

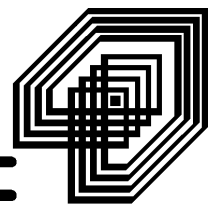
SCORBOT-ER III

User's Manual

6th Edition

Catalog No. 100038 Rev.A

ESHED ROBOTEC



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Eshed Robotec bears no responsibility for errors which may appear in this publication and retains the right to make changes to the software, hardware and manual without prior notice.

Read this manual thoroughly before attempting to install or operate the robot, controller or computer. If you have any problems during installation or operation, call your agent for assistance.

Save the original carton and all packing material. You may need them later for shipment.

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General Information

Congratulations! You are now the owner of the **SCORBOT-ER III** educational robot. Many hours of interesting and stimulating work now await you.

Read this chapter carefully before you unpack the SCORBOT-ER III robot and controller.

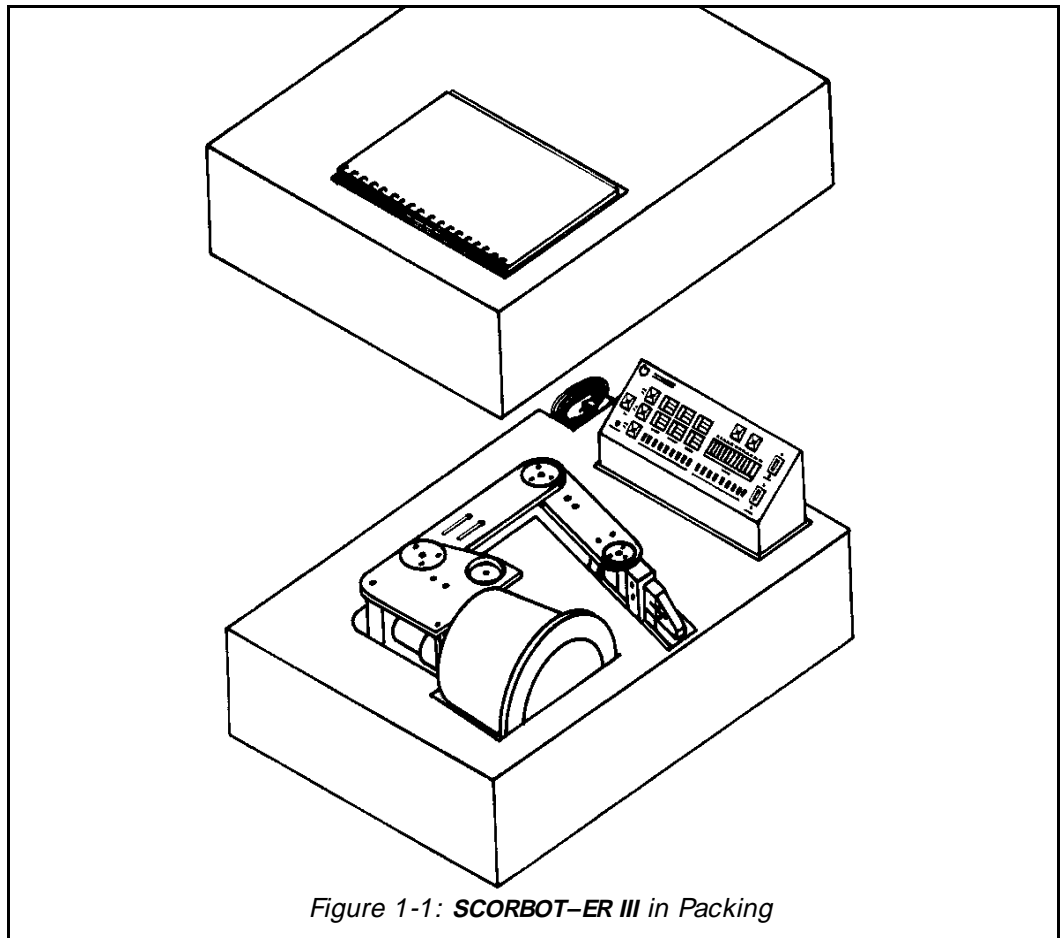


Figure 1-1: **SCORBOT-ER III** in Packing

Unpacking and Handling Instructions

The **SCORBOT-ER III** robot arm and controller are packed and shipped in a carton weighing 22 kg (48.5 lb.) and measuring:

Height: 400 mm (15.5")

Width: 460 mm (18")

Length: 610 mm (24")

After you have removed the **SCORBOT-ER III User's Manual** from the recess in the top layer of the molded foam, carefully remove the layer of foam which covers the robot and controller (see Figure 1-1).

To remove the robot, grasp the orange aluminum side plate with one hand and the black handle (carrying bar) at the rear of the robot with the other hand. Carefully lift the robot out of the box. Set the robot down on its base.

Lift and/or carry the robot arm only by grasping the carrying bar or by holding the body or the base with both hands.

Warning! Prevent damage to the robot arm. When handling, do not grasp the gripper, upper arm or forearm, and do not touch the micro-switches, cams or encoders.

To remove the controller, grasp it on its two metal sides. Set it down on its base.

Unpack the electric power cable and the RS232 cable.

To install the robot, refer to the instructions in Chapter 3.

Repacking for Shipment

Save the carton and molded foam for use when storing or shipping the equipment. The **SCORBOT-ER III** arm and controller should always be repacked in their original packing materials.

When repacking, make sure the microswitch on the base of the robot is not in contact with its cam.

Acceptance Inspection

Standard Items

Following is a list of the items included in the **SCORBOT-ER III** standard package. Make sure you have received all these items.

Check all items for any shipping damage prior to installation or operation. If any damage is evident, do not use the **SCORBOT**. Notify your freight dealer immediately and begin appropriate claims procedures.

Table 1-1: SCORBOT-ER III Standard Components

Item	Description
1.	SCORBOT-ER III Mechanical Arm
2.	SCORBOT-ER III Controller
3.	SCORBOT-ER III <i>User's Manual</i>
4.	SCORBASE Software Levels 1, 2 and 3 diskettes
5.	Power Cable
6.	RS232 Cable

Optional Accessories

Following is a list of optional accessories. Make sure you have received all the items you ordered.

Table 1-2: SCORBOT-ER III Optional Accessories

Item	Description	Catalog #
1.	Teach Pendant (includes SCORBASE Level 4)	1701
2.	SCORBASE Level 5	9003
3.	Motor Kit	1206
4.	Rotary Table	1004
5.	Conveyor (orange)	1003
6.	Experiment Table	1201
7.	Linear Slide Base	
	48" Slide Base	1001
	72" Slide Base	1002
8.	Utilities Control Box	1204
9.	Vacuum Gripper (1 pad)	601
10.	Vacuum Gripper (3 pads)	602
11.	Air Brush	603
12.	Dispenser	604
13.	Gripper Adaptor for Round Bars	606
14.	Photoelectric Sensor	1203
15.	Dual Axis Vise	

Safety Precautions

The **SCORBOT-ER III** is potentially dangerous! Use extreme caution when operating the robot. Carelessness could result in injury to the operator and people in the vicinity.

Study this manual thoroughly before you install or operate the **SCORBOT-ER III**.

1. Make sure the robot's base is fastened to the work surface by means of at least three bolts, set 120° apart (see Figure 3-1). Otherwise, the robot could become unstable and topple over during operation.
2. Make sure the robot arm has sufficient space in which to move freely.
3. Do not place your hands or fingers or any object within the robot arm's operating range, particularly while it is in motion.
4. Before you approach or handle the robot, make sure the MOTOR switch on the controller front panel has been shut off. Otherwise an unexpected signal could trigger robot motion.
5. Before you connect any input or output to the controller, make sure the controller POWER switch has been shut off.
6. Before you remove any fuses from the controller rear panel, unplug the power cable from the AC power outlet.
7. Do not open the controller housing.

Warnings

To prevent damage to the **SCORBOT-ER III**, make sure you heed the following warnings:

1. Do not plug the controller into the 220/110/100V AC outlet before making sure the voltage on the manufacturer's tag at the back of the controller matches your voltage supply. If your power supply and the controller voltage requirements are not compatible, contact your agent immediately and have the controller exchanged.
2. Do not connect voltage in excess of 24 VDC to the input ports.
3. Do not connect voltage in excess of 24 VDC to the output ports.
Always connect outputs 5 through 8 (open collector outputs) to a load.
Never connect voltage from a power supply directly to the output ports.
Never drive a current of more than 4 amp through the relay outputs.
Never drive a current of more than 0.5 amp through each of the open collector outputs. Moreover, make sure that the total current driven through outputs 5–8 does not exceed 1.5 amps.
4. Do not exert force on any part of the system. All installation and operational procedures are designed to proceed smoothly and easily.
5. Do not use physical or mechanical means to stop the movement of any part of the robot arm.
6. Do not drive the arm into another object or an obstacle.
7. Do not expose the **SCORBOT** to impact or vibration.
8. Do not operate the **SCORBOT** beyond the allowed temperature range: 5°–40°C (41°–104°F).
9. Do not allow water, liquids or metal shavings to fall on the robot or controller.
10. Do not operate the **SCORBOT** in gaseous or explosive environments, in wet or damp locations, or near dust, dirt and oil.
11. Do not overload the arm. The workload may not exceed 1 kilo (2.2 lb.). The gripper should grasp a workload at its center of gravity.
12. Do not leave any of the axes under mechanical strain for a long period, and especially do not leave the gripper grasping an object for any length of time.
13. Do not use the **SCORBOT** where the power line contains spikes of high surge voltage, or near any equipment (such as presses, oscillators, large size inverters, contactors) which generates large electrical noise.

Components and Specifications

The **SCORBOT-ER III** system consists of the mechanical arm and the electronic controller.

The Robot Arm

The **SCORBOT-ER III** is a vertically articulated robot. It has a base joint which rotates the arm in a horizontal plane, three joints which rotate the robot's links in a vertical plane, and a wrist roll joint which rotates the gripper (see Figures 2-1 and 2-2).

The body of the robot is the main frame, which contains five of the six motors.

The links (upper arm and forearm) and the joints enable the desired movements of the gripper.

The gripper is the end effector of the robot arm. For the gripper to reach the desired position, some or all of the axes must move.

The gripper fingers open and close in parallel. Various kinds of pads and end effectors, such as an air brush or a vacuum gripper, can be attached to the gripper by means of the \varnothing 4 mm (0.16") holes in the gripper fingers (see Figure 2-3).

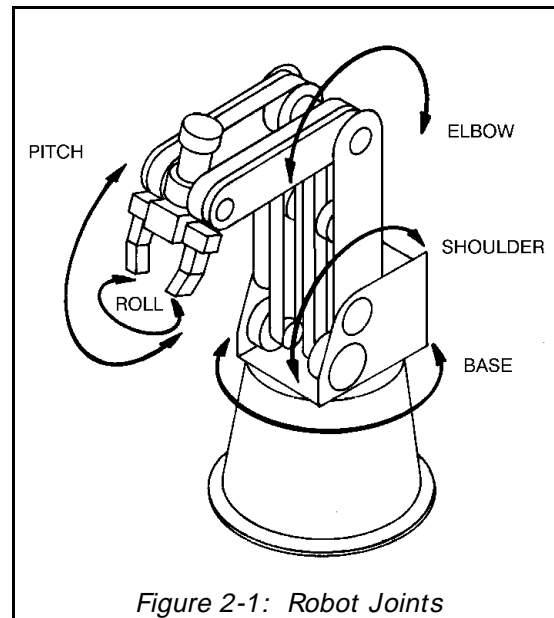
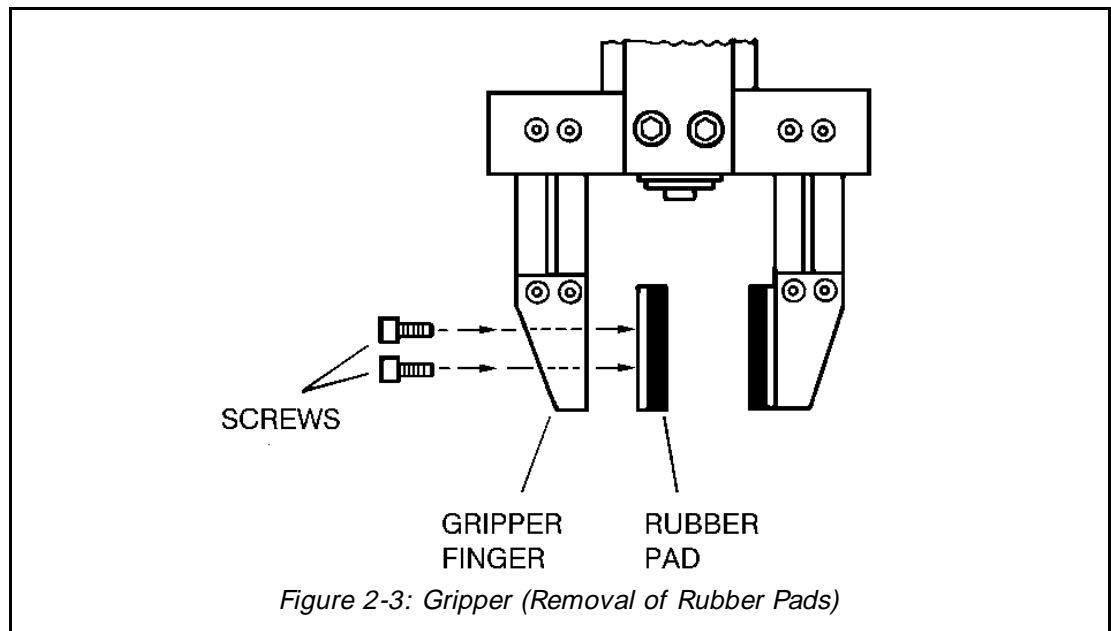
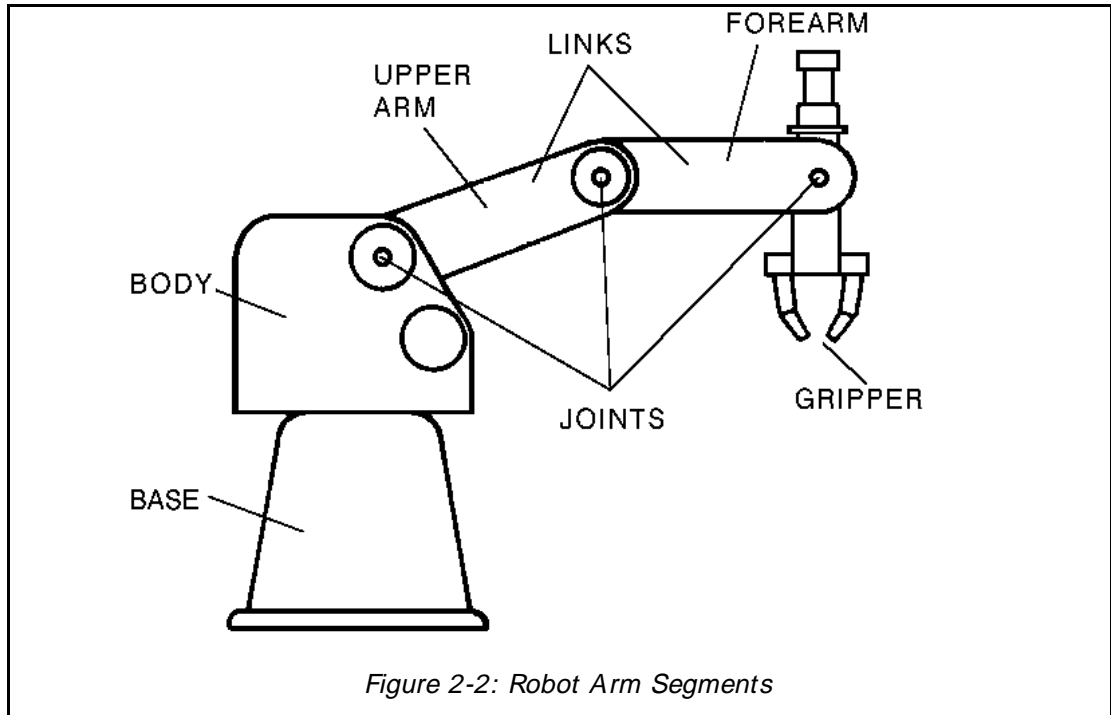


Figure 2-1: Robot Joints



The following table gives the technical specifications of the **SCORBOT-ER III** robot arm.

Table 2-1: SCORBOT-ER III Robot Arm Specifications

Item	Specification
Mechanical Structure	Vertically articulated 5 axes plus gripper Control of 8 axes simultaneously
Working Envelope:	
Axis 1: Base Rotation	310°
Axis 2: Shoulder Rotation	+ 130° / -35°
Axis 3: Elbow Rotation	± 130°
Axis 4: Wrist Pitch	± 130°
Axis 5: Wrist Roll	Unlimited
Maximum Working Radius	610 mm (24.4")
Gripper Opening	75 mm (3") without rubber pads 65 mm (2.56") with rubber pads
Maximum Work Load	1 kg (2.2 lb.)
Transmission	Gears, timing belts and lead screw
Actuators	6 DC servo motors with closed-loop control
Feedback	Optical encoders on all axes
Hard Home	Fixed reference position on all axes
Repeatability	± 0.5 mm (± 0.02")
Maximum Speed	330 mm/sec. (13"/sec.)
Weight	
Robot Arm	11 kg (24 lb.)
Controller	5 kg (11 lb.)

Motors

The five axes and the gripper are operated by DC servo motors. The direction of motor revolution is determined by the polarity of the operating voltage: positive DC voltage turns the motor in one direction, while negative DC voltage turns it in the opposite direction. Each motor has closed-loop control; that is, an encoder circuit provides the controller with feedback on the extent and direction of the movement of the motor.

Encoders

An optical encoder mounted on each motor continuously monitors the positions, direction and velocity along the path of movement. The encoder produces an electric pulse according to the rotation of the motor shaft on which it is mounted. The number and rate of the pulses are measured by the controller which then compares the actual position with the desired position, and makes any necessary adjustments. See Appendix E for more details.

Microswitches

Five microswitches are fitted onto the mechanical arm. When the robot assumes the position in which the microswitch on each joint is depressed (by the cam), this predetermined position is known as hard home. This is the point of reference for robot operation. Whenever the system is turned on, the robot should be reset to this hard home position. Refer to the Home Menu in the section, “SCORBASE Level 2,” in Chapter 4.

Transmissions

Several kinds of transmission are used to operate the links of the mechanical arm. Toothed gears move the robot base and shoulder. Toothed gears and timing belts move the robot elbow. Timing belts

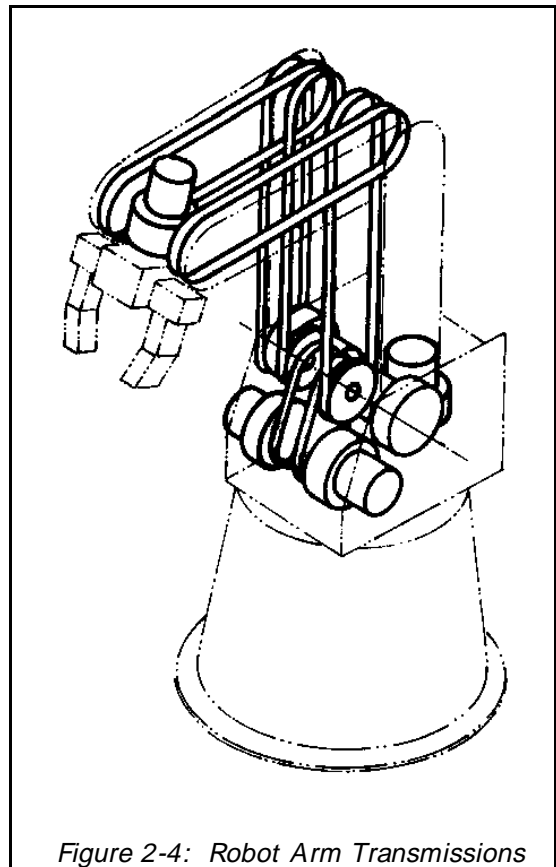


Figure 2-4: Robot Arm Transmissions

and a toothed gear differential unit at the end of the arm move the wrist. A lead screw coupled directly to a DC servo motor causes the gripper to open and close.

Robot Cable

The main cable of the robot contains 50 leads divided into six groups (one for each motor). Each group contains eight leads:

- 2 leads supply voltage to the motor.
- 2 leads receive pulses from the optical encoder (channel 0 and channel 1).
- 1 lead carries the signal from the microswitch.
- 1 lead supplies voltage to the encoder (V_{LED}).
- 1 lead provides the ground for the microswitch.
- 1 lead provides the ground for the encoder.

All commands, both operational and control, are transmitted through this cable, which is the sole connection between the robot arm and the controller. The cable runs from the robot base to the D50 connector marked ROBOT on the rear panel of the controller. See Appendix D for more details.

The Controller

The controller has six main components: the controller housing; the main controller circuit; the display and I/O circuit; two drive circuits: NPN and PNP; and the power supply

Controller Housing

The base of the controller contains the main circuit, the power supply, the transformer and the two drive circuits. The display and I/O printed circuit board is fitted into the cover (see Figure 2-5).

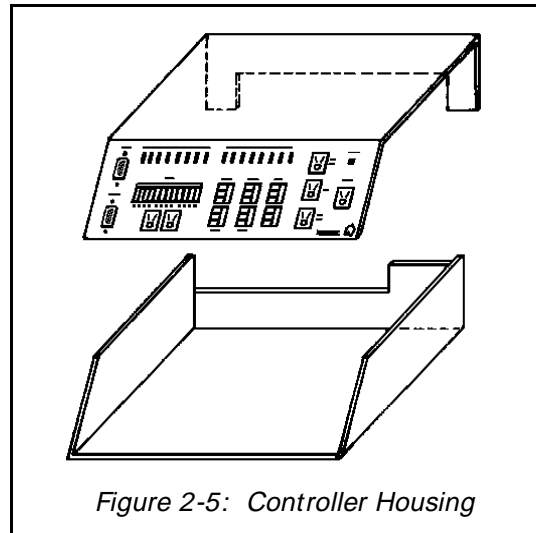


Figure 2-5: Controller Housing

Main Controller Circuitry (PC 010)

The main controller circuit operates the robot's motors, encoders, inputs, outputs, microswitches, test routine, and communication. The controller circuit is a slave of the computer, communicating by means of the RS232 serial port.

The main components of the circuit are:

- Central Processing Unit (CPU): INTEL 8031.
- EPROM: A fixed memory of 16K bytes which contains the controller's operational software.
- Logic Components and Buffers: Transmit information to the CPU and execute instructions relating to the motors, encoders, inputs and outputs.
- Multiplexers: Expand the CPU's capability for receiving input/output information.
- Drivers: Activate motors and outputs. These include switching components such as power transistors. Drivers also interface between low-power and high-power components.
- Serial Communication Components: Receive and transmit information in RS232 standard ($\pm 12V$) and exchange it with the TTL levels of the CPU. The teach pendant also communicates through the RS232 circuitry.

Altogether the main controller circuit controls eight motors (the six motors on the robot arm are connected through the cable which plugs into the port marked ROBOT at the back of the controller; two additional motors can be connected to the ports

marked MOTOR 6 and MOTOR 7 on the controller front panel.)

In addition, the main controller circuit operates eight outputs and checks the state of eight inputs. It also checks the state of up to eight microswitches and reads the state of the eight encoders.

Display and Input/Output Circuitry (PC 310)

Display Circuitry

The display circuit is fitted to the cover of the controller housing. This circuit includes push button switches, I/O terminals and LEDs (see Figure 2-6).

Switches:

- The MOTOR on/off switch for DC power to the motors.
- Two INPUT switches connected to inputs 1 and 2; these can be used to simulate inputs.
- The RESET switch resets the controller to its initial state.
- The LAMP TEST switch causes all the LEDs on the panel to light up.
- The MOTOR TEST switch initiates a diagnostic routine on the robot's motors.

Note: The MOTOR switch and INPUT switches 1 and 2 are activated by pressing them (for both on and off). Do not attempt to pull them out.

LEDs:

- A green LED (POWER light) indicates 110 VAC (220 VAC) voltage.
- A green LED (on MOTOR switch) indicates DC voltage to the motors.
- Eight yellow LEDs show whether the inputs are on or off.
- Eight green LEDs show whether the outputs are on or off.

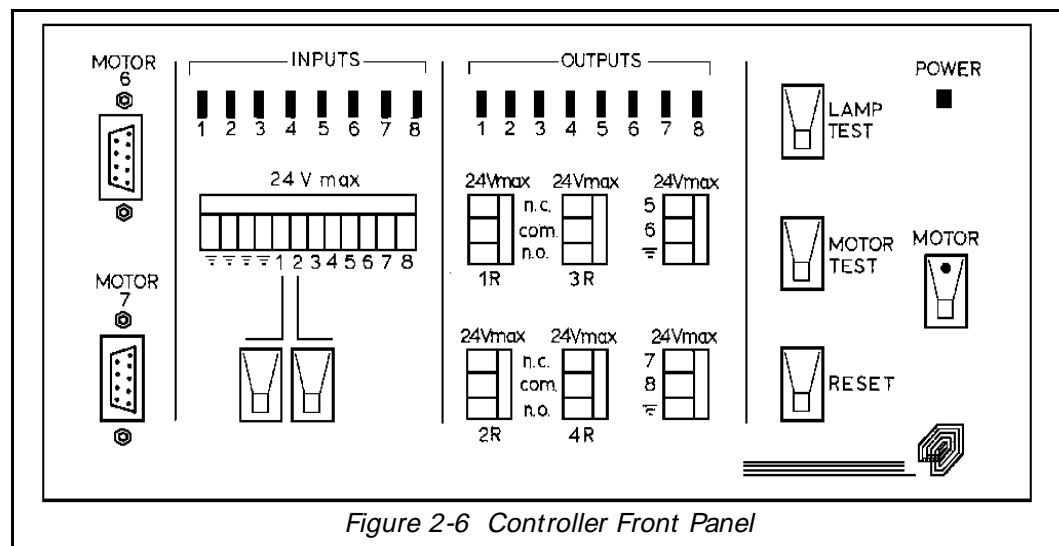
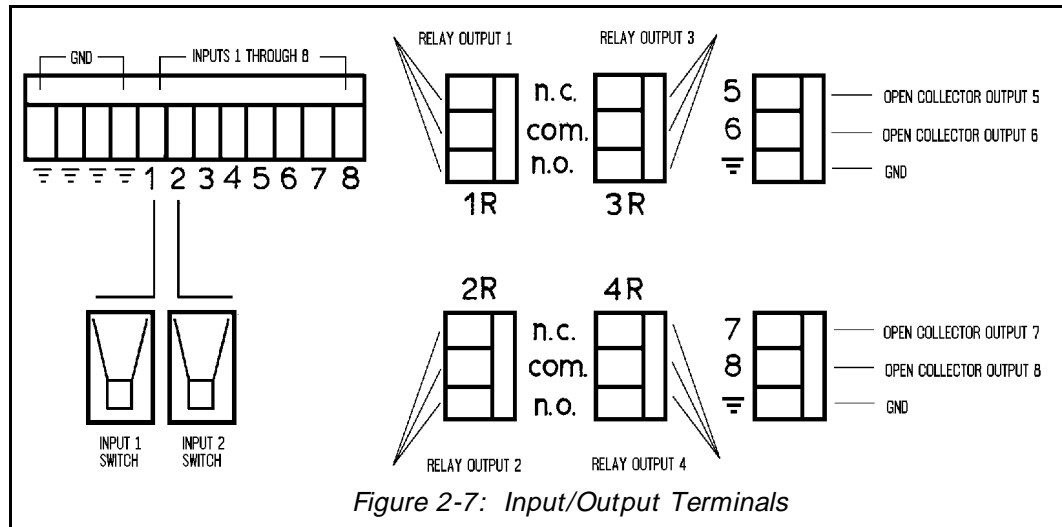


Figure 2-6 Controller Front Panel

I/O Circuitry

Warning! Make sure the controller POWER switch is **off** before you make any connections to the I/O terminals.



Inputs 1–8

Twelve screw terminal connectors are used to connect the eight inputs to the controller. The first four connectors (on the left) are connected to ground. The next eight are connected to the circuitry for inputs 1 through 8.

You can produce input signals in two ways:

- Connect a microswitch to an input terminal and to a ground terminal.
- Connect an external voltage signal to an input terminal and connect the external ground pole to the **SCORBOT-ER III** ground pole.

