fig. 7.3 (a) Replacing θ -axis limit switch (S-10)

III. S-700 MECHANICAL UNIT MAINTENANCE

1. CONFIGURATION

Fig. 1 (a), (b) show the configuration of the mechanical unit.

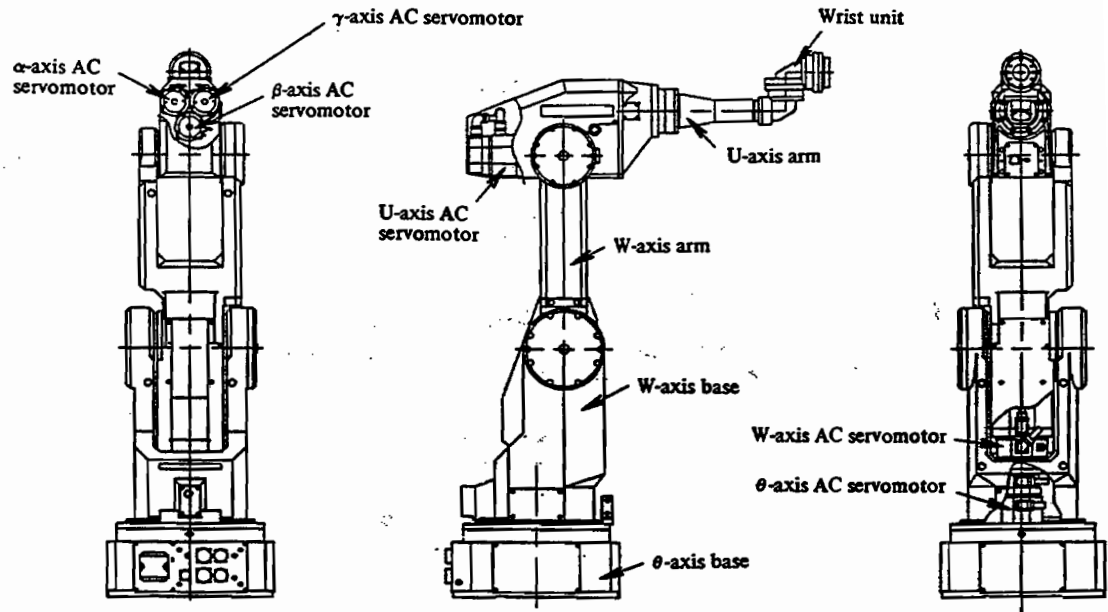


Fig. 1 (a) Mechanical unit configuration (S-700 offset wrist)

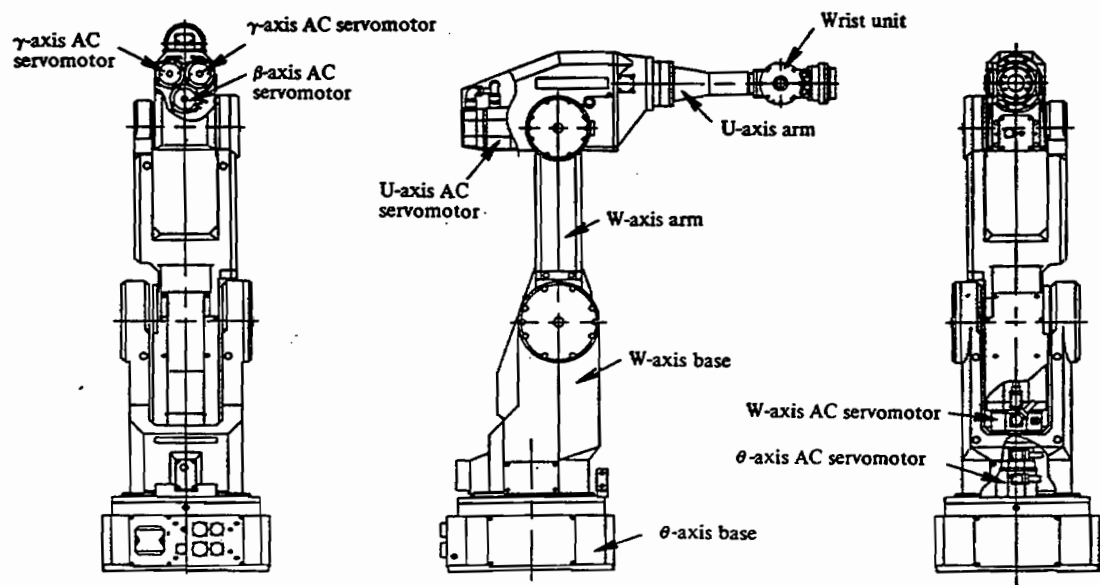


Fig. 1 (b) Mechanical unit configuration (S-700 in-line wrist)

1.1 θ -axis Drive Mechanism

Fig. 1.1 shows the θ -axis drive mechanism.

The rotation of the AC servomotor (model 5F) is decelerated by the reducer and rotates the table. The table is supported by the cross roller bearing.

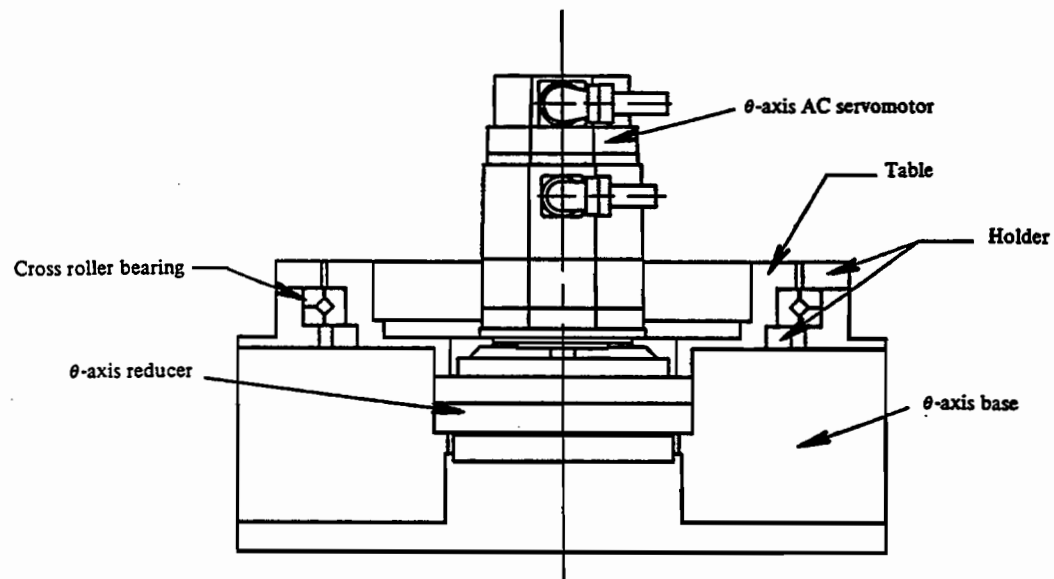


Fig. 1.1 θ -axis drive mechanism (S-700)

1.2 W-axis Drive Mechanism

Fig. 1.2 shows the W-axis drive mechanism.

The rotation of AC servomotor (model 20F) is decelerated by the reducer via the bevel gear and rotates the W-axis arm.

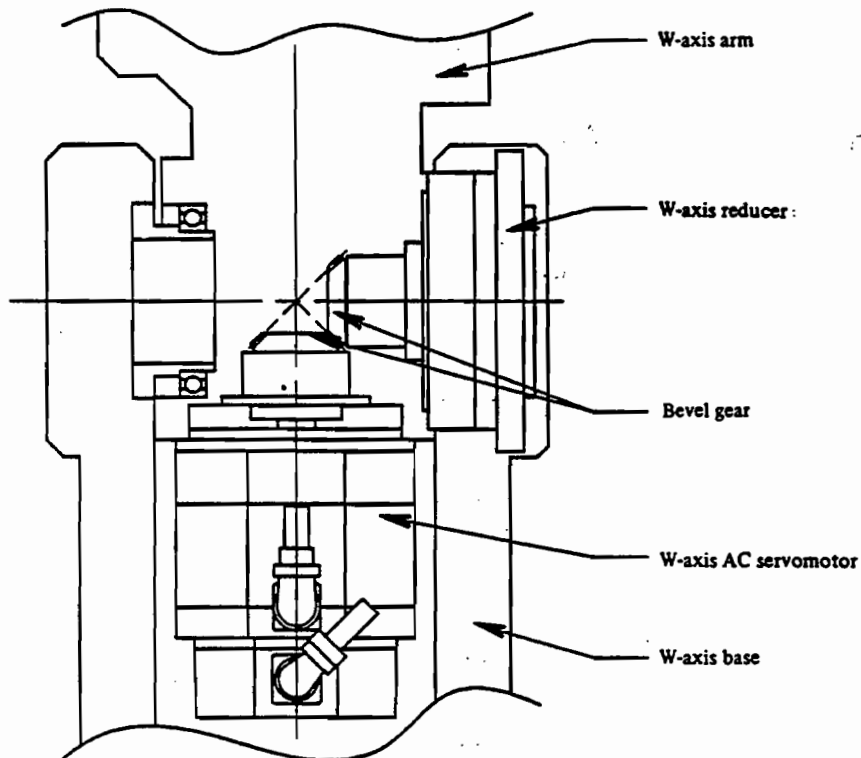


Fig. 1.2 W-axis drive mechanism (S-700)

1.3 U-axis Drive Mechanism

Fig. 1.3 shows the U-axis drive mechanism.

The rotation of the AC servomotor (model 5F) is decelerated by the reducer via the bevel gear and rotates the U-axis arm.

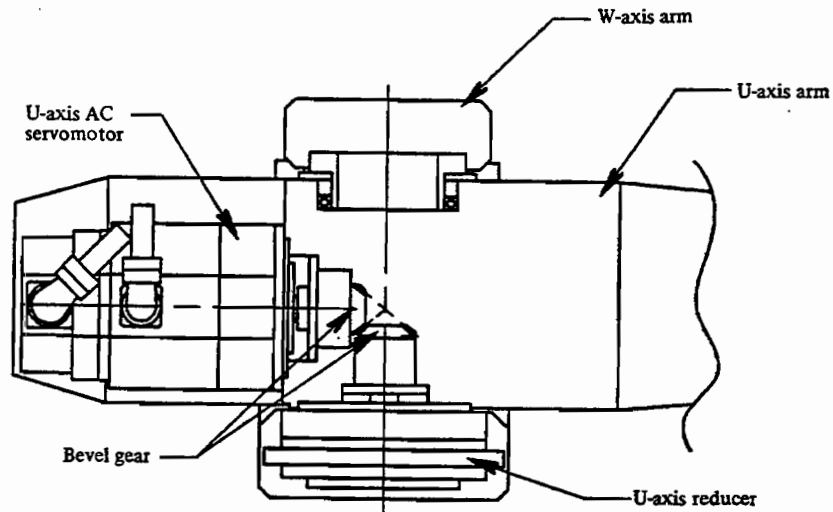


Fig. 1.3 U-axis drive mechanism (S-700)

1.4 γ -axis Drive Mechanism

Fig. 1.4 shows the γ -axis drive mechanism.

The rotation of the AC servomotor (model 1-0B/1-0HB) is decelerated by the reducer after being reduced by the helical gear and rotate the γ axis (the U-axis arm).

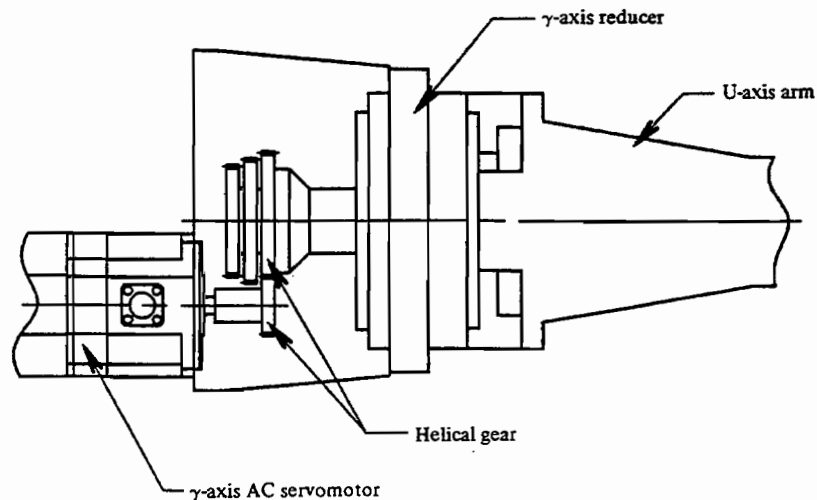


Fig. 1.4 γ -axis drive mechanism (S-700)

1.5 α/β -axis Drive Mechanism (offset wrist)

Fig. 1.5 shows the α/β -axis drive mechanism of the offset wrist. The revolution of the motor (model 1-OB/1-OHB) is transmitted to the wrist via the drive shaft after the revolution speed is reduced by gears.

For the β axis, the revolution of the drive shaft is input to the β -axis reducer via bevel gears and output directly to the β axis. On the other hand, for the α axis, the drive shaft revolution is transmitted via bevel gears and input to the α -axis reducer to revolve the α -axis output flange.

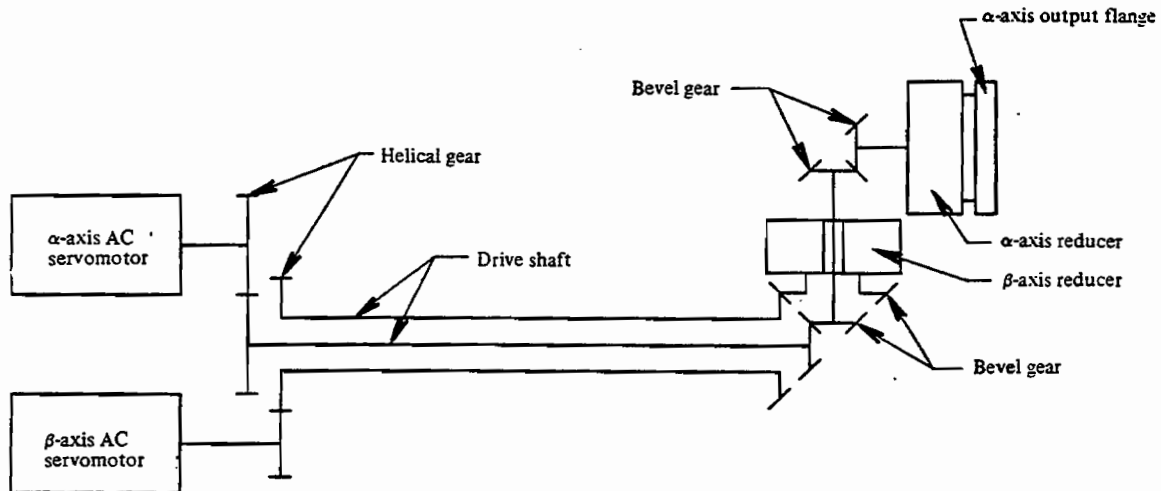


Fig. 1.5 α/β -axis drive mechanism (S-700, offset wrist)

1.6 α/β -axis Drive Mechanism (In-line)

Fig. 1.6 shows the α/β -axis drive mechanism of the in-line wrist. The revolution of the motor (model 1-OB/1-OHB) is transmitted to the wrist via the drive shaft after the revolution speed is reduced by gears.

For the β axis, the revolution of the drive shaft is input to the β -axis reducer via bevel gears and output directly to the β axis. On the other hand, for the α axis, the drive shaft revolution is transmitted via bevel and helical gears and input to the α -axis reducer to revolve the α -axis output flange.

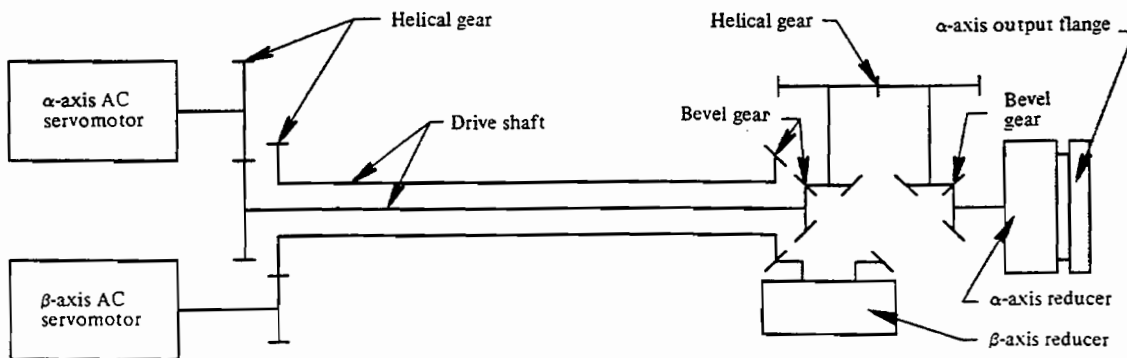


Fig. 1.6 α/β -axis drive mechanism (S-700, in-line wrist)

1.7 Major Component Specifications

1) Motor

a) Mechanical unit specification: A05B-1120-B001/B011

Specification	Model	Axis
A06B-0345-B231	5RF	θ , U
A06B-0352-B731	20F	W
A06B-0524-B351	1-0HB	α , β , γ

b) Mechanical unit specification: A05B-1120-B002/B012

Specification	Model	Axis
A06B-0345-B231	5RF	θ , U
A06B-0352-B731	20F	W
A06B-0522-B351	1-0B	α , β , γ

2) Reducer

Specification	Axis
A97L-0118-0399#135-129	θ
A97L-0118-0392#135A-129	W
A97L-0118-0393#60A-121	U
A97L-0118-0394#30A-41	γ
A97L-0118-0395#15A-57	β (Offset)
A97L-0118-0396#15A-57	β (In-line) α

3) Wrist unit

Specification	Axis
A290-7120-T501	Offset wrist
A290-7120-T511	In-line wrist

4) Gear

Specification	Axis
A290-7120-X306	W
A290-7120-X307	W
A290-7120-X406	U
A290-7120-X407	U
A290-7120-X411	α
A290-7120-X412	α
A290-7120-X413	β
A290-7120-X414	β
A290-7120-X415	γ
A290-7120-X416	γ
A290-7120-X506	β
A290-7120-X507	β (OFFSET)
A290-7120-X508	α
A290-7120-X509	α (OFFSET)
A290-7120-X510	α (OFFSET)
A290-7120-X558	β (IN-LINE)
A290-7120-X560	α (IN-LINE)
A290-7120-X561	α (IN-LINE)
A290-7120-X562	α (IN-LINE)
A290-7120-X563	α (IN-LINE)

5) Shim

Specification	Axis
A290-7120-X327, X329 (0.1T, 0.3T)	W
A290-7120-X330, X332 (0.1T, 0.3T)	W
A290-7120-X434, X436 (0.1T, 0.3T)	U
A290-7120-X437, X439 (0.1T, 0.3T)	U
A290-7120-X440, X442 (0.1T, 0.3T)	U
A290-7120-X516, X518 (0.1T, 0.3T)	β
A290-7120-X519, X521 (0.1T, 0.3T)	β
A290-7120-X522, X524 (0.1T, 0.3T)	α
A290-7120-X525, X527 (0.1T, 0.3T)	α
A290-7120-X566, X568 (0.1T, 0.3T)	α (IN-LINE)

6) Bearing

Specification	Bearing No.	Axis
A97L-0001-0192#00D000A	680DDU	α
A97L-0001-0192#0300000	6803	α
A97L-0001-0192#0400000	6804	α (IN-LINE)
A97L-0001-0192#0500000	6805	α (IN-LINE)
A97L-0001-0192#0800000	6808	β
A97L-0001-0192#21Z000A	6821ZZ	U
A97L-0001-0193#0000000	6900	α
A97L-0001-0193#0100000	6901	β (IN-LINE)
A97L-0001-0193#0600000	6906	β
A97L-0001-0193#0700000	6907	β, γ
A97L-0001-0193#0800000	6908	U, β, γ
A97L-0001-0193#1300000	6913	W
A97L-0001-0193#26Z000A	6926ZZ	W
A97L-0001-0194#05Z000A	6005ZZ	β
A97L-0001-0194#0800000	6008	W
A97L-0001-0198#00AW000	7000A	α
A97L-0001-0198#02AW000	7002A	α, β
A97L-0118-0519#7903A	7903A	α
A97L-0118-0519#7906A	7906A	U
A97L-0001-0907#35020CS	RB35020CS	θ

7) Cover

Specification	Axis
A290-7120-X213	θ
A290-7120-X214	θ
A290-7120-X309	W
A290-7120-X318	W
A290-7120-X319	W
A290-7120-X320	W
A290-7120-X321	W
A290-7120-X322	W
A290-7120-X323	W
A290-7120-X325	W
A290-7120-X333	W
A290-7120-X409	U
A290-7120-X431	U
A290-7120-X513	W, U, α/B
A290-7120-X554	α/B
A290-7120-X564	α/B

2. LUBRICATING CONDITION CHECK

2.1 Three-month Periodical Check

Be sure to check the following items every three months:

Item	Check Item	Check Contents
1	Lubricating condition of the gear box for the wrist	Remove the cover and check the grease level and if the grease is abnormally contaminated.
2	Lubricating condition of the U-axis gear box	Remove the cover and check the grease level and if the grease is abnormally contaminated.
3	Lubricating condition of the W-axis gear box	Remove the cover and check the grease level and if the grease is abnormally contaminated.

2.2 Replacing Drive Mechanism Grease

Replace the grease in the reducers of θ , W, and U axes, and in the W-axis gear box, wrist gear box, and the wrist unit every three years or 2000 hours. Be sure to use the specified grease for replacement.

Note) Be sure to apply grease to the grease nipple according to the procedure described in this manual. Greasing without opening the grease discharge port may cause the seal to be broken and grease to leak. Do not apply grease daily.

Table 2.2 Specified grease for three-month periodical replacement

	Grease Amount	Specified Grease
θ -axis reducer	500 cc	EPNOC AP 0 of Nippon Sekiyu
W-axis reducer	2000 cc	
U-axis reducer	650 cc	
Wrist gear box	1200 cc	
Offset wrist	500 cc	
In-line wrist	600 cc	

1) Replacing grease in the θ -axis reducer

- ① Remove the cover (rubber cap) on the side of the θ -axis base and the back of the W base.
- ② Remove the grease nipple on the side of the θ -axis base. (Grease discharge port)
- ③ Apply grease to the grease nipple (grease injection port) on the side of the W-axis base.
- ④ Continue applying grease until the grease discharged from the grease discharge port is clean. The standard grease injection amount is 500 cc.
- ⑤ Mount the grease nipple on the side of the θ -axis base.
- ⑥ Mount the cover.

Note 1) If grease is not discharged from the grease discharge port when 500 cc or more of grease is injected or if only a small amount of grease is discharged from the port, be sure to check for grease leakage caused by a damaged seal or other reasons.

Note 2) For a robot mounted on the ceiling, the locations of the grease injection port and grease discharge port are reversed.

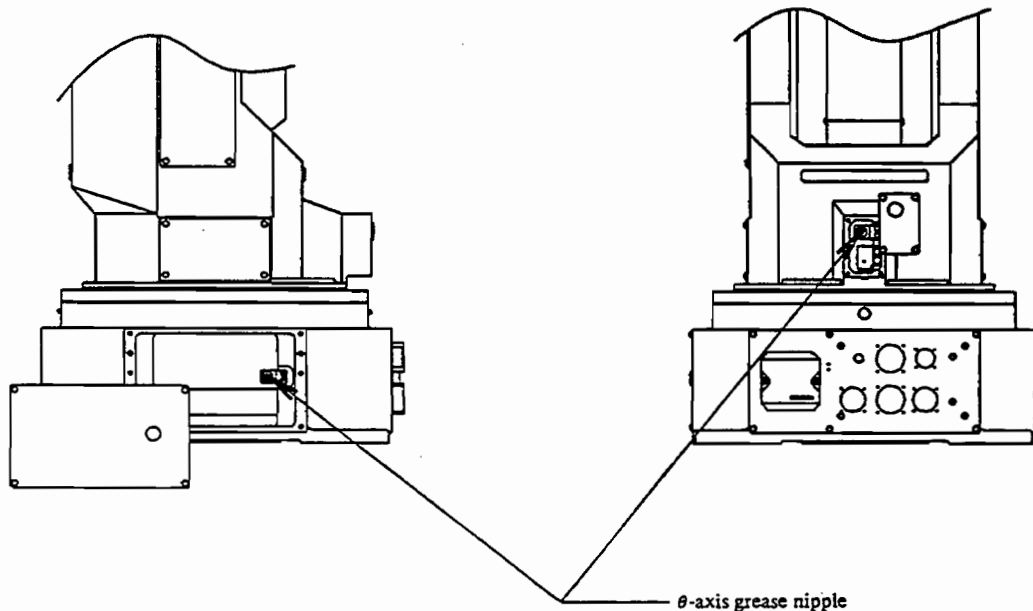


Fig. 2.2 (a) Replacing grease in θ -axis reducer (S-700)

2) Replacing of grease in W-axis reducer

- ① Remove the W-axis cover.
- ② Set the W-axis to a position of approximately 0 degrees.
- ③ Remove the grease discharge port cover. (Wipe off the grease coming out from the grease discharge port at this time.)
- ④ Apply approximately 800 cc of grease to grease nipple 1.
- ⑤ Apply grease to grease nipple 2.
- ⑥ Continue injecting grease until the grease discharged from the grease discharge port becomes clean. The standard amount of grease to be injected to grease nipple 2 is 1200 cc.
- ⑦ Mount the grease discharge port cover.
- ⑧ Mount the W-axis cover.

Note 1) If grease is not discharged from the grease discharge port when grease of 1200 cc or more is injected or if only a small amount of grease is discharged from the port, be sure to check for grease leakage caused by a damaged seal or other reasons.

Note 2) Be sure to remove the W-axis cover before setting the W-axis to the 0 degree position because the W-axis cover cannot be removed within the range of 50 to -50 degrees.

Note 3) For a robot mounted on the ceiling the locations of the grease injection port and discharge port are same as those for the robot mounted on the floor.

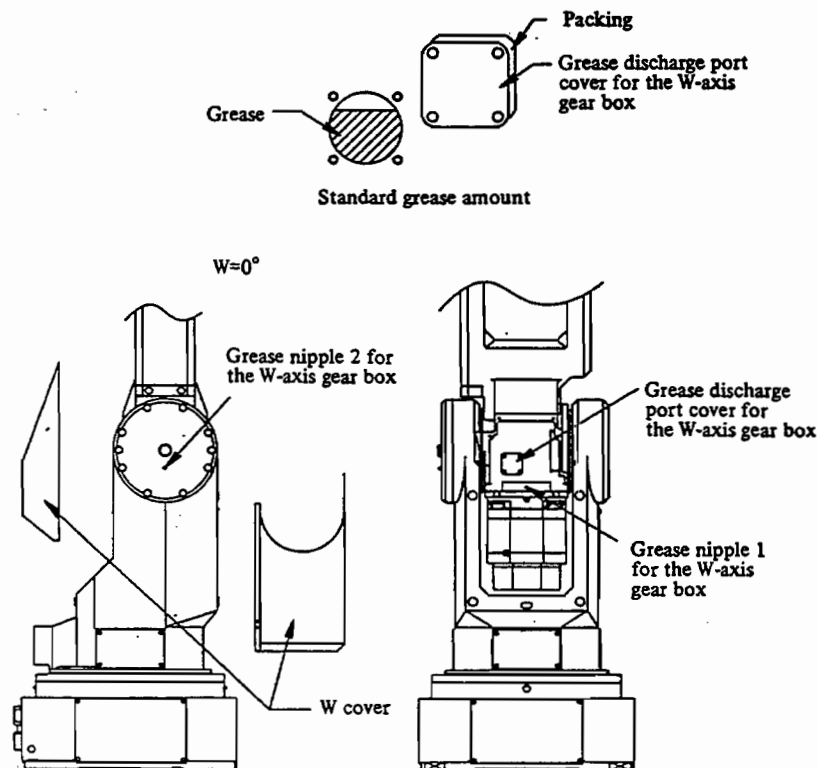


Fig. 2.2 (b) Replacing grease for W-axis reducer (S-700)

3) Replacing grease in the U-axis reducer

- ① Remove the U-axis cover.
- ② Set the U axis to a position of approximately 90 degrees.
- ③ Remove the grease discharge port cover. (Wipe off the grease coming out from the grease discharge port at this time.)
- ④ Apply approximately 100 cc of grease to grease nipple 1.
- ⑤ Apply grease to grease nipple 2.
- ⑥ Continue injecting grease until the grease discharged from the grease discharge port becomes clean. The standard amount of grease to be injected from grease nipple 2 is 550 cc.
- ⑦ Mount the grease discharge port cover.
- ⑧ Mount the U-axis cover.

Note 1) If grease is not discharged from the grease discharge port when grease of 550 cc or more is injected or if only a small amount of grease is discharged from the port, be sure to check for grease leakage caused by a damaged seal or other reasons.

Note 2) Be sure to remove the U-axis cover before setting the W axis to the 90 degree position because the U-axis cover cannot be removed within the range of 60 to -130 degrees.

Note 3) For the robot mounted on the ceiling the locations of the grease injection port and discharge ports are same as those for the robot mounted on the floor.

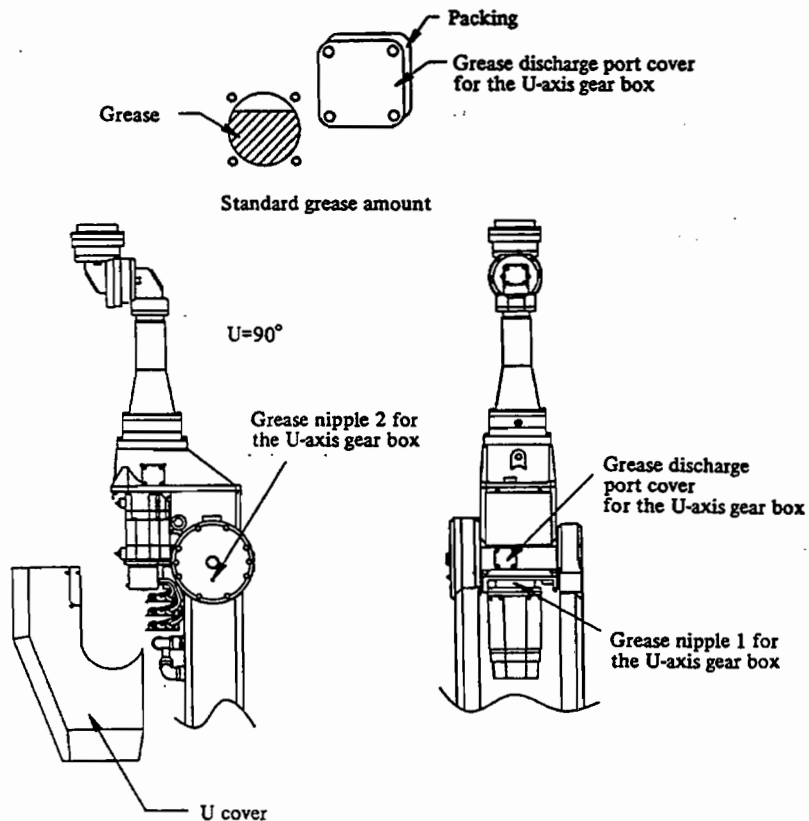


Fig. 2.2 (c) Replacing grease in U-axis reducer (S-700)

4) Replacing grease in the wrist gear box

- ① Set the U axis to a position of approximately 0 degrees and γ axis to a position of approximately 90 degrees.
- ② Remove the grease discharge port cover. (Wipe off the grease coming out from the grease discharge port at this time.)
- ③ Apply grease to the grease nipple.
- ④ Continue injecting grease until the grease discharged from the grease discharge port becomes clean. The standard amount of grease to be injected is 1200 cc.
- ⑤ Mount the grease discharge port cover.

Note 1) If grease is not discharged from the grease discharge port when grease of 1200 cc or more is charged or if only a small amount of grease is discharged from the port, be sure to check for grease leakage caused by a damaged seal or other reasons.

Note 2) Be sure to remove the W-axis cover before setting the W axis to the 0 degree position because the W-axis cover cannot be removed within the range of 50 to -50 degrees.

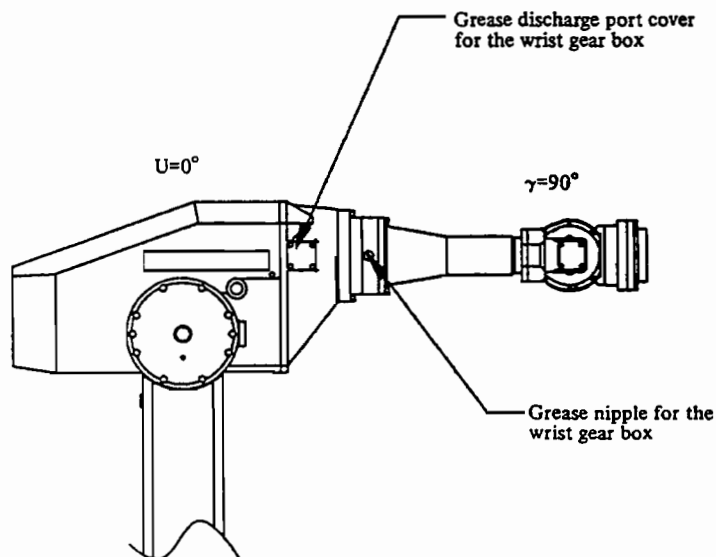
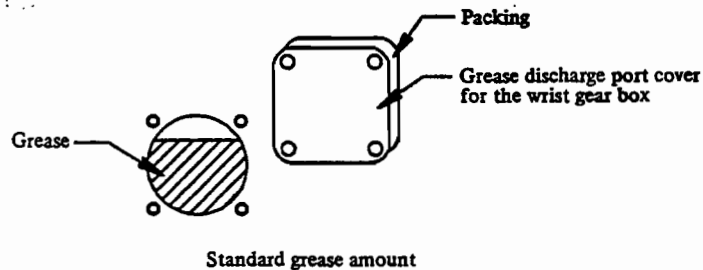


Fig. 2.2 (d) Replacement of grease in wrist gear box (S-700)

5) Replacing grease in offset wrist

- ① Set the U axis to a position of approximately 0 degrees and the γ axis to a position of approximately 90 or -90 degrees.
- ② Remove grease discharge port cover 1. (Wipe off the grease coming out from the grease discharge port at this time.)
- ③ Apply grease to the grease nipple.
- ④ Continue injecting grease until the grease discharged from grease discharge port 1 becomes clean.
- ⑤ Mount grease discharge port cover 1.
- ⑥ Remove grease discharge port cover 2. (Wipe off the grease coming out from the grease discharge port at this time.)
- ⑦ Apply grease to the grease nipple.
- ⑧ Continue injecting grease until the grease discharged from grease discharge port 2 becomes clean.
- ⑨ Mount grease discharge port cover 2.

Note 1) The standard amount of grease to be injected is 500 cc.

Note 2) Be sure to remove the W-axis cover before setting the W axis to the 0 degree position because the W-axis cover cannot be removed within the range of 50 to -50 degrees.

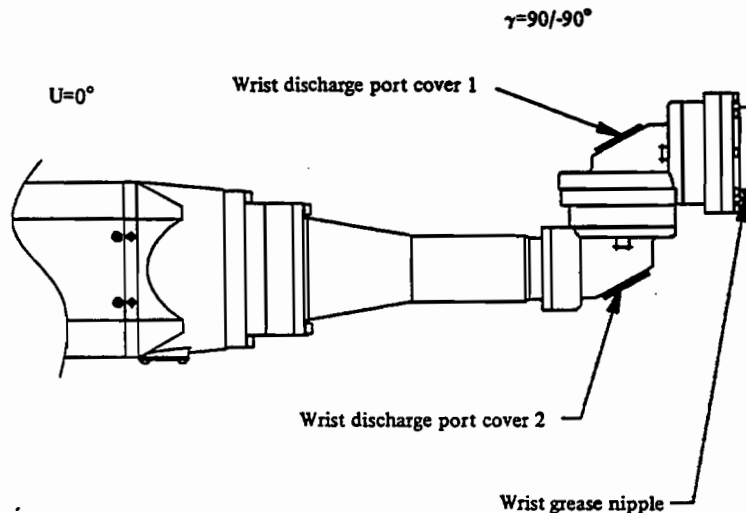


Fig. 2.2 (e) Replacing grease in wrist (S-700 offset wrist)

6) Replacing grease in the in-line wrist

- ① Set the U axis and γ axis to a position of approximately 0 degree.
- ② Remove grease discharge port plug 1.
- ③ Apply grease to the grease nipple.
- ④ Continue injecting grease until the grease discharged from grease discharge port 1 becomes clean.
- ⑤ Mount grease discharge port plug 1.
- ⑥ Remove grease discharge port plug 2. (Wipe off the grease coming out from the grease discharge port at this time.)
- ⑦ Apply grease to the grease nipple.
- ⑧ Continue injecting grease until the grease discharged from grease discharge port 2 becomes clean.
- ⑨ Mount grease discharge port plug 2.
- ⑩ Remove grease discharge port plug 3 and apply grease to the grease nipple in the same manner as above.
- ⑪ Mount grease discharge port plug 3.

Note 1) The standard amount of grease to be injected is 600 cc.

Note 2) For the robot mounted on the ceiling the locations of the grease injection port and discharge port are same as those for the robot mounted on the floor.

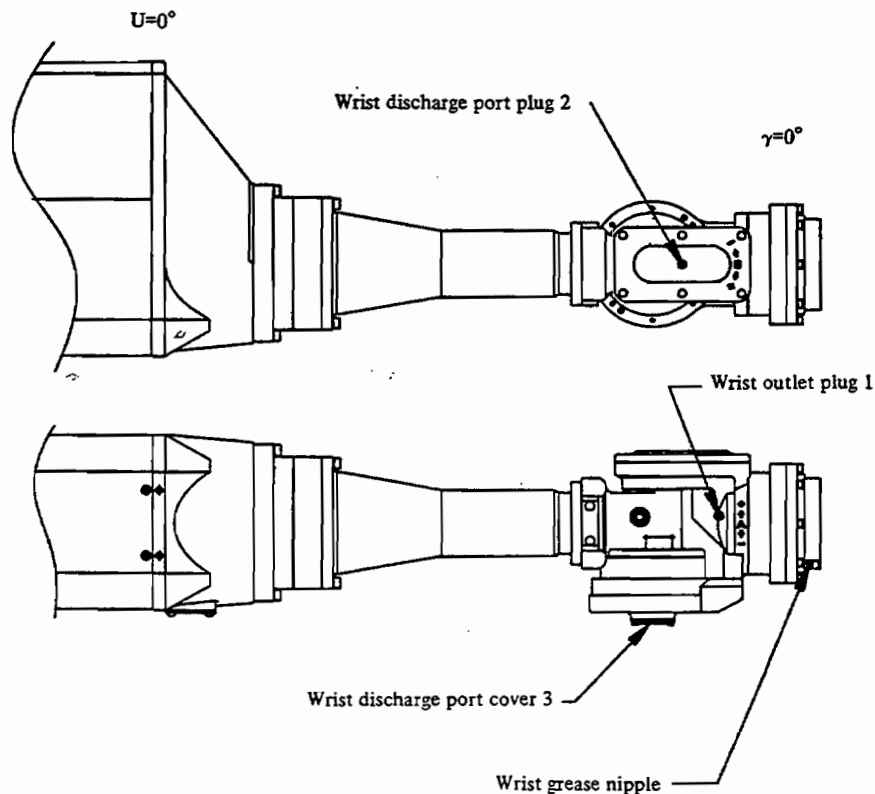


Fig. 2.2 (f) Replacing grease in wrist (S-700) (in-line wrist)

2.3 Adding Grease -- θ -axis Cross Roller Bearing

Add the grease in the θ -axis cross roller bearing every 2000 hrs. If, however, the installation environment of the robot is bad, be sure to add grease when necessary. If water is poured over the robot, be sure to change grease immediately.

For the greasing points and method, see Fig. 2.3 and Table 2.3 (a).

Table 2.3 (a) Greasing points (S-700)

Item	Greasing point	Grease	Greasing amount	Greasing method
1	θ -axis cross roller bearing	Shell ALVANIA No. 2	10 cc (Two points)	Apply grease to the grease nipple.

Table 2.3 (b) Grease (S-700)

	Grease
Mobil oil	MOBILAC GREASE No. 2
ESSO standard oil	VICON No. 2
Shell oil	SHELL ALVANIA No. 2
Mitsubishi oil	DIAMOND MULTIPURPOSE GREASE No. 2
Nihon oil	No. 2 EPNOC
Idemitsu oil	DAPHNE COLONEX GREASE No. 2
Maruzen oil	LIMAX No. 2

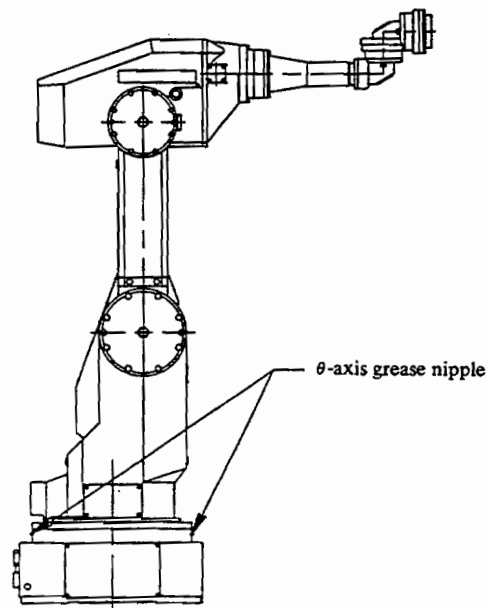


Fig. 2.3 Greasing points (S-700)

3. TROUBLESHOOTING

3.1 General

The source of mechanical unit failures may be difficult to find because of overlapping causes. Failures may become further complicated, if they are not corrected properly. Therefore, it is necessary to keep an accurate record of problems and to take proper corrective actions.

3.2 Failures and Causes

Major failures in mechanical unit and their causes are listed below:

- 1) Robot does not calibrate.
 - a) (Cause) Voltage of the memory backup battery is low.
(Measure) Replace battery. (Refer to 5.6)
- 2) Position error
 - a) (Cause) Robot struck an obstacle.
(Measure) Revise the teaching points.
 - b) (Cause) Robot is not firmly mounted.
(Measure) Mount firmly.
 - c) (Cause) Peripheral device is not properly positioned.
(Measure) Mount firmly.
 - d) (Cause) Excessive load.
(Measure) Reduce the load. Ease moving conditions.
 - e) (Cause) System variables are not standard.
(Measure) Change the system variables to standard settings. (Refer to the KAREL System Reference Manual.)
 - f) (Cause) A cable is disconnected or broken. (Pulse coder cable)
(Measure) Replace the cable. (Refer to 7.2)
 - g) (Cause) APC abnormal.
(Measure) Replace the motor. (Refer to 5.1 - 5.5)
 - h) (Cause) Excessive backlash in mechanical unit. See next page.
(Measure) Adjust the backlash. (Refer to 4.4)
- 3) The robot vibrates.
 - a) (Cause) The robot is not bolted securely on the floor.
(Measure) Tighten the bolts firmly.
 - b) (Cause) The floor itself vibrates.
(Especially when the robot is installed on the second floor and higher.)
(Measure) Change the robot mounting place.
 - c) (Cause) Excessive load.
(Measure) Reduce load. Ease moving conditions.
 - d) (Cause) The adjustment of the servo is faulty.
(Measure) Adjust the servo. (Consult GMFanuc)
 - e) (Cause) A cable is broken.
(Measure) Replace the cable. (Refer to 7.2)
 - f) (Cause) Not grounded.
(Measure) Ground the robot. (Refer to 7.2)
 - g) (Cause) The motor is faulty.
(Measure) Replace the motor. (Refer to 5.1 - 5.5)
 - h) (Cause) The reducer is faulty.
(Measure) Replace the reducer. (Refer to 5.1 - 5.5)

- i) (Cause) The time constant is faulty.
(Measure) Revise time constant. (Refer to the KAREL System Reference Manual.)
 - j) (Cause) Excessive backlash. See below.
- 4) Excessive backlash
- a) (Cause) Screws and pins are loose.
(Measure) Tighten screws. (Coat the specified area with LOCTITE.)
 - b) (Cause) The reducer is faulty.
(Measure) Replace the reducer. (Refer to 5.1 - 5.5)
 - c) (Cause) The adjustment of the gear backlash is faulty.
(Measure) Adjust the gear backlash. (Refer to 4.4)
 - d) (Cause) A gear is worn.
(Measure) Replace the gear. (Consult GMFanuc.)
 - e) (Cause) A bearing is worn.
(Measure) Replace the bearing. (Consult GMFanuc.)
 - f) (Cause) A casing is broken.
(Measure) Replace the broken parts. (Consult GMFanuc.)
- 5) Abnormal noise
- a) (Cause) Grease/oil to the gear or reducer is insufficient.
(Measure) Grease. (Refer to 2.2 - 2.3)
 - b) (Cause) Dust is in the gear or reducer.
(Measure) Flash and then grease. (Refer to 2.2 - 2.3)
 - c) (Cause) Excessive bearing pressure
(Measure) Adjust the pressure for the bearing. (Consult GMFanuc)
 - d) (Cause) The reducer is faulty.
(Measure) Replace the reducer. (Refer to 5.1 - 5.5)
 - e) (Cause) The adjustment of the gear backlash is faulty.
(Measure) Adjust the backlash. (Consult GMFanuc)
 - f) (Cause) A gear is worn.
(Measure) Replace the gear. (Consult GMFanuc)
 - g) (Cause) A bearing is worn.
(Measure) Replace the bearing. (Consult GMFanuc)
 - h) (Cause) A cable bearing is broken.
(Measure) Replace the cable. (Refer to 7.2)
 - i) (Cause) The adjustment of servo constants is faulty.
(Measure) Adjust the servo constants. (Consult GMFanuc)
- 6) Abnormal heat
- a) (Cause) Grease/oil to the gear or reducer is insufficient.
(Measure) Grease. (Refer to 2.2 - 2.3)
 - b) (Cause) Nonspecified grease/oil is used.
(Measure) Replace the grease/oil. (Refer to 2.2 - 2.3)
 - c) (Cause) Excessive bearing pressure (Consult GMFanuc)
(Measure) Adjust the pressure for the bearing.
 - d) (Cause) Overload.
(Measure) Decrease the load or speed.
 - e) (Cause) The adjustment of the gear backlash is faulty.
(Measure) Adjust the backlash. (Consult GMFanuc)
 - f) (Cause) The time constant is faulty.
(Measure) Revise time constant. (Refer to the KAREL System Reference Manual.)

- 7) Drop of an axis when the power is turned off.
- a) (Cause) Brake gap is noticeable.
(Measure) Replace the motor. (Refer to 5.1 - 5.5)
 - b) (Cause) Brake drive relay is defective.
(Measure) Replace the relay. (Refer to 5.1 - 5.5)
- 8) Leakage of grease/oil
- a) (Cause) O-ring, oil seal or packing is broken.
(Measure) Replace the broken parts.
 - b) (Cause) Casing is broken.
(Measure) Replace the broken parts. (Consult GMFanuc)
 - c) (Cause) Screws are loose.
(Measure) Tighten screws.

Table 3.2 (a) Allowable backlash value (S-700)

	θ	W	U	γ	β	α
Angle conversion (min.)	2.6	1.8	1.9	3.7	3.9	4.8
Displacement conversion (mm)	1.19 (1600)	0.36 (700)	0.40 (715)	0.17 (160)	0.18 (160)	0.28 (200)

Note) The value converted into displacement indicates the backlash in the rotary direction within the distance (shown in parentheses) from the center of each axis.

The value is measured each axis by itself. If affected by few axes, add allowable backlash value of relative axes.

Table 3.2 (b) Allowable falling value (S-700)

At power off	1.5 mm
At emergency stop	2.0 mm

3.3 Replacing Parts and Performing Adjustments

After replacing a part, an adjustment is always required. The following table shows the required replacements and adjustments.

Replacement part or function to be changed	Adjustment
Motor	(a) Mastering
Cable	(a) Routing and securing cable (b) Limit switch (c) Mastering
Limit switch	(a) Limit switch and dog
Wrist unit	(a) Output flange backlash (b) Mastering
θ -axis stroke W-axis stroke	(a) Limit switch and dog (b) Stop mounting position (θ -axis only) (c) System variable
Battery (Replace periodically once every year.)	Replace them keeping power on. No adjustment is needed.

4. ADJUSTMENTS

Mechanical parts have been adjusted to the optimum condition at the time of shipment from our company. Therefore, they normally need not be adjusted by the customer at the time of delivery.

Adjustments should be made as specified in this section after a long period of use or after replacing a part.

4.1 Adjusting Limit Switches and Dogs

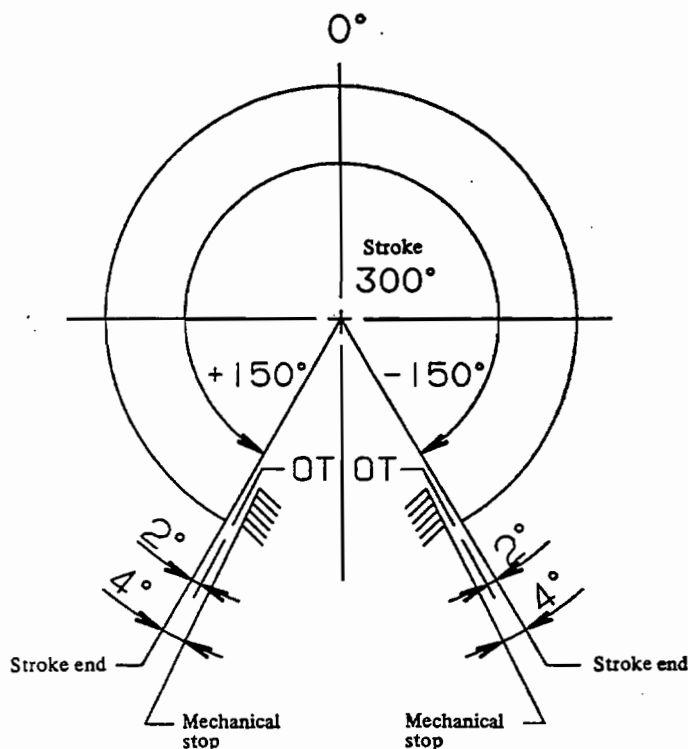
1) Zero position and working limit

Each controlled axis has its own zero position and motion limit area.

Operation range of each control axis is limited by a mechanical dog.

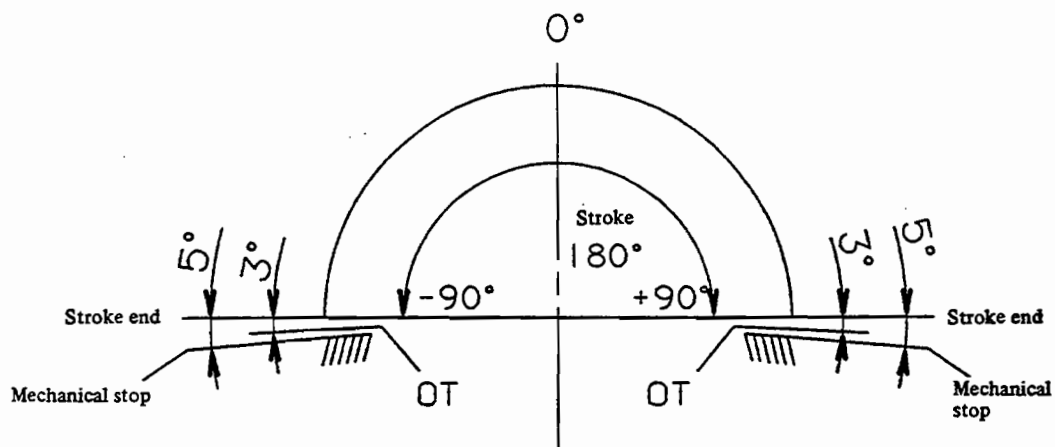
When the controlled axis reaches its working limit, it is called Overtravel (OT). Overtravel on each axis is detected at both extremes. The robot is controlled so as to operate within the operation range unless a servo system error causing the the loss of positional information or a system error occurs.

Fig. 4.1 (a) - (g) show the zero positions and motion limits of each axis.



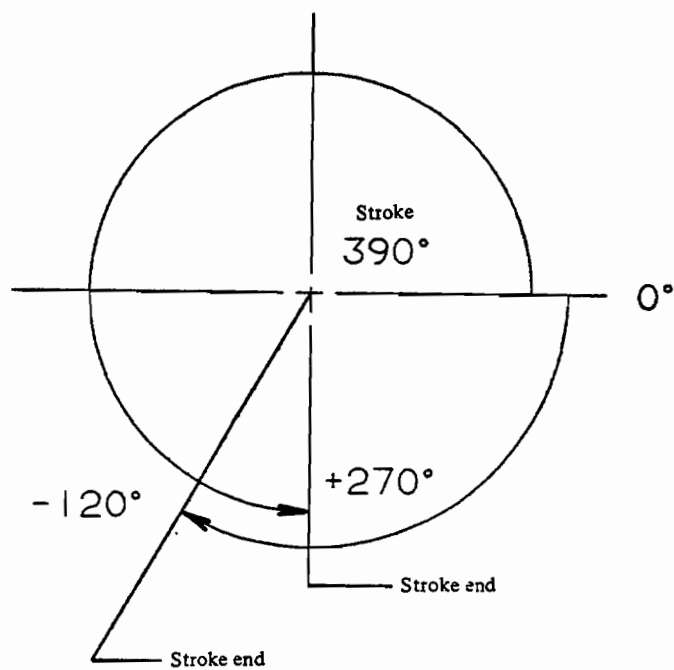
Note) The stroke can be changed.

Fig. 4.1 (a) θ -axis rotation (S-700)



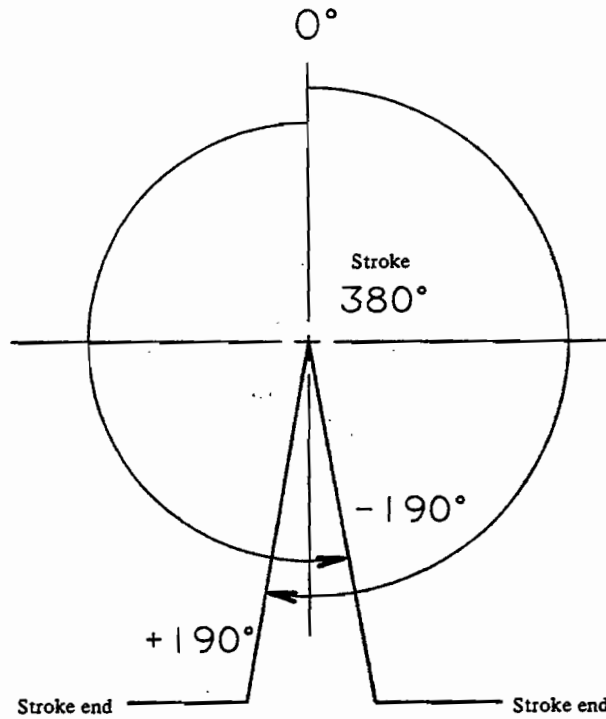
Note) The motion range is limited by the U-axis position.

Fig. 4.1 (b) W-axis rotation (S-700)



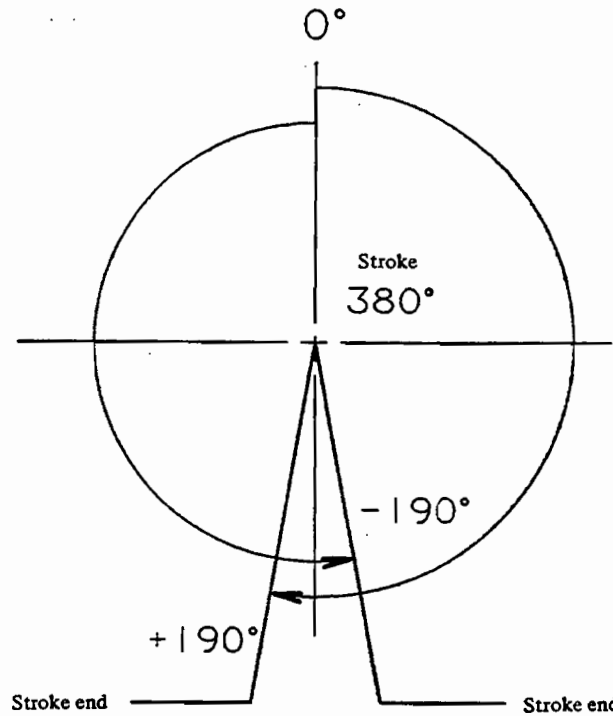
Note) The motion range is limited by the W-axis position.

Fig. 4.1 (c) U-axis rotation (S-700)



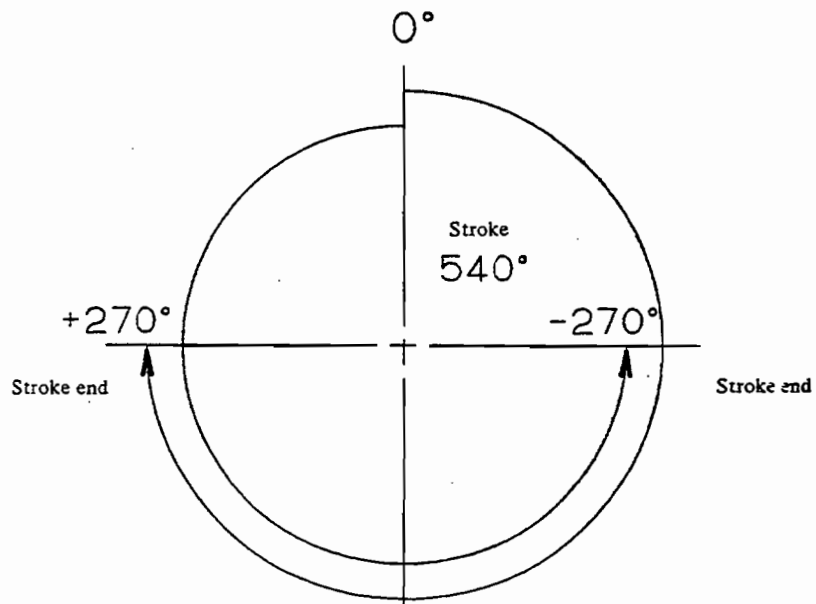
Note) The OT limit switch and mechanical stop are not used for the γ axis.

Fig. 4.1 (d) γ -axis wrist rotation (S-700)



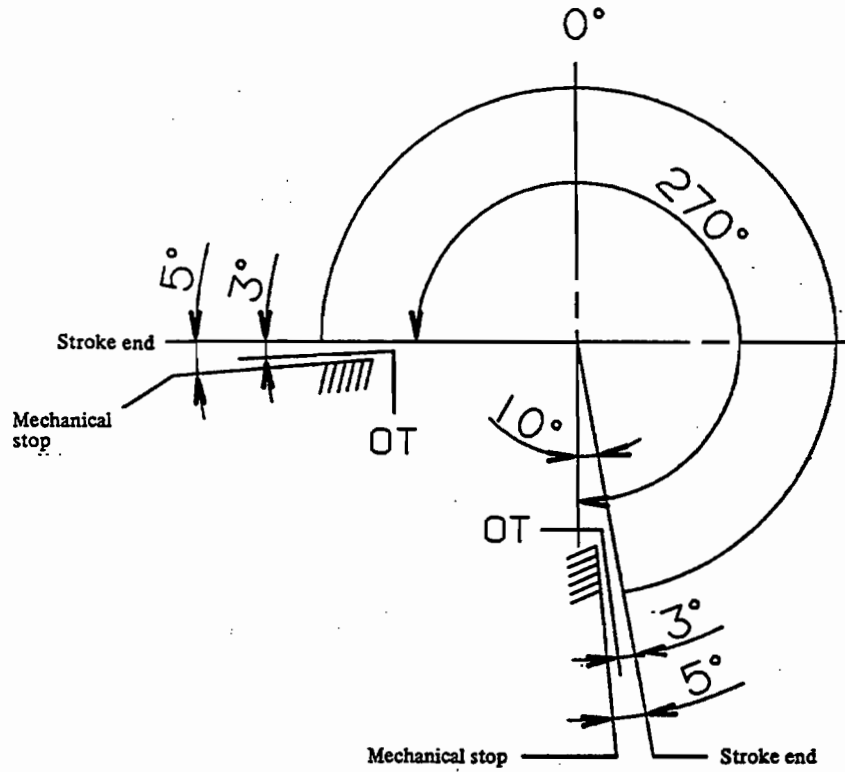
Note) The OT limit switch is not used for the β axis.

Fig. 4.1 (e) β -axis wrist rotation (S-700)



Note) The OT limit switch and a mechanical stop are not used for the α axis.

Fig. 4.1 (f) α -axis wrist rotation (S-700)



Note) The allowable range for the relative angle between the W-axis and U-axis arms is a minimum of 10° and a maximum of 270°.

Fig. 4.1 (g) W/U limit interference angles (S-700)

2) Adjustment method

a) θ -axis adjustment method

- ① Move the θ -axis to the end of the stroke.
- ② Press the EMERGENCY STOP button and remove the rear cover from the W base.
- ③ Loosen the bolt at the allotted hole of the dog and move the dog under the proximity switch.
- ④ Using the slotted hole of the proximity switch mounting plate, adjust the distance between the proximity switch and the dog (to approximately 1 mm).
At this time, check that the proximity switch lamp lights.
- ⑤ Shift the dog to a point approximately 5 mm away from the point where the lamp of the proximity switch goes off and mount the dog.
- ⑥ Check that the stroke and operation limit are as shown in Fig. 4.1 (a).
- ⑦ Mount the cover of the W base.

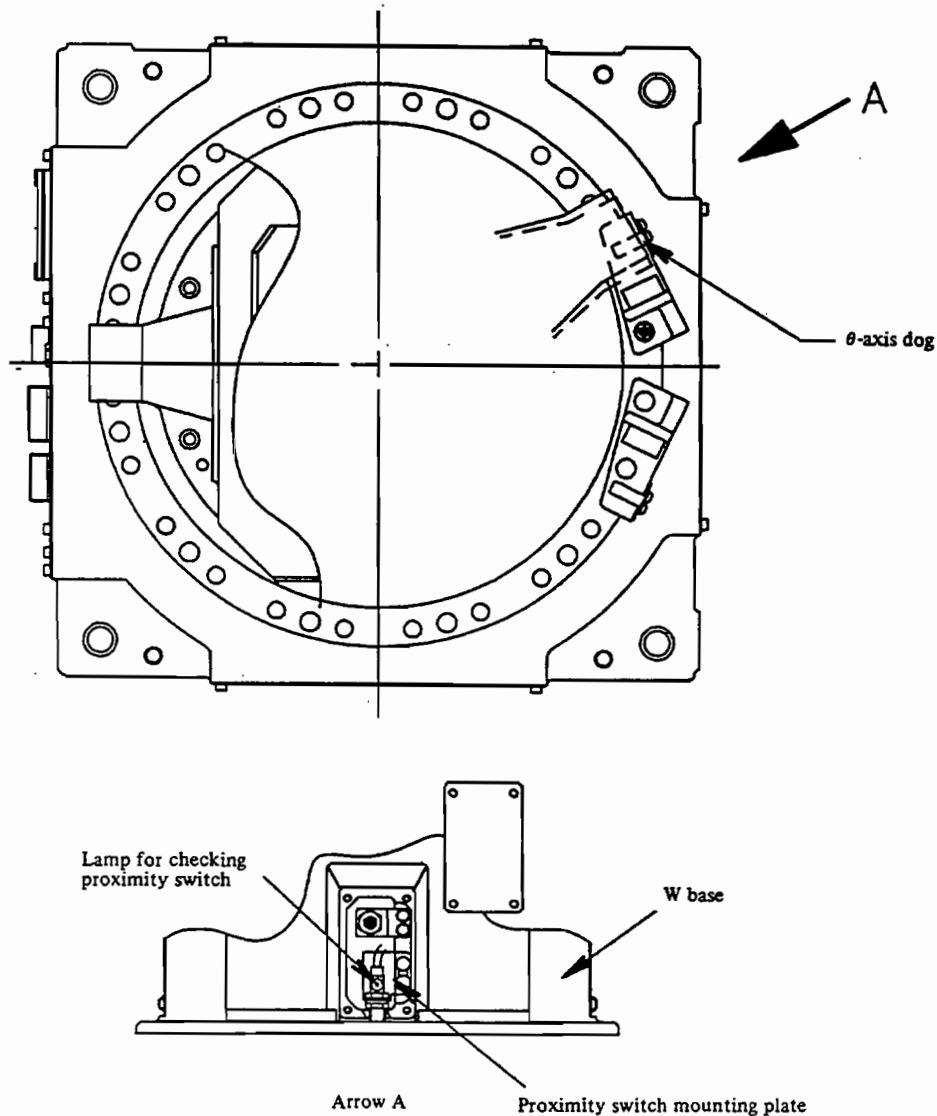


Fig. 4.1 (h) Adjustment of θ -axis OT (S-700)

b) W-axis adjustment method

- ① Move the W axis to the end of the stroke.
- ② Press the EMERGENCY STOP button. Remove the side cover.
- ③ Loosen the bolt at the slotted hole of the dog and move the dog to the position where the limit switch contacts.
- ④ Adjust the limit switch position within the specified position. (Loosen the bolt mounting the limit switch and use the slotted hole to adjust the limit switch position.)
- ⑤ Shift the dog position to a point 5 mm away from the point where the limit switch is released and mount the dog.
- ⑥ Check that the stroke and operation limit are as shown in Fig. 4.1 (b).
- ⑦ Mount the side cover.

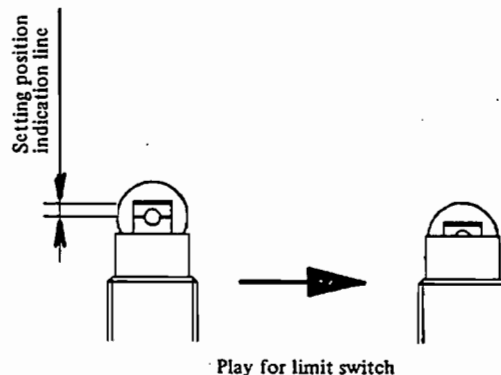
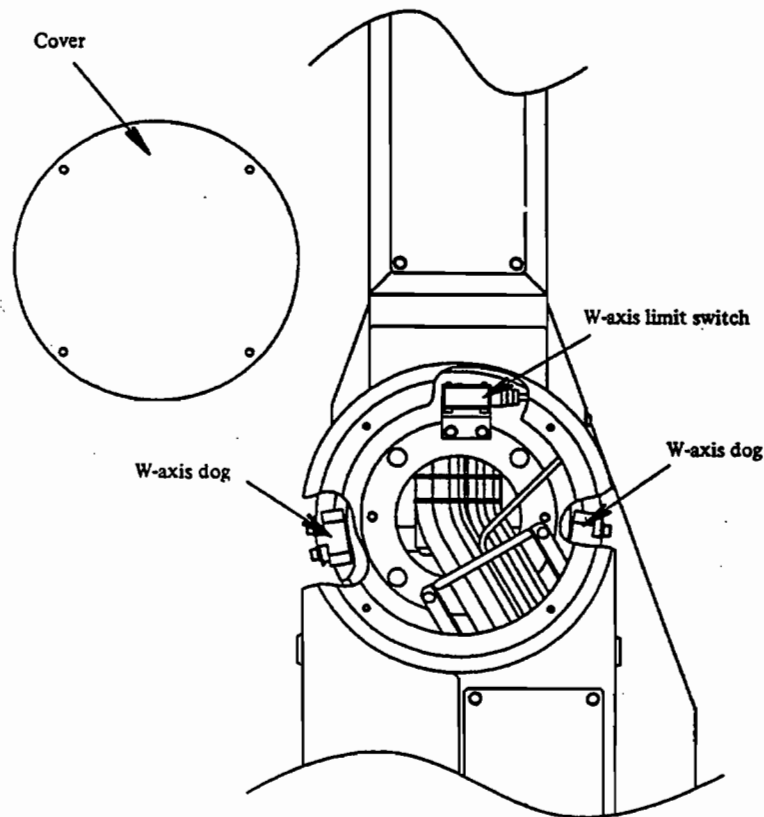


Fig. 4.1 (i) Adjustment of W-axis OT (S-700)

c) U-axis adjustment method

- ① Move the U axis to the end of the stroke.
- ② Press the EMERGENCY STOP button. Remove the side cover.
- ③ Loosen the bolt mounting the limit switch.
- ④ Adjust the limit switch position so that the limit switch is turned on at a point two to three degrees from the stroke end and mount the limit switch.
- ⑤ Check that the stroke and operation limit are as shown in Fig. 4.1 (g).
- ⑥ Mount the side cover.

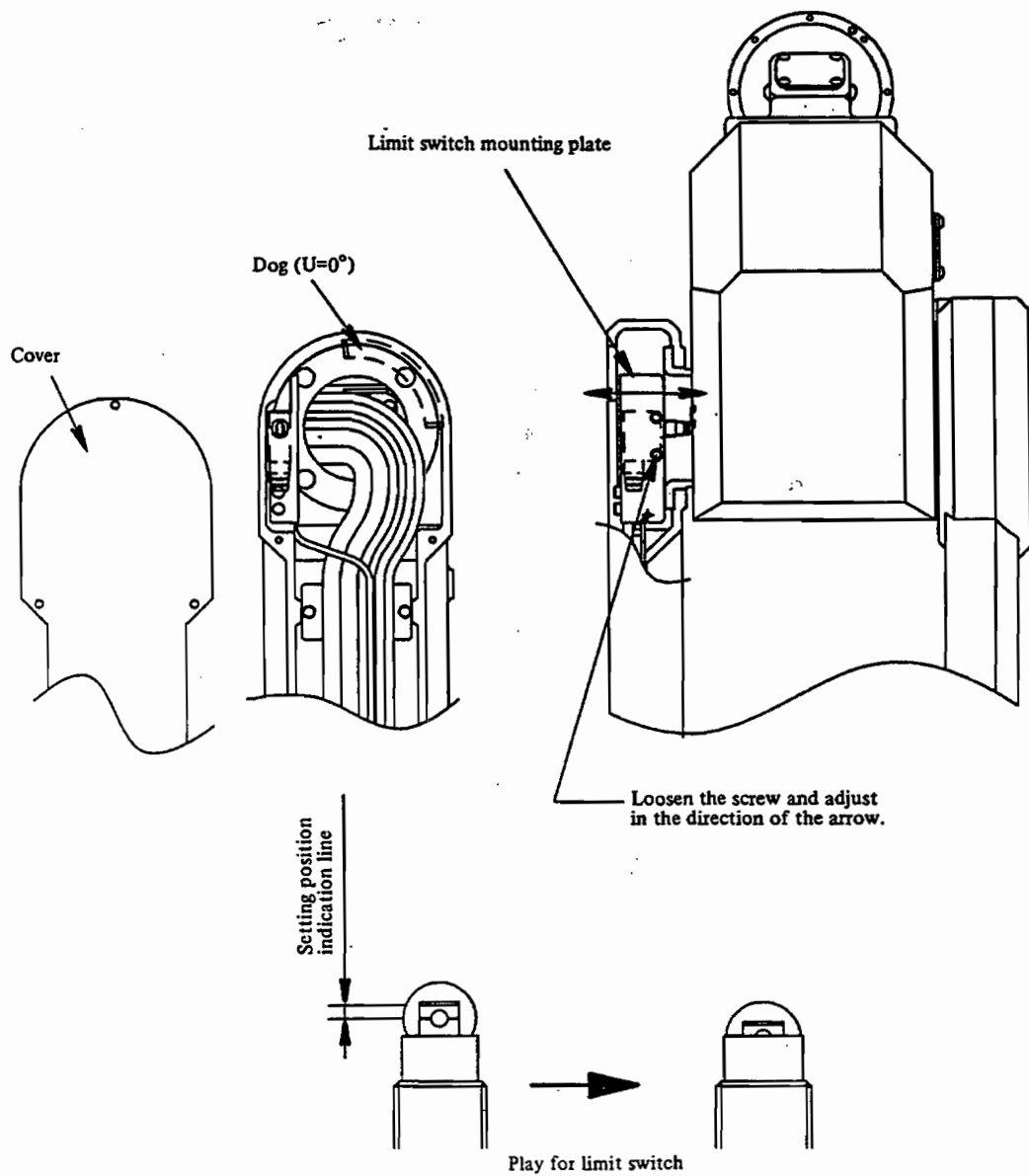


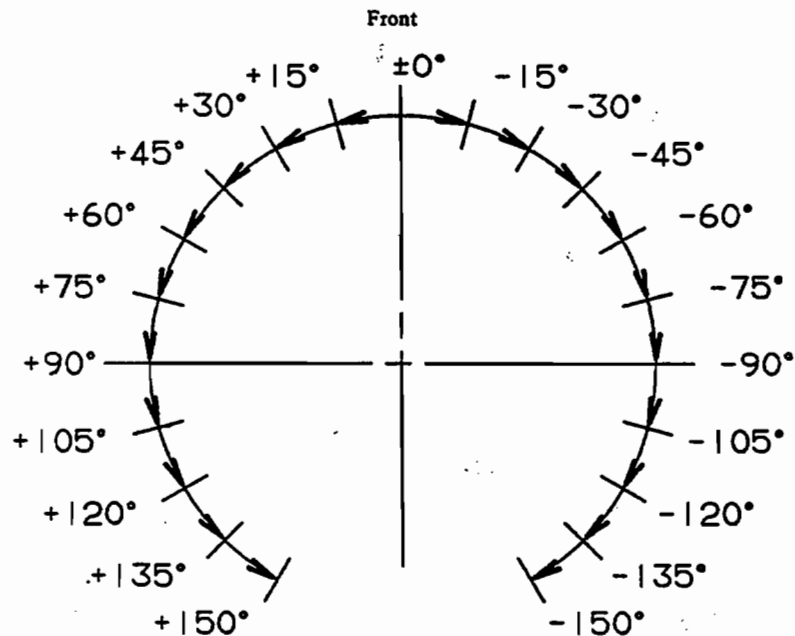
Fig. 4.1 (j) Adjustment of U-axis OT (S-700)

4.2 Stroke Modification

4.2.1 θ -axis stroke modification

It is possible to limit the θ -axis stroke as required by the surroundings for the robot. The stroke can be changed as shown in Fig. 4.2.1 (a). It can be changed in increments of 15° according to the OT stroke by changing the dog position, the mechanical stop or system variable.

The stroke must always include either 0° (front) or $\pm 90^\circ$ for mastering. In addition, select the + and - sides from the following:



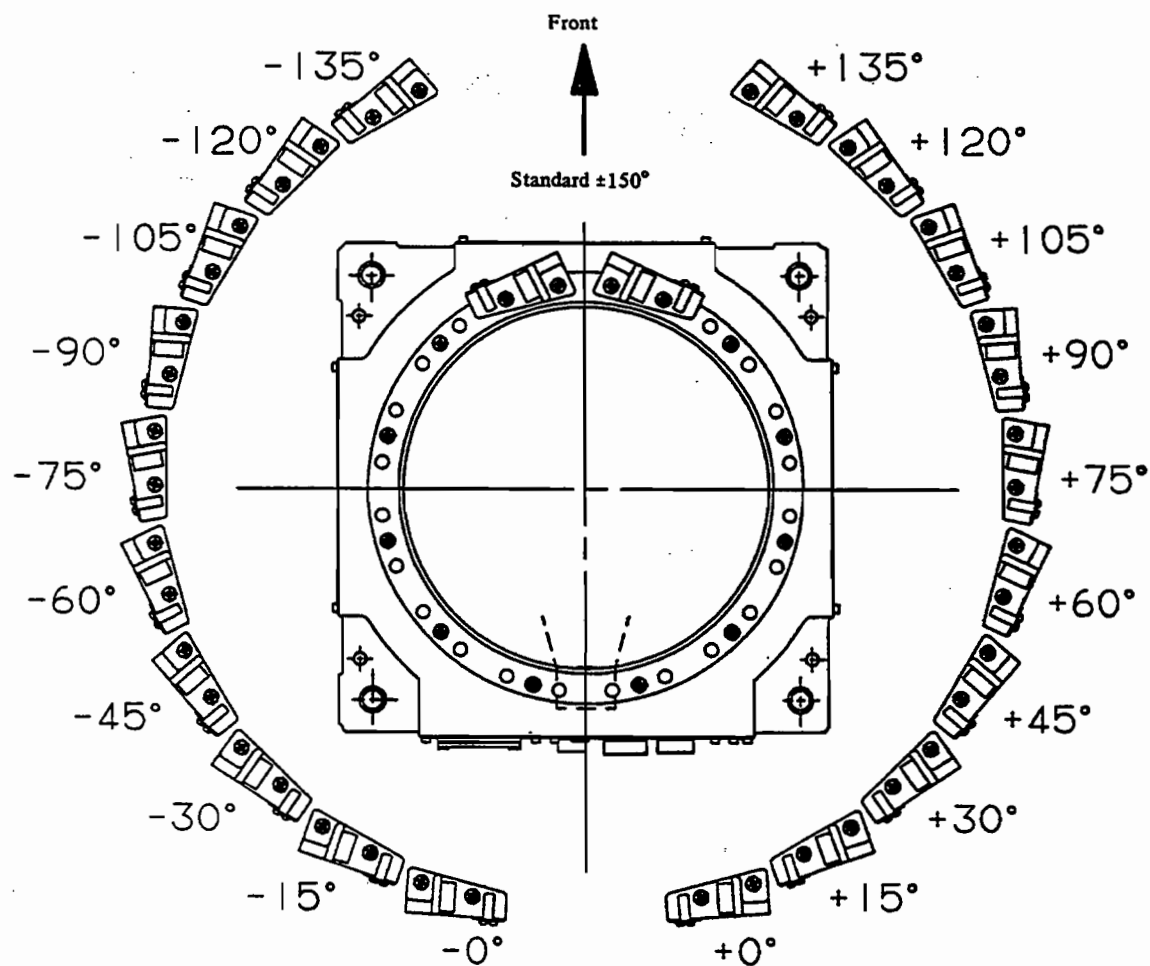
Note 1) Standard stroke
 $-150^\circ - +150^\circ$

Note 2) Always keep the stroke within the range from -150° to $+150^\circ$ when changing it.

Mastering position	Stroke setting range	
	+ side	- side
0°	$+150^\circ - +15^\circ$	$-15^\circ - -150^\circ$
$+90^\circ$	$+150^\circ - +105^\circ$	$+75^\circ - -150^\circ$
-90°	$+150^\circ - -75^\circ$	$-105^\circ - -150^\circ$

Fig. 4.2.1 (a) θ -axis stroke modification (S-700)

- 1) Changing the dog and mechanical stop positions
Change the dog and mechanical stop positions according to the desired stroke position as shown in Fig. 4.2.1 (b).



Note) Top view of θ -axis.

Fig. 4.2.1 (b) Changing dog and mechanical stop positions (S-700)

- a) Changing the minimum and maximum command pulses
 \$LOWERLIMS[1]: θ -axis stroke lower limit pulse
 \$UPPERLIMS[1]: θ -axis stroke upper limit pulse
 Set a numeral so that upper pulse should always be greater than lower pulse.

Position	\$LOWERLIMS[1] (θ -axis stroke lower limit pulses)	\$UPPERLIMS[1] (θ -axis stroke upper limit pulses)
-150°	-2.617993878	-
-135°	-2.356194490	-2.356194490
-120°	-2.094395102	-2.094395102
-105°	-1.832595714	-1.832595714
-90°	-1.570796326	-1.570796326
-75°	-1.308996939	-1.308996939
-60°	-1.047197551	-1.047197551
-45°	-0.785398163	-0.785398163
-30°	-0.523598775	-0.523598775
-15°	-0.261799387	-0.261799387
0°	0.0	0.0
+15°	0.261799387	0.261799387
+30°	0.523598775	0.523598775
+45°	0.785398163	0.785398163
+60°	1.047197551	1.047197551
+75°	1.308996939	1.308996939
+90°	1.570796326	1.570796326
+105°	1.832595714	1.832595714
+120°	2.094395102	2.094395102
+135°	2.356194490	2.356194490
+150°	-	2.617993878

4.2.2 W-axis stroke modification

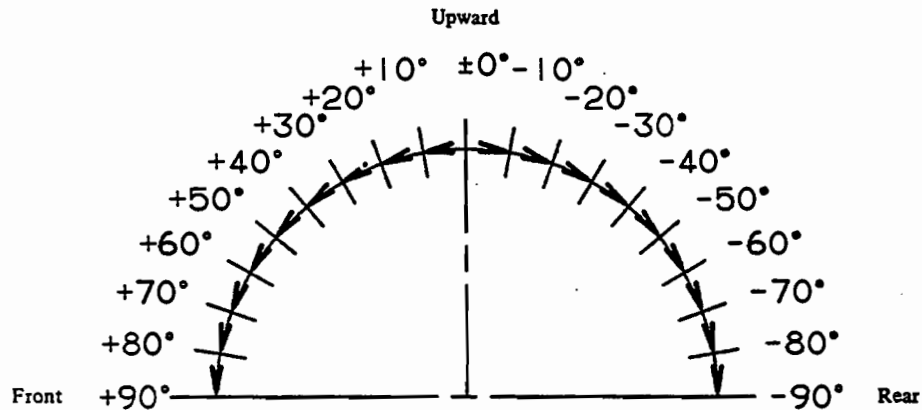
The W-axis stroke can be limited as required by the surroundings of the robot.

a) Changing the dog position

The stroke can be changed at every 10 degrees as shown in Fig. 4.2.2 (a). It can be changed in according to the OT stroke by changing the dog position.

Select the stroke from these on the + side and - side including the mastering point of 60° shown in this figure.

Note) Mechanical stop cannot be changed.



Note) Standard stroke
-90° - +90°

Mastering position	Stroke setting range	
	+ side	- side
+60°	+90° - +60°	+60° - -90°

Fig. 4.2.2 (a) W-axis stroke modification (S-700)

- b) Changing the minimum and maximum command pulses
 \$LOWERLIMS[2]: W-axis stroke lower limit pulse
 \$UPPERLIMS[2]: W-axis stroke upper limit pulse

Position	\$LOWERLIMS[2]	\$UPPERLIMS[2]
-90°	-1.570796321	
-80°	-1.396263396	
-70°	-1.221730472	
-60°	-1.047197547	
-50°	-0.872664623	
-40°	-0.698131698	
-30°	-0.523598774	
-20°	-0.349065849	
-10°	-0.174532925	
-0°	0.0	
+0°		0.0
+10°		0.174532925
+20°		0.349065849
+30°		0.523598774
+40°		0.698131698
+50°		0.872664623
+60°		1.047197547
+70°		1.221730472
+80°		1.396263396
+90°		1.570796321

1) Dog position change

Change the dog position according to the desired stroke position as shown in Fig. 4.2.2 (b).

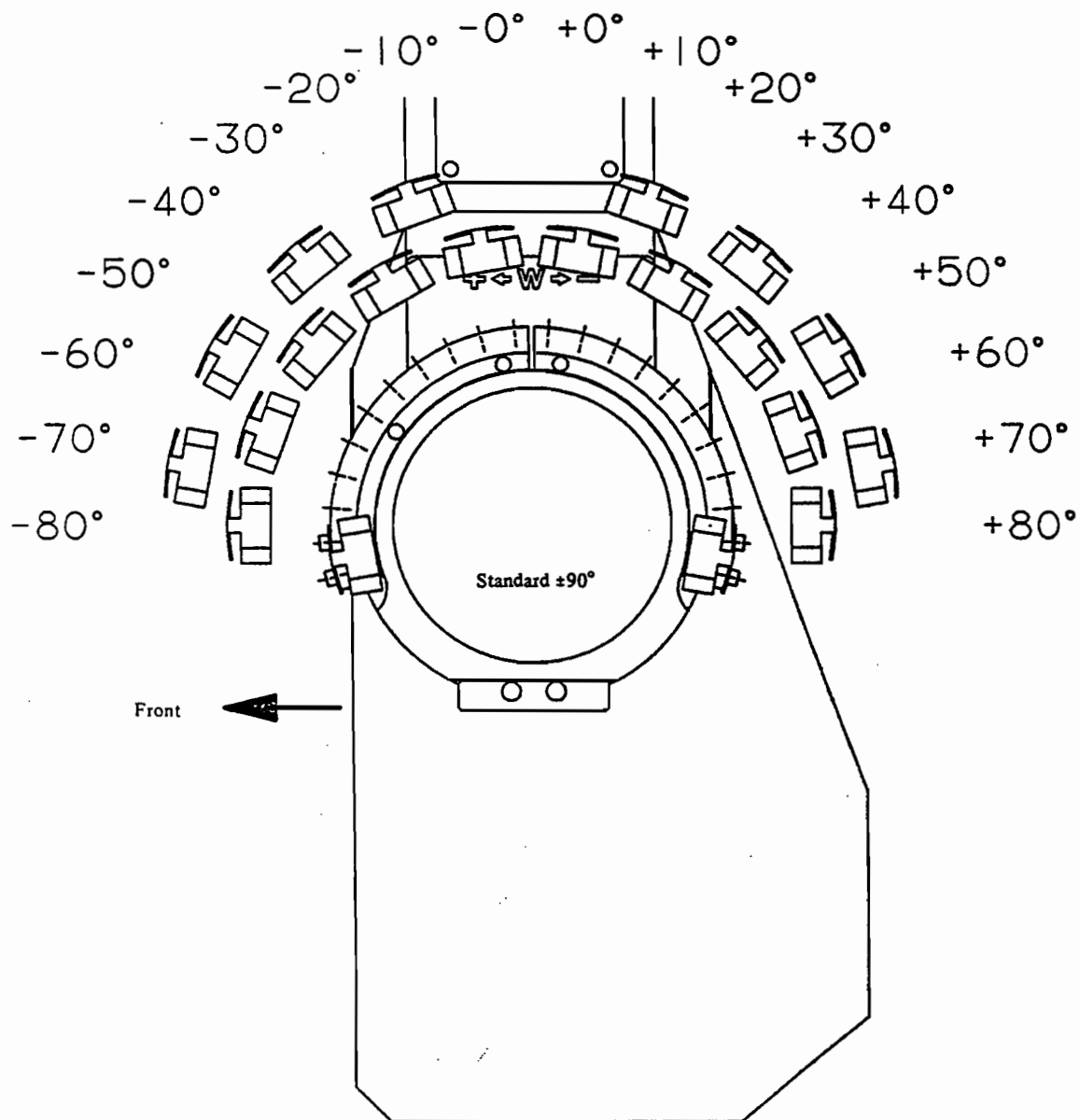


Fig. 4.2.2 (b) W-axis stroke modification (S-700)

4.3 Mastering Procedure

4.3.1 Introduction

This procedure describes the mastering procedure for a robot with an absolute pulse coder system. No operation is required for calibration with this system. The robot is automatically calibrated when power is turned on and the system becomes ready. Mastering is the establishment of an absolute reference point (or known location) as the mastering position of the robot. The known location can be the zero position (determined by aligning the zero witness marks on a particular axis or by making precise measurements according to specified distances) or a location determined by moving the axis into a mastering fixture. The method used for determining the known location is dependent on the robot model and is described in detail in Sections 4.3.3 and 4.3.4.

Using a mastering fixture is the most accurate and recommended mastering procedure. Note that the same mastering fixture should be used for all robots in a system.

Mastering is done at the factory and generally is not required as part of the daily operation. Mastering will need to be done when a mechanical part has been replaced or altered, if the system variables dealing with mastering have been lost or changed, or if the positional information from the absolute pulse coders has been lost.

4.3.2 Mastering procedure

1. Power up the controller.
2. Turn REMOTE ON/OFF switch ON.
3. Using the CRT/KB, call up the KCL display screen.
4. Using the teach pendant, jog the mechanical unit to the mastering position described in Section 4.3.3.

5. Using the CRT/KB (with REMOTE switch turned to ON) enter UTIL in response to the KCL> prompt.
6. In response to the UTIL> prompt enter MASTER.
7. Enter Y in response to the displayed question "Are you sure?"
8. At the prompt "Mastering at 0 degrees Y/N?" enter:
Y if you are mastering at the zero-degree position or
N if you are mastering using a mastering fixture.
9. Press ENTER twice.
10. Power down and up.

4.3.3 Zero-degree position

The zero-degree position of the S-700 robot is shown in Fig. 4.3.3.

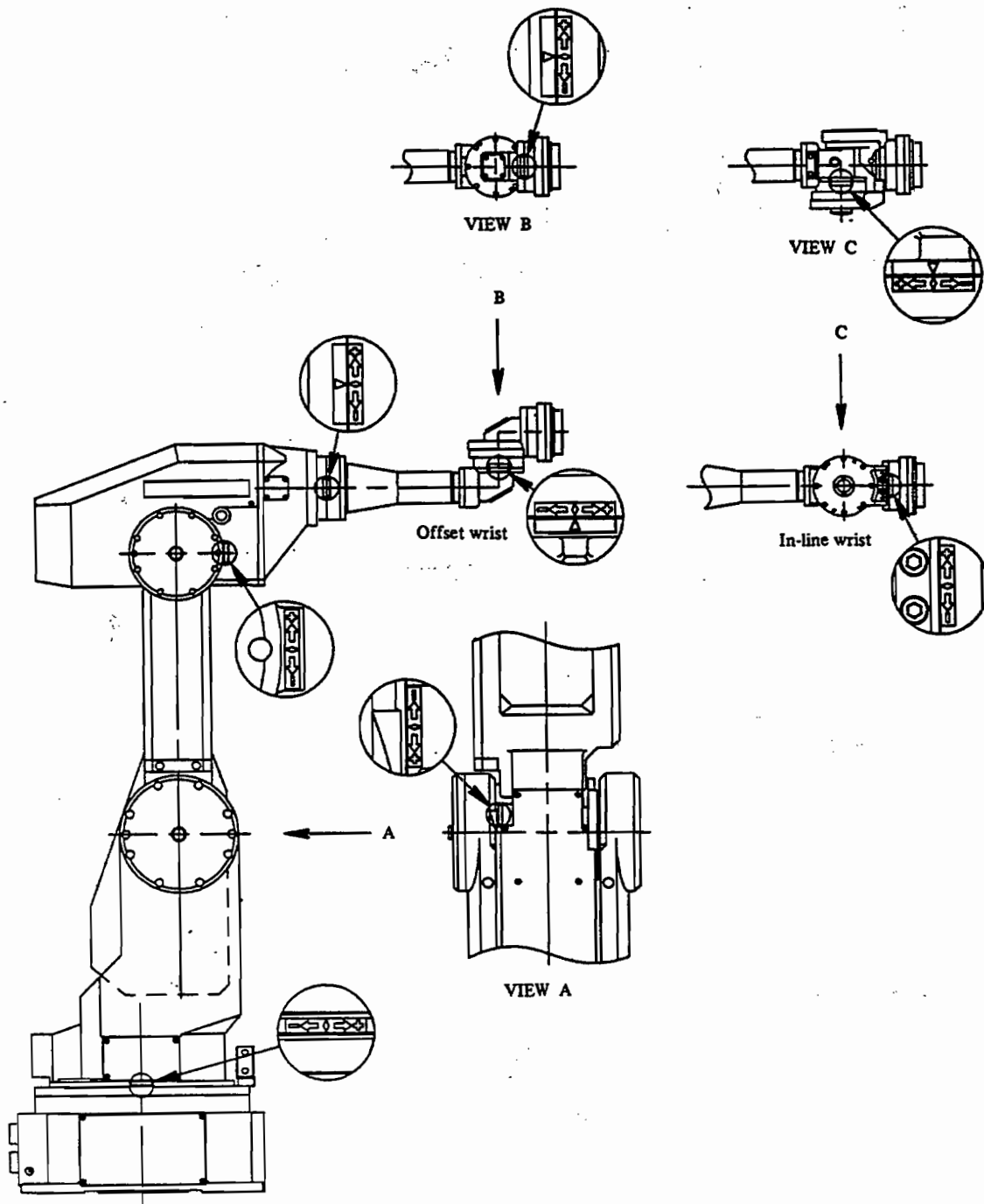


Fig. 4.3.3 Zero degree marks of each axis

4.3.4 Mastering using a mastering fixture

When a major part of the robot mechanical unit is replaced and the actual position of each axis is not the same as the current value stored through an absolute pulse coder (APC), mastering is required to establish the actual position of the robot.

When mastering the robot, meet the following conditions:

- . Level the robot mounting base. It should not deviate from the horizontal by more than 1 mm.
- . Remove the hand and other parts from the wrist.
- . Make sure that nothing is leaning on or pushing against the robot.

Note) since the axis stroke is not limited during mastering, be careful around equipment that is normally protected by the motion limits.

1) Mastering procedure

If it is necessary to change the mastering point of the θ -axis, change the system variable \$MASTER_POS[1] value before mastering according to the following procedure:

1. Using the CRT/KB, call up the KCL display screen.
2. At the KCL> prompt, enter SET VAR \$MASTER_POS[1]=
-1.570796327: $\theta = -90^\circ$
1.570796327: $\theta = 90^\circ$
0 : $\theta = 0^\circ$
3. When the KCL> prompt reappears, enter SSAVE SYS_STANDARD.

a) Mount the mastering fixture

- i) Mounting the mastering fixture on the robot main frame.

Mount two blocks and six dial indicators on the mastering fixture as shown in Figure 4.3.4 (a). If the bolts are tightened too hard, the dial indicator can be broken.

Next, remove the side cover of the θ -axis base of the robot main frame and mount the fixture on the base.

If three bolts are mounted on the back of the fixture, it is easy to mount the fixture on the base.

Besides the mastering position where $\theta =$ Zero degree, mastering can be done at $\theta = \pm 90$ degrees. In this case, to ensure accuracy, perform mastering at same point as the point for the previous mastering. At shipment, mastering is performed at the point of $\theta =$ Zero degree. Therefore, be sure to perform mastering at the point of $\theta =$ Zero degree if there is no problem.

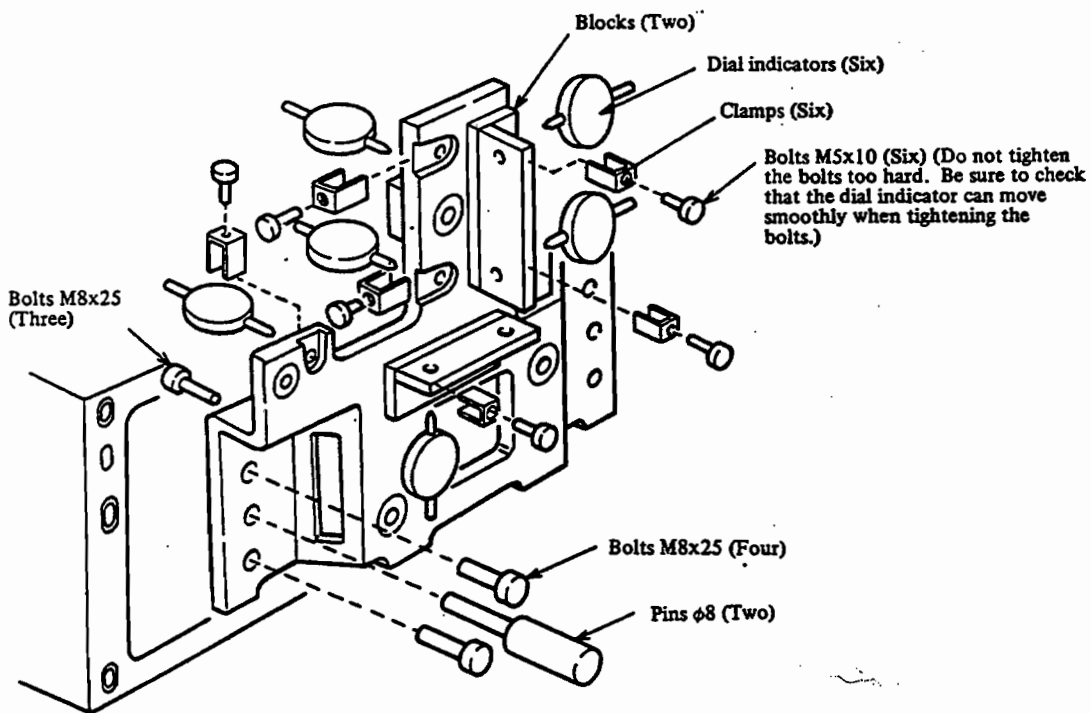


Fig. 4.3.4 (a) Mounting mastering fixture on robot main frame (S-700)

ii) Calibrating dial indicators

Mount the calibration block using collars, pins, and bolts as shown in Fig. 4.3.4 (b) and adjust each dial indicator to indicate 3.00 ± 0.02 mm.

When calibration of the dial indicators has been completed, remove the calibration block carefully and mount it on the position shown in Fig. 4.3.4 (c). At this time, be sure to check that the tip of each dial indicator moves smoothly.

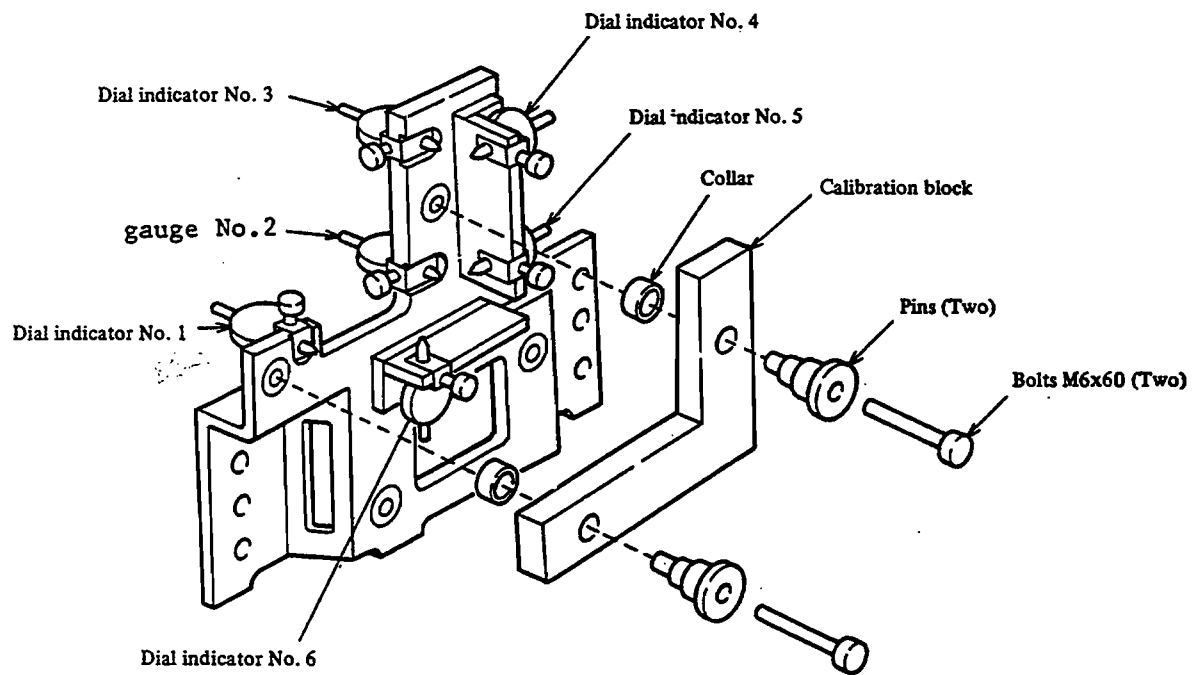


Fig. 4.3.4 (b) Dial indicator calibration (S-700)

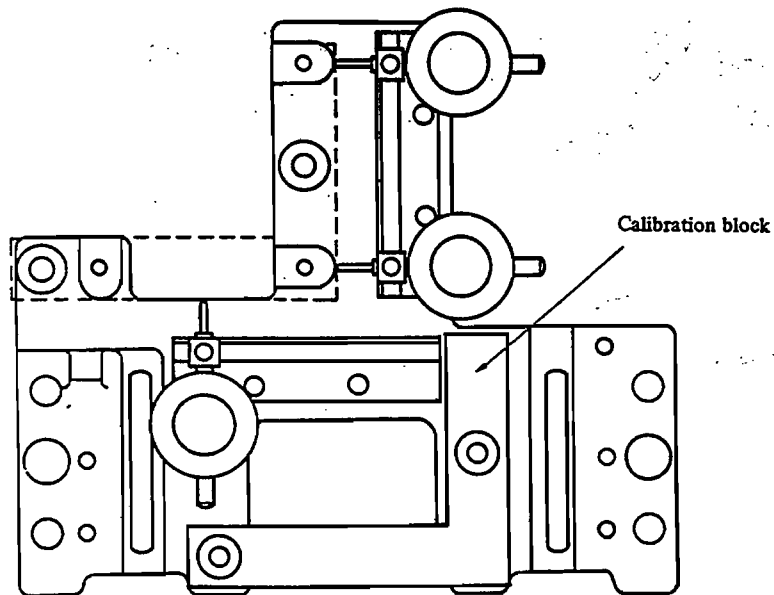


Fig. 4.3.4 (c) Calibration block mounting position after completion of calibration (S-700)

iii) Mounting fixture on wrist

Jog the wrist to the position where $\alpha = \beta = \gamma = 0$ degree, and mount the fixture on the α -axis flange as shown in Fig. 4.3.4 (d). Note that the fixture mounting surfaces of the offset wrist and of in-line wrist are reversed.