Voltage and input states are as follows:

- 2.5 V – 24 V Input OFF
- 0 V - 1.5 V Input ON

Outputs 1–4: Relay Outputs

The connectors for the relay outputs are marked 1R through 4R. Each connector contains three terminals:

- COM (common)
- NO (normally open)
- NC (normally closed)

In steady state (before the relay functions), the NO terminal is disconnected from the common line and the NC terminal is shorted to the COM terminal.

When the relay functions, the situation reverses: the NO terminal is shorted to the COM terminal, and the NC terminal is disconnected from the COM terminal.

A maximum current of 4 amp can be switched through a relay output.

Outputs 5–8: Open Collector Outputs

Each open collector output utilizes a single terminal.

An open collector output allows you to determine the external voltage level (+ V) required for the application.

- Maximum Voltage Supply (+ V): 24 V
 - Maximum Current: 0.5 amp.
- But do not drive more than a total of 1.5 amps through outputs 5–8.

Warning! Never connect an open collector output directly to a power supply; it must be connected to a load (such as a resistor, solenoid, relay or motor).

However, you can connect directly to a **SCORBOT** input without an external power supply and load.

See Appendix C for examples of input and output applications.

Motors 6 and 7

The D9 connectors, marked MOTOR 6 and MOTOR 7, are used to connect additional motors for operating mechanical equipment and accessories such as conveyors and rotary tables.

Drive Circuitry: NPN and PNP (PC 200N and PC 200P)

Figure 2-8 shows the circuitry of the power drive card.

The PNP and NPN circuits differ only in the Vcc polarity and the transistor type.

Power Supply Circuitry (PC 410)

Figure 2-9 shows the circuitry of the power supply card.

The power supply contains five different DC power supplies:

- + 15V, 4A, unregulated, supplies power to the robot motors.
- –15V, 4A, unregulated, supplies power to the robot motors.
- + 12V, 0.4A, regulated, supplies power to the I/O circuitry outputs, and to the RS232 communications.

- -12V, 0.4A, regulated, supplies power to the RS232 communications.
- + 5V, 1.5A, regulated, supplies power to the microprocessor, the memory and the logic in the control circuit.

The three regulated power supplies also feed the teach pendant's circuitry.

Warning! Never connect the ground of the motor power supply and the ground of the other power supplies to each other.

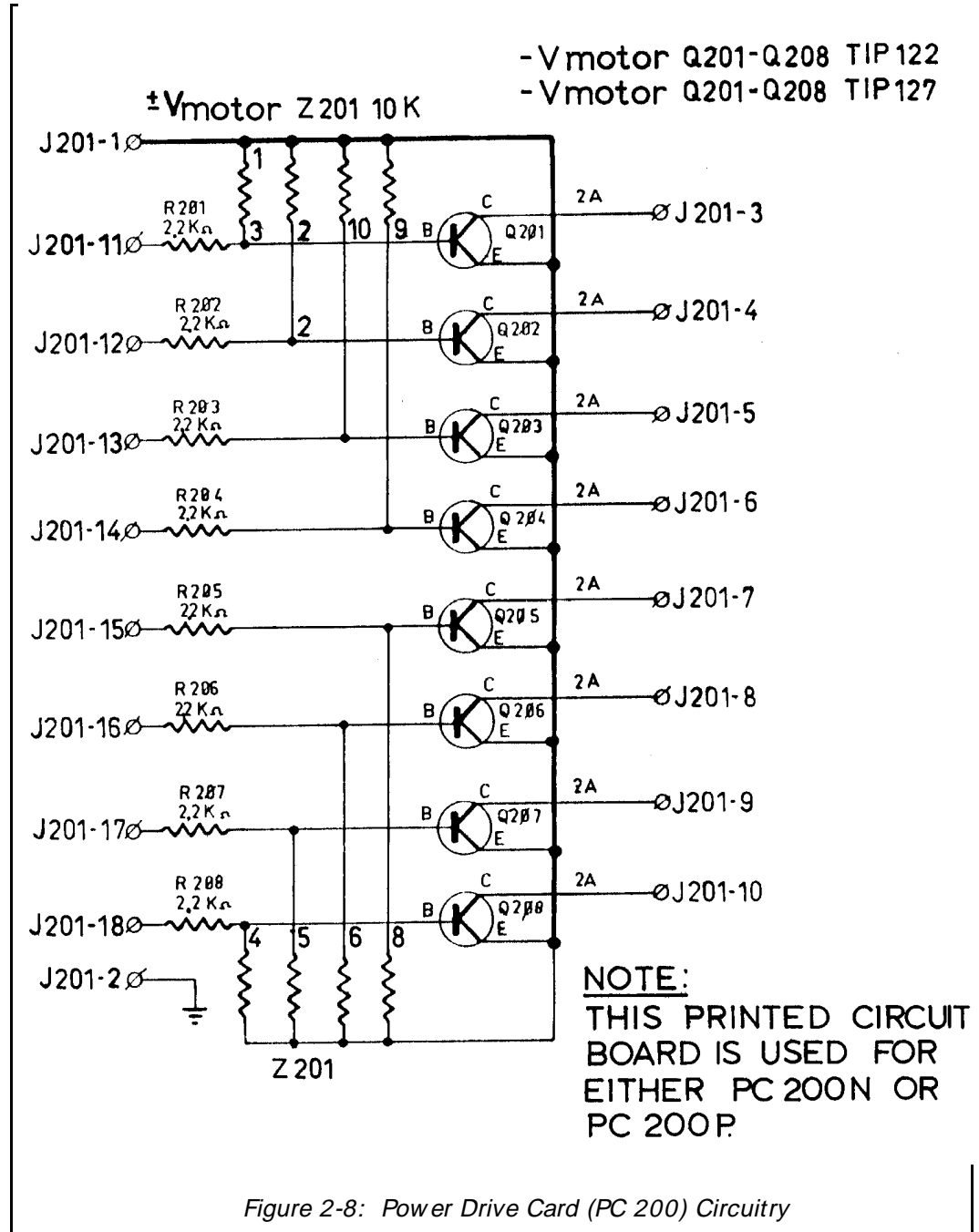


Figure 2-8: Power Drive Card (PC 200) Circuitry

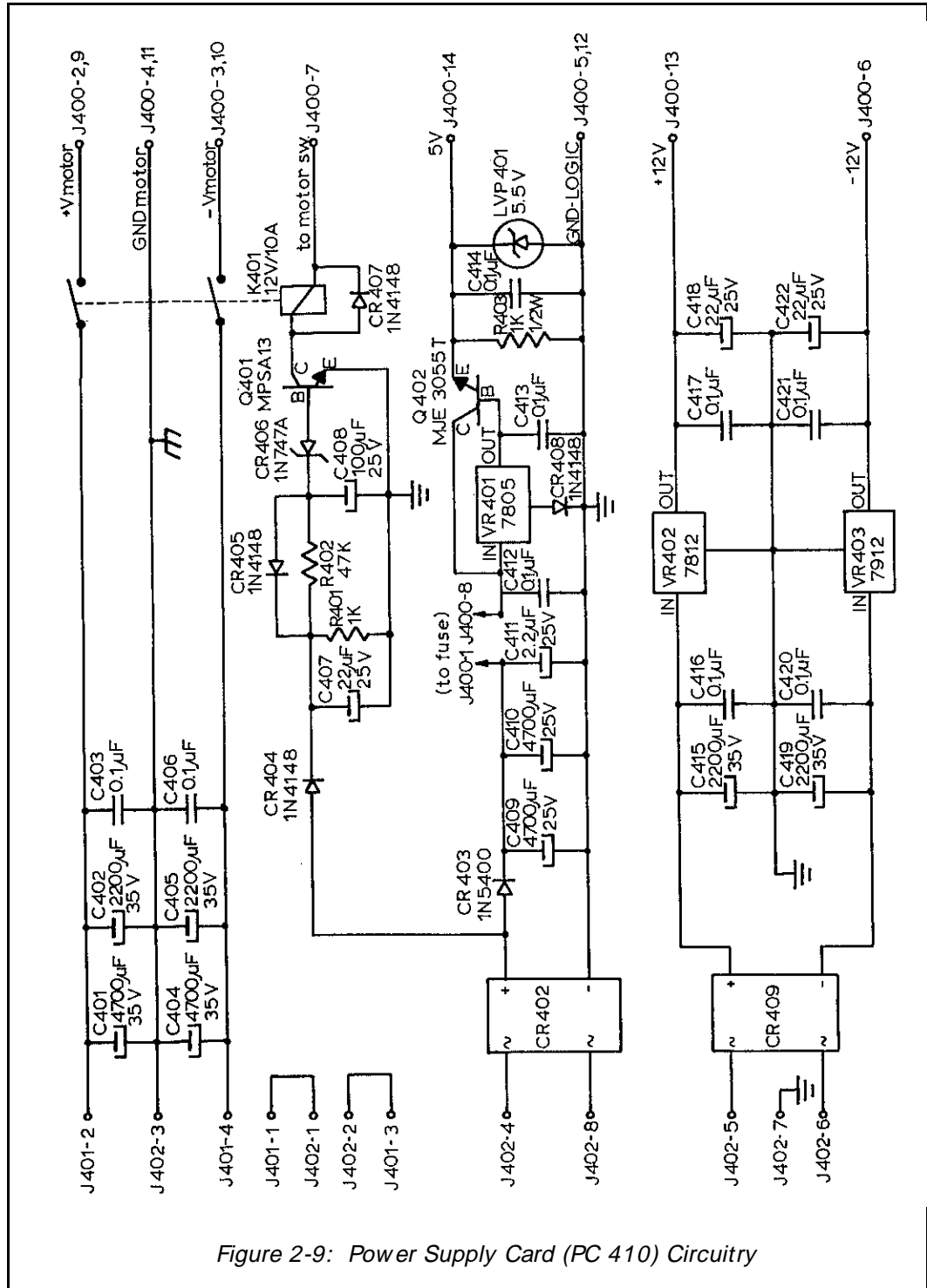


Figure 2-9: Power Supply Card (PC 410) Circuitry

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Installation

Before proceeding with the installation of **SCORBOT-ER III**, familiarize yourself with the safety instructions and warnings detailed in Chapter 1.

Connecting the Equipment

Place the arm, controller and computer on an ample and sturdy work surface. (Note that the computer/terminal is not supplied with the **SCORBOT-ER III**.)

Installing the Robot

To prevent the robot from toppling over during operation, fasten the base of the robot arm to the work surface with at least three bolts, 120° apart, as shown in Figure 2-1.

After you have bolted **SCORBOT-ER III** to the table, you may connect the robot to the controller.

Robot Base \varnothing 240 mm (9.49")
 Pitch Circle \varnothing 207 mm (8.15")
 Hole (6 off) \varnothing 8.5 mm (0.33")

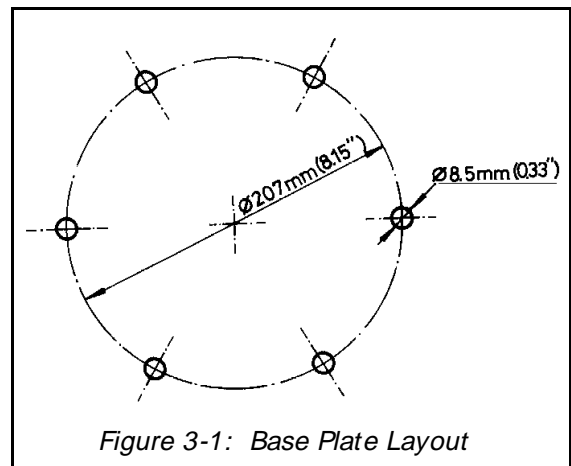
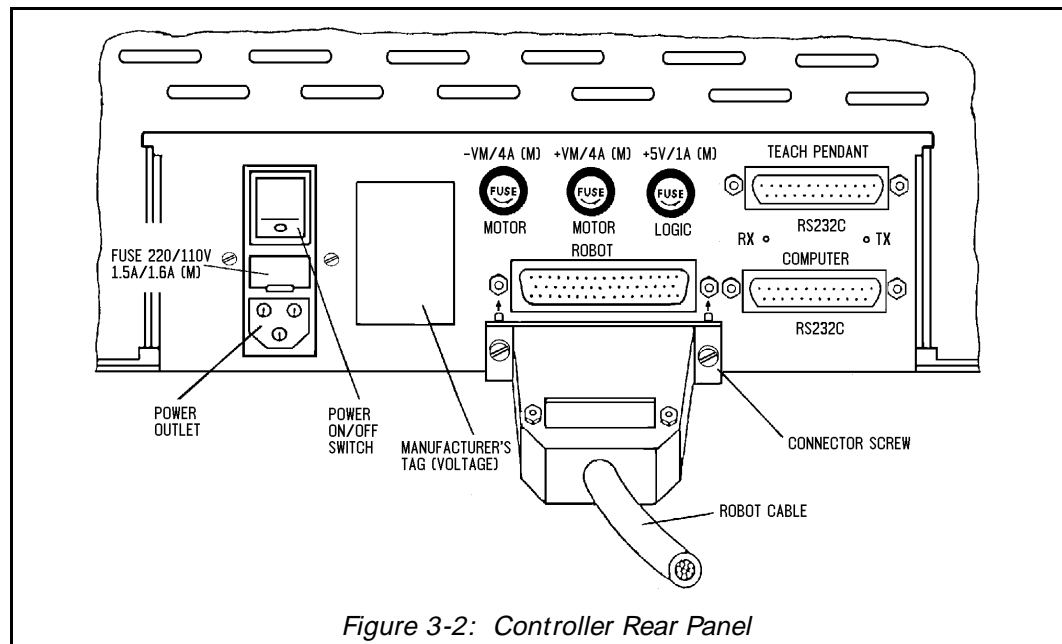


Figure 3-1: Base Plate Layout

Connecting the Robot to the Controller

1. Connect the D50 connector on the robot cable to the port marked ROBOT on the rear panel of the controller (see Figure 3-2).
2. Gently insert the two screws on the connector into the threads on the controller port. Tighten the screws just enough to keep the connector securely fastened.
3. Make sure the voltage requirement of the controller matches your power supply voltage. Make sure the POWER switch is **off**. Then plug the power cable first into the controller power port, and then into the power outlet.

Note: The power cable is a standard cable. Controllers with 220V operating voltage have a cable with a European plug. Controllers with 110V operating voltage have an American plug. If you need to alter the plug provided, make sure your connections are correct. Note that the colors of the leads in the cables are in accordance with international standards.



Connecting the Computer to the Controller

1. Make sure the power to your computer is **off**.
2. Set up your computer in your standard configuration.
 - If you are using the computer as COM1, set the RS232 card DIP switch as shown in Figure 3-3.
 - If you are using the computer as COM2, or if you are using any other type of computer, see Appendix B for additional instructions.

3. Connect the RS232 cable from the lower port, marked COMPUTER, on the rear of the controller to the RS232 port on the computer.
4. Connect the computer power cable to an AC power source.

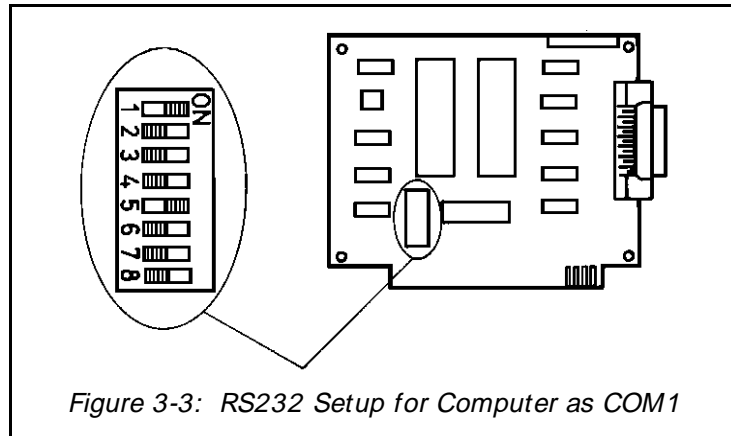


Figure 3-3: RS232 Setup for Computer as COM1

Testing the Controller Display Panel

1. Press on the POWER switch, on the rear of the controller. The power LED on the controller front panel will light up.
2. Press on the MOTOR switch, on the controller front panel. The LED in the MOTOR switch will light up.
3. Press the LAMP TEST switch; all the LEDs on the panel will light up. Release the switch; all the LEDs (except POWER and MOTOR) will go off.
4. Press on the INPUT 1 switch. The LED for Input 1 will light up.
5. Press on the INPUT 2 switch. The LED for Input 2 will light up.

Testing the Motors

1. To begin the Motor Test, the robot should be in a position similar to that shown in Figure 3-4. Initiating the test from an unsuitable position could, for example, cause the robot to knock into the work surface and result in damage to the robot.

Bring the robot arm into a proper position by one of the following means:

- Gently force the links of the robot arm into a suitable position. To do this you must first turn off the MOTOR and POWER switches.
- It is preferable that you use either the computer keyboard or the teach pendant to move the robot arm. To do this, you must first connect the robot to a computer in which **SCORBASE** is loaded, and follow the instructions for manual axis movement given in Chapters 4 and 5.

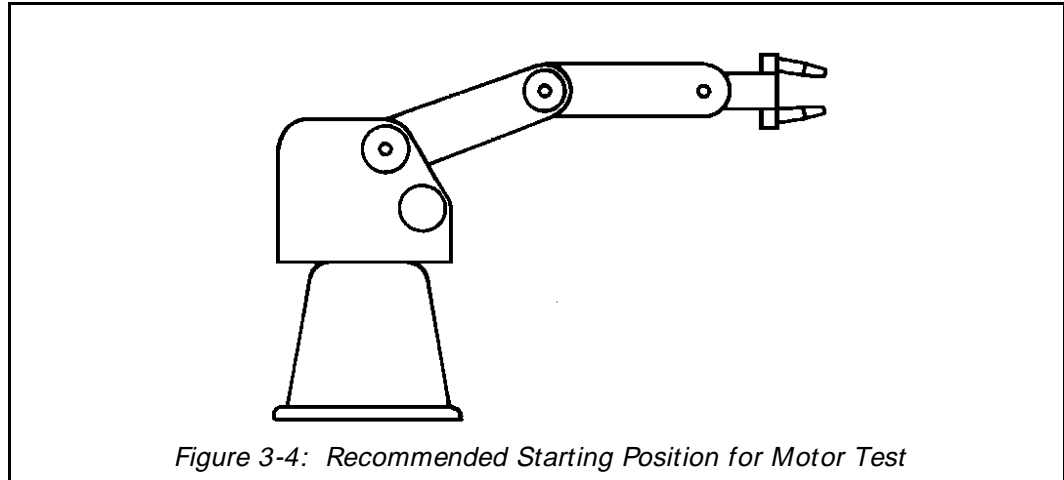


Figure 3-4: Recommended Starting Position for Motor Test

2. Once the robot is in a suitable position, turn on the POWER and the MOTOR switches. The POWER and the MOTOR LEDs on the controller front panel will light up.

Warning! Proceed with care! The controller is now in the MOTORS ON state and is supplying voltage to the motors.

3. Press the button marked MOTOR TEST.

As long as you press the button, the motors will rotate briefly, one after another, in one direction and then in the other. If a motor fails to rotate or is missing, the test will simply skip to the next motor.

After the wrist roll movement has been executed, the controller will attempt to activate motor 6 and motor 7. If no motors are found at these locations, the controller will then activate motor 8 (the gripper).

The motor test continues until you release the MOTOR TEST button. Press the MOTOR TEST button again to continue the test from the point where it was interrupted. Press the RESET button and then MOTOR TEST to restart the test at motor 1.

Note: The Motor Test does not prove the gripper motor is functioning perfectly, only that the motor rotates. Use the **SCORBASE** Level 3 command, Set Memory to Sensor (which utilizes the gripper's measuring capability) to test gripper operation.

CHAPTER 4

Operation

SCORBASE Software

SCORBASE software lets you program and operate the **SCORBOT-ER III**.

The **SCORBOT-ER III** system is supplied with **SCORBASE** Levels 1, 2 and 3. Each level offers increasingly more features and is designed to match the student's progress in learning to program and operate the robot. This chapter presents and explains the first three levels of **SCORBASE**.

SCORBASE Level 4 is provided with the teach pendant. Level 4 enables the transfer of programs between the teach pendant and the computer, and the listing of programs and positions. See Chapter 5.

SCORBASE Level 5 contains almost all the features available in Levels 1, 2 and 3, as well as more advanced features.

Loading SCORBASE

To load any level of **SCORBASE**, do the following steps:

1. Turn on the controller power supply (always do so before loading **SCORBASE**).
2. Turn on the controller MOTOR switch.
3. Turn on your display screen.
Turn on your computer, and boot using your DOS diskette.
4. When the cursor prompt is displayed, insert the **SCORBASE** diskette and type:
`GO <Enter>` or, depending on the level you want to activate:

```

SCOR1 <Enter>
SCOR2 <Enter>
SCOR3 <Enter>

```

The following message will appear on your screen:

```

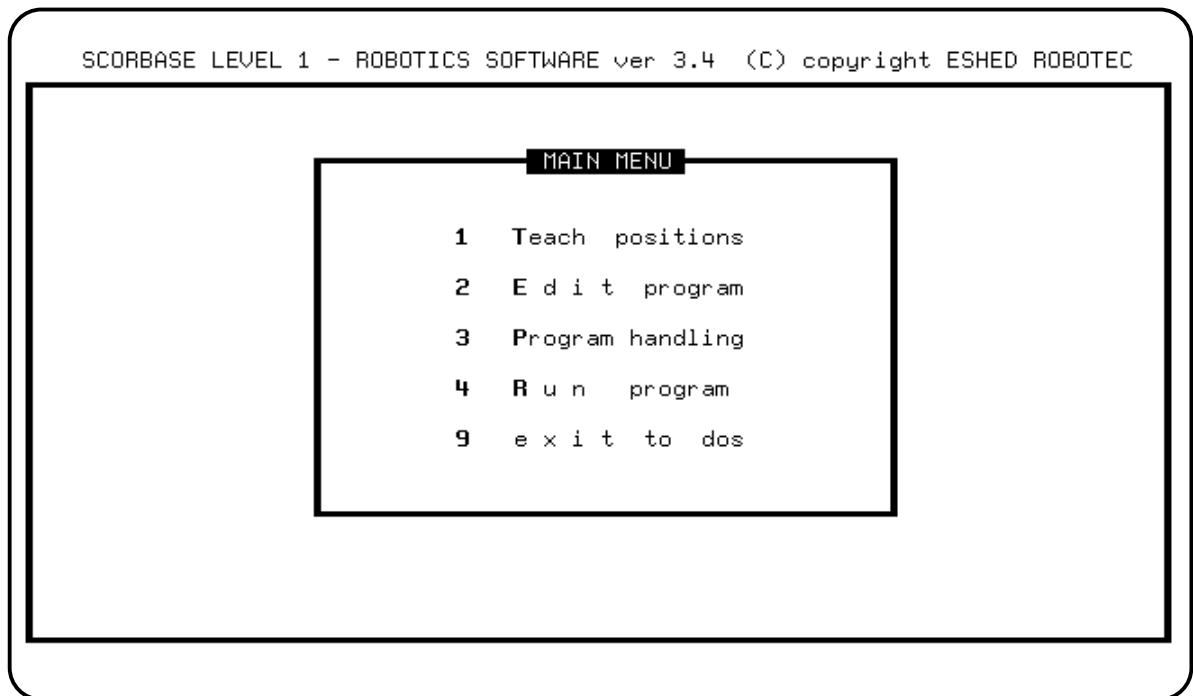
SCORBASE LEVEL # IS LOADED

```

The Main Menu will then appear on your screen.

SCORBASE Level 1

MAIN MENU



To select any of the options, press the number or the first letter of the function you want to activate. For example, press 3 or P to activate the Program Handling module. However, Exit to DOS can be activated only by pressing 9.

1 Teach Positions

This module lets you manipulate the robot and teach the robot positions.

2 Edit Program

This module lets you write and edit your robot programs.

3 Program Handling

This module lets you save programs on a disk(ette), and to load or delete them.

4 Run Program

This module lets you run a program which exists in the computer memory.

9 Exit to DOS

Press 9 to exit to DOS. **SCORBASE** will prompt you to confirm:

```
ARE YOU SURE? (Y/N)? N
```

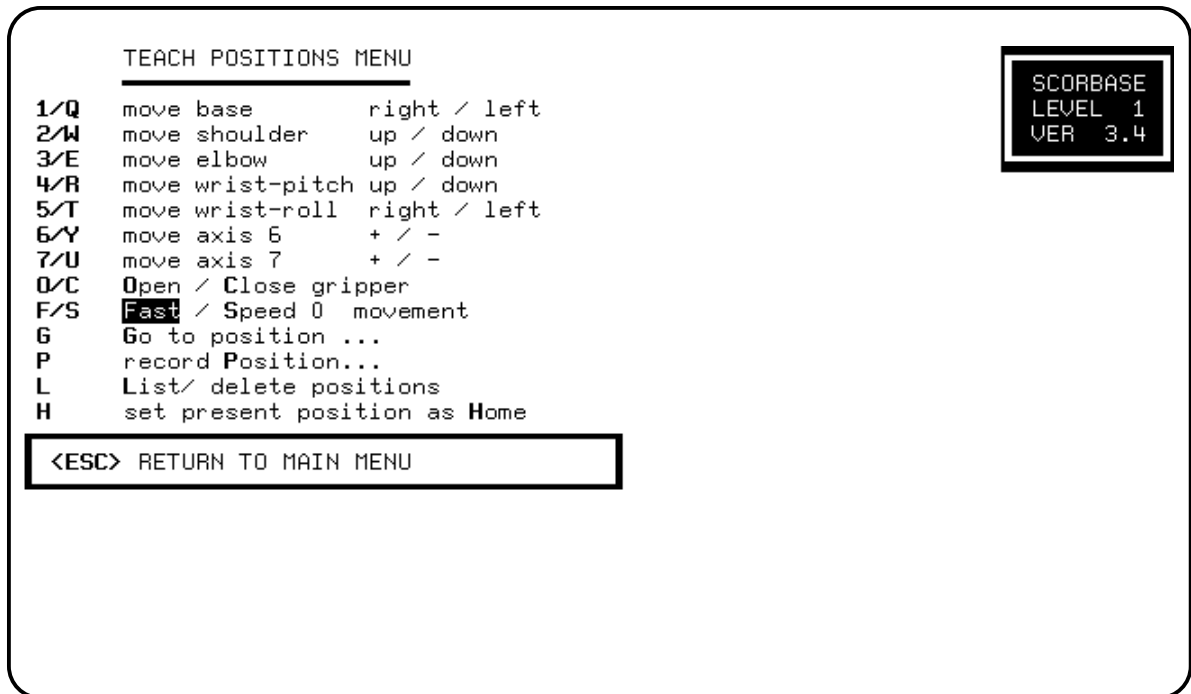
If changes to the program have been made but not yet saved, the following message will also flash on the screen:

```
WARNING !! CHANGES NOT SAVED
```

Press Y to exit to DOS. Press any other key to cancel.

TEACH POSITIONS MENU

This screen allows you to move the robot, and to teach and define positions.



The following pairs of number and letter keys are used to directly control the movement of the servo axes. The axes will continue to move as long as the activating key is depressed.

1/Q **move base** **right / left**

Robot base moves right and left.

2/W **move shoulder** **up / down**

Shoulder moves up and down.

3/E **move elbow** **up / down**

Elbow moves up and down.

4/R **move wrist-pitch** **up / down**

Wrist moves up and down.

5/T **move wrist roll** **right / left**

Wrist moves right and left.

6/Y **move axis 6** + / -

Axis no. 6 moves forward and backward.

7/U **move axis 7** + / -

Axis no. 7 moves forward and backward.

O/C **Open / Close gripper**

These commands open and close the gripper.

Press O to open the gripper.

Press C to close the gripper.

F/S **Fast / Speed 0 movement**

These commands set the speed for manual robot movement.

Press F to set the fastest speed of axis movement.

Press S, and then enter any speed from 1 (the slowest) to 9.

G **Go to position . . .**

This command sends the robot to a previously recorded position.

Press G to receive the prompt:

GO POSITION . . .

Then enter the position number. If you enter a position number which has not been recorded, a message will appear:

POSITION IS EMPTY

P **record Position . . .**

The Record Position command records the current location of the robot and peripheral axes.

Press P to receive the prompt:

RECORD POSITION (1-100) . . .

Then enter the position number you want to assign to the current location of the robot and peripheral axes. If you simply press <Enter> , **SCORBASE** will automatically enter the next sequential position number. You can record up to 100 positions.

L **List/ delete positions**

Press L to activate the List / Delete Positions screen.

H set present position as Home

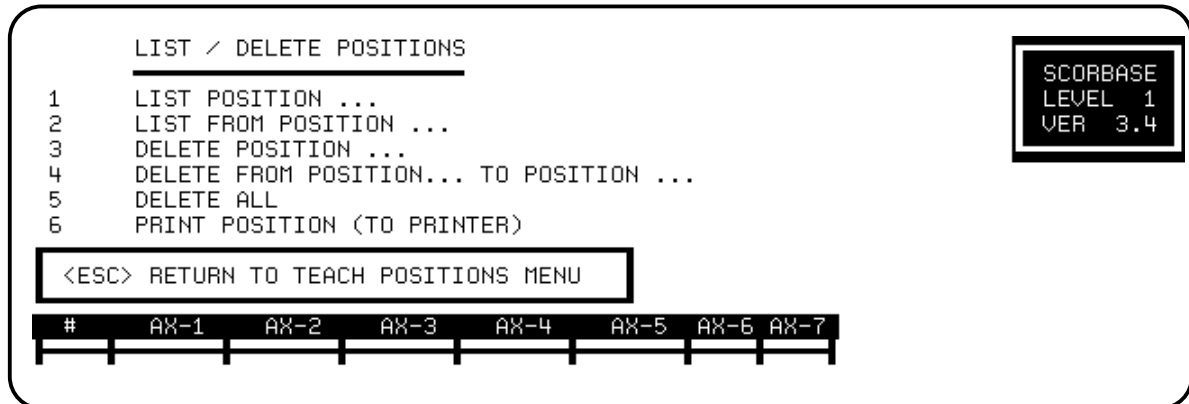
Press H to set the current position of the axes as the new home position.

Warning! This command automatically alters the physical location of all recorded positions. Changing the home position may therefore invalidate other recorded positions.

< ESC > RETURN TO MAIN MENU

LIST / DELETE POSITIONS SCREEN

This screen allows you to display, delete and print the positions you have recorded. To activate this screen, select the L option in the Teach Positions menu.



1 LIST POSITION . . .

This command displays the coordinates of the robot axes at the specified position.

Press 1 and enter the number of a position.

2 LIST FROM POSITION . . .

This command displays a listing of the coordinates of all positions, beginning with the specified position.

Press 2 and enter the number of a position.

If there are more positions listed than can be displayed in one screen, the system will pause and prompt you:

```
PRESS <ESC> TO EXIT LISTING / ANY OTHER KEY TO CONTINUE
```

Press < Enter> to move the display down one line.

Press any other key to move the display down one screen.

3 DELETE POSITION . . .

This command deletes the specified position.

Press 3 and enter the number of a position.

Note that you will be prompted to confirm whenever you give the command to delete a position:

```
ARE YOU SURE(Y/N)? N
```

4 DELETE FROM POSITION . . . TO POSITION . . .

This command deletes all points from the first position specified through the second position specified.

Press 4 and enter two position numbers.

5 DELETE ALL

Press 5 to delete all recorded positions from controller memory.

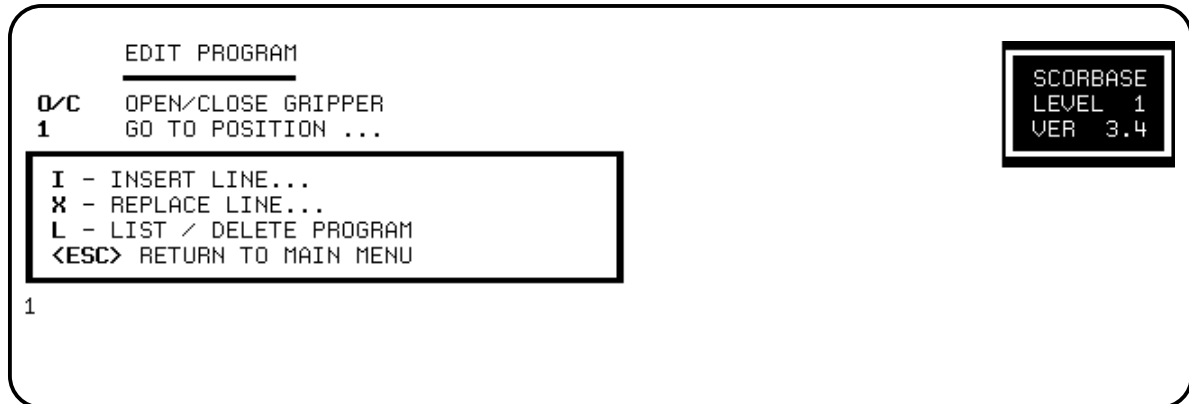
6 PRINT POSITION (TO PRINTER)

Press 6 to print out a listing of all recorded positions.

< ESC > RETURN TO TEACH POSITIONS MENU

EDIT PROGRAM MENU

This screen allows you to write and edit your robotic programs. **SCORBASE** automatically assigns numbers to your program lines.



O/C OPEN/CLOSE GRIPPER

These commands open and close the gripper.

Press O to open the gripper.

Press C to close the gripper.

1 GO TO POSITION . . .

This command sends the robot to a recorded position.

Press 1 and enter the position number.

I INSERT LINE . . .

This command allows you to insert lines into a program.

Press I. At the prompt, enter the number of the line at which you want to insert another command. Then type and enter the additional command line or lines.

Press < Enter> a second time to exit the insert mode. **SCORBASE** then displays the next available program line.

When program lines are inserted, all line numbers are automatically updated.

X REPLACE LINE . . .

This command lets you replace an existing command line with another command.

Press X. At the prompt, enter the number of the command line you want to replace. The command line is displayed and you are prompted for another command. Pressing < Enter> without a new command leaves the original line unchanged.

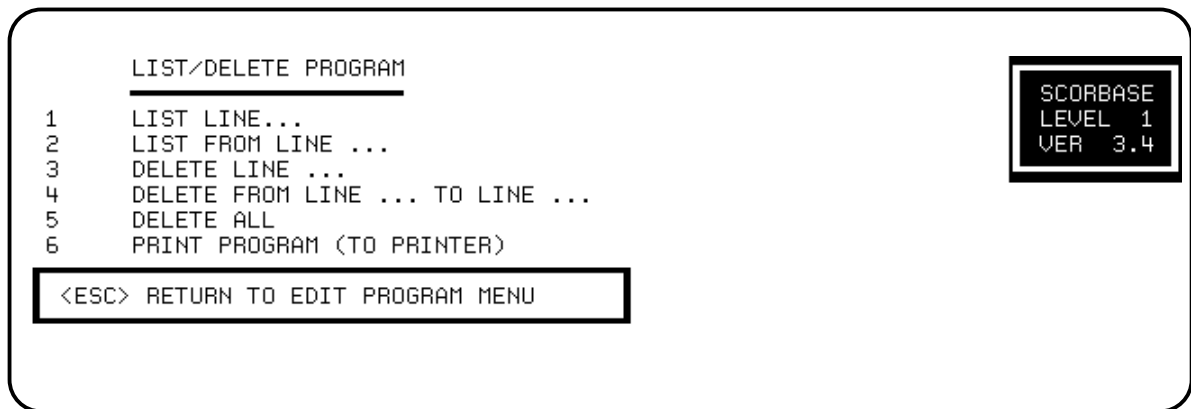
L LIST / DELETE PROGRAM

Press L to activate the List / Delete Program screen.

< ESC > RETURN TO MAIN MENU

LIST / DELETE PROGRAM SCREEN

This screen allows you to display, delete and print the programs you have written. It is similar to the List/Delete Position screen called from the Teach Positions menu. To activate this screen, press L from the Edit Program menu.



1 LIST LINE . . .

This command displays the specified program line.

Press 1 and enter the number of a program line.

2 LIST FROM LINE . . .

This command displays all program lines beginning with the line specified.

Press 2 and enter the number of a program line.

If there are more lines than can be displayed in one screen, the system will pause and prompt you:

```
PRESS <ESC> TO EXIT LISTING / ANY OTHER KEY TO CONTINUE
```

Press < Enter to move the display down one line.

Press any other key to move the display down one screen.

3 DELETE LINE . . .

This command deletes the specified line from the program.

Press 3 and enter the number of a program line.

Note that whenever you give the command to delete a line or lines, **SCORBASE** displays the line/s, and prompts you to confirm:

```
ARE YOU SURE(Y/N)? N
```

4 DELETE FROM LINE . . . TO LINE . . .

This command deletes all program lines from the first line specified through the second line specified.

Press 4 and enter two program line numbers.

5 DELETE ALL

Press 5 to delete the entire program from the controller memory.

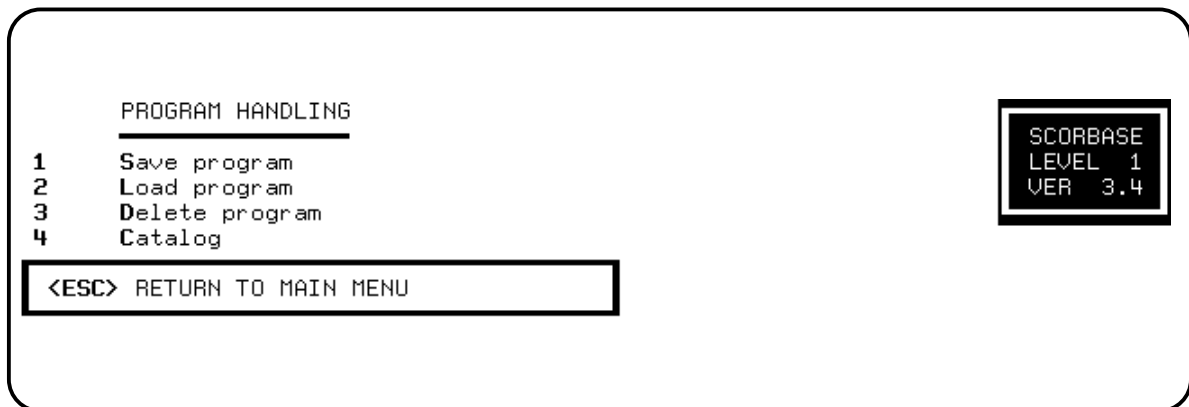
6 PRINT PROGRAM (TO PRINTER)

Press 6 to print out a listing of all program lines.

< ESC > RETURN TO EDIT PROGRAM MENU

PROGRAM HANDLING MENU

This screen allows you to delete programs and to transfer (load and save) programs between the computer memory and disk(ette).



1 Save Program

This option lets you save on disk(ette) the program you have created.

Press 1 or S. At the prompt, type the name you want to assign to the program you have created, and press < Enter> . The program is now saved on disk(ette).

When you type a program name, do not use more than 8 characters, and do not use a number for the first character of the file name.

Do not use an extension. All programs saved by **SCORBASE** are automatically assigned extensions corresponding to the level in which they were created. For example, DEMO.L1 indicates that the program DEMO was created in **SCORBASE** Level 1.

2 Load Program

This option lets you call up a program from the disk(ette) to the computer memory.

Press 2 or L, and enter the program name.

When loading a program which was created in the level in which you are operating, you need only to type the program name.

You may have programs with similar names which were written in different levels; for example, JACK.L1, JACK.L2 and JACK.L3. When loading a program which was created in a level other than the one in which you are operating, indicate the level as shown in the examples below:

2DEMO will load DEMO.L2 in another other level.

1DEMO will load DEMO.L1 in any other level.

3 Delete Program

This option allows you to delete a program from the diskette).

Press 3 or D, and enter the program name.

To delete a program, you must be operating in the level in which the program was created. For example, to delete program TOP.L3, you must be working in **SCORBASE** Level 3.

Note that whenever you give the command to delete a program, **SCORBASE** prompts you to confirm:

```
ARE YOU SURE(Y/N)? N
```

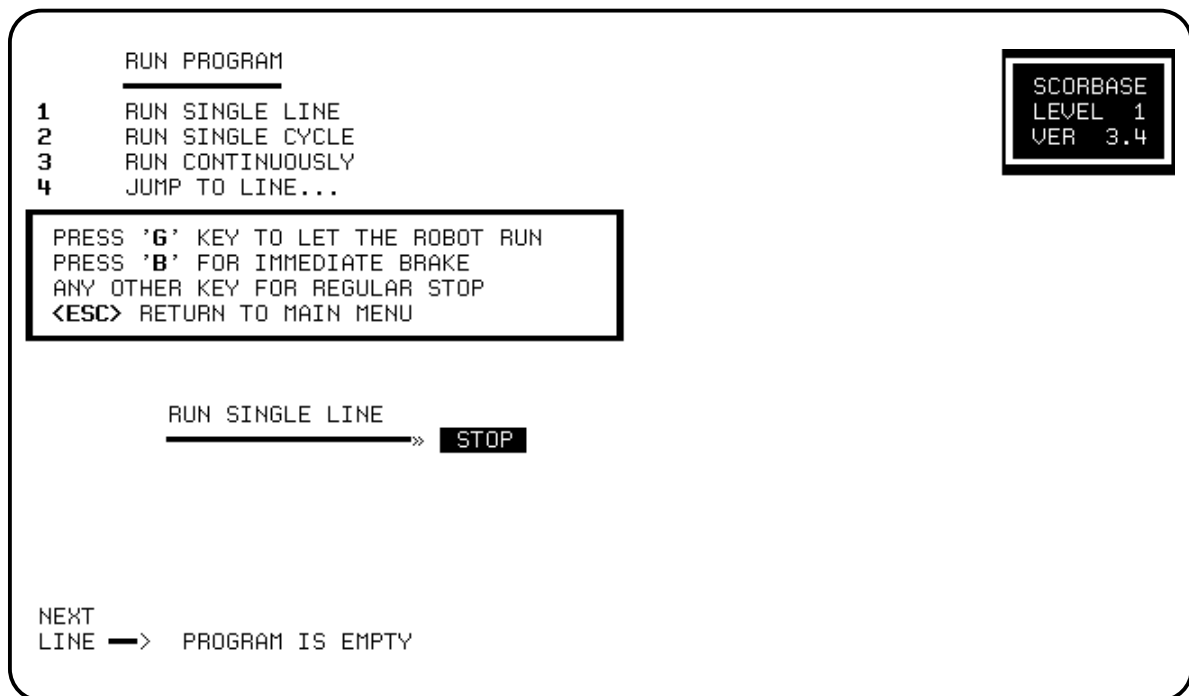
4 Catalog

Press 4 or C to display a listing of all the programs which have been saved on the diskette).

< ESC> RETURN TO MAIN MENU.

RUN PROGRAM MENU

This screen lets you run the programs you have created.



1 RUN SINGLE LINE

Press 1 and press G.

One program line (the current line) is executed each time you press G.

2 RUN SINGLE CYCLE

Press 2 and press G.

The program is executed from the NEXT LINE command to the end of the program.

3 RUN CONTINUOUSLY

Press 3 and press G.

The entire program is executed repeatedly. When it reaches the last line it automatically jumps to the first line and continues.

4 JUMP TO LINE . . .

Press 4 and enter the number of a program line. Press G to begin running the program from that line.

PRESS 'G' TO LET ROBOT RUN

You must press G to begin or restart the running of a program.

PRESS 'B' FOR IMMEDIATE BRAKE

Press B to apply an emergency brake at any time.

No loss of information will occur, and the following message is displayed:

PRESS C TO CONTINUE

PRESS M TO RETURN TO MENU

Press C to restart the program from the line at which it was stopped.

Press M to allow the activation of any other command. You can now go to another menu, or continue running the program.

ANY OTHER KEY FOR REGULAR STOP

Press any key (other than B) to halt the robot as soon as it completes execution of the current command.

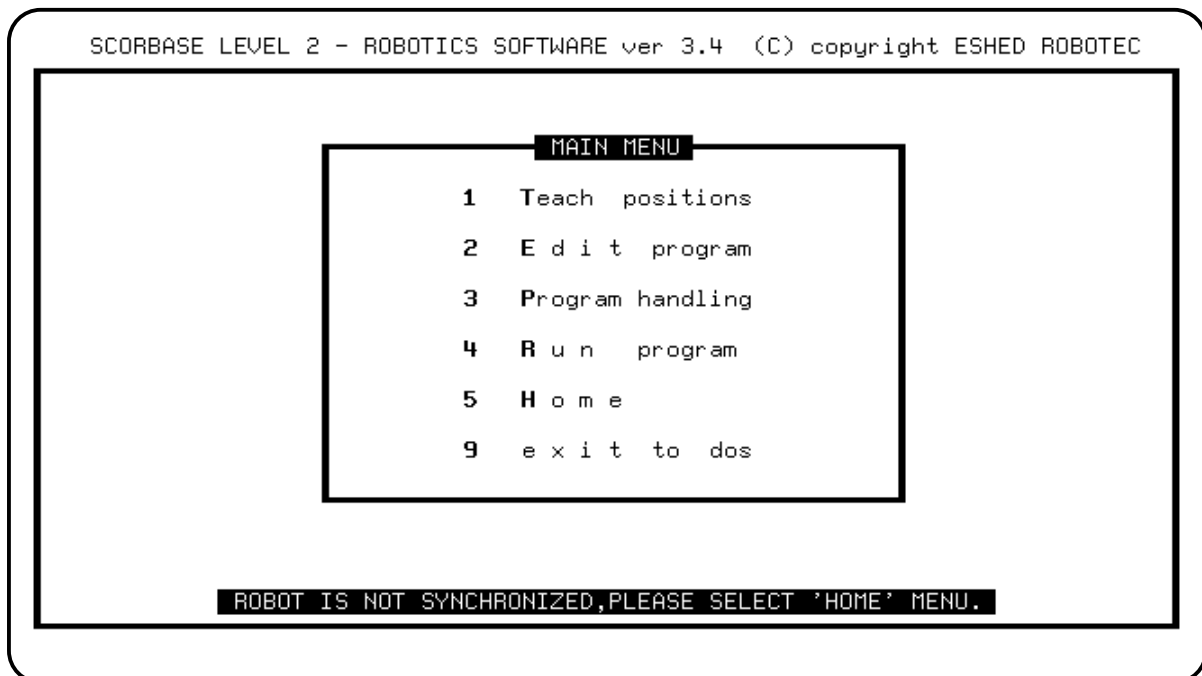
< **ESC** > **RETURN TO MAIN MENU**

SCORBASE Level 2

This section describes only the additional options offered by **SCORBASE** Level 2. Refer to the section, “**SCORBASE** Level 1,” for descriptions of all other options.

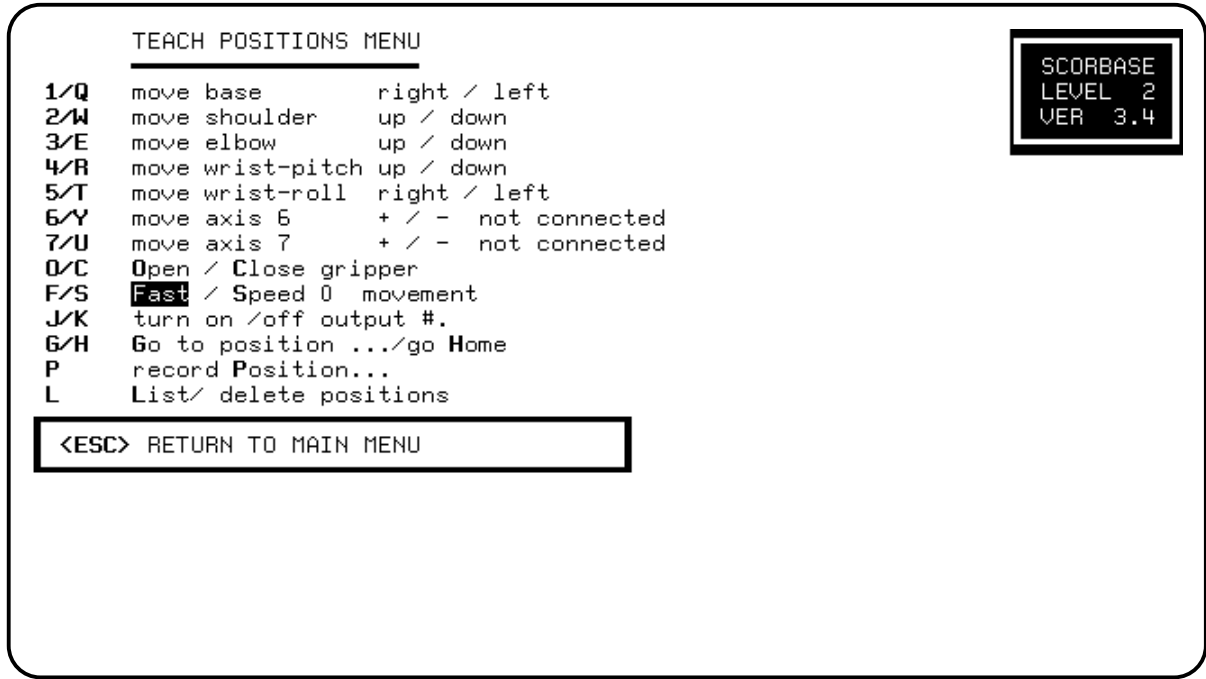
MAIN MENU

The Main Menu now allows you to activate a module for homing the robot and configuring and homing the peripheral equipment. Use the Home option to home the robot at the beginning of each working session.



TEACH POSITIONS MENU

All commands in this screen are the same as those in Level 1 with the following additions:



J/K turn on /off output

These commands activate and deactivate the controller outputs.

Press J to turn on an output.

Press K to turn off an output.

At the # prompt enter a specific output number.

G/H Go to position . . . /go Home

Press G to send the robot to a previously recorded position.

Press H to send the robot to the Home position.

LIST / DELETE POSITIONS SCREEN

All commands in this screen are identical to those found in Level 1.

EDIT PROGRAM MENU

All commands in this screen are the same as those in Level 1 with the following additions:

```

EDIT PROGRAM
O/C  OPEN/CLOSE GRIPPER
1    GO TO POSITION ... FAST/SPEED #.
2    WAIT ... SECONDS
3    IF INPUT #. JUMP TO ...
4/R  TURN ON/OFF OUTPUT #.
5    JUMP TO LINE #...

I - INSERT LINE...
X - REPLACE LINE...
L - LIST / DELETE PROGRAM
<ESC> RETURN TO MAIN MENU
1

```

1 GO TO POSITION ... FAST/SPEED

This command sends the robot to a recorded position at the specified speed.

Press 1. At the # prompt enter a position number. If you press < Enter> instead of specifying a position, **SCORBASE** automatically enters the next sequential position number.

You are then prompted for a speed. Press < Enter> or F to accept the fastest speed. Or, press S and enter a number from 1 (slowest speed) to 9 .

2 WAIT ... SECONDS

This command halts the program execution for the specified time.

Press 2. At the prompt enter the number of seconds you want the program to delay.

3 IF INPUT #. JUMP TO ...

This command causes the program to jump to the specified line if the tested input is on.

Press 3. At the # prompt enter the number of an input, from 1 to 8. At the next prompt enter the number of the line to which the program will jump.

4/R TURN ON/OFF OUTPUT #.

These commands activate and deactivate the controller outputs.

Press 4 to turn on an output.

Press R to turn off an output.

At the # prompt enter a specific output number.

5 JUMP TO LINE #...

This command causes the program to jump to the specified line.

Press 5. Then enter the number of the line to which the program will jump.

LIST / DELETE PROGRAM SCREEN

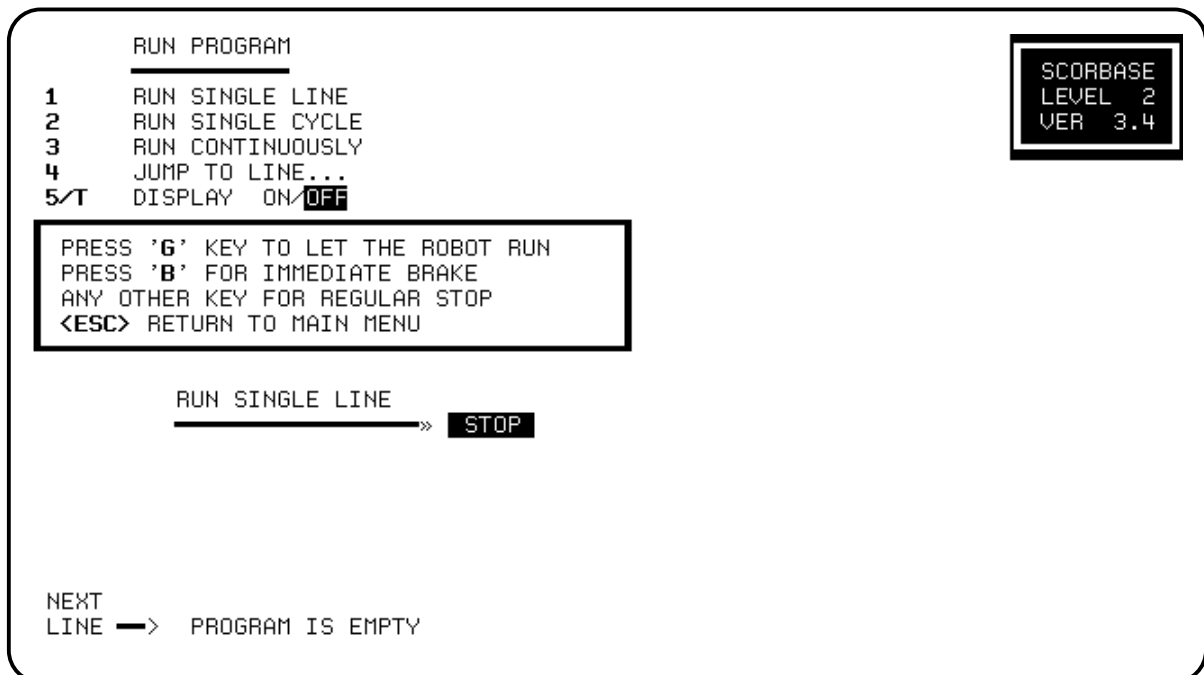
All commands in this screen are identical to those found in Level 1.

PROGRAM HANDLING MENU

All commands in this screen are identical to those found in Level 1.

RUN PROGRAM MENU

All commands in this screen are identical to those found in Level 1, with the following addition:

**5/T DISPLAY ON/ **OFF****

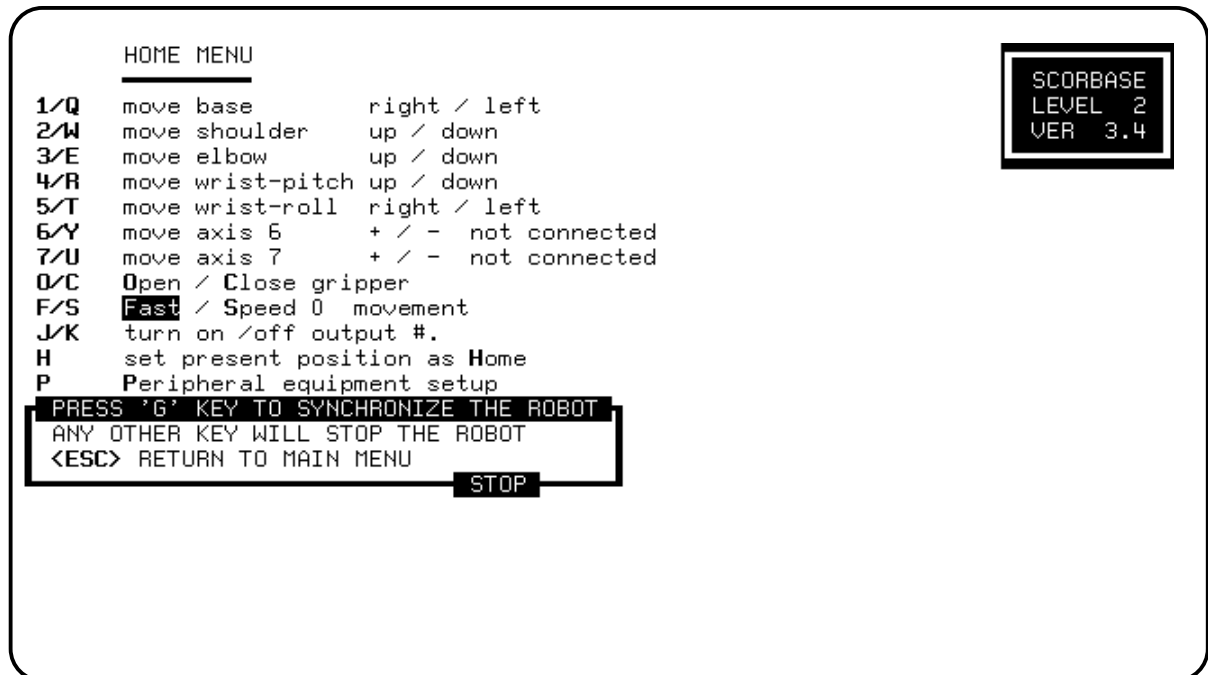
Press 5 to display the program lines during program execution.