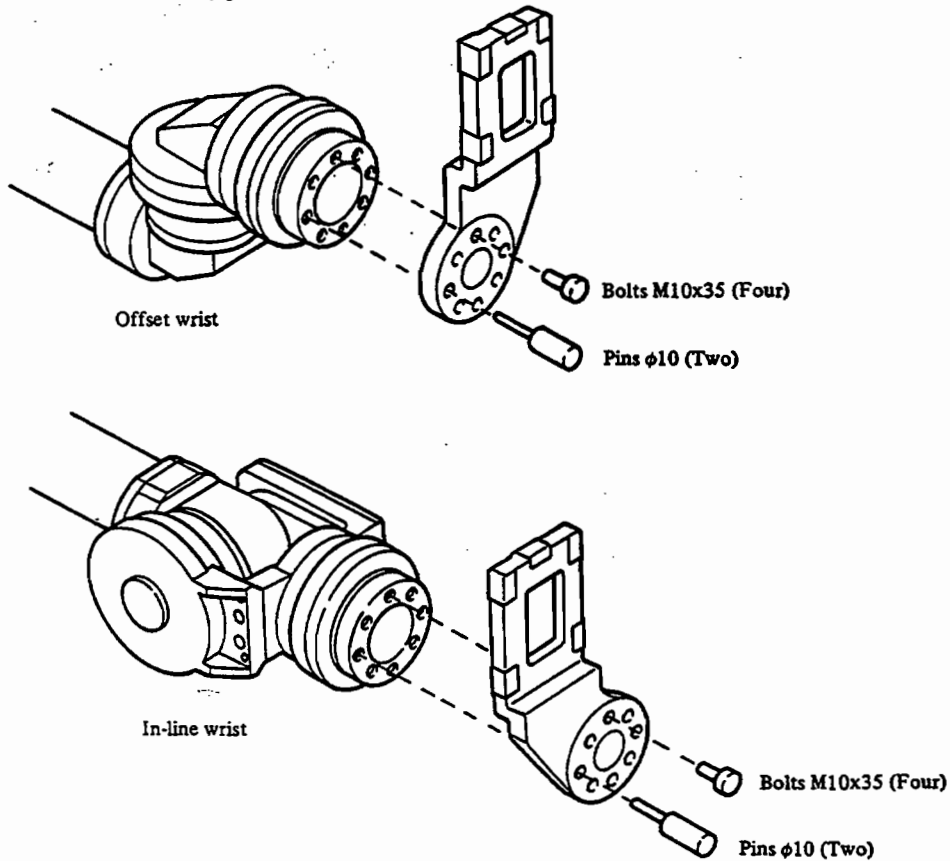
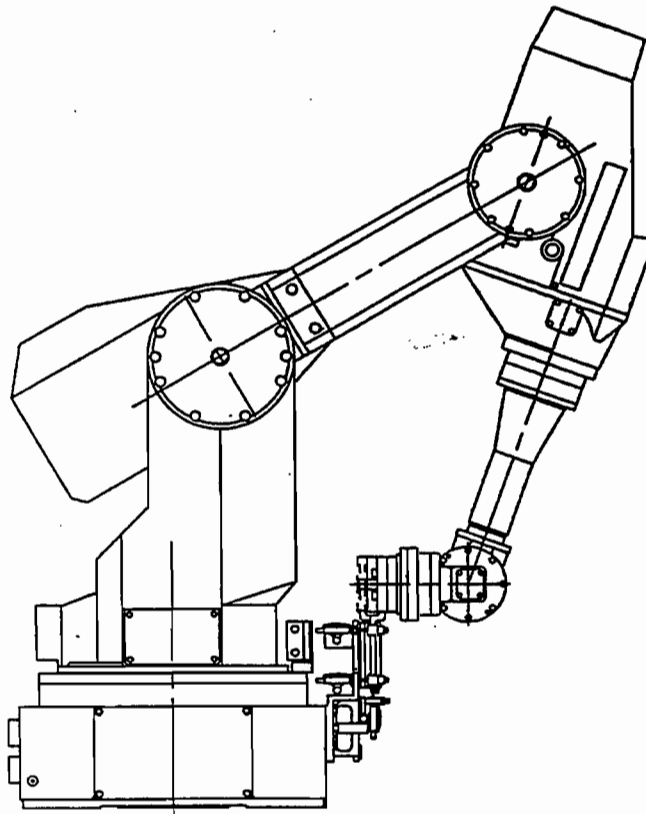


Fig. 4.3.4 (d) Mounting fixture on wrist (S-700)

b) Mastering procedure

- i) First, master the robot to the zero-degree alignment described in section 4.3.3. This mastering operation allows the setting of the temporary coordinate origin of the robot that enables the use of the Cartesian coordinate system for the following mastering operations and easy alignment of the mastering fixture.
- ii) Set the robot in the mastering position shown in Fig. 4.3.4 (e). Note that the α -axis and γ -axis positions are different for the offset wrist and in-line wrist.
 - Align the mastering fixture according to the following procedure:
 - ① Move the robot gradually to the position where the fixture mounted on the wrist touches the dial indicators. At this time, pre-adjust each axis so that dial indicators No.1, No.2, No.3, No.4, and No.5 touch the fixture almost simultaneously.
 - ② Move the γ -axis so that dial indicators No.1 and No.2 indicate the same value.

- ③ Move the α -axis so that dial indicators No.4 and No.5 indicate the same value.
 - ④ Set the Cartesian coordinate system and move the wrist in the Y direction so that dial indicators No.4 and No.5 indicate 3.00 ± 0.02 mm. If dial indicator No.1 and No.2 indicate different values, return to step ②.
 - ⑤ Move the β -axis so that dial indicators No.2 and No.3 indicate the same value.
 - ⑥ Jogging in the world coordinate system, move the wrist in the X-axis and Y-axis directions so that dial indicators No.1 and No.6 indicate 3.00 ± 0.02 mm.
 - ⑦ At completion of the above steps, check that all dial indicators indicate 3.00 ± 0.02 mm.
- iii) Perform the mastering procedure described in Section 4.3.2, starting at Step ②.



Offset wrist

$\theta = -90^\circ, 0^\circ, 90^\circ$
 $W = 60^\circ$
 $U = -110^\circ$
 $\gamma = -90^\circ$
 $\beta = -70^\circ$
 $\alpha = 90^\circ$

In-line wrist

$\theta = -90^\circ, 0^\circ, 90^\circ$
 $W = 60^\circ$
 $U = -110^\circ$
 $\gamma = 0^\circ$
 $\beta = -70^\circ$
 $\alpha = 0^\circ$

Fig. 4.3.4 (e) Mastering position (S-700)

4.4 Adjusting Bevel Gear Backlash

1) W-axis bevel gear

- ① Remove the W-axis motor. (Refer to 5.2)
- ② Remove the W-axis reducer. (Refer to 5.2)
- ③ Remove the four M6x20 bolts and gear WM unit (V302).
- ④ Remove the four M6x20 bolts and gear WR unit (V301).
- ⑤ Adjust the backlash within 0.05 - 0.1 mm (on P.C.D.) using shims (X327, X329, X330, X332). When using a dial indicator, put it to the bottom of the gear (see Fig. 3.4 (a)) and adjust the backlash within 0.015 - 0.03 mm.
- ⑥ Reassemble reversing the above procedure. Apply LOCTITE to the bolts.

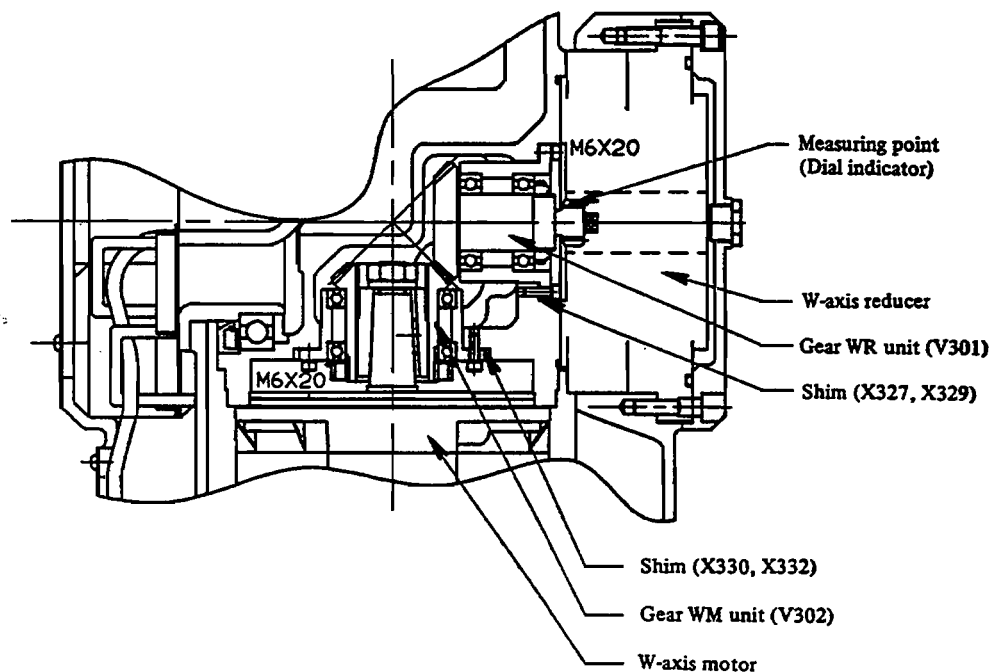


Fig. 4.4 (a) Adjusting W-axis bevel gear backlash

2) U-axis bevel gear

- ① Remove the U-axis motor (Refer to 5.3)
- ② Remove the U-axis reducer (Refer to 5.3)
- ③ Remove the four M6x20 bolts and gear UM unit (V402).
- ④ Remove the four M6x20 bolts and gear UR unit (V401).
- ⑤ Adjust the backlash within 0.05 - 0.1 mm (on P.C.D.) using shims (X434, X436, X437, X439). When using a dial indicator, put it to the bottom of the gear (see Fig. 3.4 (b)) and adjust the backlash within 0.02 - 0.04 mm.
- ⑥ Reassemble reversing the above procedure. Apply LOCTITE to the bolts.

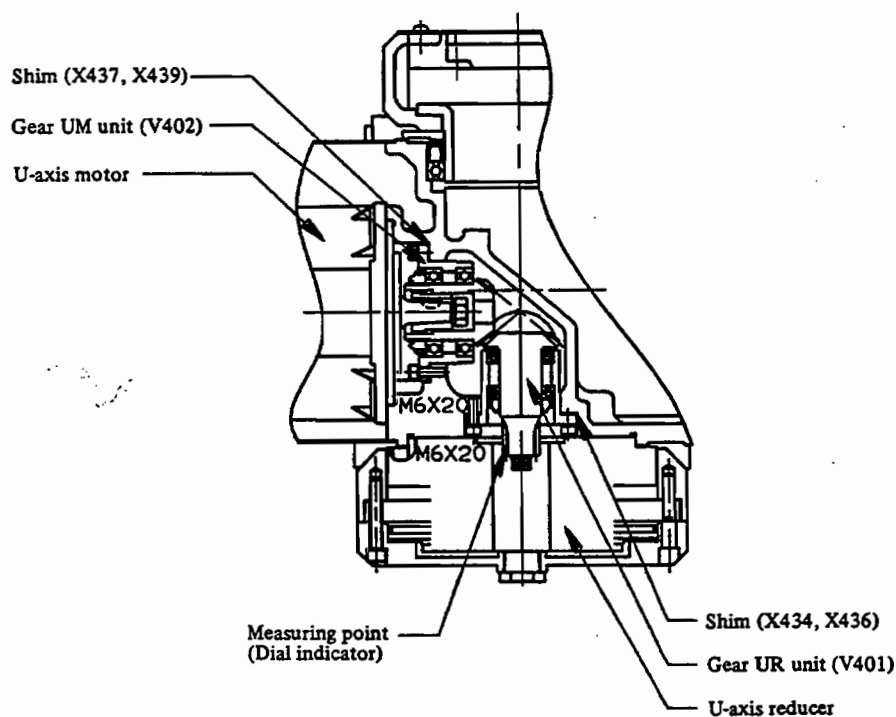


Fig. 4.4 (b) Adjusting U-axis bevel gear backlash

3) β -axis bevel gear (OFFSET WRIST)

- ① Remove the wrist unit.
- ② Remove the β -axis reducer.
- ③ Remove the four M4x12 bolts and gear α/β unit (V501).
- ④ Remove the gear BR (X507).
- ⑤ Adjust the backlash within 0.05 - 0.1 mm (on P.C.D.) using shims (X516, X518, X519, X521). When using a dial indicator, put it to the tooth of the gear.
- ⑥ Reassemble reversing the above procedure. Apply LOCTITE to the bolts.

4) α -axis bevel gear (OFFSET WRIST)

- ① Remove the wrist unit.
- ② Remove the β -axis and α -axis reducer.
- ③ Remove the four M4x12 bolts and gear α/β unit (V501).
- ④ Remove the gear A (X509).
- ⑤ Remove the gear α unit.
- ⑥ Adjust the backlash within 0.05 - 0.1 mm (on P.C.D.) using shims (X522, X524, X525, X527). When using a dial indicator, put it to the tooth of the gear.
- ⑦ Reassemble reversing the above procedure. Apply LOCTITE to the bolts.

Note) When adjusting the β -axis bevel gear, be sure to adjust the α -axis bevel gear (α/β gear unit), too.

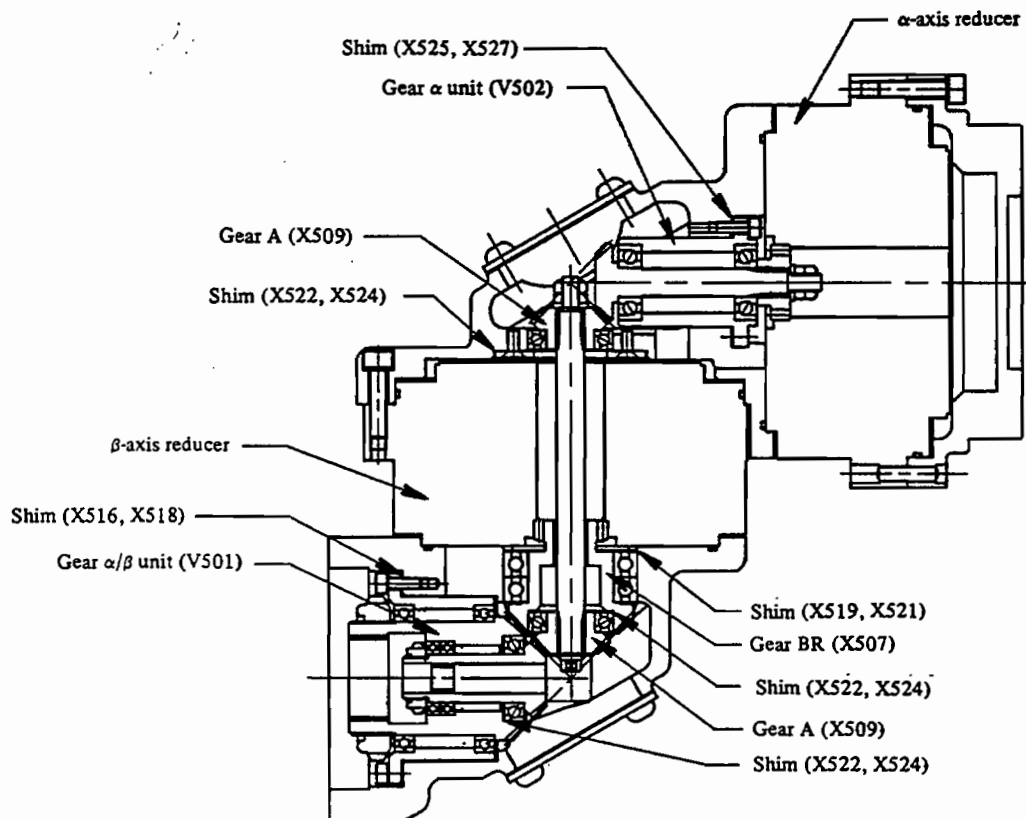


Fig. 4.4 (c) Adjusting α/β -axis bevel gear backlash (offset wrist)

5) β -axis bevel gear (IN-LINE WRIST)

- ① Remove the wrist unit.
- ② Remove the β -axis reducer.
- ③ Remove the four M4x12 bolts and gear α/β unit (V501).
- ④ Remove the gear BR (X558).
- ⑤ Adjust the backlash within 0.05 - 0.1 mm (on P.C.D.) using shims (X516, X518, X519, X521). When using a dial indicator, put it to the bottom of the gear (see Fig. 3.4 (d)) and adjust the backlash 0.06 - 0.13 mm.
- ⑥ Reassemble reversing the above procedure. Apply LOCTITE to the bolts.

6) α -axis bevel gear (IN-LINE WRIST)

- ① Remove the wrist unit.
- ② Remove the α -axis reducer.
- ③ Remove the wrist casing (X552).
- ④ Remove the gear α/β unit (V501), gear A (X560), gear $\alpha 1$ unit (V512), gear $\alpha 2$ unit (V511).
- ⑤ Adjust the backlash within 0.05 - 0.1 mm (on P.C.D.) using shims (X522, X524, X525, X527, X566, X568). When using a dial indicator, put it to the tooth of helical gear (see Fig. 3.4 (d)) and adjust the backlash 0.13 - 0.25 mm (tangential direction).
- ⑥ Reassemble reversing the above procedure. Apply LOCTITE to the bolts.

Note) When adjusting the β -axis bevel gear, be sure to adjust the α -axis bevel gear (α/β gear unit), too.

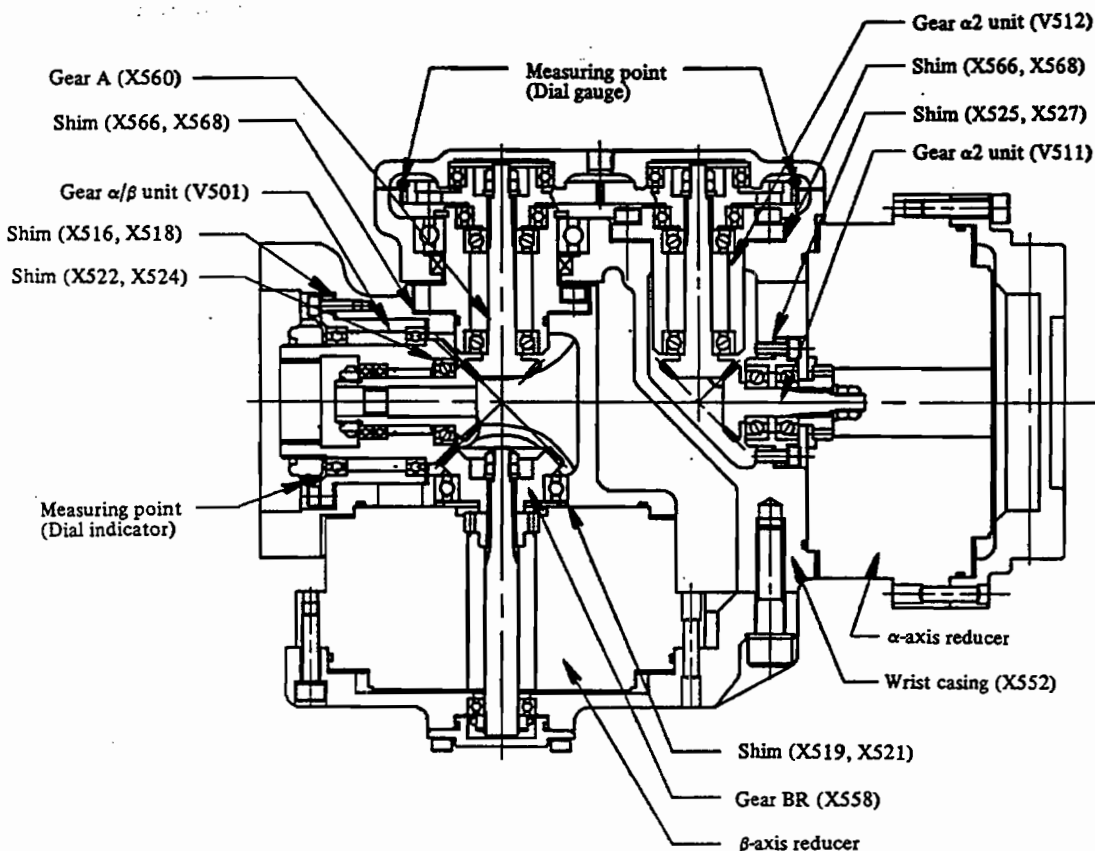


Fig. 4.4 (d) Adjusting α/β -axis bevel gear backlash (in-line wrist)

5. REPLACING PARTS

5.1 Replacing θ -axis Motor and Reducer

1) Replacing the θ -axis motor

- ① Set the W axis close to +90 degrees.
- ② Remove the bottom cover and plate and three side covers from the W-axis base.
- ③ Remove the θ -axis motor connector.
- ④ Remove the motor mounting bolt (M10x20) and the motor from the bottom window of the W-axis base.
- ⑤ Remove the C ring and pull off the input gear and coupling. Remove the draw bolt and pull off the input spline.
- ⑥ Replace the motor and mount it reversing the above procedure. Apply LOCTITE (No.242) to the draw bolt.

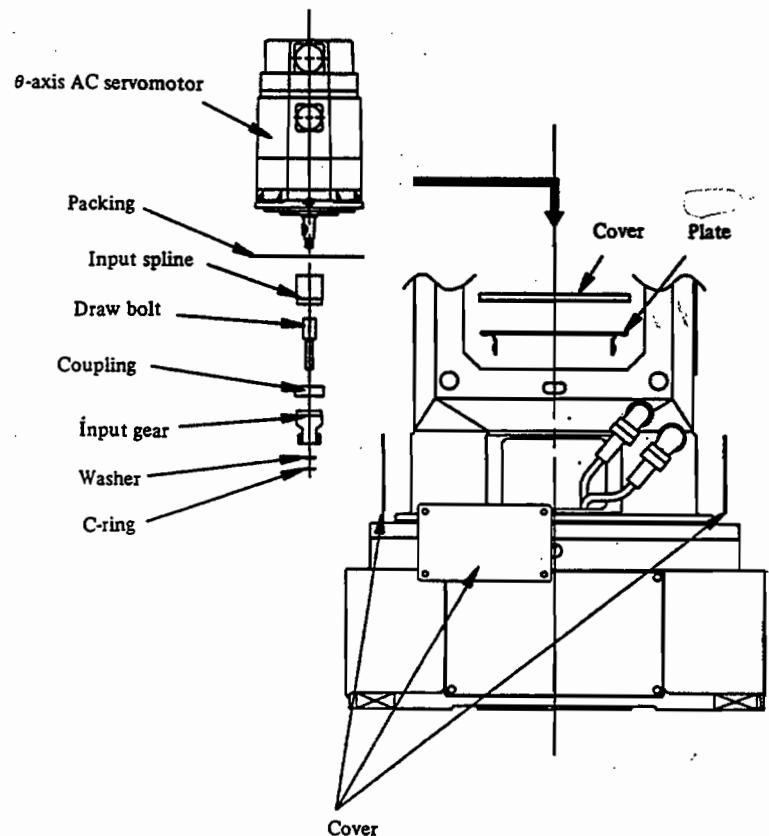


Fig. 5.1 (a) Replacing θ -axis motor (S-700)

2) Replacing the θ -axis reducer

- ① Remove the air hose and EE cable from the EE connector panel.
- ② Remove the motor connectors of all axes.
- ③ Remove the pin and clamp from the θ -axis cable and push the cable into the base.
- ④ Remove the M10x30 bolt and $\phi 10 \times 35$ spring pin mounted on the W-axis base.
- ⑤ Hang the W/U-axis unit being careful of the cable and remove it from the θ -axis unit.
- ⑥ After removing the θ -axis connector panel and ground line, remove the cable and cable track.
- ⑦ Remove the θ -axis motor mounting bolt (M10x20) and the motor.
- ⑧ Remove the bolts (M10x25) mounting the holder to the cross roller bearing and remove the holder.
- ⑨ Remove the M12x60 bolt and $\phi 10 \times 30$ taper pin mounting the table to the reducer.
- ⑩ Remove the table together with the holder and cross roller bearing, and then the O-ring.
- ⑪ Remove the reducer and the bolt (M14x110) and taper pin ($\phi 13 \times 40$) mounting the reducer to the θ -axis base.
- ⑫ Remove the reducer and replace it.
- ⑬ Mount the new reducer reversing the above procedure. Polish the reducer mounting surface and motor flange mounting surface with an oilstone. Apply LOCTITE (No.262) to the bolts removed in steps 9 and 11. Apply LOCTITE (No.242) to the taper pins removed in steps 9 and 11. Ream the hole and insert the pin.
Be sure to mount the O-ring on the specified position.
- ⑭ Apply grease.

Note) Be sure to tighten the reducer mounting bolts with the following tightening torque:

M14x110 ... 2090 kg.cm
M12x60 1310 kg.cm

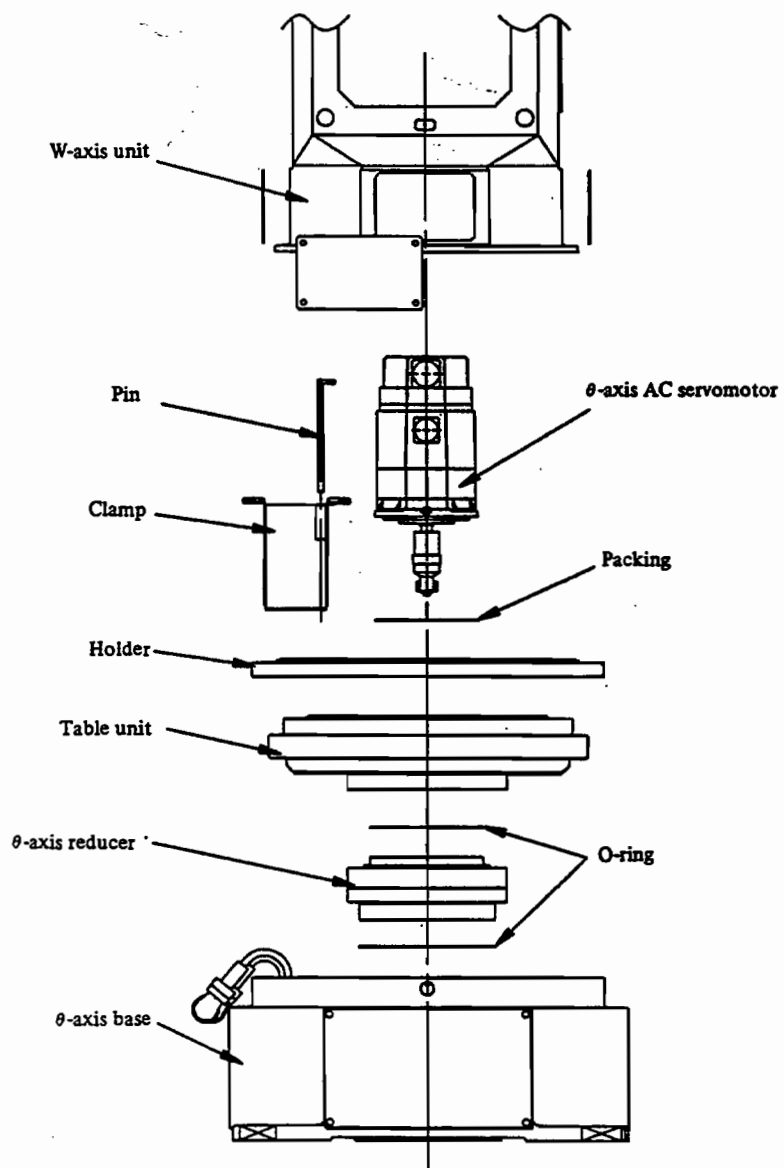


Fig. 5.1 (b) Replacing θ -axis reducer (S-700)

5.2 Replacing W-axis Motor and Reducer

1) Replacing the W-axis motor

- ① Remove the plug and move the W axis manually using a box wrench with a width of 13 mm until it lightly touches the rubber stop.
- ② Remove the cover.
- ③ Remove the cable from the motor.
- ④ Remove the motor mounting bolt (M12x30) and the motor.
- ⑤ Remove the spline from the motor.
- ⑥ Replace the motor and mount the new motor reversing the above procedure. Apply LOCTITE (No.242) to the motor screw.

Note) For manual movement, the W axis moves in the rotary direction of the manual crank.

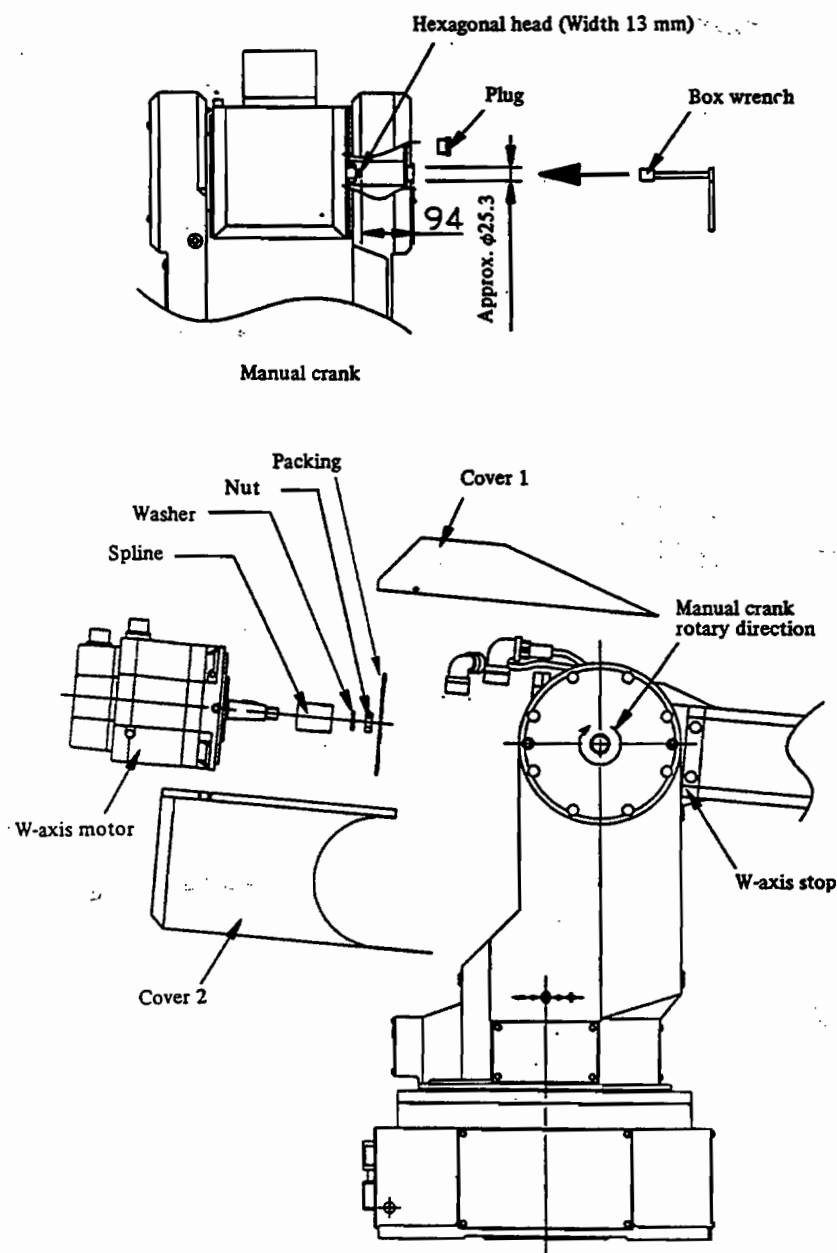


Fig. 5.2 (a) Replacing W-axis motor (S-700)

2) Replacing the W-axis reducer

- ① Remove the plug and move the W axis manually using a box wrench with a width of 13 mm until it lightly touches the rubber stop.
- ② Remove the bolt (M12x55) and taper pin ($\phi 13 \times 30$) mounting the cover to the reducer, and remove the cover and O-ring.
- ③ Remove the bolt (M14x120) and taper pin ($\phi 13 \times 40$) mounting the reducer.
- ④ Remove the reducer and replace it.
- ⑤ Mount the new reducer reversing the above procedure.
Polish the reducer mounting surface and motor flange mounting surface with an oilstone. Apply LOCTITE (No.262) to the bolts removed in steps ② and ③. Apply LOCTITE (No.242) to the taper pins removed in steps ② and ③. Ream the hole and insert the pin. Be sure to mount the O-ring on the specified position.
- ⑥ Apply grease.

Note 1) Be sure to tighten the reducer mounting bolts with the following tightening torque:

M14x120 ... 2090 kg.cm

M12x55 1310 kg.cm

Note 2) For manual movement, the W axis moves in the rotary direction of the manual crank.

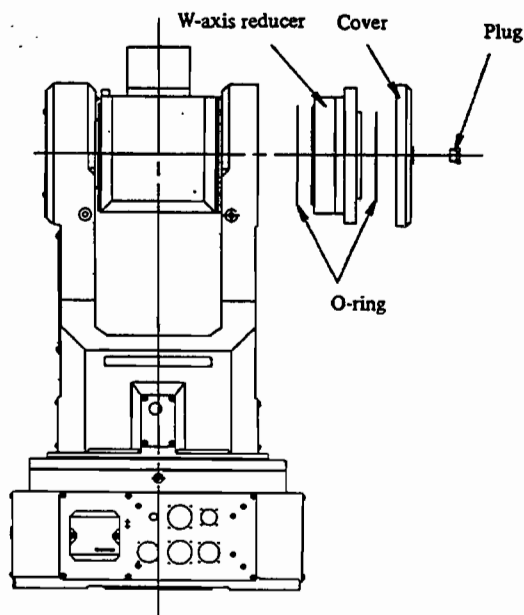
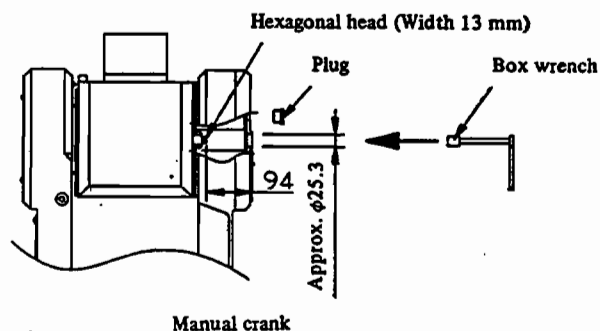


Fig. 5.2 (b) Replacing W-axis reducer (S-700)

5.3 Replacing U-axis Motor and Reducer

1) Replacing the U-axis motor

- ① Remove the plug and move the U axis manually using a box wrench with a width of 13 mm until it lightly touches the rubber stop.
- ② Remove the cover.
- ③ Remove the cable from the motor.
- ④ Remove the motor mounting bolt (M10x20) and the motor.
- ⑤ Remove the spline from the motor.
- ⑥ Replace the motor and mount the new motor reversing the above procedure. Apply LOCTITE (No.242) to the motor screw.

Note) For manual movement, the U axis moves in the rotary direction of the manual crank.

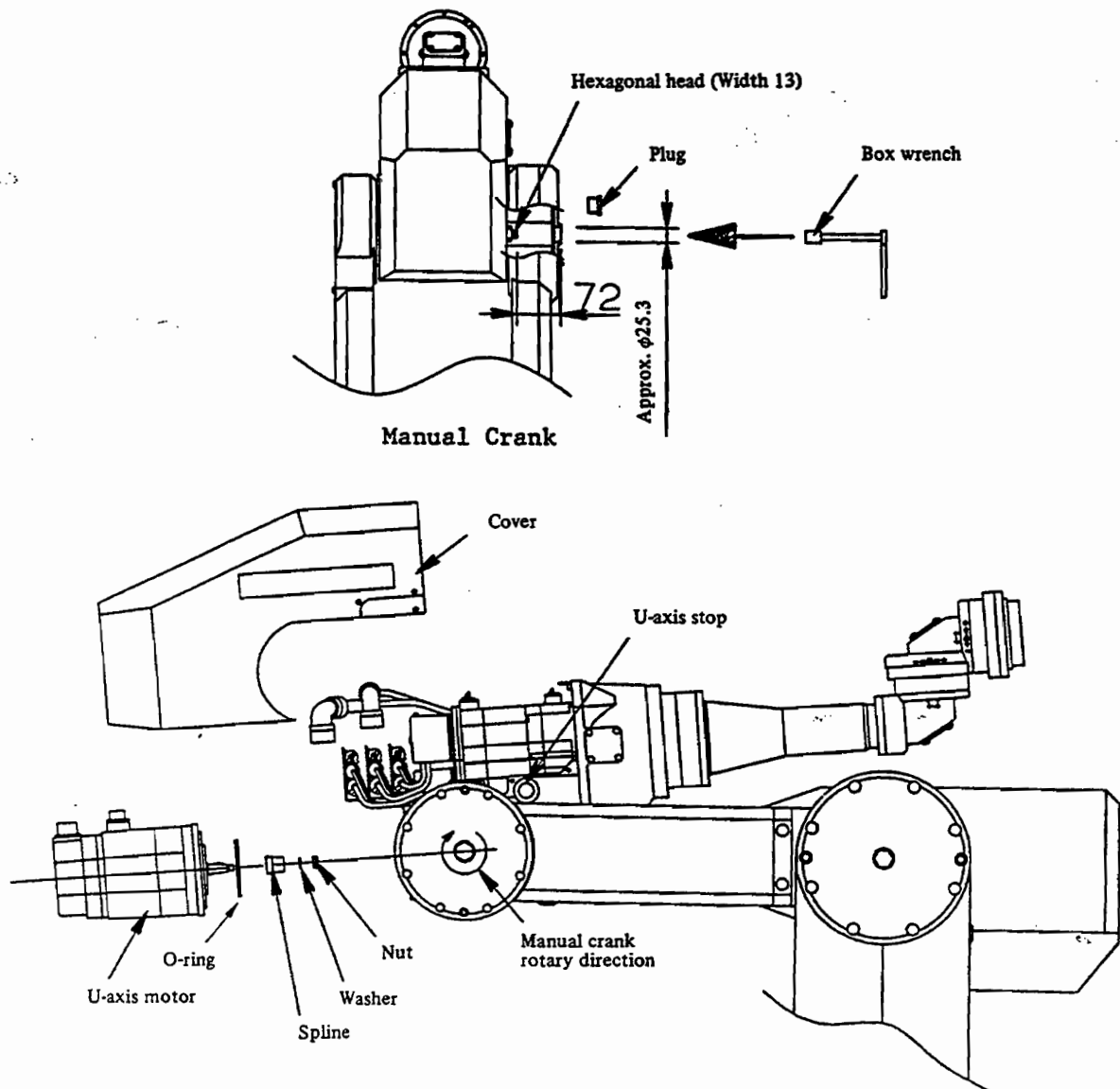


Fig. 5.3 (a) Replacing U-axis motor (S-700)

2) Replacing the U-axis reducer

- ① Remove the plug and move the U axis manually using a box wrench with a width of 13 mm until it lightly touches the rubber stop.
- ② Remove the bolt (M8x50) and taper pin ($\phi 8 \times 30$) mounting the cover to the reducer, and remove the cover and O-ring.
- ③ Remove the bolt (M12x85) and taper pin ($\phi 10 \times 40$) mounting the reducer after removing the taper pin in the reducer.
- ④ Remove the reducer and replace it.
- ⑤ Mount the new reducer reversing the above procedure. Polish the reducer mounting surface and motor flange mounting surface with an oilstone. Apply LOCTITE (No.262) to the bolts removed in steps ② and ③. Apply LOCTITE (No.242) to the taper pins removed in steps ② and ③. Ream the hole and insert the pin. Be sure to mount the O-ring on the specified position.
- ⑥ Apply grease.

Note 1) Be sure to tighten the reducer mounting bolts with the following tightening torque:

M12x85 ... 1310 kg.cm

M8x50 380 kg.cm

Note 2) For manual movement, the U axis moves in the rotary direction of the manual crank.

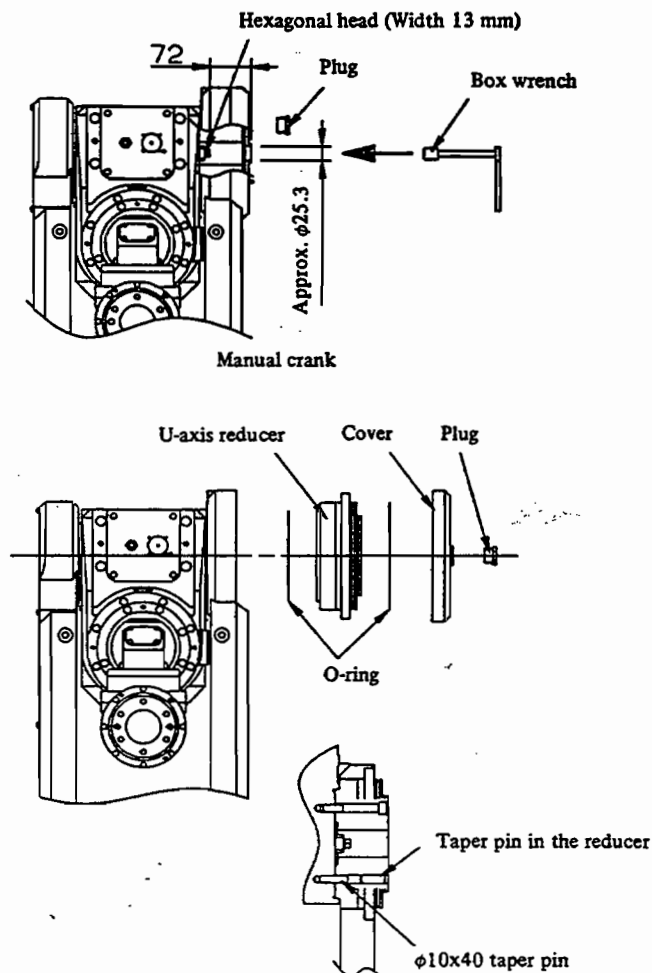


Fig. 5.3 (b) Replacing U-axis reducer (S-700)

5.4 Replacing $\alpha/\beta/\gamma$ -axis Motor and Reducer

1) Replacing the $\alpha/\beta/\gamma$ -axis motor




- ① Remove the loads such as a hand and end effector from the wrist.
- ② Drain grease from the gear box. (Note 2)
- ③ Remove the motor mounting bolt (M6x16) and the motor using the exclusive T-wrench.
- ④ Remove the nut and the gear.
- ⑤ Replace the motor and mount the new motor reversing the above procedure. (First, mount the β -axis motor.)
- ⑥ Add new grease.

Note 1) The three motors of the wrist can be mounted to any mounting hole. Therefore, be sure to mount the motor with the gear on the correct mounting position.

Note 2) When place the robot ($U = -90^\circ$) where no grease drop at motor replacement, it is not required to drain grease.

Note 3) When removing the bolts indicated by an arrow, use the exclusive long T-wrench (A05B-1120-J047).

Gear mounted on each motor

Axis	α	β	γ
Outer diameter of gear	Large	Medium	Small
Shape			

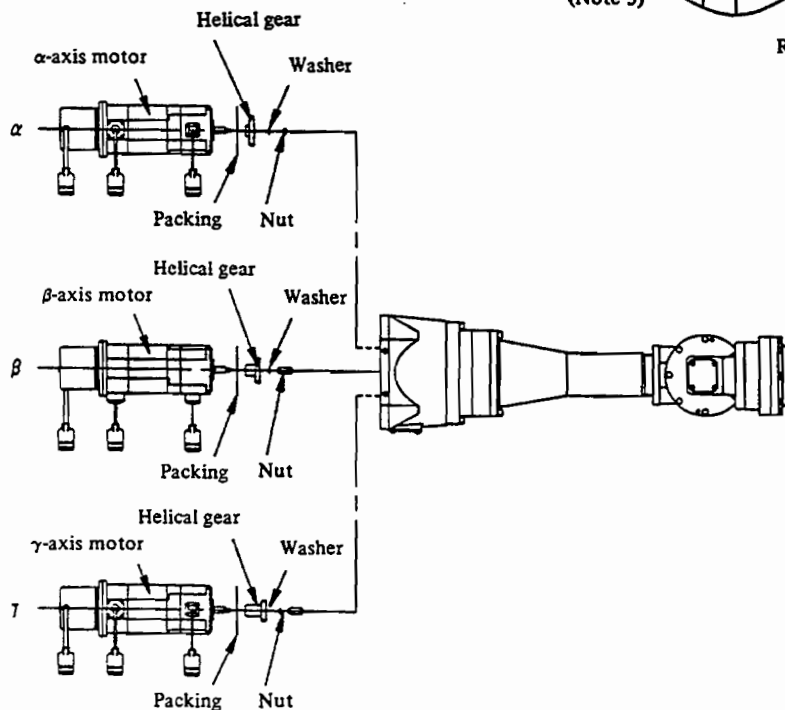
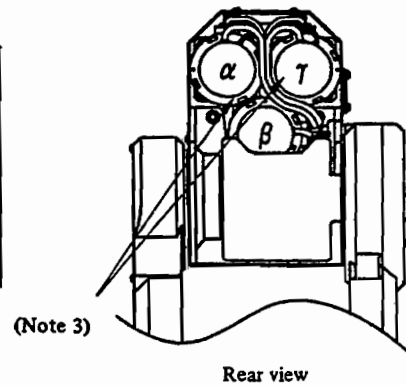


Fig. 5.4 (a) Replacing $\alpha/\beta/\gamma$ -axis motor (S-700)

2) Replacing the γ -axis reducer

- ① Remove the loads such as a hand and end effector from the wrist.
- ② Drain grease from the gear box.
- ③ Remove the arm mounting bolt (M8x30) and the spring pin $\phi 6 \times 25$), and remove the arm unit.
- ④ Remove the bolt (M12x30) and taper pin (M8x25), and remove the adapter.
- ⑤ Remove the bolt (M8x40) and taper pin ($\phi 6 \times 25$) mounting the reducer.
- ⑥ Remove the reducer and replace it.
- ⑦ Mount the new reducer reversing the above procedure. Polish the reducer mounting surface and motor flange mounting surface with an oilstone. Apply LOCTITE (No.262) to the bolts removed in steps ④ and ⑤. Apply LOCTITE (No.242) to the taper pins removed in steps ④ and ⑤. Ream the hole and insert the pin. Be sure to mount the O-ring on the specified position.
- ⑧ Apply grease.

Note 1) Be sure to tighten the reducer mounting bolts with the following tightening torque:

M12x30 ... 1310 kg.cm

M8x40 380 kg.cm

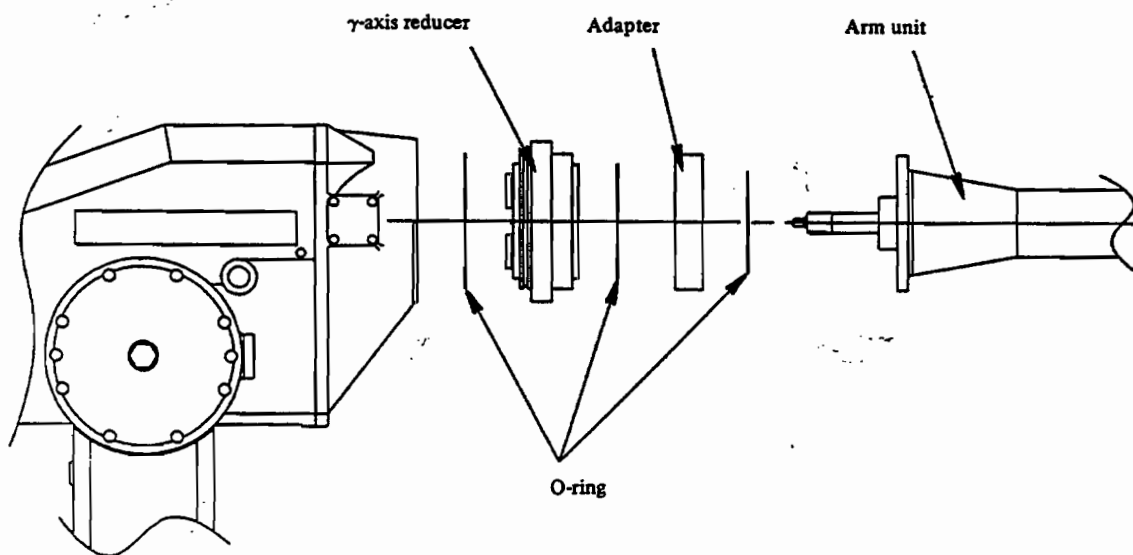


Fig. 5.4 (b) Replacing γ -axis reducer (S-700)

5.5 Replacing Wrist Unit

- ① Remove the loads such as a hand and end effector from the wrist.
- ② Drain grease from the wrist unit.
- ③ Remove the wrist unit mounting bolt (M8x25) and spring pin ($\phi 6 \times 20$), and remove the wrist unit.
- ④ Replace the wrist unit and mount the new wrist unit reversing the above procedure.
- ⑤ Apply grease.

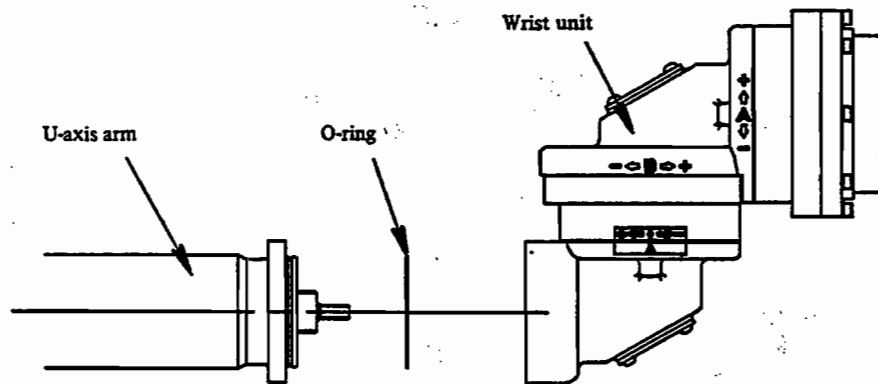


Fig. 5.5 (a) Replacing wrist unit (S-700, offset wrist)

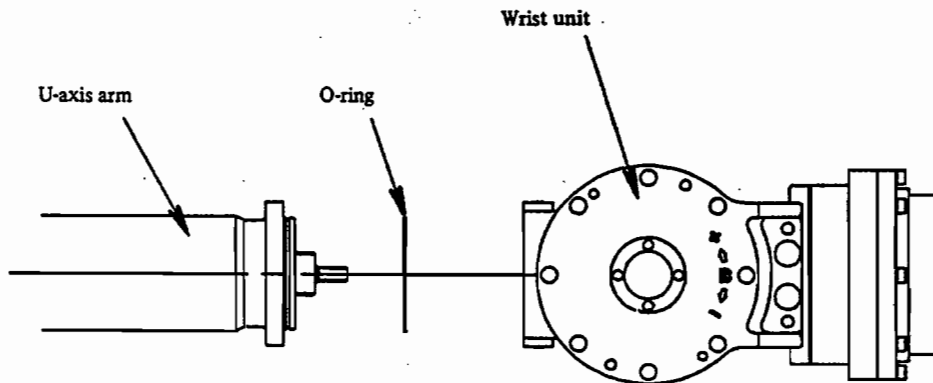


Fig. 5.5 (b) Replacing wrist unit (S-700, in-line wrist)

5.6 Replacing Battery

The positional data of each robot axis is stored by the pulse coder, which is powered by a backup battery. The battery needs to be replaced every year according to the following procedure:

- ① Turn on the power and press the EMERGENCY STOP button to prohibit the robot motion.
- ② Remove the lid from the battery case.
- ③ Remove the batteries from the battery case.
- ④ Remount the new batteries. Confirm the pole direction.
- ⑤ Remount the lid.

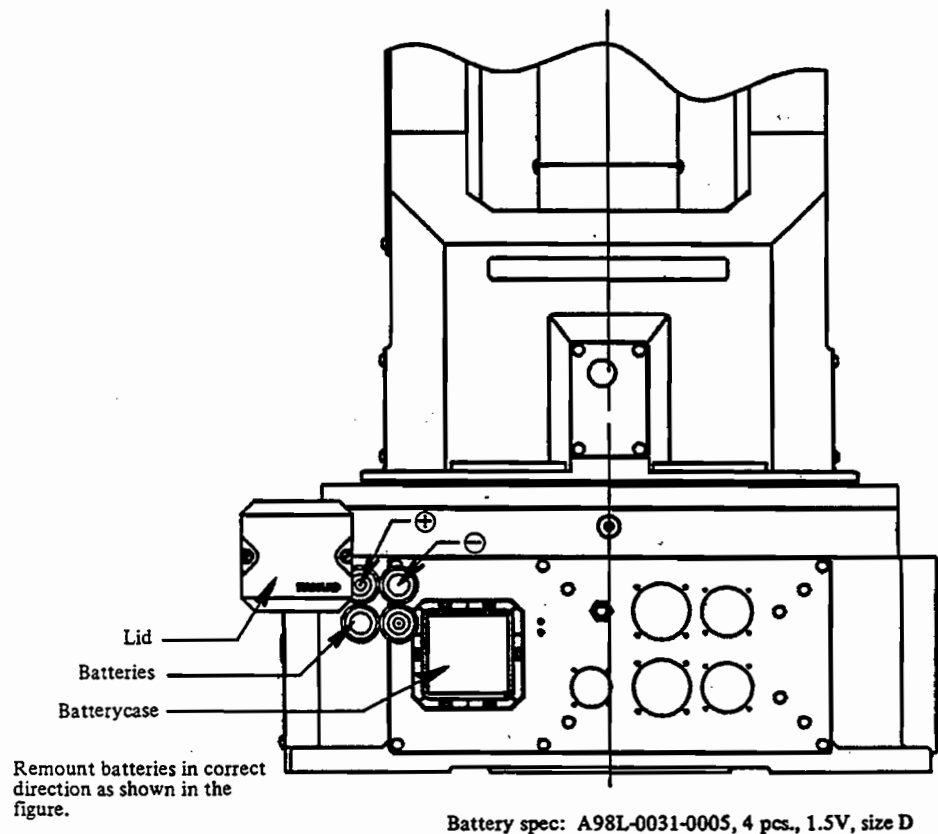


Fig. 5.6 Replacing battery (S-700)

6. WIRING AND PIPING

6.1 Piping Diagram

Fig. 6.1 shows the piping diagram of the mechanical unit.

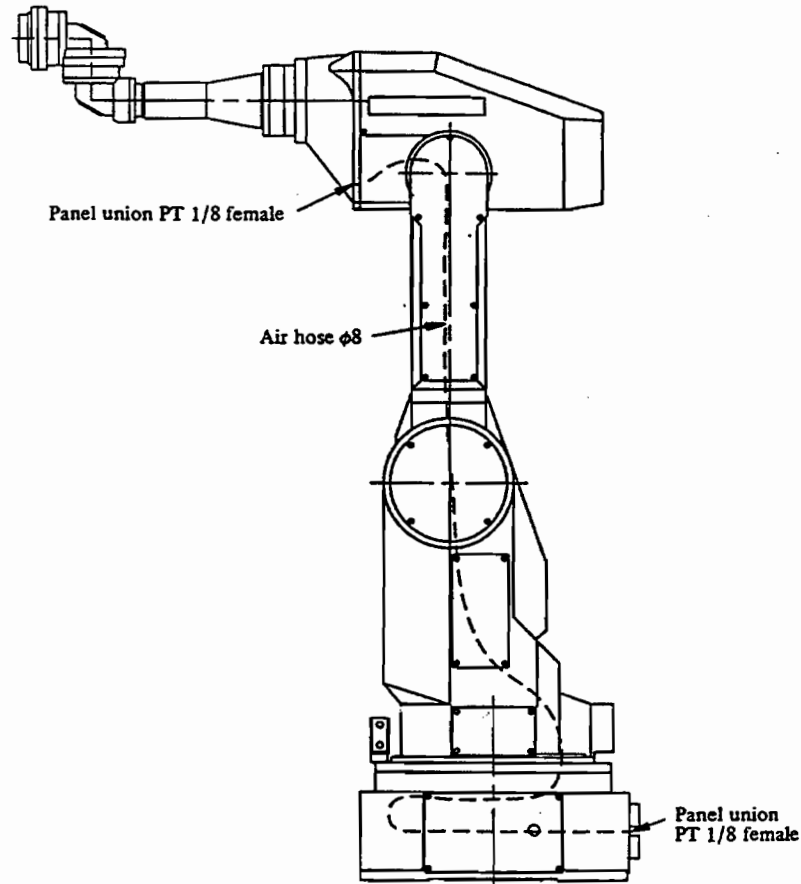


Fig. 6.1 Piping diagram (S-700)

6.2 Wiring Diagram

Table 6.2 shows the cable list and Fig. 6.2 shows the wiring diagram of the mechanical unit.

Table 6.2 Cable list (S-700)

Cable	Specification	Remarks
K101	A660-8007-T038	θ , W, U pulse coder
K102	A660-8007-T039	α , β , γ pulse coder
K103	A660-4002-T871	θ , W power, brake
K104	A660-1120-D001	α , β , γ , U power, brake
K105	A660-8007-T040	DI/DO, limit switch
K106	A660-1120-D002	θ proximity switch

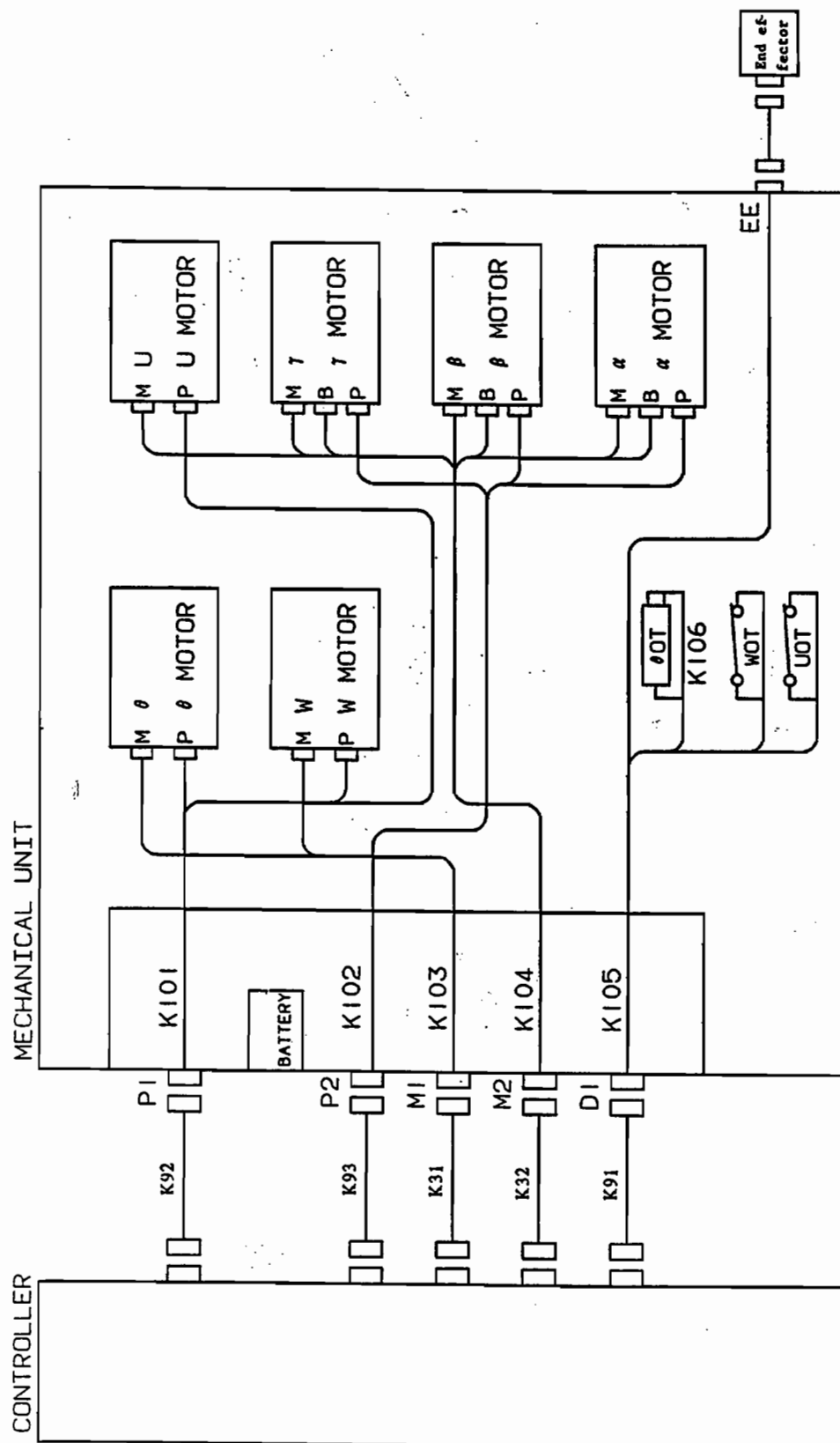


Fig. 6.2 Wiring diagram of mechanical unit (S-700)

6.3 Limit Switch Installation Diagram

Fig. 6.3 shows the installation diagram for the limit switches in the mechanical unit.

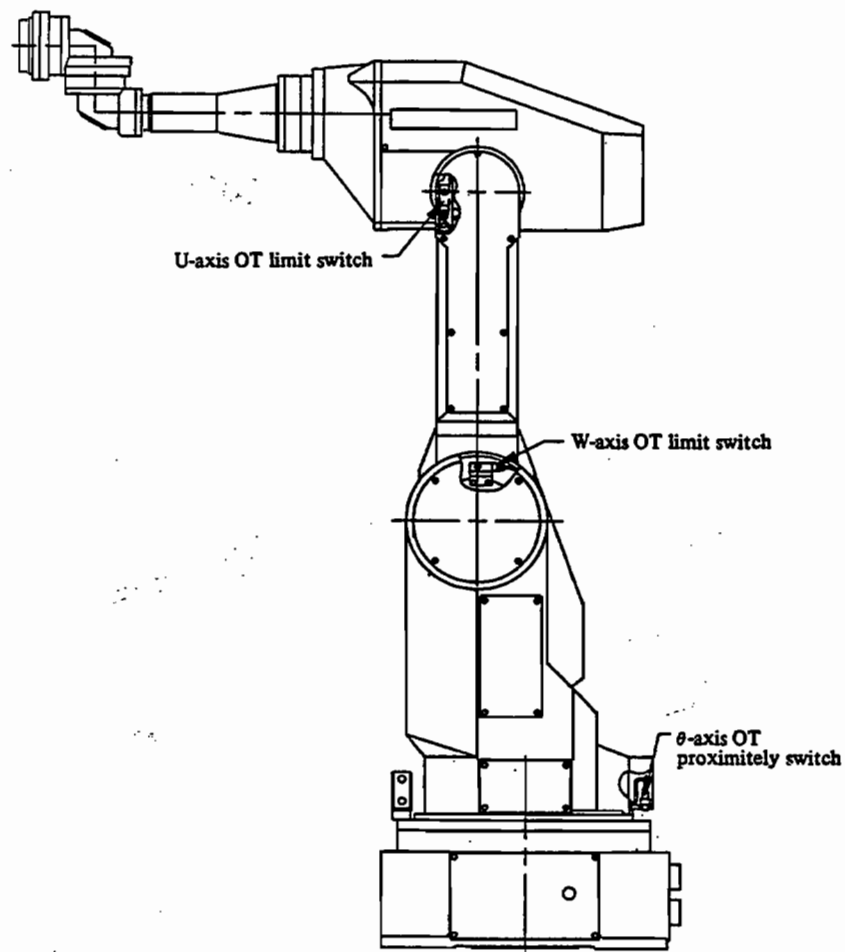


Fig. 6.3 Limit switch installation diagram (S-700)

6.4 Cable Installation Diagram

Check the appearance of each cable for any faults.

- 1) Remove the W-axis base and the side cover of the W-axis arm and check for rubbing of the cables when the W axis and U axis are moved. Also check if the cables are caught in the cover.

- 2) Check whether the routing of the cables connected to the end effector is suitable to the wrist motion or the service motion of the robot.

Fig. 6.4 shows the installation diagram for the cables in the mechanical unit.

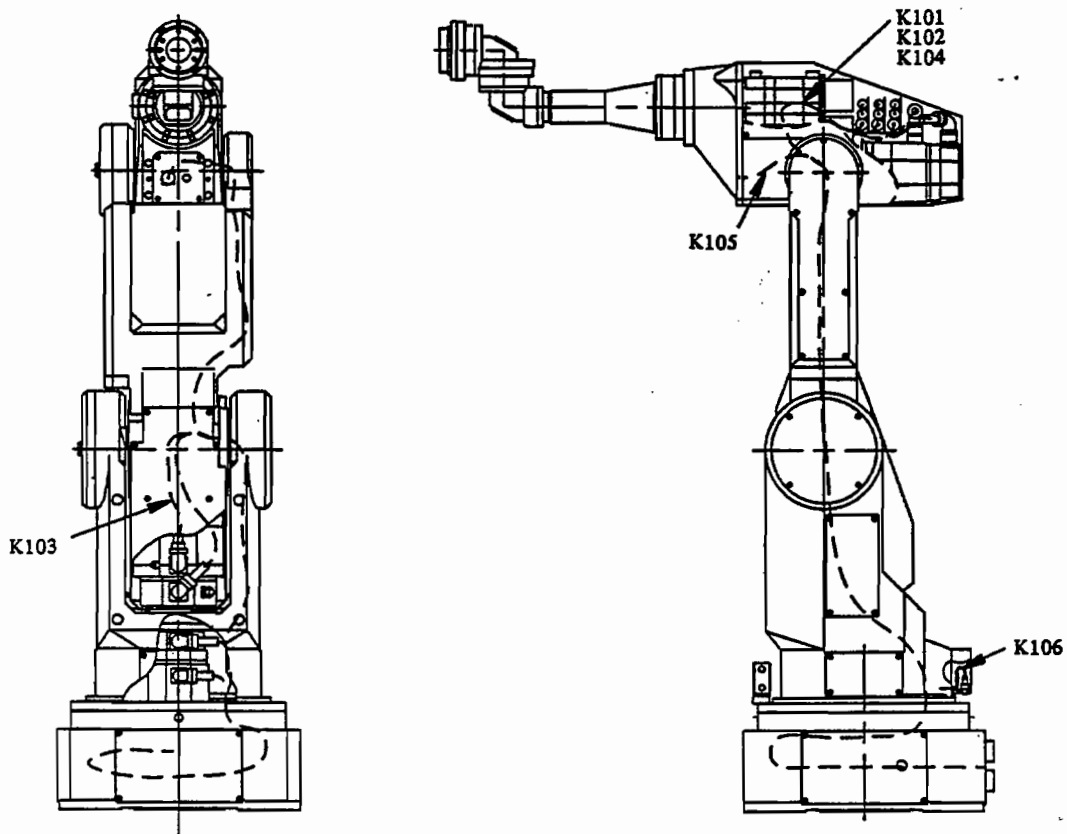


Fig. 6.4 Cable installation diagram (S-700)

7. REPLACING CABLES

A broken or damaged cable should be replaced as specified in this section. If the pulse coder cable (K101, K102) connector is disconnected at the same time that the pulse coder cable to the battery is disconnected the motor loses its absolute position. Therefore mastering is required to reestablish the present position. Be careful to disconnect only one set of cables carrying power to the pulse coder at one time.

7.1 Cable Forming

When mounting the replaced cable with clamps and tie wraps, clamp it at the positions specified in Table 8.1. Unless the cable is clamped at the specified positions, the cable may be broken due to excessive sagging or tension.

Table 7.1 Cable clamping positions (S-700)

Stamp	Cable clamping position	Stamp	Cable No.
P1	<p>Clamping position</p>	θP	K101
P2		WP	
		UP	
M1		τP	K102
		βP	
		αP	
M2		θM	K103
		WM	
		UM	K104
		τM	
		τBK	
		βM	
		βBK	
		αM	K105
		αBK	
D1		EE	

7.2 Replacing Cables

- ① Remove the U axis and cut the tie wrap mounting the connectors. (See Fig. 7.2 (a).)
- ② Remove all connectors.
- ③ Remove the end effector plate and remove the connectors.
- ④ Remove the side cover of the W-axis arm and remove the plate clamping the cables.
- ⑤ Cut the tie wrap and pull out the cables.

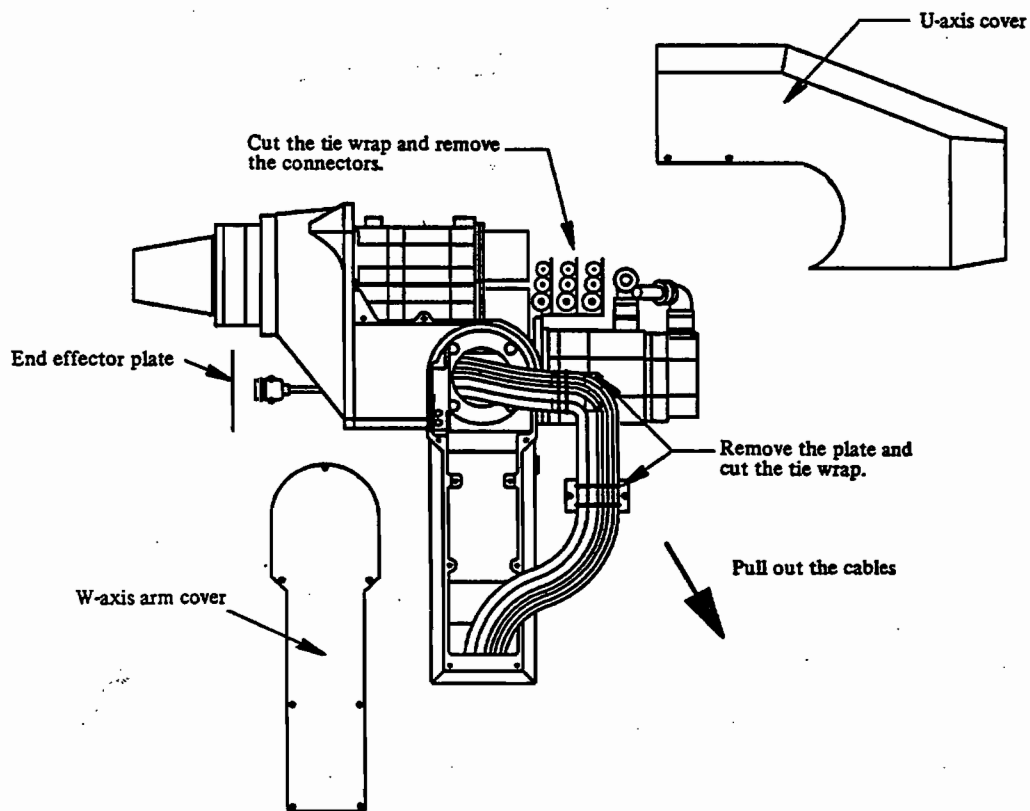


Fig. 7.2 (a) Replacing cables (S-700)

- ⑥ Remove the side cover of the W-axis base and remove the plate and cable guide clamping the cable. (See Fig. 7.2 (b).)
- ⑦ Cut the tie wrap and pull out the cables.

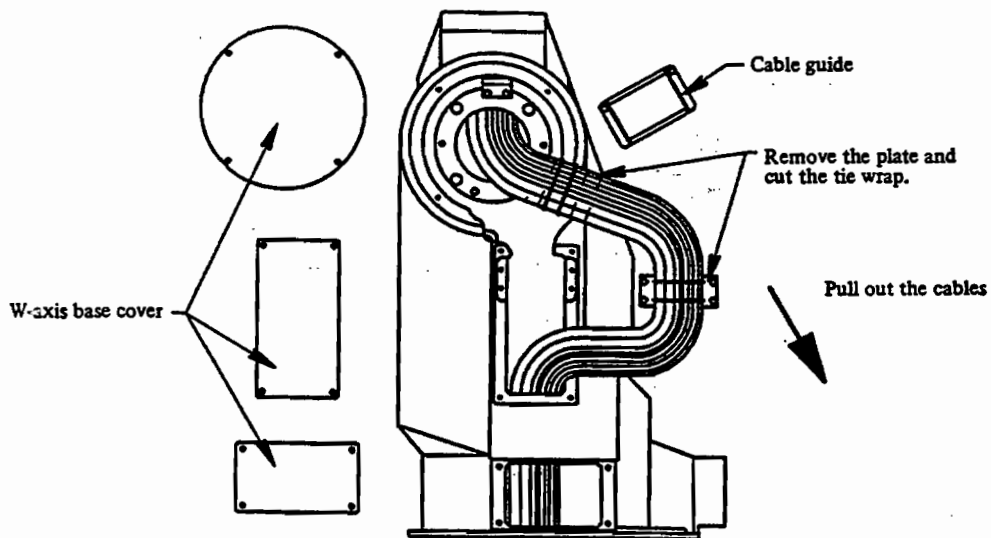


Fig. 7.2 (b) Replacing cables (S-700)

- ⑧ Remove the lower cover of the W-axis base. (See Fig. 7.2 (c).)
- ⑨ Pull off the cable guide pin and remove the plate from the support. (See Fig. 7.2 (d).)

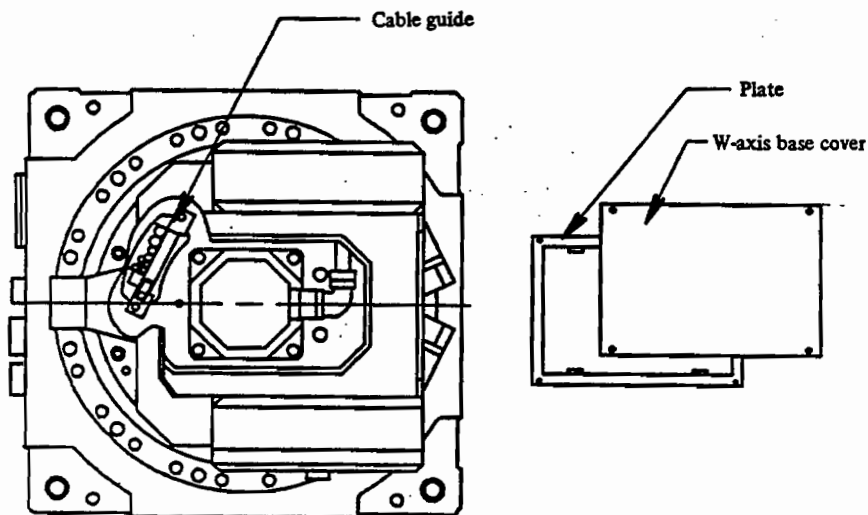


Fig. 7.2 (c) Replacing cables (S-700)

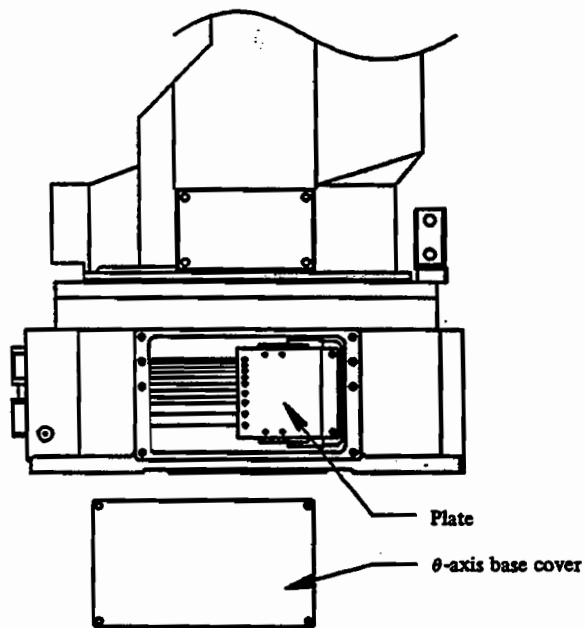


Fig. 7.2 (d) Replacing cables (S-700)

⑩ Remove the side cover of the θ-axis base and remove the plate clamping the cables. (See Fig. 7.2 (e).)

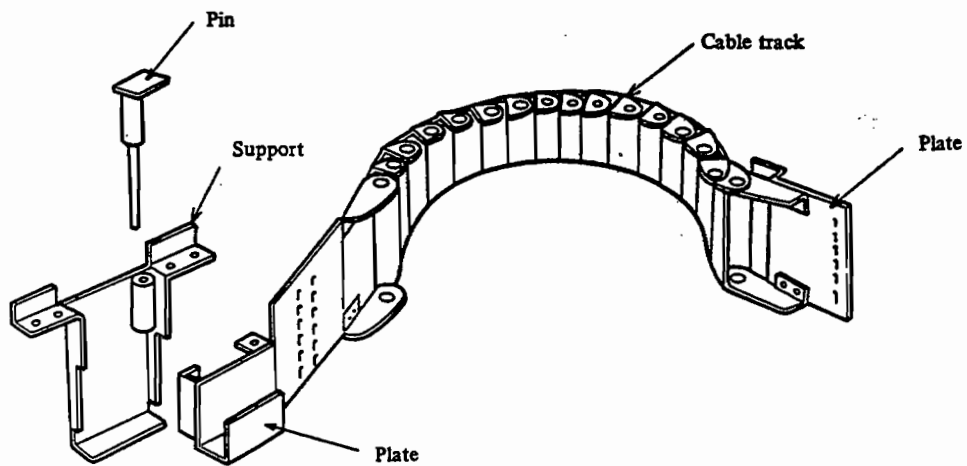


Fig. 7.2 (e) Replacing cables (S-700)

- ⑪ Remove the θ -axis connector panel and pull it halfway off. (See Fig. 7.2 (f).)
- ⑫ Remove the ground line and pull the θ -axis connector panel completely off with the cable track.

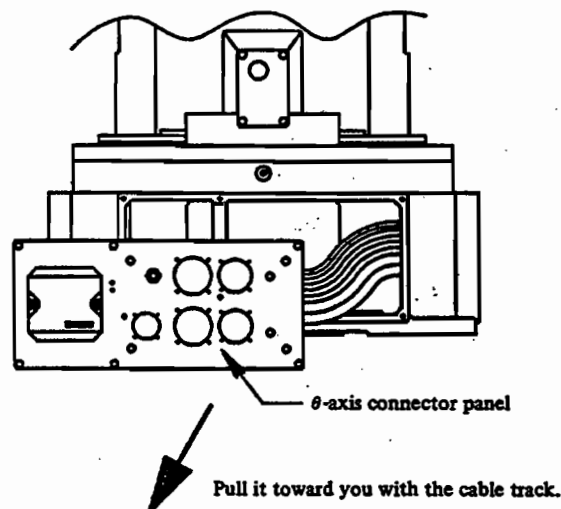


Fig. 7.2 (f) Replacing cables (S-700)

- ⑬ Open the cover of the cable track with a screw driver and pull out the cables. (See Fig. 7.2 (g).)
- ⑭ Cut all tie wraps and remove the connectors from the θ -axis connector panel.
- ⑮ Replace the cables and mount the new cables reversing the above procedure. Fig. 7.2 (g) shows the sequence of cables in the cable track. When mounting the cables, be especially careful of the clamping positions and be sure to form the cables, especially in the movable parts of the W and U axes, so that they are not pulled even when the arm moves in a full stroke.
- ⑯ The connectors to be connected to the α -axis, β -axis, and γ -axis motors can easily be misconnected. Therefore, be sure to check each cable tag carefully. (A wrong connection may causes the robot to run abnormally.)
- ⑰ Mount the connected cables to the correct places, one by one, in the order shown in Fig. 7.2 (h).
- ⑱ When all the connectors have been mounted, band the required points on the cables with the wraps as tight as possible so that the cables do not come out.
- ⑲ When all the cables have been mounted, move the robot slowly to check that there is no rubbing of the cables. When mounting the cover, take great care so that it does not catch the cables.

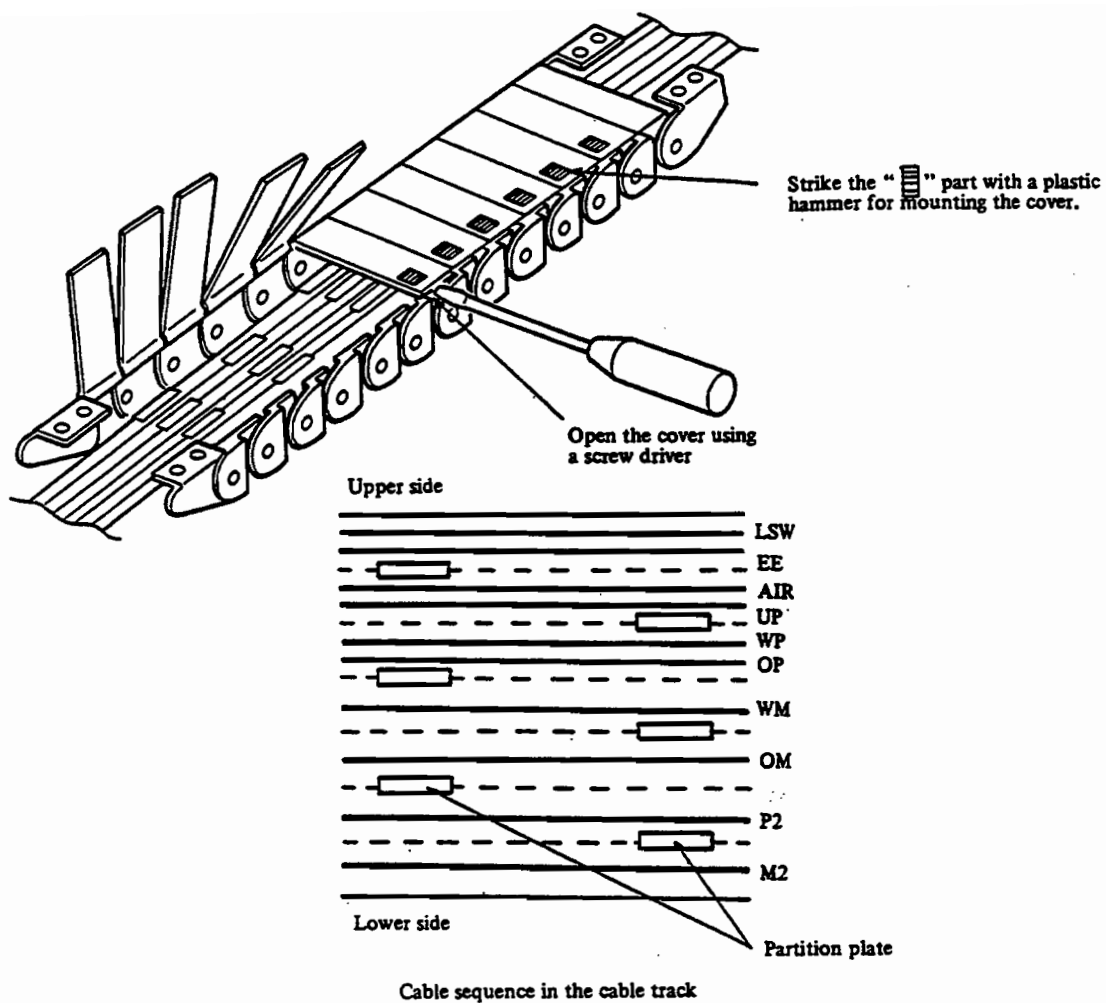
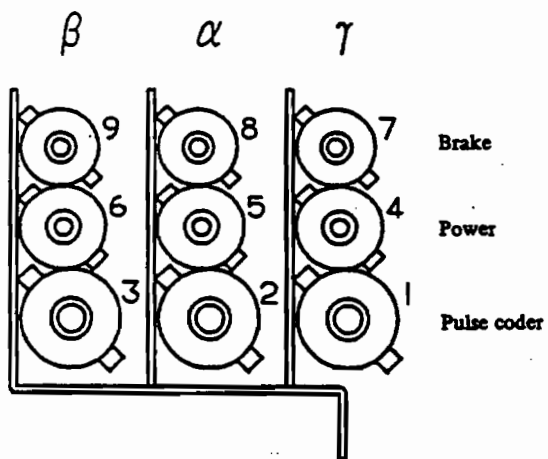


Fig. 7.2 (g) Replacing cables (S-700)



Connector layout and mounting sequence

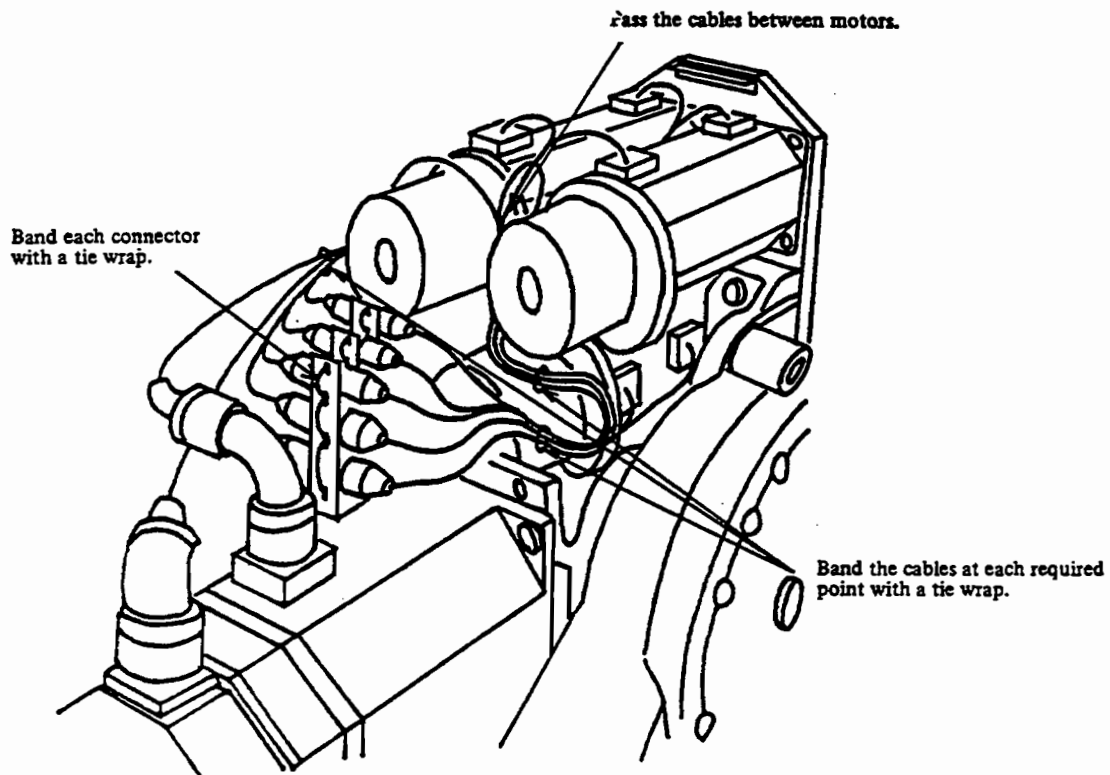


Fig. 7.2 (h) Replacing cables (S-700)

7.3 Replacing Limit Switches

1) Replacing θ -axis OT proximity switch

- ① Remove the rear cover of the W-axis base.
- ② Remove the switch plate.
- ③ Remove the proximity switch from the plate.
- ④ Remove the connector and replace the proximity switch (cable K106).
- ⑤ Mount the new proximity switch reversing the above procedure.
- ⑥ Check that the proximity switch normally operates at the overtravel position.
- ⑦ Check that the proximity switch does not operate within the θ -axis operation range. (See section 4.1 "Adjusting Limit Switch and Dog".)

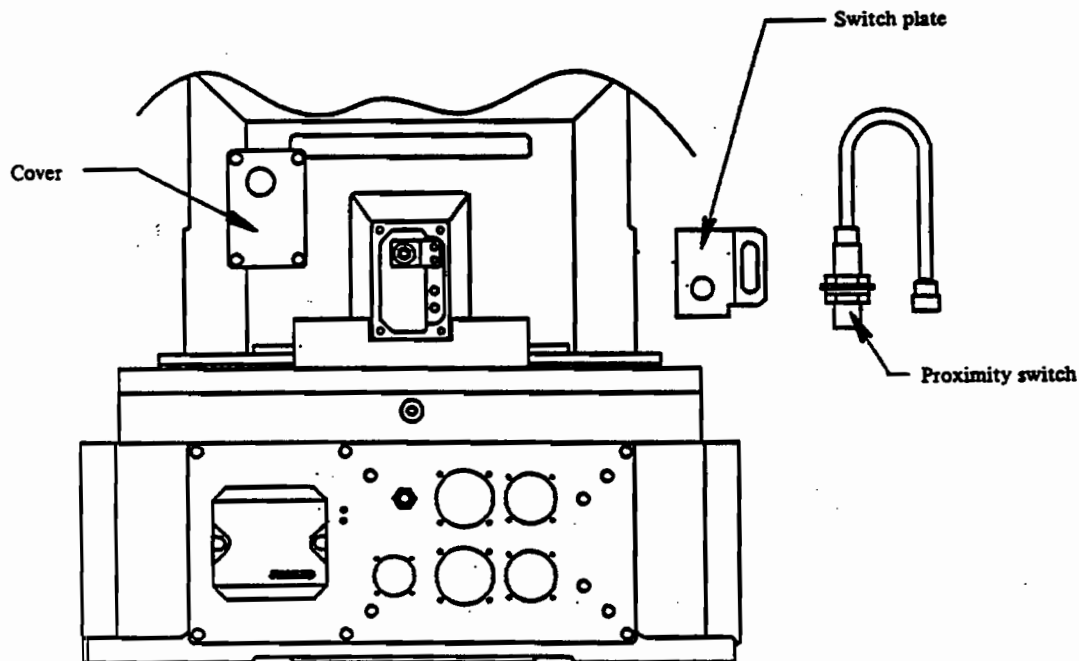


Fig. 7.3 (a) Replacing θ -axis proximity switch (S-700)

2) Replacing W-axis OT limit switch

- ① Remove the side cover of the W-axis base.
- ② Remove the limit switch plate.
- ③ Remove the limit switch from the plate.
- ④ Open the limit switch and remove the cable.
- ⑤ Replace the limit switch and mount the new limit switch reversing the above procedure.
- ⑥ Check that the limit switch normally operates at the overtravel position.
- ⑦ Check that the limit switch does not operate within the W-axis operation range. (See section 4.1 "Adjusting Limit Switch and Dog".)

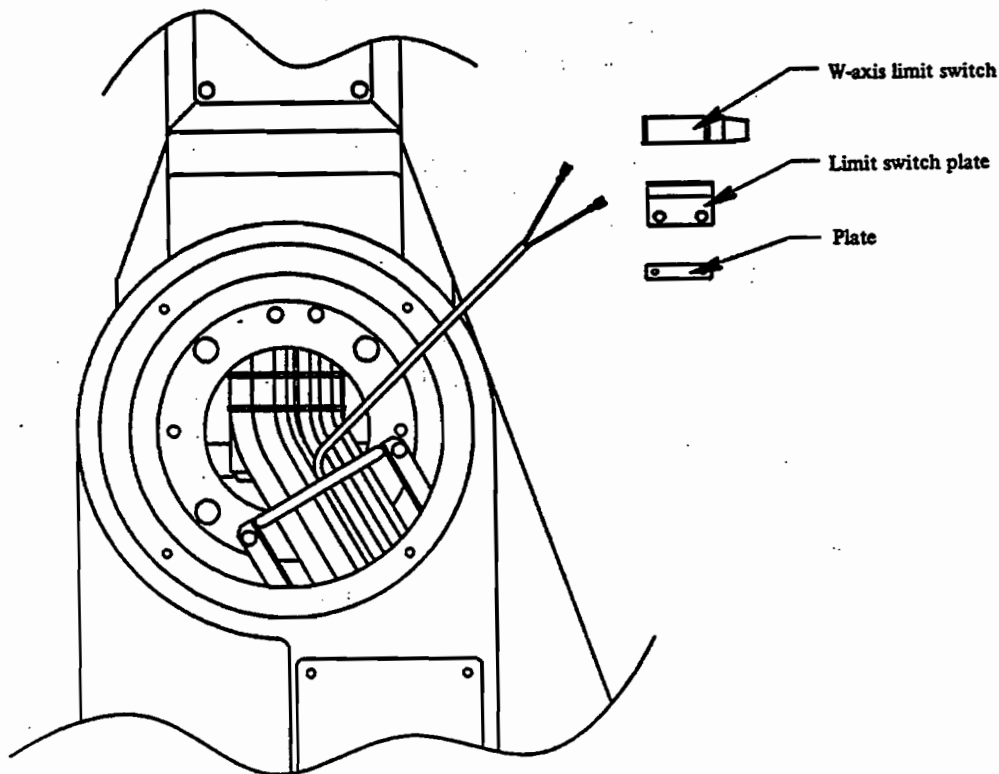


Fig. 7.3 (b) Replacing W-axis limit switch (S-700)

3) Replacing U-axis OT limit switch

- ① Remove the side cover of the W-axis arm.
- ② Remove the limit switch plate.
- ③ Remove the limit switch from the plate.
- ④ Open the limit switch and remove the cable.
- ⑤ Replace the limit switch and mount the new limit switch reversing the above removal procedure.
- ⑥ Check that the limit switch normally operates at the overtravel position.
- ⑦ Check that the limit switch does not operate within the U-axis operation range. (See section 4.1 "Adjusting Limit Switch and Dog".)

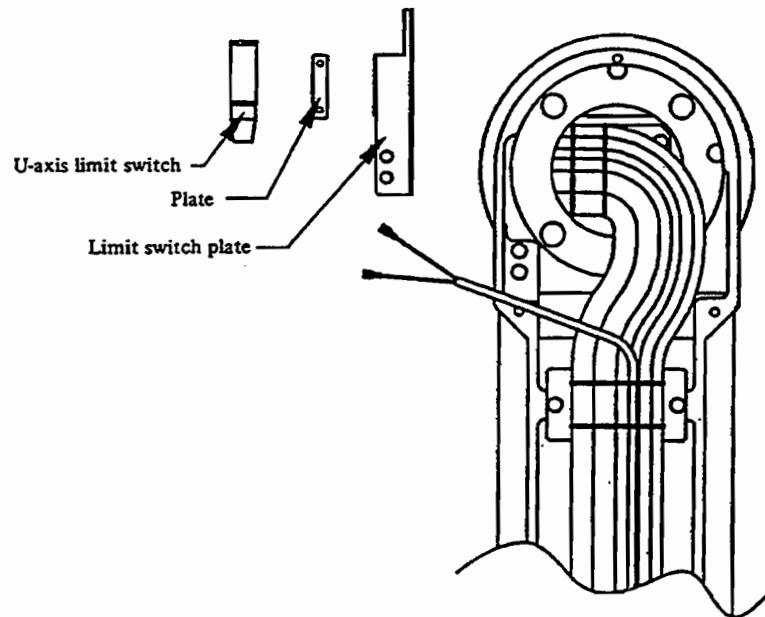


Fig. 7.3 (c) Replacing U-axis limit switch (S-700)

IV. CONNECTIONS

—

1. GENERAL

This section describes the connections between the mechanical and electrical interfaces in the robot mechanical unit and control unit and instructions for installing the robot.

1.1 Block Diagram

The block diagram of the robot connections is shown in Fig. 1.1.

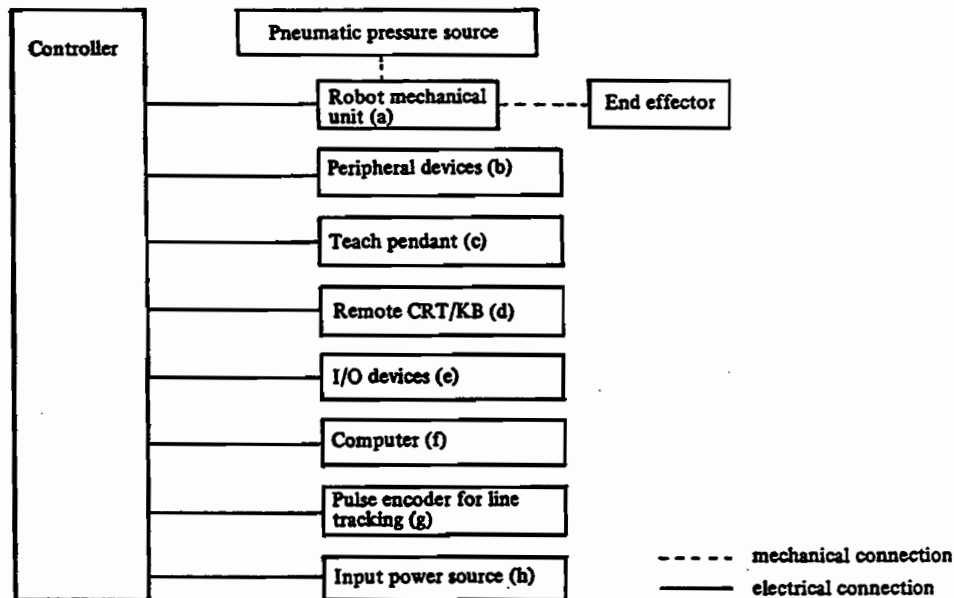


Fig. 1.1 Block diagram of the robot connection

1) Controller

The controller interfaces electrically with the following devices:

- a) Robot mechanical unit
- b) Peripheral devices
- c) Teach pendant
- d) Remote CRT/KB
- e) I/O devices
- f) Computer
- g) Pulse encoder for line tracking
- h) Input power source

2) Mechanical unit

a) End effector

This is a mechanical mounting face used for mounting the end effector of hand, etc. to the robot wrist. It also supplies pneumatic pressure and electrical signals for controlling the end effector.

b) Installation holes

There are holes in the base of the mechanical unit for mounting it to the floor. For details refer to V - 1.1.2 and 2.1.2.