Press T to turn off the display during program execution.

HOME MENU

This screen is used for configuring and homing the robot and peripheral equipment.

Many of the commands in the Home screen are identical to those found in the Teach Positions screen. The additional features are as follows:



PRESS 'G' KEY TO SYNCHRONIZE THE ROBOT

The **SCORBOT** should be homed each time the controller is turned on.

Press G to perform the hard (fixed) home search.

During the homing procedure, each joint is moved until its microswitch is depressed (closed). **SCORBASE** displays messages stating whether each of the joints has reached its fixed home position. If a joint does not reach its home location, the program will automatically execute the home search once more for that joint.

If the homing is not fully successful, the following message is displayed:

```
ROBOT IS NOT AT HOME !
```

When the robot has reached its hard home position, the following message is displayed:

```
HOMING COMPLETED
```

Figure 4-1 shows the hard home position of the robot.

Press any key to stop the homing while the operation is in progress. Press G again to restart the homing procedure.

P Peripheral equipment setup

The homing of axes 6 and 7 depends upon the peripheral equipment you have connected. Press P to define the peripheral equipment. You are then prompted:

AXIS 6/7

Press the number of the axis you have connected, for example, 6. You are then prompted:

AXIS 6 is connected to
Slidebase/Rotary-table/Conveyor/Not connected

Press S, R, C or N according to the connected equipment. The homing procedure for the peripheral equipment is as follows:

Slidebase:	The slidebase is moved to one side until it cannot move any further.
Rotary-table:	Search for a microswitch is performed.
Conveyor:	No search is performed.
Not connected:	No search is performed.

H set present position as Home

This is the same command as in the Teach Positions menu in **SCORBASE** Level 1.

Press H to set the current position as the new home position.

Warning! This command automatically alters the physical location of all recorded positions. Changing the home position may therefore invalidate other recorded positions.

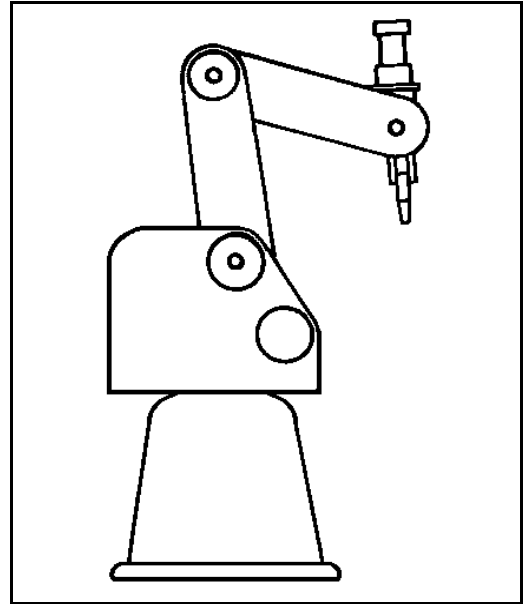


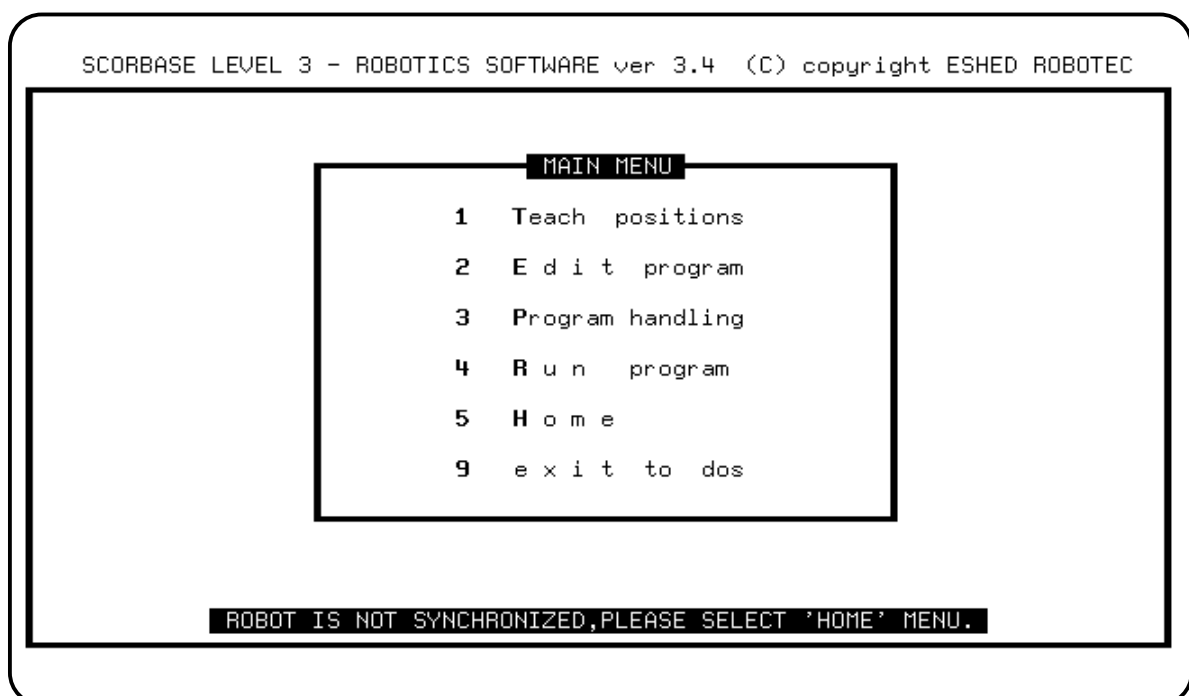
Figure 4-1: Hard Home Position

SCORBASE Level 3

SCORBASE Level 3 offers all programming and operating options available in SCORBASE Levels 1 and 2 and many additional features. This section describes all the options available in SCORBASE Level 3, including those found in preceding levels.

MAIN MENU

Once SCORBASE Level 3 has been loaded, the Main Menu screen is displayed.



To select an option, press either the number or the first letter of the function you want to activate. For example, press either 1 or T to activate the Teach Positions menu. Exit to DOS can only be activated by pressing 9.

1 Teach positions

This module allows you to control the robot movements directly and teach the robot positions. Note that movement instructions and the recording of positions are performed in the PC RAM.

2 Edit program

This module lets you write and edit your robot programs. The programs are created by SCORBASE and maintained in the PC RAM.

3 Program handling

This module lets you to save and load programs to and from disk(ette) and to delete them.

4 Run program

This module lets you run a program which exists in the computer memory.

5 Home

This module enables you to home the robot, and configure and home the peripheral equipment. Since the **SCORBOT** should be homed each time the controller is turned on, begin each working session by first activating the Home screen and performing the necessary operations.

Note that at the bottom of the Main Menu screen you may see the message:

```
ROBOT IS NOT SYNCHRONIZED, PLEASE SELECT 'HOME' MENU.
```

This message is displayed until the robot is successfully homed.

9 exit to dos

Press 9 to exit to DOS. **SCORBASE** will prompt you to confirm:

```
ARE YOU SURE (Y/N)? N
```

If changes to the program have been made but not yet saved to disk(ette), the following message will also flash on the screen:

```
WARNING !! CHANGES NOT SAVED
```

To exit to DOS, press Y. Pres any other key to cancel.

OPERATING KEYS

Throughout **SCORBASE**, the following keys are used to activate screens and enter commands and options.

< **PgUp**> Recalls the screen previously displayed.
or < **Esc**>

< **Esc**> Cancels a command line which has been activated.

< **Enter**> Accepts commands, options and field entries.

< **Backspace**> Erases field entries which have been typed, but not yet accepted.

TEACH POSITIONS MENU

This screen allows you to move the robot, and to teach and define the positions.

```

EDIT PROGRAM
O/C  OPEN/CLOSE GRIPPER
1    GO TO POSITION ... FAST/SPEED #.
2    WAIT ... SECONDS
3    IF INPUT #. JUMP TO ...
4/R  TURN ON/OFF OUTPUT #.
5    JUMP TO LINE #...
6    SET COUNTER #.. TO ...
7    DECREMENT COUNTER #..
8    IF COUNTER #.. >0 JUMP TO ...
9/O/P SET/RETURN/CALL SUBROUTINE #..
M/N  SET MEMORY #.. TO .../ TO SENSOR
U    IF MEMORY #.. <=> MEMORY #.. JUMP ...
D/Y  REMARK : / PRINT :
A    ON MOTOR #. ERROR, JUMP TO ... C/S/O
S    SET AXIS #. TO ZERO

```

SCORBASE
 LEVEL 3
 VER 3.4

I/X-INSERT/REPLACE LINE... L-LIST/DELETE <ESC> RETURN TO MAIN MENU

1

The following pairs of number and letter keys are used to directly control the movement of the servo axes. The axes will continue to move as long as the activating key is depressed.

1/Q **move base** **right / left**

Robot base moves right and left.

2/W **move shoulder** **up / down**

Shoulder moves up and down.

3/E **move elbow** **up / down**

Elbow moves up and down.

4/R **move wrist-pitch** **up / down**

Wrist moves up and down.

5/T **move wrist-roll** **right / left**

Wrist rolls right and left.

6/Y move axis 6 + / -

Axis no. 6 moves forward and backwards.

7/U move axis 7 + / -

Axis no. 7 moves forward and backwards.

O/C Open / Close gripper

These commands open and close the gripper.

Press O to open the gripper.

Press C to close the gripper.

F/S Fast / Speed 0 movement

These commands set the speed for manual robot movement.

Press F to set the fastest speed (10). This is the default speed.

Press S, and then enter any speed from 1 (the slowest) to 9 .

J/K turn on /off Output #.

These commands activate and deactivate the controller outputs.

Press J to turn on an output.

Press K to turn off an output.

At the # prompt enter a specific output number.

P/V record Position . . . /relative position

The Record Position command records the current joints position of both the robot axes and the peripheral axes.

Press P. At the prompt enter the position number you want to assign to the current location of the axes. If you simply press < Enter> , **SCORBASE** will automatically enter the next sequential position number. Up to 100 positions can be recorded.

The Record Relative Position command records the current position of the robot arm and peripheral axes relative to another (absolute) position. Make sure you have first recorded the reference position.

Press V. The format for recording a relative position is:

RECORD POSITION (1-100) ... RELATIVE TO ...

At the Record Position and Relative To prompts, type in valid position numbers and press < Enter> .

If you simply press < Enter> without specifying a number for the reference position, the position you record will be relative to the current position of the axis. For example:

```
RECORD POSITION (1-100) 12 RELATIVE TO CURRENT
```

If your position is relative to current, you are prompted to define values for the relative movement of each axis. The format is as follows:

```
RECORD POSITION (1-100) ... RELATIVE TO CURRENT
AXIS 1 = 0      .....
AXIS 2 = 0      .....
AXIS 3 = 0      .....
AXIS 4 = 0      .....
AXIS 5 = 0      .....
AXIS 6 = 0      .....
AXIS 7 = 0      .....
```

Pressing < Enter> without specifying a value for a particular axis accepts the offset default value, which in all the instances above is 0. Be sure to enter a value of 0 for axes 6 and/or 7 if peripheral equipment is not connected to these axes.

A position which is **relative to current** means the specified offset will be computed from wherever the robot is located at the time it is sent to the relative position.

If the reference position changes, the relative position also moves.

L List / delete positions

Press L to active the List/Delete Positions screen.

X/Z teach position/relative by XYZ coordinates

The Teach Position (XYZ) command enables you to teach (record) a position according to its Cartesian (XYZ) coordinates.

To define a position in Cartesian coordinates, you specify the distance (in millimeters) of the robot's gripper tip from the point of origin (the bottom center of the robot's base) along three linear axes. To complete the definition, you must also specify the pitch and roll of the gripper (in degrees).

You are prompted to complete the command as follows:

```
CURRENT POSITION                TEACH POSITION (x,y,z)
X(MM)      =163.42            .....
Y(MM)      =0.00              .....
Z(MM)      =499.07            .....
PITCH (DEG)=-64.52           .....
ROLL (DEG) =0.00              .....
RECORD POSITION (1-100) ...
```

Pressing < Enter> for a coordinate accepts the default value. The default is always the current value of the coordinate, as displayed. For example:

X (mm) =163.42

You may now enter a new X coordinate, or press < Enter> to accept the default, which is 163.42.

The Teach Relative Position (XYZ) command allows you to teach a position which is relative to another position by an XYZ offset.

You are prompted to complete the command as follows:

TEACH RELATIVE POSITION (x,y,z)
X(MM) =0.00
Y(MM) =0.00
Z(MM) =0.00
PITCH(DEG)=0.00
ROLL(DEG) =0.00
RECORD POSITION (1-100) ... RELATIVE TO ...

Pressing < Enter> for a coordinate accepts the offset default value, which in all the instances above is 0.00

Pressing < Enter> without specifying a reference position creates a position which is relative to the current position.

A position which is **relative to current** means the specified offset will be computed from wherever the robot is located at the time it is sent to the relative position.

< ESC> RETURN TO MAIN MENU

COORDINATES DISPLAY

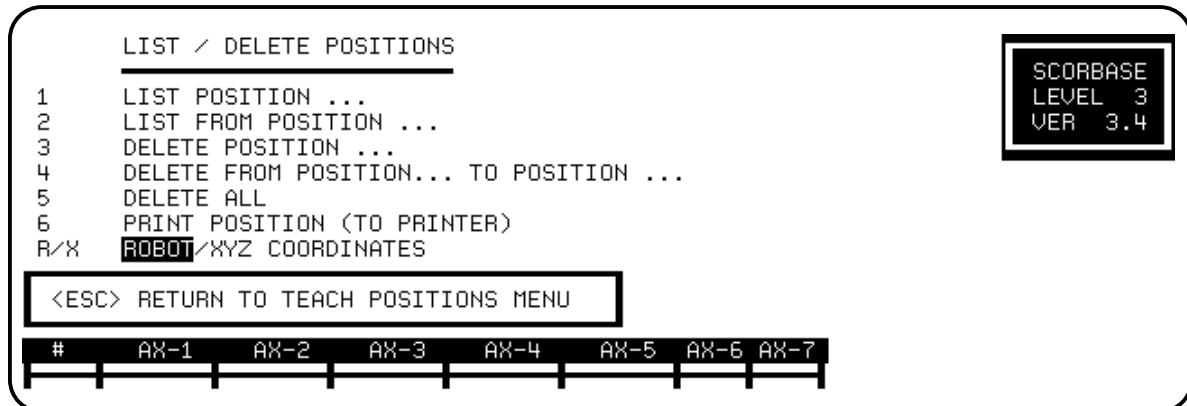
The coordinates display at the bottom of the Teach Positions menu shows the current location of the robot arm in Cartesian coordinates.

X Y Z PITCH ROLL AX-6 AX-7
163.42 0.00 499.07 -64.52 0.00 0 0

To display the axes' location in robot joints coordinates, activate the List / Delete Position screen, and use the R (Robot) command.

LIST / DELETE POSITION SCREEN

This screen lets you display, delete and print the positions you have recorded. To activate this screen, select the L option in the Teach Positions menu.



Note that the listing operations require extensive communication with the controller and may result in a delay in response time.

1 LIST POSITION . . .

This command displays the coordinates of the specified position using the currently active coordinate display system.

Press 1 and enter the number of a position.

2 LIST FROM POSITION . . .

This command displays a list of the recorded positions, starting from the specified position, using the currently active coordinate display system.

Press 2 and enter the number of a position.

If there are more positions listed than can be displayed in one screen, the system will pause and prompt you:

```
PRESS <ESC> TO EXIT LISING / ANY OTHER KEY TO CONTINUE
```

Press < Enter> to move the display down one line.

Press any other key to move the display down one screen.

3 DELETE POSITION . . .

This command deletes the position specified.

Press 3 and enter the number of a position.

Note that you will be prompted to confirm whenever you give the command to delete a position:

```
ARE YOU SURE(Y/N)? N
```

4 DELETE FROM POSITION . . . TO POSITION . . .

This command deletes all points from the first position specified through the second position specified.

Press 4 and enter two position numbers.

5 DELETE ALL

Press 5 to delete all recorded positions from controller memory.

6 PRINT POSITION (TO PRINTER)

Press 6 to print out a listing of all recorded positions.

The positions will be printed using the currently active coordinate display system.

R/X **ROBOT /XYZ COORDINATES**

SCORBASE Level 3 supports work and can display positions in two different coordinate systems: Robot joints and Cartesian (XYZ). This command determines the system used to display and print positions.

Press R to display the position coordinates in terms of encoder pulses of the robot joints.

Press X to display the position of the robot axes in Cartesian, or XYZ, coordinates. Movement of the robot axes is in millimeters, and movement of the gripper is in degrees.

Note that the location of the peripheral axes (6 and 7) is always stated in encoder pulses.

< ESC > RETURN TO TEACH POSITIONS MENU

EDIT PROGRAM MENU

This screen allows you to write and edit your robotic programs.

```

EDIT PROGRAM
O/C  OPEN/CLOSE GRIPPER
1    GO TO POSITION ... FAST/SPEED #.
2    WAIT ... SECONDS
3    IF INPUT #. JUMP TO ...
4/R  TURN ON/OFF OUTPUT #.
5    JUMP TO LINE #...
6    SET COUNTER #.. TO ...
7    DECREMENT COUNTER #..
8    IF COUNTER #.. >0 JUMP TO ...
9/O/P SET/RETURN/CALL SUBROUTINE #..
M/N  SET MEMORY #.. TO .../ TO SENSOR
V    IF MEMORY #.. <=> MEMORY #.. JUMP ...
D/Y  REMARK : / PRINT :
A    ON MOTOR #. ERROR, JUMP TO ... C/S/O
S    SET AXIS #. TO ZERO

I/X-INSERT/REPLACE LINE... L-LIST/DELETE <ESC> RETURN TO MAIN MENU
1

```

To create a program line type the character which activates the command. **SCORBASE** automatically assigns numbers to your program lines.

When you are prompted to enter a value or an option, you may also press < Enter> to accept the default setting as your choice.

O/C OPEN /CLOSE GRIPPER

These commands open and close the gripper.

1 GO TO POSITION . . . FAST/SPEED

This command sends the robot to a recorded position at the specified speed.

Press 1. At the Go Position prompt, enter a position number. If you press < Enter> instead of specifying a position, **SCORBASE** automatically enters the next sequential position number.

You are then prompted for a speed. Press < Enter> or F to enter the fastest speed. If you press S, you must also enter a number, from 1 (slowest) through 9, for the speed value.

2 WAIT . . . SECONDS

This command halts program execution for the specified time.

Press 2. At the Wait prompt, type a number and press < Enter> .

3 IF INPUT #. JUMP TO . . .

This command causes the program to jump to the specified line if the tested input is on.

Press 3. At the Input # prompt type a number from 1 through 8.

At the Jump prompt enter the line number to jump to.

4/R TURN ON/OFF OUTPUT #.

These commands activate and deactivate the controller outputs.

Press 4 to turn on an output.

Press R to turn off an output.

At the # prompt enter the number of the output.

5 JUMP TO LINE #. . .

This command causes the program to jump to the specified line.

Press 5. At the # prompt enter the line number to jump to.

6 SET COUNTER #. . . TO . . .

Together with the other counter commands, this command is used to produce loops in the program. The Set Counter command sets the value of a counter.

Press 6. At the # prompt enter the number of the counter. You can set up to 64 counters.

At the next prompt, enter a value, from 1 through 9999. This value equals the maximum number of times a program loop can be executed.

7 DECREMENT COUNTER # . . .

This command decreases the value of a counter by 1.

Press 7. At the # prompt enter the number of a counter.

8 IF COUNTER #. . > 0 JUMP TO . . .

This command produces a conditional jump. It is used to determine if the value of a counter has decreased to 0.

Press 8. At the # prompt enter the number of the counter. At the Jump prompt enter the number of the line to jump to if the counter value is greater than 0.

At run time, if the counter value is greater than 0, the jump will occur. If the counter value is 0, the program will continue at the following line.

9/0/P SET / RETURN / CALL SUBROUTINE #. .

The Set Subroutine command marks the beginning of the specified subroutine. You can program up to 64 subroutines.

Press 9. At the # prompt, enter any number from 1 through 64.

During normal program flow, the program will skip over (without executing) the lines containing a subroutine definition. The only way to execute a subroutine is to use the Call Subroutine command.

The Return from Subroutine command marks the end of a subroutine. At run-time it terminates the execution of the subroutine, and the program resumes execution at the line which follows the Call Subroutine command.

Press 0 (zero) to create this comand line.

The Call Subroutine command activates (calls) the specified subroutine.

Press P. At the # prompt, enter any number from 1 though 64.

M SET MEMORY #. . TO . . .

This command allows you to enter an arbitrary value and store it in one of 64 memory cells.

Press M. At the # prompt, enter a number from 1 through 64. At the next prompt enter a value (± 32767).

This command is most valuable for storing the size (in millimeters) of an object.

N SET MEMORY# . . TO SENSOR

This command allows you to measure the spread of the gripper fingers in order to record the size of an object being grasped by the gripper. At run-time **SCORBASE** translates this measurement into millimeters, and stores the result in a specified memory cell.

Press N. At the # prompt, enter a number from 1 through 64.

At run time, whenever this command is encountered, the measured value is displayed (in millimeters). For example:

```
SENSOR VALUE IS 45
```

V IF MEMORY #. . < = > MEMORY #. . JUMP . . .

This command is a conditional jump command. It allows you to compare the values of two memory cells, and to use that comparison to make a real-time decision regarding the continued course of action.

Press V. At the # prompt, enter a (recorded) memory number.

Then enter a comparison operator, and enter the number of another (recorded) memory. The comparison operations can be as follows:

```

=      equal to
<      smaller than
>      greater than
< =    smaller than or equal to
> =    greater than or equal to
< >   not equal

```

At the Jump prompt, type the line number to jump to if the result of the comparison is true.

D/Y REMARK : /PRINT

The Remark command lets you insert a comment line into the program for explanation and documentation. Type in any text of up to 48 characters.

The Print command prints text on the screen at run time. A maximum of 48 characters can be printed in one command line.

A ON MOTOR #. ERROR, JUMP TO . . . C/S/O

This command allows you to receive information about motor errors and to respond with a jump to another command line.

At the prompt, enter a number from 1 through 8. Or press < Enter> to accept any motor error. (Note that the command line will show Motor ALL Error.)

At the Jump prompt, enter a line number. If you simply press < Enter> without specifying a line number, the following will be displayed:

```
ON MOTOR 1 ERROR JUMP TO NEXT  Continuously/Single/Off
```

This defines a jump to the next line of the program. Should a motor error occur on the specified motor during its execution of any movement, the movement will be aborted. The program will jump to the next line and continue running.

You now have the following options:

- Press C. For example:

```
ON MOTOR 1 ERROR JUMP TO 24  CONT.
```

Any motor error on axis 1 which occurs subsequent to this command causes the program to jump to line 24. This jump occurs in the form of an interrupt.

- Press S. For example:

```
ON MOTOR 1 ERROR JUMP TO 37  SING.
```

Only the first occurrence of a motor error on axis 1 subsequent to this command causes a jump to line 24. The second occurrence will cause the program to halt and display a motor error message.

- Press O. For example:

```
ON MOTOR 1 ERROR JUMP TO 24 OFF
```

This command cancels the effect of any preceding motor error instructions in the program relating to motor 1.

S SET AXIS #. TO ZERO

This command resets the position of the axis specified by setting its value to 0. This command is very useful for performing a cyclical motion of an accessory, such as a conveyor or a rotary table.

Press S. At the # prompt, enter the number of an axis.

This command can also be entered by pressing < Ctrl> + O.

ADDITIONAL EDITING COMMANDS

< Ctrl> + J SET PRESENT POSITION AS HOME

When executed at run time, this command sets the current position of the axes to 0, thereby creating a new home position of the robot.

Warning! This command automatically alters the physical location of all recorded positions. Changing the home position may therefore invalidate other recorded positions.

< Ctrl> + L IF LIMIT SWITCH # ON JUMP TO . . .

This command causes the program to jump to the specified line if the specified limit switch is depressed (on).

Press < Ctrl> + L. At the Limit Switch prompt, enter a number from 1 through 7 (1 to 5 are on the robot; 6 and 7 are on the peripherals). At the Jump prompt, enter the line number to jump to.

< Ctrl> + K MESSAGE # . .

This command is used to display any one of 19 pre-recorded messages during program execution.

Press < Ctrl> + K. At the prompt, enter the number of the message you want displayed. Your options are as follows:

```

1  BASE IS AT HOME
2  SHOULDER IS AT HOME
3  ELBOW IS AT HOME
4  WRIST PITCH IS AT HOME
5  WRIST ROLL IS AT HOME
6  AXIS 6 IS AT HOME
7  AXIS 7 IS AT HOME
8  GRIPPER IS AT HOME

9  ROBOT STARTS PROGRAM
10 ROBOT FINISHES PROGRAM

11 BASE IS NOT AT HOME
12 SHOULDER IS NOT AT HOME
13 ELBOW IS NOT AT HOME
14 WRIST PITCH IS NOT AT HOME
15 WRIST ROLL IS NOT AT HOME
16 AXIS 6 IS NOT AT HOME
17 AXIS 7 IS NOT AT HOME
18 GRIPPER IS NOT AT HOME

19 ROBOT IS RESTING

```

Messages 11 through 18 include a code for sounding a beep.

To display any other message at run time, use the Remark command.

EDITING FUNCTIONS

I INSERT LINE . . .

This command allows you to insert lines into a program.

Press I. At the prompt, enter the number of the line at which you wish to insert another command. Then type and enter the additional command line or lines.

Press < Enter> a second time to exit the insert mode. **SCORBASE** then displays the next available program line.

When program lines are inserted, all line numbers and previously entered Jump commands are automatically updated.

X REPLACE LINE . . .

This command allows you to replace an existing command line with another command.

Press X. At the prompt, enter the number of the command line you want to replace. The command line specified is displayed and you are prompted for the new command. Pressing < Enter> without a new command leaves the original line unchanged.

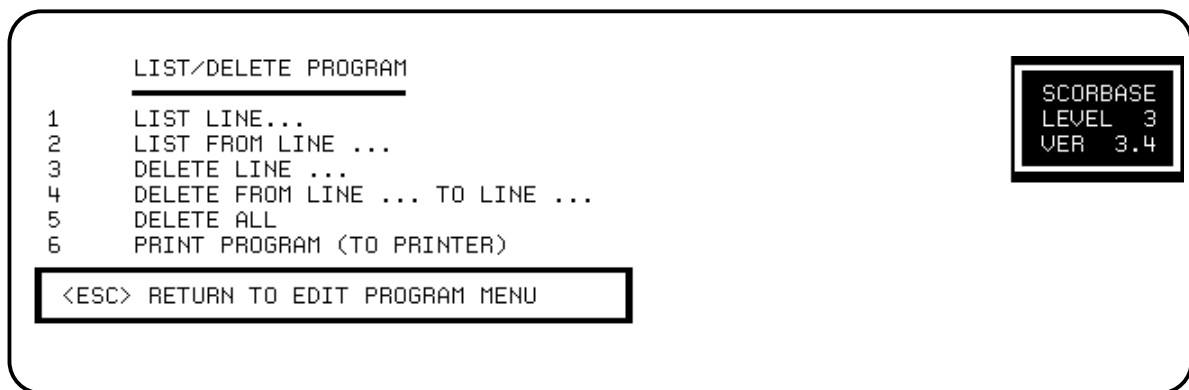
L LIST /DELETE

Press L to activate the List/Delete screen.

< ESC> RETURN TO MAIN MENU

LIST / DELETE PROGRAM SCREEN

This screen allows you to display, delete and print the programs you have written. It is similar to the List/Delete Position screen called from the Teach Positions screen. To activate this screen, press L from the Edit Program screen.

**1 LIST LINE . . .**

This command displays the specified program line.

Press 1 and enter the number of a program line.

2 LIST FROM LINE . . .

This command displays all program lines beginning with the line specified.