2. SAFETY PRECAUTIONS

2.1 General

Care should be taken to protect workers and machines (robot and peripheral devices) when operating a system which combines the robot with peripheral devices. It should be noted that the robot may move suddenly when it receives a motion command signal. First ensure workers' safety and, then, safe operation of the peripheral devices and the robot. Fig. 2.1 shows the priority of safety measures.

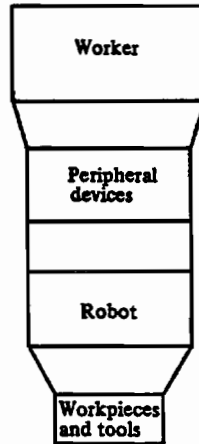


Fig. 2.1 Priority of safety measures

2.2 Safety Precautions

1) Worker's safety

Worker's safety must be ensured during the operation of a machining cell. It is very dangerous to enter the operating space of the robot during operation of the system. If it is necessary to do this, follow the protective measures given below.

If it is necessary for any reason to enter the robot area, stop the robot using the following procedures:

If power is not required, turn off the control unit power source.

If air pressure is not required, turn off the pneumatic system air pressure.

If it is necessary to inspect robot motion, check it, while monitoring the robot motion, and place the EMERGENCY STOP button where it can be pressed quickly if necessary.

If entry into the operating space of the robot is going to be necessary, take the following precautions:

a) Construct a protective fence around the system (Fig. 2.2 (a)).

Provide a safety gate. Its operation should be such that no one can enter the operating space without opening the gate.

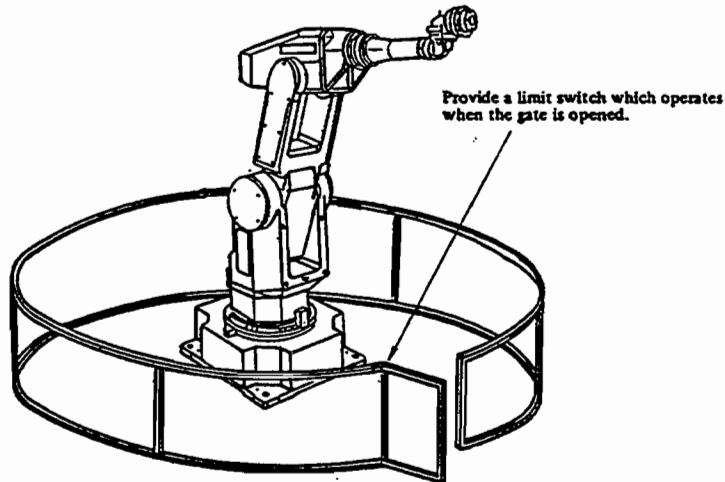


Fig. 2.2 (a) Protective fence

Provide a limit switch which operates when the gate is opened, and connect it to the power input unit according to Fig. 2.2 (b). The contact of the limit switch should be "ON" when the gate is closed; it should be "OFF" when the gate is opened. The rating of the contact should be more than 0.3 A at 24 VDC.

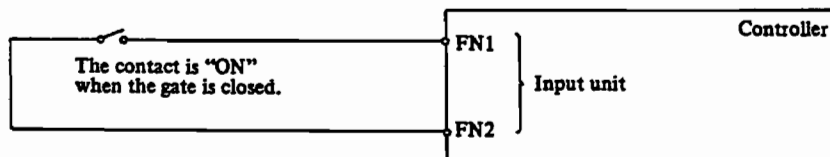


Fig. 2.2 (b) Connection of the gate limit switch

- b) Mount a mat switch or photoelectric switch on the floor to issue an alarm by means of a buzzer, light, etc., if a worker enters the operating space. If it is necessary, stop the robot operation using the same switch.
- c) Mount a limit switch with a tactile bar on the robot to stop it if it comes in contact with something.
- 2) Machine safety

Take the following precautions to prevent damage to the peripheral devices and the robot.

 - a) Setting the motion range

If the system service range is narrower than the motion range of the robot, the system variables which control the motion range of the robot can be set from the CRT/KB so that the motion range of the robot does not exceed the service range.
 - b) Using robot interlock signals

The robot has several kinds of terminals for receiving external interlock signals. The robot can be held or stopped by these signals. To use them, set up control circuits on the peripheral devices that will be activated when there is a possibility of damage to the equipment.
 - c) Use a limit switch with a tactile bar

In order to prevent injury to a worker or damage to the robot, a limit switch with tactile bar can be used.

3) The limit switch with a tactile bar

When using a limit switch with a tactile bar, use one which provides a circuit with normally closed contacts as shown in Fig. 2.2 (c). The rating of the contact should be more than 4 A at 100 VAC.

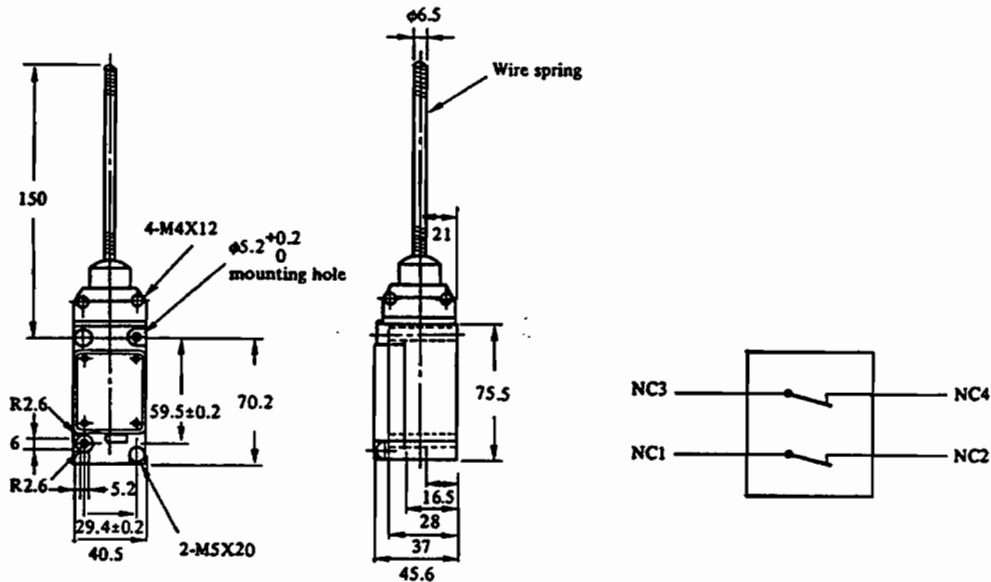


Fig. 2.2 (c) Example of a limit switch

The electrical connection of limit switches with tactile bars is shown in Fig. 2.2 (d).

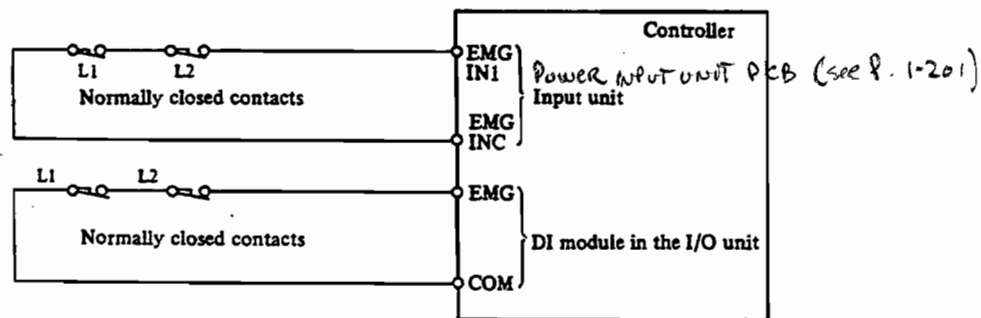


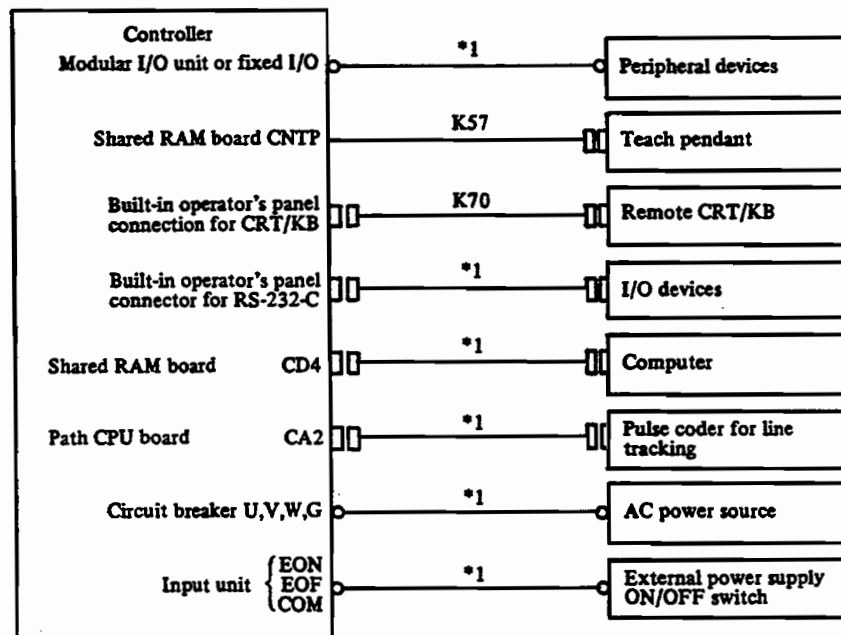
Fig. 2.2 (d) Example of connections

The normally closed contacts when several limit switches are used should be connected in series to the input unit of the controller. The other normally closed contacts should be connected in series to the DI module in the I/O unit of the controller.

3. CONTROLLER CONNECTIONS AND SIGNALS

3.1 Connection Diagram

Fig. 3.1 shows the connections of the controller with the exception of those between the controller and the mechanical unit. They are described in CONNECTIONS section 4.1.



Note) Cables marked with *1 are provided by the customer.

Fig. 3.1 Connection diagram

3.1.1 Cable clamp

Cables led into this controller should be clamped by the method shown below. This cable clamp treatment is not only for cable support but also for shield-treatment. It is very important for the stable operation of this robot system that this be performed. Peel the sheath partially as shown below and expose the shield. Push the cable and clamp it by the cable clamp. The cable clamp is attached to the control unit. The ground board is prepared at the bottom of the cabinet.

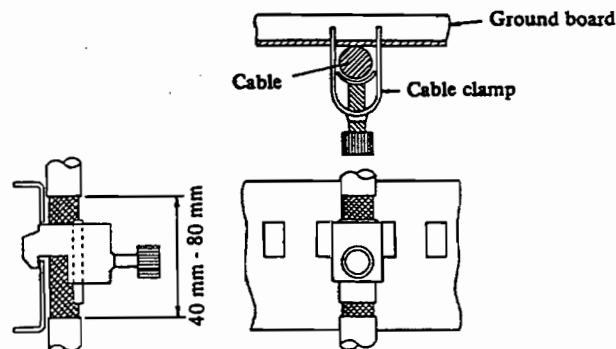
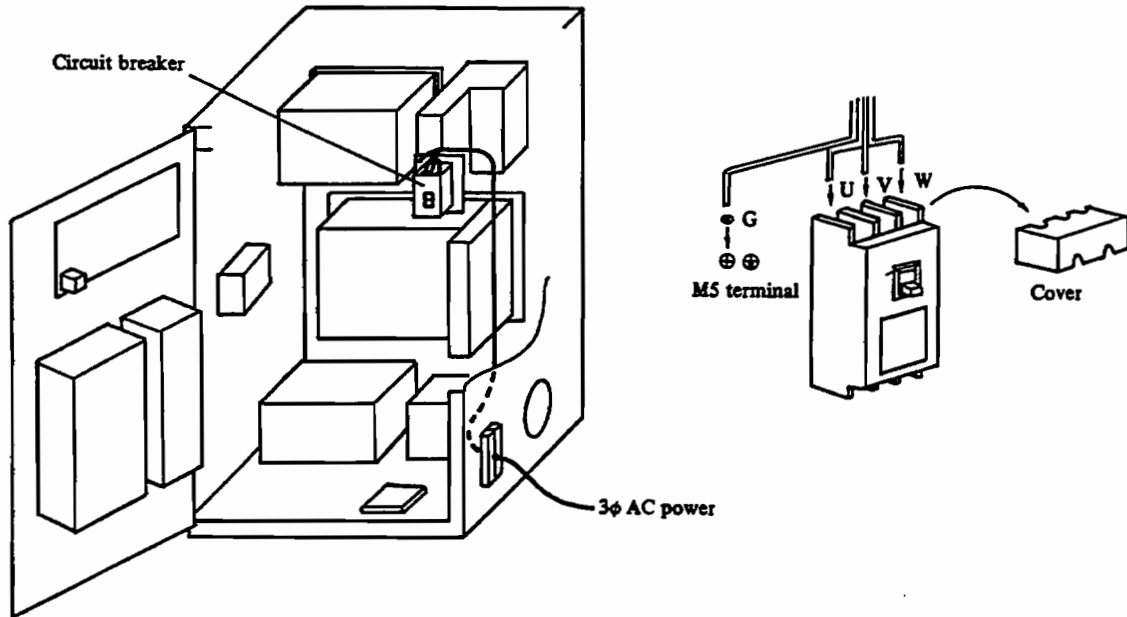


Fig. 3.1.1 Cable clamp

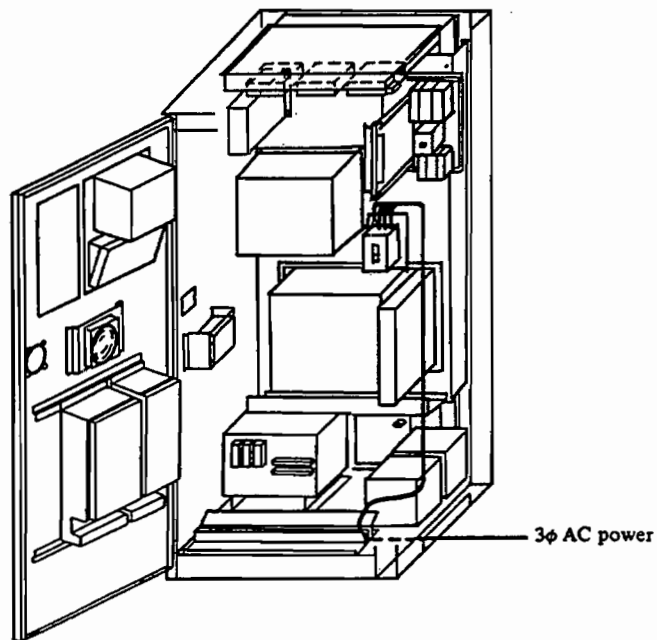
3.2 Connections

3.2.1 Input power connection



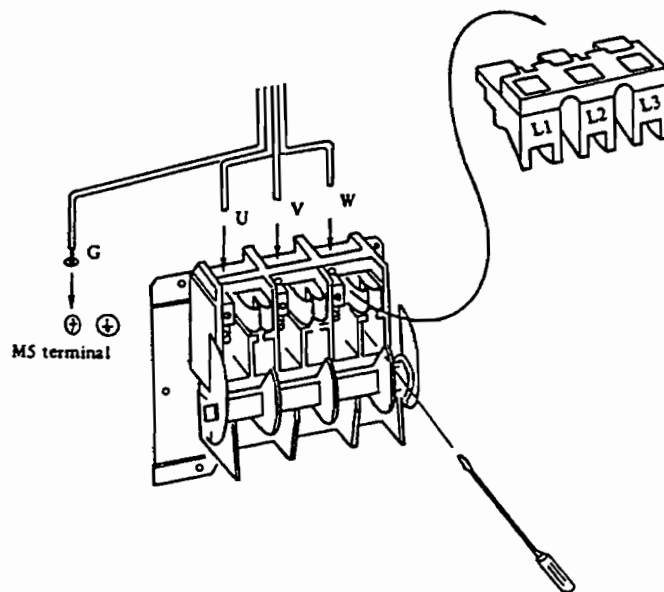
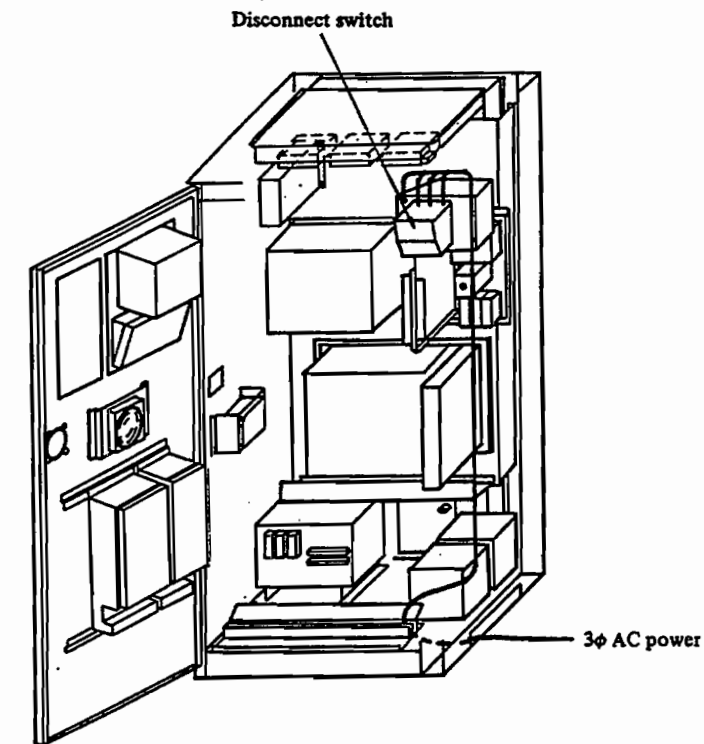
Note) Mount the cover after cabling.

Fig. 3.2.1 (a) Input power connection (S-10 controller, medium size cabinet)



Note) See Fig. 3.2.1 (a) for details of breaker connection

Fig. 3.2.1 (b) Input power connection (Large size cabinet, circuit breaker or circuit breaker with leak detector)



Note) Mount the cover after cabling.

Fig. 3.2.1 (c) Input power connection (Large size cabinet, disconnect switch)

3.2.2 Connection for external on-off control of power supply

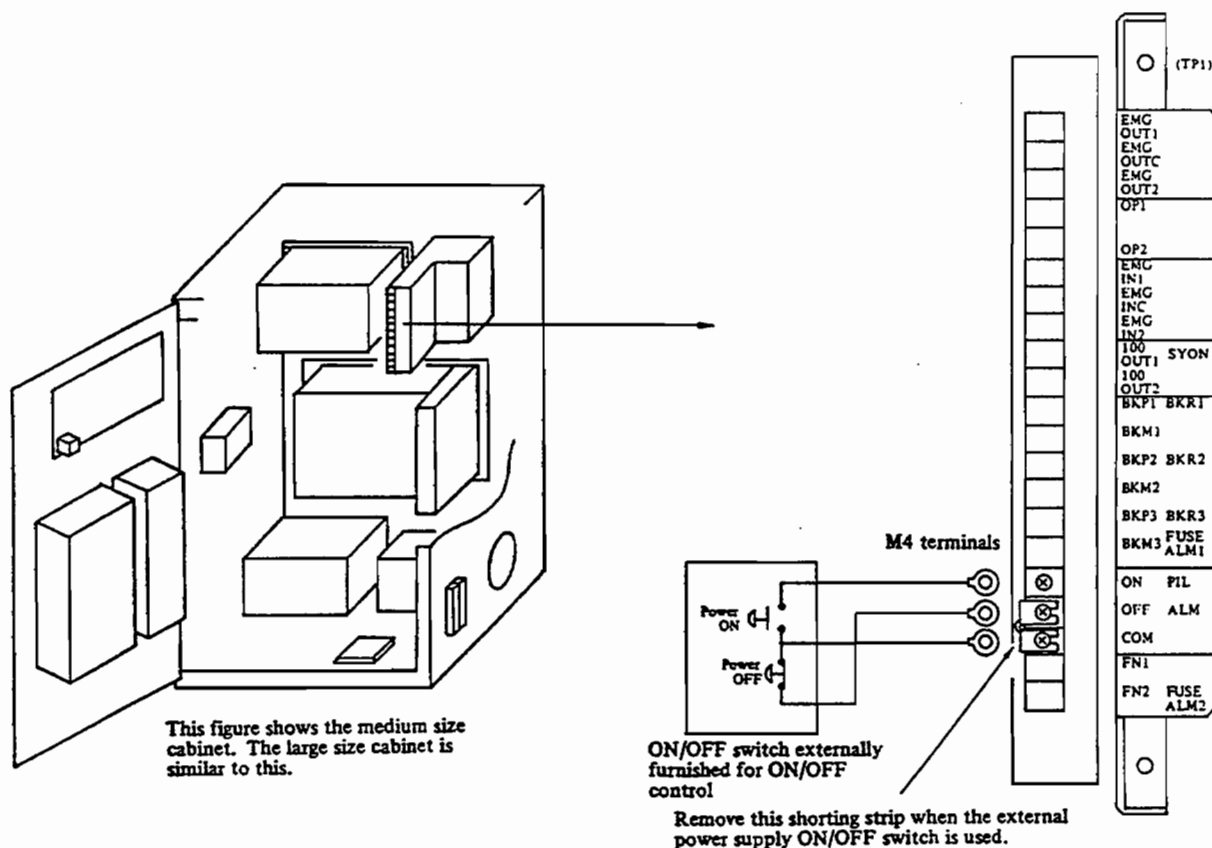
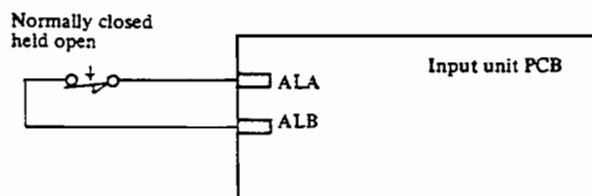


Fig. 3.2.2 Power input unit TP1 terminal

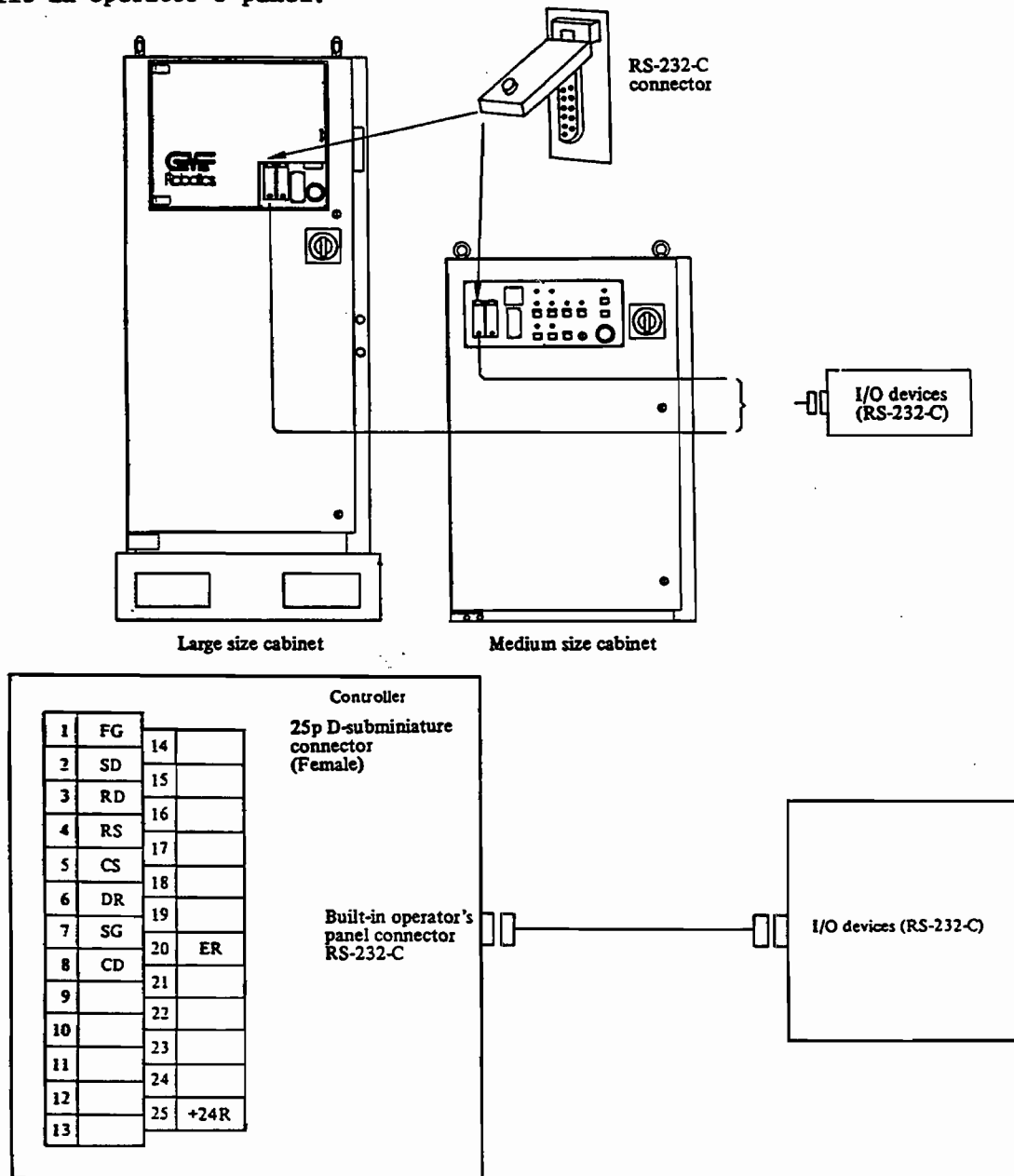
On/Off Control by Alarm Circuitry

To control power externally, a relay can be connected across the ALA and ALB terminals on the input unit PCB. Note that these terminals are not on the connector (TP1) but on the PCB itself. This should be a normally closed but held open switch. Shorting these two terminals together causes controller operating power to be lost. Recovery can be achieved by first pressing the OFF button on the controller.



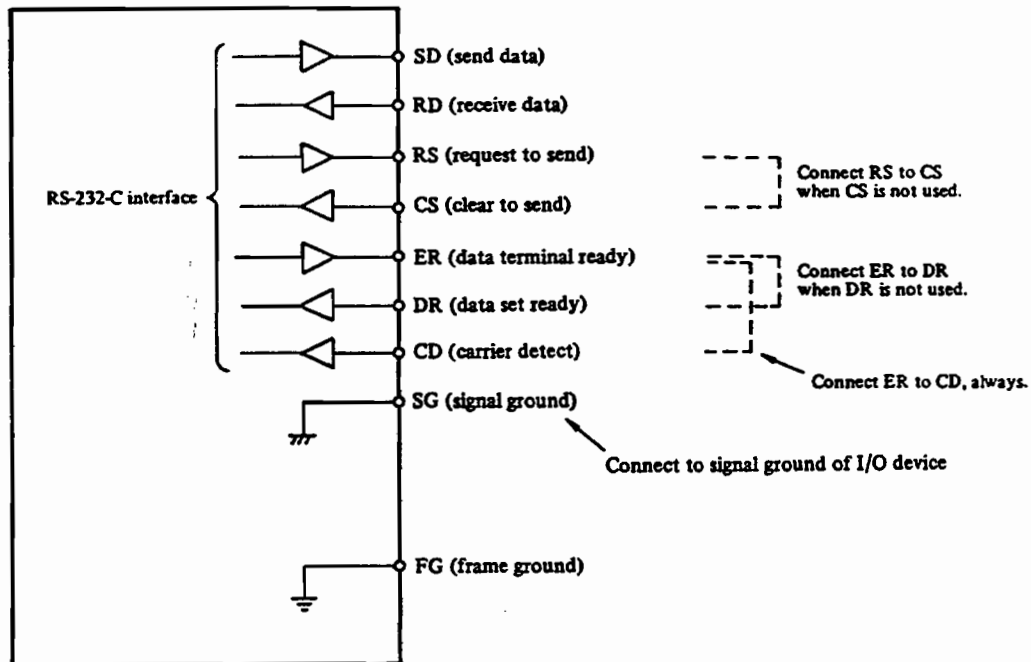
3.2.3 Connection to I/O devices

When the controller is used with a built-in operator's panel, I/O devices which have RS-232-C interface can be connected to the connector provided on the built-in operator's panel.



Note) Pin 25 has +24 V for power supply to offline storage devices.
It cannot be used for I/O devices.

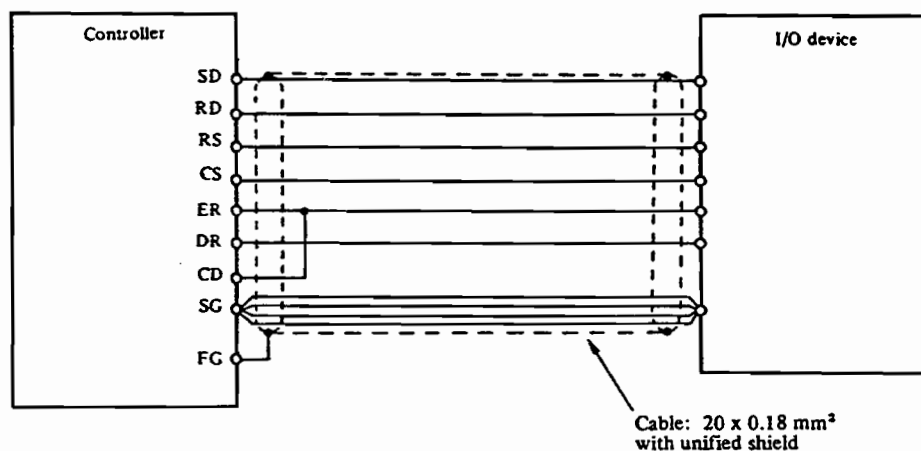
Regarding the meaning of the signals, refer to the figure shown below.



Signals ON/OFF voltage levels are given in the following table.

	Less than - 3 V	More than +3 V
Function	OFF	ON
Signal condition	Marking	Spacing

Cable connections between the controller and the I/O device should be as follows:



3.2.4 Connection to pulse encoder for line tracking

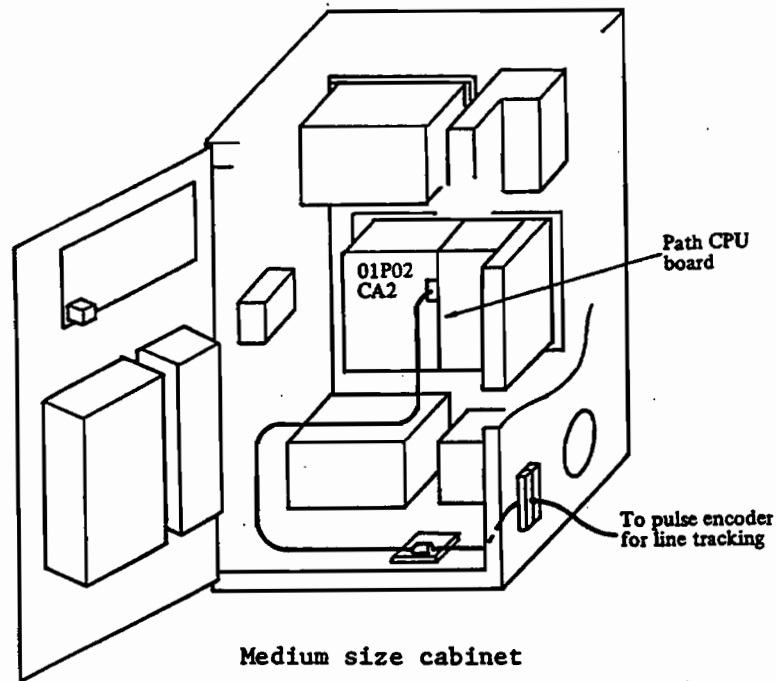
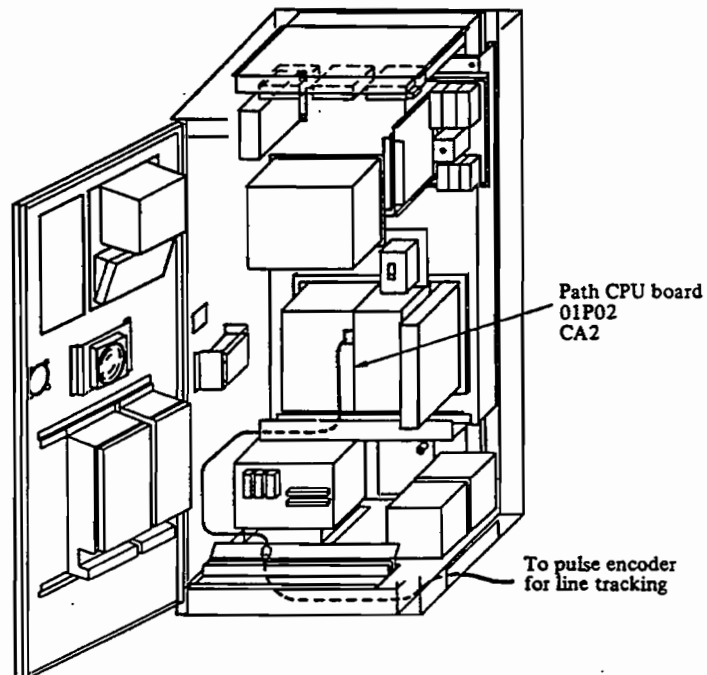
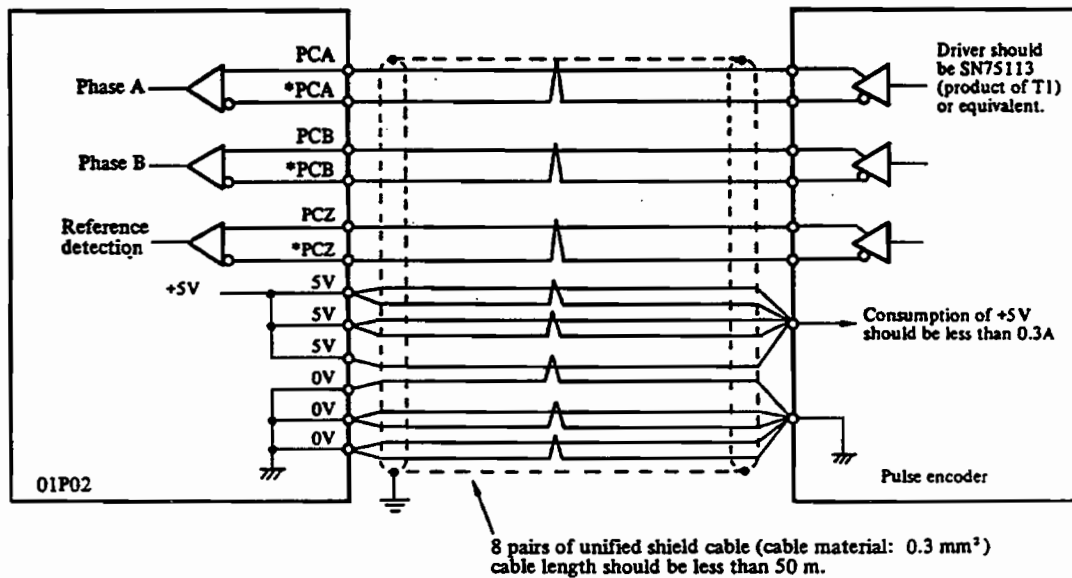
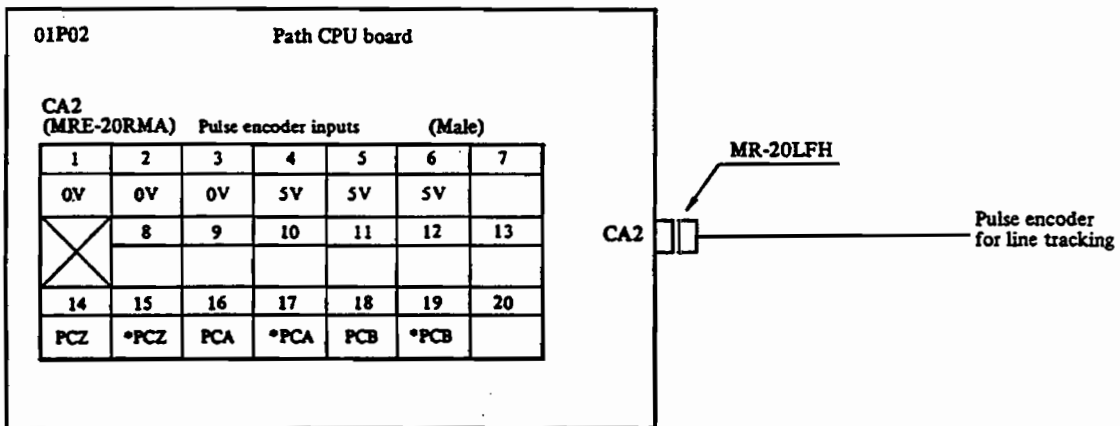


Fig. 3.2.4 (a) Connection to pulse encoder for line tracking
(S-10, medium size cabinet)



Note) Connection to the S-700 controller is similar to that shown in this figure.

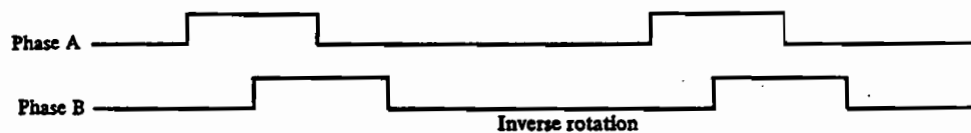
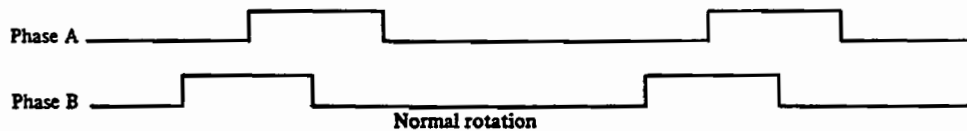
Fig. 3.2.4 (b) Connection to pulse encoder for line tracking (S-10 controller,
large size cabinet circuit breaker or circuit breaker with leak detector)



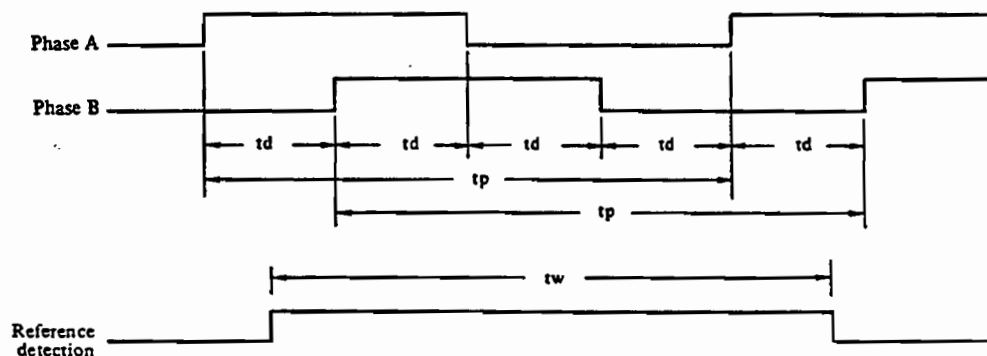
Peel the sheath of cable and attach the cable to the ground board of the controller cabinet by means of the cable clamp metal fixture.

Pulse input signals

Phase A and phase B signals are used for pulse input. The difference of phase between both signals should be 90 degrees.



Phase A, B and reference detection signals should satisfy the following requirements.



$t_d \geq 1 \mu s$
 $t_p \geq 10 \mu s$
 t_w : more than t_p

3.2.5 Controller and peripheral device connections

The R-H controller has two I/O options for communication with peripheral devices -- a fixed I/O board or a modular I/O system. The fixed I/O board is a single board system installed in the backplane. The modular I/O system hardware includes the I/O rack and I/O modules. Various types of modules can be added to the modular I/O.

Modular Input/Output System

The modular I/O structure provides a hardware interface to the I/O system. Signal lines are connected to the I/O modules, which reside in the controller I/O rack. Differing types of I/O modules can be used to connect various types of electrical signals. The I/O rack communicates I/O status information to the controller through an internal serial data link. The connections for the modular I/O system are shown in Fig. 3.2.5 (a).

One I/O rack shown in Fig. 3.2.5 (b), (c), is provided with the KAREL modular I/O system. The I/O rack has a capacity of nine I/O modules. One slot on the I/O rack, Slot 0, is reserved for the robot control module. The remaining eight slots on the I/O rack are available for user-defined I/O modules.

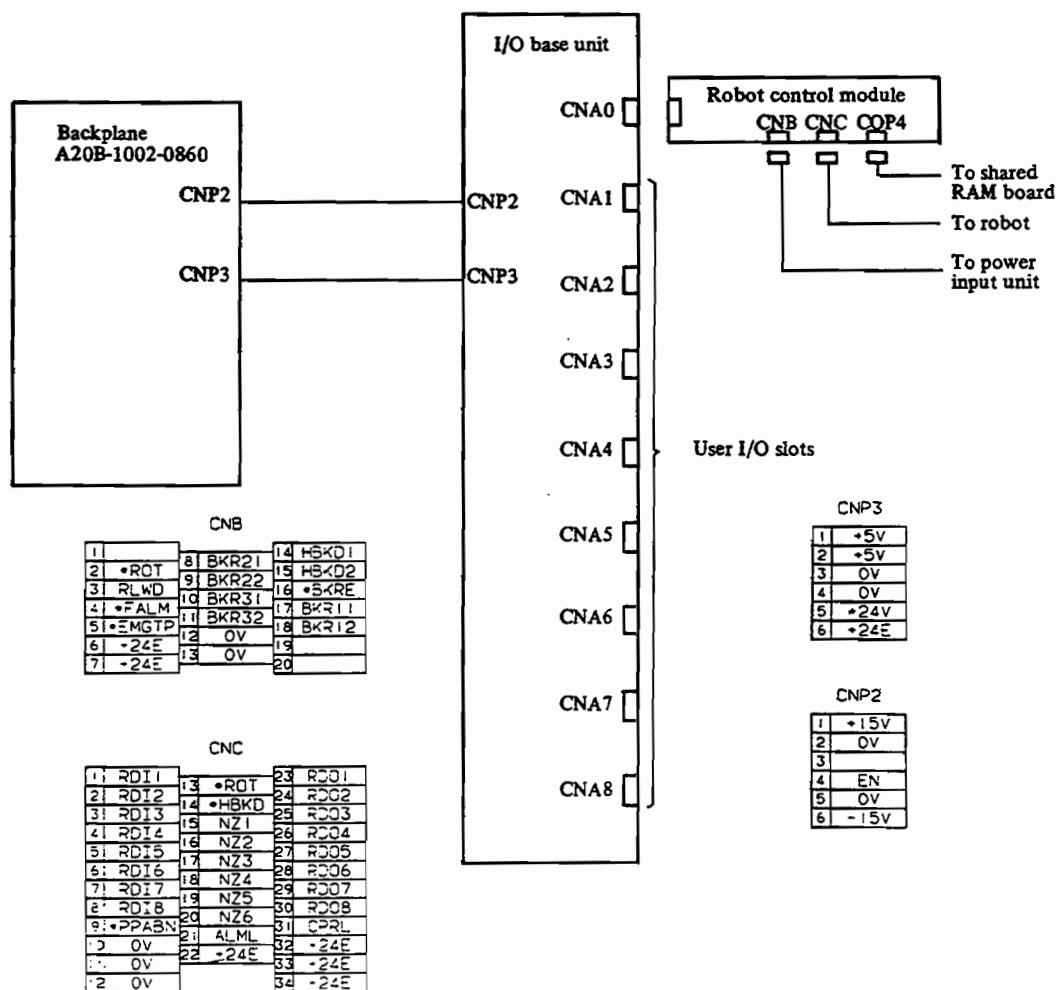


Fig. 3.2.5 (a) Modular I/O structure

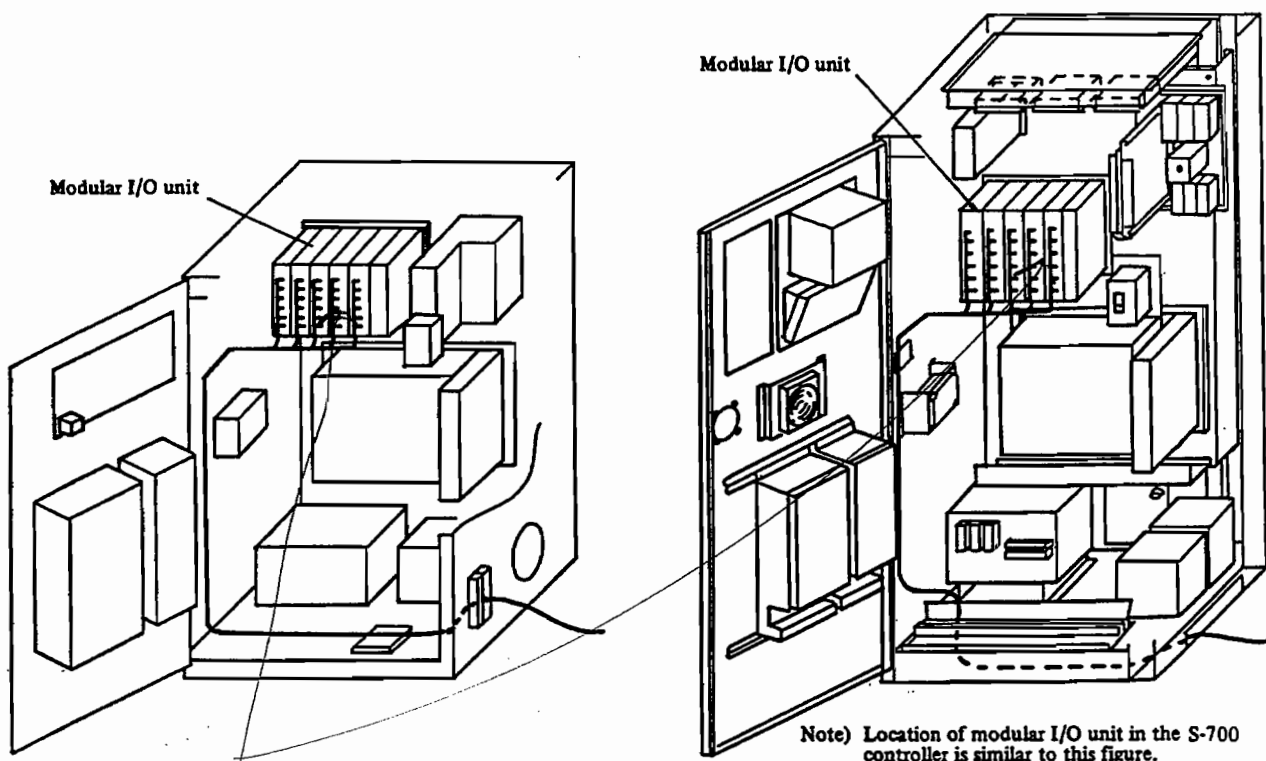


Fig. 3.2.5 (b) Location of modular I/O unit
(S-10 controller, medium size cabinet)

Fig. 3.2.5 (c) Location of modular I/O unit
(S-10 controller, large size cabinet)

The modular I/O system supports the following number of signals:

- Number of DI/DO
A maximum of 64 user digital input signals and 64 user output signals are available.
- Number of group inputs/outputs
A maximum of five group inputs and five group outputs are available.
- Number of analog inputs/outputs
A maximum of five analog inputs and five analog outputs are available.
- Hand signals
A maximum of four hand signals are available.
- Robot dedicated I/O (RDI/RDO)
The robot control module has eight input lines and eight output lines which are available at the wrist of most robot models.

Table 3.5 Fixed I/O board - input

FEATURE/CAPABILITY	VALUE/DESCRIPTION
Digital Input Signal Standards	
Type	Grounding type voltage receiver
Rated Input Voltage	+20 - 28 VDC (logic 1 "closed") 0 - +4 VDC (logic 0 "open")
Maximum Input Voltage	+28 VDC
Input Impedance	About 3.3 kohm
Response Time	5 - 20 ms
Attachment Side Contact Standards	
Rated Contact Capacity	30 VDC, 16A or over
Input Signal Width	More than 200 ms (ON and OFF)
Contact Bounce Time	Shorter than 5 ms
Closed Circuit Resistance	Lower than 100 ohm
Open Circuit Resistance	Higher than 100 kohm

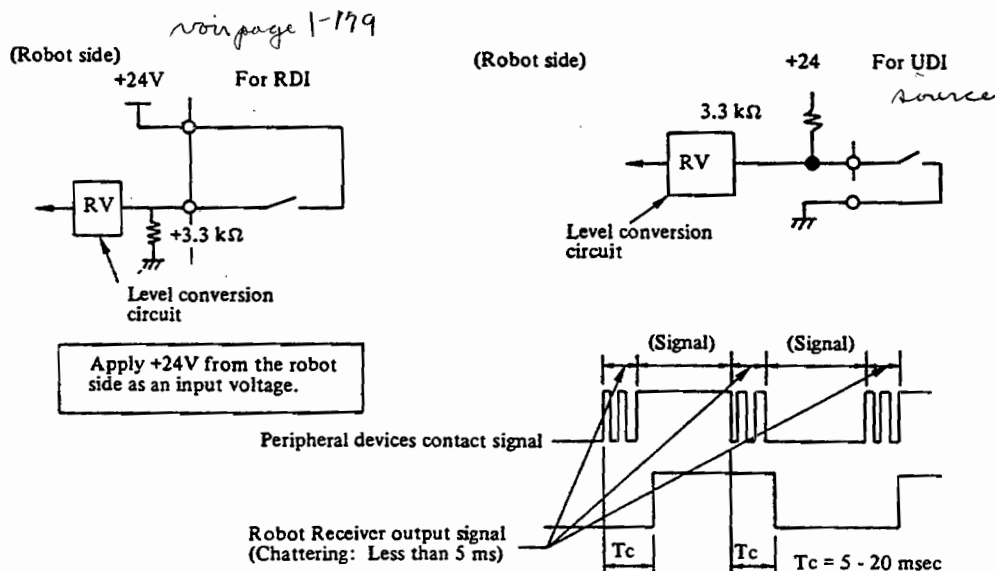


Table 3.6 Fixed I/O board - output

FEATURE/CAPABILITY	VALUE/DESCRIPTION
Rated Voltage	24 VDC
Maximum Applied Voltage	30 VDC
Maximum Load Current	0.2 A
Transistor Type	NPN
Output Pulse Width	200 ms <u>+8</u> ms
Saturation Voltage at Turn-On Time	About 1.0 V
Note: Outputs are 24 V, 200 mA sinking current devices	

Damper Diode

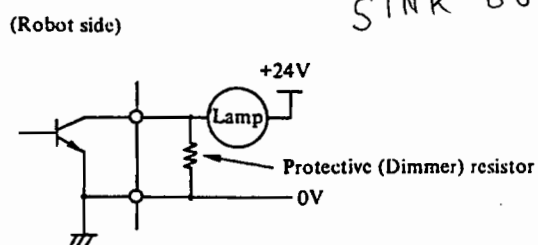
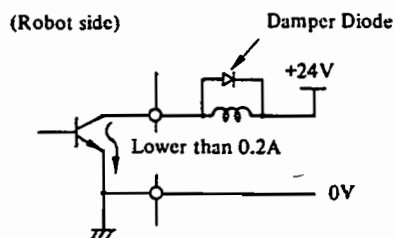
Rated peak reverse dielectric strength - Higher than 100 V

Rated effective forward current - Higher than 1 A

If a relay, solenoid, or other inductive device is used as a load, you must connect a reverse-biased diode in parallel with the load to prevent the generation of a high counter electromotive voltage across the output when the output is switched off.

Dimmer Resistor

If an incandescent lamp is used as a load, you must connect a protective resistor across the output terminals to prevent a destructive load current surge when the output is switched on.



Fixed Input/Output System

The fixed I/O system is a single I/O board which is installed in the controller backplane. Signal lines are connected to one of four connectors:

- CN1: 50 pin male, for application DI/D0.
- CN2: 20 pin female, for application DI/D0 or UOP interface if the system has a user operator panel.
- CNB: 20 pin male, for brake control.
- CNC: 34 pin male, for RDI/RDO and hand signals

The connections for the fixed I/O system are shown in Fig. 3.2.5 (d) - (f). Signal lines are connected to the appropriate connector from this board. The fixed I/O board does not support analog inputs or outputs.

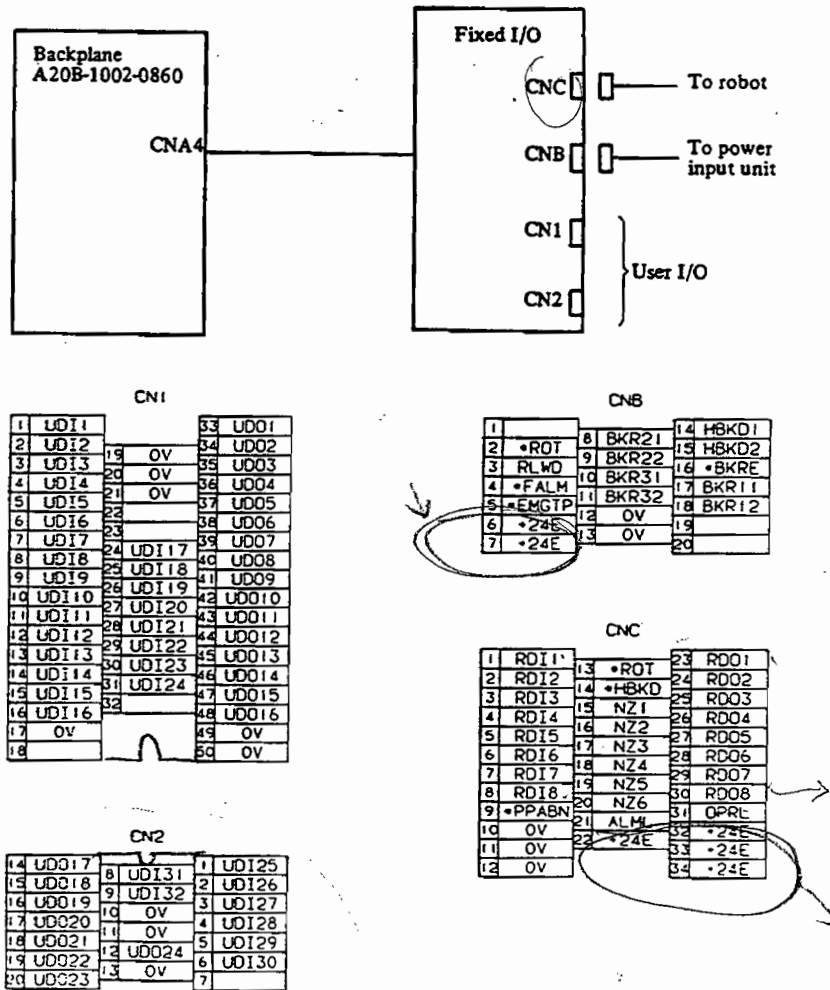


Fig. 3.2.5 (d) Fixed I/O structure

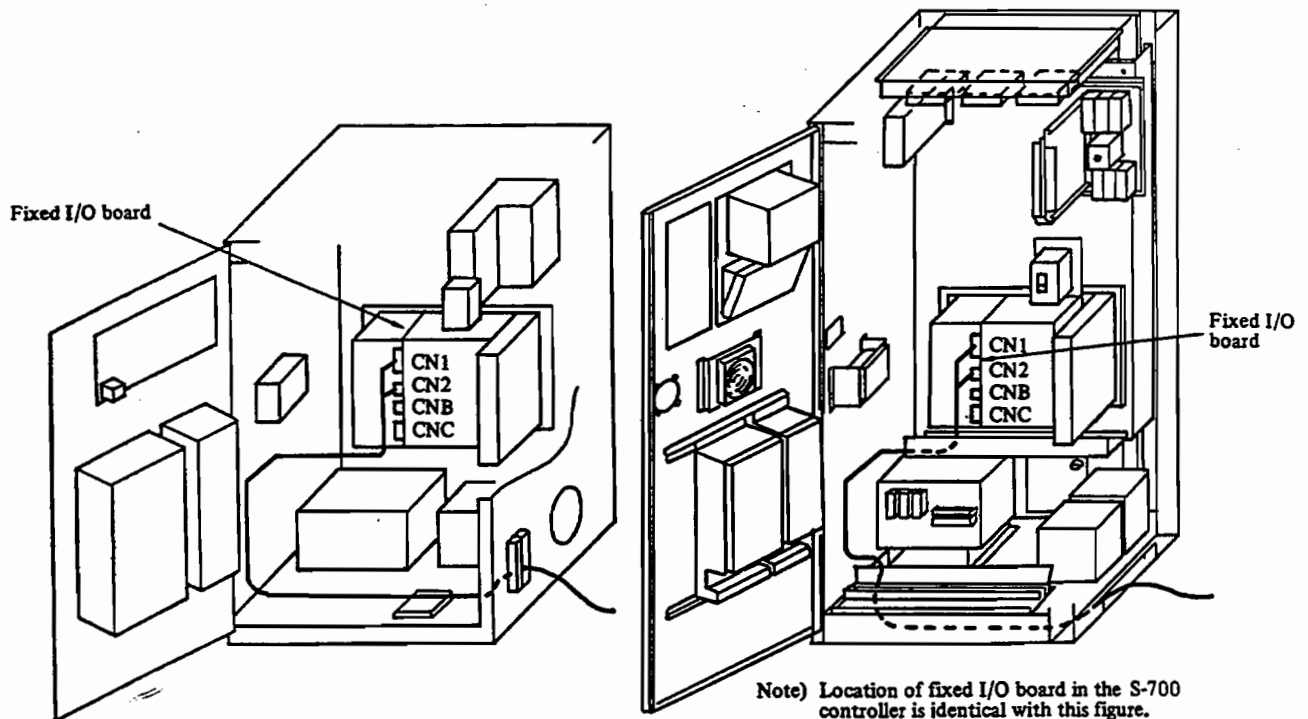


Fig. 3.2.5 (e) Location of fixed I/O board
(S-10 controller, medium size cabinet)

Fig. 3.2.5 (f) Location of fixed I/O board
(S-10 controller, large size cabinet)

With no user operator panel, the fixed I/O system has the following user I/O capabilities:

- User DI: 32 bit total
DC 24 V non-isolated receiver
(internally pulled up to +24 V with resistors)
Response time of 20 ms.
Three ground commons.
- User DO: 24 bit total
Open collector NPN transistor, non-isolated driver
24 V 200 mA current sink.
DC power output not provided.
Six ground commons.
- RDI/RDO *robot digital I/O*
Eight inputs and eight outputs are provided, located on connector CNC.

A user operator panel in the robot system will use eight DINs and eight DOUTs.

Input/Output Signal Types

User-defined signals are mapped in the User Signal Assignment Table (USAT), represented by the system variable \$USAT. You have access to user-defined signal types through the following predefined port arrays:

- DIN (digital input)
- DOUT (digital output)
- GIN (group input)
- GOUT (group output)
- AIN (analog input)
- AOUT (analog output)

Each element of a port array corresponds to a user-defined signal. You also have access to a special set of robot hand control signals through the KAREL language HAND statements, rather than through port arrays.

Discrete I/O (DIN and DOUT)

The DIN and DOUT signal types are interpreted as one-bit ON/OFF signals in KAREL. The KAREL program has access to these signals as BOOLEAN values. You can define the polarity of the signals (in eight-bit groups) through \$USAT as either active-high (ON when voltage is applied) or active-low (ON when voltage is not applied). Either AC or DC I/O modules can be used for DIN and DOUT signals.

GIN and GOUT Signal Types

The GIN and GOUT signal types provide access to a group of input or output lines interpreted as an INTEGER in a KAREL program. A group can have a size of 1 to 16 bits, with each bit corresponding to an input or output line, and can start at any place within the I/O slot. If the group size is defined as less than 16 bits the unused bits are interpreted as binary zeros. Either AC or DC I/O modules can be used for GIN and GOUT signals.

AIN and AOUT Signal Types

The AIN and AOUT signal types provide access to data in the form of an analog electrical signal. The analog data is digitized by the system and passed to the KAREL program as a 16 bit binary number, of which 12 bits or 8 bits are significant depending on the analog module. The program treats the data as an INTEGER data type. Table 3.2.5 (a) shows the correspondence between the actual signal voltage and the value assigned to the AIN or AOUT. These are available with the modular I/O system.

Table 3.2.5 (a) Analog signal value/voltage

I/O module in I/O rack			
AIN value (12 significant bits)	Input volt.	AOUT value (12 significant bits)	Output volt.
+2000	+10 V	+2000	+10 V
⋮	⋮	⋮	⋮
+1000	+5 V (+20 mA)	+1000	+5 V (+20 mA)
⋮	⋮	⋮	⋮
0	0 V (0 mA)	0	0 V (0 mA)
⋮	⋮	⋮	⋮
-1000	-5 V (-20 mA)	-1000	-5 V (-20 mA)
⋮	⋮	⋮	⋮
-2000	-10 V	-2000	-10 V
Either voltage or current range can be selected: -10 V +10 V (voltage input) -20 mA ... +20 mA (current input)			

HAND Signal Type

The HAND signal type provides a KAREL program with access to two output lines that work in a coordinated manner to control the tool. The lines are designated as the open line and the close line. Either AC or DC digital output modules can be used for HAND signals. The system can support up to four HAND signals. The following KAREL language statements are provided for controlling the signal, where "n" is the signal number defined in \$USAT:

```

OPEN HAND[n]
CLOSE HAND[n]
RELAX HAND[n]

```

Four modes of operation, which allow you to control different types of tools, are available:

- Mode 0: Single Line Mode
- Mode 1: Dual Line Mode
- Modes 2 and 3: Dual Line Pulsed Modes

UOP Signal Type

The user operator panel (UOP) is any user-supplied device that connects to the UOP signals. UOP signals have functions resembling those of the operator panel buttons, switches, and indicator lights on the front of the controller cabinet. UOP signals also allow you to execute predefined command files from the UOP.

UOP control signals connect indirectly via AC or DC I/O modules in the I/O rack (or via the fixed I/O board). UOP signals are distinguished from other system-defined signal types by their mapping in \$USAT. UOP signals are used primarily for system control and status reporting.

The modular I/O system supports 32 UOP control signals. The fixed I/O board supports 16. Special consideration must be given to safety because the UOP can cause robot motion through its input signals.

Thirty-two UOP control signals are connected through two I/O modules in the modular I/O system. Any type of digital I/O modules can be used, placed as you desire, in the I/O rack. For the fixed I/O system the 16 UOP signals are attached to connector CN2. UOP control signals must be mapped as such in the UOP input table and UOP output table of the USAT.

For the modular I/O system, sixteen of the UOP control signals are input signals to the controller. The other 16 signals are outputs. All 16 input signals and all of the output signals are implemented in the current version of KAREL software. The remaining output signals are reserved by GMF for use in future software versions.

Tables 3.2.5 (b) and 3.2.5 (c) list the UOP input and output control signals for the modular I/O system. Next to the signal name (in parentheses) is the name of the operator panel button, switch, or indicator light that has a function similar to the signal. (Refer to the KAREL operations manual for your controller model for information on operator panel functions.)

Table 3.2.5 (b) Modular I/O UOP input control signals

Number	UOP name (Operator panel function)
1	*ESTOP (EMERGENCY STOP button)
2	*HOLD (HOLD button)
3	RESET (FAULT RESET button)
4	CALIB (CALIBRATE button)
5	CSTRT (CYCLE START button)
6	CSTOP (CYCLE STOP button)
7	HOME (HOME button)
8	MPROT (MEMORY PROTECT keyswitch)
9	executes KCP_UOP1.CF
10	executes KCP_UOP2.CF
11	executes KCP_UOP3.CF
12	executes KCP_UOP4.CF
13	executes KCP_UOP5.CF
14	executes KCP_UOP6.CF
15	executes KCP_UOP7.CF
16	executes KCP_UOP8.CF

Input signals 9 through 16 activate the command files that are indicated by name in Table 3.2.5 (b). Connection of these UOP input signals is shown in Fig. 3.2.5 (g).

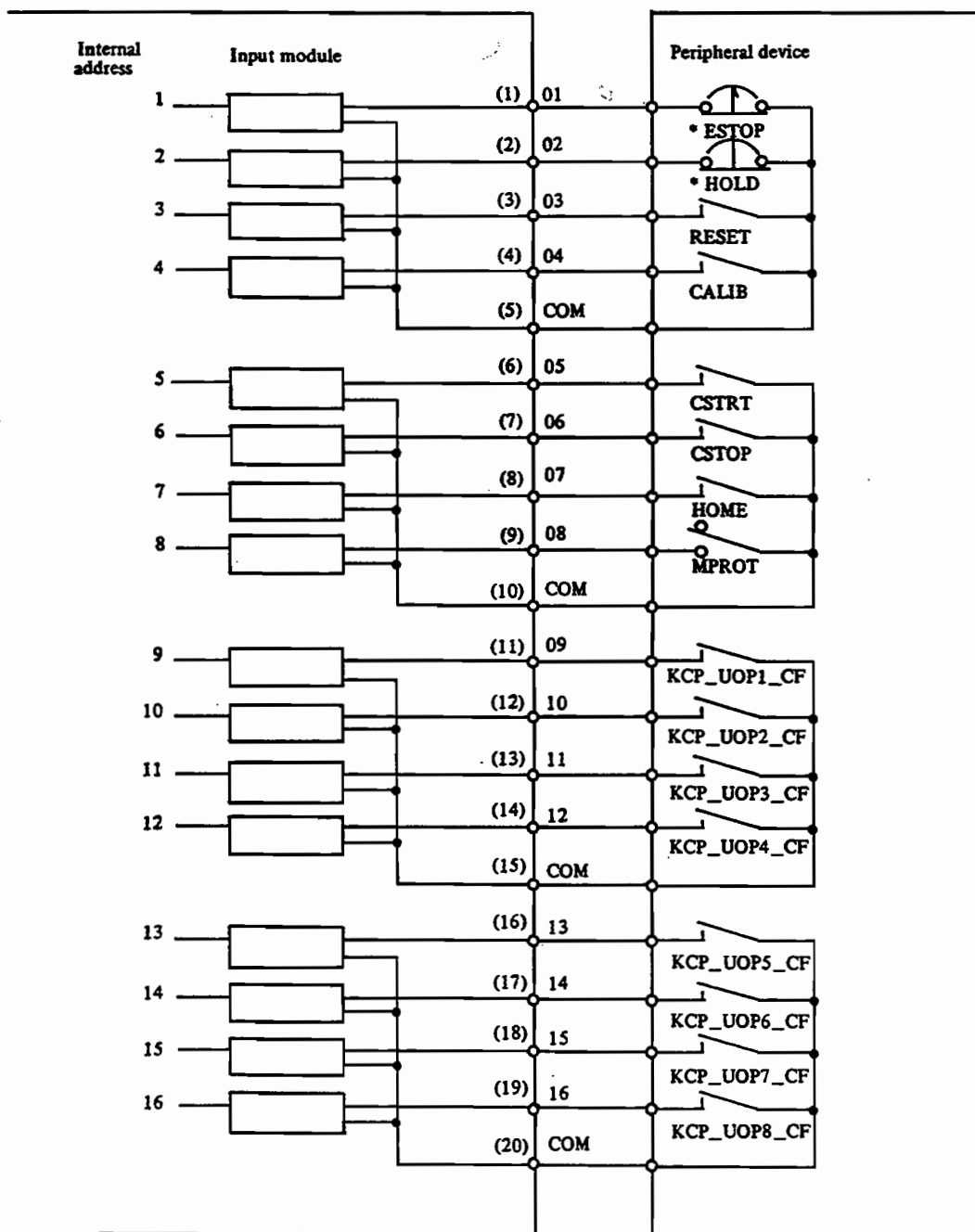


Fig. 3.2.5 (g) UOP input connections

The system variable \$UDIN_ENBL enables the upper eight bits of the UOP input module. If it is FALSE, the upper eight bits of the input module can be used for other user-defined input signals. \$UDIN_ENBL must be set to TRUE in order for the predefined command procedures to be executed.

Table 3.2.5 (c) Modular I/O UOP output control signals

Number	UOP name (Operator panel function)
1	CMDENBL (UOP only -- motion control)
2	SYSRDY (SYSTEM READY light)
3	PAUSED (UOP only -- program paused)
4	PROGRUN (UOP only -- program running)
5	UNCAL (NOT CALIBRATED light)
6	LOCKED (UOP only -- LOCK param ON)
7	HELD (ROBOT HELD light)
8	FAULT (ROBOT FAULT light)
9	TPEN (TEACH PENDANT ENABLED light)
10	UPENBL (PANEL ENABLED light)
11	CSTOP (CYCLE STOP light)
12	reserved for future use
13	reserved for future use
14	reserved for future use
15	reserved for future use
16	reserved for future use

The system variable \$FUL_RMT_OUT enables the upper eight bits of the UOP output module. If it is FALSE, the upper eight bits of the output module can be used for other user-defined output signals. Connection of these UOP output signals is shown in Fig. 3.2.5 (h).

\$FUL-RMT-OUT

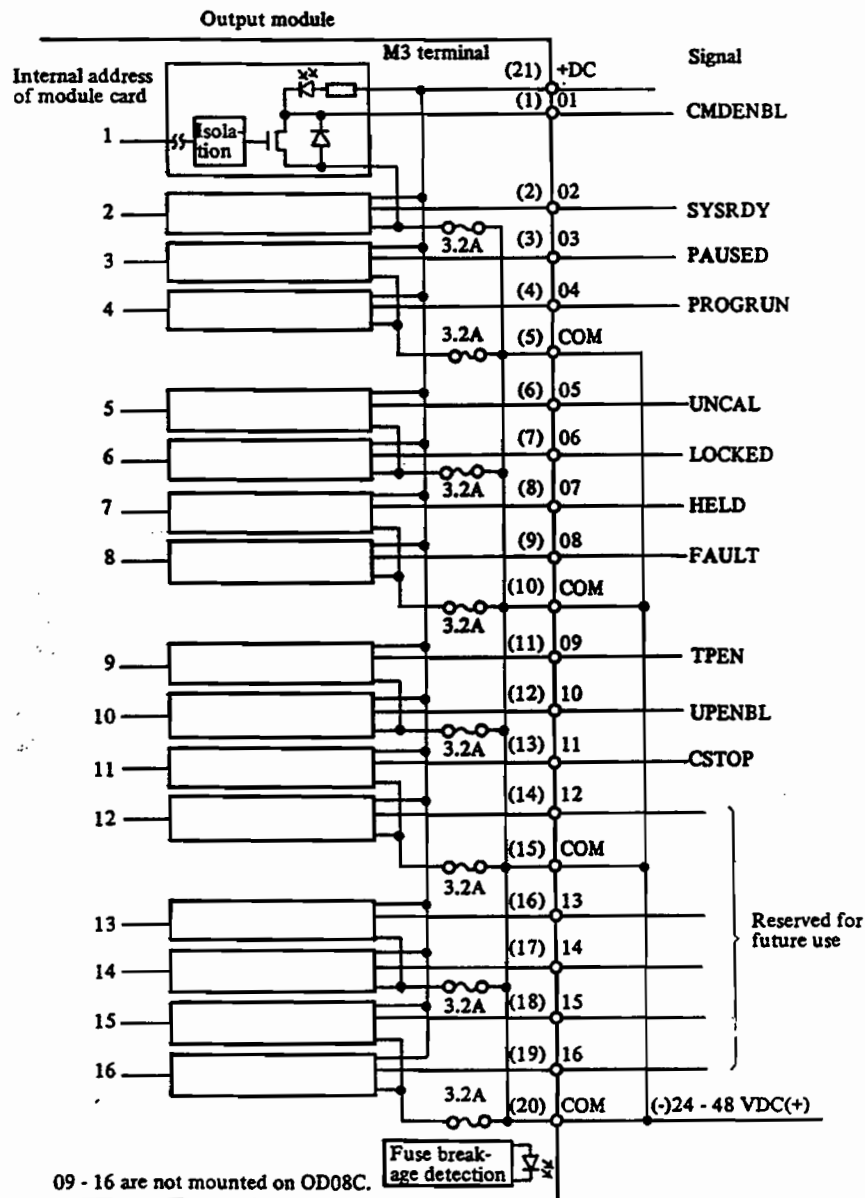


Fig. 3.2.5 (h) UOP output connections

For the fixed I/O system, eight of the UOP control signals are inputs, and the other eight are outputs. The UOP signals are available on the CN2 connector on the fixed I/O board. Tables 3.2.5 (d) and 3.2.5 (e) list the UOP input and output control signals for the fixed I/O system.

Table 3.2.5 (d) Fixed I/O UOP input control signals

Number	UOP name (Operator panel function)
1	*ESTOP (EMERGENCY STOP button)
2	*HOLD (HOLD button)
3	RESET (FAULT RESET button)
4	CALIB (CALIBRATE button)
5	CSTRT (CYCLE START button)
6	CSTOP (CYCLE STOP button)
7	HOME (HOME button)
8	MPROT (MEMORY PROTECT keyswitch)

Table 3.2.5 (e) Fixed I/O UOP output control signals

Number	UOP name (Operator panel function)
1	CMDENBL (UOP only -- motion control)
2	SYSRDY (SYSTEM READY light)
3	PAUSED (UOP only -- program paused)
4	PROGRUN (UOP only -- program running)
5	UNCAL (NOT CALIBRATED light)
6	LOCKED (UOP only -- LOCK param ON)
7	HELD (ROBOT HELD light)
8	FAULT (ROBOT FAULT light)

UOP Signal Interaction

This section describes the interaction of UOP interface signals relative to each other and to the state of the controller. The timing diagrams are used for illustrative purposes only and do not represent the actual time difference between state changes.

The diagrams represent steady-state mode input signals. Reaction to the input occurs after a new state has been maintained for 200 milliseconds. Input and output signals are distinguished in the diagrams by an (I) or (O) following the name.

UOP Motion Control

The following UOP control signals are capable of invoking commands or command procedures that cause motion:

CALIB (CALIBRATE)
 CSTRT (CYCLE START)
 HOME
 KCP_UOP1 through KCP_UOP8

As with any motion command, the device from which the command is issued must have motion control or the command is not executed. The UOP has motion control under the following conditions:

- The following UOP output signals have the indicated values:

FAULTY = OFF (No fault conditions exist.)
 SYSRDY = ON (The system is ready.)
 PROGRUN = OFF (No program is being executed.)
 TPEN = OFF (Teach pendant is not enabled.)
 UPENBL = ON (The UOP is enabled.)

- The operator panel REMOTE keyswitch (on the controller cabinet) is set to ON.

- The REMOTE parameter must be set to UOP. You can use the KCL>SET PARAM REMOTE UOP command to accomplish this. *Default => SET PARAM REMOTE KB*

The UOP must be programmed to check to ensure that it has motion control (CMDENBL = ON) before issuing motion commands. The controller does not respond to UOP motion commands while the UOP is not the motion control device.

CALIB Signal

The CALIB signal invokes the calibration sequence. CALIB is a motion command; do not issue it unless the UOP output CMDENBL = ON (active).

When the execution of the calibration sequence is complete, the UOP output UNCAL is turned OFF. (See Fig. 3.2.5 (i).)

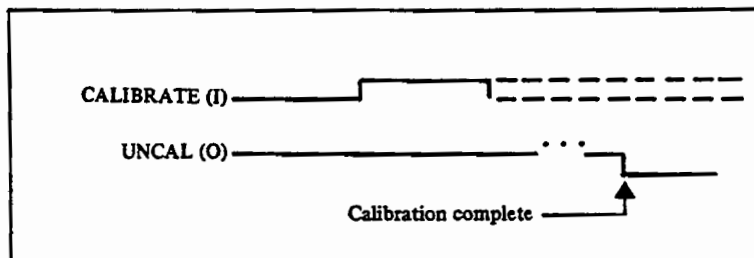


Fig. 3.2.5 (i) CALIB timing diagram

CSTRT Signal

(cycle start)

The effects of activating CSTRT depend on the controller state and the value of user-set system variables. In all cases, CSTRT causes the UOP outputs CSTOP, HELD, and PAUSED to turn OFF. (See Fig. 3.2.5 (j).)

If CSTRT is invoked while execution of a KAREL program is paused (UOP output PAUSED is ON) program execution is resumed (and PAUSED turns OFF).

In all other cases (PAUSED OFF when command issued), CSTRT executes a user-defined KCL command file, specified by the system variable \$CYCLE_STRT. If a file has not been specified, no commands are executed.

CSTRT is a motion command; do not issue it unless the UOP output CMDENBL is ON. Status of the UOP outputs can be affected by the commands issued by the KCL command file.

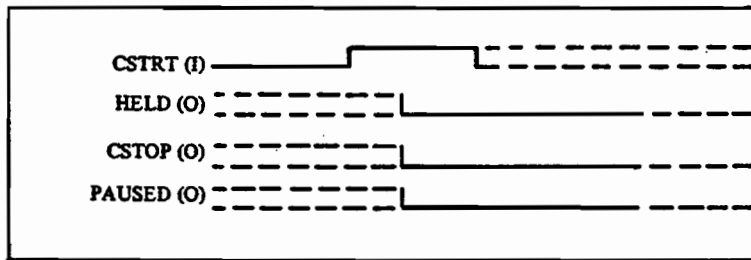


Fig. 3.2.5 (j) CSTART timing diagram

HOME Signal

The HOME signal executes the predefined command file KCP HOME.CF. If a file by that name does not exist, the HOME button executes the KCL> MOVETO \$HOME command using JOINT motion. The system variable \$HOME stores a position that you can define to be the home position for the robot.

A similar system variable, \$AUXHOME stores an auxpos, which you can define as the home position for auxiliary axes. You can then create a command procedure, using the predefined name KCP HOME.CF, to move both the robot and the auxiliary axes to their respective home positions.

HOME is a motion command; do not issue it unless the UOP output CMDENBL is ON.

*HOLD Signal

The *HOLD signal pauses program execution and thus stops motion. *HOLD is ON when the voltage is zero. Activating *HOLD causes the UOP outputs HELD and PAUSED to turn ON, and PROGRUN to turn OFF. (See Fig. 3.2.5 (k).)

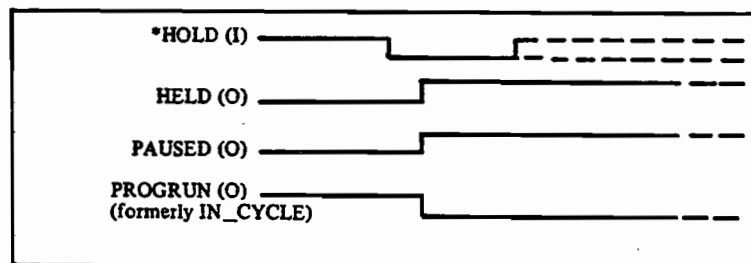


Fig. 3.2.5 (k) *HOLD timing diagram

You can clear the HOLD condition by issuing any motion command, but you can clear the PAUSED condition only by executing a KAREL program (for example, by issuing the KCL> RUN or RESUME commands or pressing the CYCLE_START button.)

CSTOP Signal

The effect of activating the CSTOP signal depends on the status of the UOP output UPENBL and the system variable \$C_STOP_ENBL.

If UOP output UPENBL is OFF the controller will not respond to CSTOP. In this case CSTOP has no effect on controller operation. If UPENBL is ON, the CSTOP input signal sets the system variable \$C_STOP to TRUE and turns on the UOP output signal CSTOP. (See Fig. 3.2.5 (l).)

In addition, if the system variable \$C_STOP_ENBL is FALSE, the CSTOP input signal acts identically to the UOP input signal *HOLD, pausing an executing program and holding motion.

If \$C_STOP_ENBL is TRUE, the CSTOP input signal does not pause the program automatically. The KAREL language C_STOP function can be used in a program to test the value of \$C_STOP and pause a program if \$C_STOP is TRUE.

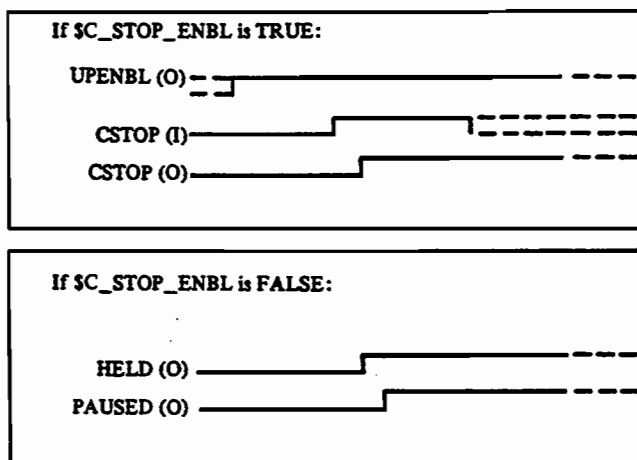


Fig. 3.2.5 (l) CSTOP timing diagram

RESET Signal

The effect of the RESET input depends on the current status of the controller.

If an error condition exists (FAULT output ON) and the cause of the error has been removed, RESET resets the error condition. If an error condition does not exist (FAULT output OFF), RESET clears the message line on the CRT/KB display. (See Fig. 3.2.5 (m).)

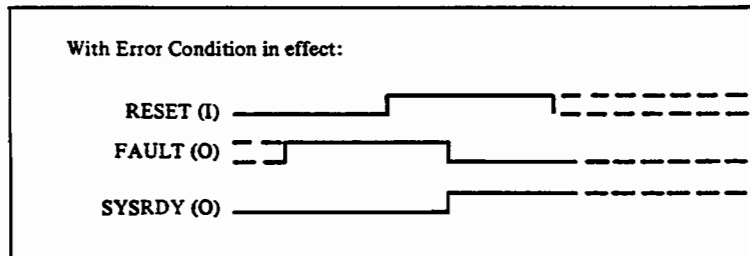


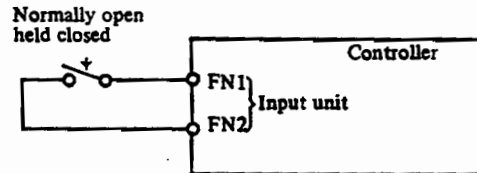
Fig. 3.2.5 (m) RESET timing diagram

3.2.6 Connection for emergency stop control

The connections described in this section are made at the input unit, the location of which is shown in Fig. 3.2.6.

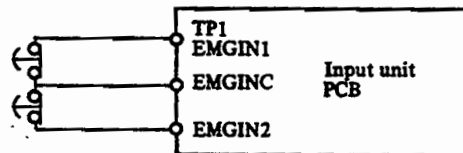
Safety Fence

This input causes an emergency stop. This emergency stop differs from the EMERGENCY STOP button on the operator panel only in the error message. This is a normally open contact held closed by a gate on a safety fence that should be connected across the terminals FN1 and FN2 on terminal TP1 on the input unit PCB.



External Emergency Stop

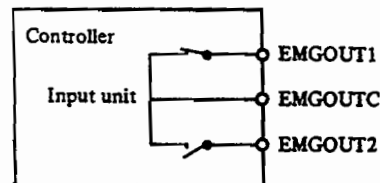
Terminals EMGIN1, EMGINC, and EMGIN2 allow for connection of external emergency stops. Both place the robot in an emergency stop condition, however the status of the emergency stop output differs.



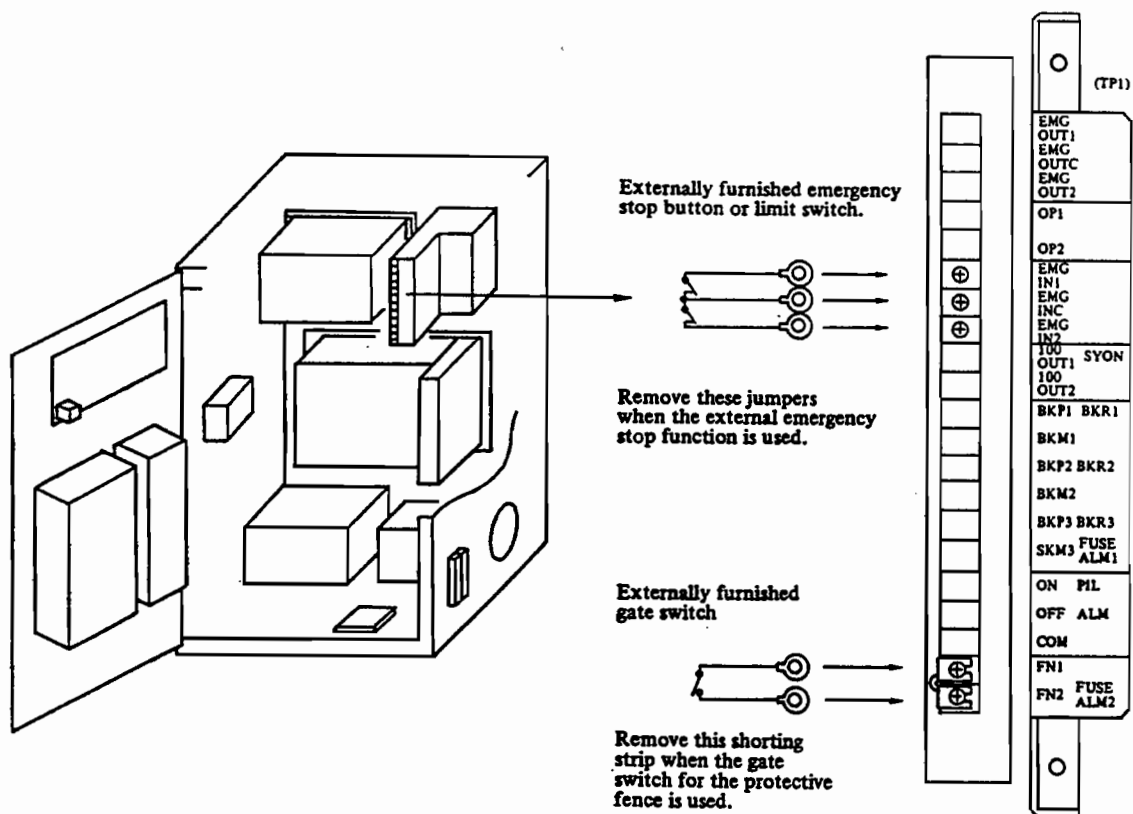
Note) Short when not used.

Emergency Stop Outputs

Emergency stops outputs are provided as shown in the following diagram.



When the emergency stop occurs in the controller or from an emergency stop from EMGIN1 - EMGINC, the contact between EMGOUT1 and EMGOUTC will be open and the contact between EMGOUTC and EMGOUT2 will be shorted. The contact specifications are as follows. The minimum load is 5 VDC and 10 mADC. The maximum voltage of the contact is 380 VAC or 125 VDC. The maximum current of the contact is 5 A. The controller also provides the interface of emergency stop inputs which do not affect the contacts of EMGOUT1, EMGOUTC, and EMGOUT2. They are called EMGINC and EMGIN2. When this contact is open, the robot is stopped by the emergency stop, but the contacts "EMGOUT1, EMGOUTC, and EMGOUT2" do not change, allowing the continued operation of the external equipment.



3.2.7 Connection to computer

The RS-232-C interface is provided for the connection to the computer in the controller.

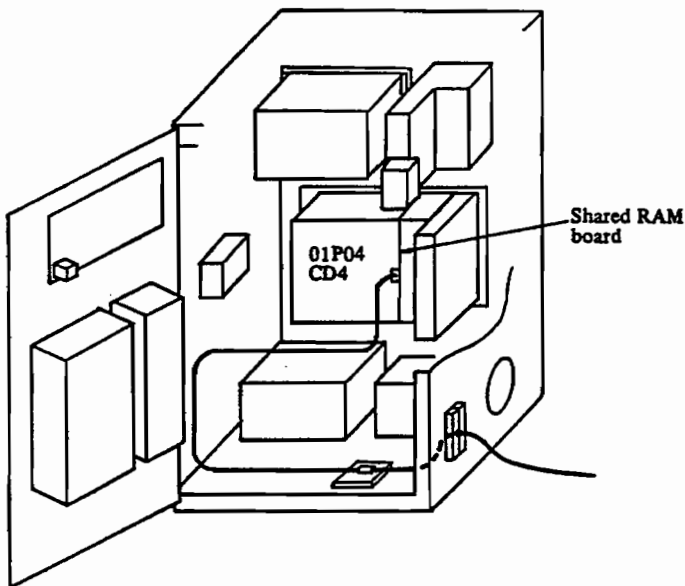


Fig. 3.2.7 (a) Connection to computer
(Medium size cabinet)

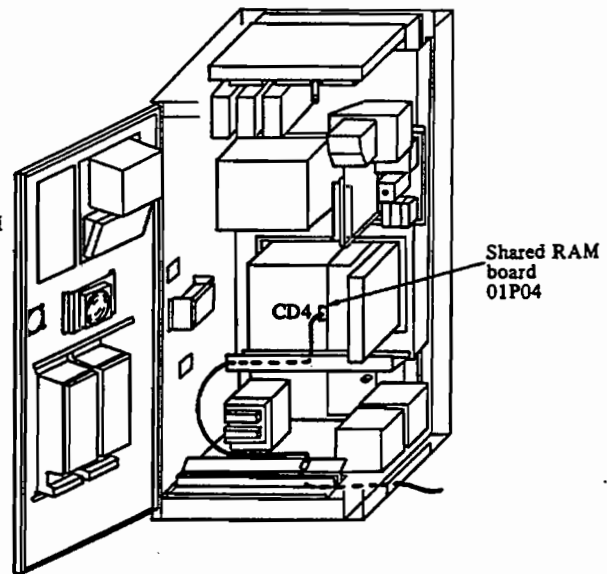
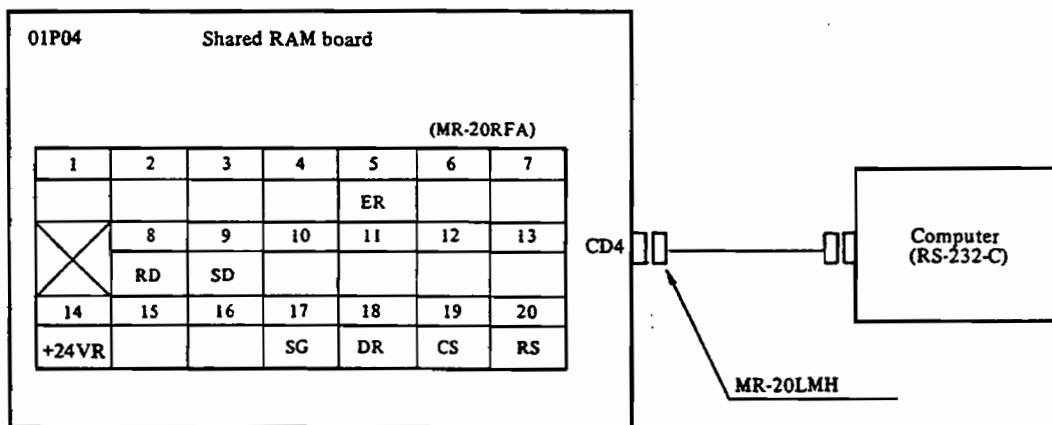
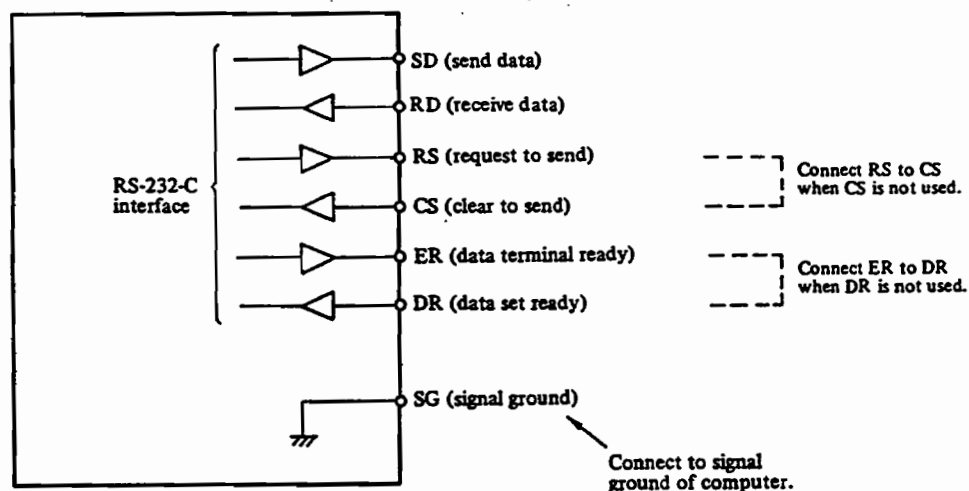


Fig. 3.2.7 (b) Connection to computer
(Large size cabinet)



Regarding the meaning of the signals, refer to the figure shown below.

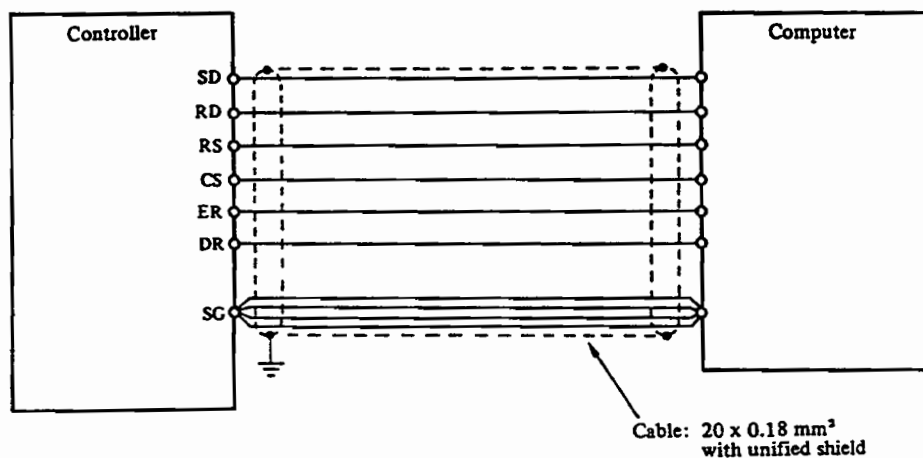


Note) +24 V cannot be used for computer.

ON/OFF voltage levels are given in the following table.

	Less than -3 V	More than +3 V
Function	OFF	ON
Signal condition	Marking	Spacing

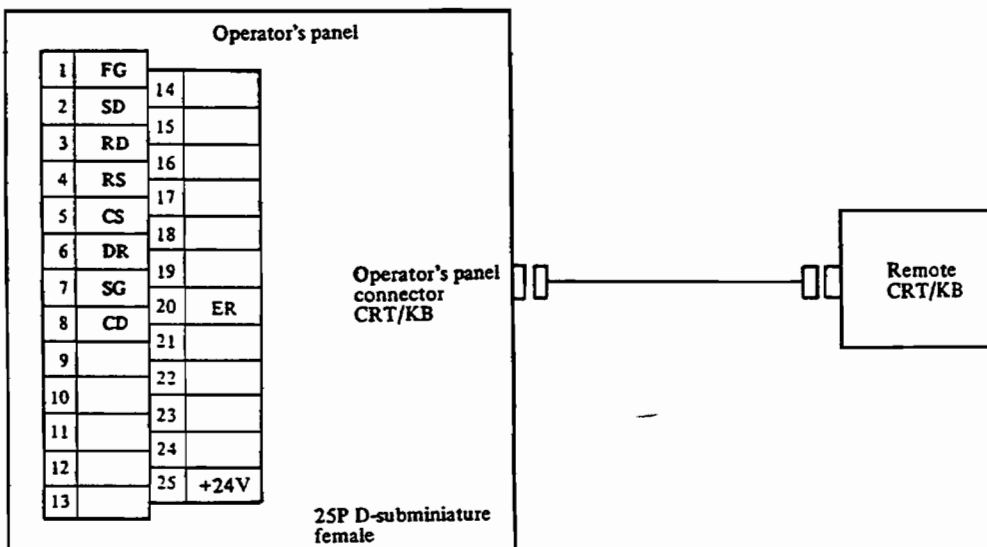
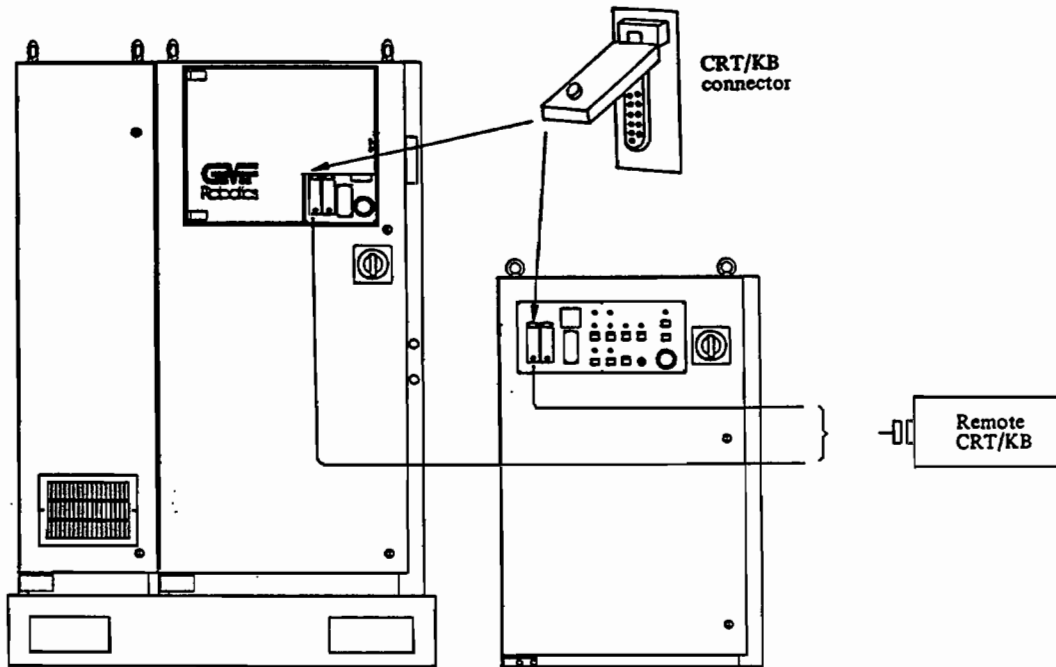
Cable connection between the controller and the computer should be as follows:



Peel the sheath of cable and attach the cable to the ground board of the controller cabinet by means of the cable clamp metal fixture.

3.2.8 Connection to remote CRT/KB

When the controller is used with the built-in operator's panel, the remote CRT/KB can be connected to the connector provided on the built-in operator's panel.



3.3 Setting USAT

The User Signal Assignment Table (USAT), a mapping of the physical signals to the system software, describes the user I/O hardware configuration to the controller. UOP and HAND signals are also mapped in the USAT. The table is stored in the system variable \$USAT.

The USAT consists of nine blocks of tables, one for each I/O signal type. Each block contains a table for each I/O signal of the corresponding type. These tables contain multiple bytes of data that describe details of the I/O hardware. The structure of the blocks and the tables within each block vary with the type of I/O signal. (See Table 3.3 (a))

After you have selected the hardware configuration and I/O types, enter the appropriate data into the table, making it available for use by the controller. If you are not using the KAREL System Software Utility Package available from GMF, perform the following steps for each entry:

1. Determine the appropriate numbers for each of the data fields.
2. Convert each number to binary format using the number of binary bits specified for the signal type.
3. Configure the data into the appropriate eight-bit binary words.
4. Convert the binary words to decimal format.