If there are more lines than can be displayed in one screen, the system will pause and prompt you:

PRESS <ESC> TO EXIT LISTING / ANY OTHER KEY TO CONTINUE

Press < Enter> to move the display down one line.

Press any other key to move the display down one screen.

3 DELETE LINE . . .

This command deletes the specified line from the program.

Press 3 and enter the number of a program line.

Note that whenever you give the command to delete a line or lines, **SCORBASE**

displays the line/s, and prompts you to confirm:

ARE YOU SURE (Y/N)? N

Press Y to delete. Press any other key to cancel.

4 DELETE FROM LINE . . . TO LINE . . .

This command deletes all program lines from the first line specified through the second line specified.

Press 4 and enter two program line numbers.

5 DELETE ALL

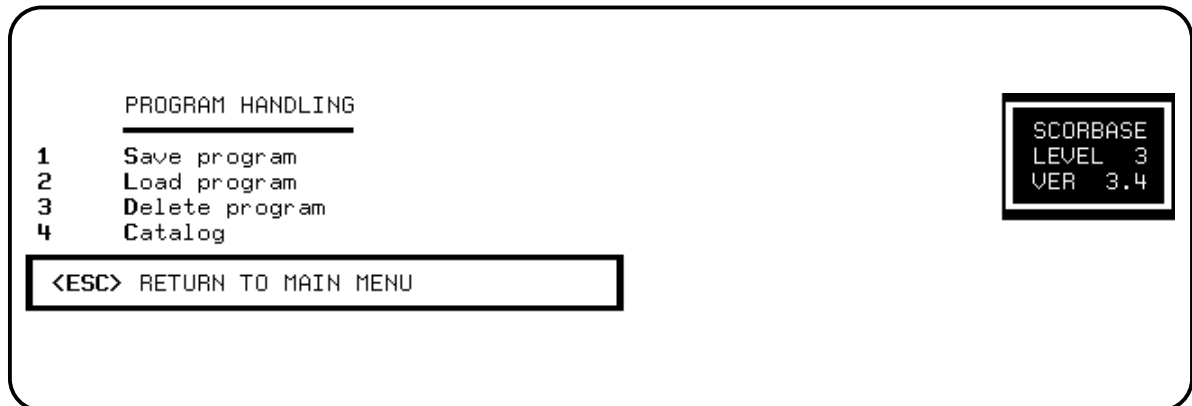
Press 5 to delete the entire program from the controller memory.

6 PRINT PROGRAM (TO PRINTER)

Press 6 to print out a listing of all program lines.

PROGRAM HANDLING MENU

This screen allows you to delete programs and to transfer (load and save) programs between the computer memory and disk(ette).



1 Save Program

This option lets you save on disk(ette) the program you have created.

Press 1 or S. At the prompt, type the name you want to assign to the program, and press < Enter> . The program is now saved on disk(ette).

When you type a program name, do not use more than 8 characters, and do not use a number for the first character of the file name.

Do not use an extension. All programs saved by **SCORBASE** are automatically assigned extensions corresponding to the level in which they were created. For example, PICKUP.L3 indicates that the program PICKUP.L3 was created in **SCORBASE** Level 3.

2 Load Program

This option lets you call up a program from the disk(ette) to the computer memory.

Press 2 or L, and enter the program name.

When loading a program which was created in the level in which you are operating, you need only to type the program name.

You may have programs with similar names which were written in different levels; for example, JACK.L1, JACK.L2 and JACK.L3. When loading a program which was created in a **SCORBASE** level other than Level 3, indicate the level as shown in the examples below:

2DEMO will load DEMO.L2.

1DEMO will load DEMO.L1.

3 Delete Program

This option allows you to delete a program from the disk(ette).

Press 3 or D, and enter the program name.

To delete a program, you must be operating in the level in which the program was created. For example, to delete program KEYS.L3, you must be working in **SCORBASE** Level 3.

Note that whenever you give the command to delete a program, **SCORBASE** prompts you to confirm:

```
ARE YOU SURE(Y/N)? N
```

4 Catalog

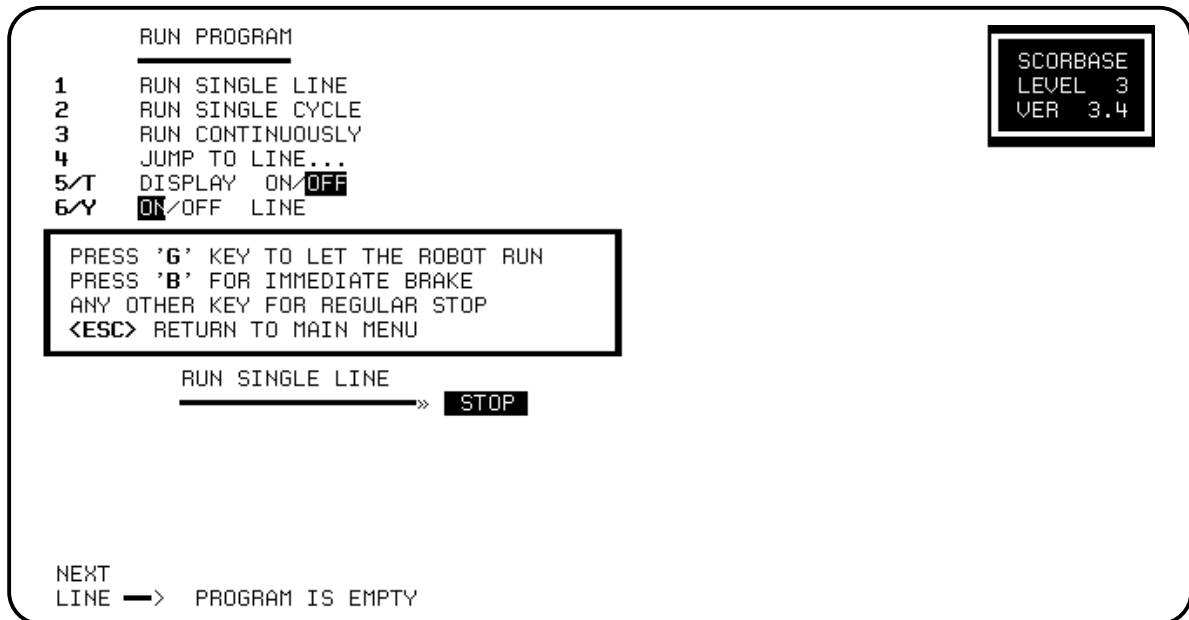
Press 4 or C to display a listing of all the programs which have been saved on the disk(ette).

Press 4 or C.

< ESC> RETURN TO MAIN MENU.

RUN PROGRAM MENU

This screen lets you run the programs you have created.



1. RUN SINGLE LINE

Press 1, and press G.

One program line (the current line) is executed each time you press G.

2. RUN SINGLE CYCLE

Press 2, and press G.

The program is executed from the NEXT LINE command to the end of the program.

3. RUN CONTINUOUSLY

Press 3, and press G.

The entire program is executed repeatedly. When it reaches the last line it automatically jumps to the first line and continues.

4. JUMP TO LINE . . .

Press 4, and enter the number of a program line.

The pointer goes to the specified line. Press G to start the program from that line.

5/T DISPLAY ON/ **OFF**

Press 5 to display program lines during program execution. (This is the default mode).

Press T to turn off the display during program execution.

6/Y ON / OFF LINE

This option lets you choose between running your programs off-line or on-line.

Press 6 to run programs on-line. When a program runs on-line, the robot, peripherals and I/Os execute all program commands. (This is the default mode).

Press Y to run programs off-line. When a program runs off-line, all commands for executing actions are suppressed. The robot arm is not moved and the outputs are not switched. The robot can even be disconnected when this mode is active.

When a program runs off-line, it will halt at the commands which test the state of the inputs or limit switches, and will prompt you for a simulated status.

Example:

When the program reaches this line:

```
IF INPUT #1 ON JUMP TO LINE 25
```

It will stop and prompt:

```
IS INPUT #1 ON (Y/N)?
```

You can thus simulate the actual execution of the program.

Note that the off-line option in this screen can also be used when **SCORBASE** is connected to a controller and is in the on-line mode.

PRESS 'G' TO LET ROBOT RUN

You must press G to begin or restart the running of a program.

PRESS 'B' FOR IMMEDIATE BRAKE

Press B to apply an emergency brake at any time.

No loss of information will occur, and the following message is displayed:

```
PRESS C TO CONTINUE
PRESS M TO RETURN O MENU
```

Press C to resume program execution from the line at which it was stopped.

Press M to allow the activation of any other command. You can now go to another menu, or continue running the program.

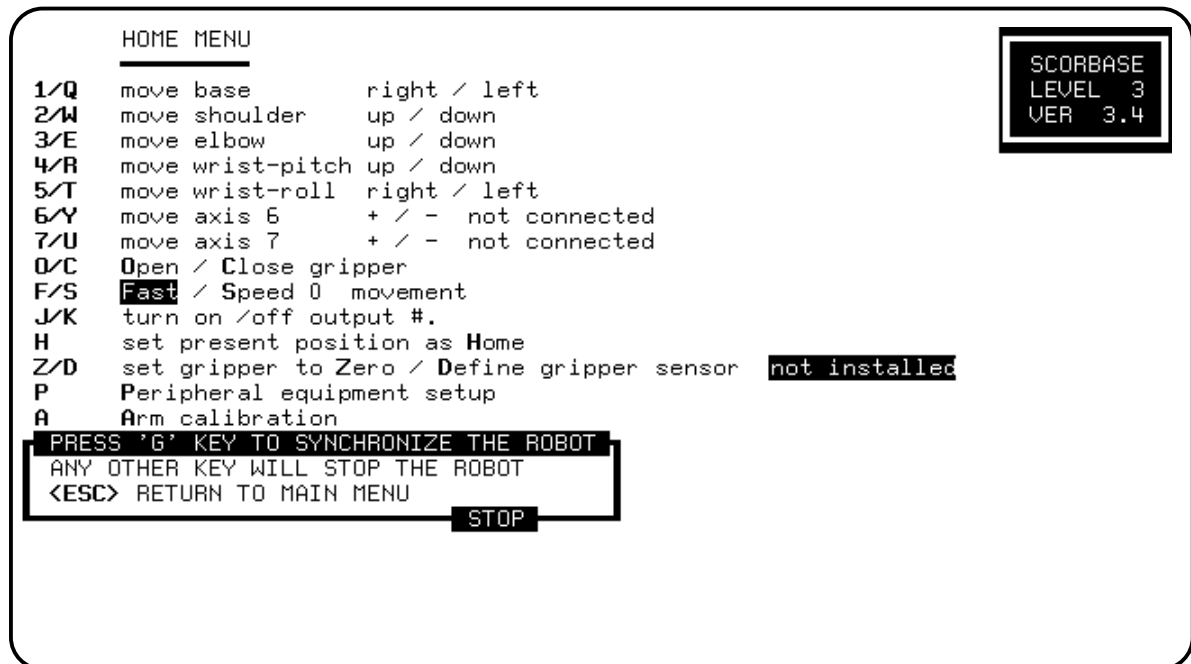
ANY OTHER KEY FOR REGULAR STOP

Press any key (other than B) to halt the robot as soon as it completes execution of the current command.

< ESC > RETURN TO MAIN MENU

HOME MENU

This screen is used for configuring and homing the robot and peripheral equipment.



Many of the commands in the Home screen are identical to those found in the Teach Positions screen. The additional features are as follows:

G PRESS 'G' KEY TO SYNCHRONIZE THE ROBOT

The **SCORBOT** should be homed each time the controller is turned on.

Press G to perform the hard (fixed) home search.

During the homing procedure, each joint is moved until its microswitch is depressed (closed). **SCORBASE** displays messages stating whether each of the joints has reached its fixed home position. If a joint does not reach its home location, the program will automatically execute the home search once more for that joint.

If the homing is not fully successful, the following message is displayed:

```
ROBOT IS NOT AT HOME !
```

When the robot reaches its home position, the following message is displayed:

```
HOMING COMPLETED
```

Press any key to stop the homing while the operation is in progress. Press G again to restart the homing procedure.

A Arm calibration

The calibration procedure for the robot arm should be performed before using **SCORBASE** for the first time, and after prolonged use of the robot. During calibration **SCORBASE** moves the axes at each of the ten speeds, measures the exact rate of movement, and calculates the true speed ratios between axes.

Press A to perform the calibration.

The robot first searches for its hard home, and then begins the calibration process. **The procedure can take up to 10 minutes.**

The calibration data is stored in the ZERO file on your disk(ette). When you copy **SCORBASE** to another diskette, be sure to copy the ZERO file as well.

P Peripheral Equipment Setup

The homing of axes 6 and 7 depends upon the peripheral equipment which is connected.

Press P to define the peripheral equipment. You are then prompted:

```
AXIS 6/7
```

Type the number of the axis/motor you want to define. The system now displays:

```
AXIS 7 IS CONNECTED TO
```

```
Slidebase/Rotary-table/Conveyor/Not connected
```

Press **S**, **R**, **C** or **N** according to the connected equipment. The homing procedure for the peripheral equipment is as follows:

Slidebase: The slidebase is moved to one side until it cannot move any further.

Rotary-table: Search for microswitch is performed.

Conveyor: No search is performed

Not connected: No search is performed.

This setup is recorded in the ZERO file and placed on your disk(ette). The next time you load **SCORBASE** the correct peripheral setup will automatically be configured. You do not need to repeat the setup operation unless you actually alter a peripheral or its axis connection.

Z/D set gripper to Zero / Define gripper sensor not installed

The Z command sets the value of the gripper to zero, which allows more accurate measurements when using the Set Memory to Sensor command. This gripper setup is also recorded in the ZERO file and placed on your disk(ette).

A sensor mounted within the gripper can be used to control the amount of force

exerted by the gripper when executing a Close Gripper (CG) command. The sensor is connected to the **SCORBOT** controller through one of the 8 input ports. When the force reaches a predefined threshold, the sensor sends an ON signal to the input.

The D command allows you to define which input port is used for the sensor connection.

Press D. You are then prompted:

```
IS GRIPPER SENSOR CONNECTED (Y/N)? Y
```

Press Y or < Enter> to connect a gripper sensor. Otherwise, press N.

If a gripper sensor is connected, the following prompt is then displayed:

```
GRIPPER SENSOR CONNECTED TO INPUT (1 - 8) ..
```

Enter the number of the input port. Your response (input 3, for example) is then reflected in the menu line:

```
Define gripper sensor input 3
```

During the execution of Close Gripper commands, this input will be checked.

H set present position as Home

If you want to start the robot from a position other than its fixed home, move the robot to the desired position

Press H to set the current position of the axes as the new home position.

Warning! This command automatically alters the physical location of all recorded positions. Changing the home position may therefore invalidate other recorded positions.

At the Change Values for XYZ (Y/N) prompt, you can insert new Cartesian values for the new home position. You can also change the following:

```
BASE HEIGHT(MM)= .....
```

Used when the robot base is not at table level.

```
TOOL LENGTH(MM) .....
```

Used when you want to program XYZ positions for the tip of a tool connected to the gripper.

< Esc> **RETURN TO MAIN MENU**

Command Line Options

When loading any level of **SCORBASE**, you can enter several command line options. The complete syntax for loading this software is:

```
SCOR# [ /L /P /T /C /O ] [programe /R /S ] [ /H ]
```

Where # is the number of the level. The options within brackets [] are strictly optional and can be omitted. During normal operation the default values are used. Once you have entered an option, it overrides the default options.

Size Options

- /L** Defines the maximum number of available program lines.
Default : 400
Maximum : 10000 (or memory limit)
- /P** Defines the maximum number of positions.
Default : 100
Maximum : 7000 (or memory limit)
- /T** Defines the maximum number of text lines (PRINT and REMARK statements) available when writing a program.
Default : 50
Maximum : 1000 (or memory limit)

Example:

```
SCOR3 /L2000 /P400 <Enter>
```

This command loads **SCORBASE** Level 3 and allow the use of up to 2000 lines and 400 positions.

Note that when you execute partial load and save operations, **SCORBASE** creates a temporary copy of the program. If you have defined a setup which uses a very large number of lines, you may be unable to execute these partial operations due to memory size limitations.

Device Options

- C** Defines the RS-232 port used for communication with the robot controller.
/C1 : COM1
/C2 : COM2

/O Defines the parallel printer port to be used when printing.

/O1 : PRN1

/O2 : PRN2

/O3 : PRN3

Example:

SCOR3 /C2

SCORBASE Level 3 will be loaded with the robot communications on COM2.

Automatic Run Options

progname If you specify a program name, this program will automatically be loaded. Note that only the program lines are loaded. The position table should already exist in the controller.

/R If you add this option, the program will automatically start running as soon as it is loaded. When execution of the program is completed, **SCORBASE** will return control to the DOS operating system.

Example:

SCOR3 TEST /R

The **SCORBASE** Level 3 program named TEST will automatically be load and executed. When execution of TEST is completed, **SCORBASE** will return control to the DOS operating system.

/S If you include this option together with a position number, the robot will automatically be sent to the position specified, and not to Home, when **SCORBASE** is loaded.

Example:

SCOR3 /S20

/H Instructs the system to run the HOME program before activating the Main Menu.

Programs on the SCORBASE Diskettes

HOME# Program

The HOME# program is included in SCORBASE Level 2 and Level 3, and is necessary for operation of the robot and for finding the home position. **Do not delete this program.**

DEMO Program

The DEMO program is included in SCORBASE Level 3. This program contains two subroutines, in loops which do not coincide.

In the first subroutine (lines 1 through 40) the robot measures two blocks and places the narrower one squarely on top of the wider one.

The blocks must be 25 mm in height. If the robot does not find the block (as a result of a measurement of less than 5 mm) the robot will open the gripper, raise and lower the arm, and reattempt to find the block.

To determine the placement of the blocks, run the DEMO program without the blocks and mark the points reached by the gripper on the work surface. If the table surface is too low for the robot to reach the blocks, raise the blocks by putting them on a higher surface (on top of a book, for example).

If INPUT 1 switch is on, program execution will stay at line 2; this allows you to rearrange the blocks, for example. Once you have arranged the blocks, turn the INPUT switch off and then on again.

If the switch remains off, the program will run continuously, without halting between the loops.

The second subroutine (lines 41-51) demonstrates the movement of the robot arm at various speeds.

The DEMO program is listed below. It is followed by position tables in joint coordinates and XYZ coordinates.

Note: A set of remarks appears in the first lines of the DEMO programs. The actual program line numbers are therefore different.

```
1 OPEN GRIPPER
2 IF INPUT #1 ON JUMP TO 2
3 SET MEMORY #3 TO 5
4 GO POSITION 2 *FAST
5 GO POSITION 1 SPEED #2
6 WAIT 1 SECONDS
7 CLOSE GRIPPER
8 SET MEMORY #1 TO SENSOR
9 OPEN GRIPPER
10 IF MEMORY#3 > MEMORY#1 JUMP 4
11 GO POSITION 2 SPEED #7
12 GO POSITION 3 SPEED #7
13 GO POSITION 4 SPEED #2
14 WAIT 1 SECONDS
15 CLOSE GRIPPER
16 SET MEMORY #2 TO SENSOR
17 IF MEMORY #2 > MEMORY #3 JUMP 20
18 OPEN GRIPPER
19 JUMP TO LINE # 12
20 IF MEMORY #2 > MEMORY #1 JUMP 28
21 GO POSITION 3 SPEED #7
22 GO POSITION 2 SPEED #7
23 GO POSITION 5 SPEED #2
24 WAIT 1 SECONDS
25 OPEN GRIPPER
26 GO POSITION 2 *FAST
27 JUMP TO LINE # 2
28 OPEN GRIPPER
29 GO POSITION 3 SPEED #7
30 GO POSITION 2 SPEED #7
31 GO POSITION 1 SPEED #2
32 WAIT 1 SECONDS
33 CLOSE GRIPPER
34 GO POSITION 2 SPEED #7
35 GO POSITION 3 SPEED #7
36 GO POSITION 6 SPEED #2
37 WAIT 1 SECONDS
38 OPEN GRIPPER
39 GO POSITION 3 SPEED #7
40 JUMP TO LINE # 2
41 GO POSITION 7 SPEED #7
42 GO POSITION 8 *FAST
43 GO POSITION 9 *FAST
44 GO POSITION 10 SPEED #4
45 GO POSITION 11 *FAST
46 GO POSITION 12 *FAST
47 GO POSITION 11 SPEED #2
48 OPEN GRIPPER
49 CLOSE GRIPPER
50 GO POSITION 13 SPEED #5
51 JUMP TO LINE # 41
```

POSITION TABLES

Joint Coordinates

#	AX-1	AX-2	AX-3	AX-4	AX-5	AX-6	AX-7
1	0	956	-871	-59	0	0	0
2	0	602	-705	-59	0	0	0
3	225	602	-705	-59	0	0	0
4	224	955	-873	-59	0	0	0
5	0	901	-862	-59	0	0	0
6	224	901	-863	-59	0	0	0
7	0	219	498	306	0	0	0
8	-962	271	-242	-51	0	0	0
9	-962	571	-570	128	0	0	0
10	177	782	-965	-51	0	0	0
11	1135	239	509	308	0	0	0
12	1135	59	1559	698	0	0	0
13	0	0	0	0	0	0	0

ROBOT PRESENT POSITION IS:

177 782 -965 -51 0 0 0

XYZ Coordinates

#	X	Y	Z	PITCH	ROLL	AX-6	AX-7
1	277.63	0.00	19.28	-92.72	0.00	0	0
2	269.40	0.00	184.87	-92.72	0.00	0	0
3	251.27	97.17	184.87	-92.72	0.00	0	0
4	258.21	99.37	19.52	-92.72	0.00	0	0
5	276.44	0.00	44.60	-92.72	0.00	0	0
6	257.59	99.13	44.49	-92.72	0.00	0	0
7	39.92	0.00	925.32	81.73	0.00	0	0
8	-1.69	-242.70	410.23	-88.89	0.00	0	0
9	-3.17	-454.22	367.58	-3.35	0.00	0	0
10	210.41	62.86	87.75	-88.89	0.00	0	0
11	-11.93	39.88	926.76	82.68	0.00	0	0
12	77.57	-259.27	297.38	269.07	0.00	0	0
13	163.42	0.00	499.07	-64.52	0.00	0	0

ROBOT PRESENT POSITION IS:

210.41 62.86 87.75 -88.89 0.00 0 0

The Teach Pendant

The teach pendant, or control box, is a hand-held controller which allows you to operate and program the robot. The teach pendant is best used for teaching the robot positions and writing short programs. For writing longer and more complex programs, it is easier to use **SCORBASE** (Level 3 or 5) after you have recorded the required positions with the teach pendant and **SCORBASE** Level 4.

The **SCORBOT-ER III** teach pendant allows a number of programming and operating functions. You can use the teach pendant to:

- Teach up to 100 positions.
- Write programs of up to 250 lines. The teach pendant uses all the commands contained in **SCORBASE** Level 2 and the gripper sensor commands from **SCORBASE** Level 3.
- Transfer programs between the teach pendant and the computer. Programs written on the teach pendant can then be saved to disk(ette). Programs on the computer can be loaded into the teach pendant for execution or editing.
- Run programs one line at a time; run complete programs; run programs starting from any line. Run a DEMO program. Use an emergency brake.
- Search for the HOME position.

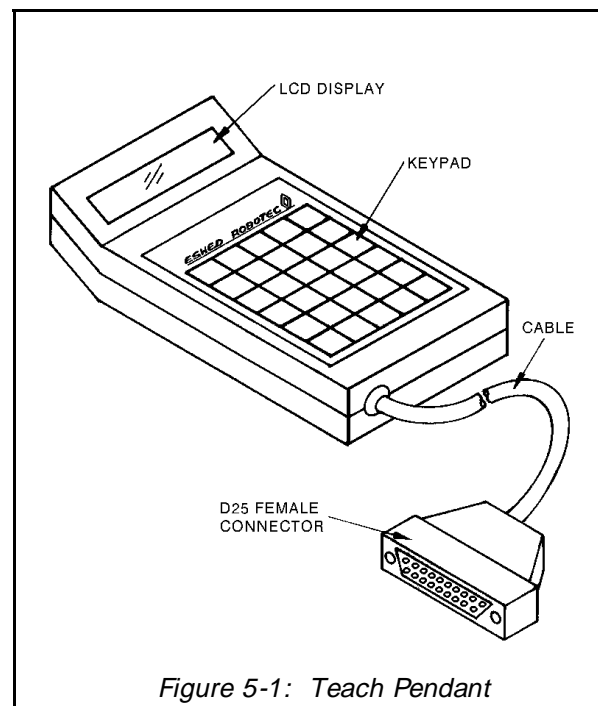


Figure 5-1: Teach Pendant

Connecting the Teach Pendant to the Controller

The teach pendant requires no battery, and has no ON/OFF switch. It is connected to the controller by a RS232 cable and connector, and turns on automatically when the controller power and motor switches are turned on.

Two RS232 serial communication connectors are located on the controller rear panel. The lower connector connects the computer to the controller. The upper connector connects the teach pendant to the controller.

The controller can transmit through only one RS232 connector at a time. Normally the controller transmits to the lower (computer) connector. However, when you connect the teach pendant to the robot controller, transmission is automatically routed to the upper (teach pendant) RS232 connector.

<p>Warning! Do not connect the computer and the teach pendant to the controller at the same time unless SCORBASE Level 4 has been loaded into the computer. Loading SCORBASE Level 1, 2 or 3 may interfere with teach pendant functions and cause communication error messages to be displayed while the robot is in motion.</p>
--

(**SCORBASE** Level 4 is not active software; that is, it does not cause robot motion. It simply enables the transfer of programs between the teach pendant and the computer, and the listing of programs and positions. These functions are discussed later in this chapter.)

To return transmission to the lower RS232 connector, press the RESET key on the controller. To return transmission to the teach pendant, press the Reset key on the teach pendant, and answer No to the prompt: ARE YOU SURE? (If you answer Yes, communication will be directed to the teach pendant, but its memory will be erased by the reset operation.)

If the teach pendant displays a communication error message and/or an axis moves improperly when activated from the teach pendant, you may have accidentally pressed the controller RESET button. To restore communication to the teach pendant, follow the steps described above.

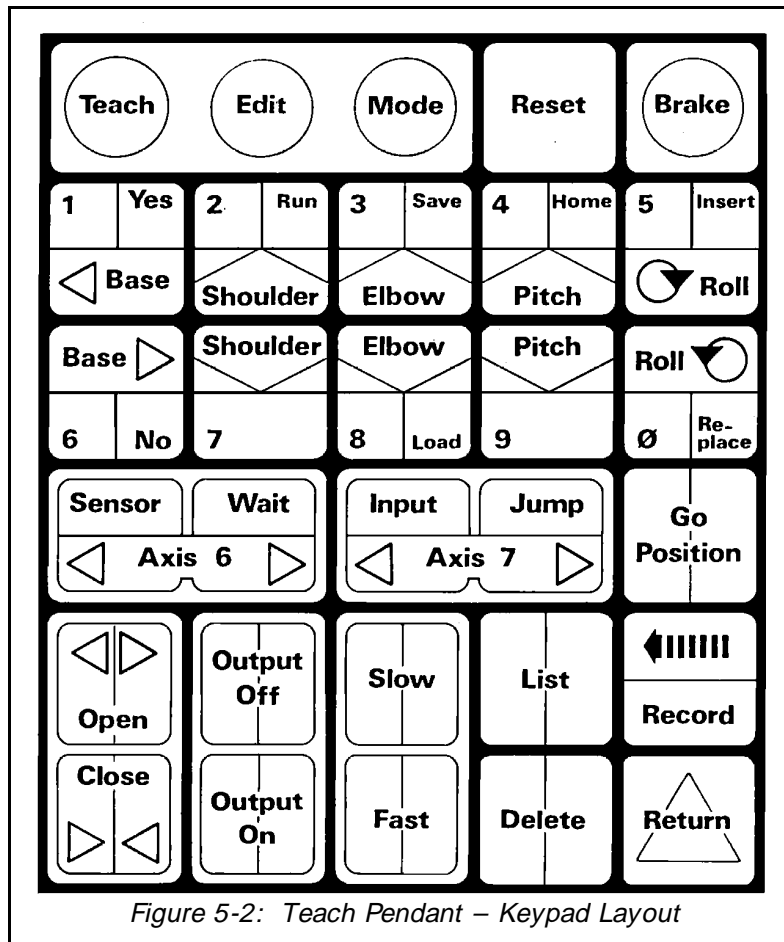
Teach Pendant Functions

The teach pendant has a 2-line, 32-character liquid crystal display (LCD) panel, and a flat keyboard with 30 keys in 6 rows.

The three main keys on the teach pendant are the mode keys at the top left of the keyboard: Teach (blue), Edit (yellow), and Mode (green). Most of the other keys are divided into blue, yellow and/or green areas which represent the functions they activate after the the mode key of the same color has been pressed.

You should hear a short beep each time you press a key. If you do not hear a beep, the key was not pressed properly and its function has not been activated. You need not press heavily on the keys. Simply press on the center of the key, where you can feel a slight depression.

When functions require the entry of numbers, type them using the keys numbered 1 – 0. To correct a mistakenly typed number (before you press Return), press the Left Arrow (←) backspace key.



When you switch on the controller to which the teach pendant is connected, several messages appear on the display panel:

```
WELCOME
ESHED ROBOTEC
```

```
NO. OF LINES 250
NO. OF POS. 100
```

```
TEACH POSITIONS
T
```

TEACH Key (TEACH MODE)

The Teach mode allows you to move the robot and teach positions.

The Teach mode commands are identical to the commands in the Teach Positions Menu in **SCORBASE** Level 3.

The Teach mode is automatically activated when you turn on the controller (to which the teach pendant is connected). To activate the Teach mode when another mode is active, press the Teach key. If a sub-menu of a different mode is active, you may have to press the Teach key more than once.

When you press the blue Teach key, the display panel shows:

```
TEACH POSITIONS
T
```

The letter T flashes until you select a Teach function or another mode.

The functions available in the Teach mode are as follows:

Base, Shoulder, Elbow, Pitch, Roll.

These keys move the joints of the robot.

Each joint has two keys. The direction of joint motion is shown by the arrow on each key. The joint will move as long as you press the key.

Axis 6, Axis 7.

These keys move the peripheral axes.

Each axis has two keys. The direction of axis motion is shown by the arrow on each key. The axis will move as long as you press the key.

Open, Close.

These keys open and close the robot gripper.

Press the Open Gripper key. The gripper will open to its widest opening.
Press the Close Gripper key. The gripper will close to its smallest opening.

Fast

This key causes the robot to move at its maximum speed.

Once you have pressed Fast, each pressing of an axis movement key will move the corresponding axis at a rate of 30 encoder pulses.

Slow

This key allows you to set a slower speed for axis movement. At the SPEED prompt, press a number, from 1 (slowest) to 9, and press Return.

Note: If the robot continues to move slowly after you have pressed the Fast key, select a slow speed, and then attempt to return to a fast speed.

Output On

This key turns on the controller outputs.

At the TURN ON OUPUT prompt, enter a number of a specific output, from 1 through 8, and press Return.

Output Off

This key turns off the controller outputs.

At the TURN OFF OUTPUT prompt, type a number of a specific output, from 1 though 8, and press Return.

Record

This key lets you teach (record) the present robot location.

After you have moved the robot to the desired location, press Record. Type the number for the position (from 1 through 100), and press Return. Pressing Return without typing in a position number will record the next available position number. Entering 0 or a number greater than 100 will cancel the command, and an error message will be displayed: VALUE OUT OF RANGE.

Go Position.

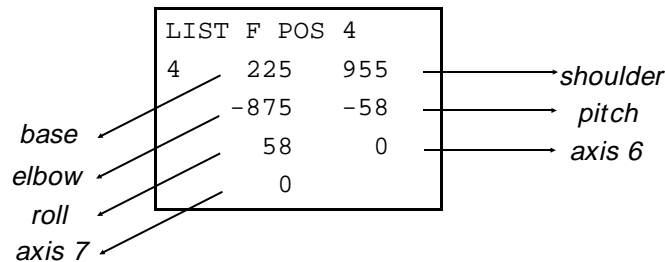
This key allows you to move the robot to a recorded position.

Press Go Position. Type in a position number and press Return. Pressing Return without typing in a position number cancels the Go Position command. If the position number has not been recorded, the robot will not move and an error message will be displayed: POSITION EMPTY.

List

This key displays the robot axis coordinates in encoder pulses for any recorded position.

Press List, then type the position number. The display format is as follows:



Press Return to display the next line of coordinates.

Hold down the Return key to scroll the coordinate display.

Press the Left Arrow (←) key to return the previous line of coordinates.

Hold down the Left Arrow key to scroll up (reverse scrolling).

Delete

This key allows you to delete any position, or any range of positions, from the teach pendant memory.

Press Delete. Type the number of the position (or the first position) to delete, and press Return. You are again prompted:

```
DEL F POS ...  
TO POS ...
```

To delete a single position, type the same position number previously entered, and press Return (or, simply press Return without typing a position number). To delete a range of positions, type the number of the last position to delete, and press Return.

Before the delete operation is executed, you are prompted: ARE YOU SURE? Press the Yes key to delete the position(s) entered. Press any other key to cancel the operation.

EDIT Key (EDIT MODE)

The Edit mode allows you to write and amend programs. The Edit commands are identical to the commands in the Edit Program Menu in **SCORBASE** Level 3.

To activate the Edit mode, press the yellow Edit key. The display panel shows:

```
EDIT PROGRAM
1  E
```

The letter E flashes until you select an Edit (yellow) function or another mode.

The number of the line currently being written or edited is displayed at the left.

The functions available in the Edit mode are as follows:

Go Position

This key creates the command which sends the robot to a previously recorded position whenever the program is run.

Press Go Position. Type in a position number and press Return. You are prompted to press Slow or Fast to enter the rate of motion.

Slow, Fast

The Slow and Fast keys determine the speed at which the robot goes to the specified position.

You are prompted to select a speed after you have entered a Go Position command.

```
EDIT PROGRAM
1  POS 2  *S/F
```

Press Fast to enter the fastest speed. Press Slow and a number from 1 through 9 for a slower speed.

Note: During program execution, the actual change in speed between slow and fast is not immediate; the shift is gradual. Also, the **SCORBOT-ER III** takes longer to decrease speed than increase speed, and stops more quickly when moving against the force of gravity.

Open

This key writes a command to open the gripper. The gripper will open each time this line is encountered during program execution.

Close

This key writes a command to close the gripper. The gripper will close each time this line is encountered during program execution.

Wait

This key writes a command which causes a delay of the specified number of seconds each time the program is run.

Press Wait, type in the number of seconds, from 1 through 250, and press Return.

Output On

This key writes a command to activate a specific controller output.

Press Output On, type in the number of the output, and press Return.

Output Off

This key writes a command to deactivate a specific controller output.

Press Output Off, type in the number of the output, and press Return.

Jump

This key writes an unconditional jump command, which causes the program to jump to the specified line each time the program is run.

Press Jump, type in the desired line number, and press Return.

Input

This key writes a conditional jump command, which causes the program to jump to the specified line if the specified input is on. If the input is off, the program simply continues at the line immediately following the Jump command line.

Press Input. You are prompted to type the desired input number. Type a number, from 1 through 8, and press Return. You are now prompted to type the desired line number. Type a number, from 1 through 250, and press Return.

Sensor

This key activates the gripper measurement commands.

Press Sensor. The following is displayed:

1 . VALUE 2 . SENS 3 . JUMP

Select one of the following:

1 . VALUE

This option lets you enter and store a predetermined value in a memory cell (SET MEMORY .. TO ..). This command provides a constant value for the size of the gripper's opening, which can be used for comparisons during program execution.

Press 1. You are prompted to type a memory cell number. Type a number, from 1 through 15, and press Return. Then enter the desired value in millimeters.

2 . SENS

This option lets you measure and store the size (in millimeters) of the gripper's opening during program execution (SET MEMORY .. TO SENSOR).

Press 2. You are prompted to type a memory cell number. Type a number, from 1 through 15, and press Return.

When this line is encountered during program execution, the size of the gripper's will be measured by the sensor and stored in the specified memory, and the value will be displayed.

3 . JUMP

This option creates a condition jump command, based on the comparison of the values stored in two memory cells (IF MEMORY ..> MEMORY .. JUMP TO LINE ...).

Press 3. You are prompted to type the numbers of two memories, and the line number to jump to if the first value is greater than the second value.

List

This key lets you review the lines in a program.

Press List. Then type the number of the line (or first line) you want to display, and press Return.

Press Return to display the next line.

Hold down the Return key to scroll down the display.

Press the Left Arrow (←) key to return to the previous line.

Hold down the Left Arrow key to scroll up (reverse scrolling).

Delete

This key lets you delete one or more command lines from the program you are editing.

Press Delete. You are prompted to type in the number of the line (or the first line) you want to delete. Type the number and press Return. You are then prompted to type the number of the last line to delete. To delete a single line, type the same line number, or simply press Return. To delete a range of lines, type in the number of the last line to delete and press Return. Before the deletion is executed, you are prompted to confirm: ARE YOU SURE? Press Yes to delete the line entered. Press any other key to cancel the operation.

Insert

This key allows you to insert additional lines into the program you are editing.

Press Insert. You are prompted to type in the number of the line at which you want to insert new line/s. Type the command line/s you want to insert. All lines and jump commands following the inserted line/s are automatically updated. Press Return again to return the pointer to the end of the program.

Replace

This key allows you to replace a line in the program you are editing.

Press Replace. You are prompted to type in the number of the line you want to replace. Type the number and press Return. The specified line is displayed and you are prompted to replace it with another. After you have entered the new line, the point returns to the end of the program.

MODE Key (SELECT MODE)

The green Mode key allows you to select modes other than the Edit and Teach modes. When you press the Mode key, the display panels shows:

CHOOSE : RUN-HOME- SAVE-LOAD

You can now activate any operation whose name appears in green on the keyboard.

The functions available through the MODE key are as follows:

Run

The Run key enables the execution of a line or lines in a program.

Press Run. Your options are displayed:

1 . SINGLE 2 . CONT- INUOUSLY 3 . JUMP .

These operations are identical to the Run Program options in **SCORBASE** Level 3.

1 . SINGLE

Press 1. A single line of the program will be executed each time you press Return.

2 . CONTINUOUSLY

Press 2. The program will run continuously once you have pressed Return.

3 . JUMP:

Press 3. You are prompted for the line number to jump to. Type the number and press Return. The program jumps to the line specified and the Run options are displayed.

To interrupt a running, press the red Brake key for an immediate stop. Press any other key to stop the program once the current line has been executed.

Home

The Home key enables homing operations of the robot and the execution of a DEMO program.

Press Home. Your options are displayed:

1 . SET	2 . SEARCH
3 . GO	4 . DEMO

1 . SET

Note: Before selecting this option, make sure the gripper is closed.

Press 1.

SET HOME
ARE YOU SURE?

The current robot axis coordinates will be reset to zero (SET PRESENT POSITION AS HOME), if you press Yes in response to the prompt. Press any other key to cancel the command.

2 . SEARCH

Press 2. You are prompted to press Return, which will cause the robot to search for its hard home.

Warning: The Search Home procedure will erase the contents of the teach pendant memory. If you have a valuable program in memory, be sure you first save it to disk(ette), using SCORBASE Level 4.
--

Press any other key to cancel the command.

Note: For more accurate repeatability, execute Search Home *twice* at the beginning of each working session, or whenever you select this option.

To run the Search program on axis 6 and axis 7, the INPUT switches on the controller must be turned on, as follows:

INPUT #1 switch on: Search for home on Axis 6.

INPUT #2 switch on: Search for home on Axis 7.

If no peripheral axis is connected, make sure these switches are off when you run the search. If either of these switches is on, and the motor axis which it represents is not connected, a **motor error** message will be displayed.

3 . GO

Press 3. If you press Yes in response to the prompt ARE YOU SURE, the robot will immediately move to its home position. Press any other key to cancel the command.

4 . DEMO

Press 4. This will load and run a demonstration program. This DEMO program resembles the DEMO program included on the **SCORBASE** Level 3 diskette.

For an explanation and listing of this program, refer to the section "Programs on the **SCORBASE** Diskettes," in Chapter 4.

After you load DEMO (from the teach pendant's EPROM to the RAM), you can amend it using the Edit and Teach modes and execute it with the Run key. List and Delete functions are also applicable to the DEMO program.

Save

Note: For Save operations, the robot controller must be connected to a computer in which **SCORBASE** Level 4 has been loaded. Refer to the following section, "**SCORBASE** Level 4."

Press Save. This key transfers the program currently in the teach pendant memory to the computer memory. When the Save operation is completed, the display will show: DONE!

Load

Note: For Load operations, the robot controller must be connected to a computer in which **SCORBASE** Level 4 has been loaded. Refer to the following section, "**SCORBASE** Level 4."

Press Load. This key loads the program currently in the computer memory into the teach pendant memory.

Note: If you load a program which was written in another level of **SCORBASE**, such as Level 3, and contains commands unknown to the teach pendant, the lines containing these commands will be blank during Run or List operations; only the line number will be displayed.

RESET Key

The gray Reset key clears the teach pendant memory.

Press Reset. You are prompted: ARE YOU SURE? If you press Yes, the teach pendant memory will be irretrievably erased. Press any other key for No.

If the teach pendant stops responding to keyboard entries and does not beep when keys are pressed, press the controller RESET switch, and then press the teach pendant Reset key. Then respond negatively to ARE YOU SURE? This will restore operation to the teach pendant but will not erase the program currently in its memory.

For more information on the Reset function, refer to the section, “Connecting the Teach Pendant to the Controller,” at the beginning of this chapter.

BRAKE Key

The red Brake key is used for emergency stops.

When running a program, you can stop the robot movement in one of two ways:

- Emergency brake: Press the Brake key. The robot will stop immediately and the following is displayed:

```
BRAKE
1 . CONTINU 2 . MENU
```

- Regular stop: Press any other key. The display panels shows: ABORT and the line currently being executed.

During program execution, if the robot encounters an obstacle (or some part of itself), or if any robot motor has difficulty moving, the emergency brake is automatically applied, and the following is displayed:

```
MOTOR # ERROR!
1 . CONTINU 2 . MENU
```

Press 1. The program resumes running from the line it failed to execute.

Press 2. The program is aborted and you are prompted to select another function.

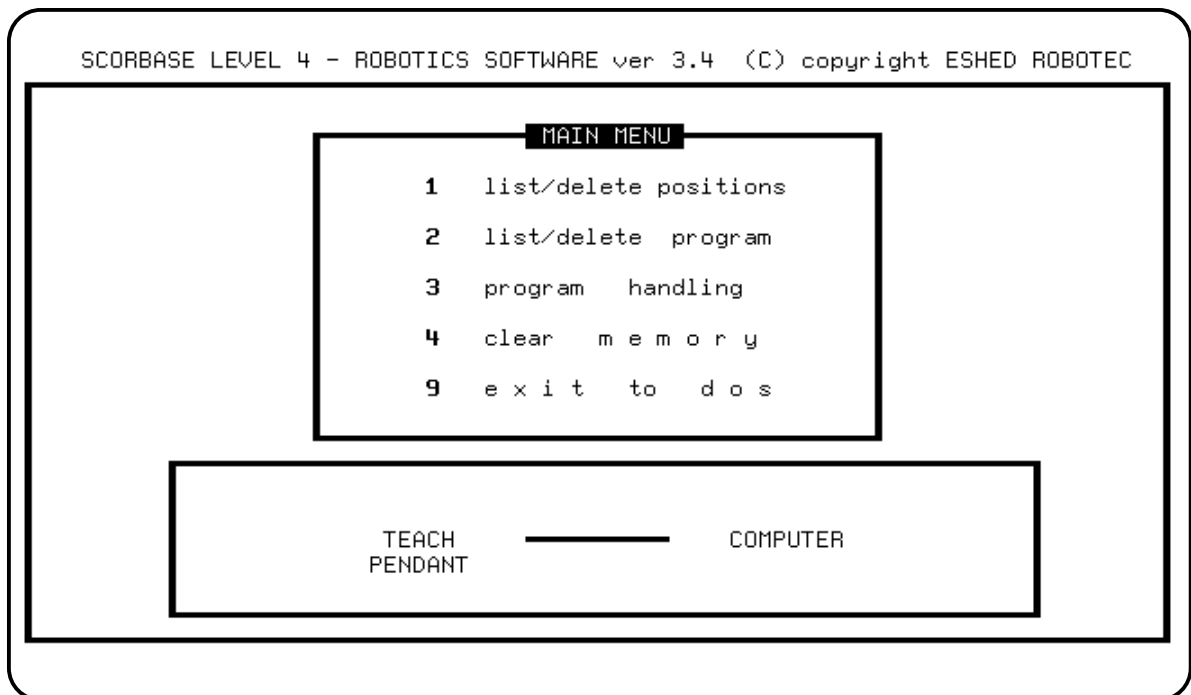
SCORBASE Level 4

SCORBASE Level 4 enables the transfer (loading and saving) of programs between the teach pendant and the computer, thereby allowing you to save programs onto disk(ette) and later recall them to the teach pendant.

Level 4 also enables the listing and deletion of positions and program lines.

Main Menu

The Main Menu must be displayed to permit the loading and saving operations which involve the teach pendant.



When saving and loading operations are executed, an arrow on the screen shows the direction in which the data is flowing. The following messages are also displayed:

PROGRAM TRANSMITTED

The program has been loaded to the teach pendant from the computer.

PROGRAM RECEIVED

The program has been saved to the computer from the teach pendant.

Other Menus

The List/Delete Positions, List/Delete Program, and the Program Handling screens in **SCORBASE** Level 4 are identical to those in **SCORBASE** Level 3.

The Clear Memory option is used to empty the teach pendant memory and positions table, and to erase unwanted programs and positions.

Note: Remember to return to the Main Menu after each list/delete, program handling, or clear memory operation. Otherwise, load and save operations cannot be executed properly.

Saving Programs from Teach Pendant to Computer Disk(ette)

1. Make sure the computer screen displays the **SCORBASE** Level 4 Main Menu.
2. Make sure the computer is connected to the lower RS232 port on the controller, and the teach pendant is connected to the upper RS232 port.
3. Activate the Mode menu on the teach pendant. (You may need to press the green Mode key more than once.)
4. Press the green Save key on the teach pendant.
5. Wait for the message PROGRAM RECEIVED to appear on the computer screen, and the message DONE! to appear on the teach pendant display panel.
6. Make sure the program was indeed transferred to the host computer. Activate the List/Delete Positions and the List/Delete Program screens. Examine the (computer's) programs and positions and compare them with those in the teach pendant.
7. Activate the Program Handling menu. Save the program. Assign the program a name of up to 8 characters (beginning with a letter), and do not use an extension.
8. Select Catalog. Check that the program just saved appears in the catalog. Note that the extension .L4 will be appended to the program name, signifying that the program was received in Level 4.

Computer Editing of Programs Written on the Teach Pendant

1. Load **SCORBASE** Level 3.
2. Remove the **SCORBASE** Level 3 diskette from the disk drive, and insert the diskette which contains the program written and saved from the teach pendant.
3. Activate the Program Handling menu. Check the Catalog. Load the program written by the teach pendant (it will be identified by the extension .L4).

When typing the name of the program to be loaded, add the figure 4 at the beginning of the name; for example, 4PROGA. Do not use the extension.

4. You can now work with the loaded program on the computer.

Important:

- The teach pendant recognizes all the commands in **SCORBASE** Level 2 and the gripper sensor commands from **SCORBASE** Level 3.
- If you edit a program in Level 3, avoid using commands not recognized by the teach pendant (for example, the Memory commands). The lines containing these commands will be displayed as blank if you attempt to load the edited program to the teach pendant.
- Also, remember to disconnect the teach pendant from the controller if you activate and work in levels of **SCORBASE** other than Level 4.

Loading Programs from Computer Disk(ette) to Teach Pendant

1. Load **SCORBASE** Level 4 into the computer.
2. Activate the Program Handling menu and load a program from the diskette.

To load programs written on the computer and saved in a level other than **SCORBASE** Level 4, do the following:

- If necessary, remove the **SCORBASE** Level 4 diskette from the disk drive and insert the diskette containing the program you want to load.
 - Load the program into the computer, prefixing the name with the number representing the level in which the program was written. For example, 3FRED.
3. Return to the Main Menu.
 4. Activate the Mode menu on the teach pendant.
 5. Press the green Load key on the teach pendant.
 6. Once the load operation has been completed, the message PROGRAM TRANSMITTED appears on the computer screen, and the message DONE! appears on the teach pendant display panel. You can now use the teach pendant to edit and execute the program.

Maintenance and Repairs

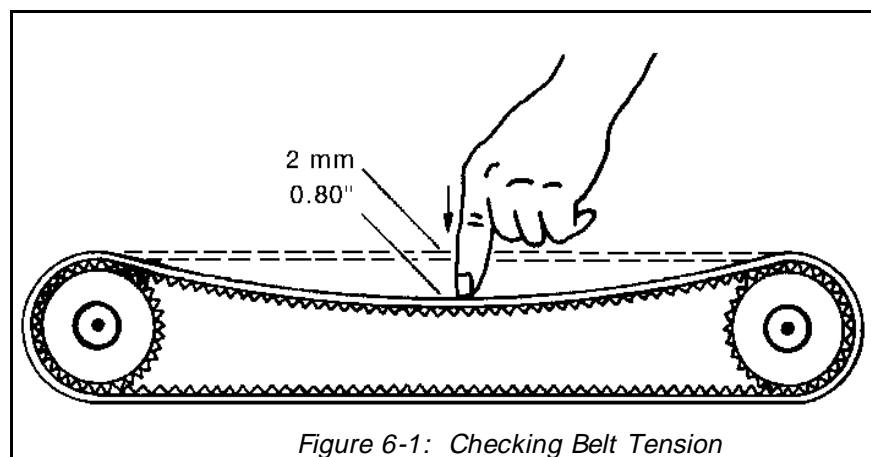
Routine Maintenance

Monthly inspection and maintenance of the **SCORBOT-ER III** should include the following:

1. Check all screws and bolts in the robot arm. Tighten any loose ones.
2. Check all leads and rubber components in the robot arm. Replace any worn ones.
3. Check the tension of the robot arm belts. When you press on a belt, it should give 2 mm (0.08") (see Figure 6-1).

Tighten the belts only if you are absolutely certain they are slipping or retarding the motors (see Figures 6-2, 6-3 and 6-4).

- Figure 6-2 shows how to tighten the belts in the forearm which move the wrist axes (pitch and roll). Loosen the two screws (1) which hold the tension shaft. Press down on the shaft and retighten the two screws.
- Figure 6-3 shows how to tighten the belts in the upper arm which move the wrist axes (2) and the belt which moves the elbow (3).



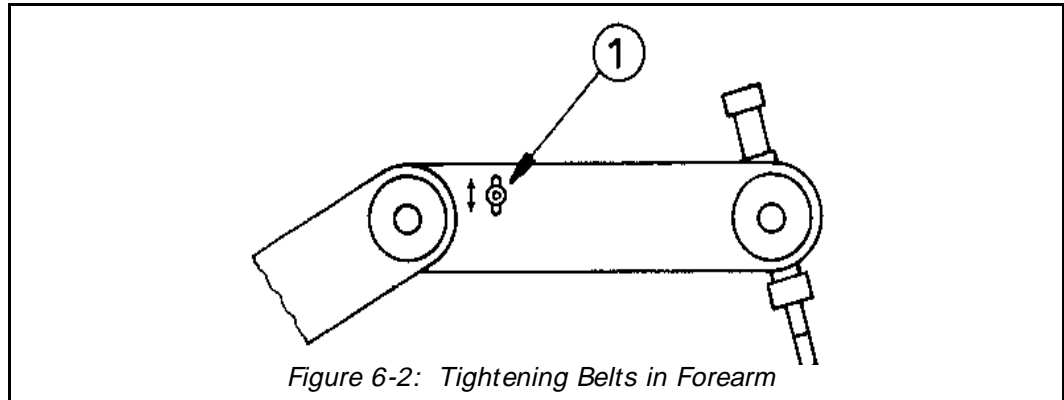


Figure 6-2: Tightening Belts in Forearm

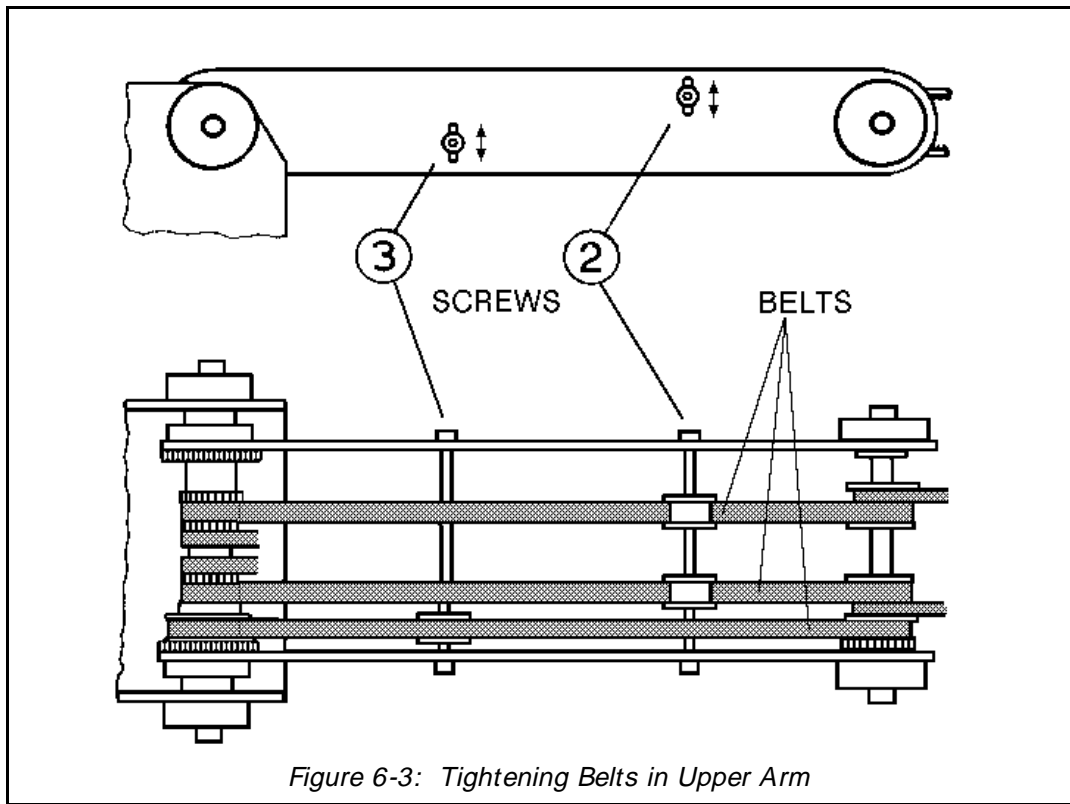


Figure 6-3: Tightening Belts in Upper Arm

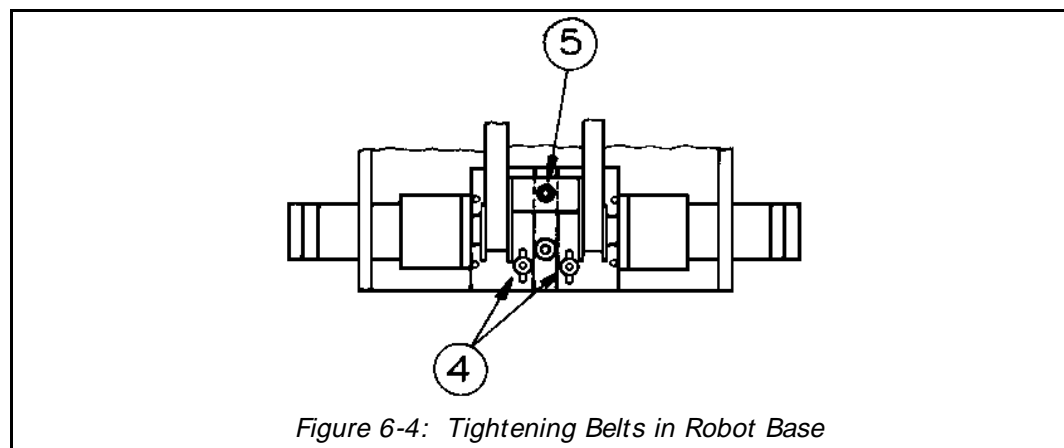


Figure 6-4: Tightening Belts in Robot Base

Figure 6-4 shows how to tighten the two belts in the robot base which move the wrist axes. First loosen the screw (5), and then loosen either one or both screws (4). Then, to tighten the belts, simultaneously pull the appropriate motor and retighten the screw/s (4). Finally, retighten the screw (5).