\$USAT is a system variable ARRAY with each element mapping a group of I/O signals. To change \$USAT ARRAY element number 9 to a value of three, enter KCL> SET VAR \$USAT[9]= 3. (See Table 3.3 (a).)

Like other system variables, \$USAT is stored in the file SYSVARS.SV (through use of the KCL> SSAVE command). Each time you power up the controller it reads these variables and uses the data from \$USAT to understand the I/O configuration you have selected.

For example, to change \$USAT ARRAY element number 9 to a value of 20 from the Non-Positional Data screen:

- 1 Highlight the Sysvars option from the program list and press ENTER. This will display an alphabetical listing of all available system variables.
- 2 Highlight the \$USAT system variable using the up/down arrow keys and press ENTER. This will display the current value for each of the 98 elements in \$USAT.
- 3 Use the arrow keys to highlight \$USAT[9] and press ENTER. Type 20 at the "Enter new value>" prompt.
- 4 To save the value to SYSVARS.SV, press the Save File Function key, F1.

Expanded I/O

It is possible to define additional signals besides those defined in \$USAT. The information for these definitions is stored in the KAREL variable file, EXP_USAT.VR. The structure of the data within this file is similar to that of \$USAT but not the same. The USAT Setting Program supports this expanded table automatically. Using this program is the only way in which you can set the expanded I/O table. Modifications to the USAT are still made through the use of the USAT Setting Program, Config I/O menus, on the CRT/KB and teach pendant. When assignments are made that exceed the standard table size, the data is added to EXP_USAT.VR automatically by the Config I/O process. When you exit the USAT Setting Program using the SAVE option, this file is saved to bubble memory.



CAUTION

If you delete the EXP_USAT.VR file from bubble memory, you will need to run the KAREL USAT Setting Program to reset the expanded I/O table.

There are now 1000 digital, 100 group and 100 analog input and output signals available to access the R-H modular I/O, the fixed I/O board, and the interfaces to GEFanuc and Allen-Bradley programmable controllers.

In addition, there are another 1000 digital and 100 group and analog signals available for the direct control of GEFanuc Genius I/O blocks as shown in the following table.

Signal Type	Module I/O	Genius I/O
Digital (DIN,DOUT)	1-1000	1001-2000
Group (GIN,GOUT)	1-100	101-200
Analog (AIN,AOUT)	1-100	101-200

To accommodate the configuration of these signals, an extension to the User Signal Assignment Table (USAT) has been added. This extension is contained in an expandable KAREL variable file EXP_USAT.VR and has a similar structure to the basic USAT stored as a system variable.

For more information on the Genius and Allen-Bradley interfaces refer to, *A User's Guide to the GMF Network Interface for GEFanuc* or *A User's Guide to the Remote I/O Interface for Allen-Bradley*.

Table 3.3 (a) USAT structure

Element number [n]	Table number	Signal number [n]	size in bytes
DIN Tables			
USAT[1]	DIN Table #1	DIN[1] - DIN[8]	2 bytes
USAT[3]	DIN Table #2	DIN[9] - DIN[16]	2 bytes
USAT[5]	DIN Table #3	DIN[17] - DIN[24]	2 bytes
USAT[7]	DIN Table #4	DIN[25] - DIN[32]	2 bytes
USAT[9]	DIN Table #5	DIN[33] - DIN[40]	2 bytes
USAT[11]	DIN Table #6	DIN[41] - DIN[48]	2 bytes
USAT[13]	DIN Table #7	DIN[49] - DIN[56]	2 bytes
USAT[15]	DIN Table #8	DIN[57] - DIN[64]	2 bytes
DOUT Tables			
USAT[17]	DOUT Table #1	DOUT[1] - DOUT[8]	2 bytes
USAT[19]	DOUT Table #2	DOUT[9] - DOUT[16]	2 bytes
USAT[21]	DOUT Table #3	DOUT[17] - DOUT[24]	2 bytes
USAT[23]	DOUT Table #4	DOUT[25] - DOUT[32]	2 bytes
USAT[25]	DOUT Table #5	DOUT[33] - DOUT[40]	2 bytes
USAT[27]	DOUT Table #6	DOUT[41] - DOUT[48]	2 bytes
USAT[29]	DOUT Table #7	DOUT[49] - DOUT[56]	2 bytes
USAT[31]	DOUT Table #8	DOUT[57] - DOUT[64]	2 bytes
GIN Tables			
USAT[33]	GIN Table #1	GIN[1]	3 bytes
USAT[36]	GIN Table #2	GIN[2]	3 bytes
USAT[39]	GIN Table #3	GIN[3]	3 bytes
USAT[42]	GIN Table #4	GIN[4]	3 bytes
USAT[45]	GIN Table #5	GIN[5]	3 bytes
USAT[48]	(unused)		
GOUT Tables			
USAT[49]	GOUT Table #1	GOUT[1]	3 bytes
USAT[52]	GOUT Table #2	GOUT[2]	3 bytes
USAT[55]	GOUT Table #3	GOUT[3]	3 bytes
USAT[58]	GOUT Table #4	GOUT[4]	3 bytes
USAT[61]	GOUT Table #5	GOUT[5]	3 bytes
USAT[64]	(unused)		
AIN Tables			
USAT[65]	AIN Table #1	AIN[1]	2 bytes
USAT[67]	AIN Table #2	AIN[2]	2 bytes
USAT[69]	AIN Table #3	AIN[3]	2 bytes
USAT[71]	AIN Table #4	AIN[4]	2 bytes
USAT[73]	AIN Table #5	AIN[5]	2 bytes

Element number [n]	Table number	Signal number [n]	size in bytes
AOUT Tables			
USAT[75]	AOUT Table #1	AOUT[1]	2 bytes
USAT[77]	AOUT Table #2	AOUT[2]	2 bytes
USAT[79]	AOUT Table #3	AOUT[3]	2 bytes
USAT[81]	AOUT Table #4	AOUT[4]	2 bytes
USAT[83]	AOUT Table #5	AOUT[5]	2 bytes
UOP Input Table			
USAT[85]	Input Table	UOP Inputs	1 byte
UOP Output Table			
USAT[86]	Output Table	UOP Outputs	1 byte
HAND Signal Tables			
USAT[87]	HAND Table #1	HAND[1]	3 bytes
USAT[90]	HAND Table #2	HAND[2]	3 bytes
USAT[93]	HAND Table #3	HAND[3]	3 bytes
USAT[96]	HAND Table #4	HAND[4]	3 bytes

Digital Input and Output Tables

The two blocks for digital input and digital output each contain eight tables (DIN Table #1 - DIN Table #8 and DOUT Table #1 - DOUT Table #8 in Table 3.3 (a)).

Each table consists of two bytes for configuring the DINs and DOUTs and describes eight signals, ordered by signal number (DIN Table #1 is for DIN[1] - DIN[8], DIN Table #2 is for DIN[9] - DIN[16], and so on).

For the modular I/O system data within each table defines the location of the I/O module for the associated signals. For the fixed I/O system data within each table determines which signals are associated with the dedicated I/O lines on the fixed I/O board. Table 3.3 (b) shows the format of the data in the DIN and DOUT tables.

Table 3.3 (b) DIN/DOUT table format

0001 16-255		0001 0-15	
Rack # (4 bits)		Slot # (4 bits)	
Base signal # (7 bits)		Polarity (1 bit)	
64 32 16 8 4 2 1		1	
1 0 0 0 0 0 1		0	

First byte

Second byte

o Rack -- I/O rack number in which the I/O module is mounted. For fixed I/O rack number must be 1.

o Slot -- Slot number (on the I/O rack) in which the I/O module is mounted. For fixed I/O slot number must be 1.

Example: Map Din 1-8 to fixed I/O UDI 1-8

Fixed I/O { Rack = 1 } First byte = $16 + 1 = 17 \Rightarrow \text{USAT}[1] = 17$
 Slot = 1

UDI 1-8 - Base signal = 65
 Polarity = 0 } Second byte = $129 + 1 \Rightarrow \text{USAT}[2] = 130$

o Base Signal --

- Modular I/O: Signal number on the I/O module that corresponds to the first DIN or DOUT in the table (1 or 9 for standard applications).
- Fixed I/O: Since the fixed I/O system has dedicated I/O lines and not modules, the base signal does not have the same meaning as for the modular I/O. Consider the fixed I/O card as an input module with 32 signals and an output module with 24 signals. The numbering of the signals is as follows:

INPUTS		OUTPUTS	
Signal name	BASE SIGNAL Number (7 bit)	Signal name	Number
RDI1	1	RD01	1
RDI2	2	RD02	2
RDI3	3	RD03	3
RDI4	4	RD04	4
RDI5	5	RD05	5
RDI6	6	RD06	6
RDI7	7	RD07	7
RDI8	8	RD08	8
UDI1	65	UD01	65
UDI2	66	UD02	66
UDI3	67	UD03	67
UDI4	68	UD04	68
UDI5	69	UD05	69
UDI6	70	UD06	70
UDI7	71	UD07	71
UDI8	72	UD08	72
UDI9	73	UD09	73
UDI10	74	UD010	74
UDI11	75	UD011	75
UDI12	76	UD012	76
UDI13	77	UD013	77
UDI14	78	UD014	78
UDI15	79	UD015	79
UDI16	80	UD016	80
UDI17	81	UD017	81
UDI18	82	UD018	82
UDI19	83	UD019	83
UDI20	84	UD020	84
UDI21	85	UD021	85
UDI22	86	UD022	86
UDI23	87	UD023	87
UDI24	88	UD024	88
UDI25	89		
UDI26	90		
UDI27	91		
UDI28	92		
UDI29	93		
UDI30	94		
UDI31	95		
UDI32	96		

The UDI/UDO number is always 64 more than the signal name. The numbers listed in the table are valid as the base signal number when setting the USAT for the fixed I/O system. As an example, to assign UDI9 - UDI16 to be DIN[1] - DIN[8], the base signal in \$USAT[2] would be 73.

- Polarity -- The polarity of the signal: 0 for active high (ON when voltage is applied), 1 for active low (ON when voltage is not applied).

Group Input and Output Tables

The two blocks for group input and group output each contain five tables (GIN Table #1 - GIN Table #5 and GOUT Table #1 - GOUT Table #5 in Table 3.3 (a)). Each table consists of three bytes for configuring the GINs and GOUTs and describes one signal, ordered by signal number (GIN Table #1 is for GIN[1], GIN Table #2 is for GIN[2], and so on). Data within each table defines the location of the I/O module for the associated signal. Table 3.3 (c) shows the format of the data in the GIN and GOUT tables.

Table 3.3 (c) GIN/GOUT table format

Rack # (4 bits)	Slot # (4 bits)	First byte
Base signal # (8 bits)		Second byte
Group size (8 bits)		Third byte

- o Rack -- I/O rack number in which the I/O module is mounted. For fixed I/O rack number must be 1.
- o Slot -- Slot number (on the I/O rack) in which the I/O module is mounted. For fixed I/O slot number must be 1.
- o Base Signal --
 - Modular I/O: Signal number on the I/O module that corresponds to the first DIN or DOUT in the table (1 or 9 for standard applications).
 - Fixed I/O: Since the fixed I/O system has dedicated I/O lines and not modules the base signal does not have the same meaning as for the modular I/O. Consider the fixed I/O board as an input module with 32 signals and an output module with 24 signals. The numbering of the signals is as follows:

INPUTS		OUTPUTS	
Signal name	Number	Signal name	Number
RDI1	1	RDO1	1
RDI2	2	RDO2	2
RDI3	3	RDO3	3
RDI4	4	RDO4	4
RDI5	5	RDO5	5
RDI6	6	RDO6	6
RDI7	7	RDO7	7
RDI8	8	RDO8	8

INPUTS		OUTPUTS	
Signal name	Number	Signal name	Number
UDI1	65	UD01	65
UDI2	66	UD02	66
UDI3	67	UD03	67
UDI4	68	UD04	68
UDI5	69	UD05	69
UDI6	70	UD06	70
UDI7	71	UD07	71
UDI8	72	UD08	72
UDI9	73	UD09	73
UDI10	74	UD010	74
UDI11	75	UD011	75
UDI12	76	UD012	76
UDI13	77	UD013	77
UDI14	78	UD014	78
UDI15	79	UD015	79
UDI16	80	UD016	80
UDI17	81	UD017	81
UDI18	82	UD018	82
UDI19	83	UD019	83
UDI20	84	UD020	84
UDI21	85	UD021	85
UDI22	86	UD022	86
UDI23	87	UD023	87
UDI24	88	UD024	88
UDI25	89		
UDI26	90		
UDI27	91		
UDI28	92		
UDI29	93		
UDI30	94		
UDI31	95		
UDI32	96		

The UDI/UDO number is always 64 more than the signal name. The numbers listed in the table are valid as the base signal number when setting the USAT for the fixed I/O system. As an example, to assign UDI9 - UDI16 to be DIN[1] - DIN[8], the base signal in \$USAT[2] would be 73.

- o Group Size -- Number of binary bits in the group (the number of lines connected to the I/O module -- always within the range of 1 to 16).

Analog Input and Output Tables

Analog inputs and outputs are available with the modular I/O system. The two blocks for analog input and analog output each contain five tables (AIN Table #1 - AIN Table #5 and AOUT Table #1 - AOUT Table #5 in Table 3.3 (a)).

Each table consists of two bytes for configuring the AINs and AOUTs and describes one signal, ordered by signal number (AIN Table #1 is for AIN[1], AIN Table #2 is for AIN[2], and so on).

Data within each table defines the location of the I/O module for the associated signal. Table 3.3 (d) shows the format of the data in the AIN and AOUT tables.

Table 3.3 (d) AIN/AOUT table format

Rack # (4 bits)	Slot # (4 bits)	First byte
Channel # (8 bits)		Second byte

- o Rack -- I/O rack number in which the I/O module is mounted.
- o Slot -- Slot number (on the I/O rack) in which the I/O module is mounted.
- o Channel -- Digital/Analog (or Analog/Digital) channel number on the I/O module which corresponds to the AIN or AOUT for this table.

UOP Input and Output Table

The UOP input and UOP output each have one block containing all of the UOP input or output signals.

Each table consists of one byte for configuring the UOP inputs and outputs. No signal number is required for UOP signals.

Data within each table defines the location of the I/O module for the associated signal. Table 3.3 (e) shows the format of the data in the UOP tables.

Table 3.3 (e) UOP input/output table format

Rack # (4 bits)	Slot # (4 bits)	First byte
-----------------	-----------------	------------

- o Rack -- I/O rack number in which the I/O module is mounted. For fixed I/O rack number must be 1.
- o Slot -- Slot number (on the I/O rack) in which the I/O module is mounted. For fixed I/O slot number must be 1.

Hand Control Signal Tables

The one block for HAND control signals contains four tables (HAND Table #1 - HAND Table #4 in Table 3.3 (a)).

Each table consists of three bytes for configuring the HAND control signals and describes one signal, ordered by signal number (HAND Table #1 is for HAND[1], HAND Table #2 is for HAND[2], and so on).

Data within each table defines the location of the output module (or the number of the fixed I/O signal) for the associated signal and the mode of operation for the signal lines. Table 3.3 (f) shows the format of the data in the HAND tables.

Table 3.3 (f) HAND signal table format

Operation mode # (8 bits)		First byte
Rack # (4 bits)	Slot # (4 bits)	Second byte
Open line # (8 bits)		Third byte

o Operation Mode -- Operation mode number is defined as follows:

- Mode 0: Single line mode
- Mode 1: Dual line mode
- Mode 2: Dual line pulsed mode, 200 msec pulses
- Mode 3: Dual line pulsed mode, 400 msec pulses

(Refer to the KAREL System Reference Manual for a detailed description of each mode.)

o Rack -- I/O rack number in which the output module is mounted. For fixed I/O rack number must be 1.

o Slot -- Slot number (on the I/O rack) in which the output module is mounted. For fixed I/O slot number must be 1.

o Open Line -- Signal number that corresponds to the open line. The next signal is the close line.

Setting Unassigned Signals

Unused I/O signals should be left unassigned in the USAT. Use a value of zero for the rack and slot numbers in the corresponding assignment table.

3.4 I/O Module Specifications

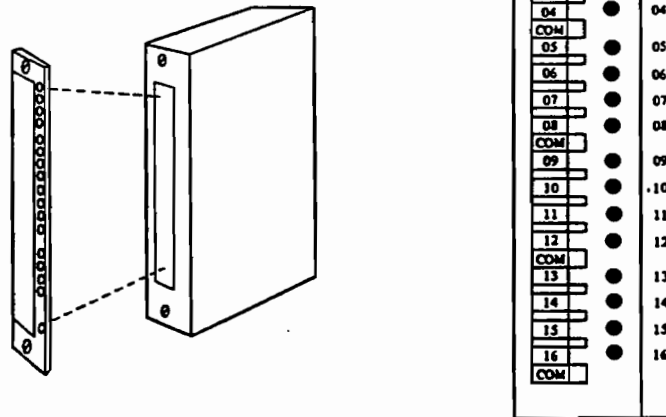


Fig. 3.4 (a) Typical output module

Various I/O modules are prepared to connect with peripheral devices. DI/DO modules are mounted in slot No. 1, 2, 3, 4, 5, 6, 7, 8 or 9 in I/O unit. For the types of DI/DO modules, refer to Tables 3.4 (a) through (d). For analog input/output modules, refer to Tables 3.4 (h) through (i). For noise suppressors, refer to Sec. 4.2.4.

Table 3.4 (a) Variety of DI modules

Module name	Rated voltage	Input current	Response time	Low level input volt (max)	High level input volt (min)	Number of inputs	External connection	LED display	Fuse	Number of commons
ID16C	24 VDC	9 mA	20 ms	8 V	15 V	16	terminal block (M3)	YES	NO	4
ID08C	24 VDC	9 mA	20 ms	8 V	15 V	8	ditto	YES	NO	2
ID16D	24 VDC	9 mA	2 ms	8 V	15 V	16	ditto	YES	NO	4
ID08D	24 VDC	9 mA	2 ms	8 V	15 V	8	ditto	YES	NO	2
IA16E	120 VAC	9 mA	50 ms	20 VAC	70 VAC	16	ditto	YES	NO	4
IA08E	120 VAC	9 mA	50 ms	20 VAC	70 VAC	8	ditto	YES	NO	2

For the connections diagram see Fig. 3.4 (b), (c).

Fig. 3.4 (b): ID16C, ID08C, ID16D, ID08D.

Fig. 3.4 (c): IA16E, IA08E.

For the specifications, refer to Table 3.4 (b), (c).

Table 3.4 (b): DC input specifications ID16C, ID08C, ID16D, ID08D.

Table 3.4 (c): AC input specifications IA16E, IA08E.

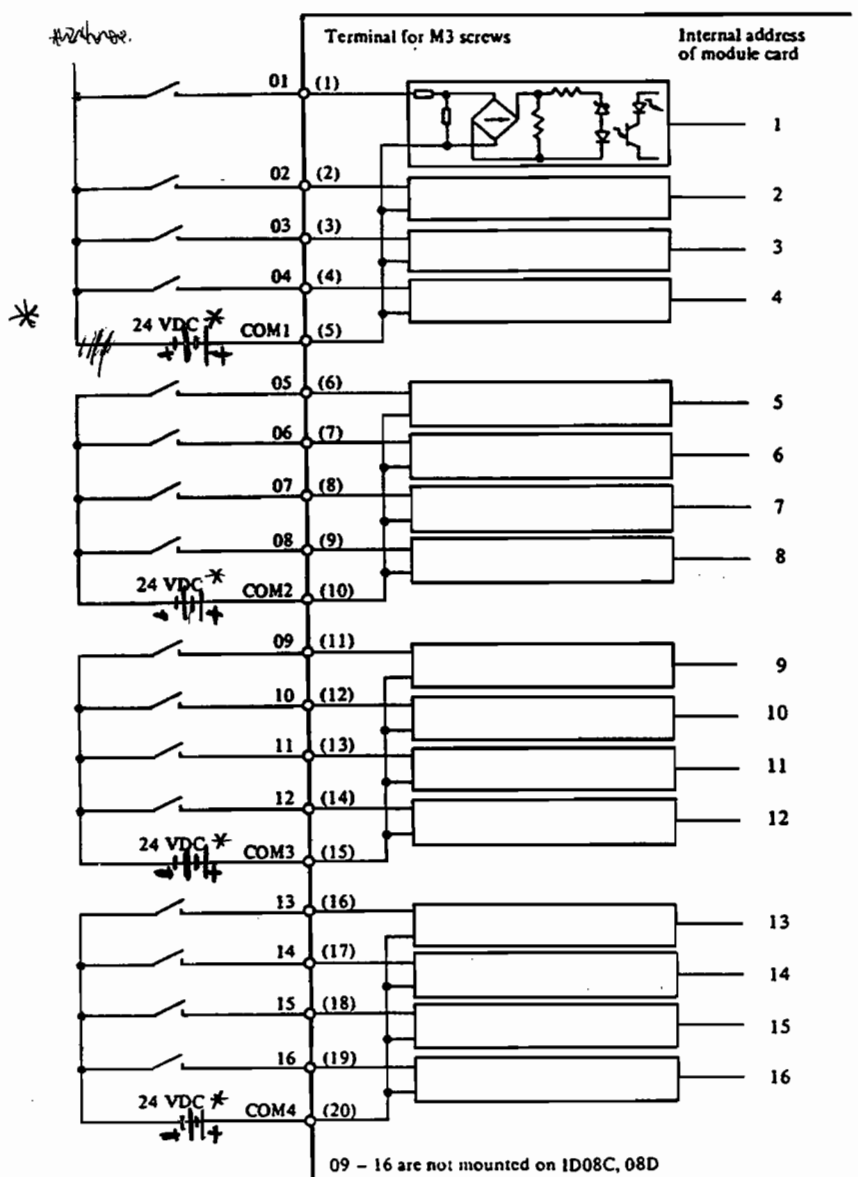


Fig. 3.4 (b) DI module ID16C, ID08C, ID16D, ID08D

* NOTE : L'ALIMENTATION PEUT ÊTRE INVERSÉE POUR UN SINK CURRENT INPUT

Table 3.4 (b) DC input specifications

Item \ Module		ID08C	ID16C	ID08D	ID16D
Points/module		8	16	8	16
Rated input voltage		24 VDC			
Maximum input voltage		30 VDC			
Operation voltage (Note 1)	ON	15 V or more			
	OFF	8 V or less			
Operation current (Note 1)	ON	4.5 mA or more			
	OFF	2 mA or less			
Input current		9 mA typical (24 VDC)			
Input impedance		2.5 kΩ approx.			
Response time (Note 2)	OFF → ON	20 ms max.		2 ms max.	
	ON → OFF	20 ms max.		2 ms max.	
Operation display		LED lights when input is ON			
External connection method		Terminal board connection (M3)			
Common points (Note 3)		1 common per 4 points input			
Dielectric strength		1 minute under 1000 VAC			

Note 1) When the voltage between the input terminal and common terminal is 15 V or more, or when the current flowing into the input terminal is 4.5 mA or more, the input signal (contact point) is regarded as ON. When the input terminal voltage is 8 V or less, or when the input current is 2 mA or less, the input signal (contact point) is regarded as OFF. When using proximity switches or photo-electric switches, be careful of current leakage when the contact point is off. If the current leakage is 2 mA or more, it will not be regarded as OFF.

Note 2) The response time shown here is the delay time from module input to output. The actual response time is this value plus the scanning time which is different for each system configuration.

Note 3) The commons are not connected to each other in the module.

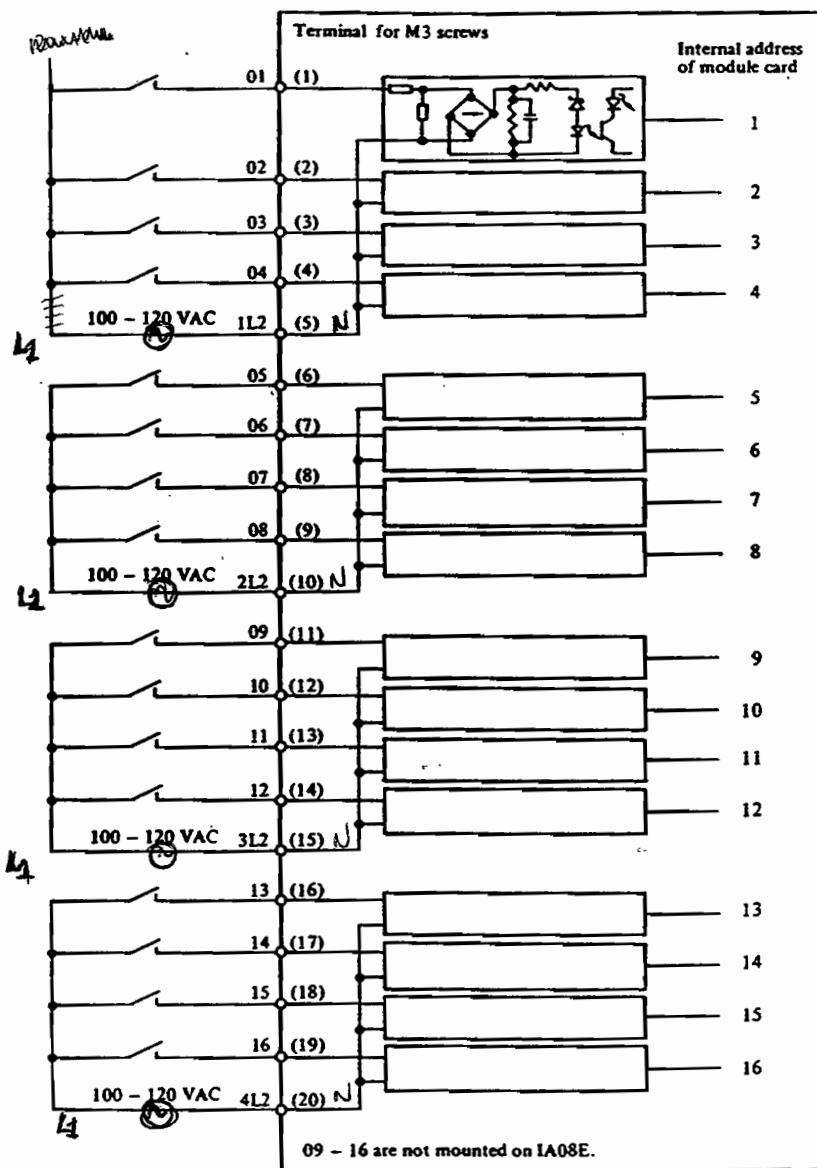


Fig. 3.4 (c) DI module IA16E, IA08E

Table 3.4 (c) AC input specifications

Item \ Module		IA08E	IA16E
Points/module		8	16
Rated input voltage		100 - 120 VAC, 50/60 Hz	
Maximum input voltage		140 VDC	
Operation voltage (Note 1)	ON	70 V or more	
	OFF	20 V or less	
Operation current (Note 1)	ON	5 mA or more	
	OFF	2 mA or less	
Input current		9 mA type (100 VAC)	
Input impedance		Approx. 12.5 k Ω	
Response time (Note 2)	OFF \rightarrow ON	50 ms max.	
	ON \rightarrow OFF	50 ms max.	
Operation display		LED lights when input is ON	
External connection method		Terminal board (M3)	
Common points (Note 3)		1 common per 4 points input	
Dielectric strength		1 minute under 1000 VAC	

Note 1) When the voltage at the input terminal is 70 V or more, or when the current flowing into the input terminal is 5 mA or more, the input signal (contact point) is regarded as ON. When the input terminal voltage is 20 V or less, or when the input current is 2 mA or less, the input signal (contact point) is regarded as OFF. When using proximity switches or photo-electric switches, be careful of current leakage when the contact point is off. If the current leakage is 2 mA or more, it will not be regarded as OFF.

Note 2) The response time is the delay time from module input to output. The actual time is this value plus the scanning time which is different for each system configuration.

Note 3) The commons are not connected to each other in the module.

Table 3.4 (d) Variety of DO modules

Module name	Rated voltage	Rated current			OFF state leak current	ON state voltage drop	Number of outputs	External connection	LED display	Fuse	Number of commons	Remarks
		Each	Per common	Total								
OD16B	24-48 VDC	0.5 A	2 A	8 A	0.1 mA	1.0 V	16	terminal block (M3)	YES	YES	4	DC sink output
OD08B	24-48 VDC	0.5 A	2 A	4 A	0.1 mA	1.0 V	8	ditto	YES	YES	2	ditto
OD16C	24-48 VDC	2 A	4 A	16 A	0.5 mA	1.0 V	16	ditto	YES	YES	4	ditto
OD08C	24-48 VDC	2 A	4 A	8 A	0.5 mA	1.0 V	8	ditto	YES	YES	2	ditto
OA16D	120 VAC	1.6 A	3.2 A	12.8 A	1.5 mA	1.5 V	16	ditto	YES	YES	4	
OA08D	120 VAC	1.6 A	3.2 A	6.4 A	1.5 mA	1.5 V	8	ditto	YES	YES	2	
OA16E	240 VAC	1.6 A	3.2 A	12.8 A	3 mA	1.5 V	16	ditto	YES	YES	4	
OA08E	240 VAC	1.6 A	3.2 A	6.4 A	3 mA	1.5 V	8	ditto	YES	YES	2	
OD16H	24-48 VDC	2 A	4 A	16 A	0.5 mA	1.0 V	16	ditto	YES	YES	4	DC source output
OD08H	24-48 VDC	2 A	4 A	8 A	0.5 mA	1.0 V	8	ditto	YES	YES	2	ditto

For the connections diagrams see Fig. 3.4 (d) - (h).

Fig. 3.4 (d): OD16B, OD08B.

Fig. 3.4 (e): OD16C, OD08C.

Fig. 3.4 (f): OA16D, OA08D.

Fig. 3.4 (g): OA16E, OA08E.

Fig. 3.4 (h): OD16H, OD08H.

For the specifications, refer to Table 3.4 (e) - (i).

Table 3.4 (e): DC output specifications OD16B, OD08B.

Table 3.4 (f): DC output specifications OD16C, OD08C.

Table 3.4 (g): AC output specifications OA16D, OA08D.

Table 3.4 (h): AC output specifications OA16E, OA08E.

Table 3.4 (i): DC output specifications OD16H, OD08H.

Table 3.4 (e) DC output specifications

Item \ Module		OD08B	OD16B
Points/module		8	16
Rated input voltage		24 - 48 VDC	
Output voltage range		50 VDC or less (Note 1)	
Max. output current	Per output	0.5 A	
	Per common	2 A	
	Total	4 A	8 A
Surge-on current		—	
Output voltage drop at ON		1 V max. (Note 6)	
Current leakage at OFF		0.1 mA max.	
Response time (Note 2)	OFF → ON	0.3 ms max. (resistance load)	
	ON → OFF	0.3 ms max. (resistance load)	
Operation display		LED lights when output is ON	
External connection method		Terminal board (M3)	
Common points (Note 3)		1 common per 4 points input	
Fuse (Note 4)		3.2 A/common	
Polarity		Exists (the common is the "-" side)	
Dielectric strength		1 minute under 1000 VAC	

Note 1) There is no lower limit in output voltage for the output operation, but the operation display LED of the modules with operation display will dim if the output voltage is 24 VDC or less.

Note 2) Response time shown here is the delay time from module input to output. The actual response time is this value plus the scanning time which is different for each system configuration.

Note 3) The commons are mutually connected to the modules, but the load current cannot be sent in the internal pattern. The common must always be connected to the minus side (0 V) of the load current.

Note 4) Fuses are inserted in each common. The red LED at the bottom of the module front will light if any of the fuses break.

Note 5) When connecting inductive loads (like relays) to the output, always connect a diode across the load. When connecting a lamp load, insert dimmer resistors across the output terminals to decrease current flow to within the standard limit.

Note 6) Output voltage drop at ON depends on the load current and is expressed as follows: $V_{sat} = 2 \times I_l$ (V_{sat} : Output voltage drop, I_l : load current)

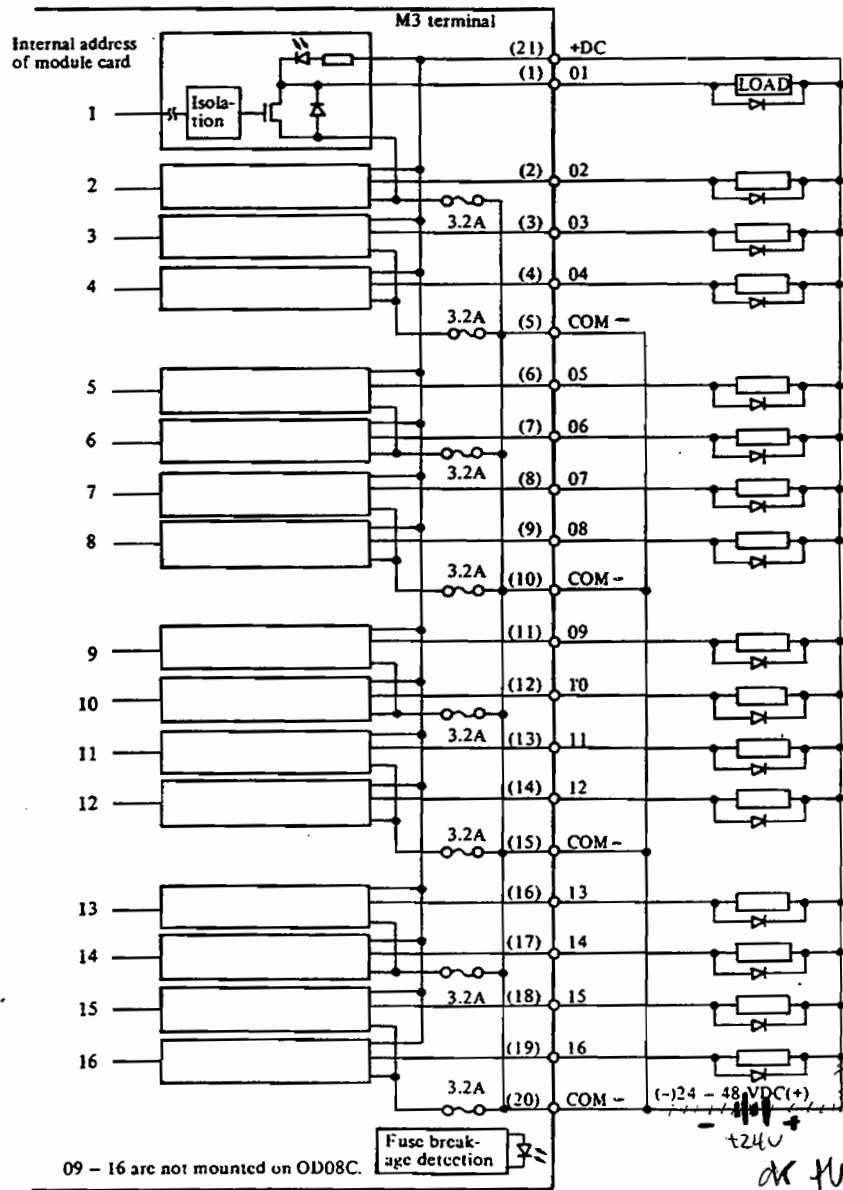


Fig. 3.4 (e) DO module OD16C, OD08C

Table 3.4 (f) DC output specifications

Item \ Module		OD08C	OD16C
Points/module		8	16
Rated input voltage		24 - 48 VDC	
Output voltage range		50 VDC or less (Note 1)	
Max. output current	Per output	2 A	
	Per common	4 A (Note 5)	
	Total	8 A	16 A
Surge-on current		—	
Output voltage drop at ON		1.0 V max. (Note 7)	
Current leakage at OFF		0.5 mA max.	
Response time (Note 2)	OFF → ON	0.4 ms max. (resistance load)	
	ON → OFF	0.4 ms max. (resistance load)	
Operation display		LED lights when output is ON	
External connection method		Terminal board connectors (M3)	
Common points (Note 3)		1 common per 4 points output	
Fuse (Note 4)		3.2 A x 2/common	
Polarity		Exists (the common is the "-" side)	
Dielectric strength		1 minute under 1000 VAC	

Note 1) There is no lower limit in output voltage for the output operation, but the operation display LED will dim if the output voltage is 24 VDC or less.

Note 2) Response time shown here is the delay time from module input to output. The actual response time is this value plus the scanning time which is different for each system configuration.

Note 3) The commons are mutually connected to the modules, but the load current cannot be sent in the internal pattern. The common must always be connected to the minus side (0 V) of the load current.

Note 4) A fuse is inserted between the following two points of outputs.
(00,01) (02,03) (04,05) (06,07)
(10,11) (12,13) (14,15) (16,17)

Note 5) The output current is limited to 2 A per fuse (group of two points).

Note 6) When connecting inductive loads (like relays) to the output, always connect a diode across the load. When connecting a lamp load, insert dimmer resistors across the output terminals to decrease current flow to within the standard limit.

Note 7) Output voltage drop at ON depends on the load current and is expressed as follows: $V_{sat} = 2 \times I_l$ (V_{sat} : Output voltage drop, I_l : load current)

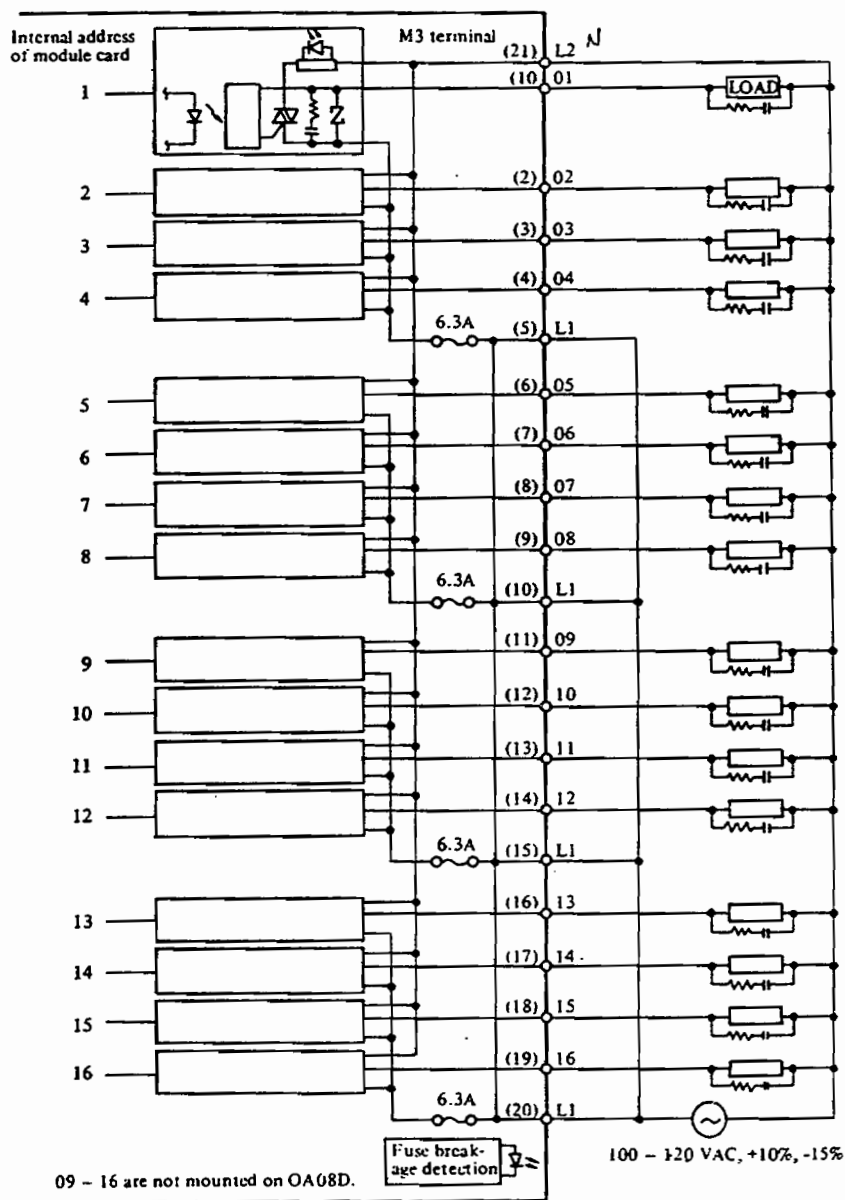


Fig. 3.4 (f) DO module OA16D, OA08D

Table 3.4 (g) AC output specifications (100 VAC type)

Item \ Module		OA08D	OA16D
Points/module		8 outputs	16 outputs
Rated input voltage		100 - 120 VAC, 50/60 Hz	
Output voltage range		85 - 132 VAC	
Max. output current	Per output	1.6 A	
	Per common	3.2 A (Note 5)	
	Total	6.4 A	12.8 A
Surge-on current		10 A (1 cycle) (Note 6)	
Output voltage drop at ON		1.5 V max. (peak)	
Current leakage at OFF		1.5 mA max.	
Response time (Note 1)	OFF → ON	0.2 ms max.	
	ON → OFF	1/2 ms max.	
Operation display		LED lights when output is turned on	
External connection system		Terminal board connectors (M3)	
No. of common points (Note 2)		1 common/4 outputs	
Fuse (Note 3)		6.3 A/common	
Polarity		None	
Dielectric strength		1 minute under 1500 VAC	

Note 1) The response time shows a delay time from an input to an output of the module. Actual response time is obtained by adding the scan time determined by the system configuration to the value shown in the above table.

Note 2) The common lines are interconnected inside the module. However, no load current is applicable to internal patterns. Always connect each common to one end of the load power supply.

Note 3) A fuse is inserted in every common line. If one of these fuses is blown the red LED lights at the bottom part of the front panel of the module.

Note 4) Mount a surge suppressor across the load if an inductive load like a relay is connected to the output. When connecting a lamp load insert a dimmer resistor across output terminals to reduce the rush current. Use the lamp load within the specified value.

Note 5) In addition to the above limitation, the output current is limited to 1.6 A for every 2-output group shown below.

(00,01) (02,03) (04,05) (06,07)

(10,11) (12,13) (14,15) (16,17)

For example, no load current can be fed to output "01", while a 1.6 A load current is being fed to output "00".

Note 6) Surge-on current means the maximum surge current which can be sent to one fuse. When two loads or more are ON simultaneously, the total value of the surge current which is set to one fuse must be within the above value.

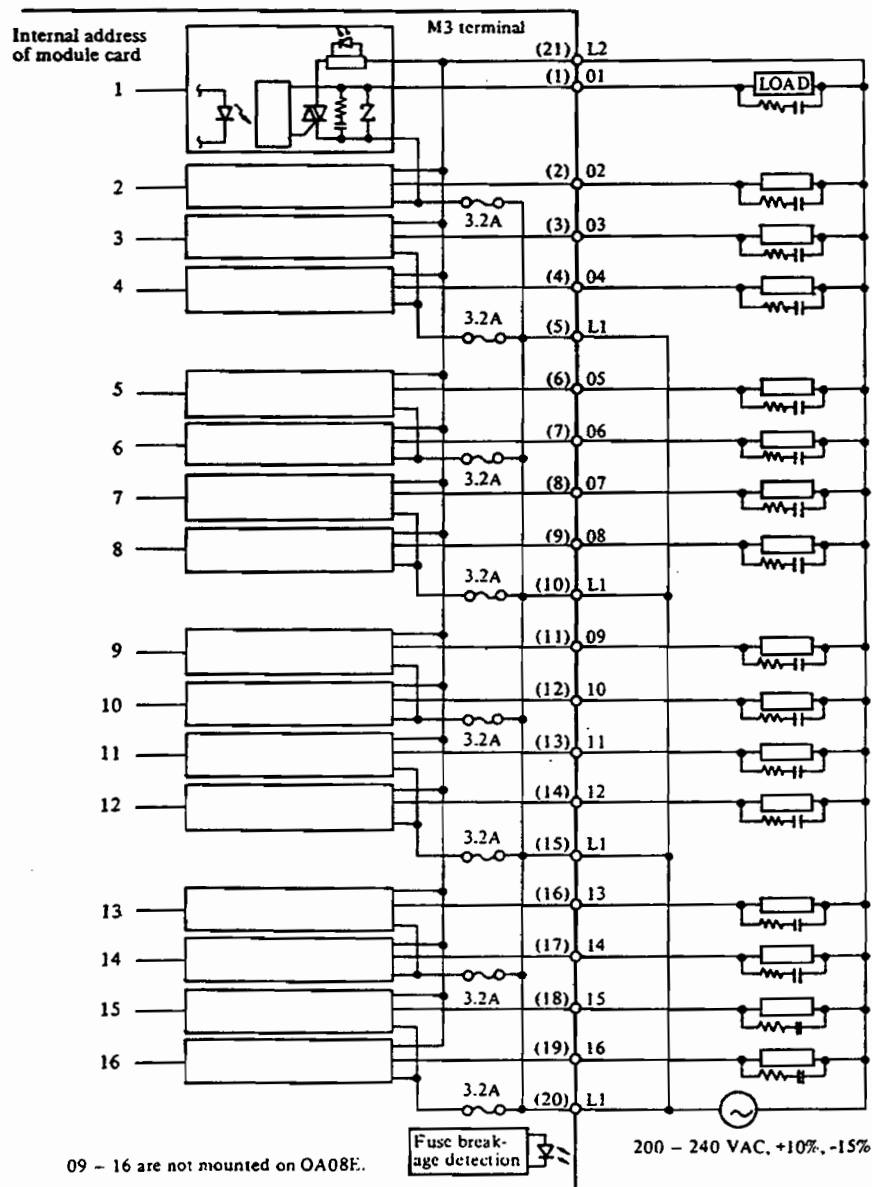


Fig. 3.4 (g) DO module OA16E, OA08E

Table 3.4 (h) AC output specifications (200 VAC type)

Item \ Module		OA08E	OA16E
Points/module		8	16
Rated input voltage		200 - 240 VAC, 50/60 Hz	
Output voltage range		160 - 264 VAC	
Max. output current	Per output	1.6 A	
	Per common	3.2 A (Note 5)	
	Total	6.4 A	12.8 A
Surge-on current		10 A (1 cycle) (Note 6)	
Output voltage drop at ON		1.5 V max. (peak)	
Leak current at OFF		3 mA max.	
Response time (Note 1)	OFF → ON	0.2 ms max.	
	ON → OFF	1/2 cycle max.	
Operation display		LED lights when output is turned on	
External connection system		Terminal board connectors (M3)	
No. of common outputs (Note 2)		1 common/4 outputs	
Fuse (Note 3)		3.2 A x 2 pcs/common	
Polarity		None	
Dielectric strength		1 minute under 1500 VAC	

Note 1) The response time shows a delay time from an input to an output of the module. Actual response time is obtained by adding the scan time determined by the system configuration to the value shown in the above table.

Note 2) The common lines are interconnected inside the module. However, no load current is applicable to internal patterns. Always connect each common to one end of the load power supply.

Note 3) Two fuses are inserted in every common line. One red LED is mounted for every two fuses. A corresponding LED lights, if a fuse is blown.

Note 4) Mount a surge suppressor across the load, if an inductive load like a relay is connected to the output. When connecting a lamp load insert a dimmer resistor across output terminals to reduce the rush current. Use the lamp load within the specified value.

Table 3.4 (i) DC output specifications

Module		OD08H	OD16H
Item			
Points/module		8	16
Rated input voltage		24 - 48 VDC	
Output voltage range		50 VDC or less (Note 1)	
Max. output current	Per output	2 A	
	Per common	4 A (Note 5)	
	Total	8 A	16 A
Surge-on current		--	
Output voltage drop at ON		1.0 V max. (Note 7)	
Current leakage at OFF		0.5 mA max.	
Response time (Note 2)	OFF → ON	0.4 ms max. (resistance load)	
	ON → OFF	0.4 ms max. (resistance load)	
Operation display		LED lights when output is ON	
External connection method		Terminal board connectors (M3)	
Common points (Note 3)		1 common per 4 points output	
Fuse (Note 4)		3.2 A x 2/common	
Polarity		Exists (the common is the "-" side)	
Dielectric strength		1 minute under 1000 VAC	

Note 1) There is no lower limit in output voltage for the output operation, but the operation display LED will dim if the output voltage is 24 VDC or less.

Note 2) The response time shown here is the delay time from module input to output. The actual response time is this value plus the scanning time which is different for each system configuration.

Note 3) The commons are not connected to each other in the module. Each common must always be connected to the minus side (0 V) of the load current.

Note 4) A fuse is inserted between the following two points of outputs.

(00,01) (02,03) (04,05) (06,07)

(10,11) (12,13) (14,15) (16,17)

The red LED at the bottom of the module front will light if any of the fuses break.

Note 5) The output current is limited to 2 A per fuse (group of two points).

Note 6) When connecting inductive Loads (like relays) to the output, always connect a diode across the load. When connecting a lamp load, insert dimmer resistors across the output terminals to decrease current flow to within the standard limit.

Note 7) Output voltage drop at ON depends on the load current and is expressed as follows: $V_{sat} = 0.5 \times I_L$ (V_{sat} : Output voltage drop, I_L : Load current)

Table 3.4 (j) Analog input module

Module name	Input points	Analog inputs	Resolution	Accuracy	Max input voltage/current	External connection
AD04A	4 points/module	-10 - +10 VDC (Input resistor 1 M Ω) -20 - +20 mADC (Input resistor 250 Ω) can be selected.	5 mV 20 μ A	+0.5% or less	+15 V +40 mA	Terminal block (M3)

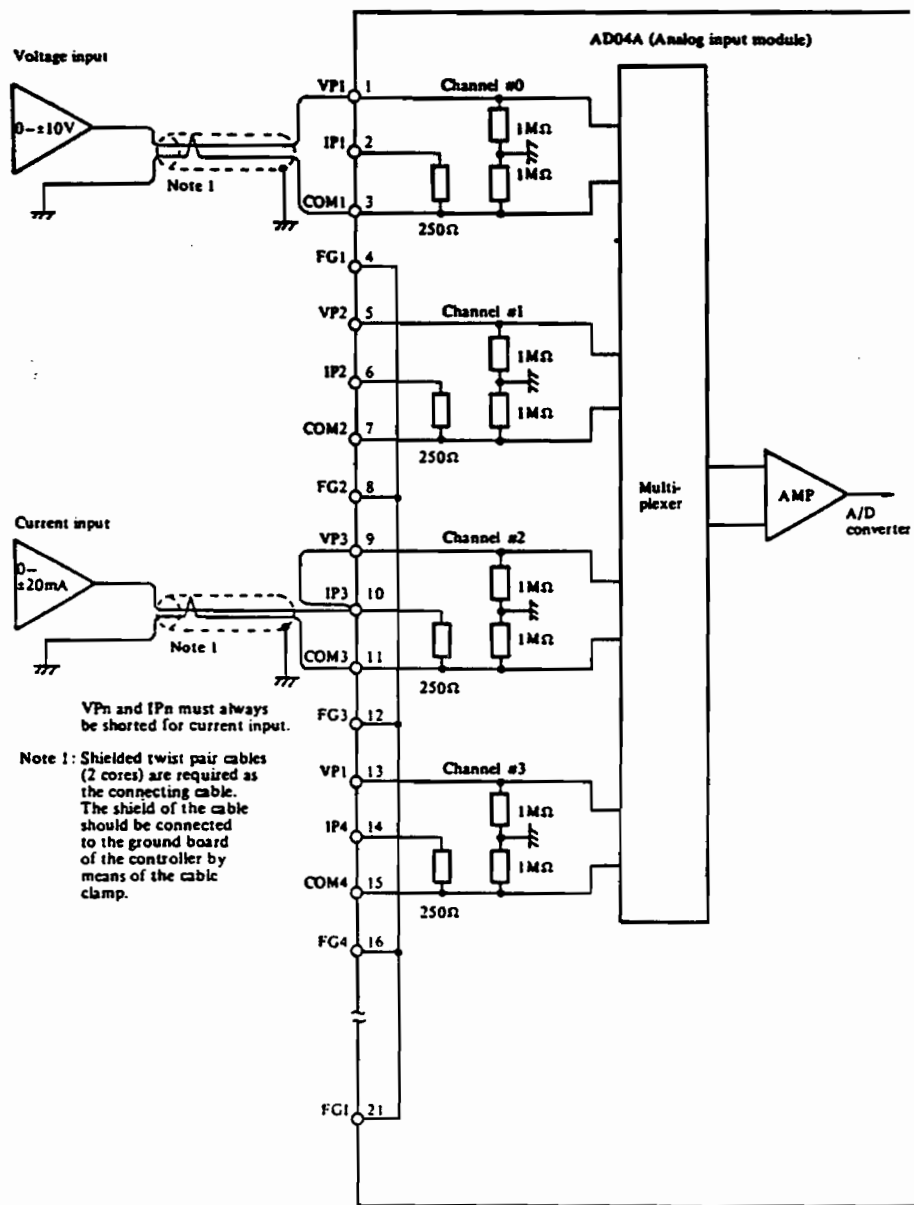


Fig. 3.4 (i) Analog input module connection

Table 3.4 (k) Analog input module

Module name	Output points	Analog outputs	Resolution overall accuracy	Isolated	External connection
DA02A	2 points/module	-10 - +10 VDC (External load resistance more than 1 K Ω) 0 - +20 mA DC (External load resistance 0 - 500 Ω) can be selected.	5 mV } within 20 μ A } 0.5%	Not isolated	Terminal board (M3)

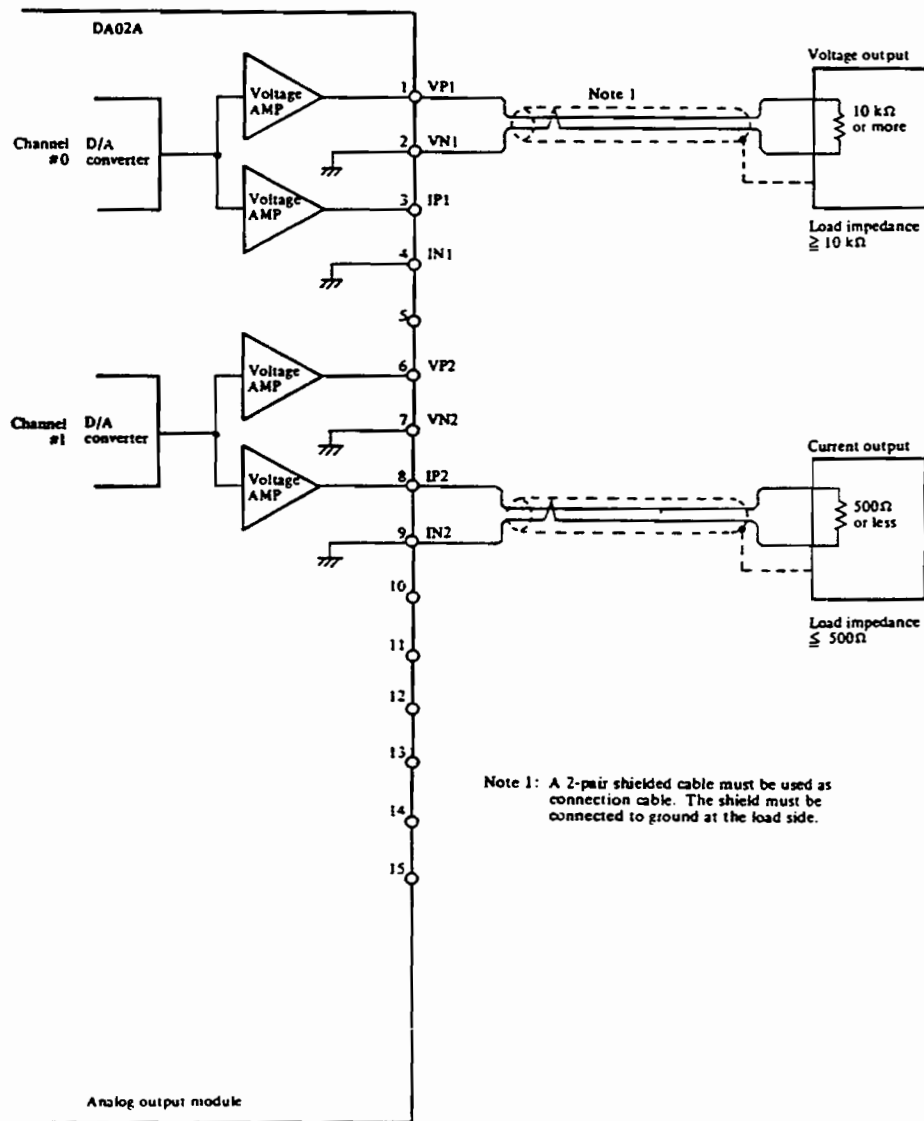


Fig 3.4 (j) Analog output module connection

4. S-10 MECHANICAL UNIT

4.1 Connection between Controller and Mechanical Unit

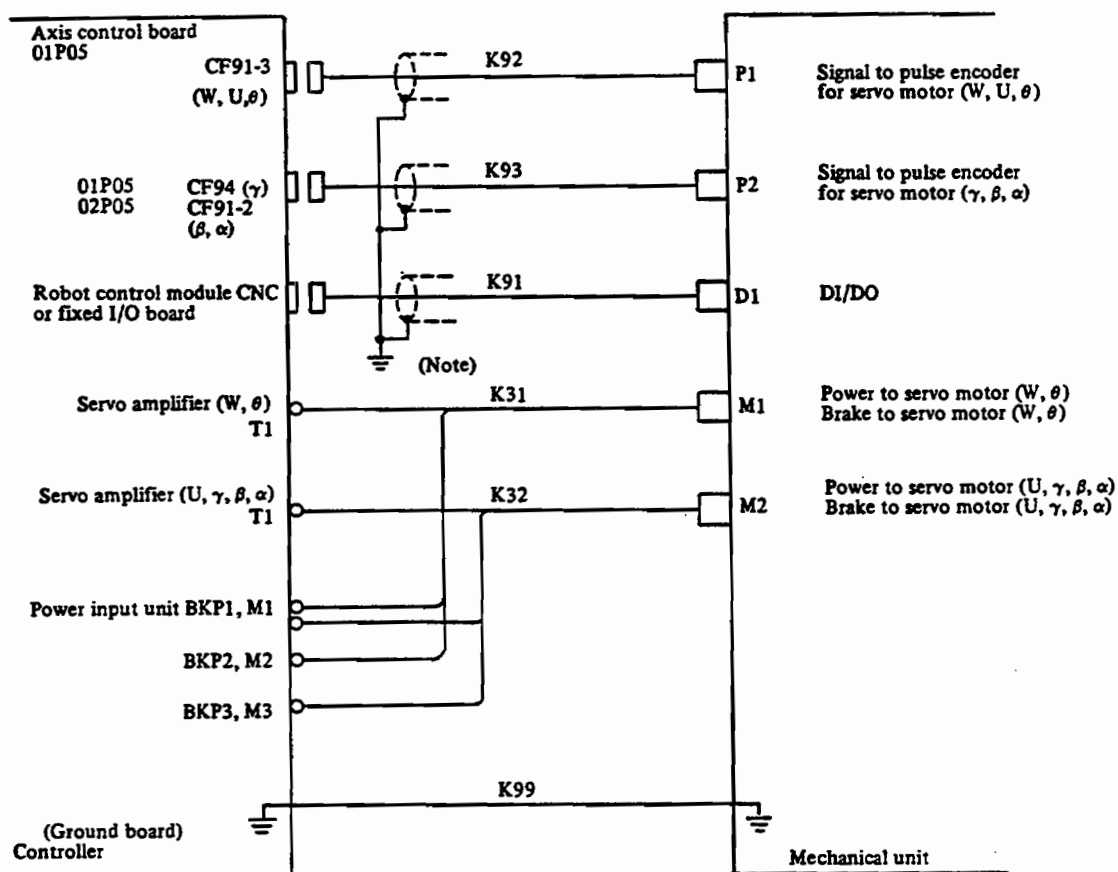


Fig. 4.1 (a) Interconnection between the controller and the S-10 mechanical unit by means of robot connection cables

Note) The shield of the cable should be connected to the ground board of the controller by means of a cable clamp.

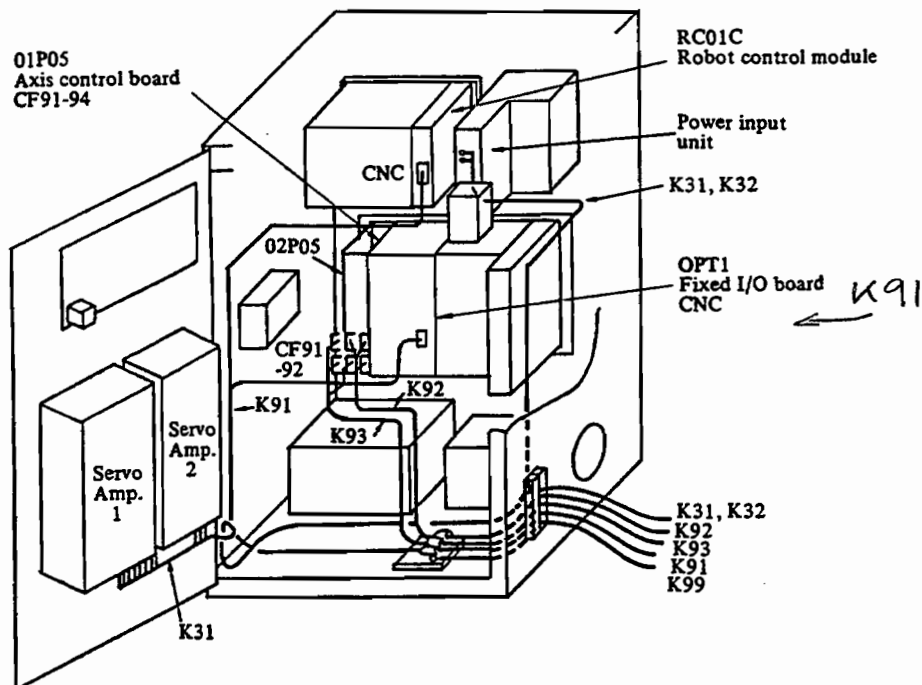


Fig. 4.1 (c) Connection diagram for the robot connection cables (S-10, medium size cabinet)

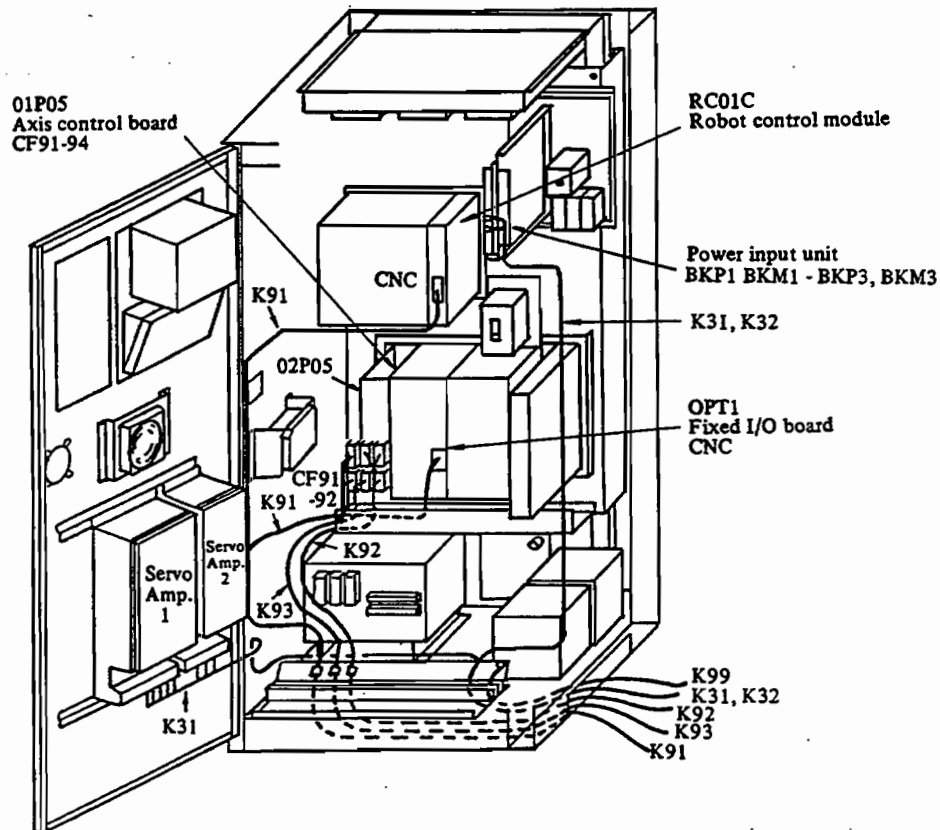
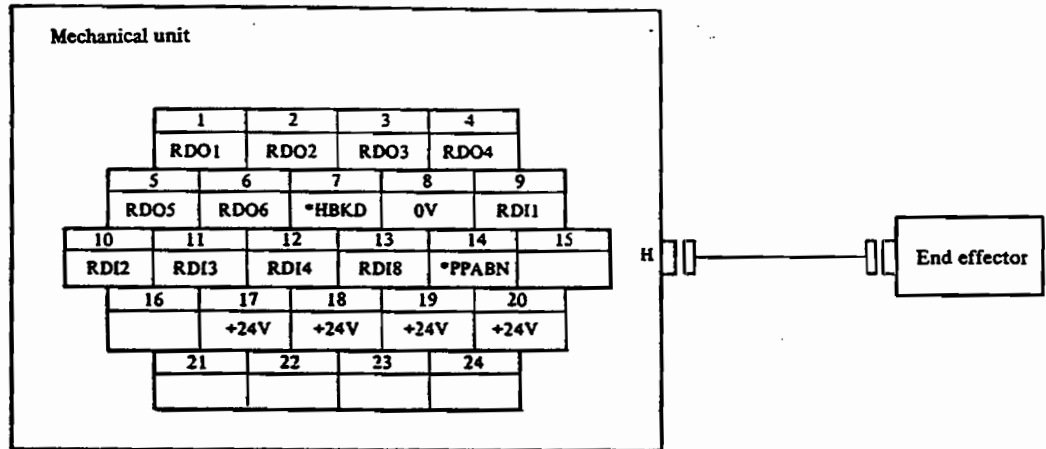


Fig. 4.1 (d) Connection diagram for the robot connection cables (S-10, large size cabinet)

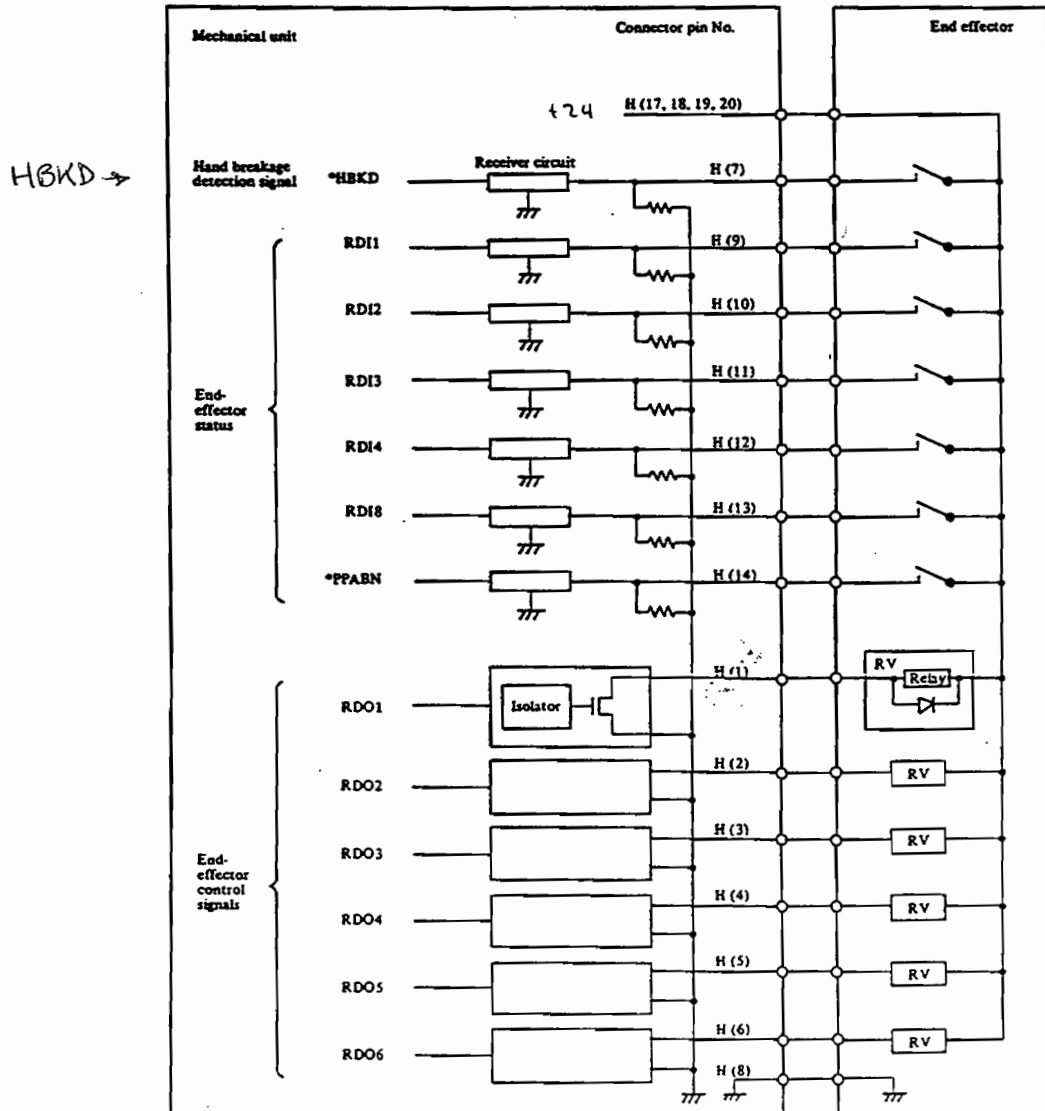
Note) Cable K91 is connected to the robot control module for modular I/O or to the fixed I/O board for fixed I/O.

4.2 Connections and Signals between Mechanical Unit and End Effector

4.2.1 Connections



Note) Connecting cables are customer provided.



4.2.2 DI/DO standards for end effector control interface

Table 4.2.2 (a) DO signal standards

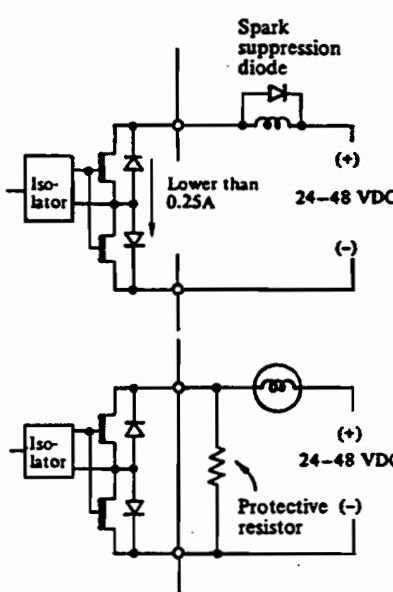
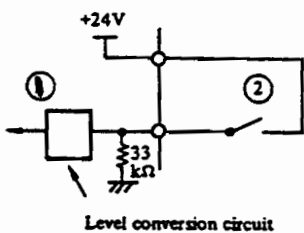
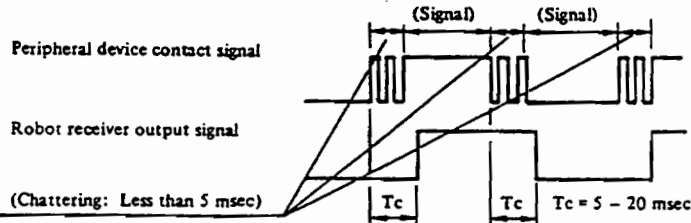
DI/DO	Type	Connection type	Signal standards	Signal
DO	Non-polarity non-contact DC output	<p>[Robot side]</p>  <p>When using a +24 VDC output signal, the robot side +24 V power source can be used within +24 VDC +7%, 0.7 A. This power source is required for driving the small solenoid valve in the end effector or other devices, within the capacity of the power supply.</p> <p><u>Spark suppression diode</u> Rated peak inverse voltage Greater than 100 VDC Rated effective forward current ... Greater than 1 A If a relay or solenoid is directly connected as a load, connect a spark suppression diode parallel with the load.</p> <p><u>Protective resistor</u> When a lamp is used, connect a dimmer resistor to prevent a rush current when it is turned on.</p>	<p>Rated voltage: 24 - 48 VDC Output voltage range: 50 VDC or less Max. output current: 0.25 A Output voltage drop at ON: 1.5 V max. Current leakage at OFF: 0.1 mA max. Response time: 0.2 ms max.</p>	RD01 - RD06

Table 4.2.2 (b) DI signal standards

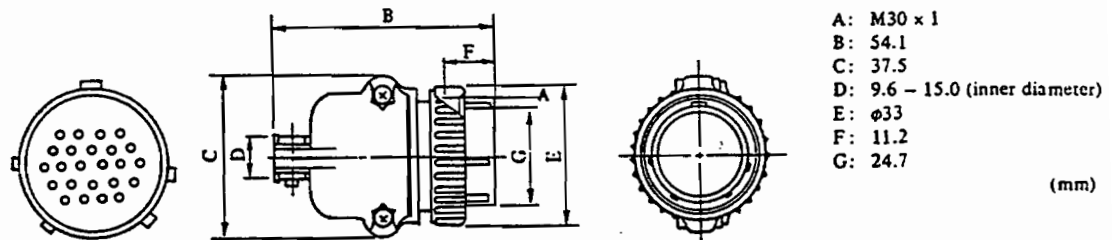
DI/DO	Type	Connection type	Signal standards	Signal
DI	Receiver contact input	<p>[Robot side]</p>  <p>Level conversion circuit</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p>use +24 V from the robot as an input voltage.</p> </div>	<p>① Digital input signal standards</p> <p>Type: Grounding type voltage receiver Rated input voltage: +20 - 28 VDC (logic "1" closed) 0 - +4 V (logic "0" open) Max. input voltage: +28 VDC Input impedance: Approx. 3.3 kΩ Response time: 5 - 20 msec</p> <p>② End effector side contact standards</p> <p>Rated contact capacity: 30 VDC, 16 A or over Chattering time: Shorter than 5 msec Closed circuit resistance: Less than 100 Ω Open circuit resistance: Greater than 100 kΩ</p>	<p>RD01 - RDI8 *PPABN *HBKD</p>



4.2.3 End effector control interface cable

1) Cable connector specifications

The wrist connector shown in Fig. 4.2.3 is attached to the end effector interface.



JMSP2524M (made by Daiichi Denshi Kogyo Co.)

Fig. 4.2.3 Specification of wrist connector

2) Wire specification for the recommended cable

Table 4.2.3 shows an example of recommended wires unshielded cabtyre cable using ETFE (ethylene-tetrafluoroethylene) as an insulator, conforming to the specifications shown in this table.

The cable should be long enough to allow the wrist to operate over its full range without interfering with the end effector.

Table 4.2.3 Cables

Specifications		A66L-0001-0143	A66L-0001-0144
No. of cores		6 cores	20 cores
Conductors	Diameter	ø1.1 mm	ø1.1 mm
	No. and types	40/0.08	40/0.08
Thickness of sheath		1 mm	1 mm
Outer diameter		ø5.3 mm	ø8.6 mm
Conductor resistance		91 Ω/km	91 Ω/km
Allowable current		3.7 A	2.3 A

4.2.4 Noise suppressors

All relays, solenoids, and motors to be used in a machine or on peripheral devices connected to the controller unit must be provided with noise suppressors. These suppressors are used also to protect the relay contacts. Fig. 4.2.4 (a) shows examples of noise suppressors.

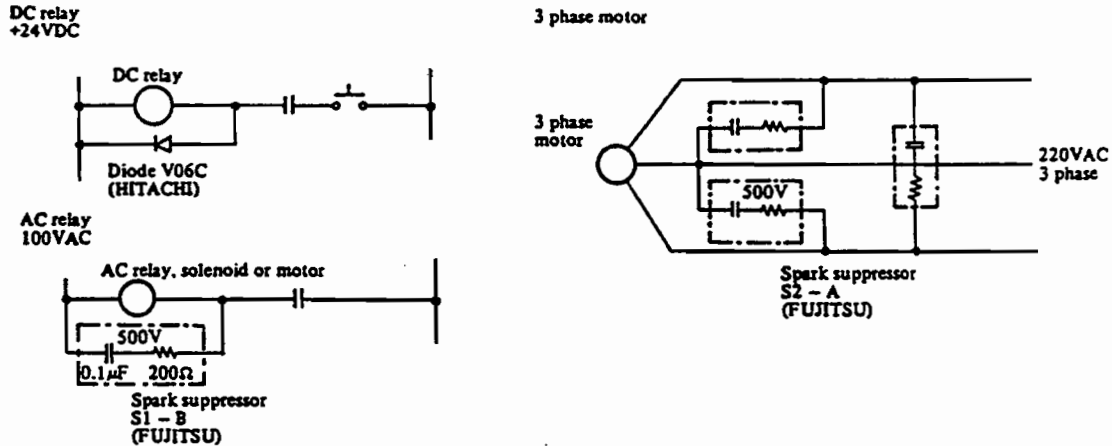
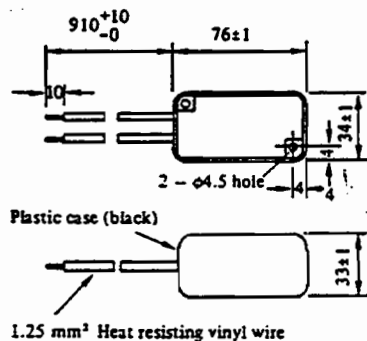


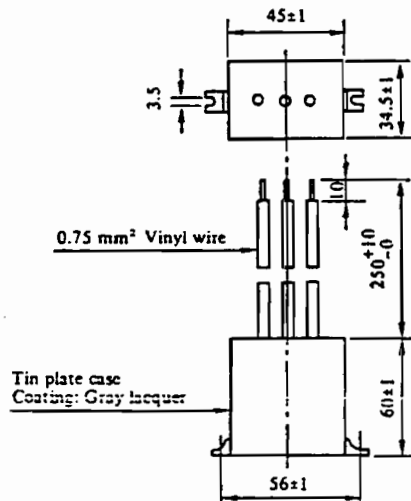
Fig. 4.2.4 (a) Noise suppressor examples

1) Dimensions and specifications for DCR2-50D100B



Capacitance	Tolerance	Rated voltage	Resistor
0.5μF	±10%	1000VDC	220Ω ±10% 2W

2) Dimensions and specifications for DCR4-60A55



Capacitance	Tolerance	Rated voltage	Resistor
0.2μF for each of three leads	±10%	550VDC	220Ω ±10% 2W

4.3 Mechanical Interface

4.3.1 Robot motion area

Fig. 4.3.1 (a) show the external dimensions of robot. When installing peripheral devices, be careful that they do not interfere with robot motion. For installation, use the 4 - $\phi 18$ hole on the bases Fig. 4.3.1 (c) shows the robot motion area.

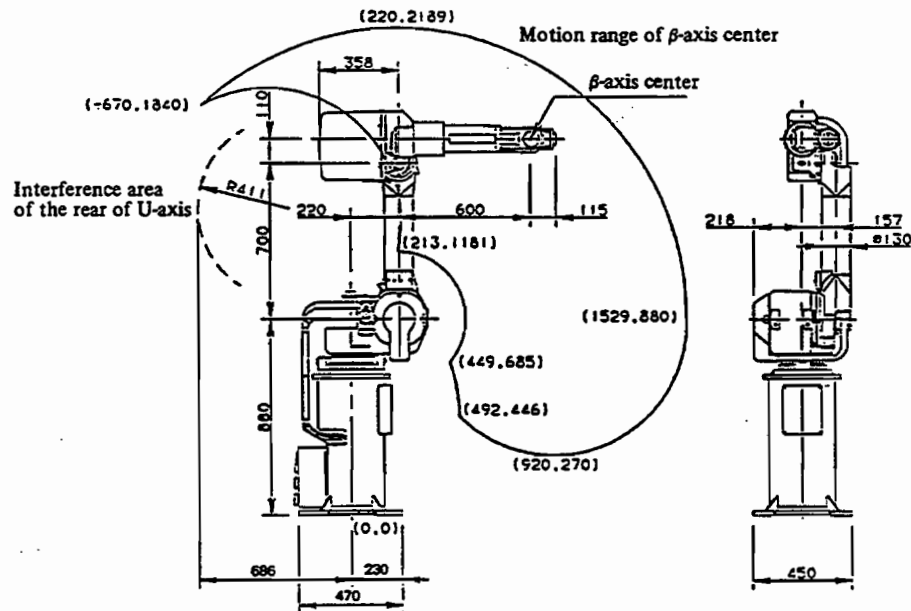


Fig. 4.3.1 (a) External dimensions mechanical unit (S-10)

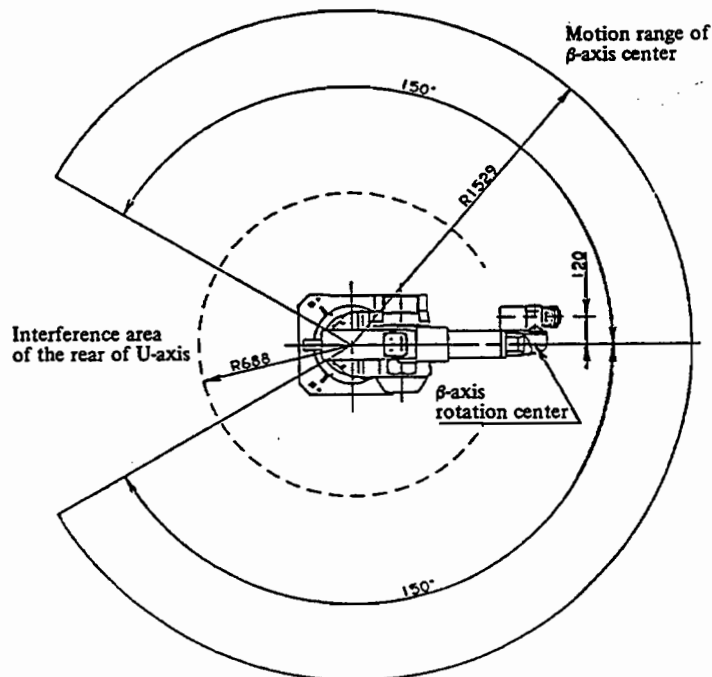


Fig. 4.3.1 (b) Robot motion area (S-10)

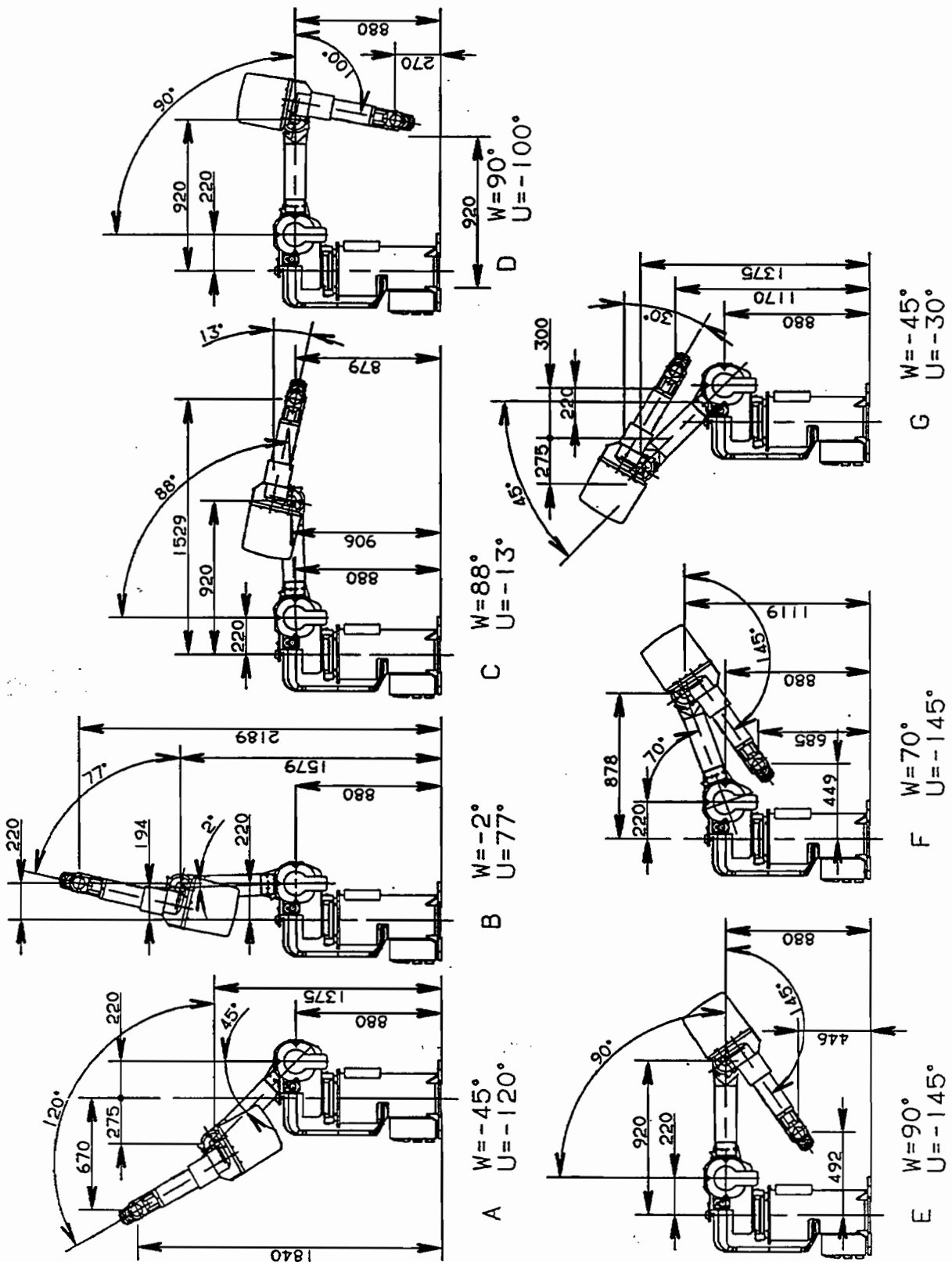
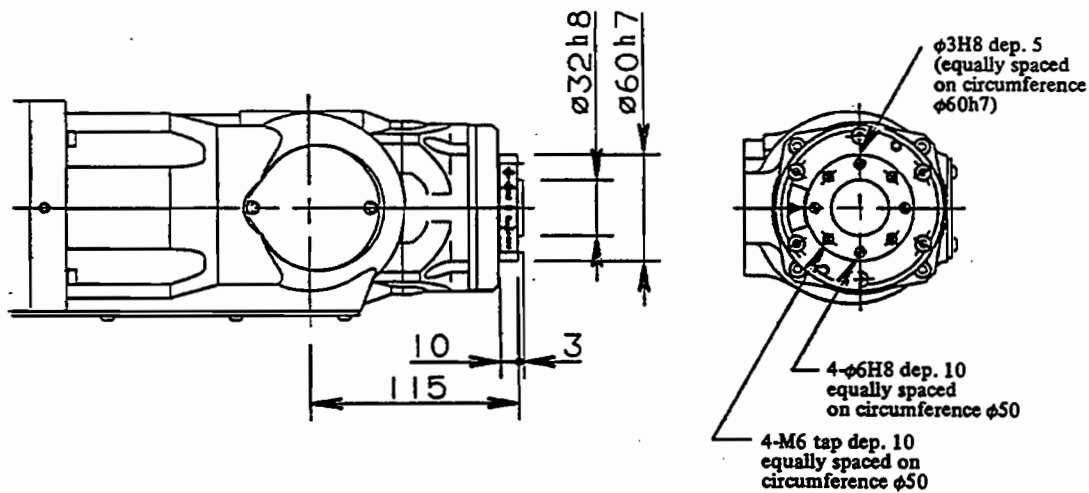


Fig. 4.3.1 (c) Operational diagram (S-10)

4.3.2 Mechanical coupling of end effector to wrist

Fig. 4.3.2 shows the end effector mounting face at the end of the wrist. Mount the end effector using the $\phi 32h8$ hole, position it using the four $\phi 6H8$ reamed holes, and bolt it with the 4-M6 tap. Select the length of the M6 bolt so that it is within the thickness of the wrist flange (10 mm).



Fgi. 4.3.2 End effector mounting face (S-10)

4.3.3 Location and dimensions of equipment mounting holes

There are three equipment mounting faces as shown in Fig. 4.3.2. Select the length of the bolt so that the threaded portion is less than 10 mm.

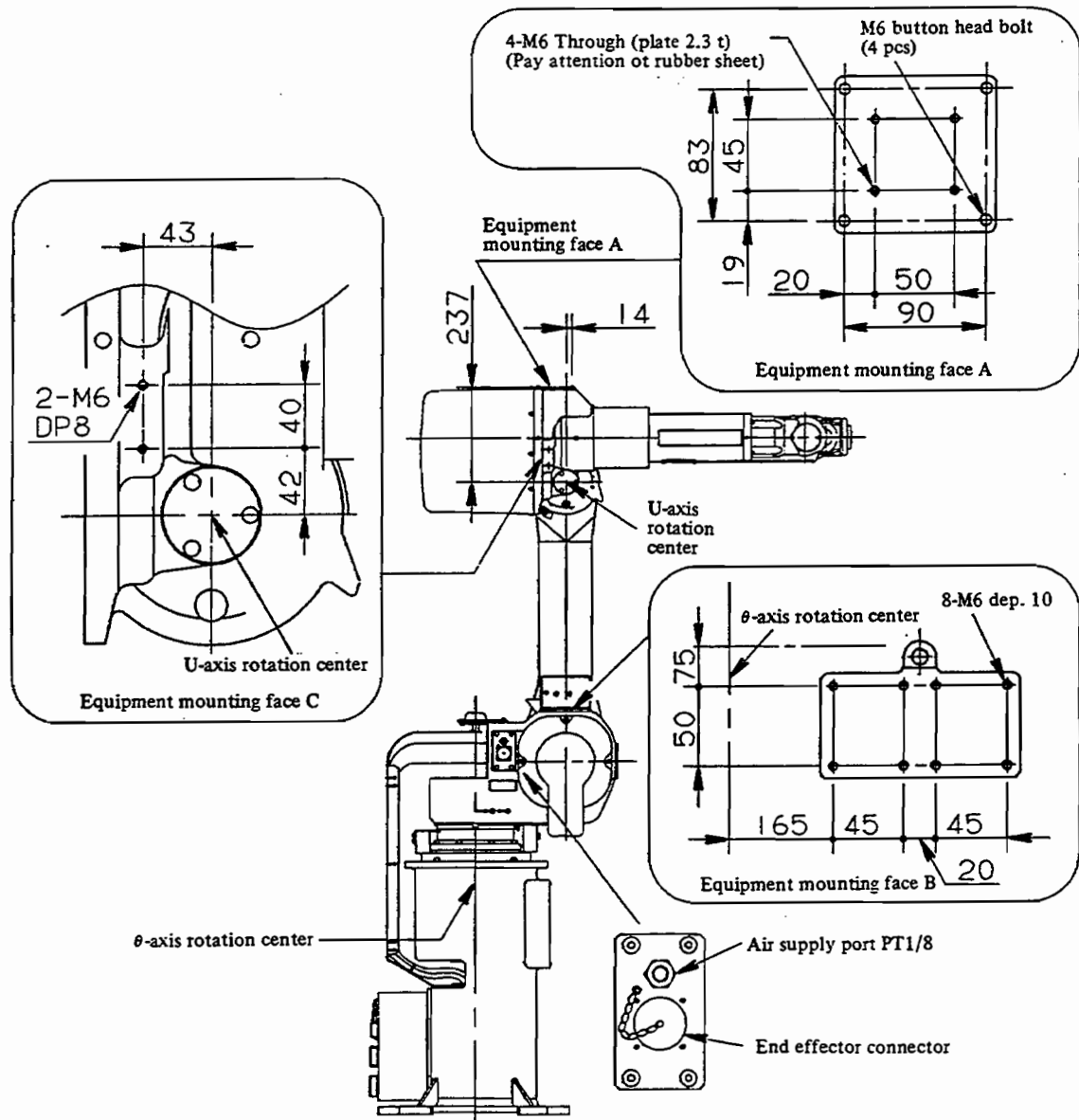


Fig. 4.3.3 Equipment mounting face (S-10)

Note 1) When mounting equipment on the mounting face, A and C should conform to the conditions of the following formula:

$$W + \frac{1}{2} (A+C) \leq 13 \text{ (kg)}$$

W: Weight of end effector at the end of the wrist (kg)

A: Weight of equipment mounted on the mounting face A (kg)

C: Weight of equipment mounted on the mounting face C (kg)

Note 2) For the equipment mounted on the mounting face B, the weight should be less than 30 kg and the θ -axis inertia should be lower than 35 kg.cm.S².

4.3.4 Air supply

An air supply port to the end effector is provided at the rear part of the W-axis base.

The aperture is female PT1/8. Since couplings are not supplied it will be necessary to prepare couplings according to the hose size (Refer to Fig. 4.3.3.)

5. S-700 MECHANICAL UNIT

5.1 Connection between Controller Unit and Mechanical Unit

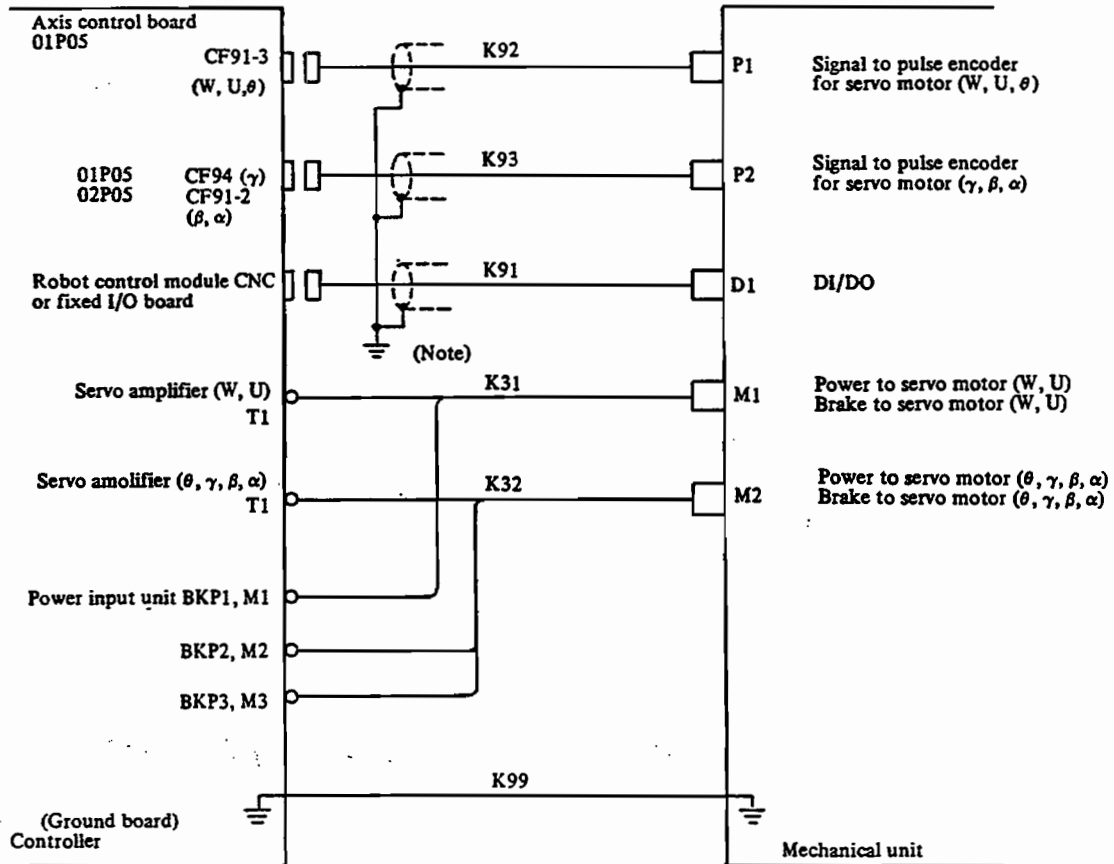
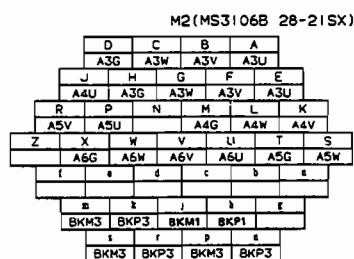
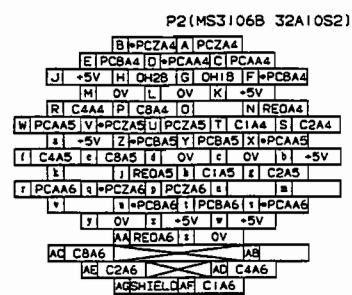
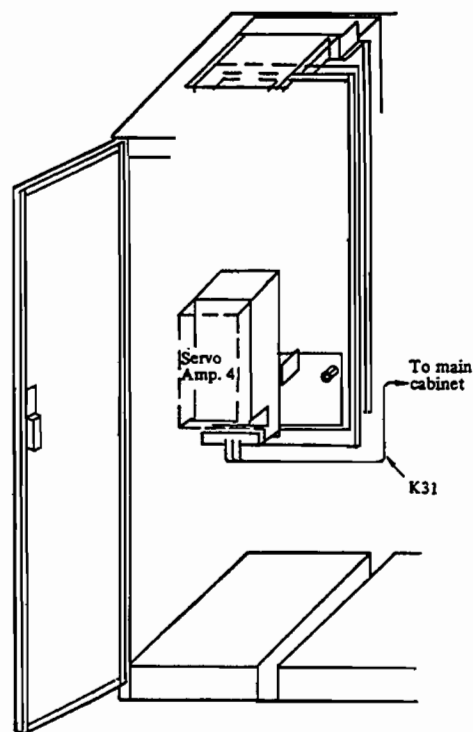
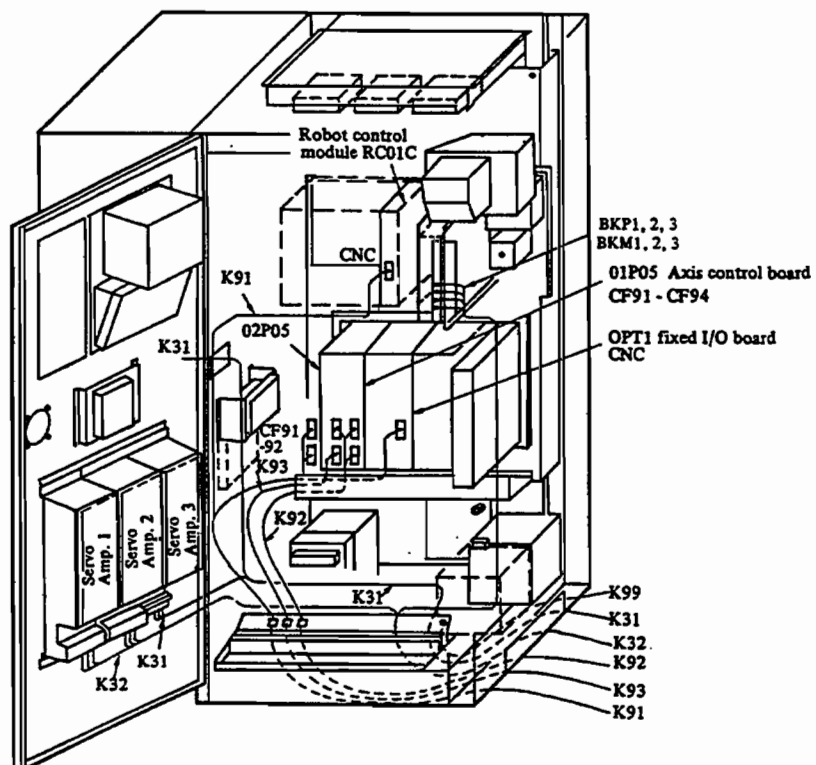


Fig. 5.1 (a) Interconnection between the controller and the S-700 mechanical unit by means of robot connection cables

Note) The shield of cable should be connected to ground board of the controller by means of cable clamp.





Note) Cable K91 is connected to the robot control module for the modular I/O or to the fixed I/O board for the fixed I/O.

Fig. 5.1 (c) Connection diagram for the robot connection cables (S-700, large size cabinet)

5.2 Connections and Signals between Mechanical Unit and End Effector

5.2.1 Connections

Refer to section 4.2.1.

5.2.2 DI/DO standards for end effector control interface

Refer to section 4.2.2.

5.2.3 End effector control interface cable

Refer to section 4.2.3.

5.2.4 Noise suppressors

Refer to section 4.2.4.

5.3 Mechanical Interface

5.3.1 Robot motion area

Fig. 5.3.1 (a), (b) show the external dimensions of the robot. When installing peripheral devices, be careful that they do not interfere with the robot motion. Four $\phi 24$ holes on the base can be used to be installation.

Fig. 5.3.1 (c), (d) show the robot motion area.

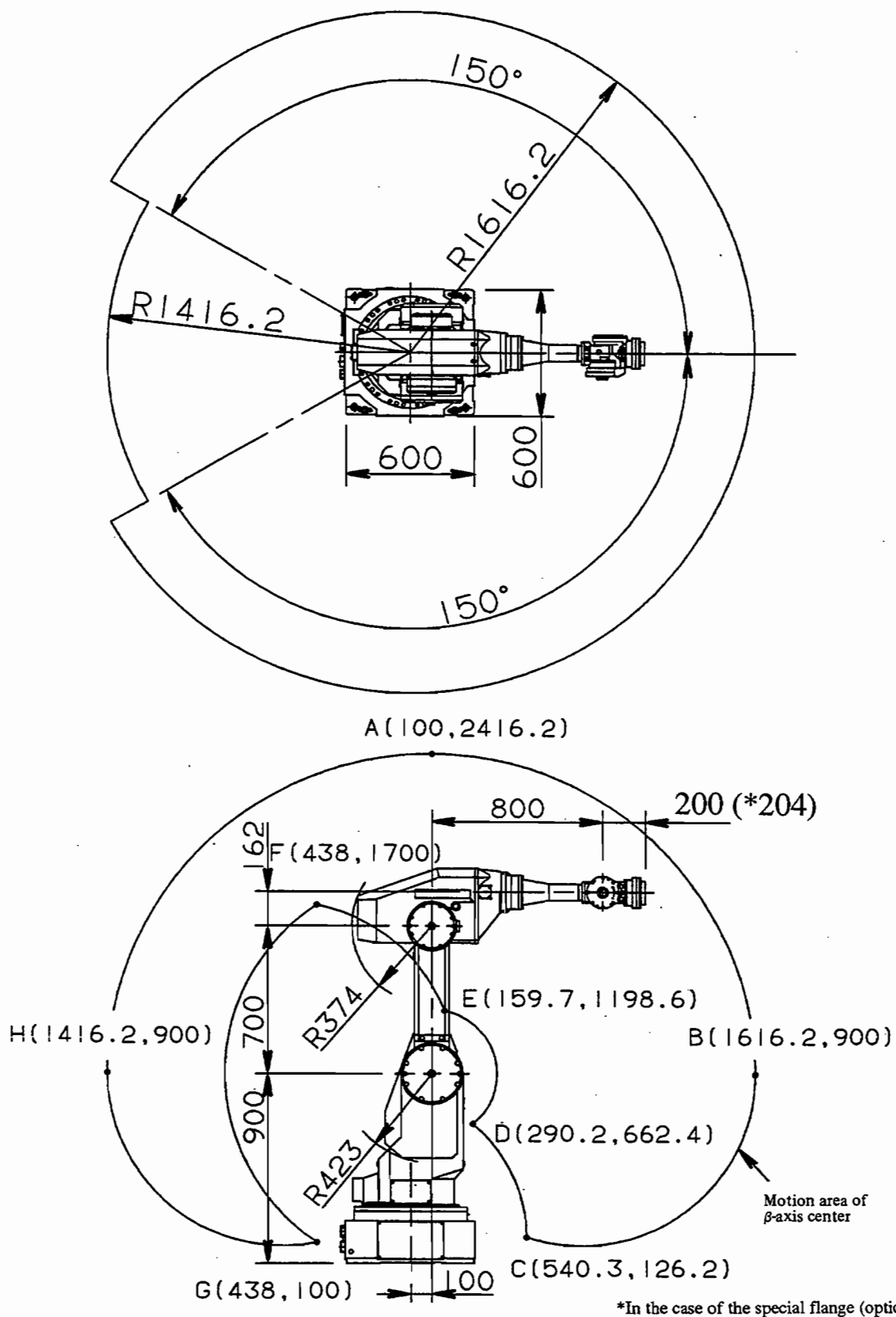


Fig. 5.3.1 (b) External dimensions of mechanical unit (S-700, in-line wrist)

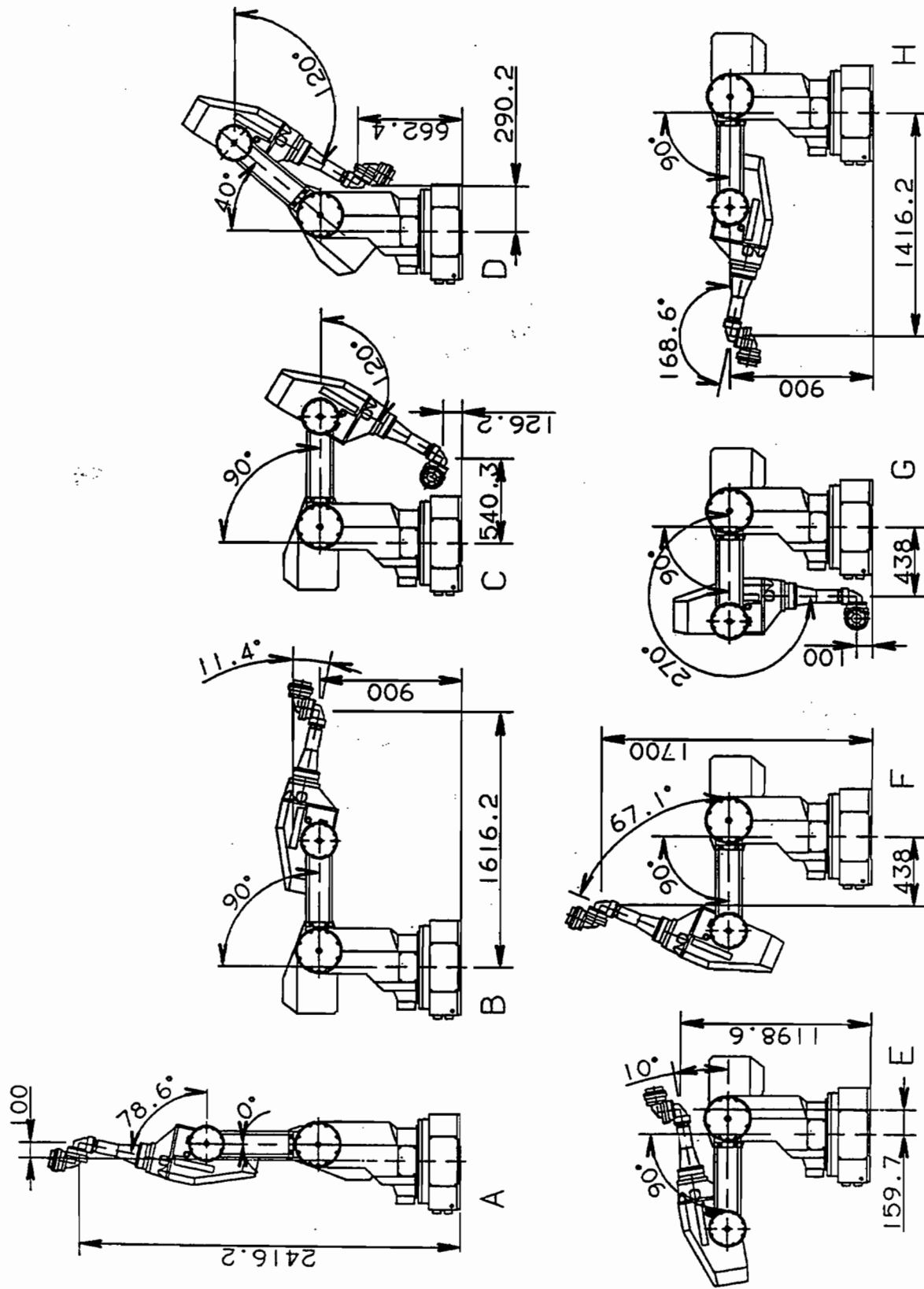


Fig. 5.3.1 (c) Operational diagram (S-700, offset wrist)

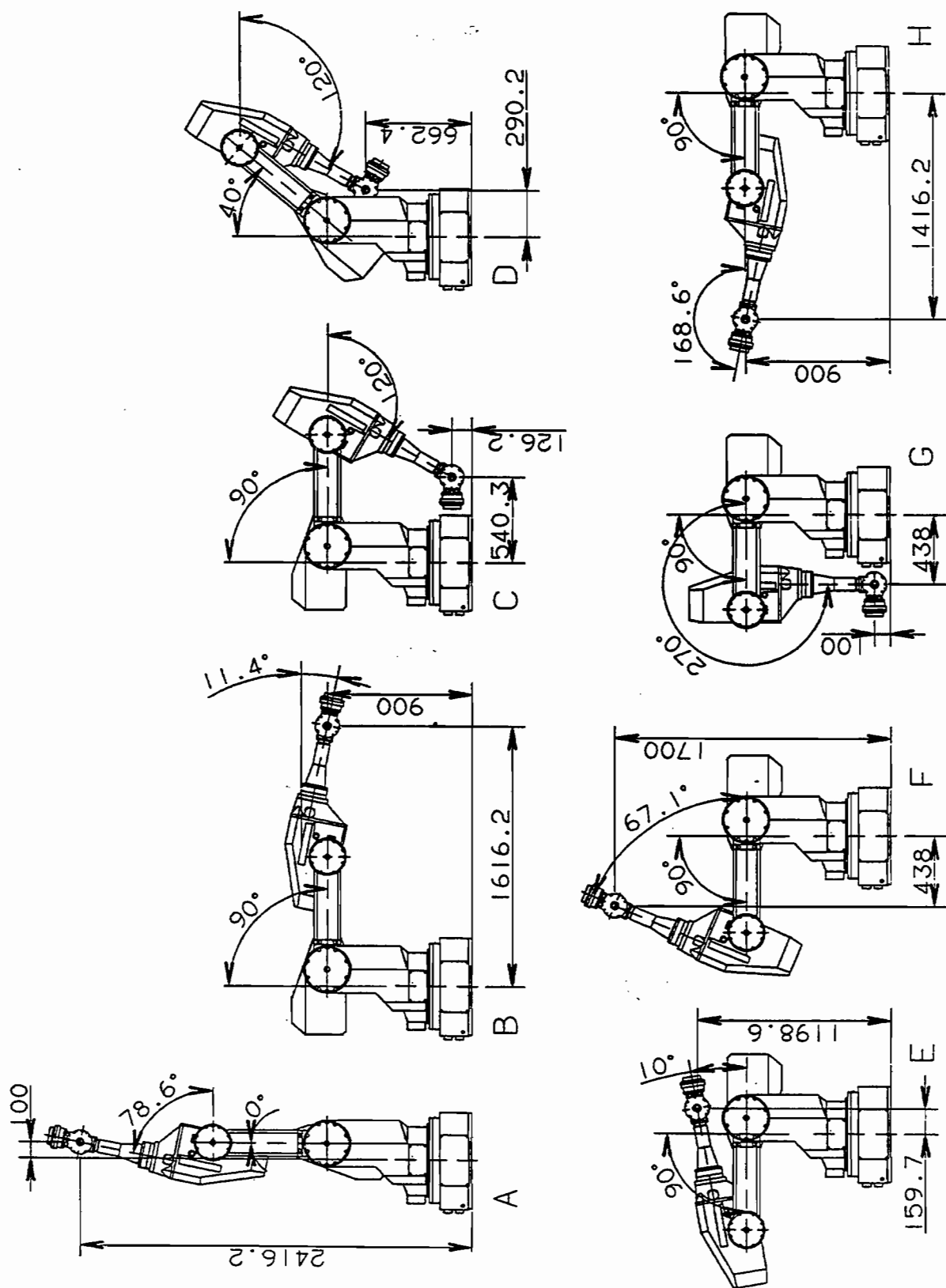


Fig. 5.3.1 (d) Operational diagram (S-700, in-line wrist)

5.3.2 Mechanical coupling of end effector to wrist

Fig. 5.3.2 shows the end effector mounting face of the wrist. Mount the end effector using the $\phi 60H7$ or $\phi 110h7$ hole. Position it by two $\phi 10H8$ reamed holes. Bolt it with the six M10 taps. Select the length of M10 bolts to be used to be within the thickness of the wrist flange (16 mm).

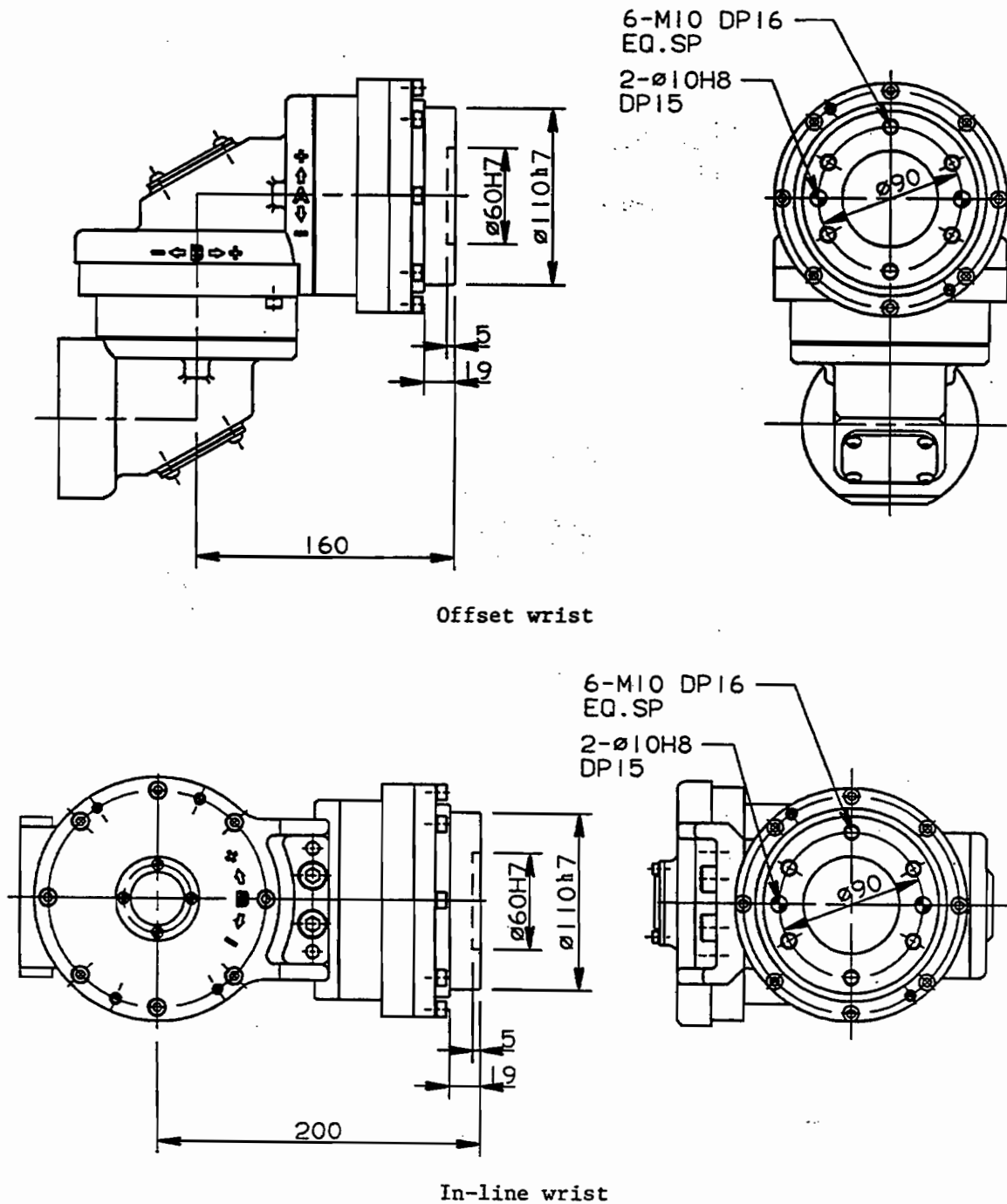


Fig. 5.3.2 End effector mounting face (S-700)

5.3.3 Location and dimensions of equipment mounting holes

Two equipment mounting faces are provided as shown in Fig. 5.3.3 (a), (b). Select the bolt length so that the threaded portion is less than 12 mm.

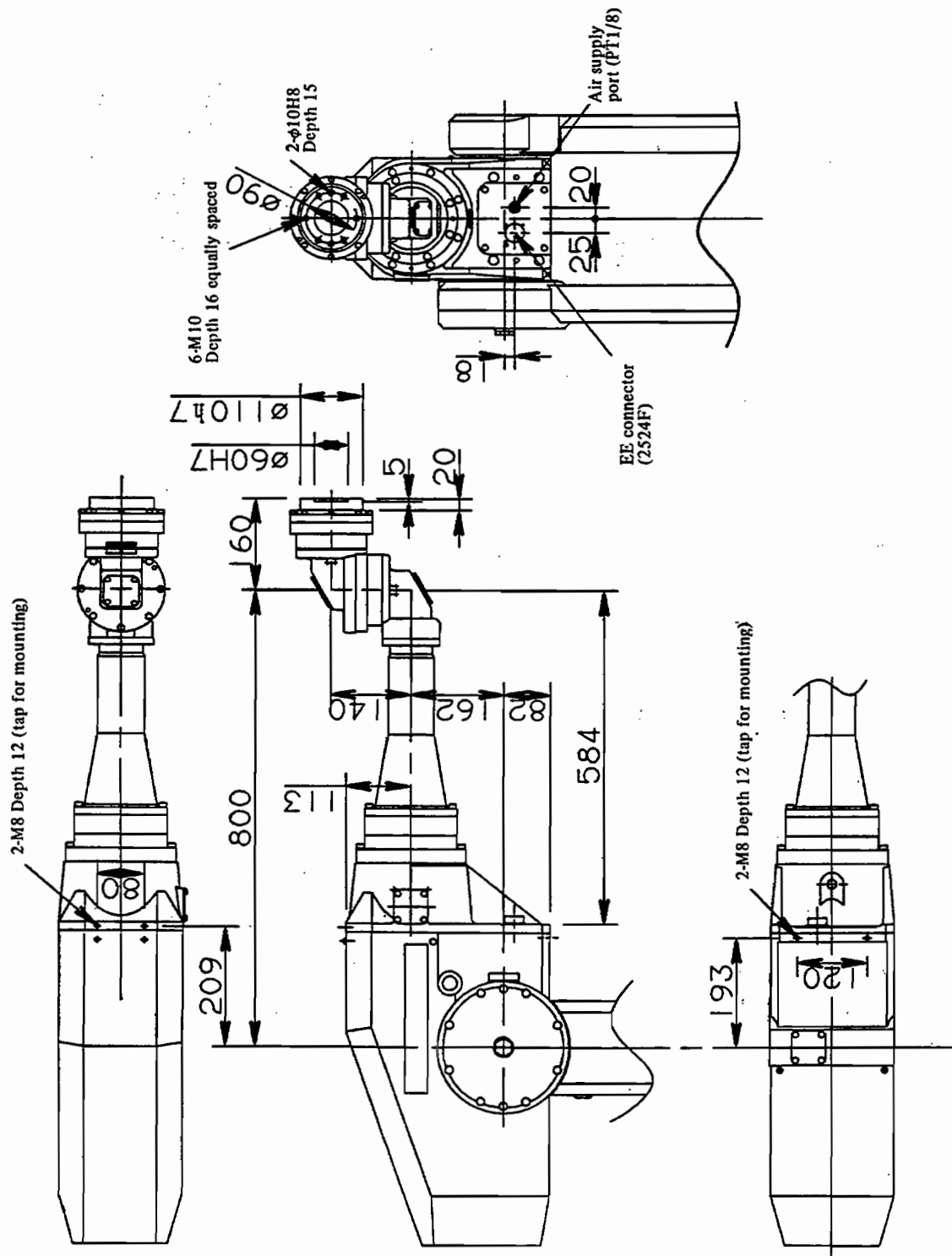
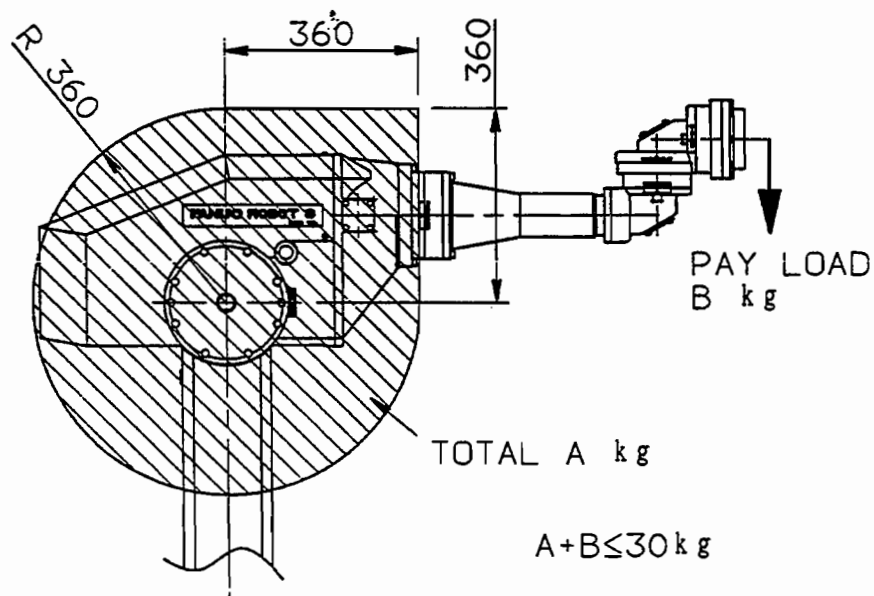
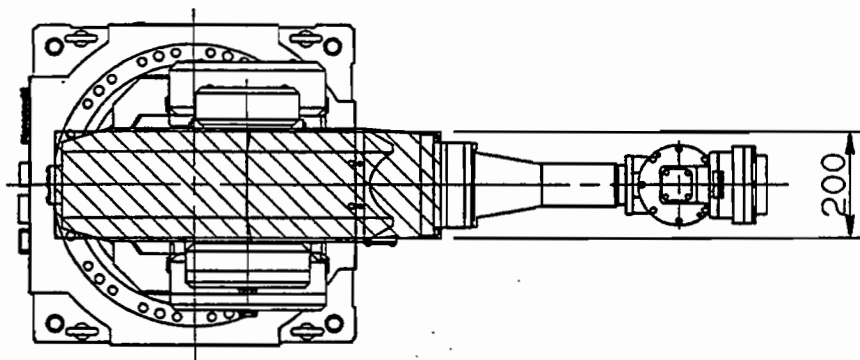


Fig. 3 (a) Equipment mounting face (S-700)



Dimensions and weight limitations for any equipment that might be mounted on the arm.

Fig. 5.3.3 (b) Dimensions and weight limitations (S-700)

5.3.4 Air supply

An air-pressure supply port on the front of the U-axis unit is used to supply air to the end effector. The aperture is a PT 1/8 female. In addition, an air-pressure supply port for the above-mentioned port is provided on the rear of the θ -axis base and the aperture is a PT 1/8 female. Since couplings are not supplied it will be necessary to prepare couplings according to the hose size.

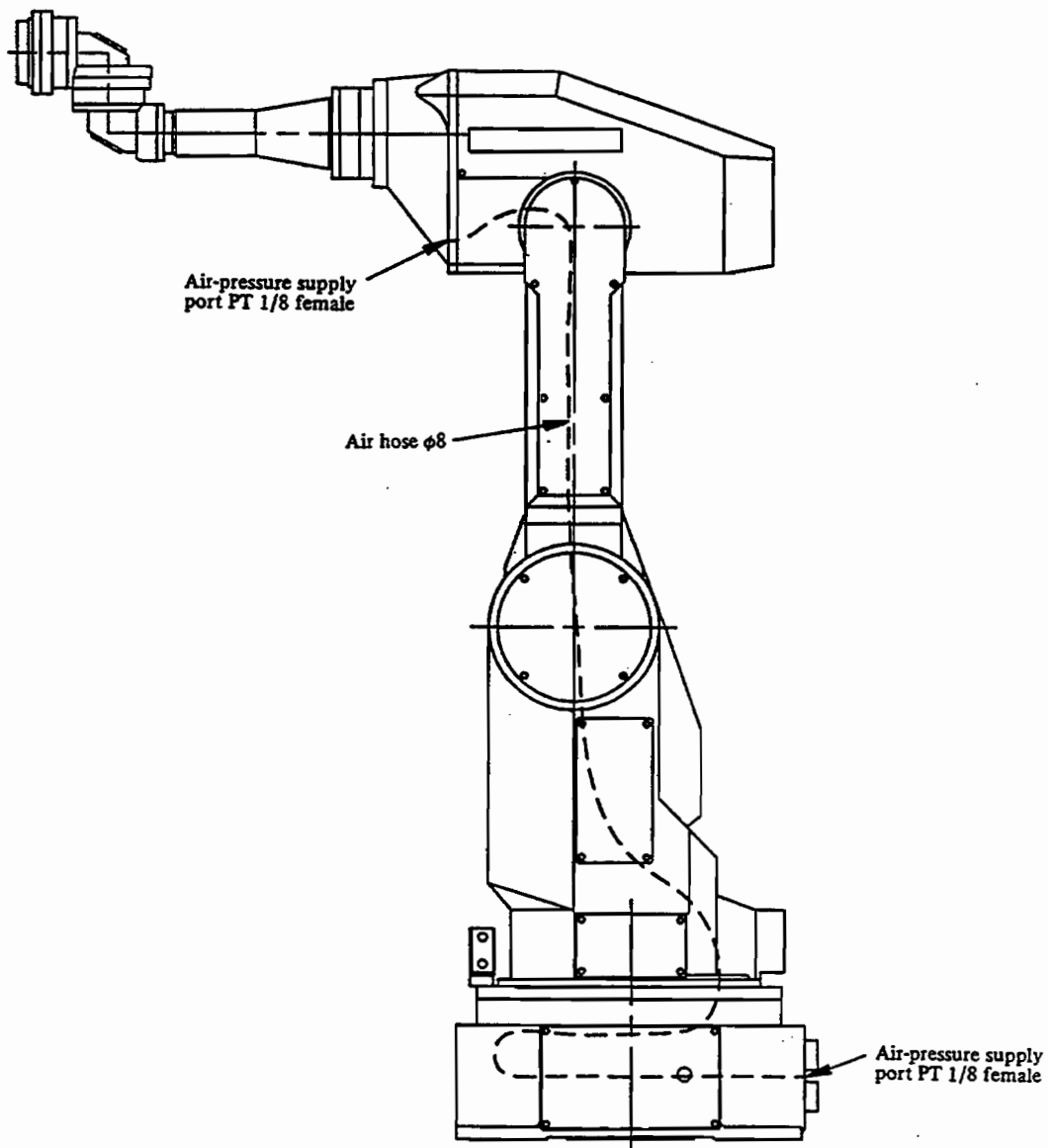


Fig. 5.3.4 Air supply port (S-700)

V. INSTALLATION

1. S-10 ROBOT

1.1 Transportation and Installation

1.1.1 Transportation

1) Transportation by crane

The robot is transported by lifting. Mount the parts required during transportation and lift it by attaching a rope to four M16 eye bolts. After installation, remove the parts for transportation and the stop. (Refer to Fig. 1.1 (a))

The stops for preventing rotation of the axes in transportation, are mounted by M12 bolts. Be sure to remove them before operating the robot.

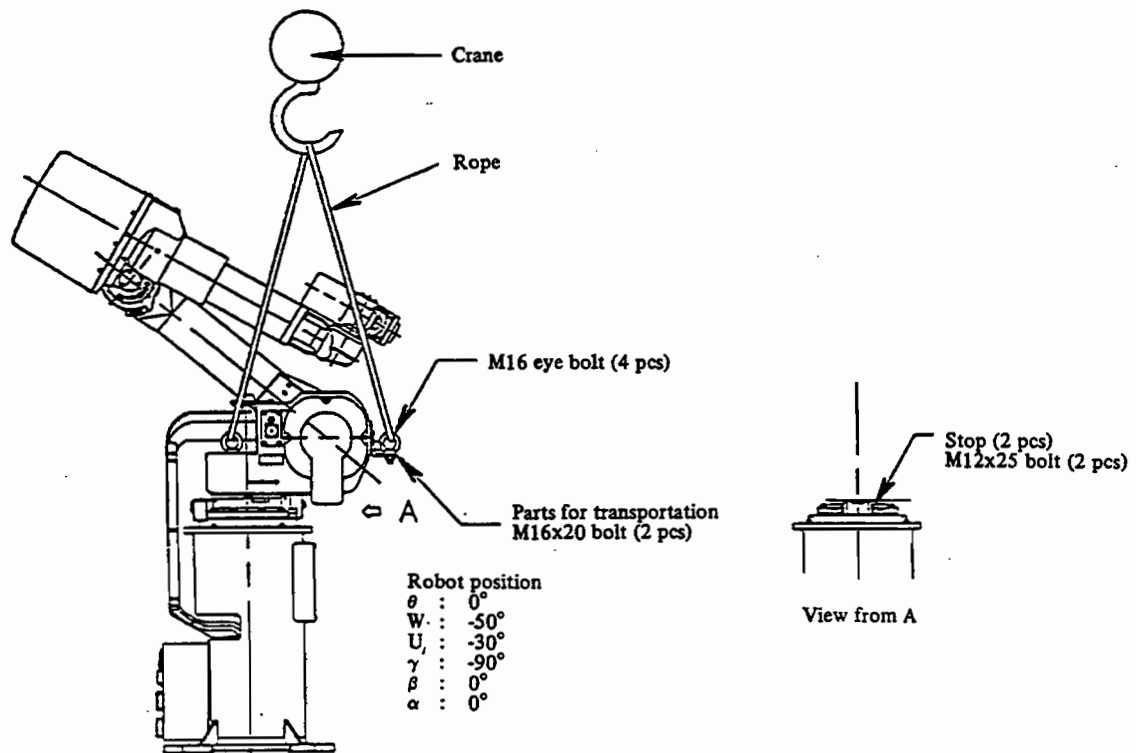


Fig. 1.1.1 (a) Transportation by crane (S-10)

2) Transportation by forklift

The robot can also be transported using a forklift. (Refer to Fig. 1.1.1

(b)) A forklift bracket can be provided as an option.

Note) Remove this cover M6x8 button-head bolt (4 pcs)

Note) The rear forklift bracket is mounted to the robot as shown below.

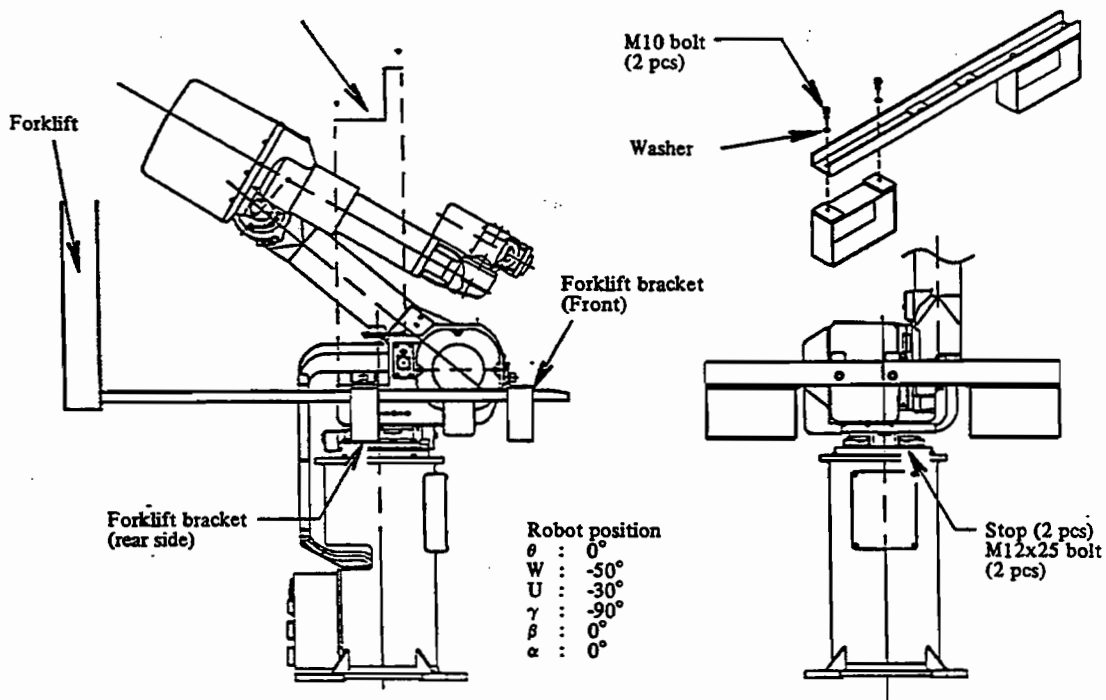


Fig. 1.1.1 (b) Transportation by forklift (S-10)

1.1.2 Installation

Mount the robot using anchor bolts to a foundation prepared by the customer. Fig. 1.1.2 (a) shows the base of a robot body, Fig. 1.1.2 (b) the base diagram, and Fig. 5.2 (c) foundation installation diagram.

Position the face shown as "XXX" on the provided reference plane or the positioning pin, and mount the robot securely.

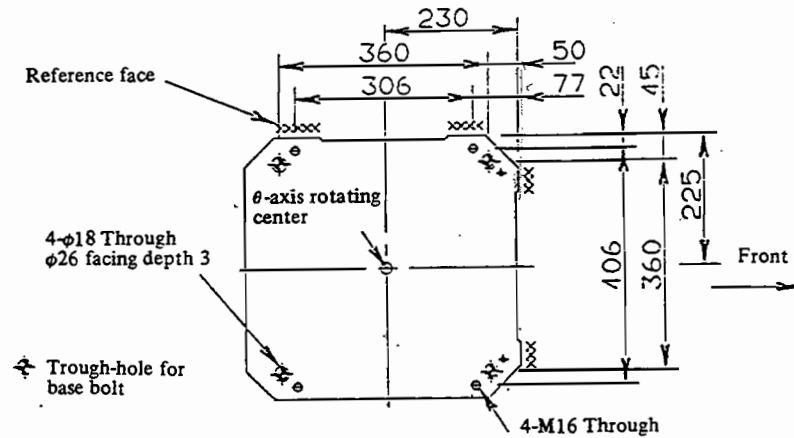


Fig. 1.1.2 (a) Dimensions of robot base (S-10)

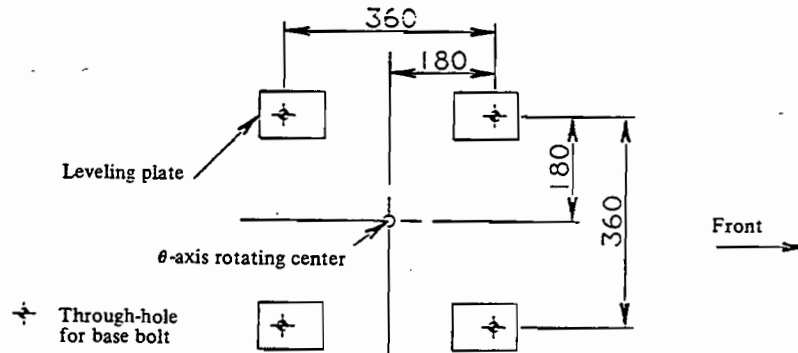


Fig. 1.1.2 (b) Base diagram (S-10)

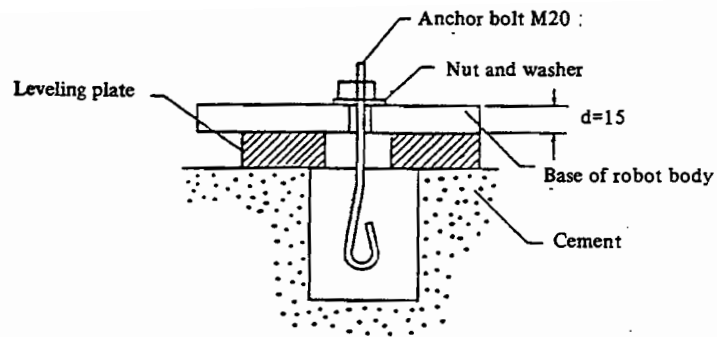


Fig. 1.1.2 (c) Foundation installation drawing (S-10)

Note) The leveling plate and anchor bolt are to be provided by the customer. Determine the foundation depth according to the size of the bolts. To ensure repeatability of the teaching points when the mechanical unit is replaced, the customer should prepare the installation plate as shown in Fig. 1.1.2 (d).

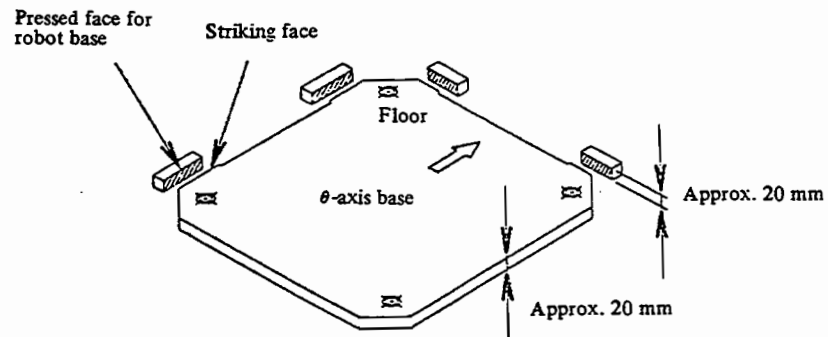


Fig. 1.1.2 (d) Installation plate (S-10)

1.1.3 Maintenance area

Fig. 1.1.3 (a) shows the maintenance area.

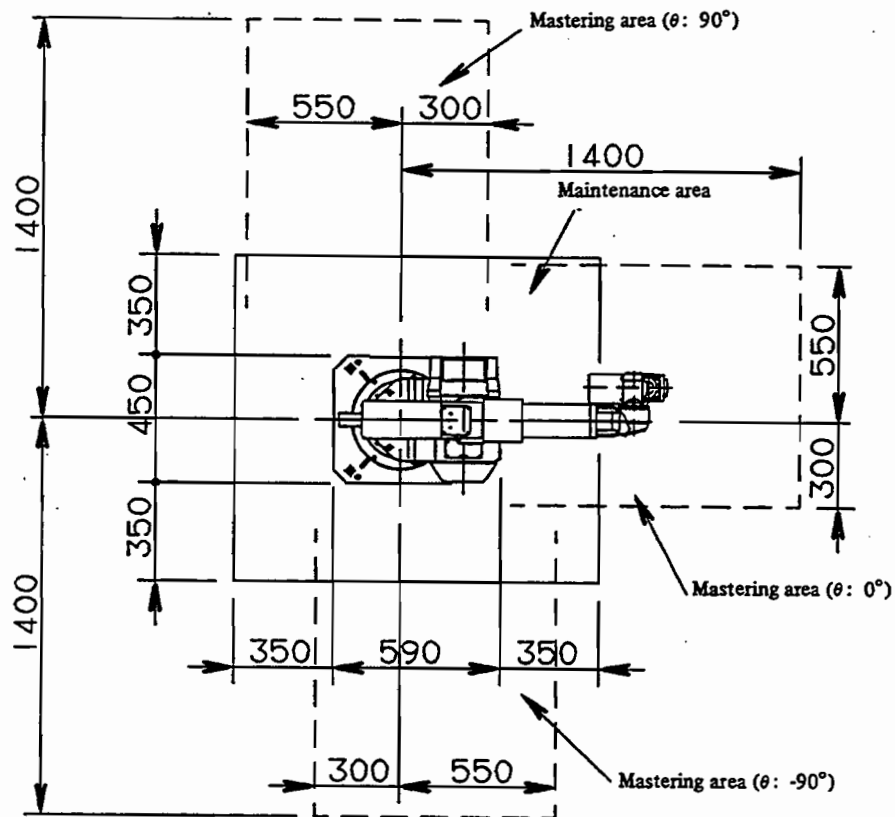


Fig. 1.1.3 (a) Maintenance area of mechanical unit

The position of the robot during mastering is shown in Fig. 1.1.3 (b). Reserve the space shown in Fig. 1.1.3 for this position. $\theta = 0^\circ$ is the position used to master the robot before shipment. To ensure repeatability when the robot is remastered allow sufficient space for this position if possible.

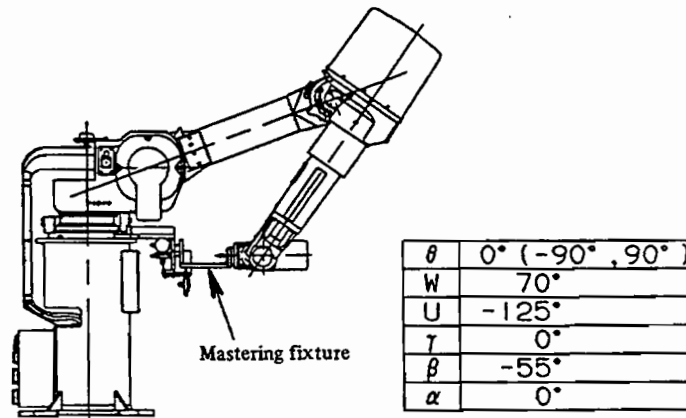


Fig. 1.1.3 (b) Mastering attitude (S-10)

1.2 Assembly During Installation

1.2.1 Robot cables

When laying a cable between a robot controller and a robot body, the customer is responsible for preparing the cable duct, etc.

The mechanical unit is shipped with connecting cables unattached (but connected to the controller). Connect the cables shown in Fig. 1.2.1 to the connector box of the mechanical unit. When connecting, take care not to damage the cables.

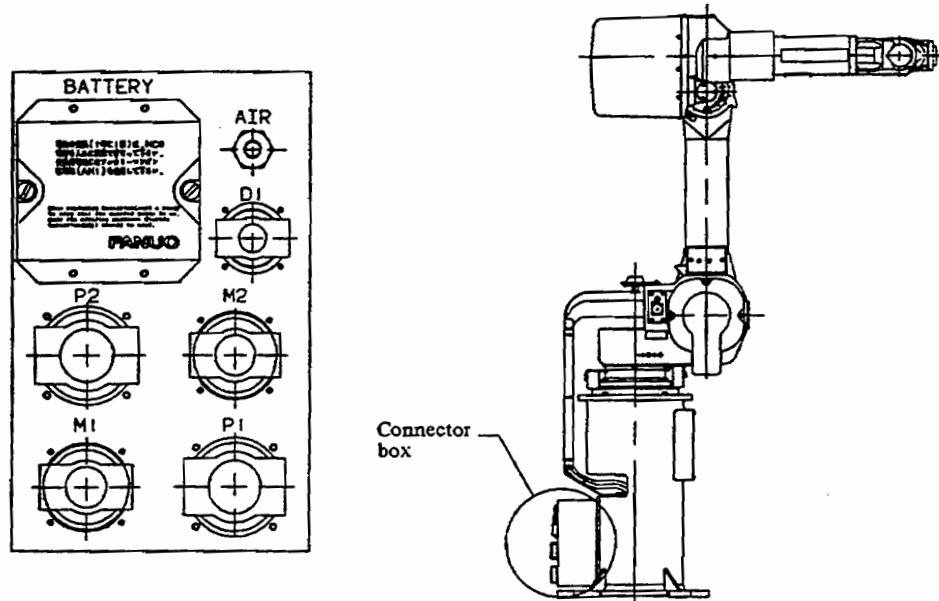


Fig. 1.2.1 Connector box of robot mechanical unit (S-10)

1.2.2 Air piping

Fig. 1.2.2 (a) shows the air piping of a robot.

If the air control set is specified as an option, the air hose between the mechanical unit and the air control set is attached. Mount the air control set according to Fig. 1.2.2 (b).

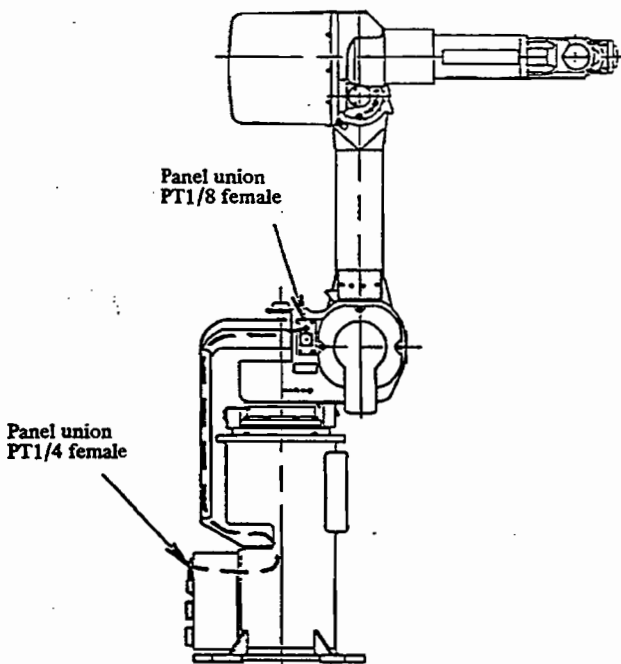


Fig. 1.2.2 (a) Air piping (S-10)

Use turbine oil #90 - #140 for the air control set, and fill to the specified level. Mounting bolts are to be provided by the customer.

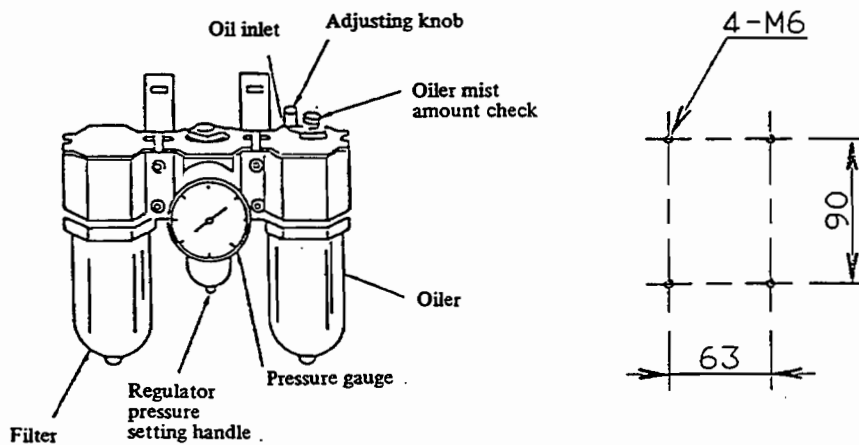


Fig. 1.2.2 (b) Air control set (S-10)

1.2.3 Installation specifications

Item		Specifications
Air pressure	Pressure	5-7 kg/cm ² G (Preset pressure 5 kg/cm ² G)
	Consumption	Maximum peak: 150 Nl/min, (Note 1)
Weight		Approximately 200 kg
Allowable ambient temperature		0 - 45°C
Allowable ambient humidity		Normally: less than 75% RH Short term (within one month): less than 90% RH maximum with no condensation
Atmosphere		Free of corrosive gas (Note 2)
Vibration		0.5 G or less

Note 1) This value indicates the capacity of the air control set. Adjust the air flow to be less than this value.

Note 2) If a robot is used in an environment with high vibration, dust, or density of cutting oil, consult the service representative.

2. S-700 ROBOT

2.1 Transportation and Installation

When transporting or installing the robot be careful of the battery cables.

2.1.1 Transportation

1) Transportation using a crane

The robot can be transported by lifting it using a crane. After mounting the metal fitting installed to prevent rotation of the W and U axes, attach the ropes to four M16 eye bolts and then lift the robot. After installing the robot, remove the parts used in transportation and the metal fitting. The support plate to prevent the θ axis from rotation during transportation is mounted by two M10 bolts.

Be sure to remove it before operating the robot.

Cover M10 tap holes using rubber caps applied thin coat of grease.

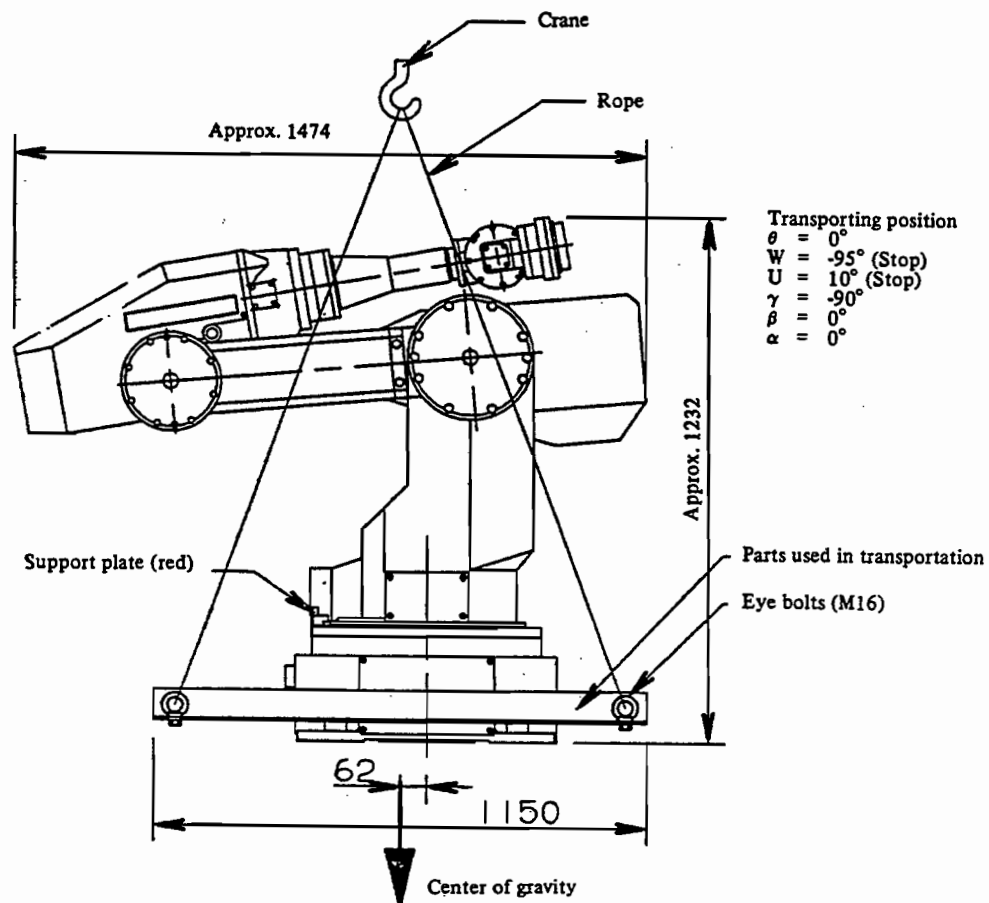


Fig. 2.1.1 (a) Transportation using a crane (S-700)

2) Transportation using a forklift

The robot can also be transported using a forklift. Optional brackets for a forklift are provided.

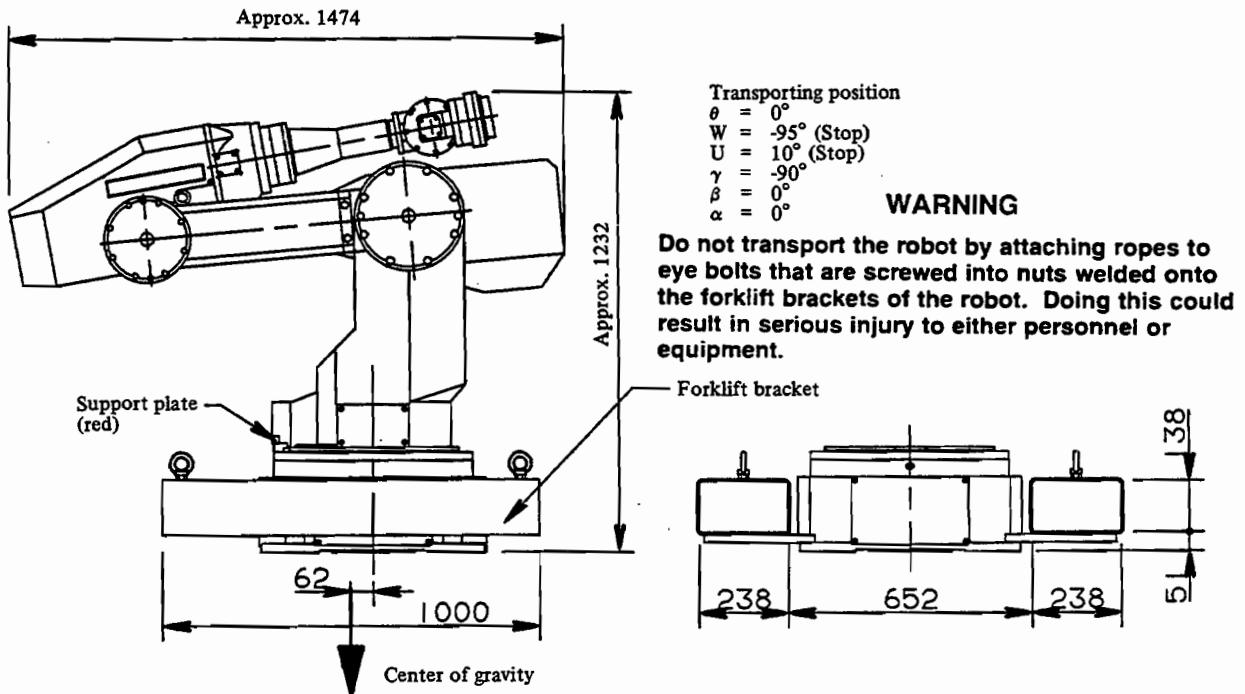


Fig. 2.1.1 (b) Transportation using a forklift (S-700)

2.1.2 Installation

Use the M20 hexagonal head bolt with strength stress of 12.9 (ISO 898/R: Min. tensile stress = 120 kg, yield stress = 90% of Min. tensile stress) and 20 mm (25 mm: ceiling mount) of thread length. Mount the robot to the foundation to be prepared by the customer using anchor bolts. Fig. 2.1.2 (a) shows the robot base dimensions and Fig. 2.1.2 (b) is the base diagram. Orient the surface indicated by "xxxx" to the direction desired or the positioning pins, and bolt the robot to the direction desired or the positioning pins, and bolt the robot to the foundation. Three surfaces indicated by "/////" can be used for the mastering fixture. Do not install an obstacle at the surface to be used for mastering.

When installing the robot on the ceiling, perform the following preparations.

- ① The installation plate shall be a steel plate of 600 x 600 mm with a thickness of 25 mm minimum.
- ② The strength of the frame shall ensure support for 500 kg·m of the robot torque and approximately 500 kg of weight in emergency.

Note) The robot installation surface shall be machined and level.

- ③ When using the optional cage, mount the robot along with the plate as shown in Fig. 2.1.2 (e).

- 3) Transportation using ceiling-mount cage
When transporting the ceiling-mount robot, the optional cage can be used.

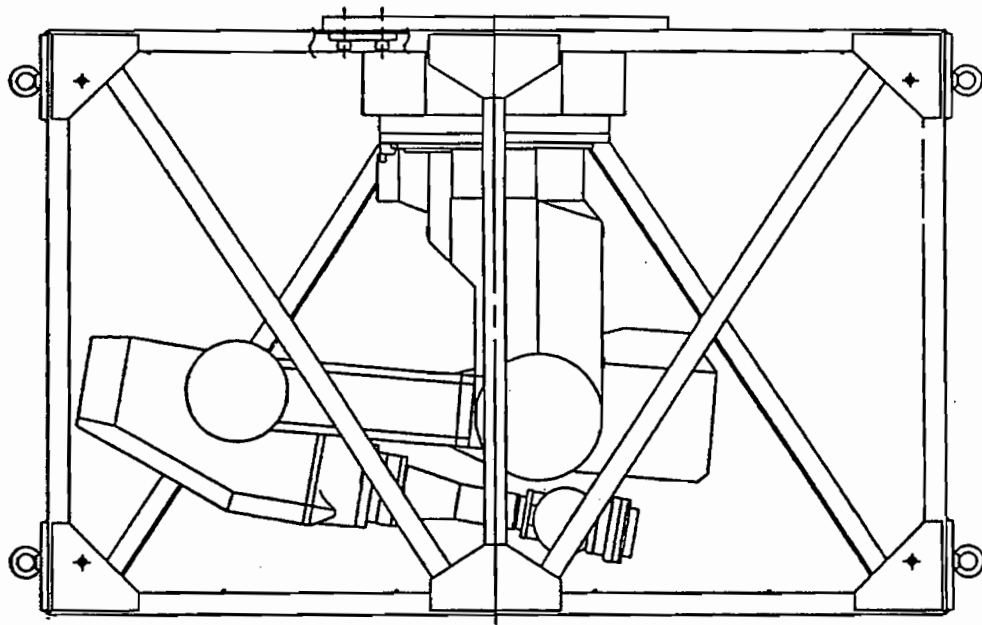


Fig. 2.1.1 (c) Transportation using ceiling-mount cage

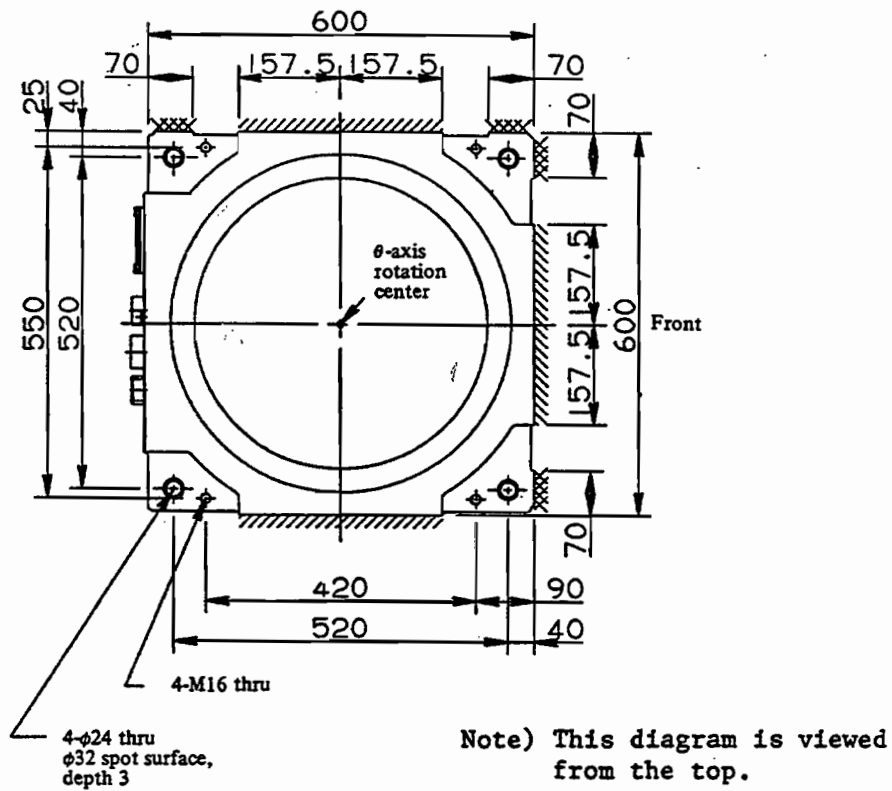


Fig. 2.1.2 (a) Robot base dimensions (S-700)

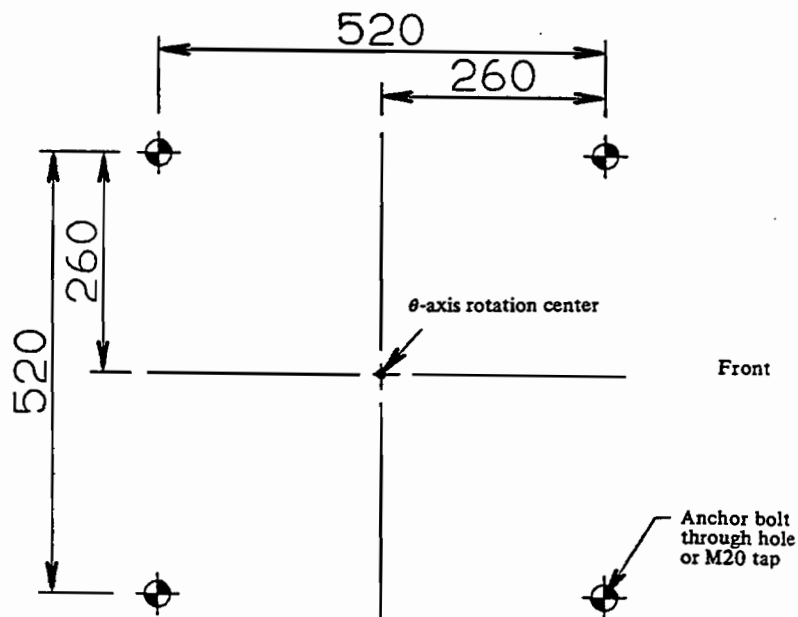


Fig. 2.1.2 (b) Base diagram (S-700)

Note) The foundation depth is determined by the size of the bolts.
 If the path taught to one robot must be transferred to the new unit when the robot mechanical unit is exchanged, the customer shall prepare an installation plate such as shown in Fig. 2.1.2 (c).

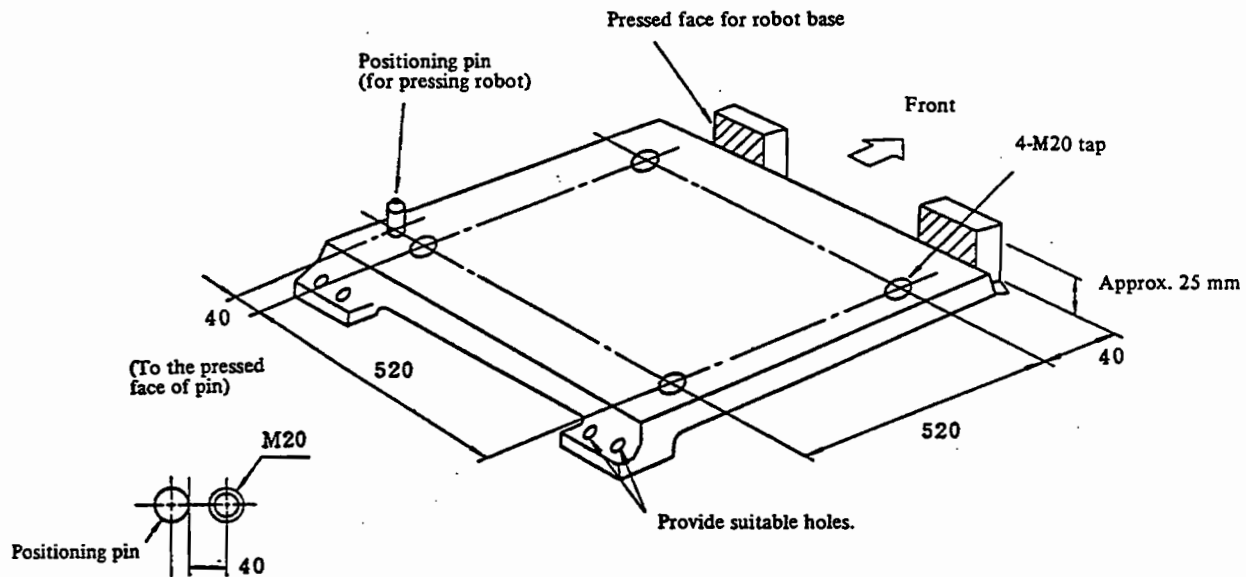


Fig. 2.1.2 (c) Installation plate (S-700)

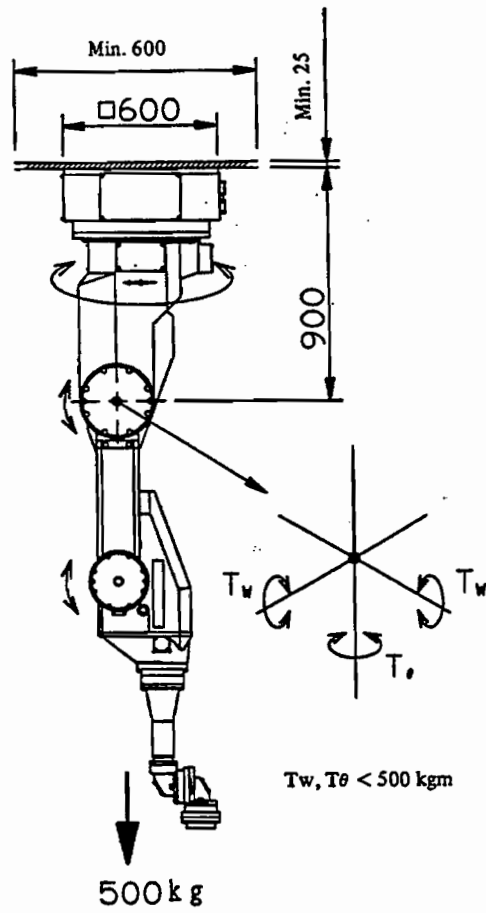


Fig. 2.1.2 (d) Ceiling mount (S-700)

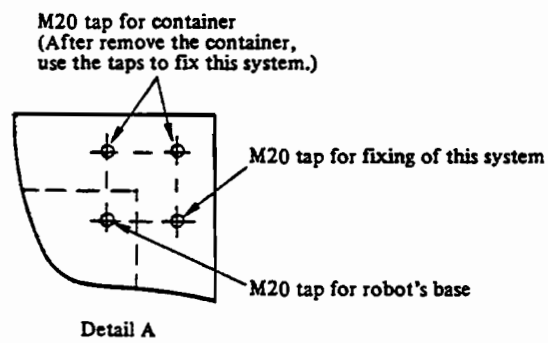
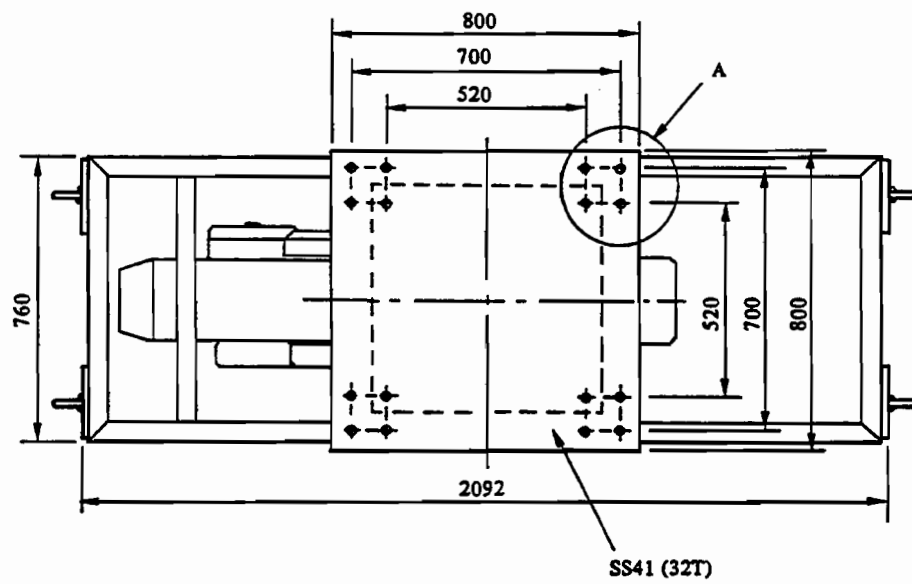


Fig. 2.1.2 (e) Ceiling-mount cage (S-700)

2.1.3 Maintenance area

Fig. 2.1.3 (a) shows the maintenance area.

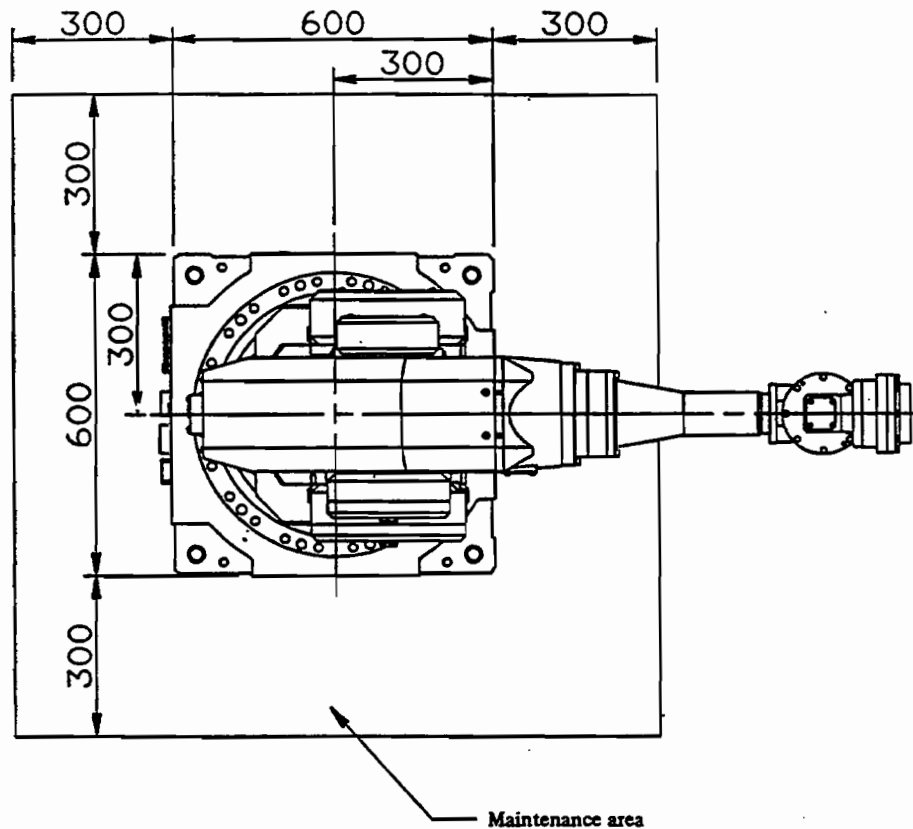


Fig. 2.1.3 (a) Maintenance area of mechanical unit (S-700)

Provide the maintenance area for mastering. Mastering can be done when $\theta = 0^\circ$, 90° or -90° with the other axes positioned as shown in Fig. 2.1.3 (b). Note that mastering is done before shipment with $\theta = 0^\circ$. Use this position if possible to ensure accurate remastering.

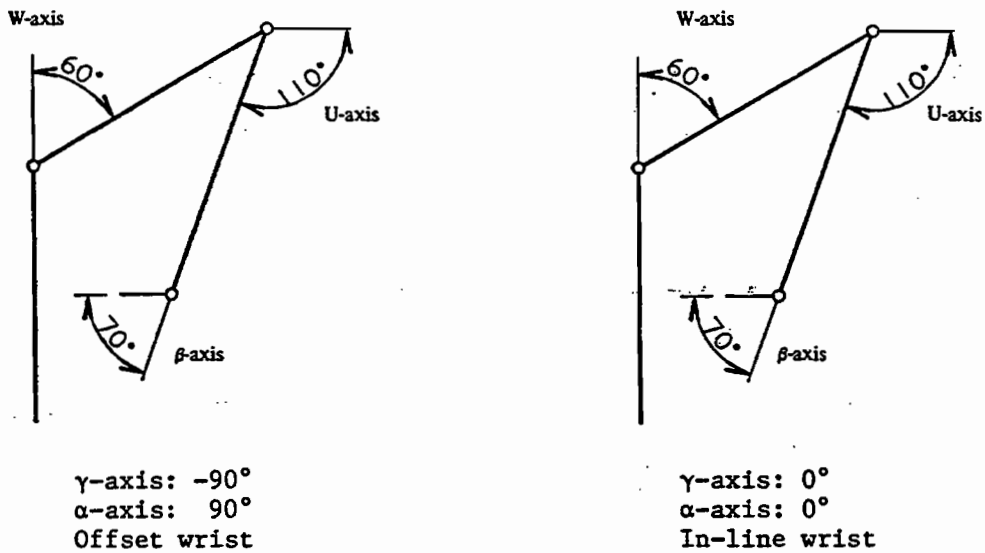


Fig. 2.1.3 (b) Mastering position (S-700)

2.2 Assembly During Installation

2.2.1 Robot cables

1) Connecting cable

Cable ducts, etc. are to be provided by the customer when the controller and mechanical unit are connected.

The mechanical unit is shipped with connecting cables unattached. The cables, however, are attached to the control unit. Connect the cables to the connector panel as shown in Fig. 2.2.1. When connecting cables be careful not to damage them.

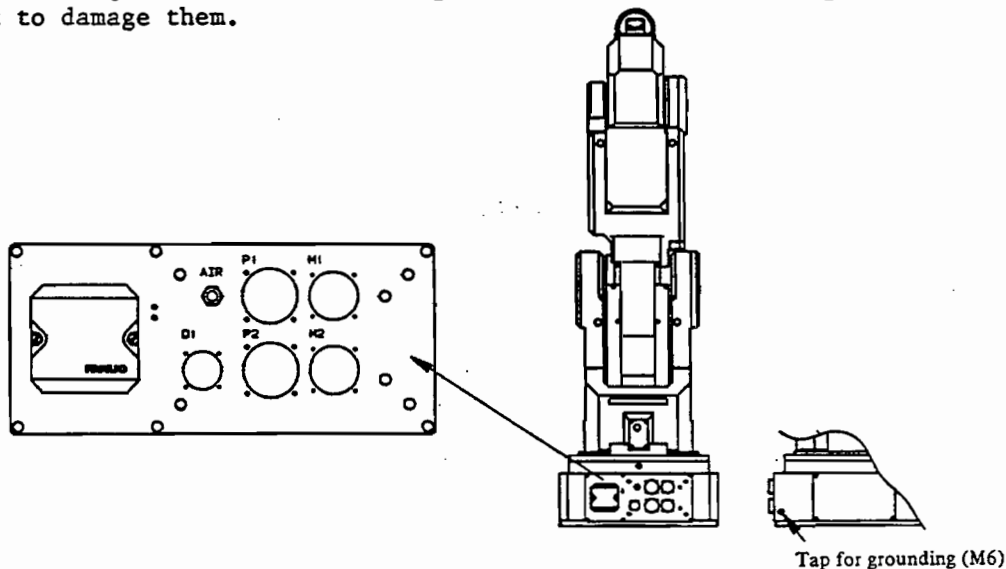


Fig. 2.2.1 (a) Connector panel of the mechanical unit (S-700)

2) Using the plate for noise-shield

When it is required to reduce the noise, the optional plate can be used. Assemble the plate using the following procedures.

- ① Remove the connector panel from the base.
- ② Place the plates 1 and 2 at the both side of the connector panel, and mount them using M6 bolts.
- ③ Tear the sheaths of cables P1, P2 and D1 at the clamp position.
- ④ Mount the cables P1, P2 and D1 using the cable clamp.

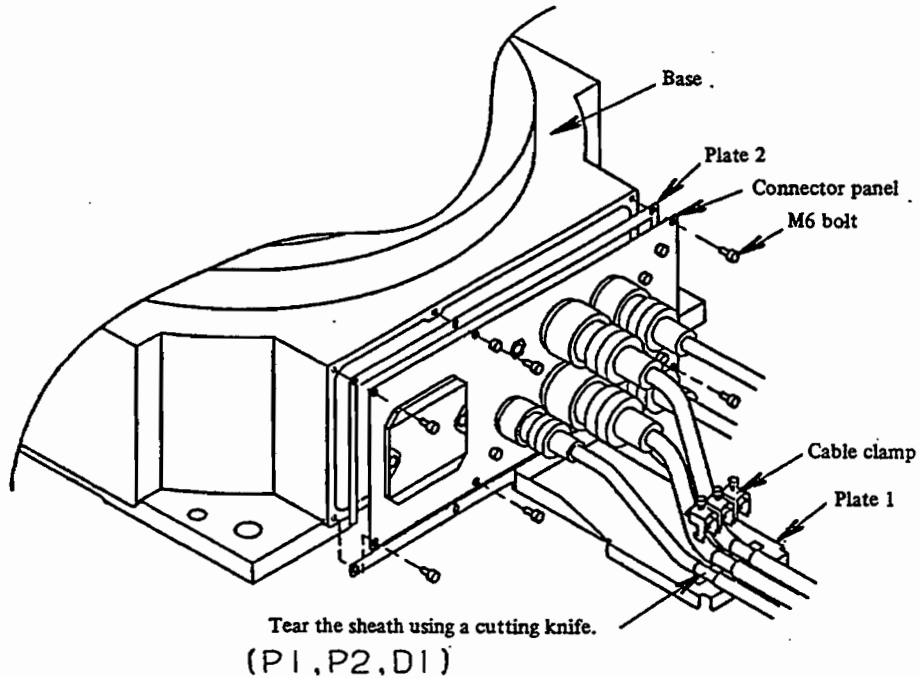


Fig. 2.2.1 (b) Assembling plate for noise-shield

2.2.2 Air piping

Fig. 2.2.2 (a) shows the method used to connect air piping to the robot. If the air control set is specified as an option, the air pipe between the mechanical unit and the air control set is attached. Mount the air control set on the customer-provided mounting port with the specified holes tapped according to the mounting hole dimensions shown in Fig. 2.2.2 (b).

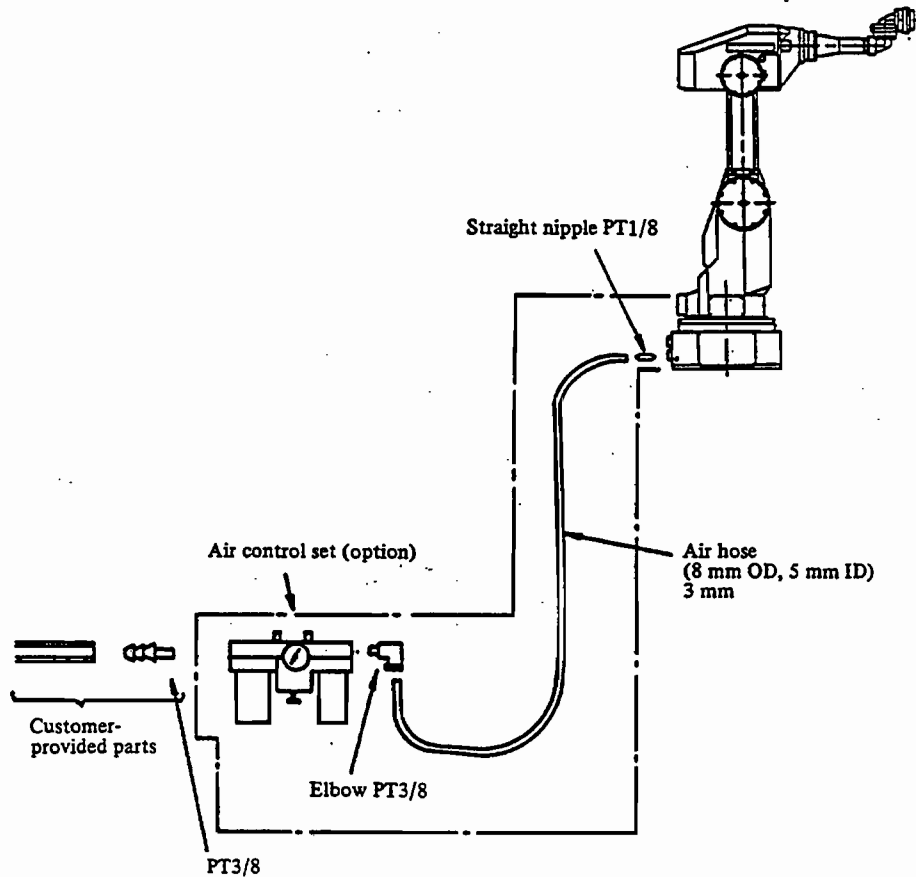


Fig. 2.2.2 (a) Air piping (S-700)

Use turbine oil #90 to #140 of the air control set, and fill to the specified level. Mounting bolts are provided by the customer.

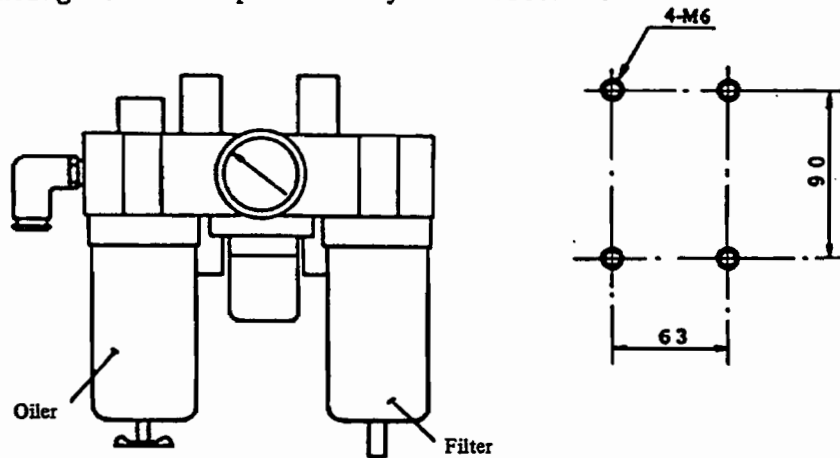


Fig. 2.2.2 (b) Air control set (S-700)

2.2.3 Installation specifications

Item		Specifications
Air pressure	Pressure	5-7 kg/cm ² G (Set pressure 5 kg/cm ² G)
	Air flow	Max. peak: 150 N liter/min. (Note 1)
Allowable ambient temperature		0 - 45°C
Weight of mechanical unit		Approx. 500 kg
Allowable ambient humidity		Usual: Less than 75% RH Short period (in one month) : Max. 95% RH or less Condensation free
Atmosphere		Free of corrosive gases (Note 2)
Vibration		Less than 0.5 G

Note 1) This value indicates the maximum capacity of the air control set. Adjust the air flow to be less than this value.

Note 2) Contact the service representative, if the robot is to be used in an environment or a place subject to severe vibrations, heavy dust, setting oil splash or other foreign substances.

3. ADJUSTMENTS AND CHECKS DURING INSTALLATION

For connecting cables between the controller and the mechanical unit of the robot, refer to IV-4.1 and 5.1. Check that these cables are connected properly to the correct axis and that the polarity is correct.

3.1 Items to be Checked

This procedure describes the adjustment procedures to be followed during installation of the controller. Adjust the robot in the sequence in which the items are listed below.

For details, refer to the paragraphs shown in the "Remarks" column in the following table.

Item	Description	Remarks
1	Visually inspect the interior and exterior appearances of the control unit and the mechanical unit.	Refer to 3.1 (1)
2	Verify that screws on the terminals are tight.	Refer to 3.1 (2)
3	Verify that the connectors and PCBs are properly mounted.	Refer to 3.1 (3)
4	Check the following: Transformer tap setting and fuse size	Refer to 3.1 (4)
5	Connect the cables to the control and mechanical units.	Refer to 3.1 (5)
6	Verify that the circuit breaker is off. Connect the power input cable.	Refer to 3.1 (6)
7	Make sure that the output voltages are not grounded.	Refer to 3.1 (7)
8	Check the input voltage.	Refer to 3.1 (8)
9	Press the EMERGENCY STOP button on the operator's panel. Turn on the power supply, and check the power supply voltages.	Refer to 3.1 (9)
10	Check the interface signals from the control unit to the mechanical unit.	Refer to 3.1 (10)
11	Check system variables. Change if necessary.	Refer to 3.1 (11)
12	Turn on the power supply, verify that the EMERGENCY STOP button is released. If it is, release it.	Refer to 3.1 (12)
13	Check the movement of each axis when it is manually jogged.	Refer to 3.1 (13)
14	Check the interface signals to the wrist and end effector.	Refer to 3.1 (14)
15	Check the peripheral device connection interface signals.	Refer to 3.1 (15)

1) Check the condition of the control unit and the mechanical unit as follows.

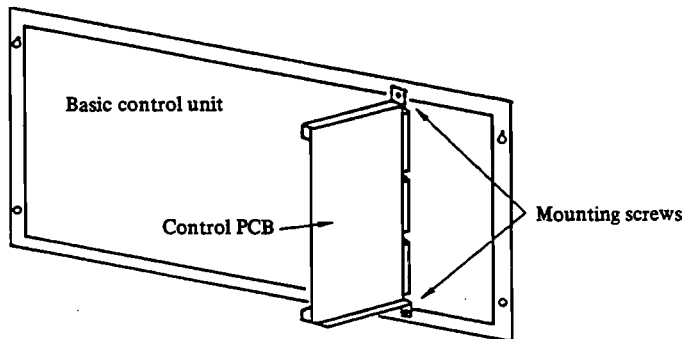
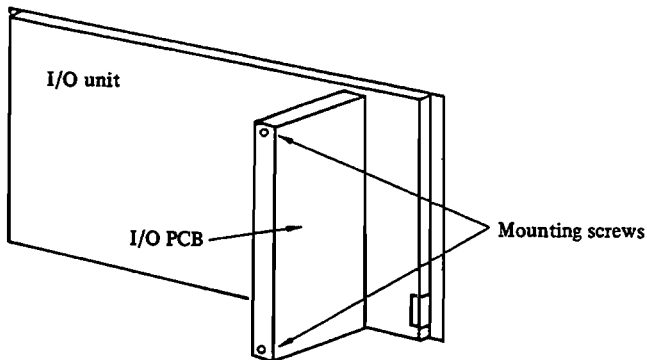
Item
Check for dirt or damage on the outside of CRT/KB panel, operator's panel, or the teach pendant.
Check for loose items inside the cabinet such as PCBs, the power unit, the input unit, or the servo amplifiers.
Check for any damage to the cables and conduits, etc. (Cover strippings, etc.)

Remove any brackets or braces used to secure the robot axes during shipping.

2) Check that the following terminals are securely connected:

Item
Terminals on the input unit (200R, 200S, 200A, 200B, 100IN1, 100IN2, 100OUT1, 100OUT2, EMGIN1, EMGINC, EMGIN2, EMGOUT1, EMGOUTC, EMGOUT2, ON, OFF, COM, ALA, ALB, OP1, OP2, FN1, FN2, BKPl, M1, P2, M2, P3, M3)
Terminals on the fuse holders
Terminals on the I/O modules
Terminals on the fan unit
Terminals on the servo amplifier
Terminals on the servo transformer TF1 (Primary side, secondary side)
Terminals on the input transformer TF4 (Primary side, secondary side)
Terminals on the discharge units
Check that terminals are covered, if required.

3) Verify that all connectors and PCBs are properly mounted.

Item
Are clamp screws in the HONDA connectors tight?
Are nail type fixtures fitted with black connector for power source?
Are nail type fixtures fitted with brown connector for power source?
Are nail type fixtures fitted with white connector for power source?
<p>Are PCB mounting screws for the backplane PCB tight?</p>  <p>The diagram shows a perspective view of a rectangular 'Basic control unit'. A smaller 'Control PCB' is shown partially inserted into the unit. Four 'Mounting screws' are indicated by arrows, securing the PCB into the unit's frame.</p>
<p>Are PCB mounting screws for the I/O modules tight?</p>  <p>The diagram shows a perspective view of a rectangular 'I/O unit'. An 'I/O PCB' is shown partially inserted into the unit. Four 'Mounting screws' are indicated by arrows, securing the PCB into the unit's frame.</p>
Are ROMs mounted in the IC sockets on PCB of 01P04, and 01P08?

- 4) Check settings of the transformers and fuse size
 The location of the power transformers is shown in "I. OVERVIEW AND CONTROLLER MAINTENANCE 3.3 Internal Components".

Item
Tap setting on the servo transformer (TF1)

Check the transformer primary tap connection to see if the power voltage is within +10% to -15% of the tap voltage.

If the voltage does not satisfy this condition, select the correct tap.

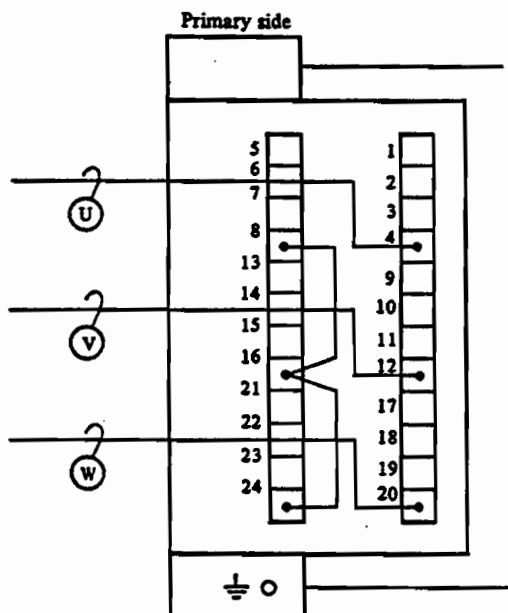


Fig. 3.1 (a) The servo transformer TF1 tap selection (input voltage: 480 VAC)

Table 3.1 (a) The servo transformer TF1 primary tap selection

Power supply voltage	Connection of primary tap					
	U	V	W	Jumper		
220 V	7	15	23	8 - 15	16 - 23	24 - 7
240 V	6	14	22	8 - 14	16 - 22	24 - 6
380 V	7	15	23	8 - 16	16 - 24	
415 V	6	14	22			
460 V	5	13	21			
480 V	4	12	20			
500 V	3	11	19			
550 V	2	10	18			
575 V	1	9	17			

Item
Tap setting on the input transformer (TF4)

Check the transformer primary tap connection to see if the power voltage is within +10% to -15% of the tap voltage.

If the voltage does not satisfy this condition, select the correct tap.

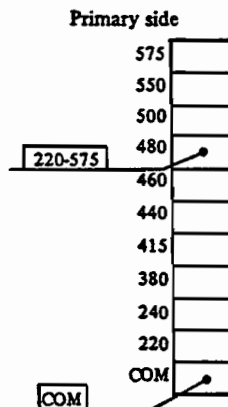


Fig. 3.1 (b) The input transformer TF4 tap selection (input voltage: 480 VAC)

Item
Tap setting on the user transformer (TF5)

Check the transformer primary tap connections to see if the power voltage is within +10% to -15% of the tap voltage.

If the voltage does not satisfy this condition, select the correct tap.

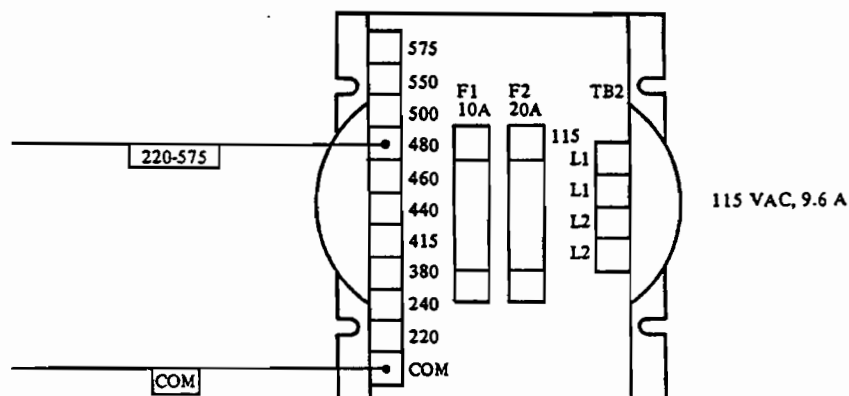


Fig. 3.1 (c) The user transformer TF5 tap selection (input voltage: 480 VAC)

Note 1) Turn off the input power supply to the control unit selecting transformer taps.

Note 2) U, V, and W in the figure correspond to input power terminals U, V, W.

Item
Fuse size for AC voltage input types (Refer to I. OVERVIEW AND CONTROLLER MAINTENANCE 23.3.1)

5) Connect the cables between the control unit and the mechanical unit

Item
Connect the AC motor power cable and brake cable for each axis
Connect the pulse coder cable for each axis
Connect the robot input/output cable
Connect the teach pendant cable

6) Connecting the power input cable

Turn the circuit breaker/disconnect switch off and then connect the power input cable.

The power cable should be brought into the cabinet through the bottom of the cabinet and connected to the U, V and W terminals on the circuit breaker/disconnect switch. (See IV-3.2.1)

7) Confirm that the following output voltages are not grounded.

Item
Check that the power unit output +5 V is not shorted to 0 V (GND).
Check that the power unit output +24 V is not shorted to 0 V (GND).
Check that the power unit output +24 V (+24 E) is not shorted to 0 V (GND).
Check that the power unit output +15 V is not shorted to 0 V (GND).
Check that the power unit output -15 V is not shorted to 0 V (GND).

8) Confirm that the input power source voltage and frequency are correct.

Item
The input power source voltage is applied as follows. 220/240/380/415/460/480/500/550/575 VAC +10%/-15% 50/60 Hz <u>+1</u> Hz, 3 ϕ
The input power source capacity should be sufficient to power the control unit.

9) Output voltage check

Press the EMERGENCY STOP button on the operator's panel. Turn on the power supply, and check the output voltage.

Item
Check that all fans in the cabinet are working normally.
Check that each power output is within the specified range at the terminals on the Path CPU board. (See I. OVERVIEW AND CONTROLLER MAINTENANCE 9.7.)
Check the each power output is within the specified range at the terminals on the servo amplifier PCB. (See I. OVERVIEW AND CONTROLLER MAINTENANCE 26.1.5, 26.2.5, 26.3.5.)
Reset the EMERGENCY STOP button on the operator panel. Press the EMERGENCY STOP button on the teach pendant and verify the display, which should indicate a teach pendant emergency stop.

10) Check the interface signals of the control unit and mechanical unit of robot. Press the EMERGENCY STOP button and check the interface signals.

Item
Check the functioning of the +, - overtravel limit switches for all axes by manually tripping them, and using diagnostics.
Check to see if the position error value is changed by the feedback signal of the pulse coder on the AXISTAT screen of the diagnostics, when the motor is rotated using an external force.

11) Check and set various system variables.

Press the EMERGENCY STOP button and check and set the system variables that, for your system, may require different values than the default values.

12) Release the EMERGENCY STOP button.

Item
If an alarm is produced, correct the problem referring to the error code tables.

- 13) Check the movement of each axis when it is manually jogged.
Refer to section 4 for initial start-up procedures.

Item
Try moving each axis using incremental jog, and see if the axis movement of the robot follows correctly.
While manually jogging each axis at low override, operate any externally mounted EMERGENCY STOP button and see if the axis stops and also check that the axis stops when an overtravel switch is tripped.
Manually jog each axis at various override speeds to make sure that there is no vibration or overshoot.

- 14) Check the operation of interface signals of the end effector.

Item
Check the operation of the robot end effector by diagnostics and executing the commands from the teach pendant.

- 15) Check the operation of peripheral device connection interface signals.

Item
Check the operation of the peripheral device by diagnostics and executing the commands from the teach pendant.

4. INITIAL START UP

The robot is shipped with one or more axes placed on hard stops. This shipping condition places those axes in an overtravel condition. Prior to initial start up, the EMERGENCY STOP button should be pressed. After initial start up, you must reset the EMERGENCY STOP button to remove the emergency stop condition and move the mechanical unit out of the overtravel condition.

4.1 Description of Initial Start Up

When power is applied to the robot the system software will be loaded automatically from bubble memory to the DRAM in the control PCBs. When this has been completed the controller will be initialized and the KAREL power up display will appear on the CRT.

The start up procedures are:

1. Press the EMERGENCY STOP button.
2. Turn circuit breaker handle to the ON position.
3. Press the ON button on the operator panel.

The display shown in Fig. 4.1 (a) will appear.

```
***** Karel R-H Controller *****
BootROM V1.11          1-Jan-1988 10:11:58

Bus Slot Module      ID FC OP AX
Main 0 Shared res    4 3 0
Main 2 Servo ctrl    5 1 0 4
Main 5 Path CPU      2 2 1
Main 6 Main CPU      9 0 3
Main 7 Bubble mem    8 0 0

Clearing DRAM memories ...

System last saved 18-May-1987 10:00:22

Booting MAIN processor/module. 768K bytes from BMO: (KAREL_RH )
Booting PATH processor/module. 135K bytes from BMO: (KAREL_RH )
Booting AXIS processor/module. 53K bytes from BMO: (KAREL_RH )
Booting SRVO processor/module. 17K bytes from BMO: (KAREL_RH )
```

Fig. 4.1 (a) Software booting display

During this time the controller software reports the location of each board in the controller backplane and indicates that the software is booting from bubble memory to the various DRAMs on the boards.

When this operation is complete, the display shown in Fig. 4.1 (b) appears.

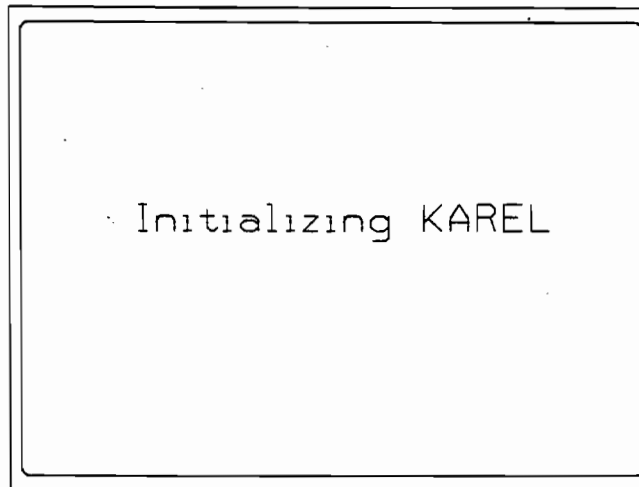


Fig. 4.1 (b) KAREL initializing display

After the initialization is completed, the display in Fig. 4.1 (c) appears.

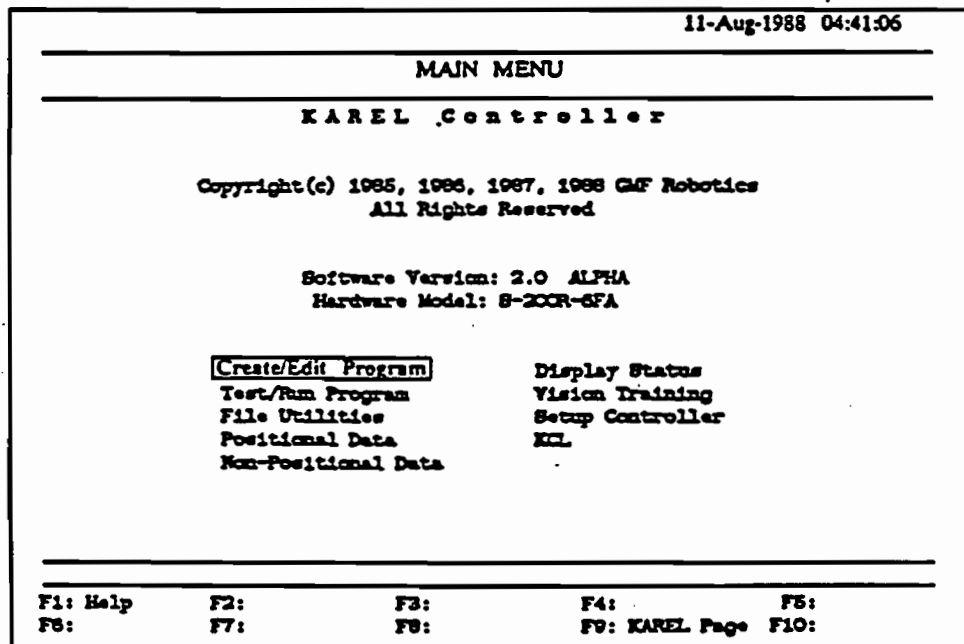


Fig. 4.1 (c) CRT main menu

4.2 Recovery from Alarm Conditions

If a user or system error occurs during operation of the robot, an error message will be displayed on the CRT display and the teach pendant LCD screen.