4. Check the backlash between the pinion (60) and the main drive (toothed gear) (32) of the elbow and shoulder motors (the two motors attached to the side plate of the robot body). Refer to Figures 7-2 and 7-4.

If the backlash is excessive, loosen the two screws (S22) which hold the motor bracket onto the side plate, and push the motor (and its pinion) towards the drive gear. Then retighten the screws.

5. Check for excessive backlash in the base axis. Refer to Figures 7-3 and 7-4

The anti-backlash unit has four gears. Two gears (22 and 27) are on top of one other with a spring (23) fitted in between. To stretch the spring, do the following:

- Make sure the robot is bolted to the work surface.
- Undo the screw holding the gear (20) closest to you. Remove this gear.
- Note the small unused hole on the base plate located near the gears (22 and 27). It will enable you to lock the gear (22) in the next step.
- To prevent the gear (22) from moving during the following steps, lock the gear by inserting a short pin through this hole and in between two teeth in this gear. Make sure the pin does not touch the lower gear (27) and that the gear (27) is free to rotate.
- Mark the two teeth which are directly above one another on the gears (22 and 27), one on the upper gear and one on the lower gear.
- Manually turn the robot body counterclockwise a distance of six to eight teeth between the marked teeth. The spring should now be correctly stretched.
- Return the gear (20) to its position and fasten the screw.
- Remove the locking pin.

Troubleshooting

Whenever there is a problem in your system, try to identify the component in which it exists – controller, arm, computer, teach pendant or RS232 connections – by using other functioning components or equipment. That is, if you have another system which you know is functioning properly, then exchange the suspected faulty component with its counterpart in the functioning system.

For example, if the robot is unable to find Home in axis 2, the problem is either in the arm or in the controller. Exchange first the arm and then the controller with their counterparts in a system you know is functioning properly.

Do not open the controller housing. Do not attempt repairs for which you are not qualified. Contact your agent or a technician, who has received proper training and certification from the manufacturer, for repairs.

The following chart provides guidelines for identifying and rectifying problems which you may encounter.

Item	Problem	Corrective Action
1.	Controller power does not turn on. The LED on the controller POWER switch does not light up.	Make sure the power cable is connected to the controller and to a proper power source. Check the 5V 1A fuse. Check the 220V/110V 1.5A/1.6A fuse; use a small screwdriver to pry open the lid. If the RS232 cable is connected, disconnect it and retry to power on the controller. If successful, reconnect the RS232 cable. Disconnect the robot cable and retry to power on the controller. If successful, reconnect the cable.
2.	No communication between the controller and computer; “Communication Error” message while operating robot from computer.	Make sure the controller POWER and MOTOR switches are on. Make sure the RS232 cable is properly wired and connected to the controller and to the computer. Make sure the RS232 card in the computer is set up properly. (See Appendix B).

Item	Problem	Corrective Action
		<p>Make sure the teach pendant is not connected to the controller's upper RS232 port. Press the controller RESET switch, or switch the controller off and then on again.</p> <p>Using the Teach screen in SCORBASE, try to move any robot axis and check whether the TX and RX LEDs at the back of the controller light up.</p> <p>If problem persists, it is probably due to a faulty RS232 cable.</p>
3.	“Communication Error” message while operating robot from teach pendant.	<p>Press the Reset key on the teach pendant and reply No to the prompt ARE YOU SURE?</p> <p>If error message reoccurs, switch the controller off and then on again.</p>
4.	Controller functioning, but robot arm cannot be activated; or one motor fails to respond and “Motor Error” appears on screen.	<p>Make sure the MOTOR switch is on and the green MOTOR LED is lit.</p> <p>Make sure the robot cable is properly connected to the controller.</p> <p>Make sure none of the axes has reached its mechanical limit.</p> <p>If no fault detected, and problem persists:</p> <p>Check the two 4A fuses.</p> <p>Check all electrical connections to the motor and the encoder.</p> <p>Open the encoder by unscrewing the two Phillips screws on its cover, and check the phototransistors and the LEDs in the encoder.</p> <p>You can try to run the motor by applying 12VDC directly to its two poles.</p> <p>Make sure there are no breaks in the leads from the motor to the controller.</p>

Item	Problem	Corrective Action
5.	The robot does not respond to instructions from the computer, but responds when MOTOR TEST switch is pressed.	<p>Enter a robot command from the computer and check whether the RX and TX LEDs on the controller rear panel light up.</p> <p>If the LEDs fail to light up, the problem is probably in the computer, or with RS232 card setup or cable. Or, the software may be faulty.</p> <p>If LEDs light, but problem persists, contact your agent.</p>
6.	Robot does not find the Home position in one of its axes. “Axis not at home” message during a Home search.	<p>Check whether the microswitch is broken. If so, replace it.</p> <p>If the microswitch is not broken, listen (for a click) and look to see if it is depressed and released during axis movement. If the microswitch is not being depressed (no click is heard), look for the faulty or loose component, and replace or adjust it.</p> <p>Check whether the microswitch shorts its two poles when depressed.</p> <p>If you cannot locate a short between the two microswitch terminals, the microswitch needs to be replaced.</p> <p>If you can locate a short between the two terminals, check the wires for conductivity between the D50 connector and the microswitch terminal while pressed. (Refer to Appendix D).</p> <p>If you detect conductivity, the problem may be in the controller; contact your agent.</p>
7.	Inaccurate robot response when executing XYZ commands.	<p>Execute a Home search. Make sure all axes reach home, as confirmed on the computer or teach pendant display.</p> <p>If one or more of the axes does not find its home position, the problem may be due to the microswitch, the cable connecting the robot to the controller, or the controller itself.</p> <p>If all axes find home but inaccuracies still occur, contact your agent for the recalibration of the Home position.</p>

Item	Problem	Corrective Action
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8. Excessive motor oscillations

The encoders link electronic and mechanical parts in the system. Each encoder measures one robot axis movement and enables the controller to stop the motor as soon as the prescribed amount of movement is executed. The motor then oscillates briefly around the brake point. Controlled by the microprocessor, the oscillation is quickly reduced by the friction created by the spring and teflon washers between the motor and the encoder disk (see Figure 6-5).

The washers might wear down and fail to exert sufficient pressure on the spring. This will cause excessive motor oscillation. You will therefore need to compress or replace the washers.

Remove the two screws on the encoder cover. Open the encoder and **carefully** remove the small printed circuit board from the encoder; it will remain attached to the electrical leads.

To compress the washers:

Loosen the two Allen screws which hold the encoder disk onto the motor shaft. Gently press the encoder disk toward the motor and retighten the Allen screw. Reattach the circuit board and cover.

To replace the washers (and spring):

Lift out the encoder disk. Remove the metal washer and the teflon washer. Remove the spring and the second teflon washer. Replace the necessary parts. Make sure the encoder disk does not touch the sides of the encoder housing.

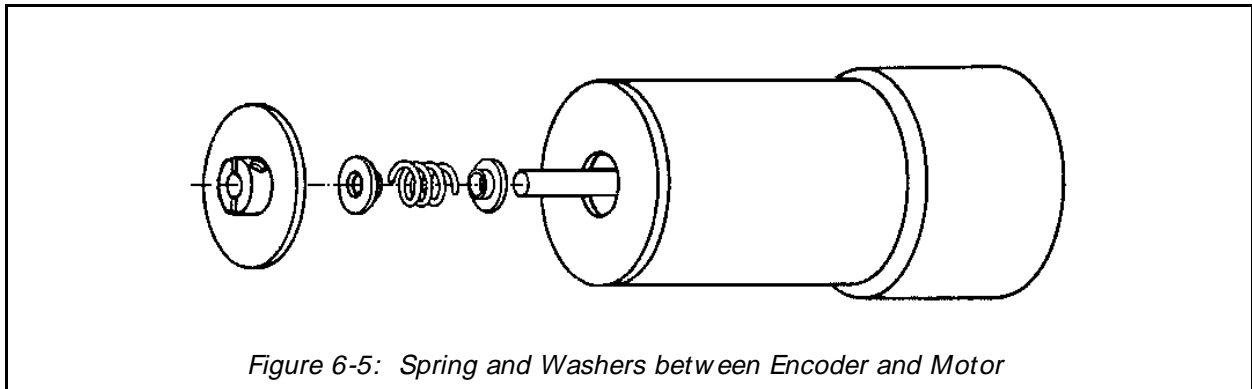


Figure 6-5: Spring and Washers between Encoder and Motor

Item	Problem	Corrective Action
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Notes:

1. If the washers are overly compressed, excessive friction will result; this will slow the motor and possibly cause motor errors while the robot is running.
2. Where the force of gravity acts upon motors (particularly in motors 2 and 3), it may be difficult to prevent the oscillation completely by compressing the washers and spring.
3. In some positions, especially when the robot arm is loaded, some minor oscillations may occur which do not cause any movement of the gripper. These slight oscillations are not a sign of a problem.

9. Errors in the accuracy of the robot

Position deviations in one or more of the axes during the running of a program may be caused by a faulty encoder.

Using an oscilloscope, check the signals received from the two phototransistors. Figure 6-6 shows the wave diagrams which emanate from the two channels (Photo 0

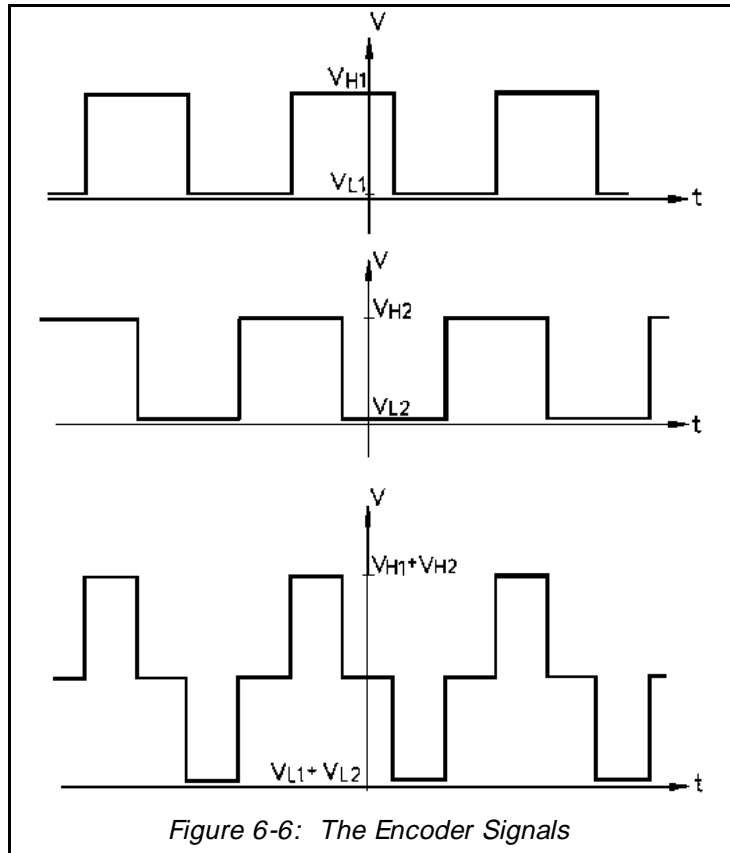


Figure 6-6: The Encoder Signals

Item	Problem	Corrective Action
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and Photo 1) of an encoder with respect to the time axis; the two upper signals should be clean square waves. The V_L (low) value should not exceed 0.4 V. The V_H (high) value should be greater than 4V.

However, you must also check the third wave which shows the sum of the two waves. The diagram reflects a time shift of a quarter cycle between the two waves. Distorted waves with an incorrect shift between them may indicate: (1) a faulty encoder which needs to be replaced or readjusted; (2) an electro-optic component is covered with dirt or dust and is therefore malfunctioning electrically; (3) the legs of the electro-optic components are bent, or are at the incorrect height; (4) the encoder disk may have a mechanical problem.

Note: To produce clean square waves with a 90° shift, the height of the optical components above the printed circuit board is very important (see Appendix E).

Robot inaccuracy may also be due to a loose or damaged component in one of the transmissions between the motor and the moving link. Check for movement continuity in all relevant transmission components; that is, check whether the gears and belts move together with the motor drive shaft.

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10. The gripper does not respond to open or close commands.

Using **SCORBASE** Level 3, activate the Home Menu and press Z to zero the gripper. Exit the Home Menu and recheck the gripper.

Follow steps for checking motor and encoder, as described in Item 4.

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11. “Sensor value is 0” message when gripper opened and when closed.

Using **SCORBASE** Level 3, activate the Home Menu and press Z to zero the gripper. Exit the Home Menu and recheck the gripper.

If the problem persists, proceed to the next item.

Item	Problem	Corrective Action
12.	The gripper opens <i>and</i> closes in response to Open Gripper command; gripper responds incorrectly to Close Gripper command.	<p>Make sure the robot D50 connector is securely connected to the controller.</p> <p>One or more of the optical components in the encoder may be faulty or not connected.</p> <p>Use an oscilloscope, as described in Item 9 above, to check for the two square waves in the phototransistor outputs as the motor rotates.</p> <p>The problem may be due to a break in the leads. Check the leads between the encoder and the motor.</p> <p>The problem may also be in the controller. If the problem persists, contact your agent.</p>
13.	The gripper opens and closes too freely; weak gripper force; the gripper motor rotates endlessly.	<p>Make sure the gripper motor output shaft is securely attached to the gripper lead screw.</p> <p>Disassemble the loose gripper (See Figure 7-1):</p> <ol style="list-style-type: none"> 1. Remove the gripper motor (S 312) from the plate (112) by unscrewing the three attachment bolts (2 bolts S 12 and one bolt S 14). Take note of part (S 313), an Oldham coupling with three parts – two metal parts fitted with bolts and an intermediate plastic part. When you remove the motor, one metal portion of the coupling will stay attached to the shaft. The second metal portion of the coupling will stay attached to the lead screw (94). The plastic portion will remain attached to either one of the two metal portions. 2. Remove the lead screw (94) from part (105) by turning it counterclockwise. 3. Fasten both metal portions to their respective shafts by firmly tightening the Allen screws (one portion to the motor output shaft and the other to the lead screw.) <p>Note: When tightening the coupling piece to the motor output shaft, ensure that the coupling is 1.5 mm to 2 mm away from the plate (112).</p> <p>Reassemble the Gripper:</p> <ol style="list-style-type: none"> 1. Make sure the coupling's plastic portion is attached to the metal portion attached to the lead screw (94). Keep

Item	Problem	Corrective Action
		<p>the gripper fingers closed. Screw the lead screw (94) with the coupling portion attached, clockwise into part (105), as tight as possible. Now release the gripper fingers.</p> <p>2. Refit the motor by aligning the coupling fitted to the motor output shaft together with the plastic coupling portion attached to the metal portion attached to the lead screw (94).</p> <p>3. When all the coupling sections are aligned and attached, turn the motor body until the holes in the plate (112) align with those in part (91). Reinsert and tighten the three bolts which you loosened at the beginning of the procedure.</p>
14.	Motor turns constantly in one direction after a move axis command is given.	<p>Press the controller RESET button.</p> <p>If pressing the RESET switch stopped the motor's rotation, the problem is probably due to the encoder, or the encoder circuitry in the controller. Check the square wave from both phototransistors while the motor is rotating.</p>
15.	Motor turns constantly in one direction when POWER and MOTOR switches are turned on.	<p>The fault probably lies in the power transistors (on the PC 200N and PC 200P boards) or in the opto-isolators (ICs U45-U48) on the main circuit board (PC 010)). Contact your agent.</p>
16.	The controller does not receive an input signal.	<p>Short the input port to ground. The corresponding LED should light up.</p> <p>If the LED does not light up, use SCORBASE to check whether the input is not functioning or whether the display is faulty.</p> <p>The problem may be in the display board (PC 310) or in the flat cable connecting it to the main circuit board (PC 010). Or, ICU9 on the main circuit board is malfunctioning. Contact your agent.</p>

Item	Problem	Corrective Action
17.	The controller does not give output signals.	<p>Check the wiring to the outputs.</p> <p>If the LEDs light up, but the output does not work, the problem is probably in the controller.</p> <p>If problem is with one of outputs 5-8 (open collector), check first whether a load has been correctly connected, as described in Chapter 2.</p> <p>If both the LED and the outputs do not operate, there is probably a fault in the internal wiring. Contact your agent.</p>
18.	The Home position suddenly changes, and the robot continues operation in relation to the new Home.	<p>This fault may occur continually or once every few hours, due to a “noisy” electrical system which disturbs the communication between the robot and the computer.</p> <p>Execute the Home routine, and reload the program you want to run.</p> <p>If the fault occurs frequently, use filtering equipment on your power line.</p> <p>Contact your agent if you are unable to rectify this problem.</p>

Parts Lists and Exploded Views

Following are parts lists detailing the components used to assemble the robot arm and the controller.

The robot arm parts list includes the isometric drawing numbers used in the diagrams at the end of this chapter.

To order spare parts or replacements, contact your agent. When ordering, specify the new and old (previous) part number and the item description.

Table 7-1: Robot Arm Components – SCORBOT-ER III

Iso.	Part #	Previous Part #	Description
1	113012	AR1	Bearing housing cover (plastic)
2	111401	AR2	Main shaft base
S 2	306003	SC1C4-14	Socket head cap screw #4-40 X 1/4
S 3	306004	SC1C4-38	Socket head cap screw #4-40 X 3/8
4	113004	AR4	Baseplate
5	113001	AR5	Base
S 6	306201	SC1C6-14	Socket head cap screw #6-32 X 1/4
S 8	306002	SC1C2-38	Socket head cap screw #2-56 x 3/8
11	111906	AR11	Tooth gear (120 teeth)
S 11	306204	SC1C8-14	Socket head cap screw #8-32 x 1/4
12	112102	AR12	Bottom Plate
S 12	301205	SC1C8-38	Socket head cap screw #8-32 x 3/8
S 13	306206	SC1C8-12	Socket head cap screw #8-32 x 1/2
S 14	306207	SC1C8-58	Socket head cap screw #8-32 x 5/8
15	112401	AR15	Motors 4+ 5 support base
16	112403	AR16	Clamp for motors (4+ 5) support

	Part #	Previous Part #	Description	
	17	110202	AR17	Right side plate
	18	110207	AR18	Left side plate
S	18	306401	SC1F10-38	Socket head cap screw #10-32 x 3/8
S	19	306402	SC1F10-12	Socket head cap screw #10-32 x 1/2
	20	111901	AR20	Anti-backlash tooth gear (transfer)
S	20	306404	SC1F10-34	Socket head cap screw #10-32 x 3/4
S	21	306405	SC1F10-78	Socket head cap screw #10-32 x 7/8
	22	111902	AR22	Anti-backlash tooth gear (upper)
S	22	306407	SC1F10-114	Socket head cap screw #10-32 x 1/4
	23	113501	AR23	Anti-backlash spring
S	23	306403	SC1F10-58	Socket head cap screw #10-32 x 5/8
	24	107003	AR24	Washer
S	26	306602	SC1C14-1	Socket head cap screw #1/4-20 x 1
	27	111903	AR27	Anti-backlash tooth gear (bottom)
S	27	306602	SC1C14-58	Socket head cap screw #1/4-20 x 5/8
	28	111907	AR28	Tooth gear (base motor)
S	31	306414	SCEF10-14	Socket head cap screw #10-32 x 3/4 x 1/4 shoulder
	32	319404	GE1018	Tooth gear (motors 2+ 3)
	34	112405	AR34	Motor support (2)
S	34	113505	SPS34	Spring 220 g. (motors 2+ 3)
	35	112404	AR35	Motor support (3)
	37	112402	AR37	Motor support (motors 4+ 5)
	38	319406	AR38	Timing belt pulley (motors 4+ 5)
	39	113502	SPS39	Spring 55 g. (motors 4+ 5)
	40	111606	AR40	Rear cross member
	46	111402	AR46	Main shoulder shaft
	47	111909	AR47	Timing belt pulley
	48	111911	AR48	Timing belt pulley
	49	111905	AR49	Tooth gear (72 teeth)
	52	111405	AR52	First tension shaft
	53	113013	AR53	Tension wheel
	55	111406	AR55	Second tension shaft
	56	113014	AR56	Tension pulley
	57	112406	AR57	Clamp – lower arm – left side plate
	58	110212	AR58	Lower arm – right side plate
	60	111904	AR60	Tooth gear (right – 72 teeth)
	61	110217	AR61	Lower arm – left side plate
	63	112407	AR63	Clamp – lower arm – left side plate

Iso.	Dwg #	Part #	Previous Part #	Description
	64	111403	AR64	Middle shaft
	67	107001	AR67	Aluminium spacer
	70	111910	AR70	Timing belt pulley
S	70	306007	SC3C4-14	Flat head socket screw #4-40 x 1/4
	72	111407	AR72	Third tension shaft
	74	111404	AR74	Gripper axis
	76	112439	AR76	Stopper (motors 4+ 5)
	77	110705	AR77	Baseplate limit switch
S	81	306201	SC3C8-38	Flat head socket screw #8-32 x 3/8
	82	113008	AR82	Timing belt pulley + miter gear
S	82	306211	SC3C8-12	Flat head socket screw #8-32 x 1/2
	84	110227	AR84	Upper arm left side plate
	86	111912	AR86	Timing belt pulley
S	87	306410	SC3F10-12	Flat head socket screw #10-32 x 1/2
	88	110222	AR88	Upper arm – right side plate
	91	112408	AR91	Gripper gear motor support
S	91	306412	SC3F10-114	Flat head socket screw #10-32 x 1/4
	94	113801	AR94	Lead screw
	96	112117	AR96	Gripper bridge
	97	112118	AR97	Gripper arm (inner)
	98	112119	AR98	Gripper arm (outer)
	99	112120	AR99	Gripper arm (short)
	100	112113	AR100	Gripper clamp
	101	110703	AR101	Mounting plate – gripper
	102	113201	AR102	Rubber pad – gripper
	103	111409	AR103	Pivot pin
	105	111408	AR105	Main shaft – gripper
	107	113802	AR107	Lead nut – gripper
	108	112115	AR108	Bearing housing
	109	112116	AR109	Bearing housing cover
	112	110229	AR112	Gripper motor base plate
	113	113503	AR113	Spring 120 g. (gripper motor)
S	115	45007	PC503	Encoder circuitry (3 slots)
	116	113009	AR116	Miter gear (bottom)
S	116	45006	PC502	Encoder circuitry (6 slots)
	127	107009	WA7S127	Spacer washer (for base bearing)
S	139	306008	SC2C4-18	Socket head set screw #4-40 x 1/8
S	153	306214	SC2C8-14	Socket head set screw #8-32 x 1/4 (without head)

Iso.	Dwg #	Part #	Previous Part #	Description
	169	40002	AR420	Gripper harness
	170	40001	AR421	Cable 50 leads + connector
	172	412364	CC7F12I3	Connector housing (12 pin)
	173	412606	PI4MA	Connector pin
	174	300008	UV6	Clamp – cable 50 lead
S	187	302002	SC5M2-10	Socket binding head screw M2 x 10 (limit switch)
S	188	302001	SC5M2-8	Slotted binding head screw M2 x 8 (limit switch)
S	189	302006	SC7M2-20	Slotted binding head screw M2x20 (encoder housing)
S	206	313001	WA1C4	Washer (for screw #4-40)
S	208	313004	WA1C10	Washer for screw #10-32
S	209	313005	WA1C14	Washer for screw Ø 1/4
S	215	314002	WA2C4	Spring washer (for screw #4-40)
S	216	314003	WA2C6	Spring washer (for screw #6-32)
S	217	314004	WA2C8	Spring washer (for screw #8-32)
S	218	314005	WA2C10	Spring washer (for screw #10-32)
S	219	314006	WA2C14	Spring washer (for screw Ø 1/4)
S	225	314503	WA3M2	Lock washer M2
S	227	313003	WA1C8	Washer (for screw #8-32)
S	232	107008	WA8S232	Teflon washer Ø 1/4" x Ø 3/8" x 0.6mm
S	233	107007	WA8S233	Teflon washer Ø 1/4" x Ø 1/2" x 0.6mm
S	234	113016	WA8S234	Nylon washer Ø 11 x Ø 4
S	240	310001	NU1U2	Hexagonal nut M2
S	253	316006	CI3C18	E-Ring Ø 1/8 DIN 6799
S	254	316003	CI1M10	Retaining ring Ø 10 DIN 471
S	255	316004	CI1M12	Retaining ring Ø 12 DIN 471
S	257	316302	CI1M25	Retaining ring Ø 25 DIN 471
S	260	320005	BE10822	Ball bearing Ø 8 x Ø 22 x 7
S	261	320004	BE11019	Ball bearing Ø 10 x Ø 19 x 5
S	262	320006	BE11026	Ball bearing Ø 10 x Ø 26 x 8
S	263	320203	BE12547	Ball bearing Ø 25 x Ø 47 x 8
S	268	320701	BE21216	Needle bearing Ø 12 x Ø 16 x 10
S	269	320702	BE21219	Needle bearing Ø 12 x Ø 19 x 16
S	270	320704	BE51215	Needle bearing Ø 15 x Ø 21 x 12
S	275	320501	BE31024	Thrust bearing Ø 10 x Ø 24 x 2
S	276	320502	AS31024	Thrust washer Ø 10 x Ø 24 x 1
S	277	320503	LS31024	Thrust washer Ø 10 x Ø 24 x 2.5
S	278	320504	BE31226	Thrust bearing Ø 12 x Ø 26 x 2
S	279	320505	AS31226	Thrust washer Ø 12 x Ø 26 x 1

Iso.	Part #	Previous Part #	Description
S 283	314501	WA4M10	Lock washer
S 285	310401	NU4M10	Lock nut – gripper
S 286	310402	NU4S286	Lock nut – base KM 5
S 288	100706	WA9S288	Washer Ø 10.5 x Ø 20 x 0.5
S 289	100705	WA9S289	Washer Ø 12.5 x Ø 22 x 0.5
S 293	319201	AR293	Timing belt
S 294	319202	AR294	Timing belt
S 295	319203	AR295	Timing belt
S 300	315202	AR300	Flange – timing belt pulley
S 301	315201	AR301	Flange – timing belt pulley
S 308	317501	PN1C18-38	Pivot pin Ø 1/8" x 3/8"
S 309	430901	AR309	Gear motor (base; no.1) 127.7:1
S 310	430901	AR310	Gear motor (shoulder/elbow; no. 2 + 3) 127.7:1
S 311	430902	AR311	Gear motor (pitch/roll; no. 4 + 5) 65.5:1
S 312	430903	AR312	Gripper motor (no. 8)
S 313	319001	AR313	Coupling
S 315	410802	SW712M0	Limit switch
S 316	310802	NU5C8	Nut for harness
S 317	300006	PA4317	Harness clamp
S 318	113006	PA113	Rubber plug (base)
S 319	300007	PA408	Harness clamp
S 320	314007	WA5M10	Conical washer
S 322	113203	PA205	Rubber grommet
S 324	113202	PA512	O-ring (rubber)
S 325	113204	PA310	Rubber stopper
S 350	317801	PN2C18-114	Roll pin Ø 1/8 x 1 1/4
S 351	317502	AR351	Ball bearing Ø - 3.5 mm
414	105001	UV414-1	Encoder disk (3 holes)
427	113005	UV427	Encoder housing (plastic)
429	105002	UV429-1	Encoder disk (6 holes)

Table 7-2: Controller Components – SCORBOT-ER III

Part #	Description
35007	110V/220V transformer
40013	Main power cable set (within controller)
40014	Diode bridge cable set (within controller)
40015	RS-232 cable set (within controller)
40016	Ground cable (within controller)
45001	PCB 010 main board
45002	NPN PCB 200 driver board
45003	PNP PCB 200 driver board
45004	PCB 310 I/O board
45005	PCB 410 power supply board
102311	Voltage tag
110707	Controller housing base
110709	Controller housing cover
110711	Transformer cover
110713	PCB 200 support bracket
307201	Phillips round head screw #4-40x3/8"
307202	Phillips countersunk head screw #4-40x1/4"
307203	Phillips countersunk head screw #4-40x3/8"
307204	Phillips countersunk head screw #4-40x1/2"
307402	Slotted round head screw #6-32x3/8"
307404	Phillips round head screw #6-32x1/4"
309001	D-connector screw and nut #4-40x3/16"
310601	Nut #4-40x3/16" – nickel plated
310604	Nut #4-40 – zinc plated
310605	Nut #6-32x5/16" – zinc plated
310606	Nut #6-32 self-locking – zinc plated
310607	Nut #6-32x7/32"
310804	Nut #8-32 self-locking – zinc plated
313003	Flat washer M4 DIN125a
313009	Fiber washer M4
314001	Spring washer UN#4 – zinc plated
314003	Spring washer UN#6
314506	Star washer #6
314507	Star washer #4 – zinc plated
315003	Plastic nut #6-32
315004	Plastic spacer
408515	LED housing