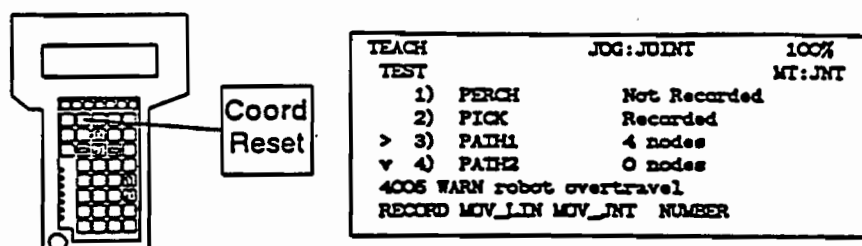


Fig. 4.2 Teach pendant RESET menu

4.2.1 General error recovery

- 1) Correct the condition that caused the error message to be displayed.
- 2) To recover from the error and resume operation, press the RESET function key (F3) on the teach pendant, shown in Fig. 4.2, or the FAULT RESET button on the operator's panel, shown in Fig. 4.2.1.

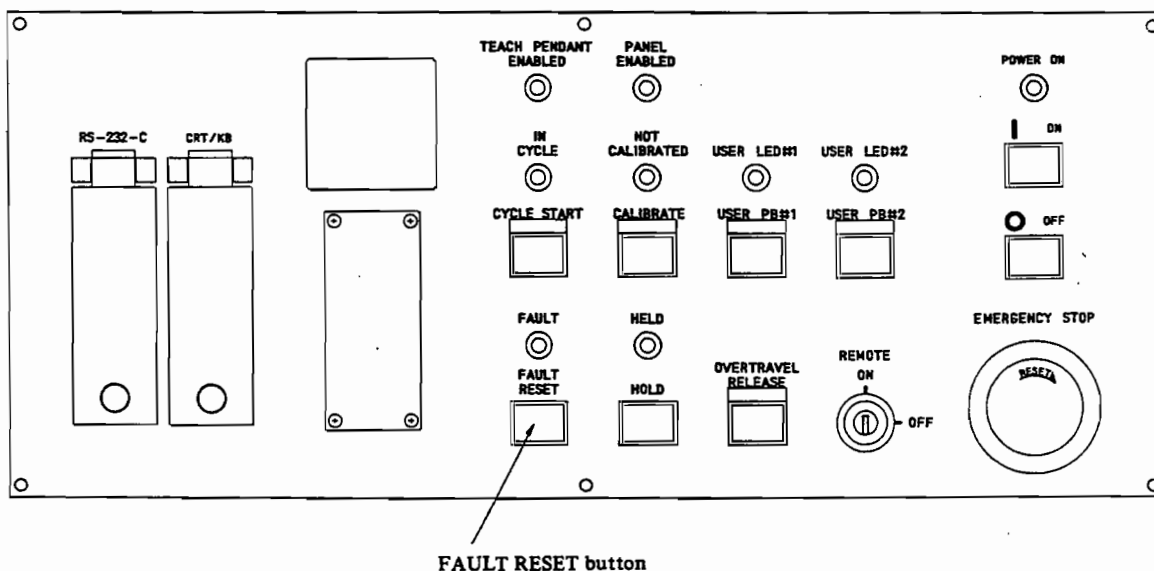


Fig. 4.2.1 Operator's panel fault reset control

4.2.2 Overtravel

When a robot axis overextends its motion limit and trips one of the axis overtravel limit switches, servo power is shut off by a hard wired relay circuit and the following overtravel error message is displayed:

4005 WARN ROBOT OVERTRAVEL

To recover from the overtravel perform the following procedure:

- 1 Press the OVERTRAVEL RELEASE button on the operator panel. This will engage a bypass circuit to supply power to the servo unit while the overtravel limit switch is pressed.
- 2 Check that the teach pendant is enabled.
- 3 This alarm can be reset from the teach pendant. Press RESET on the teach pendant, shown in Fig. 3.2, while holding the DEADMAN switch. Servo power is applied to the mechanical unit as long as a DEADMAN switch is pressed.
- 4 Jog the axis in the overtravel condition away from its motion limit.

WARNING: If a robot is jogged too far in one direction, mechanical problems can occur. Perform this procedure carefully.

If more than one axis is in an overtravel condition, you can determine which ones are in overtravel and in which direction by the following

- 5 At the CRT/KB, type in response to the KCL prompt:

KCL>SHOW VAR\$OT_MINUS or KCL>SHOW VAR\$OT_PLUS

You will see an array of \$OT_MINUS[n] or \$OT_PLUS[n] where n is the number of the axis. Any element that is set to TRUE indicates overtravel in the negative (\$OT_MINUS) or positive (\$OT_PLUS) direction.

- 6 To allow you to jog these axes out of overtravel, set these system variables to FALSE:

KCL>SET VAR \$OT_MINUS[n]=FALSE

KCL>SET VAR \$OT_PLUS[n]=FALSE

- 7 Save the changes by typing: KCL>SSAVE

4.2.3 Emergency stop

When the emergency stop is executed, servo power is shut off and the following emergency stop error message is displayed on the CRT:

4002 WARN EMERGENCY STOP XXX

where "XXX" indicates the source of the emergency stop as follows:

XXX = 100 ... operator panel
200 ... user operator panel (if equipped)
400 ... safeguard fence (if equipped)
800 ... teach pendant

To recover from an emergency stop from the operator panel:

1. Release the operator panel EMERGENCY STOP button by turning the button clockwise allowing it to unlatch.
2. Press the FAULT RESET button to reset servo power.

To recover from an emergency stop from the teach pendant:

1. Release the teach pendant EMERGENCY STOP button by pressing the button again.
2. Reset servo power by pressing the RESET softkey. (Teach pendant must be enabled and servo power must be turned on by holding the DEADMAN switch.)

To recover from an emergency stop from a user-designed device, check the recommended operating procedures for the particular installation.

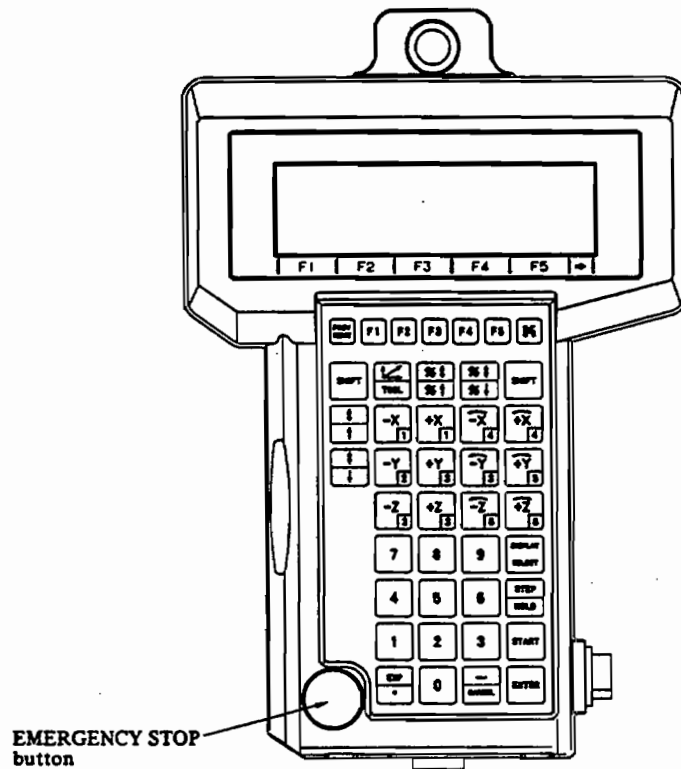
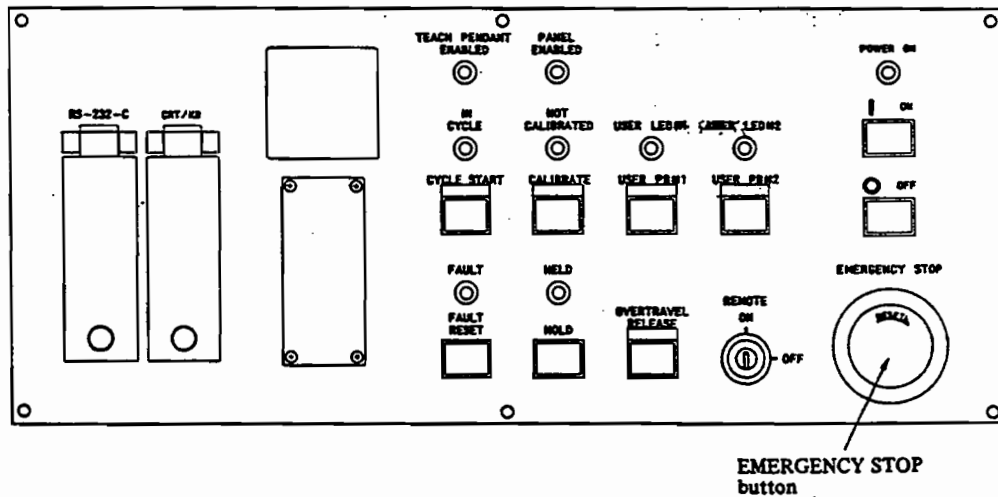


Fig. 4.2.3 Emergency stop controls

VI. APPENDIX

APPENDIX 1 INTERNAL CONNECTIONS

1.1 S-10

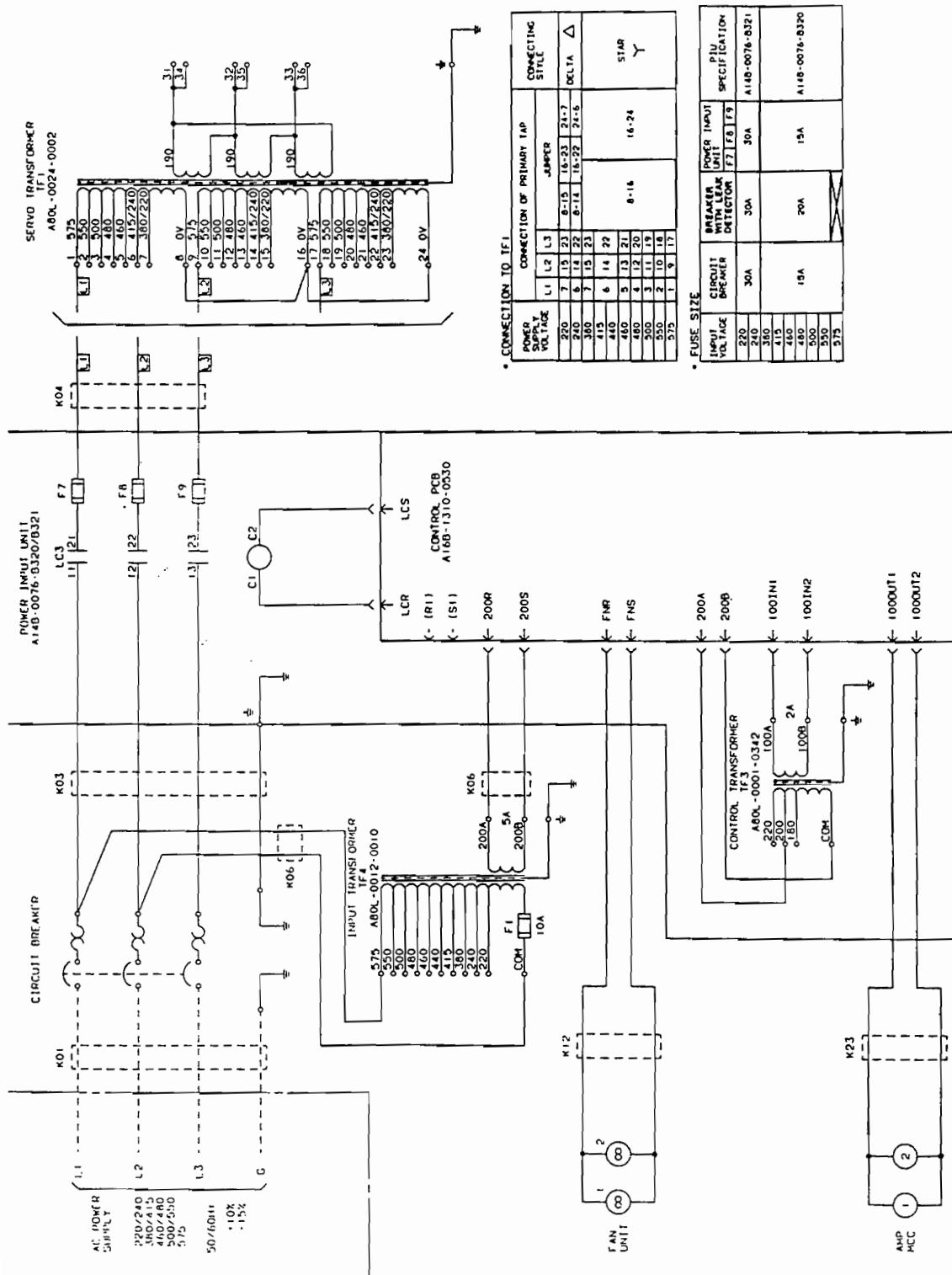


Fig. 1.1 (a) Internal connection diagram (S-10, Medium size cabinet)

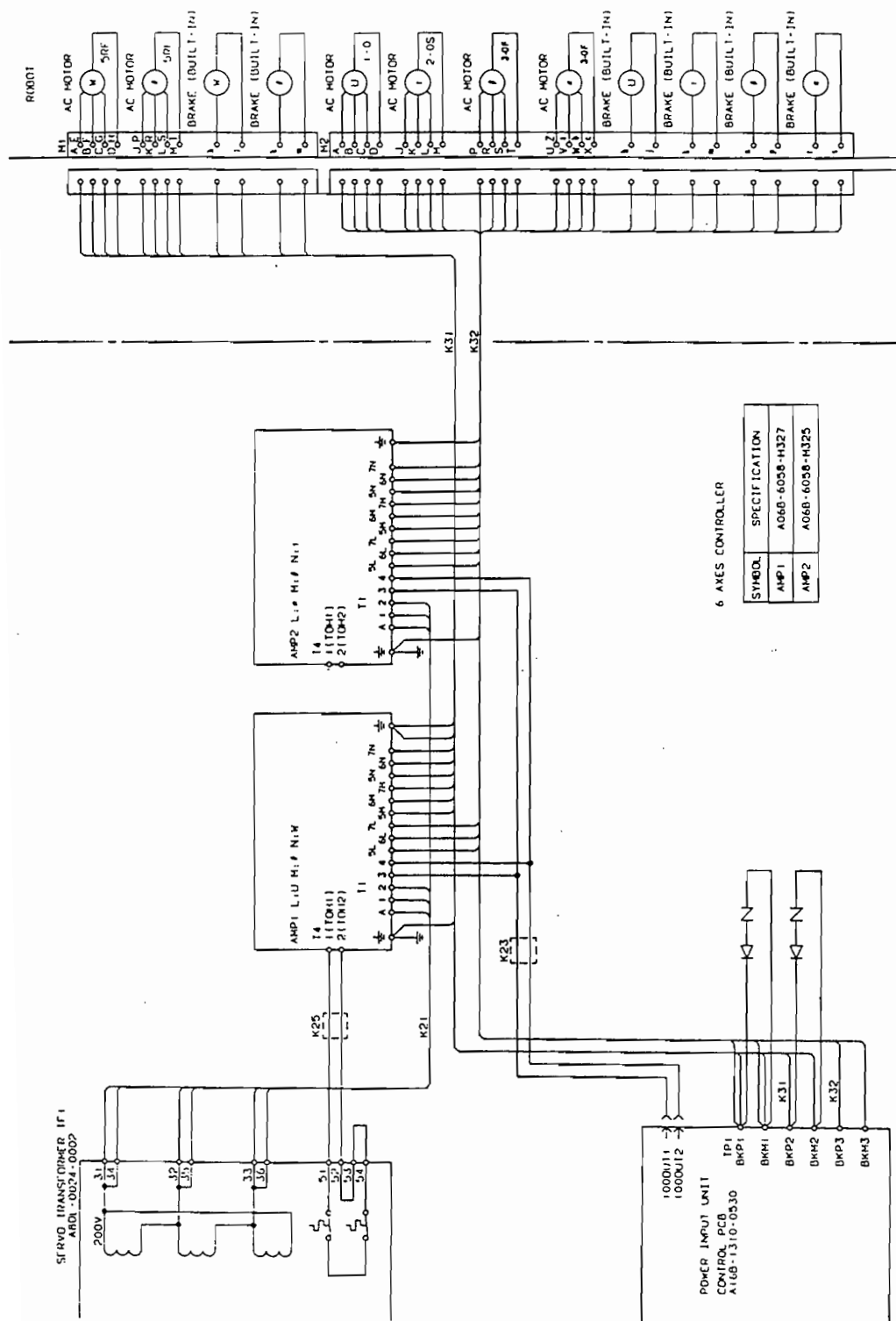


Fig. 1.1 (b) Internal connection diagram (S-10, Medium size cabinet)

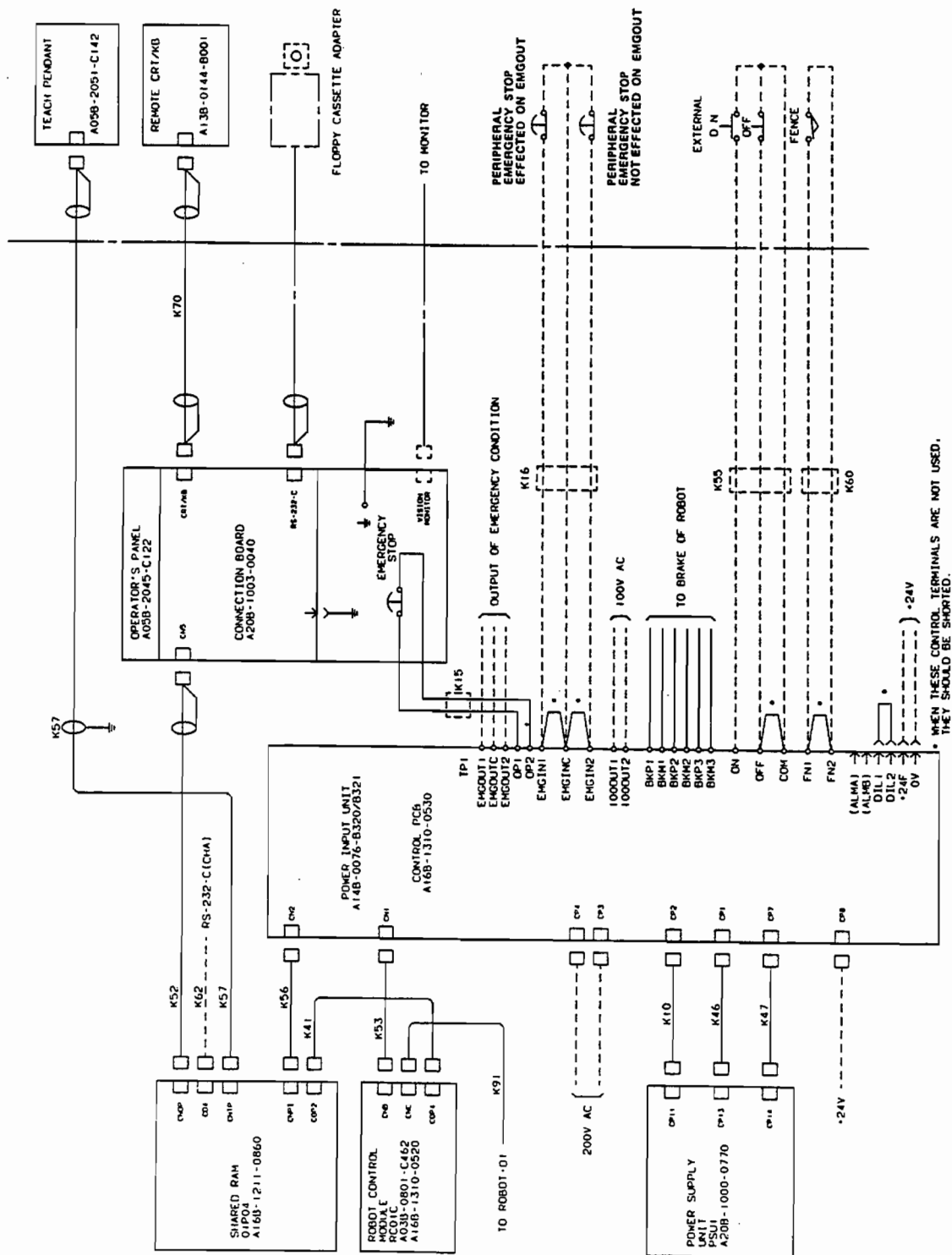


Fig.1.1 (c) Internal connection diagram (S-10, Medium size cabinet)

Fig. 1.1 (d) Internal connection diagram (S-10, Medium size cabinet)

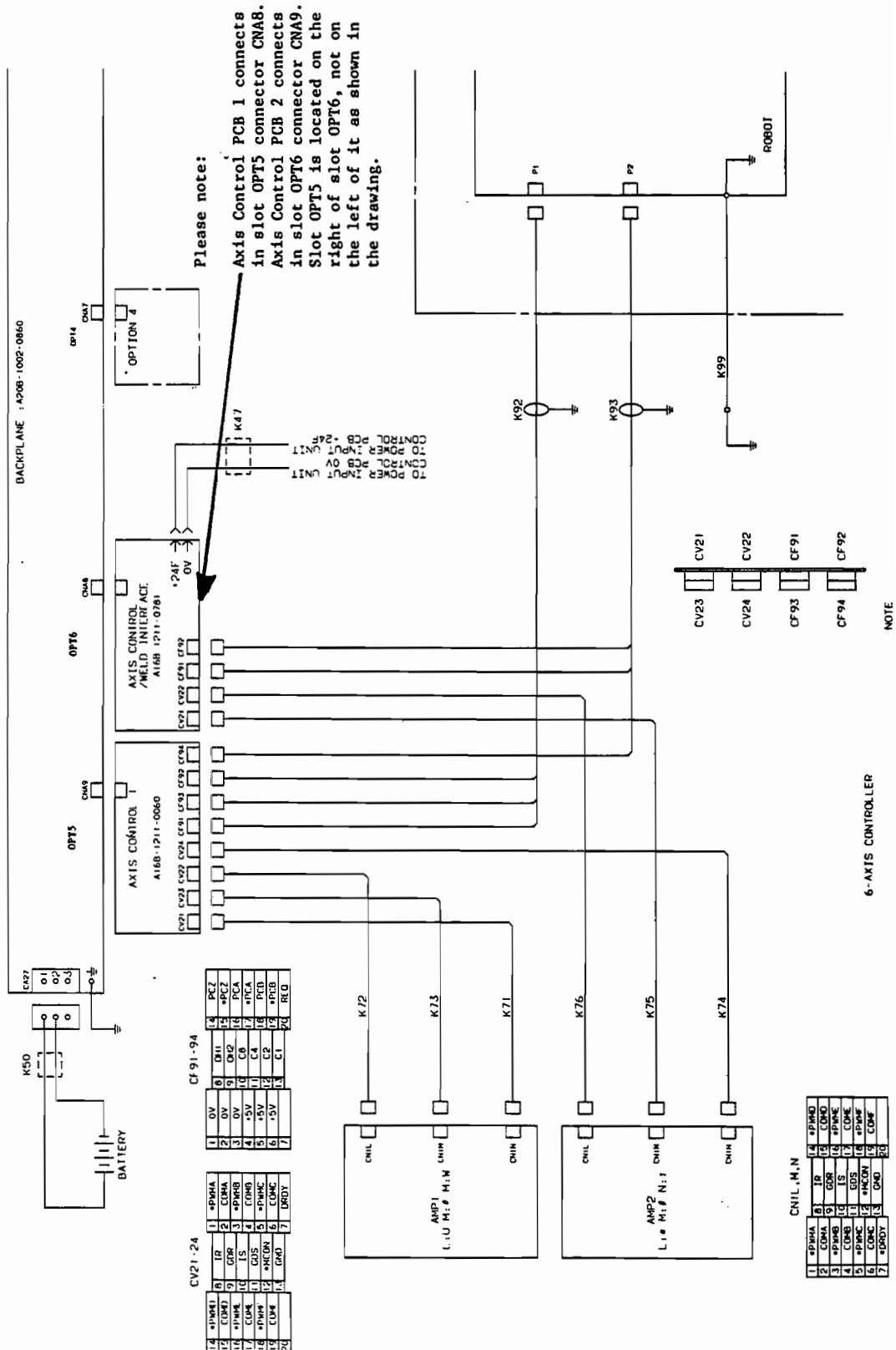
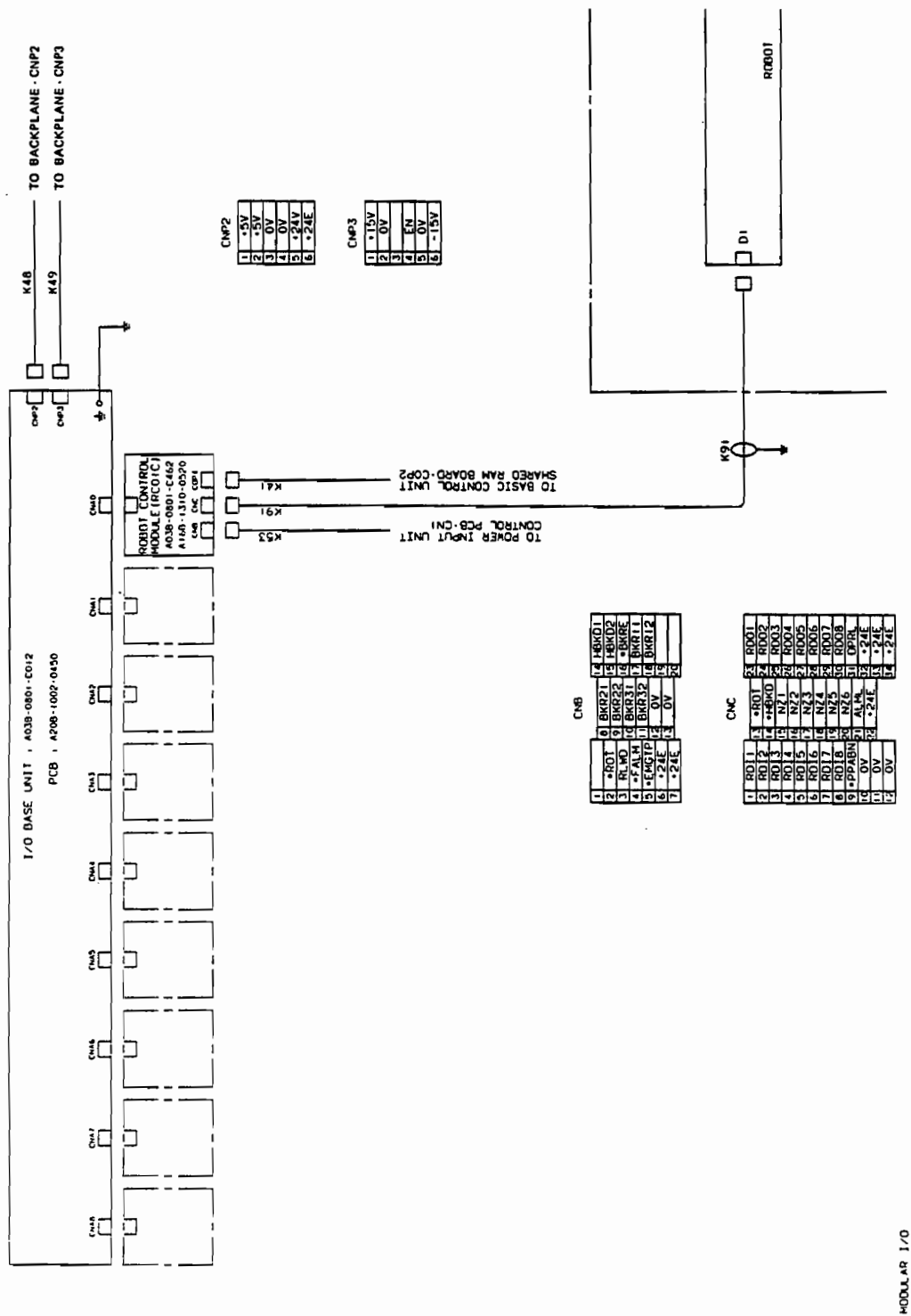


Fig. 1.1 (f) Internal connection diagram (S-10, Medium size cabinet)

Fig. 1.1 (g) Internal connection diagram (S-10, Medium size cabinet)





6-9

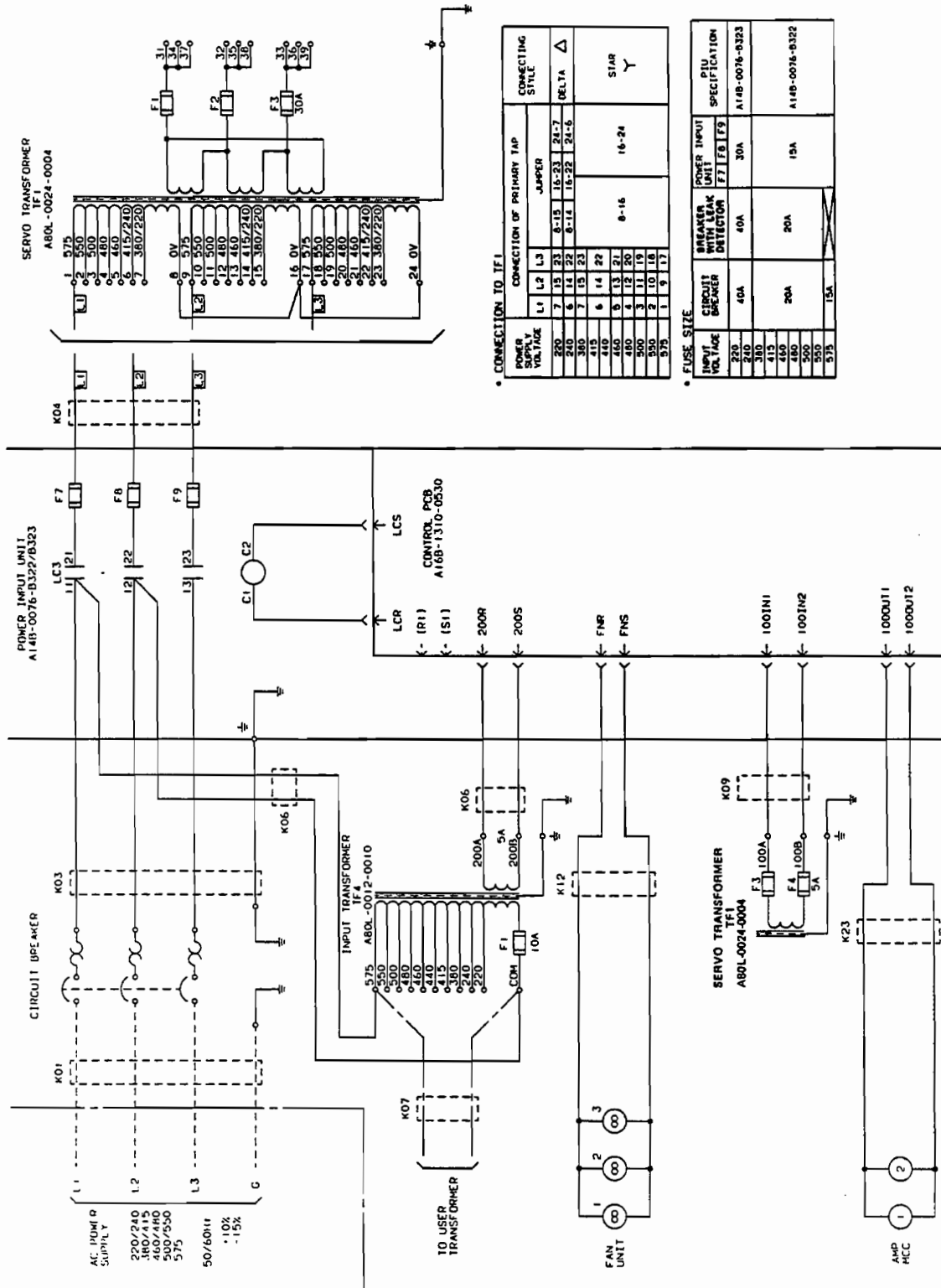


Fig. 1.1 (k) Internal connection diagram (S-10, Large size cabinet)

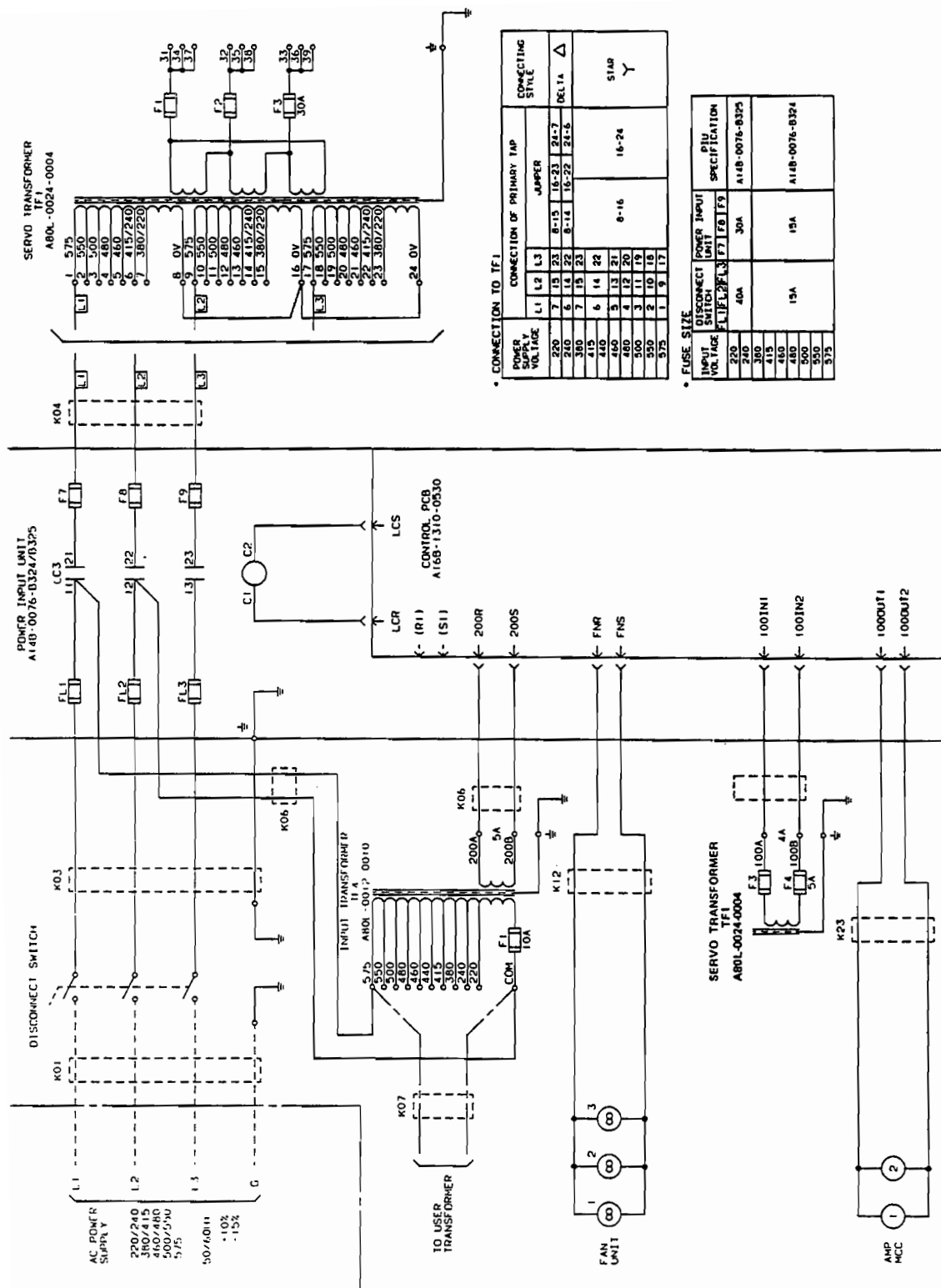


Fig. 1.1 (I) Internal connection diagram (S-10, Large size cabinet)

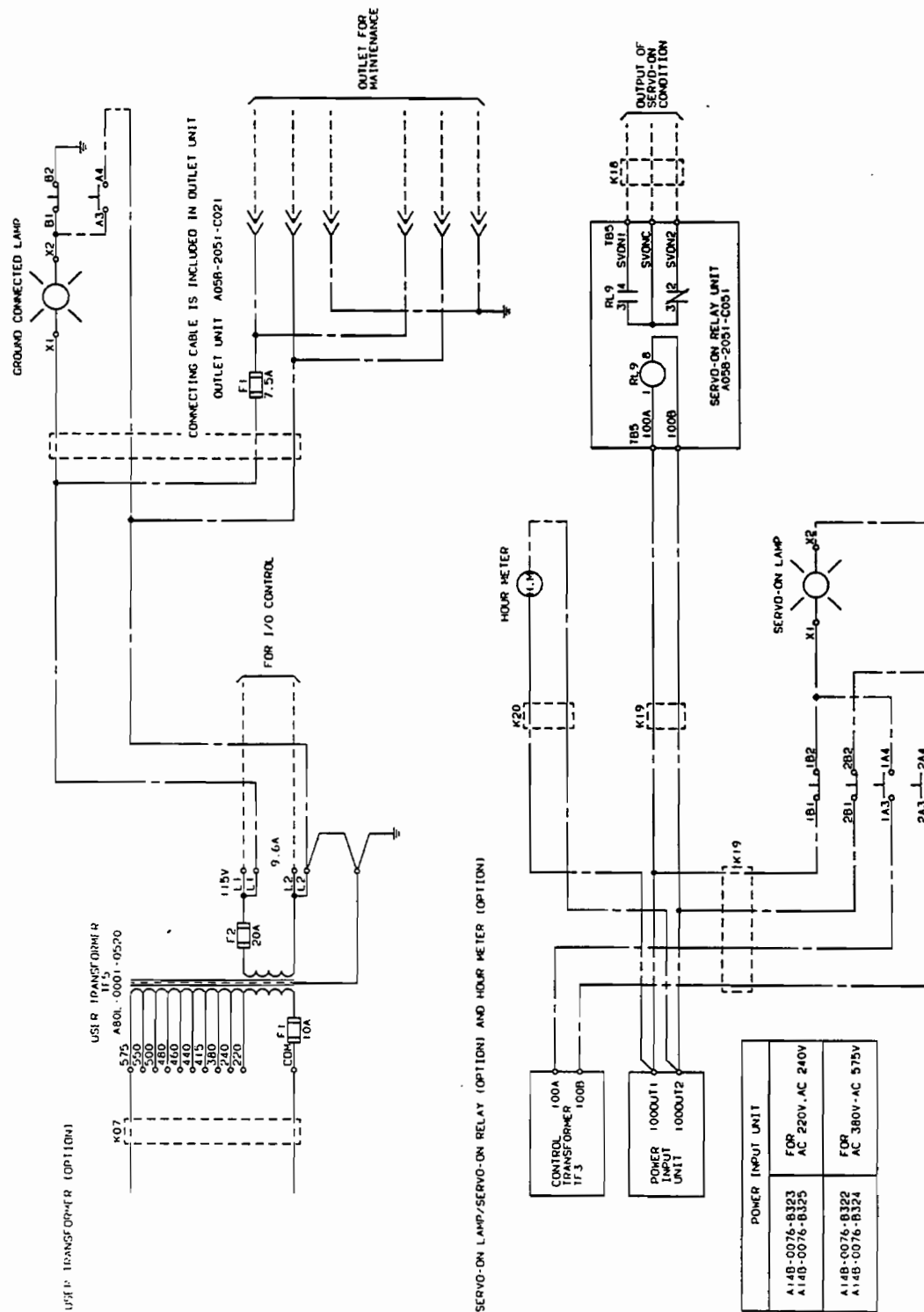
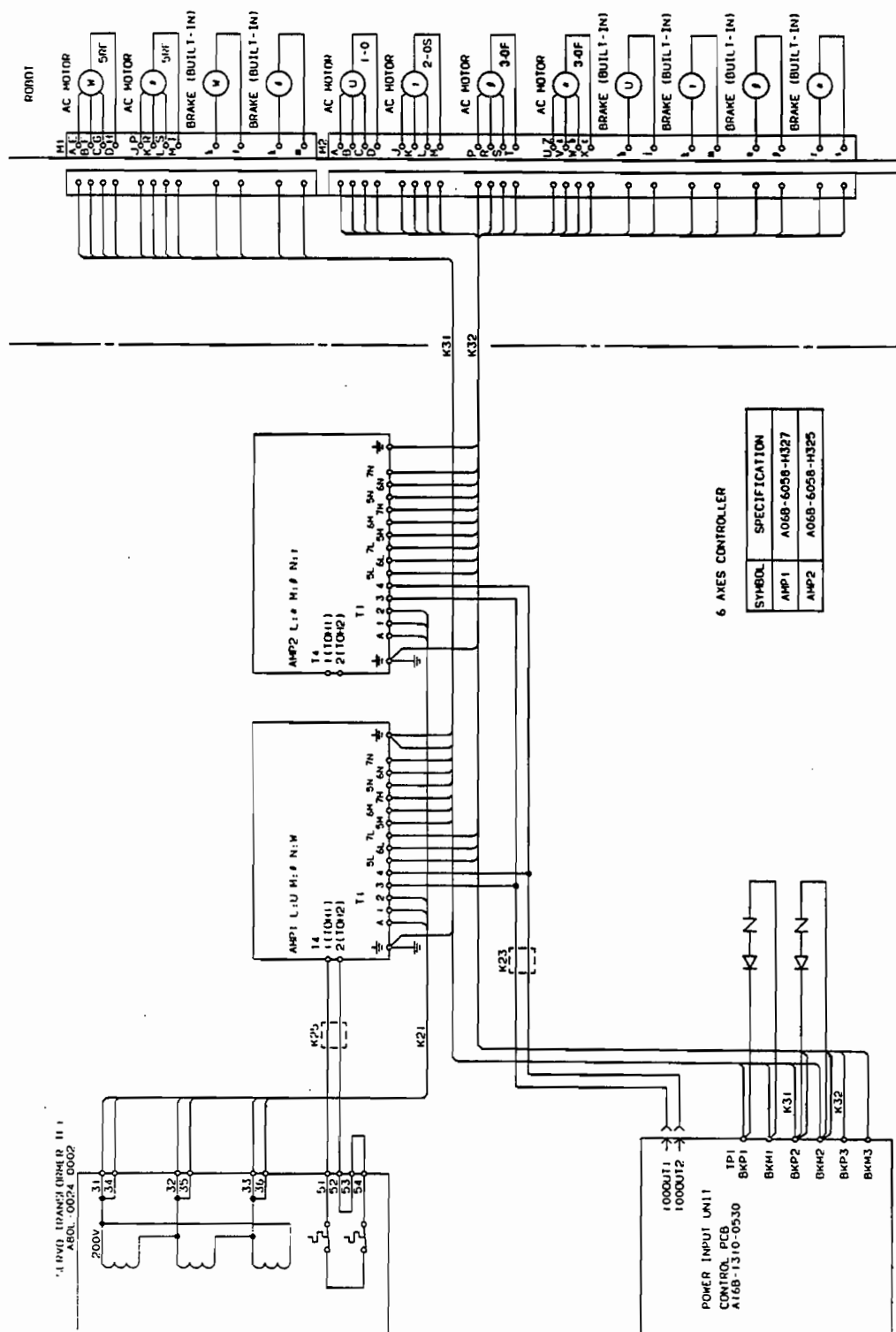


Fig. 1.1 (m) Internal connection diagram (S-10, Large size cabinet)



6 AXES CONTROLLER

SYMBOL	SPECIFICATION
AMP1	A068-6056-H327
AMP2	A068-6056-H325

Fig. 1.1 (n) Internal connection diagram (S-10, Large size cabinet)

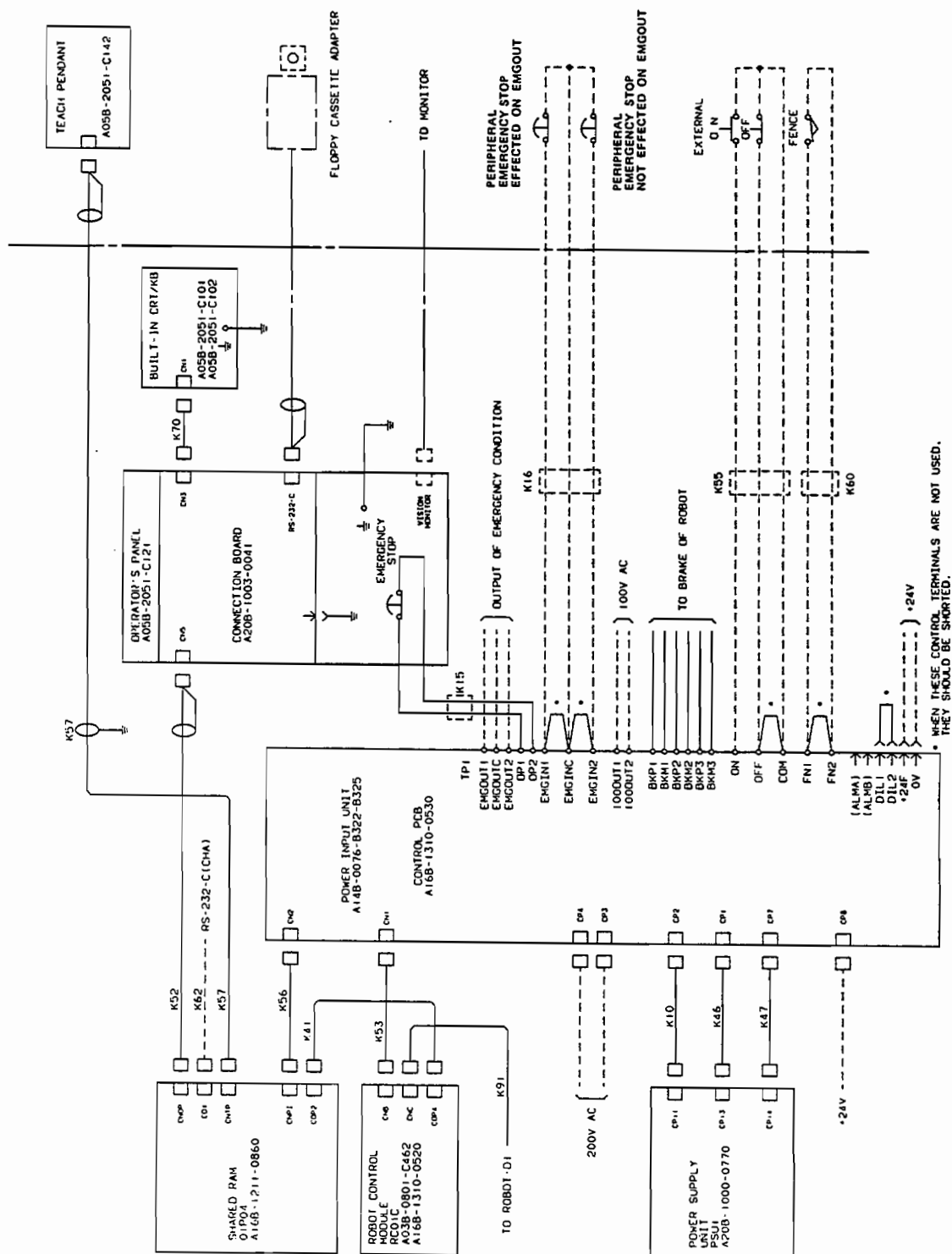
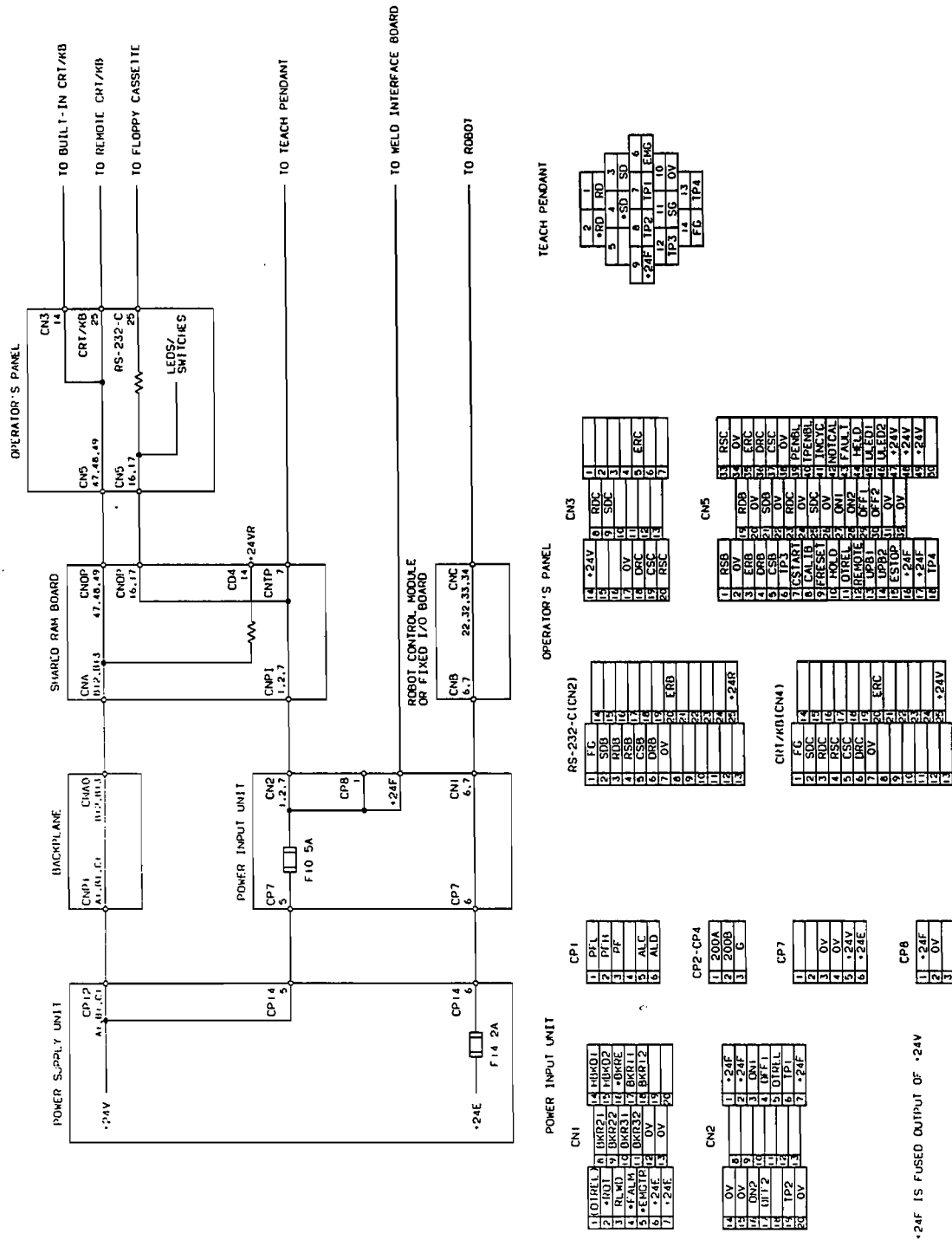


Fig. 1.1 (o) Internal connection diagram (S-10, Large size cabinet)



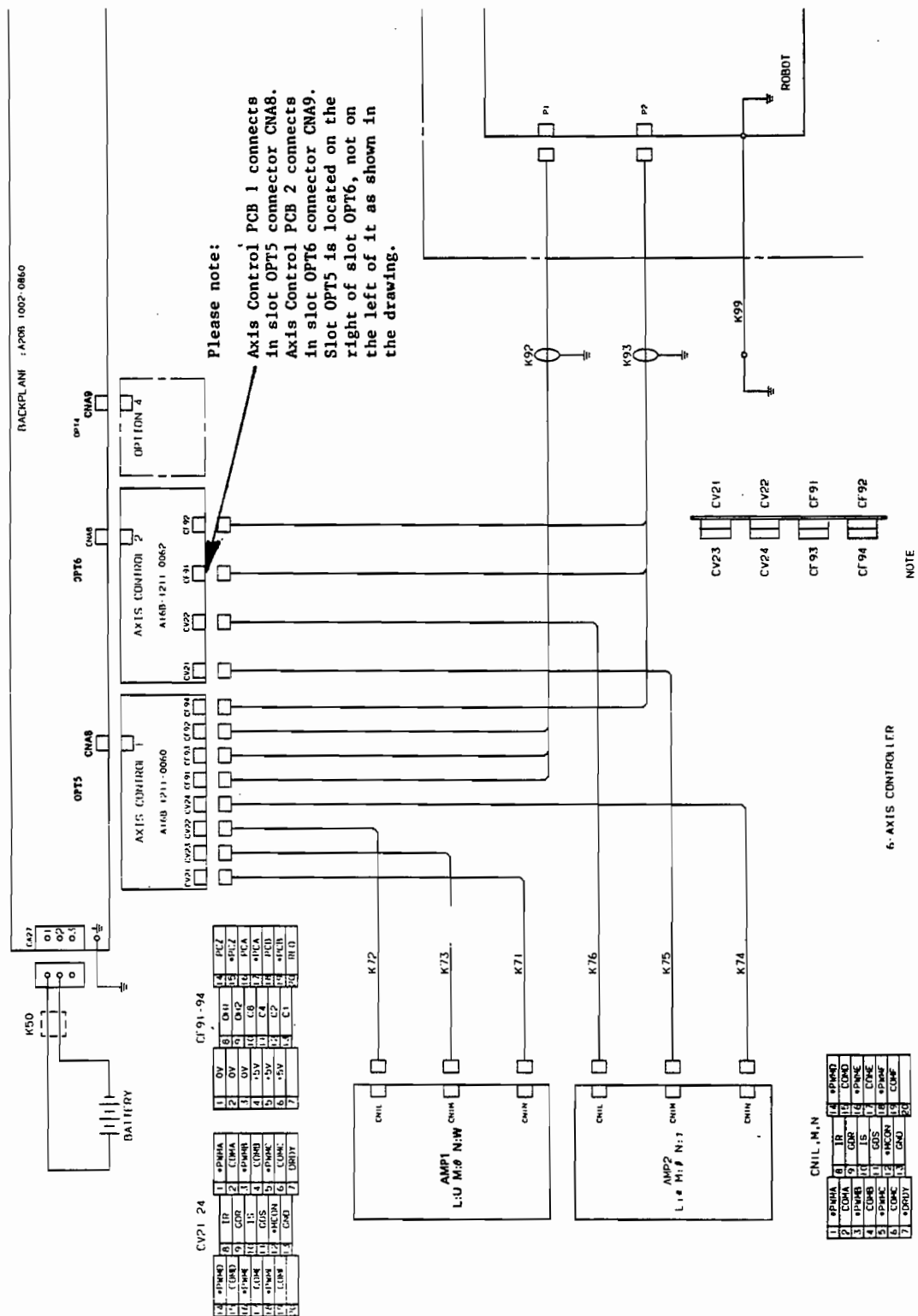


Fig. 1.1 (r) Internal connection diagram (S-10, Large size cabinet)



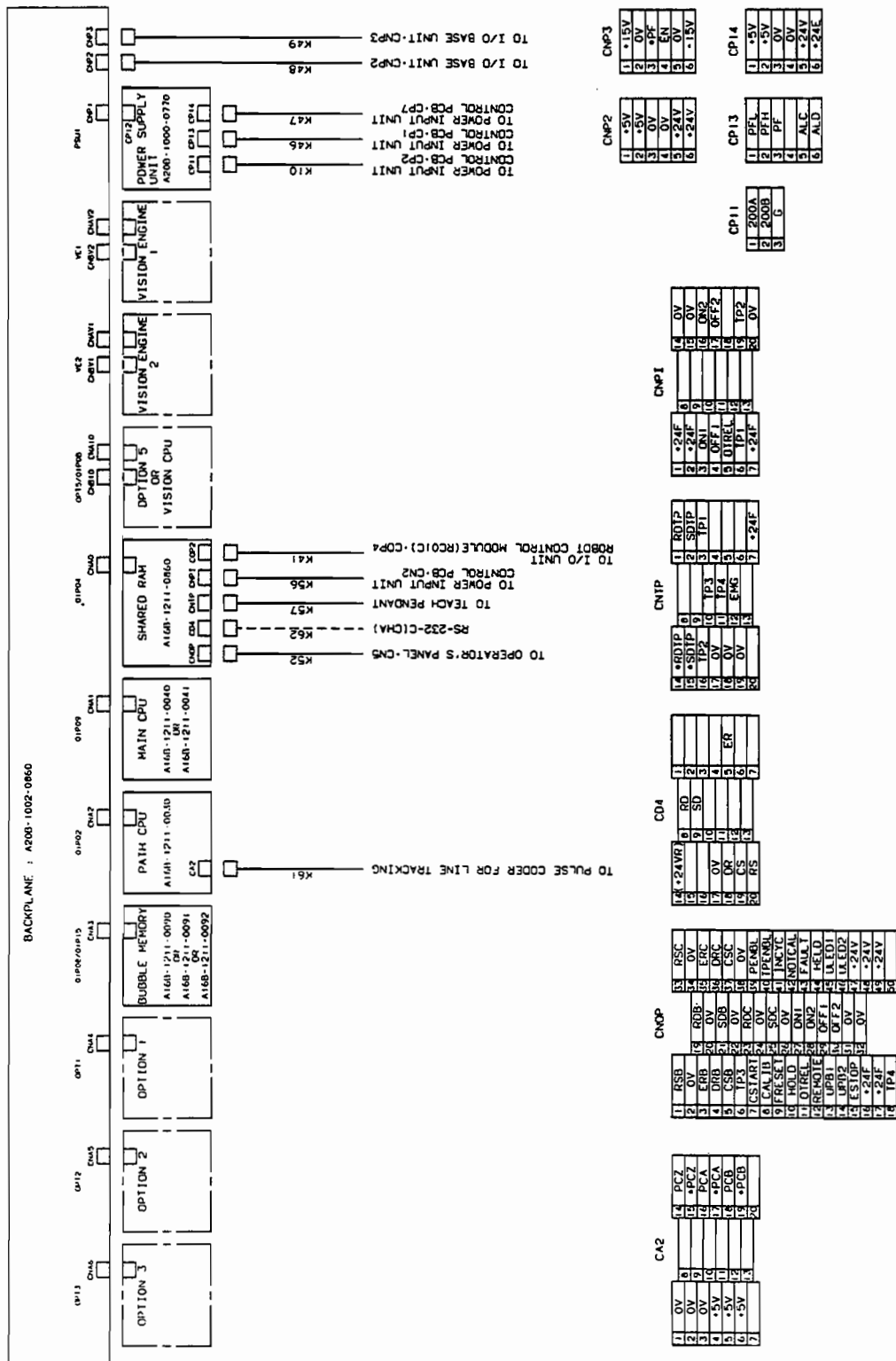
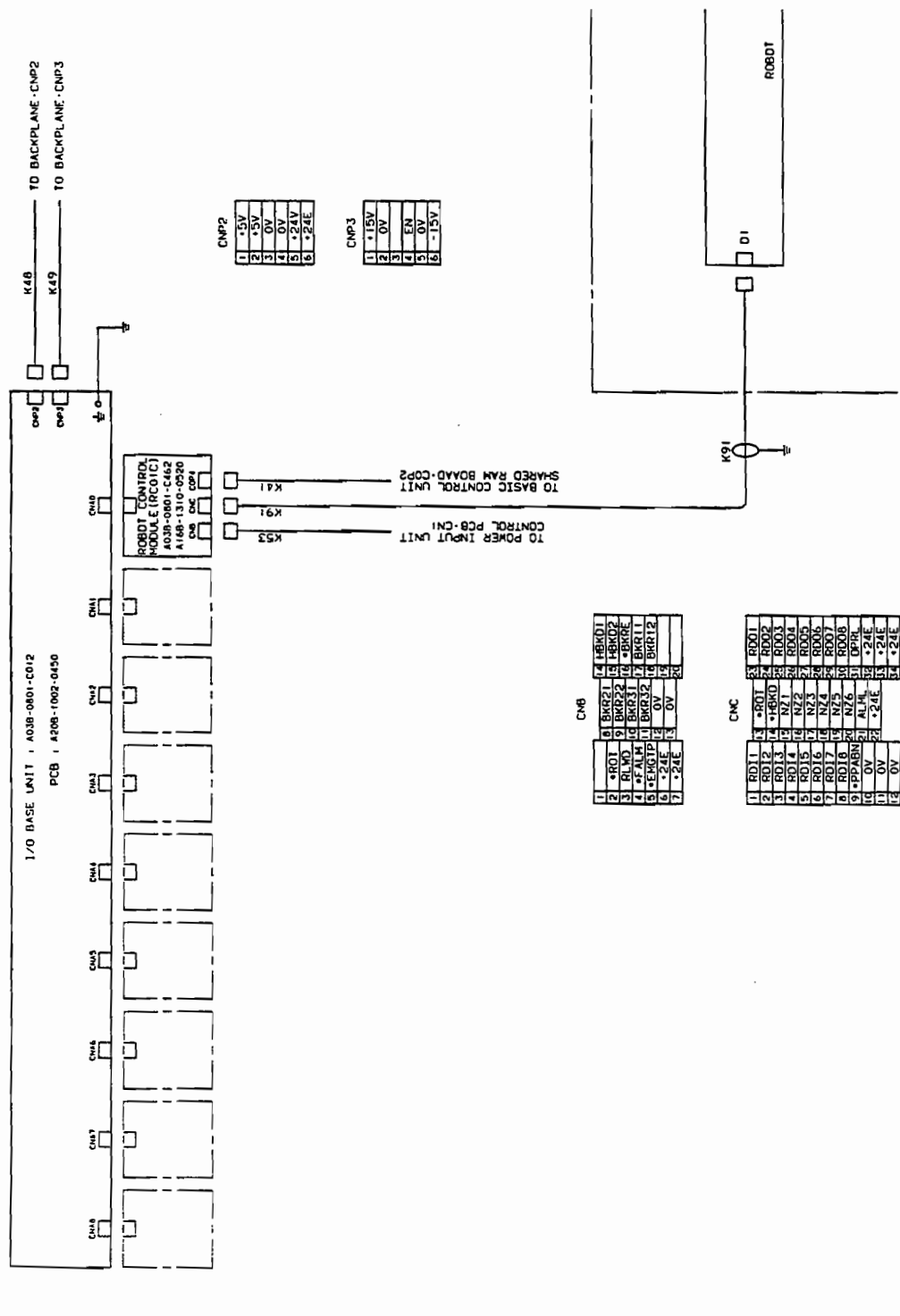


Fig. 1.1 (t) Internal connection diagram (S-10, Large size cabinet)



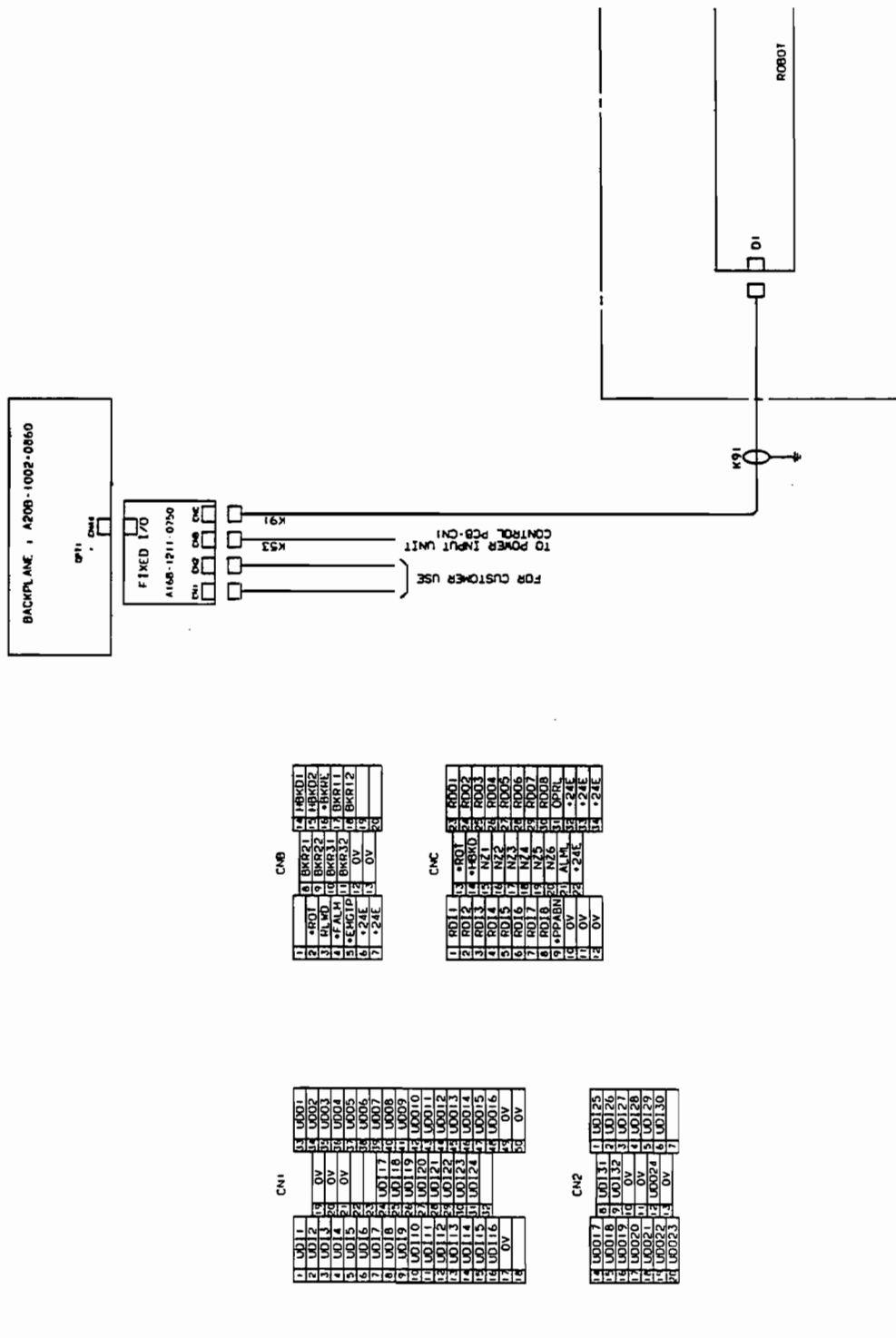


Fig. 1.1 (v) Internal connection diagram (S-10, Large size cabinet)

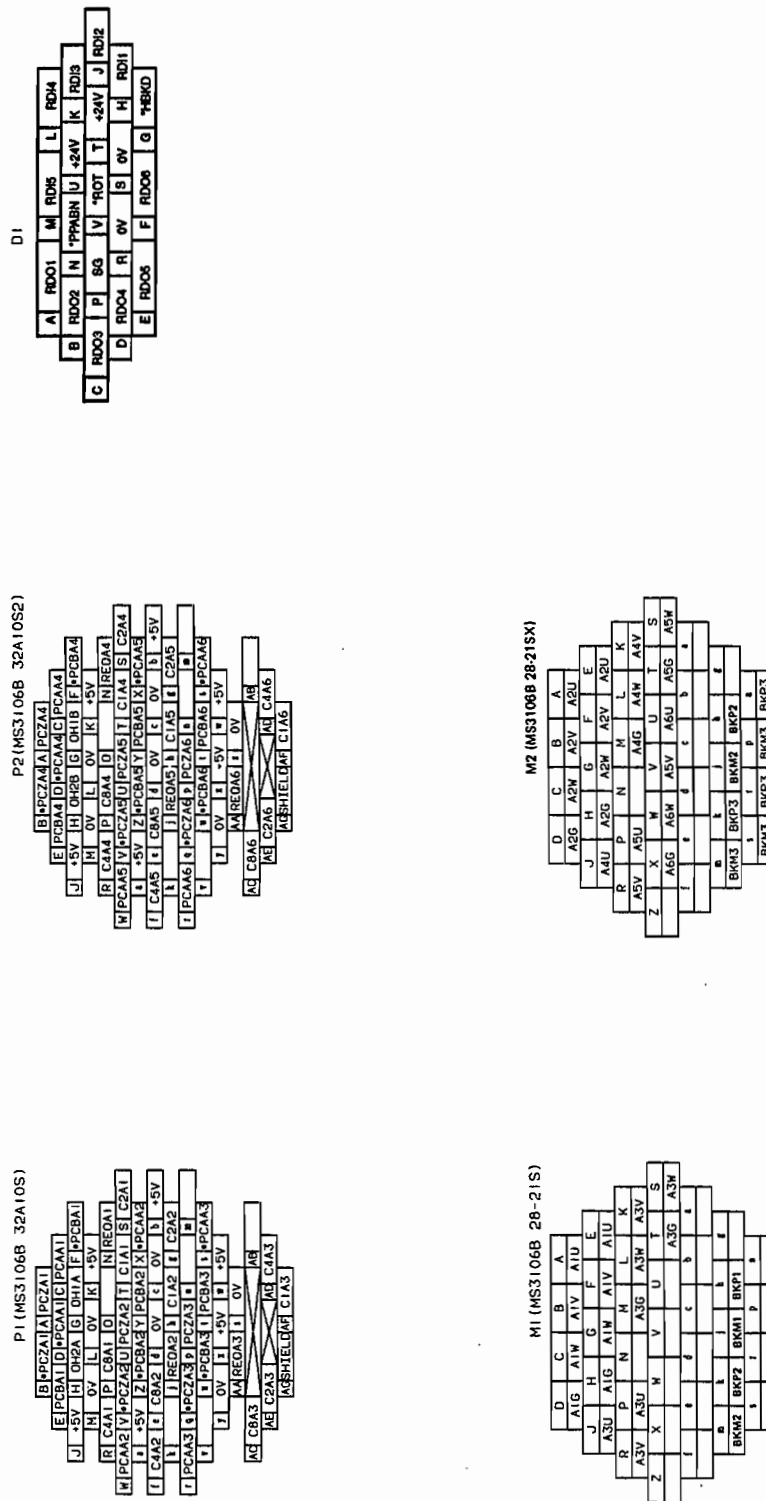


Fig. 1.1 (w) Internal connection diagram (S-10, Large size cabinet)

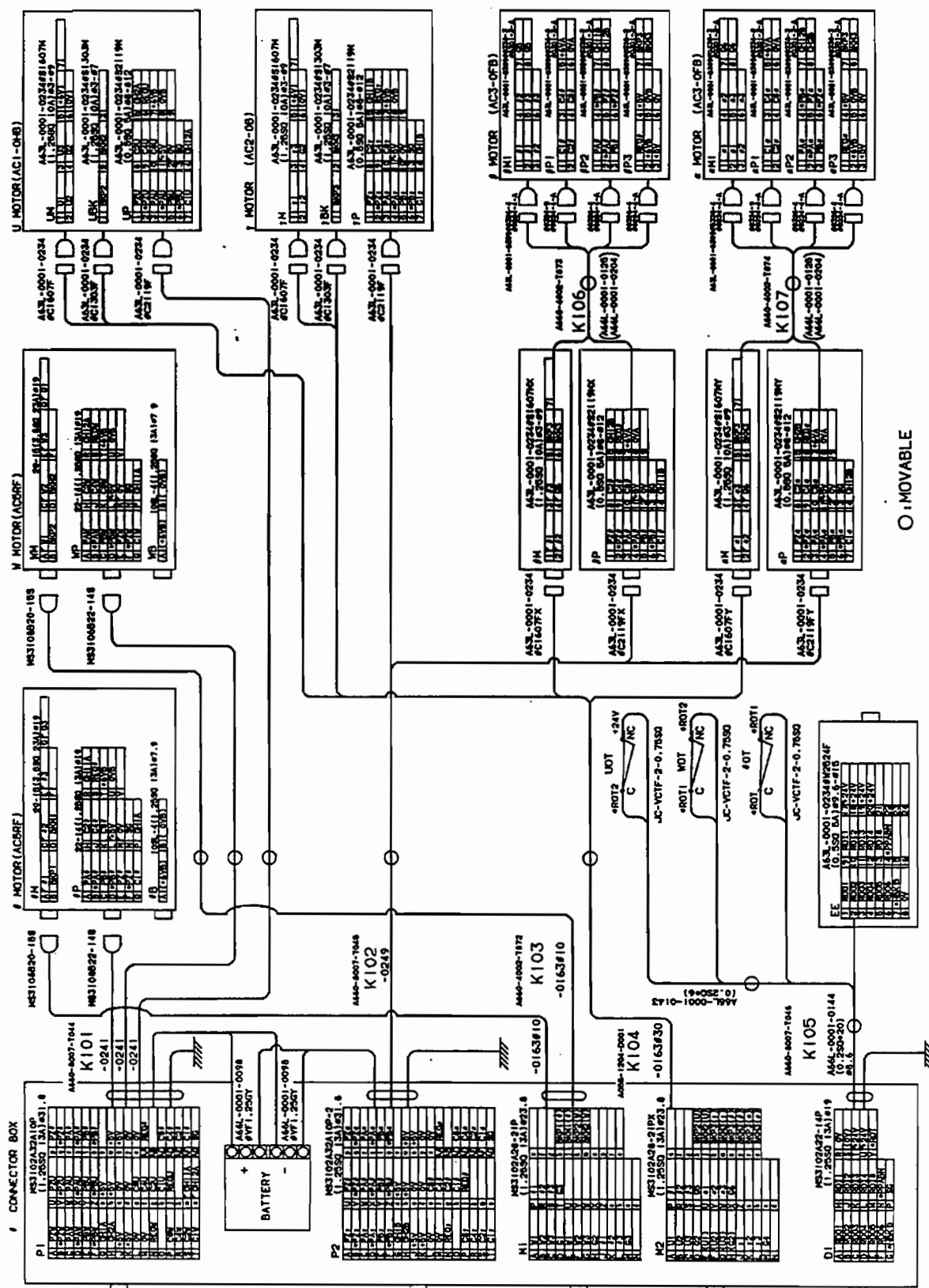


Fig. 1.1 (x) Internal connection diagram (S-10)

1.2 S-700

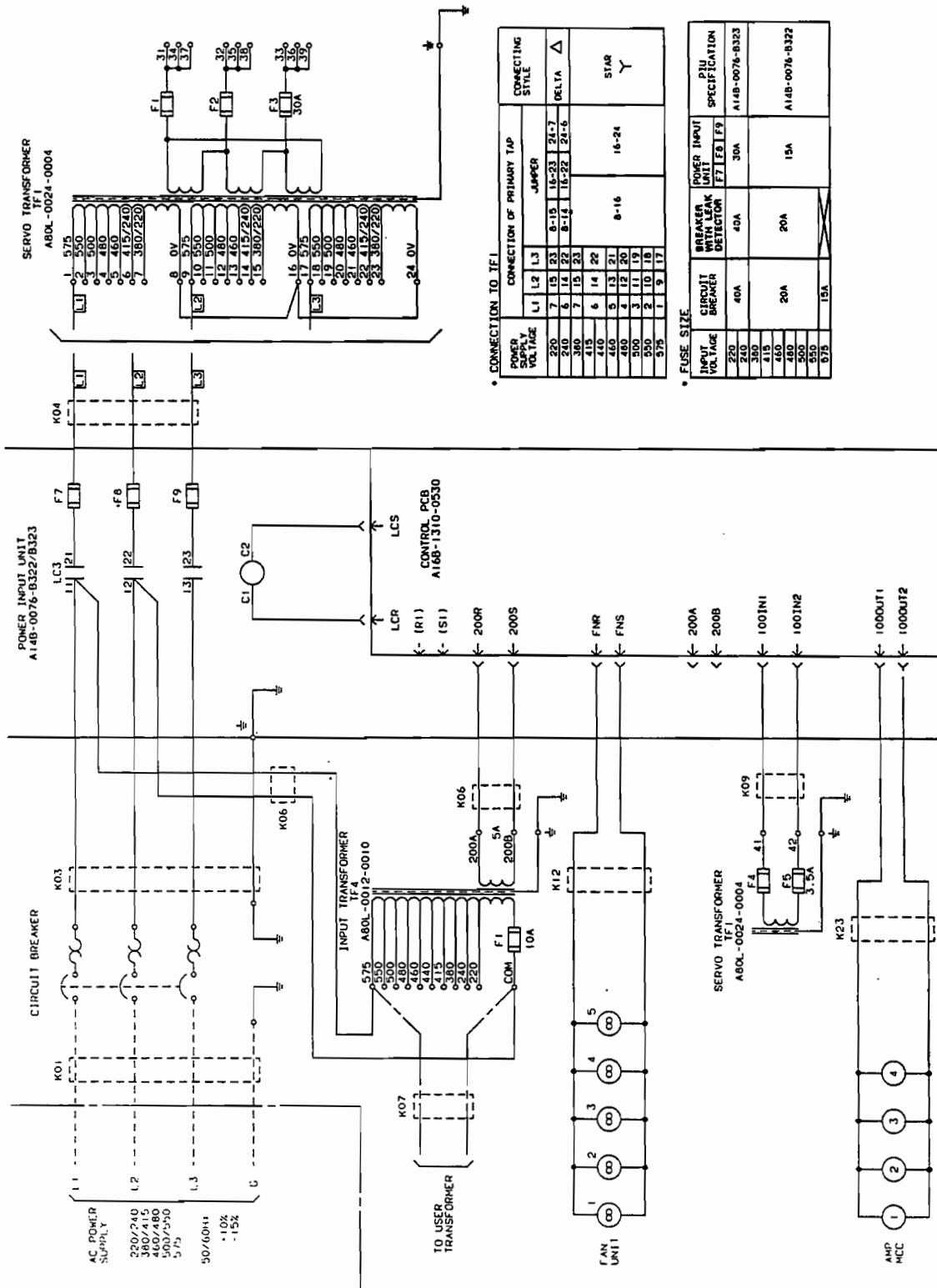


Fig. 1.2 (a) Internal connection diagram (S-700)

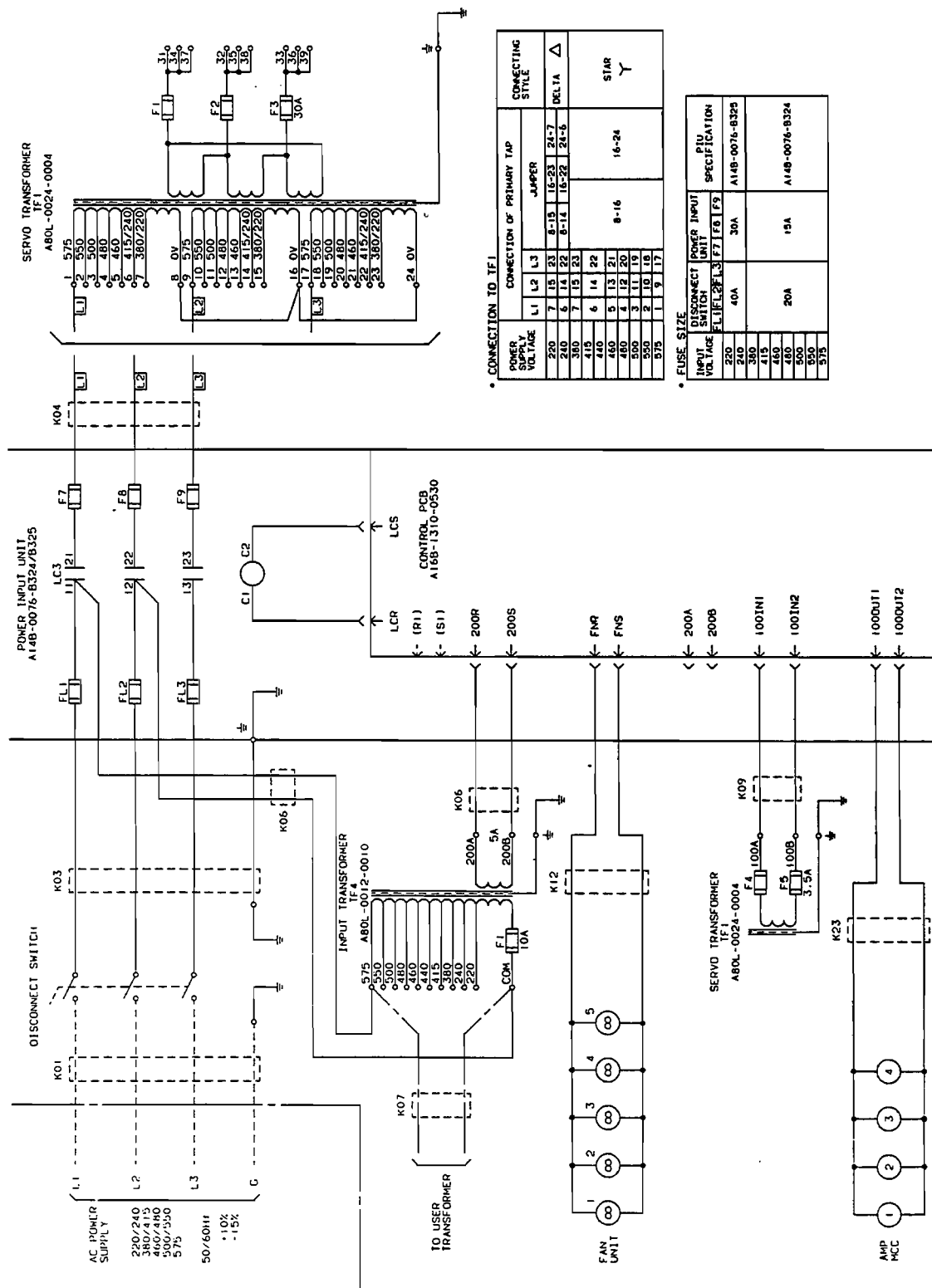


Fig. 1.2 (b) Internal connection diagram (S-700)

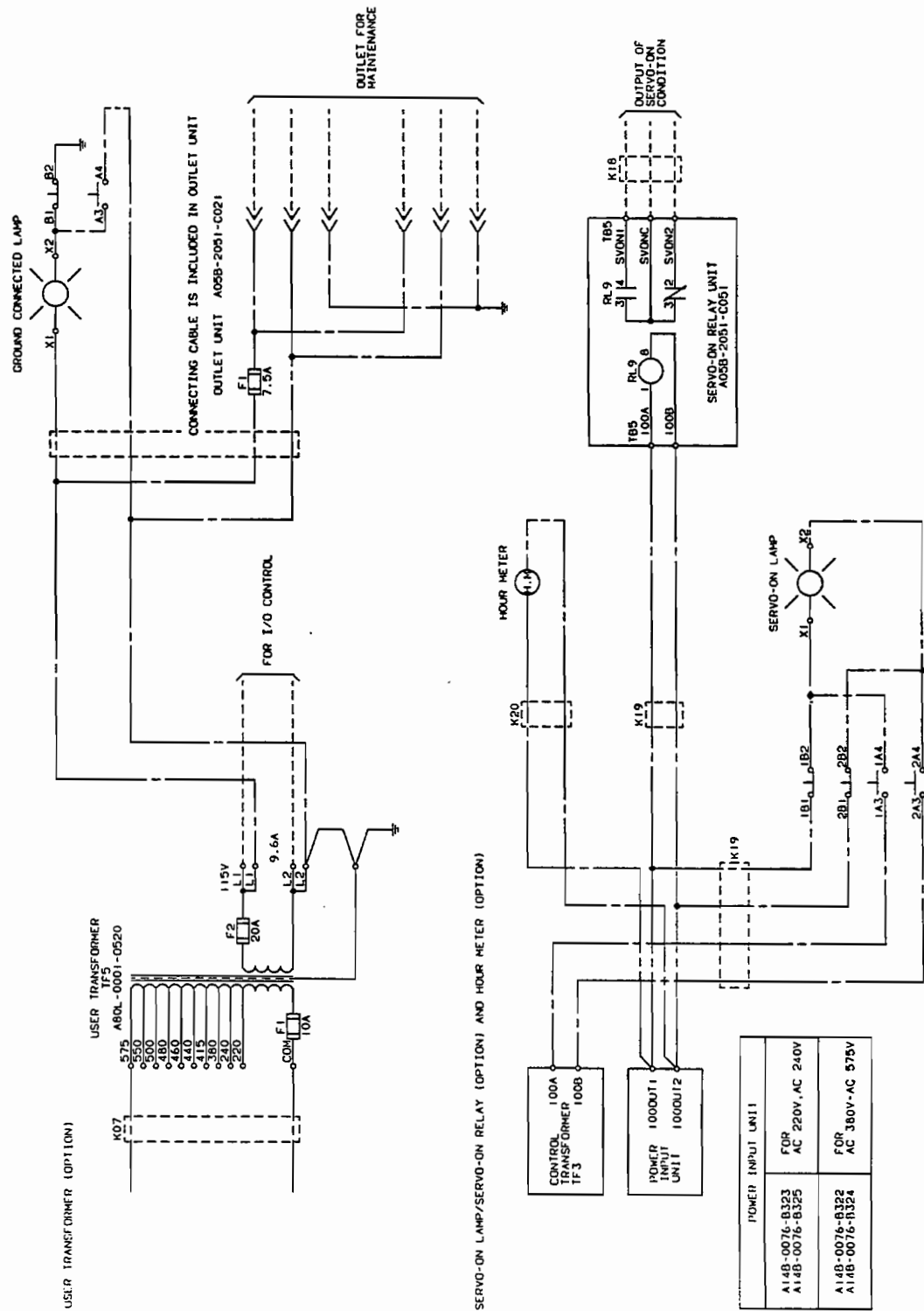


Fig.1.2 (c) Internal connection diagram (S-700)

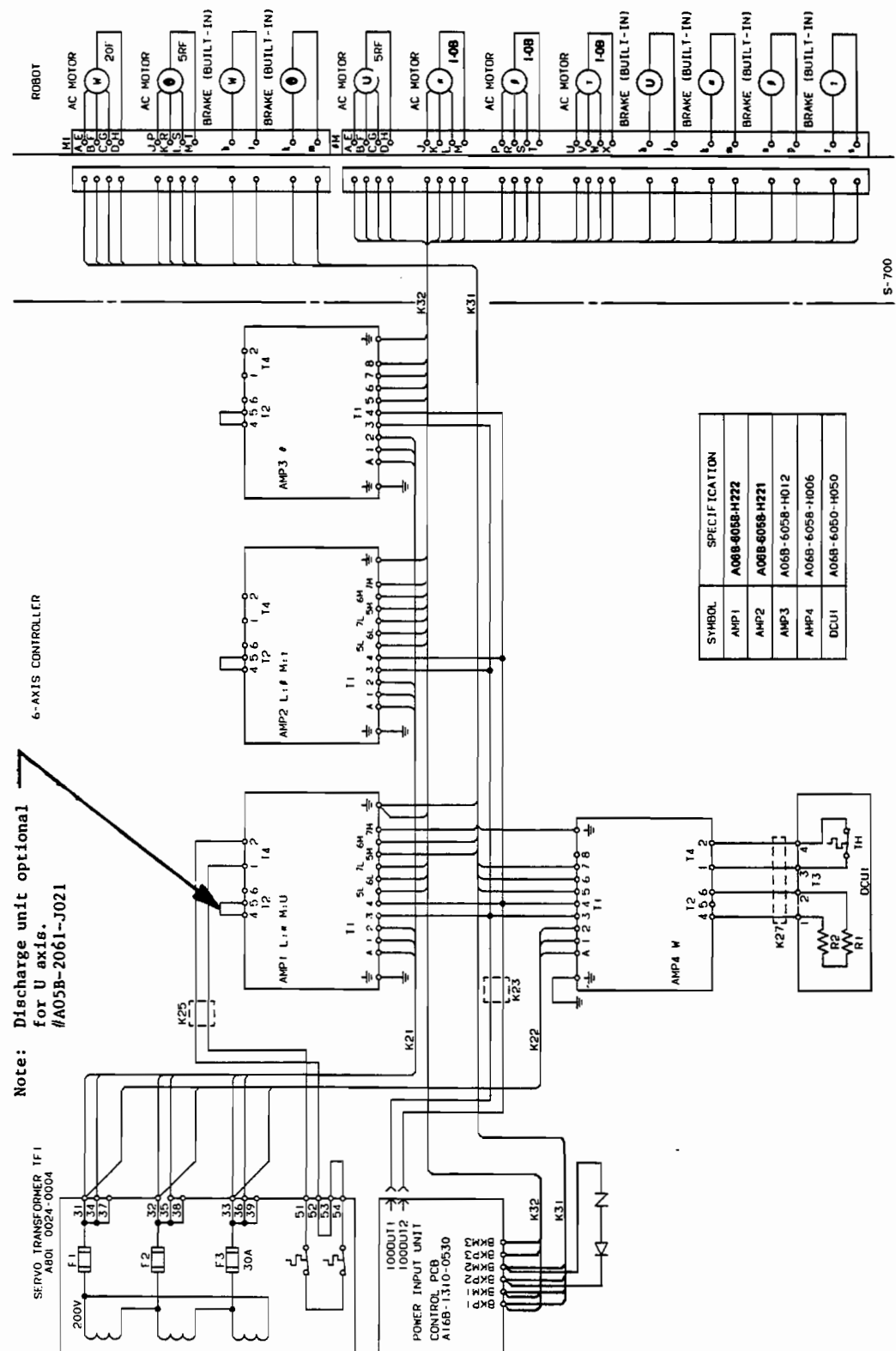


Fig. 1.2 (d) Internal connection diagram (S-700)

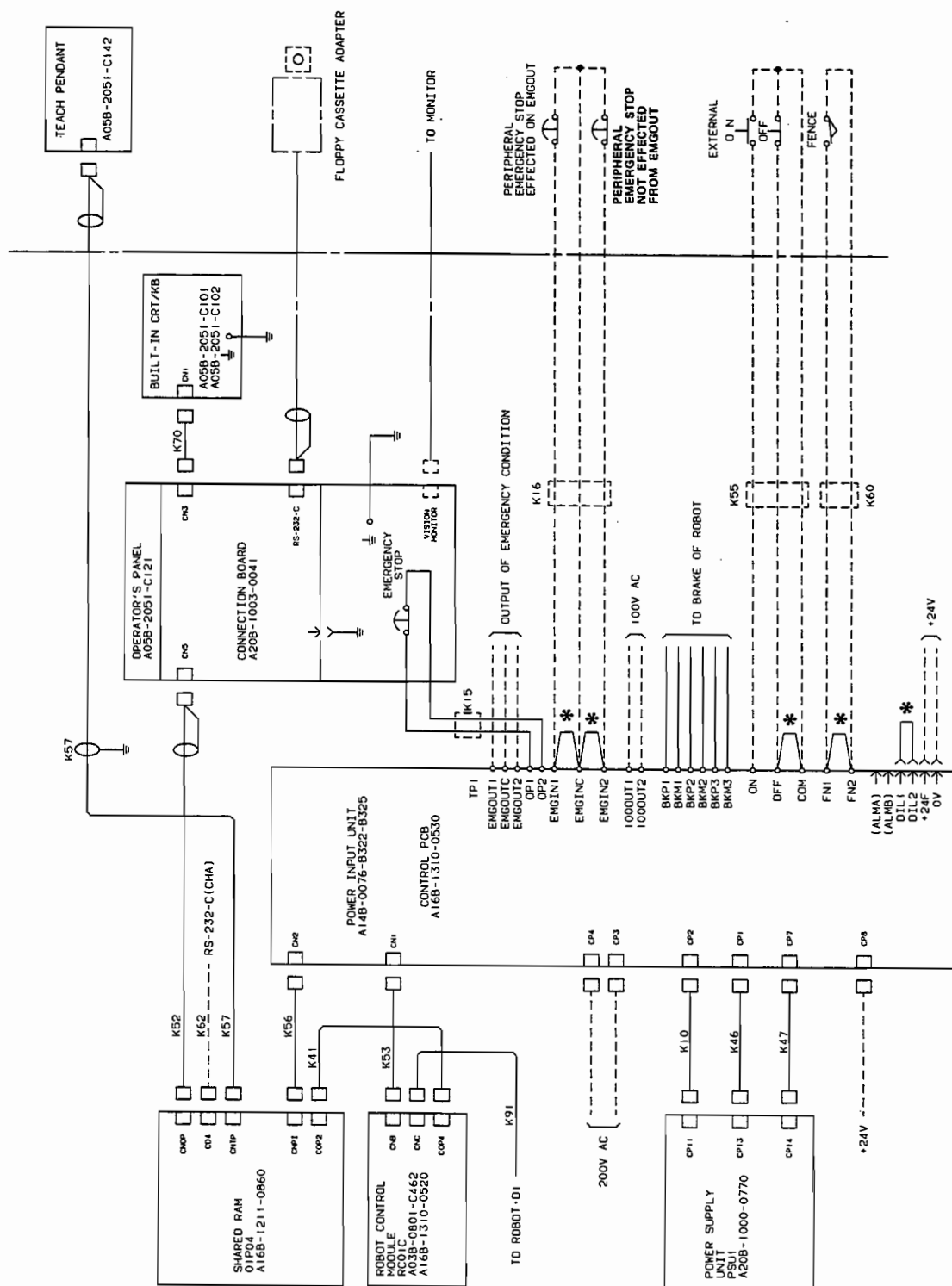


Fig. 1.2 (e) Internal connection diagram (S-700)

* When these control terminals are not used, they should be shorted.

Fig. 1.2 (g) Internal connection diagram (S-700)

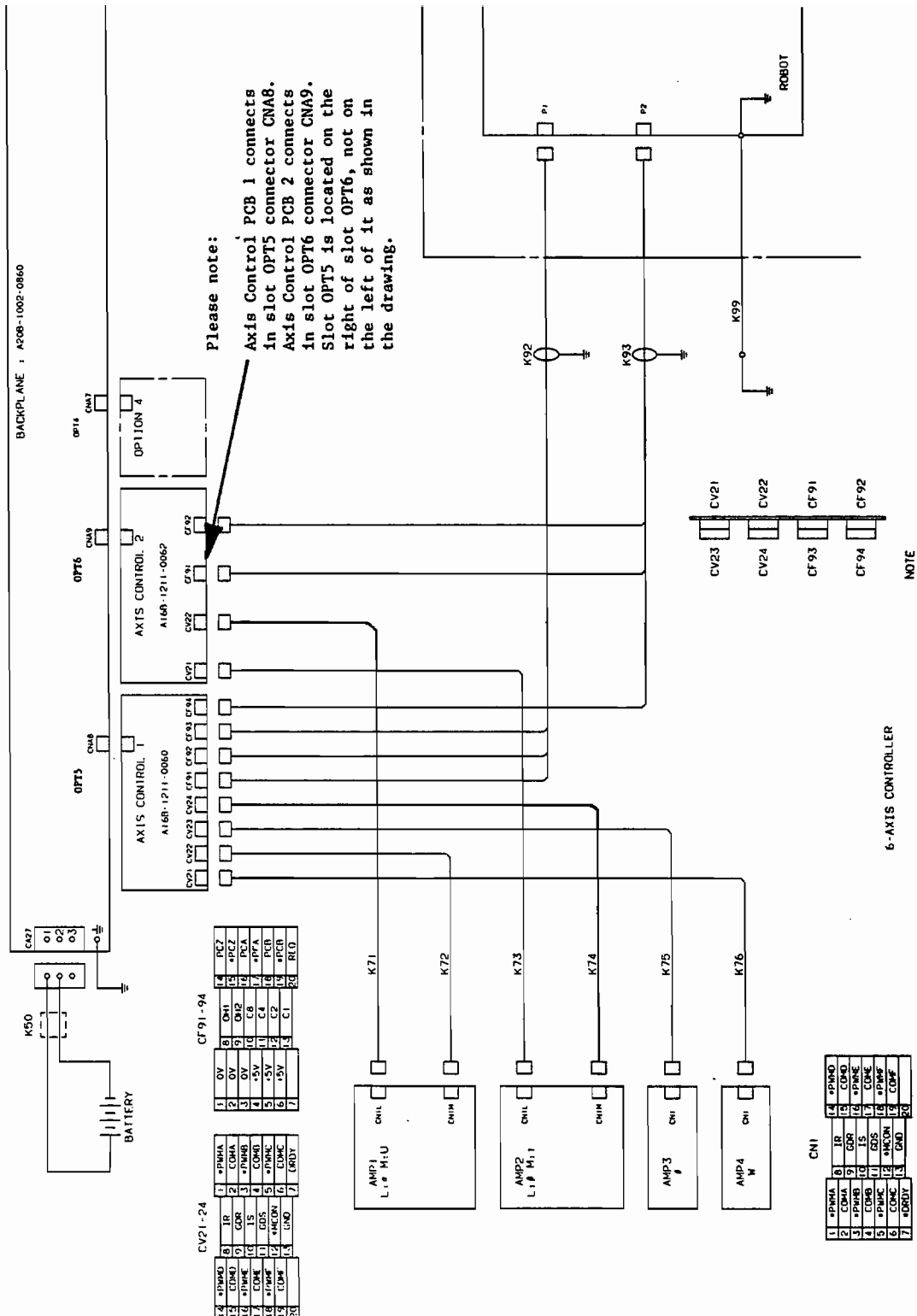


Fig. 1.2 (h) Internal connection diagram (S-700)

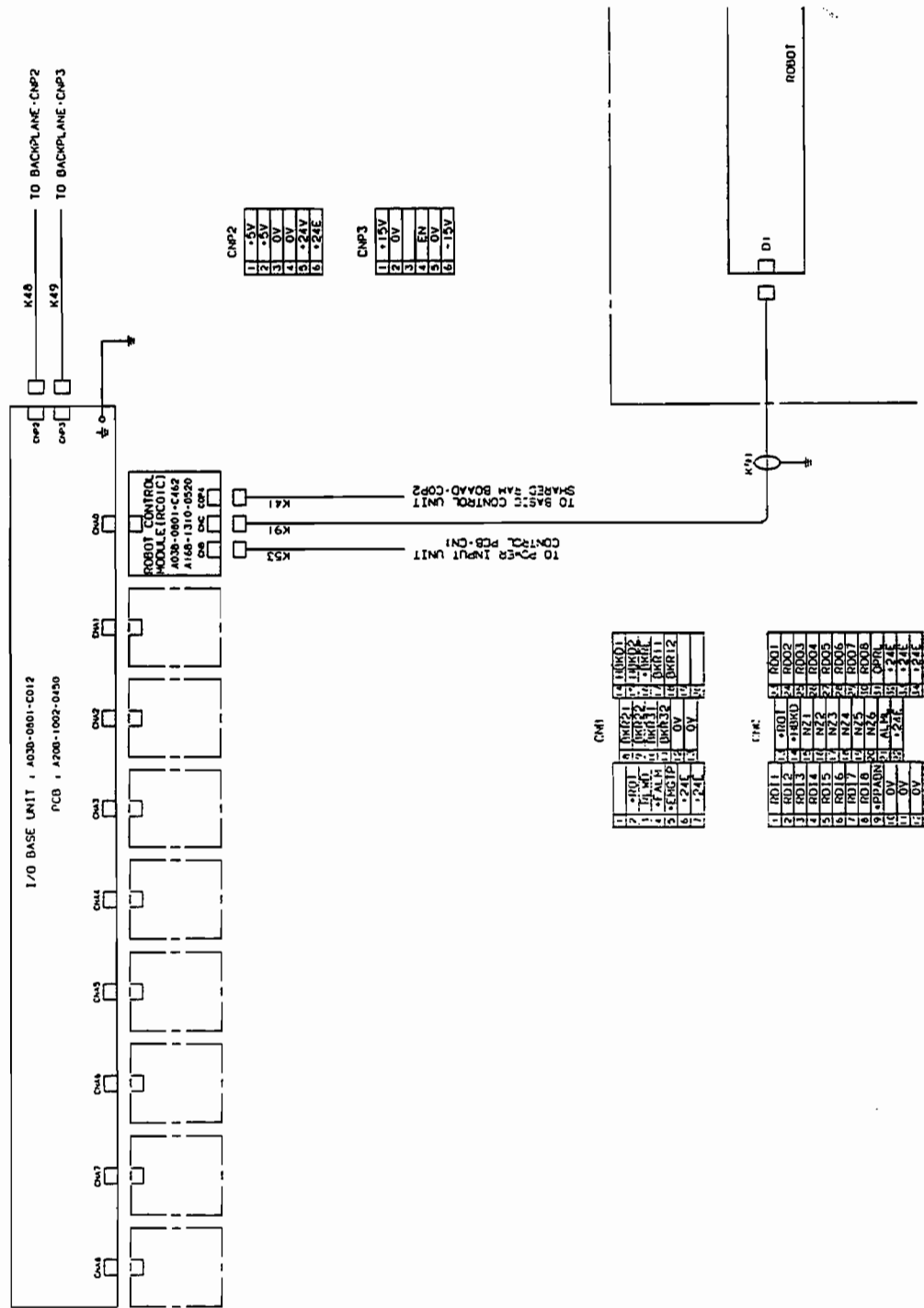


Fig. 1.2 (j) Internal connection diagram (S-700)



6-35

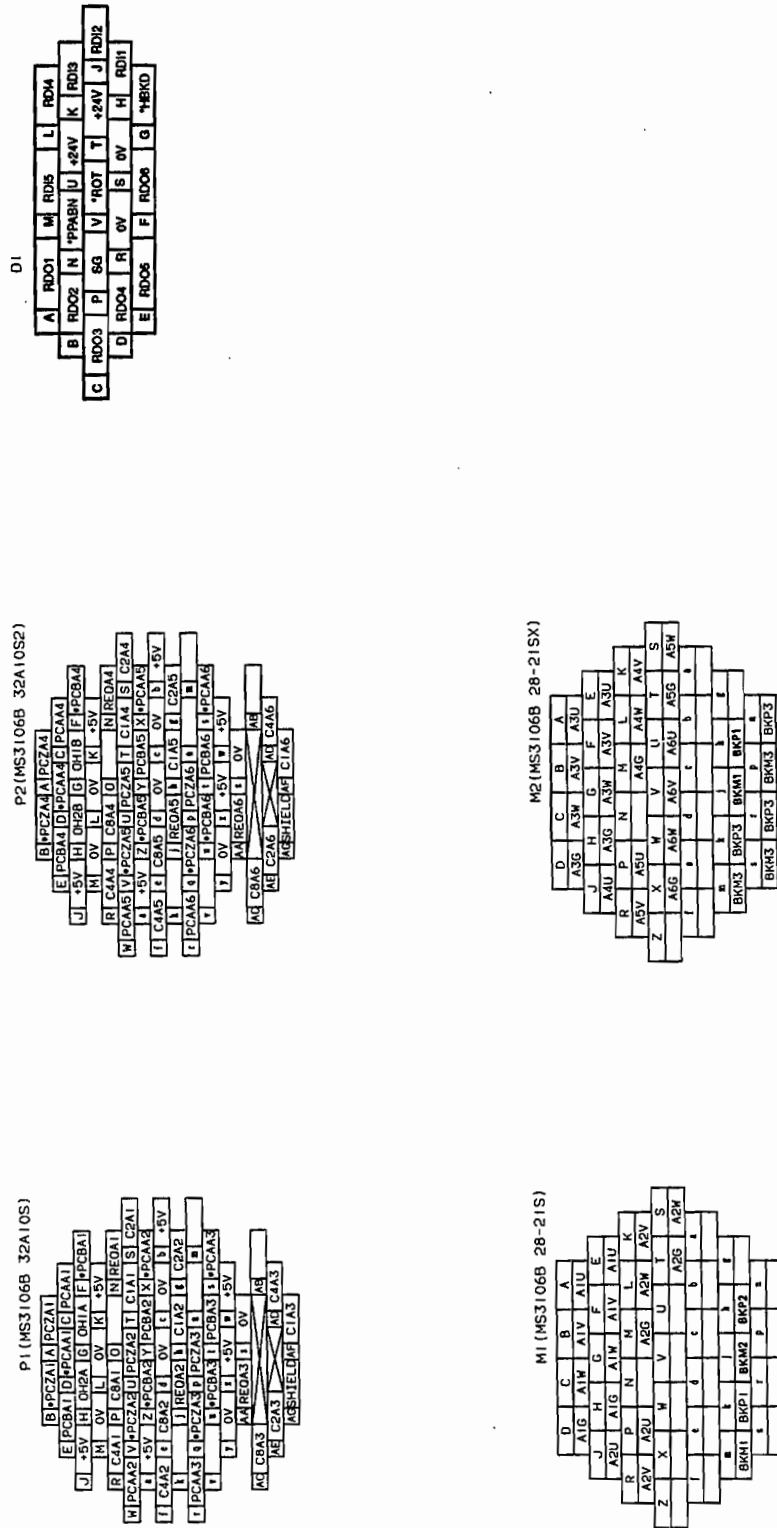


Fig. 1.2 (i) Internal connection diagram (S-700)

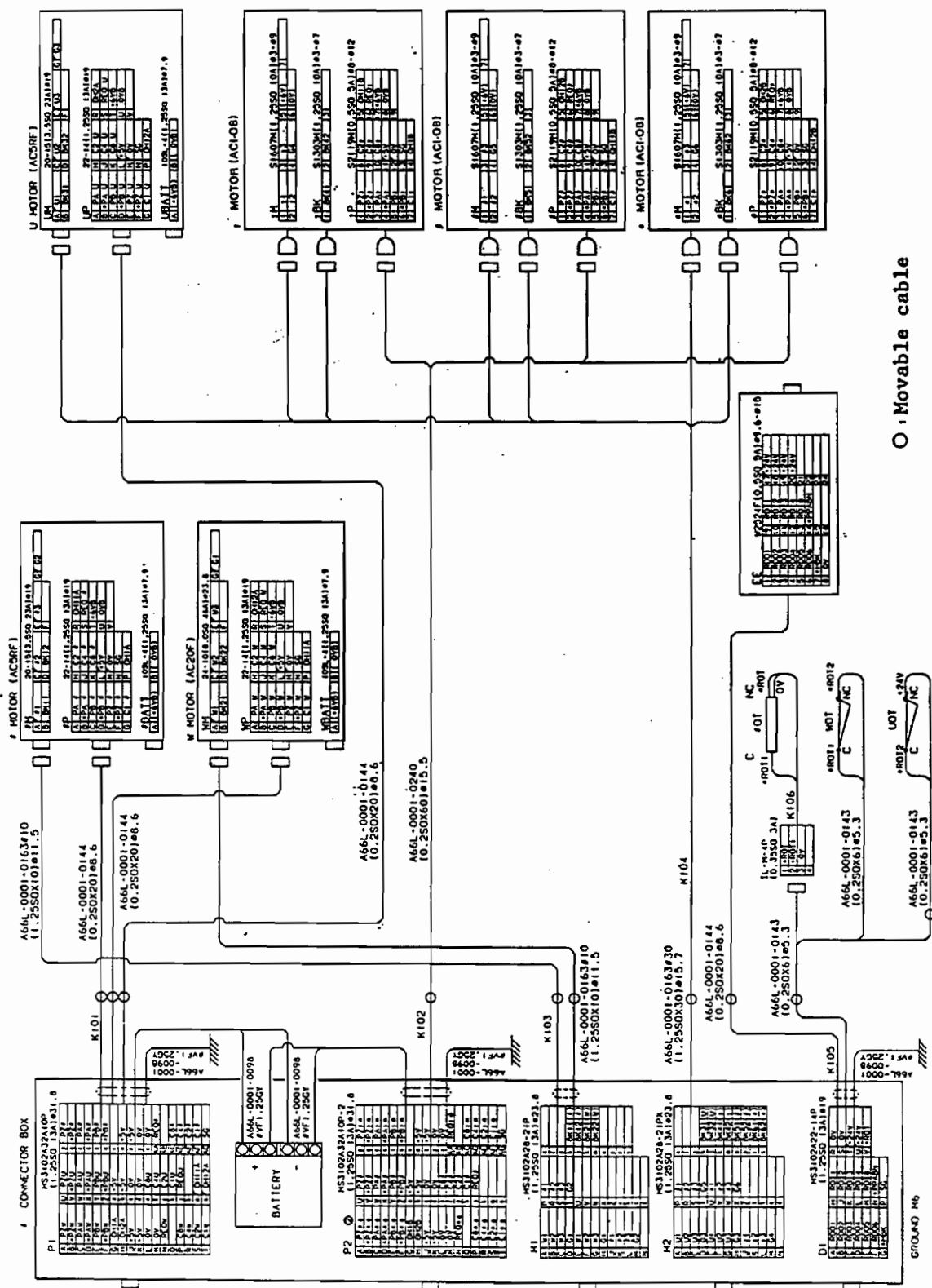


Fig. 1.2 (m) Internal connection diagram (S-700)

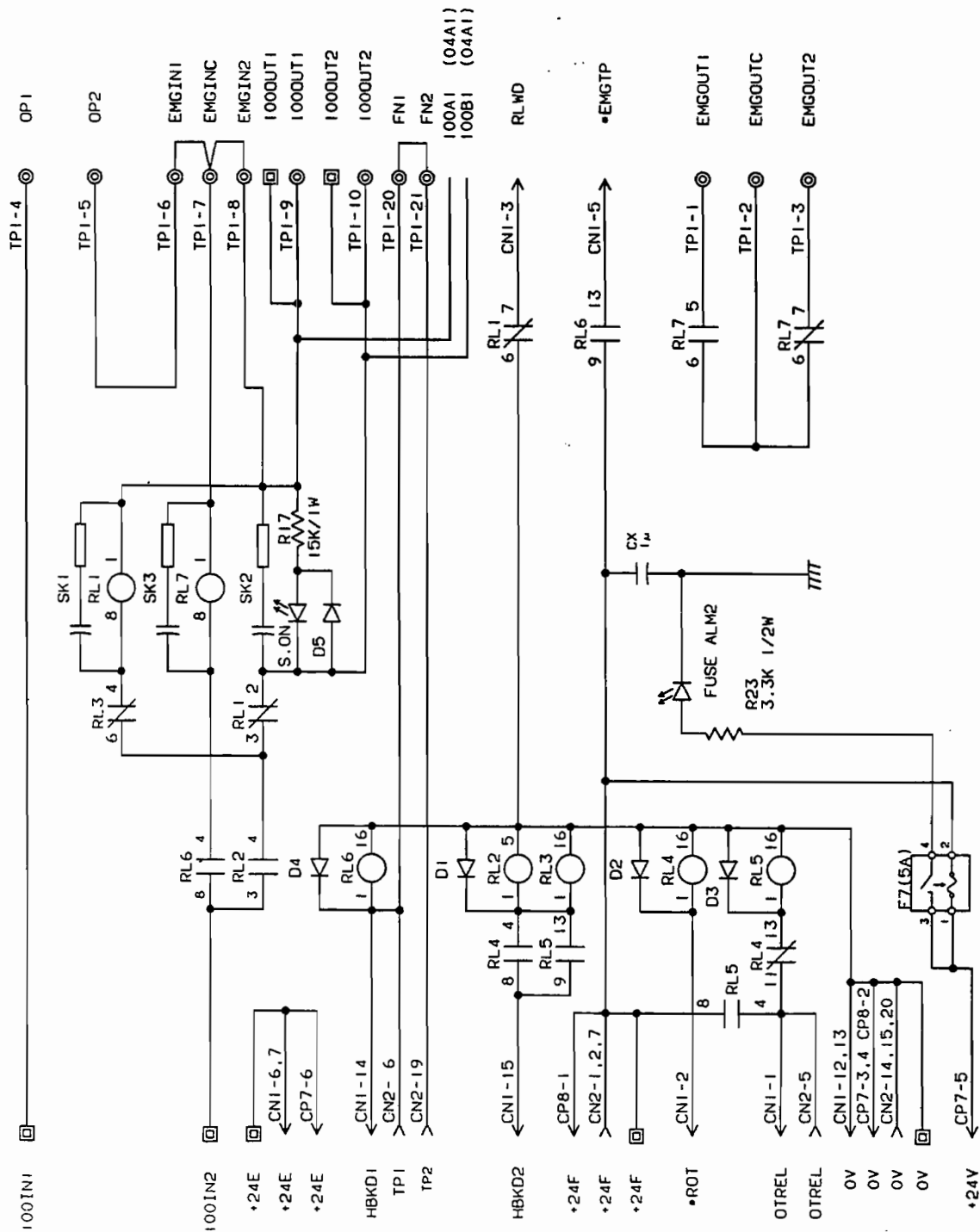


Fig. 1.3 (c) Power input unit PCB circuit diagram

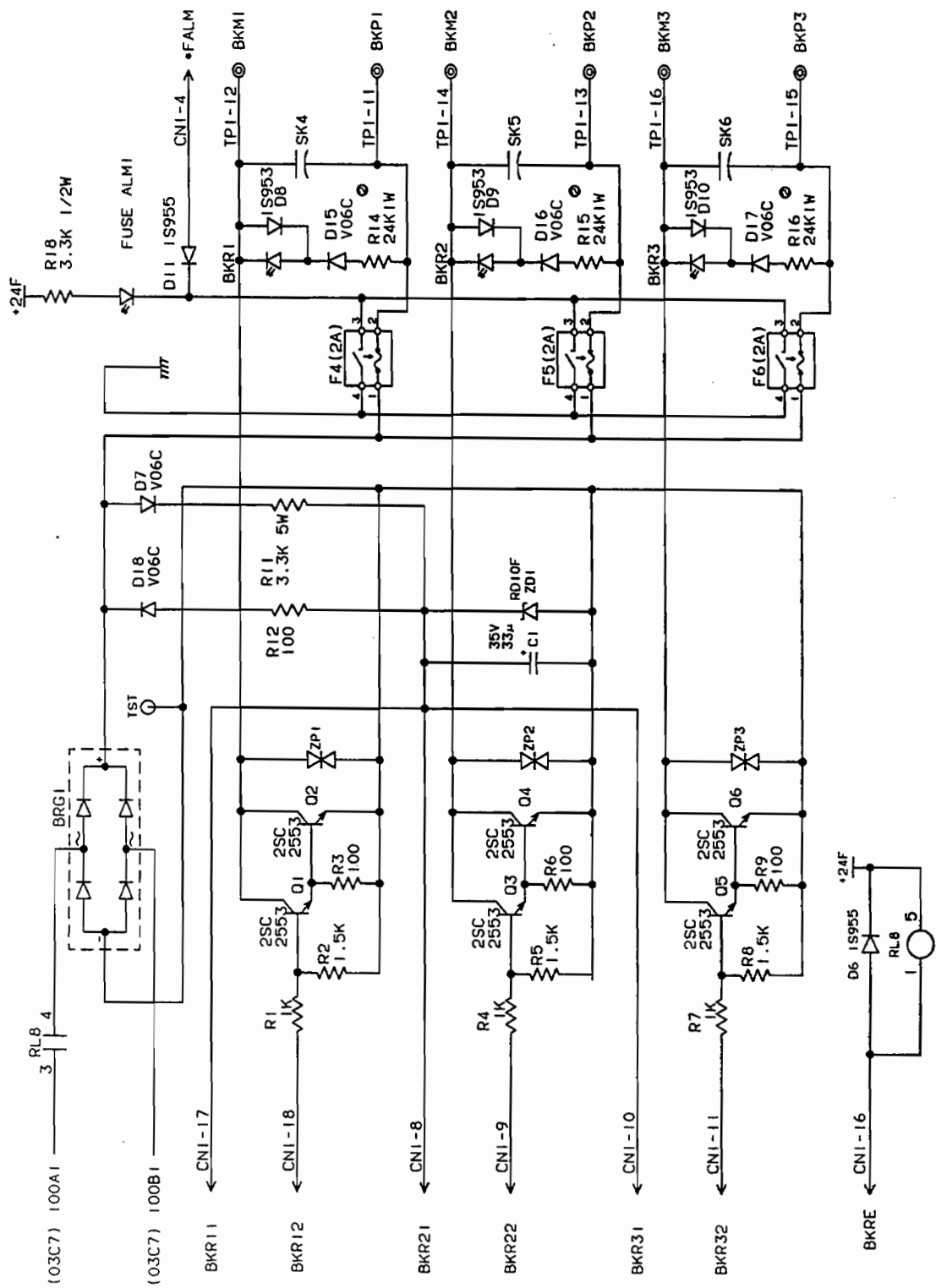


Fig. 1.3 (d) Power input unit PCB circuit diagram

APPENDIX 2 CABLE SPECIFICATIONS

1) S-10 controller (Medium size cabinet)

Cable No.	Specifications	Remarks		
K03	A660-8006-T915#L1R003	CB - PIU	Power input 1A (Breaker) (220/240 V)	
K04	A660-8006-T922#L1R503	PIU - TF1		
K06	A660-8006-T924#L1R003	TF4 - PIU		
K03	A660-8006-T914#L1R003	CB - PIU	Power input 1B (Breaker) (380 - 550 V)	
K04	A660-8006-T921#L1R503	PIU - TF1		
K06	B660-8006-T923#L1R003	TF4 - PIU		
K03	A660-8006-T916#L1R003	CB - PIU	Power input 1C (Breaker) (575 V)	
K04	A660-8006-T921#L1R503	PIU - TF1		
K06	B660-8006-T923#L1R003	TF4 - PIU		
K03	A660-8006-T918#L1R003	CB - PIU	Power input 2A (Breaker with leak detector) (220/240 V)	
K04	A660-8006-T922#L1R503	PIU - TF1		
K06	B660-8006-T924#L1R003	TF4 - PIU		
K03	A660-8006-T917#L1R003	CB - PIU	Power input 2B (Breaker with leak detector) (380 - 575 V)	
K04	A660-8006-T921#L1R503	PIU - TF1		
K06	A660-8006-T923#L1R003	TF4 - PIU		
K12	A660-8006-T658	PIU - FAN	AC power connection	
K09	A660-8006-T927#L2R203	TF3 - PIU		
K20	A660-8006-T929#L2R403	PIU - HM	Hour meter	
K21	A660-8006-T804#L900R0	TF1 - AMP	Servo amp. connection	
K23	A660-8006-T727#LE	PIU - AMP		
K71	A660-2003-T230#L1R703KA	01P05 - AMP1		
K72	A660-2003-T342#L1R803AA	01P05 - AMP1		
K73	A660-2003-T342#L1R703LA	01P05 - AMP1		
K74	A660-2003-T230#L1R503YA	01P05 - AMP2		
K75	A660-2003-T230#L1R503MA	02P05 - AMP2		
K76	A660-2003-T230#L1R503ZA	02P05 - AMP2		

Cable specifications for S-10 medium size cabinet (continued)

Cable No.	Specifications	Remarks		
K31	A660-8007-T047#L7R403	AMP - M1	Robot connection cable (7 m)	
K32	A660-8007-T048#L7R403	AMP - M2		
K91	A660-2003-T308#L9R503BB	IOU - D1		
K92	A660-4002-T803#L8R003A	01P05 - P1		
K93	A660-4002-T804#L8R003A	01/02P05 - P2		
K99	A660-8006-T909#L7R503	GROUND		
K31	A660-8007-T047#L14R43	AMP - M1	Robot connection cable (14 m)	
K32	A660-8007-T048#L14R43	AMP - M2		
K91	A660-2003-T308#L16R53BB	IOU - D1		
K92	A660-4002-T803#L15R03A	01P05-P1		
K93	A660-4002-T804#L15R03A	01/02P05 - P2		
K99	A660-8006-T909#L14R53	GROUND		
K57	A660-2003-T329#L10R03A	01P04 - TP	10 m	Teach pendant
	A660-2003-T329#L20R03A	01P04 - TP	20 m	
K15	A660-8006-T659#L2R503	OP - PIU	Operator's panel	
K52	A660-2003-T271#L1R803B	01P04 - OP		
K56	A660-2003-T216#L2R103C	01P04 - PIU		
K10	A660-2002-T944#L1R503	PIU - PSU	Power supply unit	
K46	A660-2002-T945#L1R003	PIU - PSU		
K47	A660-2002-T949#L1R003A	PIU - PSU		
K70	A660-8006-T003#L3R003	OP - CRT	Remote (3 m)	CRT/KB
	A660-8006-T003#L7R003	OP - CRT	Remote (7 m)	
K50	A660-8005-T927#L500R0A	BAT - BP	Battery unit	

Cable specifications for S-10 medium size cabinet (continued)

Cable No.	Specifications	Remarks	
K48	A660-2002-T945#L1R003A	BP - IOU	I/O unit
K49	A660-2002-T949#L1R003B	BP - IOU	
K41	A66L-6001-0005#L2R003	01P04 - IOU	
K53	A660-2003-T233#L500R0C	IOU - PIU	
K01	Connected by customer	- CB	AC power input
K55		- PIU	External power on/off
K60		- PIU	Fence
K16		- PIU	Peripheral E-stop
K61		- 01P02	Line tracking
K62		- OP	RS-232-C

Symbols used in the table

AMP : Servo amplifier
 BAT : Battery unit
 BP : Backplane
 CB : Circuit breaker
 CRT : CRT/KB unit
 IOU : Modular I/O unit
 OP : Operator's panel
 PIU : Power input unit
 PSU : Power supply unit
 TF1 : Servo transformer
 TF4 : Input transformer
 TP : Teach pendant
 01P02 : Path CPU board
 01P04 : Shared RAM board
 01P05 : Axis control board for 4 axes
 02P05 : Axis control board for 2 axes
 M1,M2,D1,P1,P2 : Connector on mechanical unit

2) S-10 controller (Large size cabinet)

Cable No.	Specifications	Remarks			
K03	A660-8006-T915#L1R303	CB - PIU	Power input 1A (Breaker) (220/240 V)		
K04	A660-8006-T922#L2R503	PIU - TF1			
K06	A660-8006-T924#L1R503	TF4 - PIU			
K03	A660-8006-T914#L1R303	CB - PIU	Power input 1B (Breaker) (380 - 550 V)		
K04	A660-8006-T921#L2R503	PIU - TF1			
K06	B660-8006-T923#L1R503	TF4 - PIU			
K03	A660-8006-T916#L1R303	CB - PIU	Power input 1C (Breaker) (575 V)		
K04	A660-8006-T921#L2R503	PIU - TF1			
K06	A660-8006-T923#L1R503	TF4 - PIU			
K03	A660-8006-T918#L1R303	CB - PIU	Power input 2A (Breaker with leak detector) (220/240 V)		
K04	A660-8006-T922#L2R503	PIU - TF1			
K06	B660-8006-T924#L1R503	TF4 - PIU			
K03	A660-8006-T917#L1R303	CB - PIU	Power input 2B (Breaker with leak detector) (380 - 575 V)		
K04	A660-8006-T921#L2R503	PIU - TF1			
K06	A660-8006-T923#L1R503	TF4 - PIU			
K03	A660-8006-T920#L600R0	DSW - PIU	Power input 3A (Disconnect switch) (220/240 V)		
K04	A660-8006-T922#L2R203	PIU - TF1			
K06	A660-8006-T924#L1R003	TF4 - PIU			
K03	A660-8006-T919#L600R0	DSW - PIU	Power input 3B (Disconnect switch) (380 - 575 V)		
K04	A660-8006-T921#L2R203	PIU - TF1			
K06	A660-8006-T923#L1R003	TF4 - PIU			
K12	A660-8006-T998	PIU - FAN	AC power connection		
K09	A660-8007-T034#L2R203	TF1 - PIU			
K07	A660-8006-T926#L250R3	TF4 - TF5	A	User transformer	
	A660-8006-T925#L250R3	TF4 - TF5	B		

Cable specifications for M-100 large size cabinet (continued)

Cable No.	Specifications	Remarks		
K19	A660-8006-T928	PIU - SVO	Servo-on relay	
K20	A660-8006-T929#L3R703	PIU - HM	Hour meter	
K21	A660-8006-T804#L900R0	TF1 - AMP	Servo amp. connection	
K23	A660-8006-T727#LE	PIU - AMP		
K71	A660-2003-T230#L1R703KA	01P05 - AMP1		
K72	A660-2003-T342#L1R803AA	01P05 - AMP1		
K73	A660-2003-T342#L1R703LA	01P05 - AMP1		
K74	A660-2003-T230#L1R503YA	01P05 - AMP2		
K75	A660-2003-T230#L1R503MA	02P05 - AMP2		
K76	A660-2003-T230#L1R503ZA	02P05 - AMP2		
K31	A660-8007-T047#L7R403	AMP - M1	Robot connection cable (7 m)	
K32	A660-8007-T048#L7R403	AMP - M2		
K91	A660-2003-T308#L9R503BB	IOU - D1		
K92	A660-4002-T803#L8R003A	01POS-P1		
K93	A660-4002-T804#L8R003A	01/02P05 - P2		
K99	A660-8006-T909#L7R503	GROUND		
K31	A660-8007-T047#L14R43	AMP - M1	Robot connection cable (14 m)	
K32	A660-8007-T048#L14R43	AMP - M2		
K91	A660-2003-T308#L16R53BB	IOU - D1		
K92	A660-4002-T803#L15R03A	01P05 - P1		
K93	A660-4002-T804#L15R03A	01/02P05 - P2		
K99	A660-8006-T909#L14R53	GROUND		
K57	A660-2003-T329#L10R03A	01P04 - TP	10 m	Teach pendant
	A660-2003-T329#L20R03A	01P04 - TP	20 m	

Cable specifications for M-100 large size cabinet (continued)

Cable No.	Specifications	Remarks		
K15	A660-8006-T659#L3R803	OP - PIU	Operator's panel	
K52	A660-2003-T271#L2R503B	01P04 - OP		
K56	A660-2003-T216#L2R503C	01P04 - PIU		
K10	A660-2003-T331#L1R803	PIU - PSU	Power supply unit	
K46	A660-2002-T945#L1R303	PIU - PSU		
K47	A660-2002-T949#L1R303A	PIU - PSU		
K70	A660-2002-T523#L500R0A	OP - CRT	Built-in	CRT/KB
	A660-8006-T003#L3R003	OP - CRT	Remote (3 m)	
	A660-8006-T003#L7R003	OP - CRT	Remote (7 m)	
K50	A660-8005-T927#L500R0A	BAT - BP	Battery unit	
K48	A660-2002-T945#L1R003A	BP - IOU	I/O unit	
K49	A660-2002-T949#L1R003B	BP - IOU		
K41	A66L-6001-0005#L2R003	01P04 - IOU		
K53	A660-2003-T233#L800R0C	IOU - PIU		
K18	Connected by customer	- SVO	Servo-on output	
K01		- CB	AC power input	
K55		- PIU	External power on/off	
K60		- PIU	Fence	
K16		- PIU	Peripheral E-stop	
K61		- 01P02	Line tracking	
K62		- OP	RS-232-C	

Symbols used in the table

AMP : Servo amplifier
 BAT : Battery unit
 BP : Backplane
 CB : Circuit breaker
 CRT : CRT/KB unit
 DSW : Disconnect switch
 IOU : Modular I/O unit

OP : Operator's panel
PIU : Power input unit
PSU : Power supply unit
SVO : Servo-on relay unit
TF1 : Servo transformer
TF3 : Control transformer
TF4 : Input transformer
TF5 : User transformer
TP : Teach pendant
01P02 : Path CPU board
01P04 : Shared RAM board
01P05 : Axis control board for 4 axes
02P05 : Axis control board for 2 axes
M1,M2,D1,P1,P2 : Connector on mechanical unit

3) S-700 controller

Cable No.	Specifications	Remarks	
K03	A660-8006-T915#L1R003	CB - PIU	Power input 1A (Breaker) (220/240 V)
K04	A660-8006-T922#L3R303	PIU - TF1	
K06	A660-8006-T924#L1R503	TF4 - PIU	
K03	A660-8006-T914#L1R303	CB - PIU	Power input 1B (Breaker) (380 - 550 V)
K04	A660-8006-T921#L3R303	PIU - TF1	
K06	A660-8006-T923#L1R503	TF4 - PIU	
K03	A660-8006-T916#L1R303	CB - PIU	Power input 1C (Breaker) (575 V)
K04	A660-8006-T921#L3R303	PIU - TF1	
K06	A660-8006-T923#L1R503	TF4 - PIU	
K03	A660-8006-T918#L1R303	CB - PIU	Power input 2A (Breaker with leak detector) (220/240 V)
K04	A660-8006-T922#L3R303	PIU - TF1	
K06	B660-8006-T924#L1R503	TF4 - PIU	
K03	A660-8006-T917#L1R303	CB - PIU	Power input 2A (Breaker with leak detector) (220/240 V)
K04	A660-8006-T921#L3R303	PIU - TF1	
K06	A660-8006-T923#L1R503	TF4 - PIU	
K03	A660-8006-T920#L600R0	DSW - PIU	Power input 3A (Disconnect switch) (220/240 V)
K04	A660-8006-T922#L3R003	PIU - TF1	
K06	A660-8006-T924#L1R003	TF4 - PIU	
K03	A660-8006-T919#L600R0	DSW - PIU	Power input 3A (Disconnect switch) (380 - 575 V)
K04	A660-8006-T921#L3R003	PIU - TF1	
K06	A660-8006-T923#L1R003	TF4 - PIU	
K12	A660-8007-T140	PIU - FAN	AC Power connection
K09	A660-8007-T034#L2R203	TF3 - PIU	

Cable specifications for S-700 (continued)

Cable No.	Specifications	Remarks		
K07	A660-8006-T926#L250R3	TF4 - TF5	A	User transformer
	A660-8006-T925#L250R3	TF4 - TF5	B	
K19	A660-8006-T928	PIU - SVO	Servo-on relay	
K20	A660-8006-T929#L3R703	PIU - HM	Hour meter	
K21	A660-8006-T829#900R0	TF1 - AMP	Servo amp. connection	
K22	A660-8007-T141#L1R103	TF1 - AMP		
K23	A660-8007-T142	PIU - AMP		
K25	A660-8006-T887#L1R403	TF1 - AMP1		
K27	A660-8007-T143	AMP - DCU1		
K71	A660-2003-T342#L1R503MA	01P05-AMP		
K72	A660-2003-T230#L1R903LA	01P05-AMP		
K73	A660-2003-T230#L2R603PA	01P05-AMP		
K74	A660-2003-T230#L1R903FA	01P05-AMP		
K75	A660-2003-T230#L1R803GA	02P05-AMP		
K76	A660-2003-T342#L1R703NA	02P05-AMP		
K31	A660-8007-T144#L7R503	AMP - M1	Robot connection cable (7 m)	
K32	A660-8007-T145#L7R503	AMP - M2		
K91	A660-2003-T308#L9R503BB	IOU - D1		
K92	A660-4002-T803#L8R003A	01P05-P1		
K93	A660-4002-T804#L8R503A	01/02P05 - P2		
K99	A660-8006-T910#L7R503	GROUND		

Cable specifications for S-700 (continued)

Cable No.	Specifications	Remarks		
K31	A660-8007-T144#L14R53	AMP - M1	Robot connection cable (14 m)	
K32	A660-8007-T145#L14R53	AMP - M2		
K91	A660-2003-T308#L15R03A	IOU - D1		
K92	A660-4002-T803#L15R03A	01P05-P1		
K93	A660-4002-T804#L15R03A	01P05 - P2		
K99	A660-8006-T910#L14R53	GROUND		
K57	A660-2003-T329#L10R03A	01P04 - TP	10 m	Teach pendant
	A660-2003-T329#L20R03A	01P04 - TP	20 m	
K15	A660-8006-T659#L3R803	OP - PIU	Operator's panel	
K52	A660-2003-T271#L2R503B	01P04 - OP		
K56	A660-2003-T216#L2R503C	01P04 - PIU		
K10	A660-2003-T331#L1R803	PIU - PSU	Power supply unit	
K46	A660-2002-T945#L1R303	PIU - PSU		
K47	A660-2002-T949#L1R303	PIU - PSU		
K70	A660-2002-T532#L500R0A	OP - CRT	Built-in	CRT/KB
K70	A660-8006-T003#L3R003	OP - CRT	Remote (3 m)	
K70	A660-8006-T003#L7R003	OP - CRT	Remote (7 m)	
K50	A660-8005-T927#L500R0A	BAT - BP	Battery unit	
K48	A660-2002-T945#L1R003A	BP - IOU	I/O unit	
K49	A660-2002-T949#L1R003B	BP - IOU		
K41	A66L-6001-0005#L2R003	01P04 - IOU		
K53	A660-2003-T233#L800ROC	IOU - PIU		

Cable specifications for S-700 (continued)

Cable No.	Specifications	Remarks	
K18	Connected by customer	- SVO	Servo-on output
K01		- CB	AC power input
K55		- PIU	External power on/off
K60		- PIU	Fence
K16		- PIU	Peripheral E-stop
K61		- 01P02	Line tracking
K62		- OP	RS-232-C

Symbols used in the table

AMP : Servo amplifier
 BAT : Battery unit
 BP : Backplane
 CB : Circuit breaker
 CRT : CRT/KB unit
 DSW : Disconnect switch
 IOU : Modular I/O unit
 OP : Operator's panel
 PIU : Power input unit
 PSU : Power supply unit
 SVO : Servo-on relay unit
 TF1 : Servo transformer
 TF3 : Control transformer
 TF4 : Input transformer
 TF5 : User transformer
 TP : Teach pendant
 01P02 : Path CPU board
 01P04 : Shared RAM board
 01P05 : Axis control board for 4 axes
 02P05 : Axis control board for 2 axes
 M1,M2,D1,P1,P2 : Connector on mechanical unit

APPENDIX 3 PREVENTIVE MAINTENANCE SCHEDULE

3.1 Preventive Maintenance Schedules

Refer to the maintenance replacement/adjustment sections for exact information pertaining to these procedures.							
Check items	Daily	350 hours	500 hours	1000 hours	2000 hours	Special purpose	As required
Overall system	*						
Greasing bearings					*		
Greasing cyclo drive						* Replace (20000 hrs)	
Greasing α/β harmonic drive (S-10)				*		Every three months	
Repeatability	* Visual check						* After repair
Mist oil							*
Cables	* Visual check						* Replace
Ventilation system	* Access doors						* Clean or repair
Backlash					* Check		* After re- placement
Belts (timing)				* Check			* Replace
Brakes					* Ob- serve drop- ping		

Check items	Daily	350 hours	500 hours	1000 hours	2000 hours	Special purpose	As required
Voltage (DC)					* Check		
Batteries (RAM memory)						* Replace once a year	* Replace

3.2 Preventive Maintenance Check List

Item	Schedule	Data checked (other than daily)											
Air control set: Air pressure Oiler oil mist Oiler oil level Hose leakage	Daily												
Cables (visual check)	Daily												
Vibration	Daily												
Repeatability	Daily												
Peripheral devices	Daily												
Each part (clean and check)	Daily												
Ventilation	Daily												
Lubrication	Monthly (500 hrs)												
Each part (for play and looseness)	Monthly (500 hrs)												
Connectors (for looseness)	Monthly (500 hrs)												
Greasing bearings	Semi- annually (2000 hrs)												
DC power voltage	Semi- annually (2000 hrs)												
Control PCB offset voltage	Semi- annually (2000 hrs)												
Lubrication oil	Semi- annually (2000 hrs)												

Item	Schedule	Data checked (other than daily)										
Backlash	Semi-annually (2000 hrs)											
RAM backup batteries (replacement)	Annually (4000 hrs)											
Cyclo drive (greasing)	20000 hrs											
Cable (replacement)	Biennially (8000 hrs)											
Timing belt (replacement)	Biennially (8000 hrs)											
Harmonic drive (greasing)	Every three months											

APPENDIX 4

SYSTEM VARIABLE ALPHABETICAL DESCRIPTIONS

System variables are variables that are declared as part of the KAREL system software. Permanently defined variable names, which begin with a dollar sign (\$), identify system variables.

Some system variables are robot specific, meaning their values depend on the type of robot that is attached to the system. Other variables reflect the current status of the system and are constantly being updated. Still others allow you to define operating parameters for a particular application.

This appendix lists all the system variables available in the KAREL system. Sections 4.2 and 4.3 in this appendix list the default values for the S-10 and S-700 robot dependant system variables. Variable names followed by a "*" are for software version 2.1 and up.

4.1 System Variable Descriptions

This section describes each system variable in alphabetical order. Each description includes a list with the following information:

Data Type:	Power Up:
Minimum/Maximum:	Saved:
Program/KCL:	Backed Up:
Default:	

- "Data Type" indicates the type of value associated with the system variable. If the type is ARRAY, the length also is included.
- "Minimum/Maximum" lists minimum and maximum values when they differ from the standard values for each data type.

SYSTEM VARIABLE DESCRIPTIONS

\$ACCLE_OVRD System Variable

- “Program/KCL” shows access rights for use in KAREL programs and for all other uses (KCL).
- “Power Up” indicates whether or not changes to the value take effect only at power up.
- “Saved” indicates whether or not the value is saved by the KCL>SSAVE command.
- “Backed Up” indicates whether or not the value is restored by the power fail recovery procedure.
- “Default” indicates the default value for the variable.

The function and any additional details of the system variable are described following this list.

Unauthorized modification of system variables identified as “reserved for GMF internal use only” could affect the performance of the KAREL system adversely.

The names, values, and effects of GMF internal system variables are subject to change without notice.

\$ACCEL_OVRD (acceleration override) *

Data Type: INTEGER
Saved: Yes
Program/KCL: RW/RW
Minimum/Maximum: 0/255

Power Up: No
Default: 0
Backed Up: Yes

\$ACCEL_OVRD scales the acceleration time if \$USERELACCEL = TRUE and if the acceleration option is installed (optional feature). Acceleration time is defined as:

$$\text{new_accel_time} = \text{default_accel_time} * \frac{\$ACCEL_OVRD}{100}$$

If \$ACCEL_OVRD = 0 it is treated as if it were 100. If RELACCEL is defined as INTEGER user-defined associated data, \$USERELACCEL = TRUE and the relaccel option is installed, then the acceleration time is defined as:

$$\text{new_accel_time} = \text{default_accel_time} * \$ACCEL_OVRD * \frac{RELACCEL}{10000}$$

SYSTEM VARIABLE DESCRIPTIONS

\$ACCEL_TIME1 System Variable

\$ACCEL_TIME1 (acceleration time 1)

Data Type: INTEGER ARRAY[9]
Minimum/Maximum: 1/2560*
Program/KCL: No/PW
Default: 320

Power Up: Yes
Saved: Yes
Backed Up: No

\$ACCEL_TIME1 is an array of times, one per axis, for the first stage of the second order acceleration/deceleration algorithm for joint motion. The value is in milliseconds (msec).

\$ACCEL_TIME1 is set by the KCL> UTILITY SINIT command, and should not be changed. For auxiliary axes, you are responsible for setting this variable using the Motion Hardware Setup Program.

*The maximum value for \$ACCEL_TIME1 is limited by the maximum value for each system (usually 500 msec).

\$ACCEL_TIME2 (acceleration time 2)

Data Type: INTEGER ARRAY[9]
Minimum/Maximum: 1/2560*
Program/KCL: No/PW
Default: 160

Power Up: Yes
Saved: Yes
Backed Up: No

\$ACCEL_TIME2 is an array of times, one per axis, for the second stage of the second order acceleration/deceleration algorithm for joint motion. The value is in milliseconds (msec).

\$ACCEL_TIME2 is set by the KCL> UTILITY SINIT command, and should not be changed. For auxiliary axes, you are responsible for setting this variable using the Motion Hardware Setup Program.

*The maximum value for \$ACCEL_TIME2 is limited by the maximum value for each system (usually 500 msec).

\$ACCURACYNUM (accuracy number) *

Data Type: INTEGER
Minimum/Maximum: 0/5
Program/KCL: RW/RW
Default: 0

Power Up: No
Saved: Yes
Backed Up: Yes

SYSTEM VARIABLE DESCRIPTIONS

\$ACCURACYNUM System Variable

\$ACCURACYNUM determines which local accuracy area will be used for subsequent motion (optional feature). The local accuracy area must have been defined and set by the GMF ACCUSIGHT High Accuracy Option Package. This option is currently supported only by the A-600 robot.

When \$ACCURACYNUM = 0, the use of the local accuracy area data is disabled.

\$AFRAMEENUM1 (auxiliary frame number 1)

Data Type: INTEGER
Minimum/Maximum: 0/3
Program/KCL: RW/RO
Default: 0

Power Up: No
Saved: No
Backed Up: Yes

\$AFRAMEENUM1 is used to connect an auxiliary axis tracking frame (defined using the KAREL language built-in DEFAUXFRAME) to a motion statement for auxiliary axis tracking (optional feature).

A value of 0, the default value, indicates a stationary frame. Values of 1, 2, or 3 indicate defined auxiliary axis tracking frames. \$AFRAMEENUM1 is set to 0 each time a program is executed.

\$AFRAMEENUM2 (auxiliary frame number 2)

Data Type: INTEGER
Minimum/Maximum: 0/3
Program/KCL: RW/RO
Default: 0

Power Up: No
Saved: No
Backed Up: Yes

\$AFRAMEENUM2 is used to connect an auxiliary axis tracking frame (defined using the KAREL language built-in DEFAUXFRAME) to a motion statement for auxiliary axis tracking (optional feature).

The default value indicates a stationary frame. Values of 1, 2, or 3 indicate defined auxiliary axis tracking frames. \$AFRAMEENUM2 is set to 0 each time a program is executed.

\$ALL_SYSVARS (all system variables)

Data Type: BOOLEAN
Saved: Yes
Program/KCL: NO/RW

Backed Up: Yes
Power Up: No
Default: FALSE

SYSTEM VARIABLE DESCRIPTIONS
\$AFRAMENUM2 System Variable

\$ALL_SYSVARS is accessed using the Non-Positional Data screen on the CRT and the teach pendant to determine whether a partial or complete list of available system variables is displayed. If \$ALL_SYSVARS is FALSE only commonly used system variables are displayed. If \$ALL_SYSVARS is TRUE all available system variables are displayed.

The following is a list of commonly used system variables. This list cannot be modified.

1	SATPERCH	14	SMOTYPE	27	\$SPIN_CTRL
2	SBRK_ON_HOLD	15	SORIENT_TYPE	28	\$SPINSPEED
3	SBRK_OUTPUT	16	\$OT_MINUS	29	\$SPINSPEEDLM
4	SBRK_OUT_ENB	17	\$OT_PLUS	30	\$STOP_ON_ERR
5	SCNSTNT_PATH	18	\$PPABN_ENABL	31	\$SV_OFF_ENB
6	SCYCLE_STRT	19	\$PWR_NORMAL	32	\$SV_OFF_TIME
7	SC_STOP_ENBL	20	\$RECOVERABLE	33	\$TERMTYPE
8	SDECELTO	21	\$ROTSPEED	34	\$USE_CONFIG
9	SFUL_RMT_OUT	22	\$SCN_HLD_NBL	35	\$USEMAXACCEL
10	SGRIDSHIFTS	23	\$SEGTERMTYPE	36	\$USER_PB1
11	SHOME	24	\$SPEED	37	\$USER_PB2
12	SJOGFRAME	25	\$SPEEDLM	38	\$UTOOL
13	SMIRRORPLANE	26	\$SPEEDLMJNT		

\$APC_DONE (absolute pulse coder done)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No
Default: FALSE

Power Up: No
Saved: No
Backed Up: No

\$APC_DONE indicates the successful completion of absolute pulse coder (APC) communication for robots with APC motors when it is TRUE. FALSE indicates communication has not been successfully completed. The value of \$APC_DONE is set and updated automatically.

\$APC_SYSTEM (absolute pulse coder system)

Data Type: BOOLEAN
Program/KCL: NO/PW
Default: TRUE

Power Up: Yes
Saved: Yes
Backed Up: No

\$APC_SYSTEM indicates the robot has absolute pulse coder (APC) system hardware for calibration when it is TRUE. Otherwise, it is FALSE and the robot has incremental calibration hardware.

The value of \$APC_SYSTEM is set by the KCL> UTILITY SINIT command and should not be changed.

SYSTEM VARIABLE DESCRIPTIONS

\$APPROACHTOL System Variable

\$APPROACHTOL (approach vector tolerance)

Data Type: REAL

Program/KCL: RW/RW

Default: 0.0003046096 (1 degree)

Power Up: No

Saved: Yes

Backed Up: No

\$APPROACHTOL is used when comparing the z-axis (approach vector) of two positions. **\$APPROACHTOL**, along with **\$LOCTOL**, **\$ORIENTTOL**, and **\$CHECKCONFIG**, is used in conjunction with the relational operator "**>=<**" to compare two positions.

If **\$APPROACHTOL** is negative, no comparison is made and the approach vectors of the two positions are "nearly" identical. When **\$APPROACHTOL** is 0.0 (1 degree), the approach vectors must be identical in order for the relational operator to return a TRUE result.

When **\$APPROACHTOL** is greater than 0 the following test is made:

```
approach1 = approach(pos1);
```

```
approach2 = approach(pos2);
```

```
If (ABS(approach1[1] - approach2[1] <= $APPROACHTOL) and  
    (ABS(approach1[2] - approach2[2] <= $APPROACHTOL) and  
    (ABS(approach1[3] - approach2[3] <= $APPROACHTOL) then  
    the approach vectors of the two positions are "nearly" identical.
```

\$ARM_TYPE (arm type)

Data Type: INTEGER

Minimum/Maximum: 0/5

Program/KCL: NO/PW

Default: Robot Specific

Power Up: No

Saved: Yes

Backed Up: No

\$ARM_TYPE defines the robot arm type using the integer values 0-5. The meanings associated with these values depend on which robot is being described.

The value of **\$ARM_TYPE** is set by the KCL> UTILITY SINIT command and should not be changed.

\$ATPERCH (at perch)

Data Type: BOOLEAN

Program/KCL: RO/RO

Power Up: No

Saved: No

Backed Up: No

Default: FALSE

\$ATPERCH returns TRUE if the robot is at the specified perch position. The variable will return FALSE if the robot is not at the perch position.

See Also:

\$PERCH and SPERCHTOL system variables for more information on setting the perch position.

\$AUXEXTREME1 (auxiliary axis extreme 1)

Data Type: REAL
Program/KCL: RW/RO
Default: Uninitialized

Power Up: No
Saved: No
Backed Up: Yes

\$AUXEXTREME1 can be used to indicate the extreme auxiliary axis position of a path for auxiliary axis tracking (optional feature).

\$AUXEXTREME1 is set uninitialized each time a program is executed, meaning extreme checking will not be performed. You can enable it by assigning a value less than 10,000,000 to \$AUXEXTREME1. The assigned value will be used for extreme checking. Assigning a value greater than 10,000,000 will discontinue extreme checking.

\$AUXEXTREME2 (auxiliary axis extreme 2)

Data Type: REAL
Program/KCL: RW/RO
Default: Uninitialized

Power Up: No
Saved: No
Backed Up: Yes

\$AUXEXTREME2 can be used to indicate the extreme auxiliary axis position of a path for auxiliary axis tracking (optional feature).

\$AUXEXTREME2 is set uninitialized each time a program is executed, meaning extreme checking will not be performed. You can enable it by assigning a value less than 10,000,000 to \$AUXEXTREME2. The assigned value will be used for extreme checking. Assigning a value greater than 10,000,000 will discontinue extreme checking.

\$AUXHOME (auxiliary axes home position)

Data Type: AUXPOS
Program/KCL: RW/PW
Power Up: No

Saved: Yes
Backed Up: Yes
Default: uninitialized

\$AUXHOME is a user-definable home position for auxiliary axes.

SYSTEM VARIABLE DESCRIPTIONS

\$AUXHOME System Variable

You can include a `KCL> MOVETO $AUXHOME` command in the predefined command file `KCP_HOME.CF`, which is executed by the `UOP HOME` signal. This command moves the auxiliary axes to their home position.

You can assign a value that defines a home position for auxiliary axes. The system variable `$HOME` represents a user-definable home position for the robot.

See Also:

Chapter 12, *KAREL Reference Manual* for more information on `KCP_HOME.CF`

\$AUXSPEED (auxiliary axis speed)

Data Type: REAL
Program/KCL: RW/RW
Default: 25.0

Power Up: No
Saved: No
Backed Up: Yes

`$AUXSPEED` is used to compute segment times for auxiliary axis motion in conjunction with `$JNTVELLIM`. The value of `$AUXSPEED` is expressed as a percentage between 0 and 100.

\$AUX_OFFSET (auxiliary axis offset)

Data Type: VECTOR
Program/KCL: RW/RW
Default: 0, 0, 0

Power Up: No
Backed Up: No

`$AUX_OFFSET` is the X, Y, Z location of the integrated auxiliary axes at the position to be tested by the KAREL built-in functions `INRANGE` or `TINRANGE`.

See Also:

Chapter 8, *KAREL Reference Manual* for more information on integrated auxiliary axes.

\$AUX_ZROSHFT (auxiliary axis zero shift)

Data Type: REAL
Program/KCL: RW/RW
Power Up: No

Saved: No
Backed Up: No
Default: 0.0

`$AUX_ZROSHFT` performs a function for auxiliary axis positions similar to that performed by `$UFRAME` for the TCP position. It affects the auxiliary axis whose number is specified by `$TRK_AXSNUM`. The zero reference point of that auxiliary axis is shifted using the value of `$AUX_ZROSHFT`.

`$AUX_ZROSHFT` is mainly for teaching auxiliary axis positions for auxiliary axis tracking applications (optional feature).

\$AXISORDER (axis order)

Data Type: INTEGER ARRAY [12]
Minimum/Maximum: 0/9
Program/KCL: NO/PW
Default: Robot Specific

Power Up: Yes
Saved: Yes
Backed Up: No

\$AXISORDER is a mapping array from software axis index to servo hardware registers. It indicates which axis is controlled by a particular servo motor.

For example, \$AXISORDER[i] = j, where axis index j is connected to servo register i. (Axis j is controlled by servo motor i.) \$AXISORDER[i] = 0 indicates that servo register i is not used.

The value of \$AXISORDER is set by the KCL> UTILITY SINIT command and should not be changed. For auxiliary axes, you are responsible for setting this variable using the Motion Hardware Setup Program.

\$BELT_ENABLE (belt alarm enable)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$BELT_ENABLE enables the belt breakage detection feature. If it is TRUE, the controller will generate an error message if a drive belt breaks.

Only the A-200 and A-510 robot models are equipped with belt-driven axes. For these, \$BELT_ENABLE should be TRUE. For all other robots, \$BELT_ENABLE should be set to FALSE.

If your system is equipped with belt-driven auxiliary axes, you can set \$BELT_ENABLE to TRUE to enable belt breakage detection on the auxiliary axes.

\$BK_TLINE (Basic KAREL testing line) *

Data Type: INTEGER
Program/KCL: RW/RW
Default: -1

Power Up: No
Backed Up: No

\$BK_TLINE contains the line number used by a Basic KAREL program to start execution. This variable is set at the teach pendant Test Run menu and is used by Basic KAREL run time programs. This system variable has been added to be used for Basic KAREL testing.

SYSTEM VARIABLE DESCRIPTIONS

\$BRK_ON_HOLD System Variable

\$BRK_ON_HOLD (brake on hold)

Data Type: BOOLEAN
Program/KCL: NO/PW
Default: TRUE

Power Up: Yes
Backed Up: No

If **\$BRK_ON_HOLD** is enabled, all holds generated by the hardware (by pressing the HOLD button on the operator panel or UOP or by pressing the HOLD/STEP key on teach pendant) shut the servo power off after the robot arm decelerates and stops its motion. Software-generated holds (KAREL HOLD statement, HOLD action, or KCL> HOLD command) are not affected by this feature.

When the servo power is shut off, the error message "4039 Brake on Hold" is displayed on the CRT. Use the RESET button or the KCL> RESET command to reset the servo power after shut down. If the HOLD input is active neither the RESET button or the KCL> RESET command will reset the servo power. This causes the error "2053 HOLD active" to be displayed. To inactivate the HOLD condition, release the HOLD button on the operator panel or the HOLD key on the teach pendant. Next, push the FAULT RESET button to turn on the servos.

\$BRK_OUTPUT (brake output)

Data Type: BOOLEAN ARRAY [9]
Program/KCL: NO/PW
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$BRK_OUTPUT is an array that you can use to set the brake output bits manually if **\$BRK_OUT_ENB** is TRUE. Note that the elements in this array do not correspond to individual axes. Several brakes might be released by a single brake output.

See Also:

Enhanced KAREL Operations Manual for robot brake information

\$BRK_OUT_ENB (brake output enable)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$BRK_OUT_ENB indicates whether or not manual setting of brake outputs is allowed. If it is TRUE brakes can be set or released manually as specified by the value of **\$BRK_OUTPUT**. If it is FALSE brakes cannot be set or released manually.

SYSTEM VARIABLE DESCRIPTIONS

\$BRK_OUT_ENB System Variable

By default, the value of \$BRK_OUT_ENB is set to FALSE. \$BRK_OUT_ENB is also set to FALSE when an emergency stop, overtravel condition, or DEADMAN switch error occurs.

\$CAL (calibrated)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$CAL indicates whether or not the robot has been calibrated. If it is TRUE, the robot is calibrated. Otherwise, it is FALSE and the robot has not been calibrated or an error that caused the robot to lose calibration has occurred. The value of \$CAL is set and updated automatically by the system.

\$CALIB_POS (calibration position)

Data Type: REAL ARRAY [9]
Program/KCL: NO/PW
Default: Robot Specific

Power Up: No
Saved: Yes
Backed Up: No

\$CALIB_POS defines the calibration position of each axis for robots that require incremental calibration procedures. During calibration, the robot moves to this position, which is often called the zero return position, although this position is not necessarily at zero.

The value of \$CALIB_POS is set by the KCL> UTILITY SINIT command and should not be changed for robot axes. For auxiliary axes, you are responsible for setting this variable using the Motion Hardware Setup Program.

\$CALSIGN (calibration sign)

Data Type: BOOLEAN ARRAY [9]
Program/KCL: NO/RW
Default: Robot Specific

Power Up: Yes
Saved: Yes
Backed Up: No

\$CALSIGN indicates the direction of axis motor rotation during calibration for incremental encoders. The system uses \$CALSIGN to determine the direction it should move to find the calibration index pulse.

The value of \$CALSIGN is set by the KCL> UTILITY SINIT command and should not be changed for robot axes. For auxiliary axes, you are responsible for setting this variable using the Motion Hardware Setup Program.

SYSTEM VARIABLE DESCRIPTIONS

\$SCALVELHIGH System Variable

\$SCALVELHIGH (calibration velocity high)

Data Type: REAL ARRAY [9]
Program/KCL: NO/RW
Default: Robot Specific

Power Up: No
Saved: Yes
Backed Up: Yes

\$SCALVELHIGH indicates the dog-search approach speed for each axis during calibration of robots with incremental encoders. The value is in millimeters or radians per second depending on whether the axis is a linear motion axis or a rotational axis.

The value of \$SCALVELHIGH is set by the KCL> UTILITY SINIT command and should not be changed for robot axes. For auxiliary axes, you are responsible for setting this variable using the Motion Hardware Setup Program.

\$SCALVELLOW (calibration velocity low)

Data Type: REAL ARRAY [9]
Program/KCL: NO/RW
Default: Robot Specific

Power Up: No
Saved: Yes
Backed Up: Yes

\$SCALVELLOW indicates the index pulse search speed for each axis during calibration of robots with incremental encoders. The value is in millimeters or radians per second depending on whether the axis is a linear motion axis or a rotational axis.

The value of \$SCALVELLOW is set by the KCL> UTILITY SINIT command and should not be changed for robot axes. For auxiliary axes, you are responsible for setting this variable using the Motion Hardware Setup Program.

\$CART_ACCEL1 (Cartesian acceleration time 1)

Data Type: INTEGER
Minimum/Maximum: 0/2560*
Program/KCL: NO/PW
Default: 224

Power Up: Yes
Saved: Yes
Backed Up: No

\$CART_ACCEL1 is the length, in ms, of the first stage of the second order acceleration/deceleration filters for Cartesian motion.

The total acceleration/deceleration time for either linear or circular Cartesian motion (except where speed override is used) is the sum of \$CART_ACCEL1 and \$CART_ACCEL2.

The value of \$CART_ACCEL1 is set by the KCL> UTILITY SINIT command and should not be changed for robot axes. For auxiliary axes, you are responsible for setting this variable using the Motion Hardware Setup Program.

*The maximum value for \$CART_ACCEL1 is limited by the maximum value for each system (usually 500 msec)

\$CART_ACCEL2 (Cartesian acceleration time 2)

Data Type: INTEGER
 Minimum/Maximum: 0/2560*
 Program/KCL: NO/PW
 Default: 128

Power Up: Yes
 Saved: Yes
 Backed Up: No

\$CART_ACCEL2 is the length in msec of the second stage of the second order acceleration/deceleration algorithm for Cartesian motion.

The total acceleration/deceleration time for either linear or circular Cartesian motion (except where speed override is used) is the sum of \$CART_ACCEL1 and \$CART_ACCEL2.

The value of \$CART_ACCEL2 is set by the KCL> UTILITY SINIT command and should not be changed for robot axes. For auxiliary axes, you are responsible for setting this variable using the Motion Hardware Setup Program.

*The maximum value for \$CART_ACCEL2 is limited by the maximum value for each system (usually 500 msec).

\$CART_AXIS (Cartesian axis)

Data Type: INTEGER
 Minimum/Maximum: 0/987
 Program/KCL: NO/PW
 Default: 0

Power Up: No
 Saved: Yes
 Backed Up: No

\$CART_AXIS indicates which auxiliary axes, if any, are to be integrated into the Cartesian calculations for the position of the TCP. Integrated motion of robot and auxiliary axes is turned on by setting \$CART_AXIS to a value other than 0. A value of 0 means that no auxiliary axes will be integrated.

The value of \$CART_AXIS is a three-digit decimal number that associates the x, y, and z components of the world coordinate system with the auxiliary axis numbers for integration.

See Also:

Chapter 8, *KAREL Reference Manual*

SYSTEM VARIABLE DESCRIPTIONS

\$CHECKCONFIG System Variable

\$CHECKCONFIG (check configuration)

Data Type: BOOLEAN
Program/KCL: RW/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$CHECKCONFIG is used to determine if the position configurations should be compared. **\$CHECKCONFIG**, along with **\$APPROACHTOL**, **\$LOCTOL**, and **\$ORIENTTOL** are used in conjunction with the relational operator "**>=<**" to compare two positions.

If **\$CHECKCONFIG** is FALSE, the configurations are not compared and the relational operator treats the configurations as being "nearly" identical. If **\$CHECKCONFIG** is TRUE, the configurations are compared by the relational operator.

\$CHK_JNT_SPD (check joint speed)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: TRUE

\$CHK_JNT_SPD indicates whether or not joint speed is checked against the system variable **\$JNTVELLIM** during Cartesian motion. If it is TRUE, the speed of each joint is checked against the corresponding joint speed limit and if a limit is exceeded, all joint speeds are reduced at the same ratio.

Please note that the motor speed limits (**\$MOT_SPD_LIM**) always are checked regardless of this variable.

See Also:

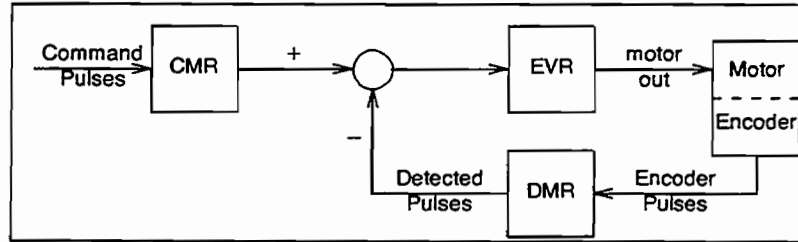
Chapter 8, *KAREL Reference Manual* for more information on speed limits

\$CMR (command multiplier ratios)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: 1/32767
Program/KCL: NO/PW
Default: 1

Power Up: Yes
Saved: Yes
Backed Up: No

\$CMR defines command multiplier ratios, one per axis. The values of \$CMR and \$DMR are used as follows:



The product of commanded pulses multiplied by \$CMR is compared with the detected pulses to drive the error counter either up or down. The resultant error register drives the motor through a gain constant.

\$DMR (detector multiplier ratio) multiplies the encoder pulses to produce detected pulses. Many system variables are tolerances or other parameters specified in detector pulses.

The value of \$CMR is set by the KCL> UTILITY SINIT command and should not be changed for robot axes. For auxiliary axes, you are responsible for setting this variable using the Motion Hardware Setup Program.

See Also:

\$KV1000 System Variable in this appendix

\$CNSTNT_PATH (constant path)

Data Type: BOOLEAN
Program/KCL: RW/RW
Power Up: No

Saved: No
Backed Up: Yes
Default: TRUE

If \$CNSTNT_PATH is TRUE the acceleration/deceleration time is adjusted for the current speed override value (\$GENOVERRIDE and \$PRGOVERRIDE) so that the path of the motion will be the same regardless of the speed override value. This adjustment only applies to the program motions. The acceleration/deceleration time for jogging or for "MOVE TO" commands, issued by KCL or the teach pendant, will not change.

If it is FALSE, the filter length is not adjusted, meaning the path taken will vary with the speed override value.

See Also:

Chapter 8, *KAREL Reference Manual*

SYSTEM VARIABLE DESCRIPTIONS

\$COARSETOL System Variable

\$COARSETOL (coarse tolerance)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: 0/32767
Program/KCL: NO/RW
Default: 300

Power Up: No
Saved: Yes
Backed Up: No

\$COARSETOL is an array of in-position tolerances used to determine when the robot is in position when **\$TERMTYPE = COARSE**. The value is in units of detector pulses (as explained under **\$CMR**). The tolerance in radians or millimeters is computed as follows:

$$\text{coarse angle} = \frac{\$COARSETOL}{\$CMR * \$ENCSCALE}$$

The value of **\$COARSETOL** is set by the **KCL> UTILITY SINIT** command and should not be changed.

\$COND_TIME (condition handler scan time)

Data Type: INTEGER
Minimum/Maximum: 1/128
Program/KCL: NO/PW
Default: 32

Power Up: Yes
Saved: Yes
Backed Up: Yes

\$COND_TIME is used to specify the time between scans in a condition handler. The value, in milliseconds, is rounded to the next lowest multiple of 8 msec. **\$COND_TIME** is the default scanning time. The actual scanning time is the value you specify in **\$SCAN_TIME** multiplied by **\$COND_TIME**.

See Also:

\$SCAN_TIME Condition Handler Qualifier in this appendix
WITH Clause, Appendix A, *KAREL Reference Manual*
for more information on using **\$COND_TIME** and **\$SCAN_TIME**

\$CONFIG_MASK (configuration mask)

Data Type: INTEGER
 Program/KCL: RO/PW
 Default: Robot Specific

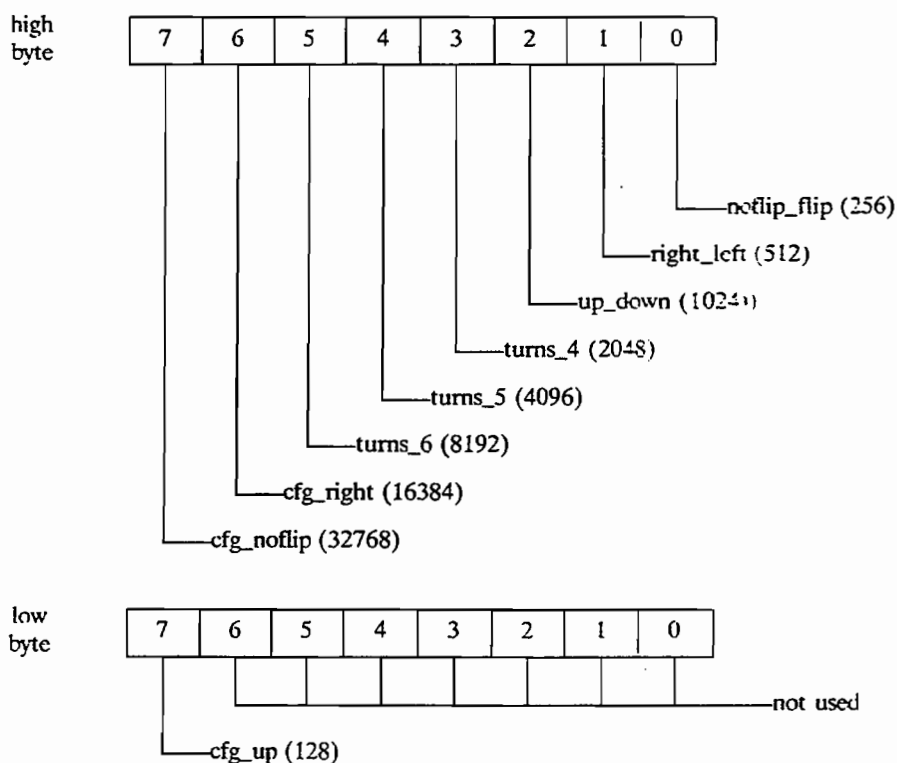
Power Up: No
 Saved: Yes
 Backed Up: No

\$CONFIG_MASK indicates which configuration bits are tested in the solution programs. The value depends on robot type. **\$CONFIG_MASK** also indicates when multiple-turn joints are used.

\$CONFIG_MASK affects the input and display of the configuration string when you specify or display positions.

The value of **\$CONFIG_MASK** is set by the KCL> UTILITY SINIT command and should not be changed.

This variable is set up on the characteristics of each model robot. Each bit is defined as follows:



SYSTEM VARIABLE DESCRIPTIONS

\$CONFIG_MASK System Variable

The labels in the bit masks have the following meanings:

LABEL	MEANING
noflip_flip	1 : no noflip_flip ocfiguration 0 : has noflip_flip configuration
right_left	1 : no right_left configuration 0 : has right_left configuration
up_down	1 : no up_down configuration 0 : has up_down configuration
turns_4	1 : no multiple turn for 4th joint 0 : has multiple turn for 4th joint
turns_5	1 : no multiple turn for 5th joint 0 : has multiple turn for 5th joint
turns_6	1 : no multiple turn for 6th joint 0 : has multiple turn for 6th joint
cfg_right	1 : default configuration right 0 : default configuration left
cfg_noflip	1 : default configuration noflip 0 : default configuration flip
cfg_up	1 : default configuration up 0 : default configuration down

See Also:

Enhanced KAREL Operations Manual for specific robot configuration information.

\$CONTAXISNUM (continuous axis number)

Data Type: INTEGER
Minimum/Maximum: 0/9
Program/KCL: NO/PW
Default: 0

Power Up: Yes
Saved: Yes
Backed Up: No

\$CONTAXISNUM indicates which axis operates in continuous turn mode (optional feature) and enables continuous turn for that axis. The only valid values for \$CONTAXISNUM are the highest robot axis number or an auxiliary axis number.

The default value indicates that no axis will operate in continuous mode (all axes operate normally.)

\$CONTAXISVEL (continuous axis velocity)

Data Type: REAL
Program/KCL: RW/RO
Power Up: No

Saved: No
Backed Up: Yes
Default: 0.0

\$CONTAXISVEL indicates the velocity of continuous turn motion, including both magnitude and direction. \$CONTAXISVEL can have values between -100.0 and +100.0. The magnitude is a percentage of maximum joint speed expressed as a REAL value and a positive or negative direction is indicated by the + or - sign.

If \$CONTAXISNUM has a value other than 0, the specified axis begins continuous turn motion with the next motion statement after the value is assigned to \$CONTAXISVEL. The velocity of the continuous turn motion is determined by the value of \$CONTAXISVEL.

The motion terminates during or at the completion of the next motion statement after \$CONTAXISVEL is set back to 0.

The default is set each time a program is run. This means you must assign a value within a program if you want to use continuous turn mode (optional feature).

See Also:

Continuous Turn Manual for more information

\$CUR_CRFRAME (current circular reference frame)

Data Type: POSITION
Program/KCL: RW/RW
Power Up: No

Saved: No
Backed Up: No

\$CUR_CRFRAME is effective only for circular moves in the Path Relative Frame (optional feature). \$CUR_CRFRAME is updated by the system, which indicates the current circular reference frame defined by the arc of the motion. It is used in conjunction with \$CUR_PRFRAME and \$PFR_RESUME to resume a stopped motion smoothly for moves in the Path Relative Frame.

See Also:

\$TTOOLNUM System Variable in this appendix

\$CUR_PRFRAME (current path relative frame)

Data Type: POSITION
Program/KCL: RW/RW
Power Up: No

Saved: No
Backed Up: No

\$CUR_PRFRAME is effective only for linear moves in Path Relative Frame (optional feature). \$CUR_PRFRAME indicates the current Path Relative Frame with respect to the World Coordinate Frame and is updated by the system. It is used in conjunction with \$CUR_CRFRAME and \$PFR_RESUME to resume a stopped motion for moves in the Path Relative Frame.

SYSTEM VARIABLE DESCRIPTIONS

\$CUR_PRFRAME System Variable

\$CYCLE_STRT (cycle start)

Data Type: STRING
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: Yes
Default: ' ' (blank)

\$CYCLE_STRT specifies the KCL command procedure that is executed when the operator panel CYCLE START button is pressed. If the command procedure is not found, the system will search for a p-code file of the same name as specified in **\$CYCLE_START**. If found in RAM, this file will be executed. If it is found in bubble memory, the file will be loaded before execution.

The command procedure is executed only if a KAREL program is not running or paused. You are responsible for setting the value of **\$CYCLE_STRT** if you want the CYCLE START button to execute a command procedure.

See Also:

Enhanced KAREL Operations Manual for more information on setting **\$CYCLE_STRT**.

\$C_STOP (cycle stop)

Data Type: BOOLEAN
Program/KCL: NO/RO
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$C_STOP indicates whether or not the UOP CYCLE STOP signal has been activated.

The value of **\$C_STOP** automatically is set to TRUE after CYCLE STOP is activated. It is set to FALSE after CYCLE START is activated.

\$C_STOP_ENBL (cycle stop enable)

Data Type: BOOLEAN
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$C_STOP_ENBL controls the function of the UOP CYCLE STOP signal. If it is FALSE, CYCLE STOP performs the same function as HOLD.

If you set **\$C_STOP_ENBL** to TRUE, the CYCLE STOP button will not pause the program automatically. You can use the KAREL language **C_STOP** function in a program to test the value of **\$C_STOP** and pause a program if **\$C_STOP** is TRUE.

\$DDCMP_PARAM (DDCMP parameter)

Data Type: INTEGER ARRAY [2]
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No

\$DDCMP_PARAM is an ARRAY which specifies the DDCMP communications parameters. The array elements represent the following parameters:

- \$DDCMP_PARAM[1] indicates the maximum number (between 0 and 3) of simultaneous DDCMP connections.
- \$DDCMP_PARAM[2] currently is not used.

See Also:

KAREL-MAP Installation and Maintenance Manual

\$DECELTO (deceleration tolerance)

Data Type: INTEGER
Minimum/Maximum: 1/99
Program/KCL: RW/RW
Default: 50

Power Up: No
Saved: No
Backed Up: Yes

\$DECELTO specifies the percent of deceleration distance that must be covered before a motion is considered finished and the next segment is permitted to start. It is used with the VARDECEL termination type.

Setting \$DECELTO to 1 makes VARDECEL nearly equivalent to the NODECEL termination type. Setting \$DECELTO to 99 makes VARDECEL nearly equivalent to NOSETTLE.

See Also:

Chapter 8, *KAREL Reference Manual* for more information on termination types.

SYSTEM VARIABLE DESCRIPTIONS

\$DELTAFRAME System Variable

\$DELTAFRAME (delta frame)

Data Type: POSITION
Program/KCL: RW/RO
Default: \$NILP

Power Up: No
Saved: No
Backed Up: No

\$DELTAFRAME represents the positional data needed to integrate the robot motion with an external sensor. The value of **\$DELTAFRAME** is used to provide dynamic path modification by incorporating it into path planning to change the nominal path.

\$DELTAFRAME can be set based on external sensor data, internal auxiliary axes positions (table coordinates), a generated vector (for weaving applications), or by some other method. Its value can be with respect to the world coordinate system or the user frame, based on the application and on the value of **\$TFRAMENUM**.

\$DELTAFRAME	\$TFRAMENUM	Coordinate Frame
location	-1	World
location + orientation	-2	World
location	-3	User Frame
location + orientation	-4	User Frame

\$TFRAMENUM can be set in a KAREL program to determine, in conjunction with **\$DELTAFRAME**, the desired coordinate system.

See Also:

\$TFRAMENUM System Variable in this appendix

\$DELTATool (delta tool)

Data Type: POSITION
Program/KCL: RW/RO
Power Up: No

Saved: No
Backed Up: No

\$DELTATool represents the position change with respect to the tool frame based on external sensor data. The value of **\$DELTATool**, is incorporated into path planning to change the nominal path dynamically. Its value can be used with respect to the tool coordinate system or the path relative coordinate system attached to the path trajectory depending on the value of **\$TToolNUM**.

SYSTEM VARIABLE DESCRIPTIONS
\$DELTATool System Variable

\$DELTATool	\$TToolNUM	Coordinate System
location	1	Tool
location + orientation	2	Tool
disabled	0	
location + orientation	0	Path Relative Frame
location - 1	Path Relative Frame	
location + orientation	-2	Path Relative Frame
location - 3	Path Relative Frame	
location + orientation	-4	Path Relative Frame

\$TToolNUM can be set in a KAREL program to determine the desired coordinate system.

See Also:

\$TToolNUM System Variable in this appendix

\$DFLT_PROG (default program)

Data Type: STRING
Program/KCL: NO/RO
Power Up: No

Saved: No
Backed Up: Yes
Default: ' ' (blank)

\$DFLT_PROG identifies the default program name that is used by KCL commands and the teach pendant when you do not specify a program name.

You set the value of **\$DFLT_PROG** using the KCL> DEFAULT command.

\$DISPLAY_ON (display on)

Data Type: BOOLEAN
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: Yes
Default: TRUE

\$DISPLAY_ON indicates whether or not a program will be displayed on the CRT/KB as it is being translated. If the value is TRUE the program is displayed.

If you set it to FALSE, only header information indicating which file is being translated is displayed. If a translation error occurs, it will also be displayed. Translation will proceed faster if **\$DISPLAY_ON** is FALSE.

The value of **\$DISPLAY_ON** can be overridden using the /DISPLAY or /NODISPLAY options with the KCL> TRANSLATE command.

SYSTEM VARIABLE DESCRIPTIONS

\$DMR System Variable

\$DMR (detector multiplier ratio)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: 0/7
Program/KCL: NO/PW
Default: Robot Specific

Power Up: Yes
Saved: Yes
Backed Up: No

\$DMR multiplies encoder pulses to produce detected pulses. \$DMR is encoded as follows:

0 : 0.5	1 : 1.0	2 : 1.5	3 : 2.0
4 : 2.5	5 : 3.0	6 : 3.5	7 : 4.0

The value of \$DMR is set by the KCL> UTILITY SINIT command and should not be changed for robot axes. For auxiliary axes, set this variable using only the Motion Hardware Setup Program.

See Also:

SCMR System Variable in this appendix

\$DO_RECOVER (do recover)

Data Type: BOOLEAN
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$DO_RECOVER indicates whether or not the power fail recovery (optional feature) is enabled.

At power up, the system loads \$DO_RECOVER from bubble memory. If the value of \$DO_RECOVER is TRUE, the system tries to recover. If \$DO_RECOVER is FALSE, the system will not attempt to recover. Also, if the SYSVARS.SV file is not present, the value of \$DO_RECOVER is set to FALSE automatically and the system will not recover.

You are responsible for setting the value of \$DO_RECOVER to indicate whether or not you want the power fail recovery procedure to be executed.

See Also:

Power Fail Recovery R-H Controller Manual for more information

\$DRY_RUN (dry run)

Data Type: BOOLEAN
Program/KCL: NO/RO
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$DRY_RUN indicates whether or not a program is being run with servo power off and the robot locked.

The value of \$DRY_RUN is set and cleared automatically when the machine LOCK parameter is set by a KCL command or by the teach pendant.

\$DYNAMICFLTR (dynamic filter)

Data Type: BOOLEAN
Program/KCL: NO/PW
Default: FALSE

Power Up: No
Saved: Yes
Backed Up: No

When \$DYNAMICFLTR is set to FALSE, the default acceleration/deceleration time constants at power up are used. When \$DYNAMICFLTR is TRUE, the acceleration/deceleration time constants of the axes are computed dynamically based on the inertia of the robot at the start and destination positions. Hence, the acceleration/deceleration time is equal to or shorter than the default case in order to improve the cycle time.

NOTE

Currently this feature is implemented only on the first joint (θ axis) of the S-420 robot.

\$ENBL_OVRD (enable override)

Data Type: BOOLEAN
Program/KCL: RW/RN
Power Up: No

Saved: No
Backed Up: Yes
Default: FALSE

\$ENBL_OVRD enables the setting of the general override from the teach pendant while the teach pendant is disabled.

If \$ENBL_OVRD is FALSE, the OVERRIDE UP and DOWN keys on the teach pendant only function when the teach pendant is enabled in order to prevent inadvertent changes to the robot motion during production.

If \$ENBL_OVRD is TRUE, the OVERRIDE keys will work at all times.

SYSTEM VARIABLE DESCRIPTIONS

\$ENCOFFSTS System Variable

\$ENBL_OVRD is program accessible so that KAREL program-driven “teaching programs” can permit an operator to change the override while the teaching program is running.

\$ENCOFFSTS (encoder offsets)

Data Type: INTEGER ARRAY [9]
Program/KCL: NO/PW
Power Up: Yes

Saved: Yes
Backed Up: No

\$ENCOFFSTS indicates encoder offsets, one per axis, in command pulses. The formula for conversion from joint angles to command pulses is:

$$\text{command pulses}[i] = \text{\$ENCOFFSTS}[i] + (\text{\$ENCSCALES}[i] * \text{joint-angle}[i])$$

The value of **\$ENCOFFSTS** is set internally and should not be changed.

See Also:

\$CMR and **\$ENCSCALES** System Variables in this appendix

\$ENCSCALES (encoder scale factor)

Data Type: REAL ARRAY [9]
Program/KCL: NO/PW
Default: Robot Specific

Power Up: Yes
Saved: Yes
Backed Up: No

\$ENCSCALES defines a scaling factor, in counts/unit, used to convert from units to pulses. It is used in the formula defined for **\$ENCOFFSTS**.

The value of **\$ENCSCALES** is set by the KCL> UTILITY SINIT command and should not be changed for robot axes. For auxiliary axes, set this variable using the Motion Hardware Setup Program.

\$FB_MON_ENB (feedback monitor enable)

Data Type: BOOLEAN ARRAY [9]
Program/KCL: NO/PW
Power Up: Yes

Saved: Yes
Backed Up: No
Default: TRUE

\$FB_MON_ENB indicates whether or not feedback monitor alarm checking is enabled for each axis.

\$FINETOL (fine tolerance)

Data Type: INTEGER ARRAY [9]

Minimum/Maximum: 0/32767

Program/KCL: NO/RW

Default: Robot Specific

Power Up: No

Saved: Yes

Backed Up: No

\$FINETOL is an array of in-position tolerances used to determine when the robot is in position when \$TERMTYPE = FINE. The value is in units of detector pulses (as explained under \$CMR).

The value of \$FINETOL is set by the KCL> UTILITY SINIT command and should not be changed. For auxiliary axes, set this variable using the Motion Hardware Setup Program.

See Also:

\$COARSETOL System Variable in this appendix to compute the tolerance in radians or millimeters.

\$FUL_RMT_OUT (full remote output)

Data Type: BOOLEAN

Program/KCL: NO/PW

Power Up: No

Default: FALSE

Power Up: No

Saved: Yes

Backed Up: No

\$FUL_RMT_OUT determines whether 8 or 16 outputs are available for remote interface. If it is FALSE, only the lower 8 bits are used. If it is TRUE, all 16 bits are used for remote interface.

See Also:

Chapter 13, *KAREL Reference Manual*

SYSTEM VARIABLE DESCRIPTIONS

\$GAINS System Variable

\$GAINS (gains)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: 1/50
Program/KCL: NO/PW
Default: 20

Power Up: Yes
Saved: Yes
Backed Up: No

\$GAINS defines an array of gains of the servo system.

The value of \$GAINS is set by the KCL> UTILITY SINIT command and should not be changed. For auxiliary axes, set this variable using the Motion Hardware Setup Program.

\$GENOVERRIDE (general override)

Data Type: INTEGER
Minimum/Maximum: 1/100
Program/KCL: RO/RW
Default: 10

Power Up: No
Saved: No
Backed Up: No

\$GENOVERRIDE, a scaling factor, is expressed as a percentage of the motion speed.

For all programmed motion \$GENOVERRIDE is multiplied with \$PRGOVERRIDE to obtain a total override value, which is then multiplied by the motion speed.

As a safety feature, the value of \$GENOVERRIDE automatically is set to 10 if you do not confirm the setting before jogging the robot. You can set the value of \$GENOVERRIDE using the teach pendant OVERRIDE UP and DOWN keys or KCL commands.

\$GRID (grid)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: 1/9
Program/KCL: NO/PW
Default: Robot Specific

Power Up: Yes
Saved: Yes
Backed Up: No

\$GRID defines the number of detector pulses per revolution of the encoder. The word "grid" refers to the repeating pattern of lines or pulses produced by an incremental encoder with each revolution.

The grid is in units of detector pulses. For example, if the actual encoder has 2000 grid lines per revolution, and a DMR of 4 is used, the detector grid size is 8000 pulses.

\$GRID is encoded as follows:

Formula: $\text{gridsize} = (\$GRID + 1) * 1000$
Example: \$GRID = 7 : grid size = 8000
 \$GRID = 3 : grid size = 4000
 (\$GRID = 6 or 8 is an invalid value.)

The value of \$GRID is set by the KCL> UTILITY SINIT command and should not be changed. For auxiliary axes, set this variable using only the Motion Hardware Setup Program.

See Also:

\$DMR System Variable in this appendix

\$GRIDSHIFTS (grid shifts)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: -32768/32767
Program/KCL: NO/PW
Default: 0

Power Up: Yes
Saved: Yes
Backed Up: No

\$GRIDSHIFTS is an array of grid shifts for incremental encoders, one per axis, used to shift the location of the detected encoder index pulse relative to the actual index pulse. This allows the servo system to be used to adjust the apparent position of the encoder on its shaft without performing a physical adjustment.

You might need to change the default value following a dog check. Use the KCL> DOGCHECK command to adjust the value of \$GRIDSHIFTS.

See Also:

DOGCHECK command, Appendix B, *KAREL Reference Manual*

\$HOLD (hold)

Data Type: BOOLEAN
Program/KCL: NO/RW
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$HOLD causes robot motion to be held. While \$HOLD is TRUE, interpolation of the motion is suspended; the robot decelerates to a stop and remains stopped until \$HOLD is FALSE.

Pressing the operator panel HOLD button or teach pendant HOLD key sets the value of \$HOLD to TRUE. To set \$HOLD to FALSE, use the KCL> RESUME command.

SYSTEM VARIABLE DESCRIPTIONS

\$HOME System Variable

\$HOME (home position)

Data Type: POSITION
Program/KCL: RW/PW
Power Up: No

Saved: Yes
Backed Up: Yes
Default: Uninitialized

\$HOME is a user-definable home position for the robot. Activating the UOP HOME signal moves the robot to this position unless a predefined command file, KCP_HOME.CF, exists, in which case the command file is executed. You can also use the KCL> MOVETO command to move the robot to the HOME position.

\$INC_DEC_DIS (incremental deceleration distance)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: -32768/32767
Program/KCL: NO/PW

Power Up: No
Saved: Yes
Backed Up: No

\$INC_DEC_DIS indicates the distance for approaching the dog for each axis on robots with incremental encoders. It is usually expressed in units of negative pulse counts.

For auxiliary axes, you are responsible for setting the value of \$INC_DEC_DIS to correctly define the calibration sequences using the Motion Hardware Setup Program.

\$INC_FWD_DIS (incremental forward distance)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: -32768/32767
Program/KCL: NO/PW

Power Up: No
Saved: Yes
Backed Up: No

\$INC_FWD_DIS indicates the distance for moving away from the dog, for each axis on robots with incremental encoders. It is expressed in units of positive pulse counts.

For auxiliary axes, you are responsible for setting the value of \$INC_FWD_DIS to correctly define the calibration sequences using the Motion Hardware Setup Program.

\$INC_OFFSET (incremental offset)

Data Type: REAL ARRAY [9]
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: 0.0

The value of \$INC_OFFSET is determined automatically by the mastering procedure. It is the positive or negative difference in radians (or millimeters in prismatic joints) between the one-revolution index pulse and the actual calibration position for each axis on robots with incremental encoders.

When the mastering data has been altered (for example, by replacing a motor), the index position of the robot will not correspond to the calibration position. By moving the robot to the mastering position this error can be determined. \$INC_OFFSET represents this value.

\$INC_RVS_DIS (incremental reverse distance)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: -32768/32767
Program/KCL: NO/PW

Power Up: No
Saved: Yes
Backed Up: No

\$INC_RVS_DIS indicates the distance for approaching close to the one-revolution index pulse for each axis on robots with incremental encoders. It is expressed in units of negative pulse counts.

For auxiliary axes, you are responsible for setting the value of \$INC_RVS_DIS to correctly define the calibration sequences using the Motion Hardware Setup Program.

\$INPOSITION (in position)

Data Type: BOOLEAN ARRAY [9]
Program/KCL: NO/RO
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$INPOSITION is an array of flags indicating the axes that are in position. At the beginning of a segment the flags are automatically set to FALSE. By the end of the segment all of the flags are TRUE, indicating each axis is within tolerance for the specified position.

The value of \$INPOSITION is set and updated automatically.

\$INTP_STATUS (interpreter status)

Data Type: INTEGER
Minimum/Maximum: -1/1
Program/KCL: NO/RO

Power Up: No
Saved: No
Backed Up: No

SYSTEM VARIABLE DESCRIPTIONS

\$INTP_STATUS System Variable

\$INTP_STATUS indicates the current status of the program interpreter using the following values:

-1 = running

0 = paused

+1 = aborted

\$INTP_STATUS is set and updated automatically.

\$IN_USERMENU (in usermenu)

Data Type: BOOLEAN

Program/KCL: RO/RO

Power Up: No

Saved: No

Backed Up: Yes

Default: FALSE

\$IN_USERMENU indicates **USERMENU** is displayed on the teach pendant. It is used in conjunction with **\$LOCK_TPMENU** to tell a program when the teach pendant menu has been locked to the **USERMENU**.

\$IN_USERMENU automatically is set to **TRUE** whenever **USERMENU** is displayed on the teach pendant.

\$IO_TIMEOUT (input/output time-out)

Data Type: INTEGER

Minimum: 0

Program/KCL: RW/RW

Default: 0

Power Up: No

Saved: Yes

Backed Up: Yes

\$IO_TIMEOUT indicates the time-out value in milliseconds. It is used on KAREL language **READ** and **WRITE** statements. An **\$IO_TIMEOUT** value of 0 indicates an infinite time-out value.

\$JNTCALSEQ (joint calibration sequence)

Data Type: INTEGER ARRAY [9]

Minimum/Maximum: 0/9

Program/KCL: NO/PW

Default: Robot Specific

Power Up: No

Saved: Yes

Backed Up: No

\$JNTCALSEQ indicates the sequence in which each axis moves to the calibration position for incremental calibration.

The value of \$JNTCALSEQ is set by the KCL> UTILITY SINIT command and should not be changed. For auxiliary axes, you are responsible for setting the value of \$JNTCALSEQ to correctly define the calibration sequences using the Motion Hardware Setup Program.

\$JNTFOLERR (joint following error)

Data Type: INTEGER ARRAY [9]
Program/KCL: NO/RO
Power Up: No

Saved: No
Backed Up: No
Default: 0

\$JNTFOLERR indicates the joint following error. The units are detector pulses.
The value of \$JNTFOLERR is set and updated automatically.

\$JNTVELLIM (joint velocity limit)

Data Type: REAL ARRAY [9]
Program/KCL: NO/RW
Default: Robot Specific

Power Up: No
Saved: Yes
Backed Up: Yes

\$JNTVELLIM defines joint speed limits in units of radians per second or millimeters per second for each robot joint. It is used to calculate the speed of all joint interpolated motion.

If motion speed of any joint exceeds the value of \$JNTVELLIM during linear or circular motion, the robot speed will slow down so that the joint velocity becomes within its limit, and the warning message, "Joint speed limit used." will be displayed. Since the accuracy of motion is not guaranteed in this case, this condition should be avoided by reteaching the positions.

The value of \$JNTVELLIM is set by the KCL> UTILITY SINIT command and should not be increased beyond the default values for robot axes. For auxiliary axes, you are responsible for setting the value correctly using the Motion Hardware Setup Program.

See Also:

Chapter 8, *KAREL Reference Manual*

\$JOGFRAME (jogging frame)

Data Type: POSITION
Program/KCL: RW/RW
Power Up: No

Saved: Yes
Backed Up: Yes
Default: \$NILP

SYSTEM VARIABLE DESCRIPTIONS

\$JOGFRAME System Variable

\$JOGFRAME is used as the frame of reference for jogging when "JOGFRAME" is selected on the teach pendant. For most cases, it is convenient to set it to the same value as \$UFRAME. It will allow you to jog the robot along the x,y,z direction defined by \$UFRAME.

For some cases you may want to set \$JOGFRAME to a different value than \$UFRAME. This will allow you to jog the robot independently of \$UFRAME and still permit you to RECORD positions in reference to \$UFRAME.

See Also:

\$JOG_COORD System Variable in this appendix

Enhanced Karel Operations Manual

\$JOGLOCK (jog lock) *

Data Type: BOOLEAN

Program/KCL: RW/NO

Power Up: No

Saved: No

Backed Up: Yes

Default: FALSE

\$JOGLOCK, together with \$JOGLOCK_EN, allow the **SHIFT** keys on the teach pendant to be locked in the pressed position. This eliminates having to manually hold them down while jogging the robot.

There are two methods you can use to lock the **SHIFT** keys:

- Press both **SHIFT** keys on the teach pendant when the teach pendant is enabled and the system variable \$JOGLOCK_EN = TRUE.
- Set \$JOGLOCK = TRUE from a running KAREL program while the teach pendant is enabled and \$JOGLOCK_EN = TRUE.

The **SHIFT** keys cannot be locked in place if \$JOGLOCK_EN = FALSE.

When the SHIFT keys are locked, an "L" will replace the "%" sign on the top right corner of the teach pendant screen.

\$JOGLOCK_EN will be set to FALSE automatically if you are prompted to enter an INTEGER or REAL value from the teach pendant when the **SHIFT** keys are locked in place. When this occurs, the "L" will change to a "%".

WARNING

If a KAREL RELEASE statement is executed in the program, the teach pendant will have motion control. Therefore, \$JOGLOCK_EN will not be reset and the robot will begin jogging if the **SHIFT** keys are locked and you press a numeric/jog key in response to a prompt which asks for an INTEGER or REAL value.

See Also:

\$JOGLOCK_EN System Variable

Enhanced KAREL Operations Manual for more information on jogging and teaching.

\$JOGLOCK_EN (jog lock enable) *

Data Type: BOOLEAN
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$JOGLOCK, together with \$JOGLOCK_EN, allow the **SHIFT** keys on the teach pendant to be locked in the pressed position. This eliminates having to hold them down while jogging the robot. Both \$JOGLOCK_EN and \$JOGLOCK must be TRUE to lock the **SHIFT** keys in place.

\$JOGLOCK_EN cannot be set from within a KAREL program.

See Also:

\$JOGLOCK System Variable

Enhanced KAREL Operations Manual for more information on jogging and teaching.

\$JOGWRISTJNT (jog orientation method)

Data Type: BOOLEAN
Program/KCL: RW/RW
Power Up: No

Saved: No
Backed Up: Yes
Default: FALSE

\$JOGWRISTJNT indicates the currently selected orientational method for the teach pendant. The following values are used:

- TRUE = Two angle orientation
- FALSE = Wrist joint orientation

\$JOGWRISTJNT is set automatically by the teach pendant by selecting the SETUP key to display the Setup screen, selecting the **F1** SETFRAME function key and then selecting the **F3** UJOG function key.

\$JOG_COORD (jog coordinate system)

Data Type: INTEGER
Minimum/Maximum: 0/4
Program/KCL: RW/RW

Power Up: No
Saved: No
Backed Up: Yes

SYSTEM VARIABLE DESCRIPTIONS

\$JOG_COORD System Variable

\$JOG_COORD indicates the currently selected jog coordinate system for the teach pendant, using the following values:

- 0 = JOINT
- 1 = JOGFRAME
- 2 = WORLDFRAME
- 3 = TOOLFRAME
- 4 = AUX AXIS

\$JOG_COORD is automatically set by the teach pendant COORD key on the teach pendant.

\$KEPTMIRLIM (KEPT Motion Instruction Record LIMits)

Data Type: INTEGER
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: 0

\$KEPTMIRLIM is the number of motion instruction records kept in the path planning system during motion. Adjusting this value makes it possible to recover all interrupted motions after a servo error (for example, EMERGENCY STOP).

The range of **\$KEPTMIRLIM** is from 0-9 but must be less than or equal to (**\$NUM_MIR** - 3).

See Also:

\$NUM_MIR System Variable in this appendix

\$KL_USERSTAT (KAREL screen user status line)

Data Type: BOOLEAN
Program/KCL: RW/RO
Power Up: No

Saved: No
Backed Up: Yes
Default: FALSE

\$KL_USERSTAT indicates whether the KAREL system or application program has control of the KAREL screen status line on the CRT/KB.

If **\$KL_USERSTAT** is set to TRUE and a KAREL program is running or paused the system stops updating the status line, giving control to the program. The predefined constant CRTSTATUS can be used to write to the status line when **\$KL_USERSTAT** is TRUE.

If **\$KL_USERSTAT** is set to FALSE the system automatically updates the status line. By default, **\$KL_USERSTAT** is set to FALSE each time a program is executed. It automatically resets to FALSE when program execution ends or the program is aborted.

See Also:

Enhanced KAREL Operations Manual for more information
on CRT/KB screens.

\$KNCP_PARAM (KNCP parameter)

Data Type: INTEGER ARRAY [8]
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No

\$KNCP_PARAM is an array which specifies NCP communications parameters. The array elements represent the following parameters:

- \$KNCP_PARAM[1] is the number of copies of NCP running DDCMP connections. By default, the value is set to 1.
- \$KNCP_PARAM[2] is the number of copies of NCP running MAP connections. By default, the value is set to 1.

NOTE

KAREL can run a maximum of 2 copies of NCP. Therefore, the sum of \$KNCP_PARAM[1] and \$KNCP_PARAM[2] cannot exceed 2.

- \$KNCP_PARAM[3] indicates which severity category of error codes is reported. You can specify no category, a particular category, or all categories. By default, the value is set to 0, meaning no errors are reported.
- \$KNCP_PARAM[4] is a coded value indicating which "facility" or KAREL subsystem reports errors. By default, the value is set to 0, meaning no errors are reported.
\$KNCP_PARAM[4] enables Subsystems 19-17.
- \$KNCP_PARAM[5] is a coded value indicating which "facility" or KAREL subsystem reports errors. By default, the value is set to 0, meaning no errors are reported.
\$KNCP_PARAM[5] enables Subsystems 16-1.
- \$KNCP_PARAM[6] currently is not used.
- \$KNCP_PARAM[7] currently is not used.
- \$KNCP_PARAM[8] currently is not used.

Values are assigned to \$KNCP_PARAM by default. However, you might need to change these values to tailor the system for specific communication applications.

See Also:

SERIAL Communication Reference Manual for more information on setting \$KNCP_PARAM

SYSTEM VARIABLE DESCRIPTIONS

\$LINK_LEN_1 System Variable

\$LINK_LEN_1 (link length 1)

Data Type: REAL
Program/KCL: NO/PW
Default: Robot Specific

Power Up: No
Saved: Yes
Backed Up: No

\$LINK_LEN_1 has a meaning that is robot specific. It is intended primarily to support multiple versions of a given robot model, where the differences are only in link lengths.

It can also be used in some cases to support multiple versions with other minor differences in kinematic parameters.

The value of **\$LINK_LEN_1** is set by the KCL> UTILITY SINIT command and should not be changed.

\$LINK_LEN_2 (link length 2)

Data Type: REAL
Program/KCL: NO/PW
Default: Robot Specific

Power Up: No
Backed Up: No

\$LINK_LEN_2 has a meaning that is robot specific.

The value of **\$LINK_LEN_2** is set by the KCL> UTILITY SINIT command and should not be changed.

See Also:

\$LINK_LEN_1 System Variable in this appendix to compute the tolerance in radians or millimeters.

\$LIST_ON (list on)

Data Type: BOOLEAN
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$LIST_ON indicates whether or not the language translator will generate a listing file when a source file is translated. To conserve space, the same file specification, LISTING.LS, is used for all listing files.

If you set the value to TRUE, a listing file is generated. If you set it to FALSE, a listing file is not generated and the translation procedure is faster.

The value of **\$LIST_ON** can be overridden using the /LISTING or /NOLISTING options with the KCL> TRANSLATE command.

\$LOCK_KLMENU (lock KAREL menu) *

Data Type: BOOLEAN
Program/KCL: RW/PW
Default: FALSE

Power Up: No
Backed Up: Yes
Saved: No

\$LOCK_KLMENU provides KAREL programs with the ability to lock any KAREL screen or menu displayed on the CRT while a program is running. When a KAREL screen or menu is locked, all function keys are accessible by the program, however, they will be blank unless the program writes to them. Setting \$LOCK_KLMENU = TRUE will lock the display of the current KAREL screen or menu.

While the CRT screen is locked, the function key, **F10**, will not be active. Therefore, the program has control over which menu is being displayed. The DISPLAYPG built-in must be used within the program to force a KAREL screen or menu to be displayed.

If \$LOCK_KLMENU is FALSE, all system defined function keys will be displayed and active.

\$LOCK_TPMENU (lock teach pendant menu)

Data Type: BOOLEAN
Program/KCL: RW/PW
Power Up: No

Saved: No
Backed Up: Yes
Default: FALSE

\$LOCK_TPMENU is a program accessible variable intended for use in "teaching programs" to prevent novice operators from "escaping" the control of the KAREL program. KCL command access is also permitted to allow start-up command files to lock the menu.

If \$LOCK_TPMENU is TRUE, the teach pendant is locked at the USERMENU display. \$LOCK_TPMENU can only be used if a program is running.

If USERMENU is not being displayed when \$LOCK_TPMENU is first set to TRUE, the lock function does not take effect until the user selects the USERMENU on the teach pendant. (The value of \$IN_USERMENU indicates whether or not the USERMENU is has been selected.)

\$LOCTOL (location vector tolerance)

Data Type: REAL
Program/KCL: RW/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: 3.0

SYSTEM VARIABLE DESCRIPTIONS

\$LOCTOL System Variable

\$LOCTOL is used when comparing the location vector of two positions. \$LOCTOL, along with \$APPROACHTOL, \$ORIENTTOL, and \$CHECKCONFIG is used in conjunction with the relational operator ">=<" to compare two positions.

If \$LOCTOL is negative, no comparison is made and the location vectors of the two positions are "nearly" identical. When \$LOCTOL is 0, the location vectors must be identical in order for the relational operator to return TRUE.

When \$LOCTOL is greater than 0 the following test is made:

```
loc1 = LOC(pos1);  
loc2 = LOC(pos2);  
If (ABS(loc1[1] - loc2[1]) <= $LOCTOL) and  
   (ABS(loc1[2] - loc2[2]) <= $LOCTOL) and  
   (ABS(loc1[3] - loc2[3]) <= $LOCTOL) then  
the location vectors of the two positions are "nearly" identical.
```

\$LOWERLIMS (lower joint limits)

Data Type: REAL ARRAY [9]
Program/KCL: NO/PW
Default: Robot Specific

Power Up: Yes
Saved: Yes
Backed Up: No

\$LOWERLIMS defines the lower joint limits in radians or millimeters.

The value of \$LOWERLIMS is set by the KCL> UTILITY SINIT command and should not be changed for robot axes. For auxiliary axes, you are responsible for setting the value correctly using the Motion Hardware Setup Program.

\$M0_KNAME (MAP0 node name)

Data Type: STRING[64]
Program/KCL: RW/PW
Power Up: No

Saved: Yes
Backed Up: Yes

\$M0_KNAME specifies the port name (application process title) of the specific KAREL controller for which it is defined. The name must be unique on the MAP network. It is required to receive connections on the MAP0 channel. You are responsible for setting the value of \$M0_KNAME before any associations are attempted on the MAP0 channel.

See Also:

KAREL-MAP, Installation and Maintenance

\$M1_FNAME (MAP1 foreign node name)

Data Type: STRING[64]
Program/KCL: RW/PW
Power Up: No

Saved: Yes
Backed Up: Yes

\$M1_FNAME specifies the port name of the foreign application process title to which the KAREL controller is to be connected when requesting an association on the MAP1 channel. You are responsible for setting the value of \$M1_FNAME before any associations are requested on the MAP1 channel.

See Also:

KAREL-MAP, Installation and Maintenance

\$M1_KNAME (MAP1 node name)

Data Type: STRING[64]
Program/KCL: RW/PW
Power Up: No

Saved: Yes
Backed Up: Yes

\$M1_KNAME specifies the port name (application process title) of the specific KAREL controller on which it is defined. The name must be unique on the MAP network. It is required to initiate connections on the MAP1 channel.

You are responsible for setting the value of \$M1_KNAME before any associations are attempted on the MAP1 channel.

See Also:

KAREL-MAP, Installation and Maintenance

\$MANLIM (manual motion speed limit)

Data Type: INTEGER
Minimum/Maximum: 0/100
Program/KCL: NO/PW
Default: 25

Power Up: No
Saved: Yes
Backed Up: No

\$MANLIM, a scaling factor, is expressed as a percentage of the maximum speed for jogging. For joint motion the maximum speed is \$JNTVELIM, and for Cartesian motion it is \$SPEEDLIM. \$MANLIM is used to calculate the speed of joint and Cartesian jog motions as well as the default value of \$SPEED.

See Also:

Chapter 8, *KAREL Reference Manual*

SYSTEM VARIABLE DESCRIPTIONS

\$MAP_PARAM System Variable

\$MAP_PARAM (MAP parameter)

Data Type: INTEGER ARRAY [8]
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No

\$MAP_PARAM is an array that specifies MAP communications parameters. The array elements represent the following parameters:

- \$MAP_PARAM[1] is the data rate of the CIM to INI serial link. It is effective when \$MAP_PARAM = 0. By default, the value is set to 8 which represents 56K bits/sec. (Maximum value = 9).
- \$MAP_PARAM[2] is the time-out value on KAREL-MAIN service associations and releases. By default, the value is set to 60 seconds, the minimum allowable.
- \$MAP_PARAM[3] indicates whether an internal or external clock is used on the MAP card. By default, the value is set to 0 (internal clock). A value of 1 represents the external clock.
- \$MAP_PARAM[4] is the MG-400 response time-out value. By default, the value is set to 15 (1.5 seconds).
- \$MAP_PARAM[5] disables MMFS syntax checking (Default: 0 = enable, 1 = disable).
- \$MAP_PARAM[6] indicates the MAP/TBI restart time in seconds (Default: 0 = 60 seconds).
- \$MAP_PARAM[7] is reserved for future use.
- \$MAP_PARAM[8] is reserved for future use.

Values are assigned to \$MAP_PARAM by default. However, you might need to change these values to tailor the system for specific communication applications.

See Also:

KAREL-MAP, Installation and Maintenance

\$MASTER_DONE (master done)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$MASTER_DONE indicates whether or not the mastering procedure has been performed. If it is TRUE, mastering has been done. Currently, \$MASTER_DONE is implemented only for APC systems.

The value of \$MASTER_DONE is set and updated automatically.

\$MASTER_POS (master position)

Data Type: REAL ARRAY [9]
Program/KCL: NO/PW
Default: Robot Specific

Saved: Yes
Backed Up: No

\$MASTER_POS defines the mastering position of the robot as determined by the mastering fixture. The value of \$MASTER_POS is in radians for rotary axes and millimeters for linear axes.

\$MASTER_POS is set by the KCL> UTILITY SINIT command and should not be changed. For auxiliary axes, you are responsible for setting the value correctly using the Motion Hardware Setup Program.

\$MAXDATAPGMS (maximum data programs)

Data Type: INTEGER
Minimum/Maximum: 2/500
Program/KCL: NO/RW
Default: 21

Power Up: Yes
Saved: Yes
Backed Up: No

\$MAXDATAPGMS specifies the maximum number of programs for which static variables can be defined. System variables are counted as one static variable program. The maximum number of programs available is \$MAXDATAPGMS - 1.

\$MAXROUTINES (maximum routines)

Data Type: INTEGER
Minimum/Maximum: 50/1000
Program/KCL: NO/RW
Default: 300

Power Up: Yes
Saved: Yes
Backed Up: No

\$MAXROUTINES specifies the maximum number of routines that can be declared in all of the programs that are loaded in RAM. Each loaded program is also counted as a routine. Each program or routine is counted only once.

\$MIN_ACCTIME (minimum acceleration time)

Data Type: INTEGER ARRAY[9]
Minimum/Maximum: 1/2560*
Program/KCL: NO/PW
Default: 160

Power Up: Yes
Saved: Yes
Backed Up: No

SYSTEM VARIABLE DESCRIPTIONS

\$MIN_ACCTIME System Variable

\$MIN_ACCTIME defines the minimum acceleration/deceleration time in milliseconds while the short motion speed up algorithm is used. It is the sum of the first and second stages.

The value of **\$MIN_ACCTIME** is set by the **KCL> UTILITY SINIT** command and should not be changed. For auxiliary axes, you are responsible for setting the value correctly using the Motion Hardware Setup Program.

*The maximum value for **\$MIN_ACCTIME** is limited by the maximum value for each system (usually 500 msec.)

\$MIRRORPLANE (mirror xz-plane)

Data Type: POSITION
Program/KCL: RO/RW
Default: \$NILP

Power Up: No
Saved: Ye
Backed Up: Yes

\$MIRRORPLANE indicates a position whose xz-plane is used as the mirroring plane in the **KCL> MIRROR** command, which is part of the optional Mirror Image feature.

When **\$MIRRORPLANE** and **\$UFRAME** are set to nil, data is mirrored about the xz-plane of the world coordinate system. This is the normal case for mirroring across assembly lines where the mirrored data is used on a robot that is also rotated by 180 degrees.

You can set the value of **\$MIRRORPLANE** for the optional Mirror Image feature using either KCL commands or the teach pendant.

\$MODEL_ID (model identifier)

Data Type: STRING
Program/KCL: NO/RO
Power Up: No

Saved: No
Backed Up: No
Default: Robot Specific

\$MODEL_ID defines the robot model identifier (name). The string value appears on the POWER UP screen of the CRT/KB. **\$MODEL_ID** is set by the system and cannot be changed.

\$MOSIGN (motion sign)

Data Type: BOOLEAN ARRAY [9]
Program/KCL: NO/RW
Default: Robot Specific

Power Up: No
Saved: Yes
Backed Up: No

\$MOSIGN defines the direction of axis motor rotation for each axis during calibration of robots with absolute encoders.

The value of **\$MOSIGN** is set by the **KCL> UTILITY SINIT** command and should not be changed for robot axes. For auxiliary axes, you are responsible for setting the value correctly using the Motion Hardware Setup Program.

\$MOTYPE (motion type)

Data Type: INTEGER
Minimum/Maximum: 6/8
Program/KCL: RW/RW
Default: 6

Power Up: No
Saved: No
Backed Up: Yes

\$MOTYPE defines the type of motion interpolation used for motion statements using the following values:

6 = JOINT

7 = LINEAR

8 = CIRCULAR

The value of **\$MOTYPE** can be overridden in a path by setting the **SEGMOTYPE** field in the standard associated data.

The default value is set each time a program is executed.

\$MOT_SPD_LIM (motor speed limit)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: 0/32767
Program/KCL: NO/PW
Default: Robot Specific

Power Up: Yes
Saved: Yes
Backed Up: No

\$MOT_SPD_LIM defines an array of motor speed limits, one per motor, in units of RPM.

The value of **\$MOT_SPD_LIM** is set by the **KCL> UTILITY SINIT** command and should not be changed.

\$MOVEDIST (move distance)

Data Type: REAL
Program/KCL: RO/RO
Power Up: No

Saved: No
Backed Up: No

SYSTEM VARIABLE DESCRIPTIONS

\$MOVEDIST System Variable

\$MOVEDIST indicates the Cartesian distance the robot has traveled since the beginning of the current interval. It is only valid for Cartesian moves. Joint interpolated segments are treated as zero length segments.

The value of **\$MOVEDIST** is automatically set to zero at the beginning of an interval. It is updated at the Cartesian interpolation rate appropriate for the segment being interpolated. The final value of **\$MOVEDIST** remains valid until the next interval begins.

\$MOVERRLIM (move error limit)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: 0/32767
Program/KCL: NO/PW
Default: Robot Specific

Power Up: Yes
Saved: Yes
Backed Up: No

\$MOVERRLIM defines a motion following the error limit during motion for each axis, in units of detector pulses. If the following error exceeds its limit while the robot is in motion, servo power shuts off and the system displays the message "Move error excess."

The value of **\$MOVERRLIM** is set by the KCL> UTILITY SINIT command and should not be changed. For auxiliary axes, you are responsible for setting the value correctly using the Motion Hardware Setup Program.

\$MSTUSE_RST (must use reset)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$MSTUSE_RST indicates whether or not pressing the DEADMAN switch while the teach pendant is enabled will activate servo power automatically.

If it is TRUE, the servo power can be activated only by issuing a RESET using the operator panel RESET button, the teach pendant RESET softkey, or the KCL> RESET command. If it is FALSE, servo power is activated automatically by pressing the DEADMAN switch on the enabled teach pendant.

A value of FALSE allows you to use the DEADMAN switch to control servo power.

\$MSTUSE_STRT (must use start)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: TRUE

SYSTEM VARIABLE DESCRIPTIONS

\$MSTUSE_STRT System Variable

\$MSTUSE_STRT indicates whether or not the START button on the teach pendant must be held down in order for a program to continue running during a test run. If it is TRUE, the program continues to run only as long as the START button is held down. If it is FALSE, the program continues to run even when the START button is released.

As a safety consideration it should remain TRUE except in cases where the application demands that the user have a free hand during test runs.

\$NILP (nil position)

Data Type: POSITION
Program/KCL: RO/RO
Power Up: No

Saved: No
Backed Up: Yes
Default: 0,0,0,0,0,0,'N'

\$NILP defines a nil or zero position, which is useful in program assignment statements. For example, the statement **\$UTOOL = \$NILP** assigns a nil position to **\$UTOOL**.

\$NLOG_CHAN (network log channel)

Data Type: INTEGER
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: 0

\$NLOG_CHAN identifies the communication channel to which alarm conditions are to be reported using the following values:

- 0 = no device
- 1 = C0:
- 4 = C3:
- 8 = M0:
- 16 = M1:

See Also:

KAREL-MAP, Installation and Maintenance

\$NUM_AUX_AXS (number of auxiliary axes)

Data Type: INTEGER
Minimum/Maximum: 0/9
Program/KCL: RO/PW
Default: 0

Power Up: Yes
Saved: Yes
Backed Up: No

\$NUM_AUX_AXS defines the number of auxiliary axes used in the system. Its value is used to determine the size of AUXPOS data types.

SYSTEM VARIABLE DESCRIPTIONS

\$NUM_AUX_AXS System Variable

The sum of the values of \$NUM_AUX_AXS and \$NUM_ROB_AXS cannot exceed nine. The value will be adjusted at power up and the message "2132 \$NUM_AUX_AXS adjusted to n" will appear if the sum of the two variables is greater than nine. The new value of \$NUM_AUX_AXS is $9 - \$NUM_ROB_AXS$.

If the system has auxiliary axis control (optional feature), the value of \$NUM_AUX_AXS must be set and saved as part of the initial setup procedure using the Motion Hardware Setup Program.

\$NUM_MIR (number of motion instruction records)

Data Type: INTEGER
Program/KCL: NO/PW
Minimum/Maximum: 3/20
Default: 10

Power Up: Yes
Saved: Yes
Backed Up: No

\$NUM_MIR is the number of motion instruction records (internal data structure) to be created in the system. It affects the maximum number of STOPS to be executed in a row and the memory size available to the user.

\$NUM_ROB_AXS (number of robot axes)

Data Type: INTEGER
Minimum/Maximum: 0/9
Program/KCL: RO/PW
Default: Robot Specific

Power Up: Yes
Saved: Yes
Backed Up: No

\$NUM_ROB_AXS defines the number of robot axes for the robot.

The value of \$NUM_ROB_AXS is set by the KCL> UTILITY SINIT command and should not be changed.

\$ORIENT_TYPE (orientation type)

Data Type: INTEGER
 Minimum/Maximum: 1/3
 Program/KCL: RW/RW
 Default: 1 (RSWORLD)

Power Up: No
 Saved: No
 Backed Up: Yes

\$ORIENT_TYPE indicates the type of orientation control to be used when \$MOTYPE is set to LINEAR motion. The following values are used:

- 1 = RSWORLD, two angle orientation control
- 2 = AESWORLD, three angle orientation control
- 3 = WRISTJOINT, wrist-joint orientation control

For CIRCULAR motion, three angle orientation planning is used regardless of the value of \$ORIENT_TYPE.

The default value of \$ORIENT_TYPE is set each time a program is executed.

See Also:

Chapter 8, *KAREL Reference Manual* for more information on orientation types.

\$ORIENTTOL (orient vector tolerance)

Data Type: REAL
 Program/KCL: RW/RW
 Power Up: No

Saved: Yes
 Backed Up: No
 Default: 0.003046096 (1 degree)

\$ORIENTTOL is used when comparing the y-axis (orient vector) of two positions. \$ORIENTTOL, along with \$APPROACHTOL, \$LOCTOL, and \$CHECKCONFIG, is used in conjunction with the relational operator ">=<" to compare two positions.

If \$ORIENTTOL is negative, no comparison is made and the orient vectors are "nearly" identical. When \$ORIENTTOL is 0 the orient vectors must be identical in order for the relational operator to return TRUE. When \$ORIENTTOL is greater than 0 the following test is made:

```
orient1 = orient(pos1);
orient2 = orient(pos2);
If (ABS(orient1[1] - orient2[1]) <= $ORIENTTOL) and
   (ABS(orient1[2] - orient2[2]) <= $ORIENTTOL) and
   (ABS(orient1[3] - orient2[3]) <= $ORIENTTOL) then
the orient vectors of the two positions are "nearly" identical.
```

SYSTEM VARIABLE DESCRIPTIONS

\$OT_MINUS System Variable

\$OT_MINUS (overtravel minus)

Data Type: BOOLEAN ARRAY [9]
Program/KCL: NO/PW
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$OT_MINUS is an array with each element representing the overtravel condition for the respective axis. If an element is set TRUE, the corresponding axis has a minus overtravel condition and can be jogged only in the positive direction. When an overtravel does not exist, all of the array elements are reset to FALSE.

The appropriate array elements in \$OT_MINUS are automatically set to TRUE when an overtravel occurs in the minus direction, and automatically set back to FALSE when the condition is corrected.

This variable is saved to the DYNMSTR.DY system file automatically every time its value is changed and is automatically loaded into the system at power up.

\$OT_PLUS (overtravel plus)

Data Type: BOOLEAN ARRAY [9]
Program/KCL: NO/PW
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$OT_PLUS is an array with each element representing the overtravel condition for the respective axis. If an element is set TRUE, the corresponding axis has a plus overtravel condition and can be jogged only in the negative direction. When an overtravel does not exist, all of the array elements are FALSE.

The appropriate array elements in \$OT_PLUS are automatically set to TRUE when an overtravel occurs in the plus direction, and automatically set back to FALSE when the condition is corrected.

This variable is saved to the DYNMSTR.DY system file automatically every time its value is changed and is automatically loaded into the system at power up.

\$PATH_NODE (path node)

Data Type: INTEGER
Minimum/Maximum: 1/32767
Program/KCL: RO/RO

Power Up: No
Saved: No
Backed Up: No

\$PATH_NODE indicates the path node to which the robot is moving or has most recently moved.

After an error, KAREL programs can test to determine the node toward which the robot is or was most recently moving when the error occurred. For emergency stops or errors that cause brakes to be applied and drive power to the servo system to be shut off, \$PATH_NODE might be ahead of the robot's actual position.

The value of \$PATH_NODE is set and updated automatically.

\$PATHREFPOS (path reference position of path relative frame) *

Data Type: POSITION
Program/KCL: RW/RO
Power Up: No

Saved: No
Backed Up: Yes
Default: Uninitialized

\$PATHREFPOS is a user-definable position to establish the desired Path Relative Frame (optional feature).

\$PCODR_REF (pulse coder reference)

Data Type: INTEGER ARRAY [9]
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: Robot Specific

For APC systems, \$PCODR_REF is the APC counter value of each axis at the reference position. It is part of the mastering data and is saved into the DYNMSTR.DY file automatically every time the KCL> MASTER command is executed or the remastering procedure takes place.

\$PENDMOCOUNT (pending motion count)

Data Type: INTEGER
Program/KCL: RO/RO
Power Up: No

Saved: No
Backed Up: No
Default: 0

\$PENDMOCOUNT keeps track of how many motions have been issued but have not yet been completed. It is automatically incremented each time the program interpreter issues a motion and decremented each time the motion interpolator finishes a motion.

SYSTEM VARIABLE DESCRIPTIONS

\$PERCH System Variable

\$PERCH (perch)

Data Type: ARRAY[9] of REAL
Program/KCL: No/RW
Backed Up: No

Power Up: Yes
Saved: Yes
Default: 0.00

\$PERCH is used to set the perch position. The **\$ATPERCH** system variable can be used to determine if the current position of the robot is the same position as specified by **\$PERCH**.

For robot axes, **\$PERCH[i]** is in degrees or millimeters depending on the value of **\$ROTARY_AXIS**. For auxiliary axes, **\$PERCH[i]** is in the coordinates determined by **\$ENSCALES**. **\$PERCH** is set using the **\$SETPERCH** built-in procedure.

See Also:

\$ATPERCH and **\$PERCHTOL** System Variables in this appendix
SETPERCH Built-In Procedure, Appendix A, *KAREL Reference Manual*

\$PERCHTOL (perch tolerance)

Data Type: ARRAY[9] of REAL
Program/KCL: No/RW
Backed Up: No

Power Up: Yes
Saved: Yes
Default: -1.0

\$PERCHTOL is used to define the tolerance used when the robot position is checked using **\$PERCH**.

For robot axes, **\$PERCHTOL[i]** is in degrees or millimeters depending on the value of **\$ROTARY_AXIS**. For auxiliary axes, **\$PERCHTOL[i]** is in the coordinates determined by **\$ENSCALES**. If **\$PERCHTOL[i]** is negative, perch checking is turned off for axis i. **\$PERCHTOL** is normally set using the built-in function **SETPERCH**.

See Also:

\$ATPERCH and **\$PERCH** System Variables in this appendix
SETPERCH Built-In Procedure, Appendix A, *KAREL Reference Manual*

\$PPABN_ENABL (pneumatic pressure abnormal enable)

Data Type: BOOLEAN
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$PPABN_ENABL indicates whether or not digital input that indicates abnormal pneumatic pressure is enabled. If it is **TRUE**, sensing of low line-pressure input on the robot control module (for systems with modular I/O) or the fixed I/O board is enabled.

See Also:

Chapter 13, *KAREL Reference Manual*

\$PRF_RESUME (path relative frame resume)

Data Type: **BOOLEAN**
Program/KCL: **RW/RW**
Power Up: **No**

Saved: **No**
Backed Up: **No**
Default: **FALSE**

\$PRF_RESUME is effective only for linear moves in Path Relative Frame.

If the robot stops during motion, the user can set **\$PRF_RESUME** to **TRUE** in order for the motion to continue without any loss of continuity. Once the motion is resumed, **\$PRF_RESUME** is reset to **FALSE** by the system.

See Also:

\$CUR_PRFRAME and **\$CUR_CRFRAME** System Variables in this appendix
\$TTOOLNUM System Variable in this appendix for more
information on Path Relative Frame

\$PRGOVERRIDE (program override)

Data Type: **INTEGER**
Minimum/Maximum: **1/100**
Program/KCL: **RW/RO**
Default: **100**

Power Up: **No**
Saved: **No**
Backed Up: **No**

\$PRGOVERRIDE, a scaling factor, is expressed as a percentage of the motion speed.

For all programmed motion, **\$PRGOVERRIDE** is multiplied by **\$GENOVERRIDE** to obtain a total override value, which is then multiplied by the motion speed.

\$PRGOVERRIDE has no effect for motions other than program motion. You can assign a value to **\$PRGOVERRIDE** from a program or from the teach pendant.

\$PRIORITY

Program/KCL: **WO/NO**

\$PRIORITY can be used only in a condition handler statement **WITH** clause. This condition handler qualifier is not a normal system variable. It has write only (**WO**) access by programs and cannot be accessed by KCL (**NO**).

SYSTEM VARIABLE DESCRIPTIONS

\$PRIORITY Condition Handler Qualifier

\$PRIORITY is used to specify the priority of execution for the indicated routine. An interrupt routine with a low priority will not be executed until control is returned to the program from a higher-priority routine. Therefore, the actual priority value specified is not important; only that one must be larger than the other.

Where \$PRIORITY is not specified, a default value of 0 is assumed. Two interrupt routines that have the same priority value, or default values of 0, can interrupt each other.

See Also:

Chapter 6, *KAREL Reference Manual*

WITH Clause, Appendix A, *KAREL Reference Manual*

\$PRODUCT_ID (product identifier)

Data Type: STRING[12]
Program/KCL: RO/RO
Power Up: No

Saved: No
Backed Up: No
Default: 'R-H'

\$PRODUCT_ID allows KAREL programs to determine which controller is being used. This allows the program to access controller-specific system variables and functions (for example, 80 columns of the CRT on the R-H controller as opposed to 40 columns on the R-F controller).

\$PROG_BASE (program base) *

Data Type: STRING[12]
Program/KCL: RW/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: 'prog_'

\$PROG_BASE allows Basic and Enhanced KAREL users to select programs by number from the teach pendant. An ASCII number is appended to \$PROG_BASE to form the program name. When you select PRGM # from the teach pendant you are prompted to input the program number. For example, if you type "1" in answer to this prompt, you will be selecting "PROG_01" as the default program name. The program "PROG_01" must already exist as a program in order for you to select it as the default program.

Two characters are reserved for the program number. This allows for programs to be listed in order through program #99. \$PROG_BASE is limited to a maximum of 10 characters.

\$PTH_MODEL (path model)

Data Type: STRING
Program/KCL: NO/RO
Default: Robot Specific

Power Up: No
Saved: No
Backed Up: No

\$PTH_MODEL defines the robot model identifier. The value of \$PTH_MODEL matches the value of \$MODEL_ID and is set and used internally. It cannot be changed.

\$PTH_VERSION (path version)

Data Type: STRING
Program/KCL: NO/RO
Default: Robot Specific

Power Up: No
Saved: No
Backed Up: No

\$PTH_VERSION identifies the KAREL software version currently in use. The value of \$PTH_VERSION matches the value of \$VERSION_ID and is set and used internally. It cannot be changed.

\$PWR_FAIL (power fail)

Data Type: STRING
Program/KCL: NO/RW
Power Up: Yes

Saved: Yes
Backed Up: No
Default: ' '(blank)

\$PWR_FAIL specifies the name of the KCL command file that is executed if the system is in a recoverable state at power up. If no name is specified, a KCL command procedure is not executed.

You are responsible for setting the value of \$PWR_FAIL if you want a command procedure to be executed at power up when the system is in a recoverable state.

If you assign a command procedure name to \$PWR_FAIL the message "Running Power Fail File file_name" is displayed on the CRTKB at power up, while the procedure is being executed, where file_name is the command file name.

See Also:

\$RECOVERABLE System Variable

SYSTEM VARIABLE DESCRIPTIONS

\$PWR_NORMAL System Variable

\$PWR_NORMAL (power normal)

Data Type: STRING

Program/KCL: NO/RW

Power Up: Yes

Saved: Yes

Backed Up: No

Default: ' ' (blank)

\$PWR_NORMAL specifies the name of the KCL command file that is executed if the system is not in a recoverable state at power up and the conditions for using the **\$PWR_RESTART** command file are not met. If no name is specified, a KCL command procedure is not executed.

You are responsible for setting the value of **\$PWR_NORMAL** if you want a command procedure to be executed at power up when the system is not in a recoverable state.

If you assign a command procedure name to **\$PWR_NORMAL** the message "Running Power Up File file_name" is displayed on the CRT/KB at power up, while the procedure is being executed, where file_name is the command file name.

See Also:

\$RECOVERABLE System Variable

\$RECOVERABLE (recoverable)

Data Type: INTEGER

Program/KCL: NO/RO

Power Up: No

Saved: No

Backed Up: Yes

Default: 0

\$RECOVERABLE indicates whether or not the system is in a recoverable state for the power fail recovery procedure (optional feature). If it is zero, then the system is in a recoverable state (**\$PWR_FAIL** is executed). Otherwise, it is a nonzero value and the system is not recoverable (**\$PWR_NORMAL** is executed).

The value of **\$RECOVERABLE** is set automatically as part of the power fail recovery procedure.

\$REMOTE (remote)

Data Type: BOOLEAN

Program/KCL: NO/RO

Power Up: No

Saved: No

Backed Up: No

Default: TRUE

\$REMOTE indicates the operator panel REMOTE keyswitch setting. It is TRUE when the key is set to ON and a remote device has motion control. It is FALSE when the key is set to OFF and the operator panel has motion control.

The value of \$REMOTE is set and updated automatically.

\$RESULT (result)

Data Type: INTEGER
Program/KCL: RW/RN
Power Up: No

Saved: No
Backed Up: Yes

The function of \$RESULT depends on how it is used within a program. It allows the programmer to assign an integer value to a system variable.

The value of \$RESULT can be set by the RESULT condition handler action as part of a WHEN or UNTIL clause.

See Also:
Chapter 6, *KAREL Reference Manual*

\$ROTARY_AXIS (rotary axis)

Data Type: BOOLEAN ARRAY [9]
Program/KCL: NO/PW
Default: Robot Specific

Power Up: No
Saved: Yes
Backed Up: No

\$ROTARY_AXIS is an array, with one element for each axis, indicating whether the axis is rotary or linear. A value of TRUE indicates a rotary axis and FALSE indicates a linear axis.

The value of \$ROTARY_AXIS is set by the KCL> UTILITY SINIT command and should not be changed. For auxiliary axes, the default value is TRUE.

\$ROTSPEED (rotational speed)

Data Type: REAL
Program/KCL: RW/RO
Default: Uninitialized

Power Up: No
Saved: No
Backed Up: Yes

\$ROTSPEED controls how fast the robot is allowed to rotate the tool center point (TCP) approach vector for programmed Cartesian motion (linear, circular.) The value is expressed in radians per second.

SYSTEM VARIABLE DESCRIPTIONS

\$ROTSPEED System Variable

By default, the value of \$ROTSPEED is set to an uninitialized value each time a program is executed. If you do not assign a value to \$ROTSPEED in the program and the speed of the programmed motion is higher than the value of \$ROTSPEEDLIM, the warning message "ROTATION SPEED LIMITS USED" is displayed. The robot speed will then slow down so that the rotation speed is less than \$ROTSPEEDLIM.

See Also:

\$ROTSPEEDLIM, \$SPINSPEED, SSPINSPEEDLIM System Variables in this appendix
Chapter 8, *KAREL Reference Manual*

\$ROTSPEEDLIM (rotational speed limit)

Data Type: REAL
Program/KCL: RO/RW
Power Up: No

Saved: Yes
Backed Up: Yes
Default: 1.5

\$ROTSPEEDLIM is the maximum value for the rotational speed of the TCP approach vector in programmed Cartesian motion. The value is expressed in radians per second.

The default value may be reset to a higher value to increase the speed of the robot. If the new value is too large, the error message, "Joint velocity Limit (\$JNTVELLIM)" will be displayed.

\$RUNWITHERR (run with error)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$RUNWITHERR, when set to TRUE, allows KCL> RUN and KCL> RESUME to execute while an error is pending. If \$RUNWITHERR is FALSE, the error must be cleared before the KCL> RUN or KCL> RESUME commands will execute. Note that the program will not be able to issue a motion if an error is pending.

\$SCAN_TIME (scan time condition handler qualifier)

Program/KCL: WO/NO
Minimum/Maximum: 1/512
Default: 1

\$SCAN_TIME can only be used in a condition handler statement WITH clause. This condition handler qualifier is not a normal system variable. It cannot be accessed by KCL (NO) and has write only (WO) access by programs.

SYSTEM VARIABLE DESCRIPTIONS
\$SCAN_TIME Condition Handler Qualifier

\$SCAN_TIME is used to specify the time in milliseconds between scans in a condition handler. The syntax for **\$SCAN_TIME** = time_in_ms where time_in_ms is an INTEGER expression.

Actual time_in_ms values will be one of the following: 1, 2, 4, 8, 16, 32, 64, 128, 256, 512, times the value of the **\$COND_TIME** system variable. Any value less than **\$COND_TIME** will default to the value of **\$COND_TIME**. Any value greater than (512 * **\$COND_TIME**) ms will default to (512 * **\$COND_TIME**). Any value between one of the above intervals will default to the next lower value.

See Also:

\$COND_TIME System Variable

\$SCN_HLD_NBL (screen hold enable)

Data Type: BOOLEAN
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: TRUE

\$SCN_HLD_NBL indicates whether or not the CRT/KB HOLD SCREEN key, which stops the screen display from scrolling, is enabled. By default, **\$SCN_HLD_NBL** is TRUE.

\$SCREEN_HELD (screen held)

Data Type: BOOLEAN
Program/KCL: NO/RO
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$SCREEN_HELD indicates that scrolling on the CRT screen is currently being held by the CRT/KB HOLD SCREEN key. **\$SCREEN_HELD** is updated automatically each time you press the HOLD SCREEN key.

\$SEGFRACTION (segment fraction)

Data Type: REAL
Program/KCL: RO/RO
Power Up: No

Saved: No
Backed Up: No
Default: 0.0

SYSTEM VARIABLE DESCRIPTIONS

\$SEGFACTION System Variable

\$SEGFACTION indicates what fraction of the current segment has been interpolated. For example:

0.0 means interpolation is just beginning.

0.5 means interpolation is half done.

1.0 means interpolation is complete, and robot is starting to decelerate toward the destination

Note that when the value is 1.0, the robot will not be exactly at the indicated position because of the digital filters. The robot still needs to decelerate. **\$SEGFACTION** is set and updated automatically.

\$SEGLENGTH (segment length)

Data Type: REAL
Program/KCL: RO/RO
Power Up: No

Saved: No
Backed Up: No
Default: 0.0

\$SEGLENGTH indicates the current Cartesian length of a straight line segment or the arc length of a circular segment as computed by the motion planner for the segment currently being executed by the motion environment. Joint interpolated segments are treated as zero length segments.

\$SEGLENGTH is set and updated automatically.

\$SEGTERMTYPE (segment termination type)

Data Type: INTEGER
Minimum/Maximum: 1/5
Program/KCL: RW/RW
Default: 4 (NODECEL)

Power Up: No
Saved: No
Backed Up: Yes

\$SEGTERMTYPE indicates the default termination type for intermediate path nodes (all but the last node in a path), using the following values:

- 1 = FINE
- 2 = COARSE
- 3 = NOSETTLE
- 4 = NODECEL
- 5 = VARDECEL

If the **SEGTERMTYPE** associated data field is set to anything other than one of these values, then **SEGTERMTYPE** associated data overrides the **\$SEGTERMTYPE** system variable value. If the **SEGTERMTYPE** field is left to the default then the type specified by the value of **\$SEGTERMTYPE** is used.

\$SEG_TIME (segment time)

Data Type: INTEGER
Program/KCL: RW/RO
Power Up: No

Saved: No
Backed Up: Yes
Default: 0

\$SEG_TIME indicates the time required for a motion segment. By specifying a value for \$SEG_TIME, you are specifying the time it will take to complete the segment. The speed will vary depending on the distance (as opposed to \$SPEED in which the speed remains constant and the time varies).

Motion statements are executed using \$SEG_TIME as long as \$SEG_TIME has a value that is greater than 0. \$SEG_TIME is set to 0 each time a program is executed. The segment time is specified in units of milliseconds as an INTEGER value greater than or equal to 0. A value of 0 indicates \$SPEED will be used instead of a segment time.

\$SERVO_READY (servo ready)

Data Type: BOOLEAN
Program/KCL: RO/RO
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$SERVO_READY indicates whether or not servo power is active.

The value of \$SERVO_READY is set and updated automatically.

\$SIMUL_CAL (simultaneous calibration)

Data Type: BOOLEAN
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: TRUE

\$SIMUL_CAL controls whether or not the axes move simultaneously during incremental calibration. If it is TRUE the axes (or groups of axes) move simultaneously. If it is FALSE the axes move one at a time.

\$SIMUL_CAL has no meaning on robots with an APC system.

\$SPEED (speed)

Data Type: REAL
Program/KCL: RW/RO
Power Up: No

Saved: No
Backed Up: Yes
Default: 375*

SYSTEM VARIABLE DESCRIPTIONS

\$SPEED System Variable

\$SPEED is the TCP translation speed of the programmed motions, expressed in mm/sec. It is used to calculate the speed of all programmed motion.

*By default, the value of **\$SPEED** is set to the product of **\$MANLIM/100** multiplied by **\$SPEEDLIM** each time a program is executed. You can assign a new value within the program.

See Also:

Chapter 8, *KAREL Reference Manual*

\$SPEEDLIM (speed limit)

Data Type: REAL

Program/KCL: RO/RW

Power Up: No

Saved: Yes

Backed Up: Yes

Default: 1500

\$SPEEDLIM is the motion translation speed limit, expressed in mm/sec. It is the maximum value that can be assigned to **\$SPEED** for Cartesian motion. It is also used in calculating the speed of Cartesian jog motion.

The default value may be reset as long as it is a valid value specified by the robot specifications or the error message, "Joint speed limits used" will be displayed.

See Also:

Chapter 8, *KAREL Reference Manual*

\$SPEEDLIMJNT (speed limit joint)

Data Type: REAL

Program/KCL: RO/RW

Power Up: No

Saved: Yes

Backed Up: Yes

Default: 1500

\$SPEEDLIMJNT is the maximum value of **\$SPEED** for programmed, joint interpolated motion. It is used to calculate the motion speed of each joint.

See Also:

Chapter 8, *KAREL Reference Manual*

\$SPINSPEED (spin speed)

Data Type: REAL

Program/KCL: RW/RO

Default: Uninitialized

Power Up: No

Saved: No

Backed Up: Yes

\$SPINSPEED controls how fast the robot is allowed to spin about the tool center point (TCP) approach vector for programmed Cartesian motion (linear, circular). The value is expressed in radians per second.

By default, the value of **\$SPINSPEED** is set to an uninitialized value each time a program is executed. If you do not assign a value to **\$SPINSPEED** in the program, and if the spin speed of the programmed motion is larger than the value of **\$SPINSPEEDLIM**, the warning error message "ROTATION SPEED LIMITS USED" is displayed. The robot will then slow down so that the spin speed is within **\$SPINSPEEDLIM**.

See Also:

\$ROTSPEED, **\$ROTSPEEDLIM**, **\$SPINSPEEDLIM** System Variables in this appendix
Chapter 8, *KAREL Reference Manual*

\$SPINSPEEDLIM (spin speed limit)

Data Type: REAL
Program/KCL: RO/RW
Power Up: No

Saved: Yes
Backed Up: Yes
Default: 1.5

\$SPINSPEEDLIM is the maximum value for the spin speed about the TCP approach vector in programmed Cartesian motion. The value is expressed in radians per second.

The default value may be reset to a higher value to increase the speed of the robot. If the new value is too large, the error message, "Joint velocity Limit (\$JNTVELLIM)" will be displayed.

\$SPIN_CTRL (spin control)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: Yes

Saved: Yes
Backed Up: No
Default: FALSE

\$SPIN_CTRL indicates which type of control is used for 5-axis robots. If it is FALSE, approach vector control is used. If it is TRUE, spin control is used.

\$SRVO_BLOCK1 Reserved for GMF internal use only.

\$SRVO_BLOCK2 Reserved for GMF internal use only.

\$SRVO_BLOCK3 Reserved for GMF internal use only.

SYSTEM VARIABLE DESCRIPTIONS

\$SRVO_BLOCK4 System Variable

\$SRVO_BLOCK4 Reserved for GMF internal use only.

\$SRVO_BLOCK5 Reserved for GMF internal use only.

\$SRVO_BLOCK6 Reserved for GMF internal use only.

\$SRV_CODE_ID (servo code identification)

Data Type: STRING
Program/KCL: NO/RO
Default: Robot Specific

Power Up: No
Saved: No
Backed Up: No

\$SRV_CODE_ID is the revision level of the digital servo code. It is set internally and cannot be changed.

\$SRV_PARM_ID (servo parameters identification)

Data Type: STRING
Program/KCL: NO/RO
Default: Robot Specific

Power Up: No
Saved: No
Backed Up: No

\$SRV_PARM_ID is the revision level of the default digital servo parameters. It is set internally and cannot be changed.

If **\$SRV_PARAM_ID** is blank or uninitialized at power up, the user will be prompted to enter the Servo Parameter Setting Program disk. This will copy the file KSSP.CF and execute it. Power down and power up the controller to continue.

\$STOPERLIM (stop error limit)

Data Type: INTEGER ARRAY [9]
Minimum/Maximum: 0/32767
Program/KCL: NO/PW
Default: Robot Specific

Power Up: Yes
Saved: Yes
Backed Up: No

\$STOPERLIM defines an array of the servo following error tolerances while stopping for each axis. It is expressed in units of detector pulses.

The value of **\$STOPERLIM** is set by the KCL> UTILITY SINIT command and should not be changed. For auxiliary axes, you are responsible for setting the value correctly using the Motion Hardware Setup Program.

\$STOP_ON_ERR (stop on error)

Data Type: BOOLEAN
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$STOP_ON_ERR indicates whether or not the system stops on a KCL command file error. If TRUE, execution of the command procedure stops if any error condition is found.

You can set and clear \$STOP_ON_ERR within a command procedure to control the execution of command files depending on desired response to errors.

Note that \$STOP_ON_ERR applies only to errors that can be detected by the KCL command interpreter. For example, a KCL> MOVETO command can cause a solution error that prevents the motion from proceeding, but the KCL command interpreter will continue because the motion command itself has succeeded.

\$SV_OFF_ENB (servo off enable)

Data Type: BOOLEAN ARRAY [9]
Program/KCL: NO/PW
Power Up: Yes

Saved: Yes
Backed Up: No
Default: FALSE

\$SV_OFF_ENB controls whether or not each servo motor uses a timed servo shutdown feature. It is used with \$SV_OFF_TIME to shut off servo motors after motion has been completed.

This feature is used primarily for energy saving purposes.

The value of \$SV_OFF_ENB is set by the KCL> UTILITY SINIT command and should not be changed.

\$SV_OFF_TIME (servo off time)

Data Type: INTEGER
Program/KCL: NO/PW
Power Up: Yes

Saved: Yes
Backed Up: No
Default: 10000

\$SV_OFF_TIME defines the time interval, in milliseconds, after which the servo motors are shut down.

The value of \$SV_OFF_TIME is set by the KCL> UTILITY SINIT command and should not be changed.

SYSTEM VARIABLE DESCRIPTIONS

\$SV_OFF_TIME System Variable

See Also:

\$SV_OFF_ENB System Variable in this appendix

\$SYNC_GAIN (synchronous compensation gain)

Data Type: INTEGER

Minimum/Maximum: 0/127

Program/KCL: NO/PW

Default: 20

Power Up: Yes

Saved: Yes

Backed Up: No

\$SYNC_GAIN defines the compensation gain for robot models with dual drive (synchronous) control.

The value of \$SYNC_GAIN is set by the KCL> UTILITY SINIT command and should not be changed.

\$SYNC_M_AXIS (synchronous master axis)

Data Type: INTEGER

Minimum/Maximum: 0/9

Program/KCL: NO/PW

Default: 0

Power Up: Yes

Saved: Yes

Backed Up: No

\$SYNC_M_AXIS indicates which robot axis motor has been designated as the master axis for robot models with dual drive (synchronous) control.

The value of \$SYNC_M_AXIS is set by the KCL> UTILITY SINIT command and should not be changed.

\$SYNC_OFFSET (synchronous compensation offset)

Data Type: INTEGER

Minimum/Maximum: 0/32767

Program/KCL: NO/PW

Default: 150

Power Up: Yes

Saved: Yes

Backed Up: No

\$SYNC_OFFSET defines the compensation offset for robot models with dual drive (synchronous) control.

The value of \$SYNC_OFFSET is set by the KCL> UTILITY SINIT command and should not be changed.

\$SYNC_S_AXIS (synchronous slave axis)

Data Type: INTEGER
Minimum/Maximum: 0/9
Program/KCL: NO/PW
Default: 0

Power Up: No
Saved: Yes
Backed Up: No

\$SYNC_S_AXIS indicates which robot axis motor has been designated as the slave axis for robot models with dual drive, or synchronous, control.

The value of \$SYNC_S_AXIS is set by the KCL> UTILITY SINIT command and should not be changed.

\$SYN_ADJ_MOD (synchronous adjust mode)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

For robot models with dual drive (synchronous) control, \$SYN_ADJ_MOD indicates whether or not the synchronous adjust mode is enabled.

If it is TRUE, synchronous adjust mode is enabled and you can jog only the master or only the slave motor. You cannot move any of the other axes while synchronous adjust mode is enabled. If it is FALSE, you cannot jog the master and slave motors independently.

\$SYN_ADJ_MOD should remain FALSE for all normal operation. If it is set to TRUE, the robot loses its calibration and must be recalibrated after \$SYN_ADJ_MOD is set back to FALSE.

\$SYN_ADJ_SEL (synchronous adjust selection)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

For robot models with dual drive (synchronous) control, \$SYN_ADJ_SEL indicates which axis, either master or slave, is selected for synchronous adjust mode. If it is TRUE, the slave axis is selected. If it is FALSE, the master axis is selected.

If you want to adjust the slave axis, you must set \$SYN_ADJ_SEL to TRUE.

SYSTEM VARIABLE DESCRIPTIONS

\$SYN_ERR_CNT System Variable

\$SYN_ERR_CNT (synchronous error counter)

Data Type: INTEGER
Program/KCL: NO/RO
Power Up: No

Saved: No
Backed Up: No
Default: 0

\$SYN_ERR_CNT is the value of the error counter for robot models with dual drive (synchronous) control.

\$SYN_ERR_LIM (synchronous error limit)

Data Type: INTEGER
Minimum/Maximum: 0/32767
Program/KCL: NO/PW
Default: 1000

Power Up: Yes
Saved: Yes
Backed Up: No

\$SYN_ERR_LIM defines the error limit for robot models with dual drive (synchronous) control.

The value of **\$SYN_ERR_LIM** is set by the KCL> UTILITY SINIT command and should not be changed.

\$TCPEXTREME (tool center point extreme)

Data Type: POSITION
Program/KCL: RW/RO
Default: Uninitialized

Power Up: No
Saved: No
Backed Up: Yes

\$TCPEXTREME can be used to indicate the x-extreme position of a path for rail tracking (optional feature). **\$TCPEXTREME** is used to ensure that a path is not executed until this extreme enters the lower boundary.

\$TCPEXTREME is set uninitialized each time a program is executed. Extreme checking is performed only if **\$TFRAMENUM** is greater than 1.

\$TERMTYPE (motion termination type)

Data Type: INTEGER
Minimum/Maximum: 1/5
Program/KCL: RW/RW
Default: 2 (COARSE)

Power Up: No
Saved: No
Backed Up: Yes

\$TERMTYPE defines the type of motion termination at the end of an interval using the following values:

- 1 = FINE
- 2 = COARSE
- 3 = NOSETTLE
- 4 = NODECEL
- 5 = VARDECEL

The default value of \$TERMTYPE is set each time a program is executed.

See Also:

Chapter 8, *KAREL Reference Manual*

\$TFRAMENUM (tracking frame number)

Data Type: INTEGER
Minimum/Maximum: -4/3
Program/KCL: RW/RO
Default: 0

Power Up: No
Saved: No
Backed Up: Yes

\$TFRAMENUM is used by the motion environment to determine which tracking frame to use for line tracking and dynamic path modification. If it is 0, SUFRAME is used for all motions. The values 1, 2, and 3 specify tracking frames 1, 2, and 3. When used in conjunction with dynamic path modification, the values determine the coordinate frame of reference as listed in the following table:

\$TFRAMENUM	\$DELTAFRAME	Coordinate Frame
-1	location	World
-2	location + orientation	World
-3	location	User Frame
-4	location + orientation	User Frame

\$TFRAMENUM is used only for motions caused by the KAREL interpreter. All KCL or teach pendant motions are always relative to \$UFRAME.

See Also:

\$DELTAFRAME System Variable in this appendix

SYSTEM VARIABLE DESCRIPTIONS

\$TP_USERSTAT System Variable

\$TP_USERSTAT (teach pendant user status line)

Data Type: BOOLEAN
Program/KCL: RW/RO
Power Up: No

Saved: No
Backed Up: Yes
Default: FALSE

\$TP_USERSTAT indicates whether the KAREL system or the application program has control of the teach pendant status line.

If **\$TP_USERSTAT** is set to TRUE and a KAREL program is running or paused, the system stops updating the status line, giving control to the program. The predefined constant TPSTATUS can be used to write to the status line when **\$TP_USERSTAT** is TRUE.

If **\$TP_USERSTAT** is set to FALSE the system automatically updates the status line. By default, **\$TP_USERSTAT** is set to FALSE each time a program is executed. It automatically resets to FALSE when program execution ends or the program is aborted.

\$TRK_AXSNUM (tracking auxiliary axis number)

Data Type: INTEGER ARRAY [2]
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: 0

\$TRK_AXSNUM is used mainly for teaching positions for auxiliary axis tracking applications (optional feature). Each element of **\$TRK_AXSNUM** can be assigned an auxiliary axis number. Then **\$AUX_ZROSHFT** will be applied to the specified axis.

\$TSPEED (TCP speed)

Data Type: INTEGER
Program/KCL: RO/RO
Power Up: No

Saved: No
Backed Up: No
Default: 0

\$TSPEED is the tool center point (TCP) speed estimate. It is derived from the following equation:

$$\text{\$TSPEED} = \text{\$TSPEEDSCALE} * \text{estim_tcp_speed} + \text{\$TSPEEDOFST}$$

(If **\$TSPEEDSCALE** = 1.0 and **\$TSPEEDOFST** = 0 then **\$TSPEED** is in mm/sec.)

The value of \$TSPEED is set by the interpolator at the Cartesian update rate for the current segment. The estimate is passed through the acceleration/deceleration algorithm, so it will have approximately the same acceleration/deceleration profile as the joints.

See Also:

\$TSPEEDENBL System Variable in this appendix

\$TSPEEDENBL (TCP speed enable)

Data Type: BOOLEAN
Program/KCL: RW/RW
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$TSPEEDENBL enables the TCP speed estimation. If it is FALSE, \$TSPEED is 0.

By default, the value of \$TSPEEDENBL is set to FALSE.

See Also:

\$TSPEED System Variable in this appendix

\$TSPEEDOFST (TCP speed offset)

Data Type: INTEGER
Program/KCL: RW/RW
Power Up: No

Saved: No
Backed Up: No
Default: 0

\$TSPEEDOFST is used in calculating the value of \$TSPEED when you want \$TSPEED to have a value other than zero when the robot is not moving.

You are responsible for setting the value of \$TSPEEDOFST.

See Also:

\$TSPEED System Variable in this appendix

\$TSPEEDSCALE (TCP speed scale)

Data Type: REAL
Program/KCL: RW/RW
Power Up: No

Saved: No
Backed Up: No
Default: 1.0

\$TSPEEDSCALE, a scaling factor, is used in calculating the value of \$TSPEED. It is used to scale the value of \$TSPEED if mm/sec is not the desired unit.

You are responsible for setting the value of \$TSPEEDSCALE.

See Also:

\$TSPEED System Variable in this appendix

SYSTEM VARIABLE DESCRIPTIONS

\$TTOOLNUM System Variable

\$TTOOLNUM (tracking tool frame number)

Data Type: INTEGER
Minimum/Maximum: -4/2
Program/KCL: RW/RO
Default: 0

Power Up: No
Saved: No
Backed Up: Yes

\$TTOOLNUM is used to indicate how \$DELTATool is to be applied. Its value determines whether \$DELTATool will be with respect to the tool coordinate system or the path relative coordinate system (attached to the path trajectory). \$TTOOLNUM can be set in a KAREL program. The values for \$TTOOLNUM, \$DELTATool, and the coordinate systems used are listed in the following table:

\$TTOOLNUM	\$DELTATool	Coordinate System
1	location	Tool
2	location + orientation	Tool
0	none	
-1	location	Path Relative Frame
-2	location + orientation	Path Relative Frame
-3	location	Path Relative Frame
-4	location + orientation	Path Relative Frame

See Also:

\$DELTATool System Variable in this appendix

\$UDIN_ENBL (user definable input enable)

Data Type: BOOLEAN
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: FALSE

\$UDIN_ENBL enables the upper eight bits of the UOP (user operator panel) input module for user-definable input. If it is FALSE, the upper eight bits of the input module can be used for other user-defined input signals.

\$UDIN_ENBL must be set to TRUE in order for the predefined command procedures KCP_UOP1 through KCP_UOP8 to be executed.

\$UFRAME (user frame)

Data Type: POSITION
Program/KCL: RW/RW
Default: \$NILP

Power Up: No
Saved: Yes
Backed Up: Yes

\$UFRAME is the position of a user frame of reference. All programmed positions are defined with respect to \$UFRAME.

Any value you assign to \$UFRAME is defined with respect to the world coordinate system. By default, \$UFRAME is identical to the world coordinate system, meaning \$UFRAME = \$NILP.

Chapter 8, "Motion"

\$UO_POLARITY (user operator panel polarity)

Data Type: INTEGER
Program/KCL: NO/PW
Power Up: No

Saved: Yes
Backed Up: No
Default: 0

\$UO_POLARITY indicates the polarity of user operator panel (UOP) signals. When the decimal INTEGER is converted to a binary number, each bit of the \$UO_POLARITY value corresponds to a bit in the UOP output value.

If a bit is set to 0, the polarity of the signal is not changed. If a bit is set to 1, the polarity is inverted.

\$UPPERLIMS (upper joint limits)

Data Type: REAL ARRAY [9]
Program/KCL: NO/PW
Default: Robot Specific

Power Up: Yes
Saved: Yes
Backed Up: No

\$UPPERLIMS defines the upper joint limits, in radians or millimeters.

The value of \$UPPERLIMS is set by the KCL> UTILITY SINIT command and should not be changed. For auxiliary axes, you are responsible for setting the value correctly using the Motion Hardware Setup Program.

SYSTEM VARIABLE DESCRIPTIONS

\$USAT System Variable

\$USAT (user signal assignment table)

Data Type: INTEGER ARRAY [98]
Program/KCL: NO/PW
Power Up: Yes

Saved: Yes
Backed Up: No
Default: 0

\$USAT is an array that corresponds to the User Signal Assignment Table (USAT).

You are responsible for setting the value of **\$USAT** if you want to use user-definable input and output.

See Also:

Chapter 13, *KAREL Reference Manual* for more information on the USAT

\$USE_CAL (use calibration procedure)

Data Type: BOOLEAN
Program/KCL: NO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: TRUE

\$USE_CAL enables or disables automatic calibration. If it is TRUE, automatic calibration is executed when the operator panel CALIBRATE button is pressed.

If **\$USE_CAL** is FALSE, the current position of the robot is taken as the zero position for all axes and the register values are returned to zero when you press the CALIBRATE button. In this case, the normal calibration procedures are not used.

\$USE_CARTACC (use cartesian acceleration) *

Data Type: BOOLEAN
Saved: No
Program/KCL: NO/RW

Power Up: Yes
Default: FALSE
Backed Up: No

By setting the system variable **\$USE_CARTACC**, path accuracy can be improved for both position and speed for Cartesian acceleration (optional feature). The improvement becomes more noticeable as speed increases. However, at very high speeds, the motion will not be as smooth.

When **\$USE_CARTACC** is TRUE, about 60% of the acceleration is performed in Cartesian space (for example, in the direction of a line for linear motion or along the circle for circular motion).

\$USE_CARTACC is set to FALSE every time a program is executed. The motion clause, WITH **\$USE_CARTACC** = TRUE or WITH **\$USE_CARTACC** = FALSE, applies only to that particular motion.

\$USE_CONFIG (use configuration)

Data Type: BOOLEAN
Program/KCL: RW/RW
Power Up: No

Saved: No
Backed Up: Yes
Default: FALSE

\$USE_CONFIG indicates how the system handles Cartesian moves where the configuration is inconsistent from one position to the next. For example, configurations having flip and noflip configuration are inconsistent with one another.

If the value of \$USE_CONFIG is TRUE the inconsistency causes an error that pauses the program. If the value is FALSE, the motion is carried out, using the joint placement of the beginning position.

For example, if \$USE_CONFIG is FALSE and a move is from a position with a noflip joint placement to one with a flip joint placement, noflip is used.

Configuration not only includes joint placement (flip, noflip) but also turn number. If \$USE_CONFIG is set to TRUE the turn number from the taught point will be applied to determine the destination position. If \$USE_CONFIG is set to FALSE the turn number from the taught point will be ignored.

See Also:

Chapter 8, *KAREL Reference Manual*

\$USEMAXACCEL (use maximum acceleration)

Data Type: BOOLEAN
Program/KCL: RW/RW
Power Up: No

Saved: No
Backed Up: No
Default: FALSE

\$USEMAXACCEL enables or disables the fast acceleration/deceleration feature. If it is TRUE the required acceleration time is linearly reduced to improve fast acceleration and deceleration, reduce the percentage of corner rounding, and improve the cycle time. If it is FALSE, the normal acceleration time is applied.

By default, \$USEMAXACCEL is set to FALSE each time a program is executed.

SYSTEM VARIABLE DESCRIPTIONS

\$USERELACCEL System Variable

\$USERELACCEL (use relative acceleration)

Data Type: BOOLEAN

Saved:

Program/KCL:

Power Up:

Default:

Backed Up:

If \$USERELACCEL is True, the desired motion will use the \$ACCEL_OVRD and RELACCEL values (optional feature). If \$USERELACCEL is False, the acceleration time defined in \$ACCEL_OVRD will be ignored.

\$USER_ALARM (user alarm)

Data Type: BOOLEAN

Saved: No

Program/KCL: NO/RW

Power Up: No

Default: FALSE

Backed Up: No

\$USER_ALARM can be used to turn off servo power while switching the multiplex auxiliary axes. If \$USER_ALARM is TRUE, the servo alarm error message, 4037 "User servo alarm," will be displayed, the servo power will be dropped and the program will pause. You must set \$USER_ALARM to FALSE, and press the reset button or use the RESET KCL command to reset the servo power.

The user alarm is generated by the software and will not affect the emergency stop contact status.

\$USER_PB1 (user pushbutton 1) *

Data Type: STRING[12]
Program/KCL: RO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: ' ' (blank)

\$USER_PB1 specifies the KCL command procedure that is executed when the operator panel USER PB1 button is pressed. If the command procedure is not found, the system will search for a p-code file of the same name as specified in \$USER_PB1. If found in RAM, this file will be executed. If it is found in bubble memory, the file will be loaded before execution.

The command procedure is executed whether or not a KAREL program is running. You are responsible for setting the value of \$USER_PB1 if you want the USER PB1 button to execute a command procedure.

See Also:

Enhanced KAREL Operations Manual for more information on setting \$USER_PB1.

\$USER_PB2 (user pushbutton 2) *

Data Type: STRING[12]
Program/KCL: RO/RW
Power Up: No

Saved: Yes
Backed Up: No
Default: ' ' (blank)

\$USER_PB2 specifies the KCL command procedure that is executed when the operator panel USER PB2 button is pressed. If the command procedure is not found, the system will search for a p-code file of the same name as specified in \$USER_PB2. If found in RAM, this file will be executed. If it is found in bubble memory, the file will be loaded before execution.

The command procedure is executed whether or not a KAREL program is running. You are responsible for setting the value of \$USER_PB2 if you want the USER PB2 button to execute a command procedure.

See Also:

Enhanced KAREL Operations Manual for more information on setting \$USER_PB2.

\$UTOOL (user tool)

Data Type: POSITION
Program/KCL: RW/RW
Power Up: No

Saved: Yes
Backed Up: Yes
Default: \$NILP

SYSTEM VARIABLE DESCRIPTIONS

\$UTOOL System Variable

\$UTOOL defines the location and orientation of the tool that is attached to the faceplate. The position in **\$UTOOL** is defined with respect to a fixed coordinate system on the robot faceplate and is the origin of the **TOOL FRAME**.

By default, the value of **\$UTOOL** is set to **\$NILP**, which means the position of the TCP is identical to the location and orientation of the faceplate coordinate system.

You must change the value of **\$UTOOL** to define the specific tool you are using.

See Also:

Chapter 8, *KAREL Reference Manual*

\$VERSION_ID (version identifier)

Data Type: STRING

Program/KCL: NO/RO

Default: Software Specific

Power Up: No

Saved: No

Backed Up: No

\$VERSION_ID identifies the KAREL software version currently in use. The **\$VERSION_ID** string appears on the **POWER UP** screen of the CRT.

The value of **\$VERSION_ID** is set internally.

\$WRIST_TYPE (wrist type)

Data Type: INTEGER

Minimum/Maximum: 0/9

Program/KCL: NO/PW

Default: Robot Specific

Power Up: Yes

Saved: Yes

Backed Up: No

\$WRIST_TYPE defines the type of wrist and the number of robot axes used with that wrist. The meanings associated with the values 0 through 9 depend on which robot is being described.

The value of **\$WRIST_TYPE** is set by the **KCL> UTILITY SINIT** command and should not be changed.

SYSTEM VARIABLE DESCRIPTIONS
S-10 SYSTEM VARIABLE DEFAULT VALUES

4.2 S-10 System Variable Default Values

Table 4.2. S-10 System Variable Default Values

S-10	Default Value	Notes
\$ACCEL_TIME1[1]	352	
\$ACCEL_TIME1[2]	352	
\$ACCEL_TIME1[3]	352	
\$ACCEL_TIME1[4]	352	
\$ACCEL_TIME1[5]	352	
\$ACCEL_TIME1[6]	352	
\$ACCEL_TIME2[1]	32	Payload \leq 1.0 kg
\$ACCEL_TIME2[2]	32	Payload \leq 1.0 kg
\$ACCEL_TIME2[3]	32	Payload \leq 1.0 kg
\$ACCEL_TIME2[4]	32	Payload \leq 1.0 kg
\$ACCEL_TIME2[5]	32	Payload \leq 1.0 kg
\$ACCEL_TIME2[6]	32	Payload \leq 1.0 kg
\$ACCEL_TIME2[1]	ROUND {(payload/2.0)-0.4}*32	Payload > 1.0 kg
\$ACCEL_TIME2[2]	ROUND {(payload/2.0)-0.4}*32	Payload > 1.0 kg
\$ACCEL_TIME2[3]	ROUND {(payload/2.0)-0.4}*32	Payload > 1.0 kg
\$ACCEL_TIME2[4]	ROUND {(payload/2.0)-0.4}*32	Payload > 1.0 kg
\$ACCEL_TIME2[5]	ROUND {(payload/2.0)-0.4}*32	Payload > 1.0 kg
\$ACCEL_TIME2[6]	ROUND {(payload/2.0)-0.4}*32	Payload > 1.0 kg
\$APC_SYSTEM	TRUE	S-10 has APC system
\$ARM_TYPE		
\$AXISORDER[1]	2	W
\$AXISORDER[2]	3	U
\$AXISORDER[3]	1	θ
\$AXISORDER[4]	4	γ
\$AXISORDER[5]	5	β
\$AXISORDER[6]	6	α
\$BELT_ENABLE	FALSE	
\$BRK_ON_HOLD	FALSE	
\$CART_ACCEL1	224	
\$CART_ACCEL2	128	
\$CMR[1]	1	Command multiplier ratio
\$CMR[2]	1	Command multiplier ratio
\$CMR[3]	1	Command multiplier ratio
\$CMR[4]	1	Command multiplier ratio

SYSTEM VARIABLE DESCRIPTIONS
S-10 SYSTEM VARIABLE DEFAULT VALUES

Table 4.2. S-10 System Variable Default Values (Continued)

S-10	Default Value	Notes
\$CMR[5]	1	Command multiplier ratio
\$CMR[6]	1	Command multiplier ratio
\$COARSETOL[1]	300	Detector pulses
\$COARSETOL[2]	300	Detector pulses
\$COARSETOL[3]	300	Detector pulses
\$COARSETOL[4]	300	Detector pulses
\$COARSETOL[5]	300	Detector pulses
\$COARSETOL[6]	300	Detector pulses
\$CONFIG_MASK*	-12160	11010000 10000000
\$DMR[1]	7	Detector multiplier ratio = 4
\$DMR[2]	7	Detector multiplier ratio = 4
\$DMR[3]	7	Detector multiplier ratio = 4
\$DMR[4]	7	Detector multiplier ratio = 4
\$DMR[5]	7	Detector multiplier ratio = 4
\$DMR[6]	7	Detector multiplier ratio = 4
\$DYNAMICFLTR	FALSE	
\$ENCSCALES[1]	154061.9849	484000/ π counts/rad
\$ENCSCALES[2]	194805.6503	612000/ π counts/rad
\$ENCSCALES[3]	133690.1522	420000/ π counts/rad
\$ENCSCALES[4]	68118.31564	214000/ π counts/rad
\$ENCSCALES[5]	101859.1636	320000/ π counts/rad
\$ENCSCALES[6]	63661.97724	200000/ π counts/rad
\$FB_MON_ENB[1]	TRUE	
\$FB_MON_ENB[2]	TRUE	
\$FB_MON_ENB[3]	TRUE	
\$FB_MON_ENB[4]	TRUE	
\$FB_MON_ENB[5]	TRUE	
\$FB_MON_ENB[6]	TRUE	
\$FINETOL[1]	150	Detector pulses
\$FINETOL[2]	150	Detector pulses
\$FINETOL[3]	150	Detector pulses

* Refer to \$CONFIG_MASK in the System Variable Alphabetical Description of this handout for definition of the \$CONFIG_MASK bits.

SYSTEM VARIABLE DESCRIPTIONS
S-10 SYSTEM VARIABLE DEFAULT VALUES

Table 4.2. S-10 System Variable Default Values (Continued)

S-10	Default Value	Notes
\$FINETOL[4]	150	Detector pulses
\$FINETOL[5]	150	Detector pulses
\$FINETOL[6]	150	Detector pulses
\$GAINS[1]	20	
\$GAINS[2]	20	
\$GAINS[3]	20	
\$GAINS[4]	20	
\$GAINS[5]	20	
\$GAINS[6]	20	
\$GRID[1]	7	8000 pulses/rev
\$GRID[2]	7	8000 pulses/rev
\$GRID[3]	7	8000 pulses/rev
\$GRID[4]	7	8000 pulses/rev
\$GRID[5]	7	8000 pulses/rev
\$GRID[6]	7	8000 pulses/rev
\$JNTVELLIM[1]		Depends on mounting angle (refer to the formula that follows this list)
\$JNTVELLIM[2]	1.570796327	90 deg/sec
\$JNTVELLIM[3]	2.35619449	135 deg/sec
\$JNTVELLIM[4]	4.188790205	240 deg/sec
\$JNTVELLIM[5]	4.188790205	240 deg/sec
\$JNTVELLIM[6]	6.981317008	240 deg/sec
\$LINK_LEN_1	0.0	
\$LINK_LEN_2	0.0	
\$LOWERLIMS[1]	-2.1617993878	Depends on mounting angle (refer to the formula that follows this list)
\$LOWERLIMS[2]	-0.785398163	-45 deg
\$LOWERLIMS[3]	-2.530727415	-145 deg
\$LOWERLIMS[4]	-3.316125579	-190 deg
\$LOWERLIMS[5]	-2.443460953	-140 deg
\$LOWERLIMS[6]	-4.71238898	-270 deg
\$MASTER_POS[1]	0.0	0 deg
\$MASTER_POS[2]	1.221730476	70 deg
\$MASTER_POS[3]	-2.181661565	-125 deg

SYSTEM VARIABLE DESCRIPTIONS
S-10 SYSTEM VARIABLE DEFAULT VALUES

Table 4.2. S-10 System Variable Default Values (Continued)

S-10	Default Value	Notes
\$MASTER_POS[4]	0.0	0 deg
\$MASTER_POS[5]	-0.959931088	-55 deg
\$MASTER_POS[6]	0.0	0 deg
\$MIN_ACCTIME[1]	160	
\$MIN_ACCTIME[2]	160	
\$MIN_ACCTIME[3]	160	
\$MIN_ACCTIME[4]	160	
\$MIN_ACCTIME[5]	160	
\$MIN_ACCTIME[6]	160	
\$MOT_SPD_LIM[1]	2723	rpm (Depends on mounting angle. Refer to the formula that follows this list.)
\$MOT_SPD_LIM[2]	2295	rpm
\$MOT_SPD_LIM[3]	3000	rpm (clamped to 3000 rpm)
\$MOT_SPD_LIM[4]	2140	rpm
\$MOT_SPD_LIM[5]	3200	rpm
\$MOT_SPD_LIM[6]	3333	rpm
\$MOVERRLIM[1]	22692	max 2723 rpm, P Gain 20
\$MOVERRLIM[2]	19125	max 2295 rpm, P Gain 20
\$MOVERRLIM[3]	25000	max 3000 rpm, P Gain 20
\$MOVERRLIM[4]	17833	max 2140 rpm, P Gain 20
\$MOVERRLIM[5]	26666	max 3200 rpm, P Gain 20
\$MOVERRLIM[6]	27775	max 3333 rpm, P Gain 20
\$NUM_MIR	10	
\$NUM_ROB_AXS	6	
\$PPABN_ENABL	FALSE	
\$ROTARY_AXIS[1]	TRUE	
\$ROTARY_AXIS[2]	TRUE	
\$ROTARY_AXIS[3]	TRUE	
\$ROTARY_AXIS[4]	TRUE	
\$ROTARY_AXIS[5]	TRUE	
\$ROTARY_AXIS[6]	TRUE	
\$SPIN_CTRL	FALSE	
\$STOPERLIM[1]	500	Detector pulses
\$STOPERLIM[2]	500	Detector pulses

Table 4.2. S-10 System Variable Default Values (Continued)

S-10	Default Value	Notes
\$STOPERLIM[3]	500	Detector pulses
\$STOPERLIM[4]	500	Detector pulses
\$STOPERLIM[5]	500	Detector pulses
\$STOPERLIM[6]	500	Detector pulses
\$SV_OFF_ENB[1]	FALSE	
\$SV_OFF_ENB[2]	FALSE	
\$SV_OFF_ENB[3]	FALSE	
\$SV_OFF_ENB[4]	FALSE	
\$SV_OFF_ENB[5]	FALSE	
\$SV_OFF_ENB[6]	FALSE	
\$SV_OFF_TIME	30000	
\$UPPERLIMS[1]	2.617993878	Depends on mounting angle (refer to the formula that follows this list)
\$UPPERLIMS[2]	1.570796327	90 deg
\$UPPERLIMS[3]	2.094395102	120 deg
\$UPPERLIMS[4]	3.316125579	190 deg
\$UPPERLIMS[5]	2.443460953	140 deg
\$UPPERLIMS[6]	4.71238898	270 deg

SYSTEM VARIABLE DESCRIPTIONS
S-10 SYSTEM VARIABLE DEFAULT VALUES

Formula for computing axis 1 range and joint velocity limit:

Let α be the mounting angle with respect to the horizontal,
and $\sqrt{2} = \text{sqrt}(2)$.

For $0 \text{ deg} \leq \alpha \leq 45 \text{ deg}$ and $135 \text{ deg} \leq \alpha \leq 180 \text{ deg}$

UPPERLIMS = 150 deg

LOWERLIMS = -150 deg

JNTVELLIM = ROUND((130.8 - 58.8 * $\sqrt{2}$ * sin(α)) * 25 / 120) * 5 deg/sec

For $45 \text{ deg} < \alpha < 135 \text{ deg}$

UPPERLIMS = ROUND(ARCSIN(1/($\sqrt{2}$ * sin(α))) / 15) * 15

LOWERLIMS = -UPPERLIMS

JNTVELLIM = ROUND((130.8 - 58.8 * $\sqrt{2}$ * sin(UPPERLIMS) * sin(α)) * 25 / 120) * 5 deg/s

The following tables can be constructed using these formulas:

α (deg)	0	10	20	30	40	45
\$UPPERLIMS (deg)	150	150	150	150	150	150
\$LOWERLIMS (deg)	-150	-150	-150	-150	-150	-150
\$JNTVELLIM (deg/s)	135	120	105	95	80	75

α (deg)	50	60	70	80	90	100	110	120	130
\$UPPERLIMS (deg)	60	60	45	45	45	45	45	60	60
\$LOWERLIMS (deg)	-60	-60	-45	-45	-45	-45	-45	-60	-60
\$JNTVELLIM (deg/s)	80	70	80	75	75	75	80	70	80

α (deg)	135	140	150	160	170	180
\$UPPERLIMS (deg)	150	150	150	150	150	150
\$LOWERLIMS (deg)	-150	-150	-150	-150	-150	-150
\$JNTVELLIM (deg/s)	75	80	95	105	120	135

Finally, convert degrees into radians

$$\text{\$UPPERLIMS}[1] = \text{UPPERLIMS} * \pi / 180 \text{ rad}$$

$$\text{\$LOWERLIMS}[1] = \text{LOWERLIMS} * \pi / 180 \text{ rad}$$

$$\text{\$JNTVELLIM}[1] = \text{JNTVELLIM} * \pi / 180 \text{ rad/sec}$$

where $\pi = 3.141592654$

Formula for computing \$ACCEL_TIME2 for Axis 1 to 6:

For no load : $\text{\$ACCEL_TIME2}[1] \text{ to } \text{\$ACCEL_TIME2}[6] = 32$

For payload = 1 kg : $\text{\$ACCEL_TIME2}[1] \text{ to } \text{\$ACCEL_TIME2}[6] = 32$

For payload = 2 kg to 10 kg :

$$\text{\$ACCEL_TIME2}[1] \text{ to } \text{\$ACCEL_TIME2}[6] = \text{ROUND}((\text{payload}/2) - 0.4) * 32$$

The following table can be constructed using these formulas:

Payload (kg)	0	1	2	3	4	5	6	7	8	9	10
\$ACCEL_TIME2[1] to \$ACCEL_TIME2[6]	32	32	32	32	64	64	96	96	128	128	160

SYSTEM VARIABLE DESCRIPTIONS

S-700 SYSTEM VARIABLE DEFAULT VALUES

4.3 S-700 System Variable Default Values

Table 4.3. S-700 System Variable Default Values

S-700	Default Value	Notes
\$ACCEL_TIME1[1]	384	
\$ACCEL_TIME1[2]	384	
\$ACCEL_TIME1[3]	384	
\$ACCEL_TIME1[4]	288	
\$ACCEL_TIME1[5]	288	
\$ACCEL_TIME1[6]	288	
\$ACCEL_TIME2[1]	192	
\$ACCEL_TIME2[2]	192	
\$ACCEL_TIME2[3]	192	
\$ACCEL_TIME2[4]	128	
\$ACCEL_TIME2[5]	128	
\$ACCEL_TIME2[6]	128	
\$APC_SYSTEM	TRUE	
\$AXISORDER[1]	2	W
\$AXISORDER[2]	3	U
\$AXISORDER[3]	1	θ
\$AXISORDER[4]	6	α
\$AXISORDER[5]	5	β
\$AXISORDER[6]	4	γ
\$BELT_ENABLE	FALSE	
\$BRK_ON_HOLD	FALSE	
\$CART_ACCEL1	224	
\$CART_ACCEL2	128	
\$CMR[1]	1	Command multiplier ratio = 1
\$CMR[2]	1	Command multiplier ratio = 1
\$CMR[3]	1	Command multiplier ratio = 1
\$CMR[4]	1	Command multiplier ratio = 1
\$CMR[5]	1	Command multiplier ratio = 1
\$CMR[6]	1	Command multiplier ratio = 1
\$COARSETOL[1]	300	Detector pulses
\$COARSETOL[2]	300	Detector pulses
\$COARSETOL[3]	300	Detector pulses
\$COARSETOL[4]	300	Detector pulses
\$COARSETOL[5]	300	Detector pulses

Table 4.3. S-700 System Variable Default Values (Continued)

S-700	Default Value	Notes
\$COARSETOL[6]	300	Detector pulses
\$CONFIG_MASK*	-12160	11010000 10000000
\$DMR[1]	7	Detector multiplier ratio = 4
\$DMR[2]	7	Detector multiplier ratio = 4
\$DMR[3]	7	Detector multiplier ratio = 4
\$DMR[4]	7	Detector multiplier ratio = 4
\$DMR[5]	7	Detector multiplier ratio = 4
\$DMR[6]	7	Detector multiplier ratio = 4
\$DYNAMICFLTR	FALSE	
\$ENCSCALES[1]	164247.9013	516000/ π counts/rad
\$ENCSCALES[2]	162974.6617	512000/ π counts/rad
\$ENCSCALES[3]	186741.7999	1760000/3 π counts/rad
\$ENCSCALES[4]	122830.1678	6560000/17 π counts/rad
\$ENCSCALES[5]	122230.9963	384000/ π counts/rad
\$ENCSCALES[6]	91265.81056	7168000/25 π counts/rad
\$FB_MON_ENB[1]	TRUE	
\$FB_MON_ENB[2]	TRUE	
\$FB_MON_ENB[3]	TRUE	
\$FB_MON_ENB[4]	TRUE	
\$FB_MON_ENB[5]	TRUE	
\$FB_MON_ENB[6]	TRUE	
\$FINETOL[1]	150	Detector pulses
\$FINETOL[2]	150	Detector pulses
\$FINETOL[3]	150	Detector pulses
\$FINETOL[4]	150	Detector pulses
\$FINETOL[5]	150	Detector pulses
\$FINETOL[6]	150	Detector pulses
\$GAINS[1]	20	
\$GAINS[2]	20	
\$GAINS[3]	20	

* Refer to \$CONFIG_M\$ASK in the System Variable Alphabetical Description of this handout for definition of the \$CONFIG_MASK bits.

SYSTEM VARIABLE DESCRIPTIONS
S-700 SYSTEM VARIABLE DEFAULT VALUES

Table 4.3. S-700 System Variable Default Values (Continued)

S-700	Default Value	Notes
\$GAINS[4]	20	
\$GAINS[5]	20	
\$GAINS[6]	20	
\$GRID[1]	7	means 8000 pulses/rev
\$GRID[2]	7	means 8000 pulses/rev
\$GRID[3]	7	means 8000 pulses/rev
\$GRID[4]	7	means 8000 pulses/rev
\$GRID[5]	7	means 8000 pulses/rev
\$GRID[6]	7	means 8000 pulses/rev
\$JNTVELLIM[1]	2.094395102	120 deg/sec
\$JNTVELLIM[2]	1.832595715	105 deg/sec
\$JNTVELLIM[3]	1.832595715	105 deg/sec
\$JNTVELLIM[4]	3.141592654	180 deg/sec
\$JNTVELLIM[5]	3.141592654	180 deg/sec
\$JNTVELLIM[6]	4.188790205	240 deg/sec
\$LINK_LEN_1	0.0	
\$LINK_LEN_2	0.0	
\$LOWERLIMS[1]	-2.617993878	-150 deg
\$LOWERLIMS[2]	-1.570796327	-90 deg
\$LOWERLIMS[3]	-2.094395102	-120 deg
\$LOWERLIMS[4]	-3.316125579	-190 deg
\$LOWERLIMS[5]	-2.094395102	-120 deg
\$LOWERLIMS[6]	-4.71238898	-270 deg
\$MASTER_POS[1]	0.0	0 deg
\$MASTER_POS[2]	1.047197551	60 deg
\$MASTER_POS[3]	-1.919862177	-110 deg
\$MASTER_POS[4]	0.0	0 deg
\$MASTER_POS[5]	-1.221730476	-70 deg
\$MASTER_POS[6]	0.0	0 deg
\$MIN_ACCTIME[1]	160	
\$MIN_ACCTIME[2]	160	
\$MIN_ACCTIME[3]	160	
\$MIN_ACCTIME[4]	160	
\$MIN_ACCTIME[5]	160	

SYSTEM VARIABLE DESCRIPTIONS
S-700 SYSTEM VARIABLE DEFAULT VALUES

Table 4.3. S-700 System Variable Default Values (Continued)

S-700	Default Value	Notes
\$MIN_ACCTIME[6]	160	
\$MOT_SPD_LIM[1]	2580	rpm
\$MOT_SPD_LIM[2]	2258	rpm
\$MOT_SPD_LIM[3]	3000	rpm (clamped to max. 3000 rpm)
\$MOT_SPD_LIM[4]	2932	rpm
\$MOT_SPD_LIM[5]	2932	rpm
\$MOT_SPD_LIM[6]	2944	rpm
\$MOVERRLIM[1]	22360	gain of 20
\$MOVERRLIM[2]	19413	gain of 20
\$MOVERRLIM[3]	26000	gain of 20
\$MOVERRLIM[4]	24434	max 2932 rpm, gain of 20
\$MOVERRLIM[5]	24434	max 2932 rpm, gain of 20
\$MOVERRLIM[6]	24534	max 2944 rpm, gain of 20
\$NUM_MIR	10	
\$NUM_ROB_AXS	6	
\$PPABN_ENABL	FALSE	
\$ROTARY_AXIS[1]	TRUE	
\$ROTARY_AXIS[2]	TRUE	
\$ROTARY_AXIS[3]	TRUE	
\$ROTARY_AXIS[4]	TRUE	
\$ROTARY_AXIS[5]	TRUE	
\$ROTARY_AXIS[6]	TRUE	
\$SPIN_CTRL	FALSE	
\$STOPERLIM[1]	500	Detector pulses
\$STOPERLIM[2]	500	Detector pulses
\$STOPERLIM[3]	500	Detector pulses
\$STOPERLIM[4]	500	Detector pulses
\$STOPERLIM[5]	500	Detector pulses
\$STOPERLIM[6]	500	Detector pulses
\$SV_OFF_ENB[1]	FALSE	
\$SV_OFF_ENB[2]	FALSE	
\$SV_OFF_ENB[3]	FALSE	
\$SV_OFF_ENB[4]	FALSE	
\$SV_OFF_ENB[5]	FALSE	

SYSTEM VARIABLE DESCRIPTIONS
S-700 SYSTEM VARIABLE DEFAULT VALUES

Table 4.3. S-700 System Variable Default Values (Continued)

S-700	Default Value	Notes
\$SV_OFF_ENB[6]	FALSE	
\$SV_OFF_TIME	10000	
\$UPPERLIMS[1]	2.617993878	150 deg
\$UPPERLIMS[2]	1.570796327	90 deg
\$UPPERLIMS[3]	4.71238898	270 deg
\$UPPERLIMS[4]	3.316125579	190 deg
\$UPPERLIMS[5]	2.094395102	120 deg
\$UPPERLIMS[6]	4.71238898	270 deg

4.3 S-700 System Variable Default Values

Table 4.3. S-700 System Variable Default Values

S-700	Default Value	Notes
\$ACCEL_TIME1[1]	384	
\$ACCEL_TIME1[2]	384	
\$ACCEL_TIME1[3]	384	
\$ACCEL_TIME1[4]	288	
\$ACCEL_TIME1[5]	288	
\$ACCEL_TIME1[6]	288	
\$ACCEL_TIME2[1]	192	
\$ACCEL_TIME2[2]	192	
\$ACCEL_TIME2[3]	192	
\$ACCEL_TIME2[4]	128	
\$ACCEL_TIME2[5]	128	
\$ACCEL_TIME2[6]	128	
\$APC_SYSTEM	TRUE	
\$AXISORDER[1]	2	W
\$AXISORDER[2]	3	U
\$AXISORDER[3]	1	θ
\$AXISORDER[4]	6	α
\$AXISORDER[5]	5	β
\$AXISORDER[6]	4	γ
\$BELT_ENABLE	FALSE	
\$BRK_ON_HOLD	FALSE	
\$CART_ACCEL1	224	
\$CART_ACCEL2	128	
\$CMR[1]	1	Command multiplier ratio = 1
\$CMR[2]	1	Command multiplier ratio = 1
\$CMR[3]	1	Command multiplier ratio = 1
\$CMR[4]	1	Command multiplier ratio = 1
\$CMR[5]	1	Command multiplier ratio = 1
\$CMR[6]	1	Command multiplier ratio = 1
\$COARSETOL[1]	300	Detector pulses
\$COARSETOL[2]	300	Detector pulses
\$COARSETOL[3]	300	Detector pulses
\$COARSETOL[4]	300	Detector pulses
\$COARSETOL[5]	300	Detector pulses

SYSTEM VARIABLE DESCRIPTIONS
S-700 SYSTEM VARIABLE DEFAULT VALUES

Table 4.3. S-700 System Variable Default Values (Continued)

S-700	Default Value	Notes
\$COARSETOL[6]	300	Detector pulses
\$COND_TIME	32	
\$CONFIG_MASK*	-12160	11010000 10000000
\$DMR[1]	7	Detector multiplier ratio = 4
\$DMR[2]	7	Detector multiplier ratio = 4
\$DMR[3]	7	Detector multiplier ratio = 4
\$DMR[4]	7	Detector multiplier ratio = 4
\$DMR[5]	7	Detector multiplier ratio = 4
\$DMR[6]	7	Detector multiplier ratio = 4
\$DYNAMICFLTR	FALSE	
\$ENCSCALES[1]	164247.9013	516000/ π counts/rad
\$ENCSCALES[2]	162974.6617	512000/ π counts/rad
\$ENCSCALES[3]	186741.7999	1760000/3 π counts/rad
\$ENCSCALES[4]	122830.1678	6560000/17 π counts/rad
\$ENCSCALES[5]	122230.9963	384000/ π counts/rad
\$ENCSCALES[6]	91265.81056	7168000/25 π counts/rad
\$FB_MON_ENB[1]	TRUE	
\$FB_MON_ENB[2]	TRUE	
\$FB_MON_ENB[3]	TRUE	
\$FB_MON_ENB[4]	TRUE	
\$FB_MON_ENB[5]	TRUE	
\$FB_MON_ENB[6]	TRUE	
\$FINETOL[1]	150	Detector pulses
\$FINETOL[2]	150	Detector pulses
\$FINETOL[3]	150	Detector pulses
\$FINETOL[4]	150	Detector pulses
\$FINETOL[5]	150	Detector pulses
\$FINETOL[6]	150	Detector pulses
\$GAINS[1]	20	
\$GAINS[2]	20	
\$GAINS[3]	20	

* Refer to \$CONFIG_M\$ASK in the System Variable Alphabetical Description of this handout for definition of the \$CONFIG_MASK bits.

Table 4.3. S-700 System Variable Default Values (Continued)

S-700	Default Value	Notes
\$GAINS[4]	20	
\$GAINS[5]	20	
\$GAINS[6]	20	
\$GRID[1]	7	means 8000 pulses/rev
\$GRID[2]	7	means 8000 pulses/rev
\$GRID[3]	7	means 8000 pulses/rev
\$GRID[4]	7	means 8000 pulses/rev
\$GRID[5]	7	means 8000 pulses/rev
\$GRID[6]	7	means 8000 pulses/rev
\$JNTVELLIM[1]	2.094395102	120 deg/sec
\$JNTVELLIM[2]	1.832595715	105 deg/sec
\$JNTVELLIM[3]	1.832595715	105 deg/sec
\$JNTVELLIM[4]	3.141592654	180 deg/sec
\$JNTVELLIM[5]	3.141592654	180 deg/sec
\$JNTVELLIM[6]	4.188790205	240 deg/sec
\$LINK_LEN_1	0.0	
\$LINK_LEN_2	0.0	
\$LOWERLIMS[1]	-2.617993878	-150 deg
\$LOWERLIMS[2]	-1.570796327	-90 deg
\$LOWERLIMS[3]	-2.094395102	-120 deg
\$LOWERLIMS[4]	-3.316125579	-190 deg
\$LOWERLIMS[5]	-2.094395102	-120 deg
\$LOWERLIMS[6]	-4.71238898	-270 deg
\$MASTER_POS[1]	0.0	0 deg
\$MASTER_POS[2]	1.047197551	60 deg
\$MASTER_POS[3]	-1.919862177	-110 deg
\$MASTER_POS[4]	0.0	0 deg
\$MASTER_POS[5]	-1.221730476	-70 deg
\$MASTER_POS[6]	0.0	0 deg
\$MIN_ACCTIME[1]	160	
\$MIN_ACCTIME[2]	160	
\$MIN_ACCTIME[3]	160	
\$MIN_ACCTIME[4]	160	
\$MIN_ACCTIME[5]	160	

SYSTEM VARIABLE DESCRIPTIONS
S-700 SYSTEM VARIABLE DEFAULT VALUES

Table 4.3. S-700 System Variable Default Values (Continued)

S-700	Default Value	Notes
\$MIN_ACCTIME[6]	160	
\$MOT_SPD_LIM[1]	2580	rpm
\$MOT_SPD_LIM[2]	2258	rpm
\$MOT_SPD_LIM[3]	3000	rpm (clamped to max. 3000 rpm)
\$MOT_SPD_LIM[4]	2932	rpm
\$MOT_SPD_LIM[5]	2932	rpm
\$MOT_SPD_LIM[6]	2944	rpm
\$MOVERRRLIM[1]	22360	gain of 20
\$MOVERRRLIM[2]	19413	gain of 20
\$MOVERRRLIM[3]	26000	gain of 20
\$MOVERRRLIM[4]	24434	max 2932 rpm, gain of 20
\$MOVERRRLIM[5]	24434	max 2932 rpm, gain of 20
\$MOVERRRLIM[6]	24534	max 2944 rpm, gain of 20
\$NUM_MIR	10	
\$NUM_ROB_AXS	6	
\$PPABN_ENABL	FALSE	
\$ROTARY_AXIS[1]	TRUE	
\$ROTARY_AXIS[2]	TRUE	
\$ROTARY_AXIS[3]	TRUE	
\$ROTARY_AXIS[4]	TRUE	
\$ROTARY_AXIS[5]	TRUE	
\$ROTARY_AXIS[6]	TRUE	
\$SPIN_CTRL	FALSE	
\$STOPERLIM[1]	500	Detector pulses
\$STOPERLIM[2]	500	Detector pulses
\$STOPERLIM[3]	500	Detector pulses
\$STOPERLIM[4]	500	Detector pulses
\$STOPERLIM[5]	500	Detector pulses
\$STOPERLIM[6]	500	Detector pulses
\$SV_OFF_ENB[1]	FALSE	
\$SV_OFF_ENB[2]	FALSE	
\$SV_OFF_ENB[3]	FALSE	
\$SV_OFF_ENB[4]	FALSE	
\$SV_OFF_ENB[5]	FALSE	

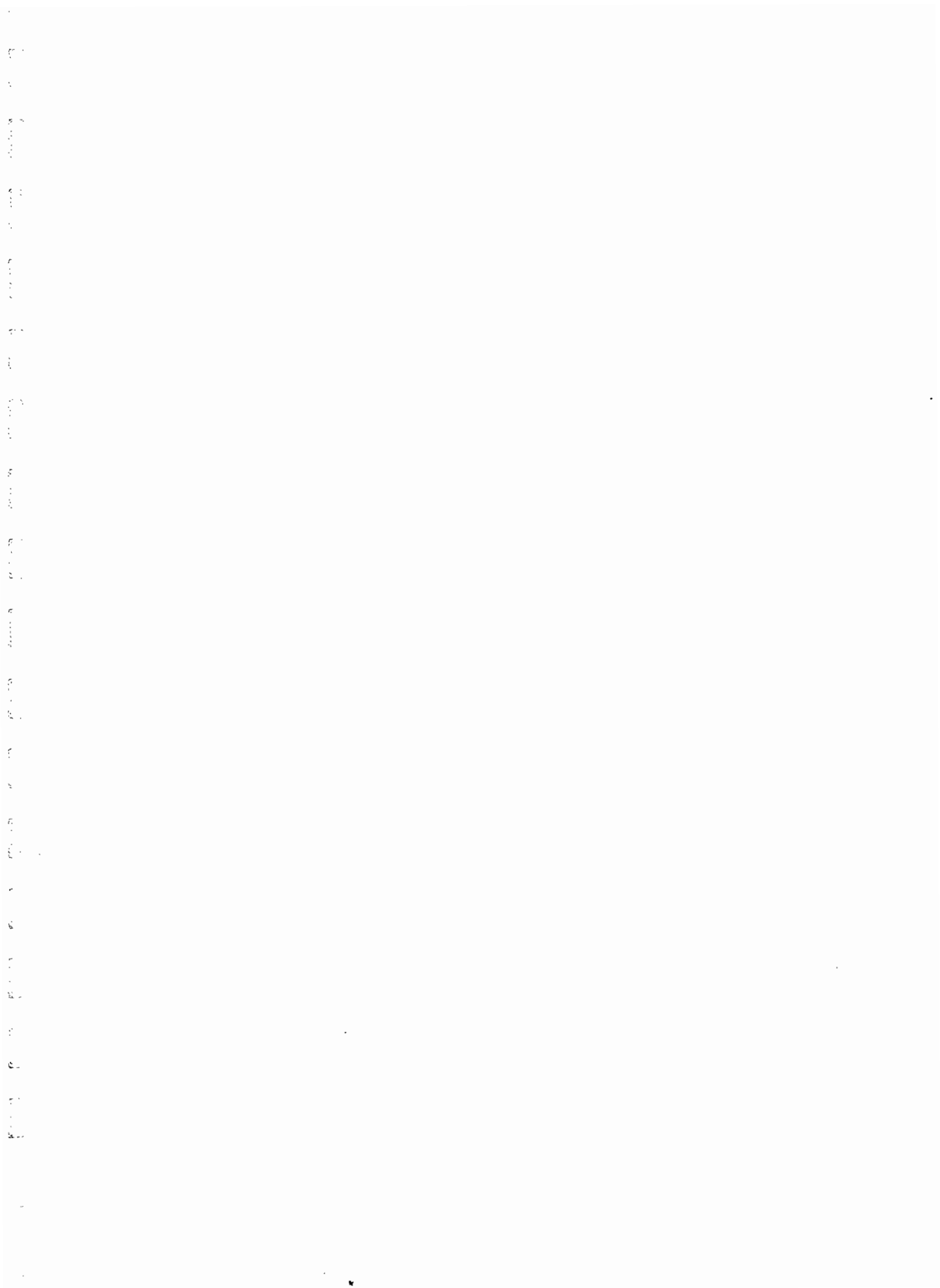
SYSTEM VARIABLE DESCRIPTIONS
S-700 SYSTEM VARIABLE DEFAULT VALUES

Table 4.3. S-700 System Variable Default Values (Continued)

S-700	Default Value	Notes
\$SV_OFF_ENB[6]	FALSE	
\$SV_OFF_TIME	10000	
\$UPPERLIMS[1]	2.617993878	150 deg
\$UPPERLIMS[2]	1.570796327	90 deg
\$UPPERLIMS[3]	4.71238898	270 deg
\$UPPERLIMS[4]	3.316125579	190 deg
\$UPPERLIMS[5]	2.094395102	120 deg
\$UPPERLIMS[6]	4.71238898	270 deg

Revision Record
S-10/S-700 MAINTENANCE REFERENCE MANUAL (B-67395E-G)

04	12-7-89	Section added on Absolute Pulse Coder. Supplement issued.			
03	6-6-89	Appendix 4 revised 6-6-89. Warning added for Transporting.			
02	12-88	Appendix 4 added on 12-5-88.			
	10-88	Changes made on pages 6-19 and 6-32			
01	'88, 8	_____	05	5-93	Changes made in original and supplement issued.
Edition	Date	Contents	Edition	Date	Contents



**S-10/S-700 Maintenance and
Troubleshooting Reference Manual
Addendum**

MARXMS17H0884EF

**Addendum to the S-10/S-700 Maintenance
and Troubleshooting Reference Manual
MARMKS17H0885EF**

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The attached pages contain the most recent updates. Please keep this addendum with the S-10/S-700 Maintenance and Troubleshooting Reference Manual, part number MARMKS17H0885EF.

CMOS RAM BOARD (A16B-2200-0760,0761,0762)

Theory of Operation

The CMOS RAM board, also called the CMOS Data Memory PCB, IC File PCB, CMOS Memory PCB, and CMOS RAM PCB, is a non-volatile mass-storage device. It is an alternative to the bubble memory board and performs the same functions as the bubble memory board, except as noted in this supplement.

CMOS RAM provides faster data access speed, resulting in

- Improved power-on time (approximately 2X faster)
- Faster application/user software loading to RAM
- Slightly faster access for file operations

CMOS RAM and bubble memory cannot be mixed in a controller.

Part Numbers

A16B-2200-0760	2 Mbyte capacity
A16B-2200-0761	1 Mbyte capacity
A16B-2200-0762	512 Kbyte capacity

Capacity Limitations

Only two CMOS RAM boards can be installed in an R-H controller. This limits the maximum amount of storage to four MBytes.

Power Source

Unlike the bubble memory board, the CMOS RAM board must have DC power supplied to it at all times, in order to retain stored data.

When the controller is turned off, power is provided by the same battery unit that powers the CMOS RAM chips on the path CPU board.

Battery life varies with the total amount of CMOS RAM in the controller, and the percentage of time that the controller is turned on.

The worst case condition is with 4 Mbytes of CMOS RAM present (this is the maximum amount that the controller can accomodate) and the controller never turned on. In this case, the batteries would be exhausted after about 220 days.

Under most circumstances, the batteries will last well past the specified annual replacement.

A capacitor mounted on the CMOS RAM board stores sufficient charge to maintain memory for about 30 minutes if the board is removed from the controller or if the batteries are removed while the controller is turned off.

Connector/Signal Identification

CA27 is a connector on the front edge of the board. It allows you to attach an R-H Battery Pack (A98L-0004-0096) (Batteries A98L-0031-0005) with Power Cord (A660-8005-T927/L2R703, or XGMF-04226) if you need to store the board outside of the controller for longer than 30 minutes.

The connector on the controller battery unit can be plugged directly into this connector if necessary.

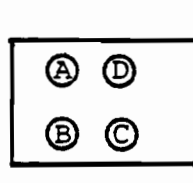
1	VB	VB: + Battery
2	0V	0V: - Battery
3	VB	

Connector CNA connects the CMOS RAM board to the Backplane PCB. It has the same configuration as connector CNA of the bubble memory board.

Lights and Indicators

The CMOS board has a block of four red LEDs, similar to those on the CPU and shared RAM boards.

They are laid out in the following configuration:



LED "A" is a parity alarm lamp, providing the same type of information as those on the other boards.

LED "D" is a low battery voltage indicator lamp, providing the same information as LED "D" on the shared RAM board.

LEDs "B" and "C" are not used.

Other Indicators

Operator's Panel User LED # 2 is reassigned as a low battery indicator lamp and acts as a repeater for the low battery LEDs on the CMOS RAM and shared RAM boards. It is labelled "BATTERY LOW" on controllers that use CMOS RAM boards, and the color of the LED has been changed from green to red. The LED lights when battery voltage is low or absent.

The "10017 BACKUP BATTERY LOW VOLTAGE" message on the CRT and teach pendant also indicates that battery voltage is low or absent.

When battery voltage is low, GMFanuc recommends replacing the batteries before powering down the controller.

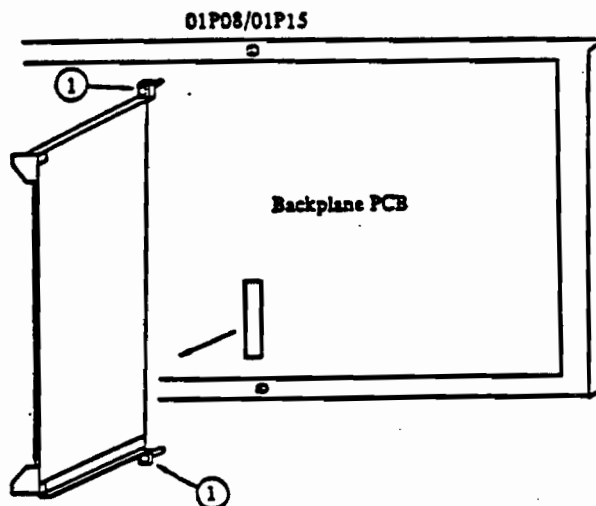
Test Points

Two test pins are mounted on the front edge of the board. They allow you to measure the battery voltage applied to the board.

TES1	O
GND2	O

TES1	Approximately +4.5 VDC
GND2	0 VDC

Removal/Replacement



1) Procedure

- ① Detach PCB by loosening the screws ①.
- ② Mount new PCB.

Caution

Do not keep the board out of the controller for longer than 30 minutes without connecting an external battery pack to connector CN27. Otherwise, all data stored on the board could be lost.

1. Detach The PCB by loosening the screws (1)
2. Mount new PCB