Part #	Description
410506	Fuse 1A
4109511	Fuse 4A
410601	Fuse housing
411815	Flat cable to ER III

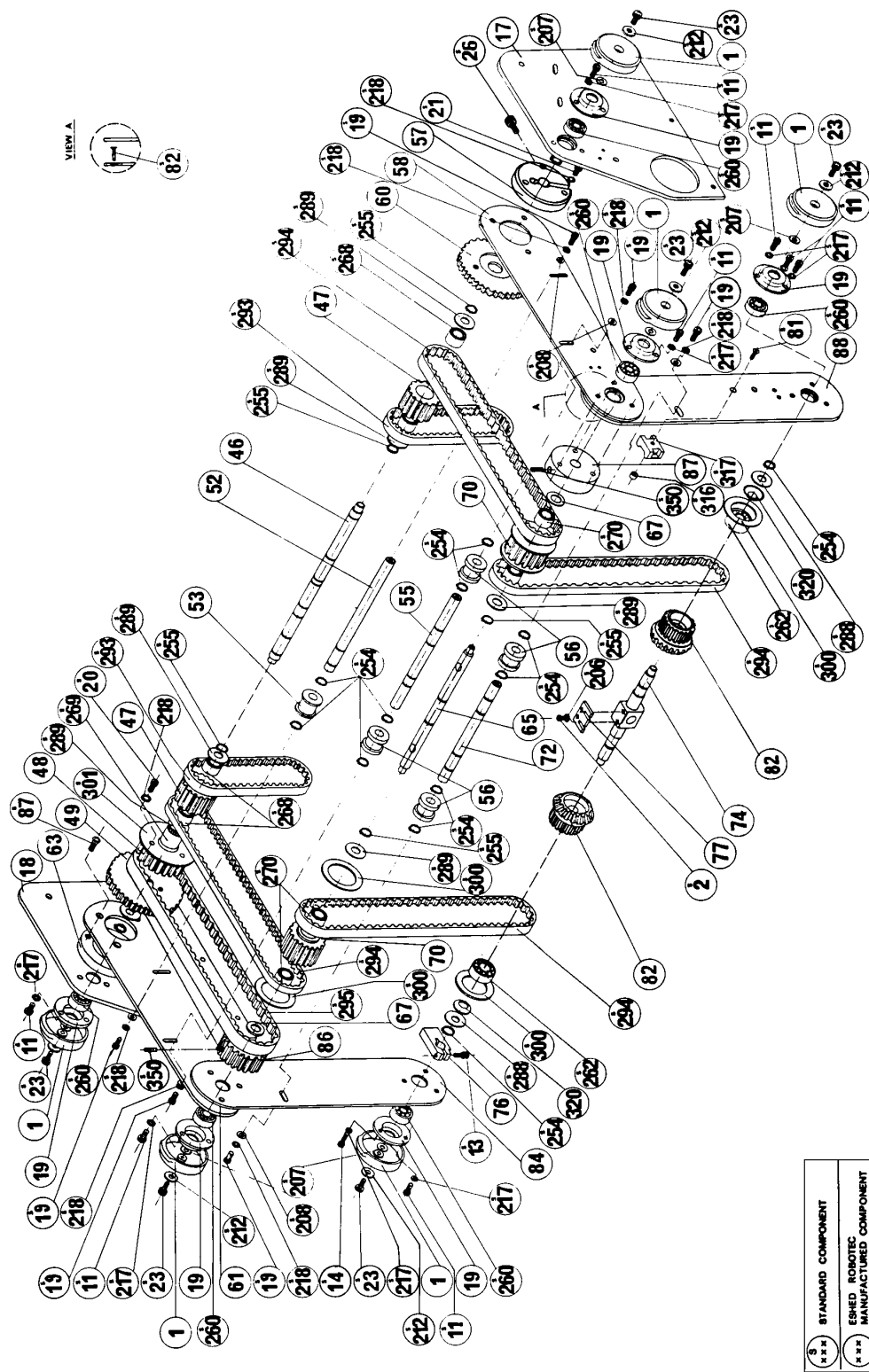


Figure 7-2: Robot Arm Assembly

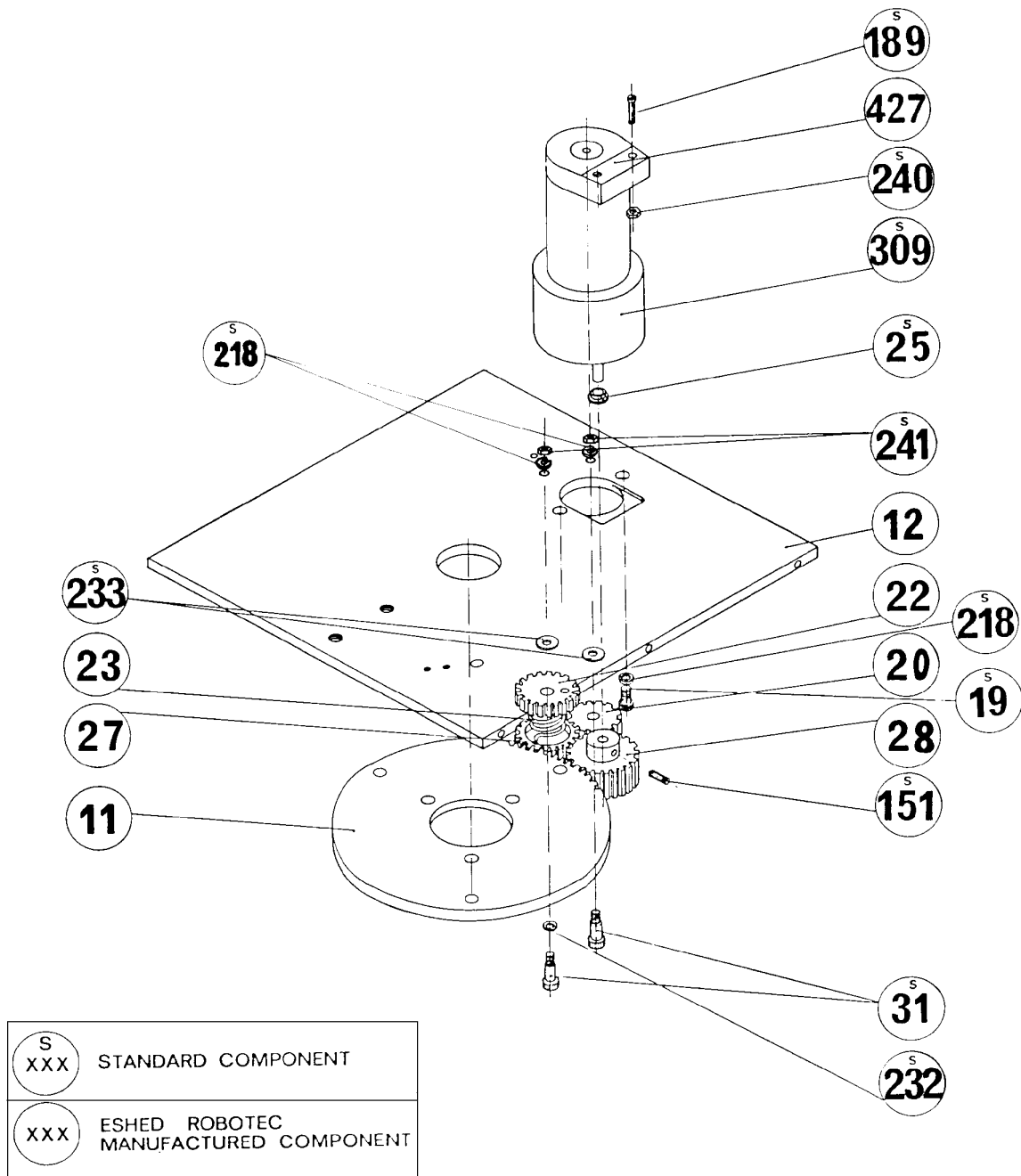


Figure 7-3: Anti-Backlash Assembly

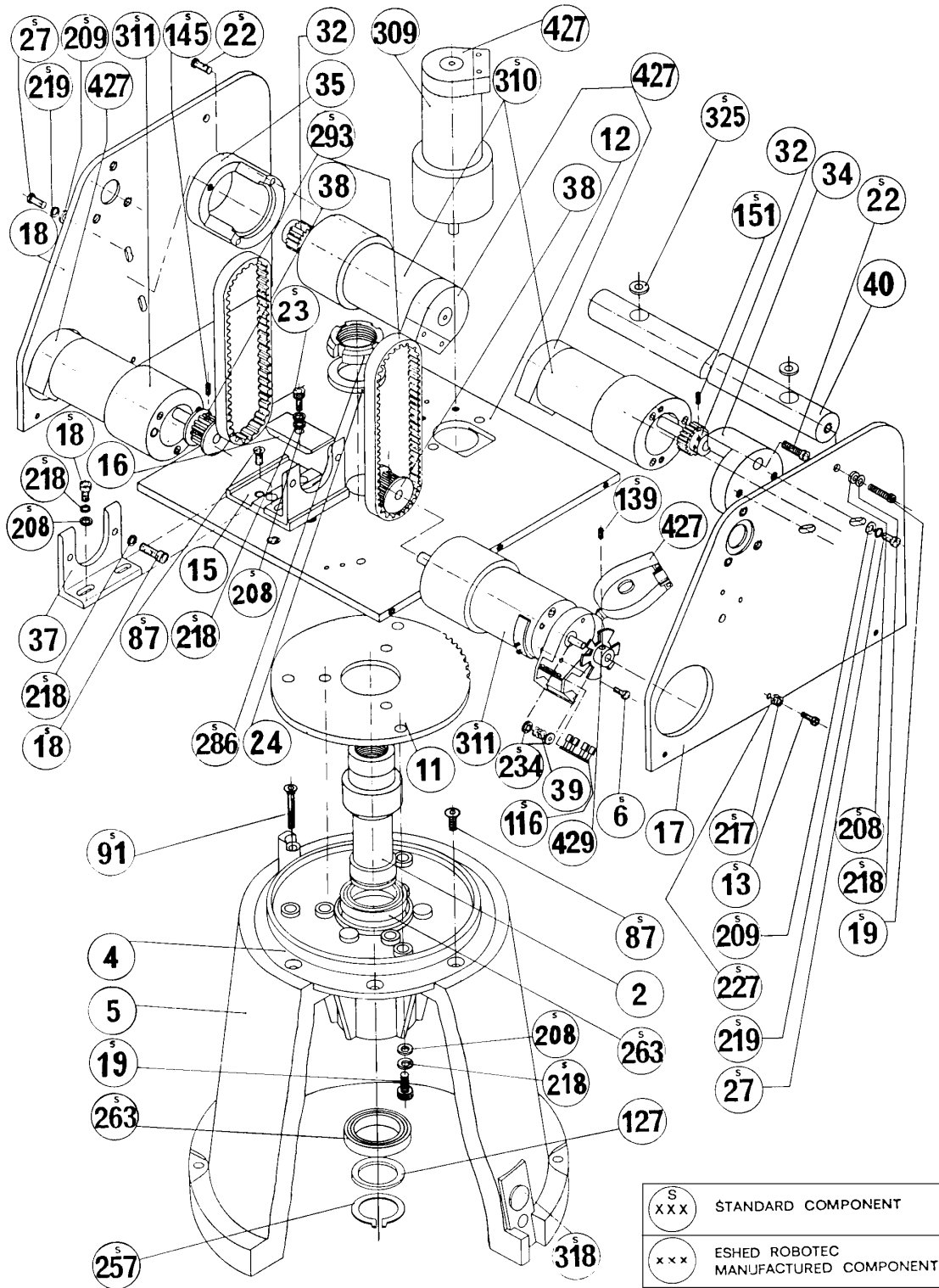


Figure 7-4: Base and Motors Assembly

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Writing Software for SCORBOT-ER III

The SCORBOT-ER III Operating System

The operating system incorporated in the robot controller lets you program the robot without using **SCORBASE**.

The operating system of the robot is stored in an EPROM in the controller. It allows you to type on the computer keyboard the ASCII characters for robot commands.

To input these commands, use one of the following:

- A terminal.
- DOS with COM1 device.
- A communication utility program.
- Eshed Robotec's UTILITIES+ program.

Controller Operating System Commands

Communication is initiated by the host computer, which sends all its commands to the controller as a continuous serial transmission of ASCII codes. Commands may be categorized according to the controller response which they elicit:

- | | |
|-------------------------|--|
| Uni-directional: | The controller does not transmit a response. |
| Regular bi-directional: | The controller response is one ASCII character, such as 0 or 1 . |
| Special bi-directional: | The controller response consists of two consecutive bytes. |

Note that the TX and RX LEDs on the controller rear panel light up to indicate that communication between the controller and the host computer is functioning properly. If you are having trouble operating the robot, check that these LEDs are indeed lit.

Uni-Directional Commands

Uni-directional commands are sent to the controller as a continuous serial transmission of ASCII codes. These commands activate robot operations. The controller does not transmit a response to these command.

Motor Movement

a M ± bcde ↵

- a** A digit from 1 to 8, denotes the number of the motor to be operated.
- M** Designates a **motor movement** command.
- ±** A plus (+) or a minus (−) sign, denotes the required direction of motor rotation. If no sign is used, the direction is considered positive.
- bcde** A four-digit number, ranging from + 8000 to −80000, denotes the required amount of motion, measured in encoder pulses.
- ↵** Carriage return.

On receipt of ↵, the controller will operate the specified motor for the prescribed extent of motion. The defined number of encoder pulses is stored in the register of the specified motor. The processor recognizes that the value stored in the register is not equal to 0, and connects the voltage for motor operation. As the motor turns, so does its encoder, which transmits pulses to the controller. With each pulse received, the value stored in the register is decremented by 1; when the value stored in the register equals 0, the processor disconnects the voltage from the motor.

If a new movement command for the motor is entered before the motor stops, the number of pulses defined in the new command will be added to the value remaining in the motor's register.

Warning! Use small numbers at first, to reduce the danger of the motor stalling following a collision of the robot arm with objects or with itself, or the motor coming to a mechanical end stop. If, despite this precaution, the motor stalls, press the RESET switch on the controller front panel; this will reset all motor registers to zero, thus stopping all motors.

Set Speed of Motors

a V b

- a** A digit from 1 to 8, denotes the number of the motors whose speed is to be set. Use 0 to denote all motors.
- V** Designates a **motor speed** command.
- b** A digit from 0 to 9, denotes the speed setting. The slowest speed is 1, increasing to 9. The fastest speed is 0.

Set Output

a S

- a** A digit from 1 to 8, denotes the number of the output to be operated.
- S** Designates a **set output** command.

On receipt of S, the controller will activate the desired output. The output LED will light. If the number of the output selected is between 1 and 4, a soft click will be heard as the output relay contacts close.

Reset Output

a R

- a** A digit from 1 to 8, denotes the number of the output to be disconnected.
- R** Designates a **reset output** command.

On receipt of R, the controller will disconnect the desired output. The output LED will go out. If the number of the output selected is between 1 and 4, a soft click will be heard as the output relay contacts open.

Stop Motor Movement (with Loss of Information)

a P

- a** A digit from 1 to 8, denotes the number of the motor to be stopped.
- P** Designates a **stop motor movement** command.

On receipt of P, the controller will reset the register of the specified motor, thus causing an immediate stop. Since the register of that motor contained a value indicating the amount of motor motion still to be carried out, resetting the register

to zero will cause the controller to lose all information on the amount of motion executed by that motor before it received the stop command.

Emergency Brake all Motors (without Loss of Information)

B

B Designates an **emergency brake** command.

On receipt of B, the controller will stop all robot motor motion. At the moment of braking, the controller resets all motor registers to zero, but stores the information required to complete the interrupted movement in a special area of the backup memory.

Resume Motor Movement (following Emergency Brake)

C

C Designates a **resume motor movement** command.

On receipt of C, the controller will restore the robot motion information from the backup memory to the motor registers, causing the robot motor to restart and complete the originally programmed motion.

Set a New Offset

U abc *

U Designates the **change offset** command.

abc A three-digit number, denoting the new offset, instead of 14 pulses.

***** Denotes end of command.

Refer to the bi-directional command E for checking the completion of motor movement.

Disable Interrupt Mode

X

X Designates the **disable interrupt mode** command.

This command prevents the controller from sending interrupts to the host computer (by means of the RS-232C port) when the events listed above occur.

Refer to the bi-directional command W for enabling the interrupt mode.

Regular Bi-Directional Commands

To reduce the possibility of error, it is recommended that bi-directional commands be transmitted twice in succession (for example, A I A I). Then refer only to the controller's second response.

Check Input Status

a I

- a** A digit from 1 to 8, denoting the number of the input to be checked.
- I** Designates an **input status check** command.

On receipt of I, the controller will check the status of the specified input and respond with the following ASCII codes:

- 1 If the input is ON (that is, if a short circuit exists between the two input terminals).
- 0 If the input is OFF (that is, if a state of disconnection exists between the two input terminals).

Check the controller response to the status of inputs 1 and 2 by turning input switches 1 and 2 on and then off. Also check the controller response to the status of inputs 3 through 8 by changing their status (short circuit or disconnect) from the controller front panel.

Check Limit Switch Status

a L

- a** A digit from 1 to 8, denoting the number of the limit switch to be checked.
- L** Designates a **limit switch status check** command.

On receipt of L, the controller will check the status of the specified limit switch and respond with the following ASCII codes:

- 1 If the limit switch is ON (that is, if the limit switch on the robot arm is depressed).
- 0 If the limit switch is OFF (that is, if the limit switch on the robot arm is released).

Check Completion of All Motor Movement

T

T Designates a **movement completion check** command.

On receipt of T, the controller will check whether all robot motors have completed their programmed motion – that is, whether all motor registers are set to zero – and respond with the following ASCII codes:

- 1 If all robot motors have completed their programmed movement.
- 0 If any robot motor has not completed its programmed movement.

Check Expected Completion of All Motor Movement (Offset of 14 Pulses)

E

E Designates an **expected movement completion check** command.

This command resembles the T command, with one exception. The T command checks whether all motor registers are set to zero. The E command checks whether all motor registers store values less than 14.

On receipt of E, the controller will check whether all robot motors are about to completed their programmed motion – that is, whether all motor registers have less than 14 steps, or encoder pulses, remaining to completed their programmed motion – and will respond with the following ASCII codes:

- 1 If all robot motors are about to complete their programmed movement.
- 0 If any robot motor is not about to complete its programmed movement.

This command is used to ensure smooth robot arm motion between positions. The controller is sent a movement command to the next position before the robot arm has reached the previous position, to prevent discontinuity of motion.

Refer to the uni-directional command U for setting a new offset.

Check Status of Motors

A

A Designates a **check motor status** command.

On receipt of A, the controller will check the status of all motors and respond with the following ASCII codes:

- 0 If none of the motors is moving, and none is intended to move.
- If all the motors have less than the offset number of encoder pulses to complete their movements.
- + If there are motors which still have to complete more than the offset number of pulses to complete their movement.
- 1 . . . 8 If a motor error has occurred on motor 1 through 8; that is, the motor does not move as instructed.

Enable Interrupt Mode

W

W Designates the **enable interrupt mode** command.

On receipt of W, the controller will effect interrupts to the computer whenever specific events occur. The controller sends the following ASCII codes as interrupts:

- 0 Change from motor movement to motor stop on all the motors.
- Change from the state in which at least one motor has more than the offset remaining to state where no motor has more than the offset remaining.
- 1 Change from the state of the movement of the motors 1 though 8 to a state in which they are stalled or fail to move (motor error).
- L1 . . . L8 When limit switch (1 through 8) goes from OFF to ON state.
- K1 . . . K8 When limit switch (1 through 8) goes from ON to OFF state.
- I1 . . . I8 When input (1 through 8) goes from OFF to ON state.
- J1 . . . J8 When input (1 through 8) goes from ON to OFF state.

Refer to the uni-directional command X for disabling the interrupt mode.

Special Bi-Directional Commands

Controller response to the special bi-directional commands is two bytes in binary code.

Check Remainder of Motor Movement

a Q

- a** A digit from 1 to 8, denotes the number of the motor to be operated.
- Q** Designates a **check remainder of motor movement** command.

On receipt of Q, the controller will check the quantity of motion remaining to be performed by the motor, as stored in the register of that motor.

The controller response is in two bytes because robot axis motion is measured in thousands of encoder pulses. Since a maximum remaining quantity is 8000, the controller's response will be transmitted as follows:

- (1) Division of the 14-bit response into 2 bytes of 7 bits each.
- (2) Addition of an eighth bit, with a value of 1, to each byte, to serve as most significant bit (MSB).
- (3) Transmission of the two bytes to the host computer – first the most significant byte, then the least significant byte, with no transmission between or following the two bytes.

Check Remainder of Motor Movement (following Emergency Brake)

a Z

- a** A digit from 1 to 8, denotes the number of the motor to be operated.
- Z** Designates a **check remainder of motor movement** command **following emergency brake**.

The Z command is identical to the Q command, with the following exception. The Q command is used while the robot is in motion. The Z command is used only after an emergency brake command, to update the present position of the robot motor (relative to the start of the programmed motion).

Switching the Communication Ports

As explained in the section, “Connecting the Teach Pendant to the Controller,” in Chapter 5, the controller normally transmits through the lower RS-232C port to the computer. When the teach pendant is connected to the system, transmission is automatically routed through the upper RS-232C port (to the teach pendant.)

To transfer programs between the teach pendant and the computer, the controller produces an echo; that is, transmissions entering through the upper port are transmitted by the controller to the lower port, and vice versa.

The commands which enable communication between the teach pendant and the external computer are as follows:

- F** Switches the transmission line of the controller from the current port to other port. After the switching, the ASCII code F is transmitted through the new current transmission line.
- G, H, J, K** Lifts the Load-Save flag to the ON state. The character is then transmitted through the current transmission line.

When the flag is on, every byte which reaches the controller with its most significant bit (MSB) equal to 1 is transmitted through the current transmission line of the controller. (MSB = 1, indicates data to be transmitted by controller; MSB = 0, denotes a command for controller execution.)

If the flag is off, the controller does not check the MSB.

G Transmits programs between TP and computer.

H Transmits positions between TP and computer.

J TP requests programs from computer.

K TP request positions from computer.

- D** Denotes end of command. Drops the Load-Save flag to the OFF state. The controller then transmits the ASCII code D through the current transmission line.

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Controller-Computer RS232 Setup

The robot controller contains a microprocessor which runs under the control of an external computer. The two units communicate by means of RS232 connections.

SCORBOT-ER III RS232 Specifications

- Baud rate: 9600
- Data bits: 8
- Stop bits: 2
- No parity

The two D25 ports are located at the rear of the controller (see Figure 3-2). The lower port connects the controller to the computer. The upper port connects the controller to the teach pendant.

Between these ports are two LEDs marked TX (for transmission) and RX (for reception). These LEDs flicker as signals pass through the RS232 cable, signifying that communication between **SCORBOT** and computer is occurring.

Note: The computer and the teach pendant can be connected to the controller at the same time, only if **SCORBASE** Level 4 has been loaded. Refer to the section, “Connecting the Teach Pendant to the Controller,” in Chapter 5.

RS232 Cable Connections

When a computer (IBM PC or compatible) is used to operate the **SCORBOT-ER III**, the RS232 cable connections should be as listed in the chart below. Pin functions are as follows:

Pin 2: Transmission
Pin 3: Reception
Pin 7: Signal Ground

PC Computer
(D25 female connector)

SCORBOT-ER III Controller
(D25 male connector)

Pin 2	to	Pin 3
Pin 3	to	Pin 2
Pin 7	to	Pin 7
Pin 4	to	Pin 5
Pin 6	to	Pin 8 and 20

Other computers and terminals may require different RS232 connections. Check the manufacturer's specifications.

RS232 Card Setup

1. All Eshed Robotec software packages are set with the first serial port as COM1 and require that the RS232 communication **interrupt** is **enabled** (see Figure 3-3).

<u>Configuration</u>	<u>DIP switch position</u>
Serial Port 1 = COM 1	1 ON
COM1 interrupt (IRQ4)	5 ON
	6 OFF

2. All Eshed Robotec software packages can be modified for use with the COM2 port, by adding the option /C2 when activating the software.

For example, for regular operation of **SCORBASE** Level 3, type:

```
SCOR3 <Enter>
```

For use of **SCORBASE** Level 3 with the COM2 port, type:

```
SCOR3 /C2 <Enter>
```

When using COM2, make sure the interrupt for that port is enabled, and make sure the RS232 card is properly configured. Check the manufacturer's specifications.

Input/Output Applications

Inputs

Figure C-1 shows the internal interface circuitry of a SCORBOT-ER III input.

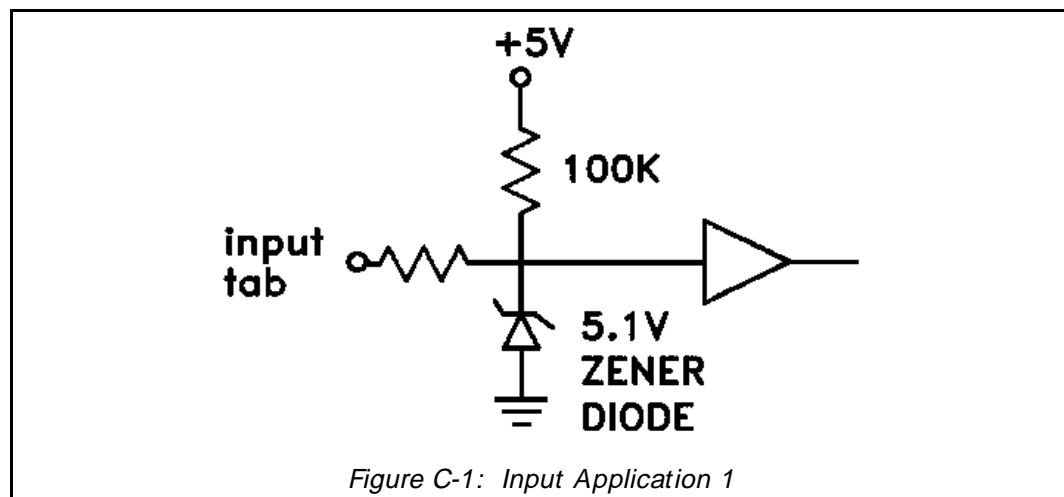
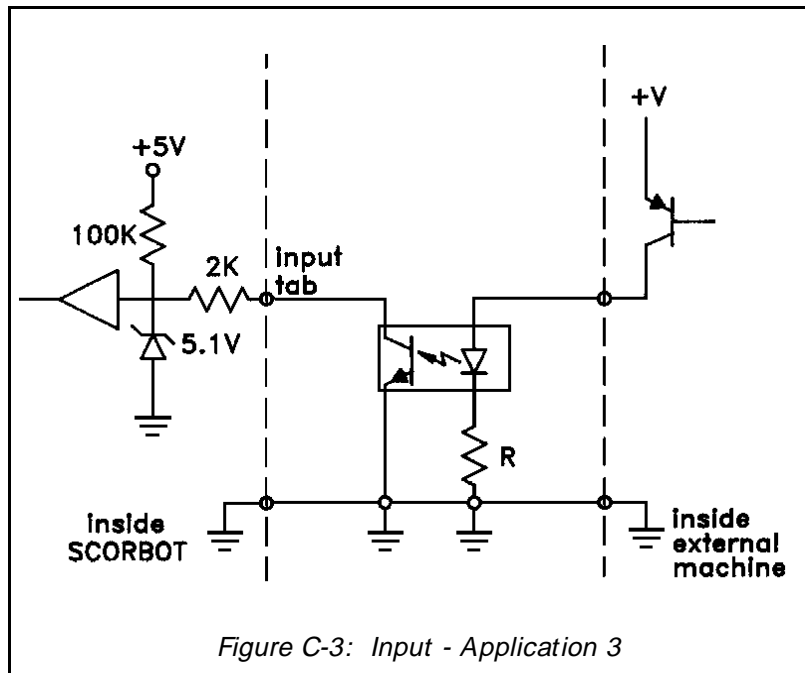
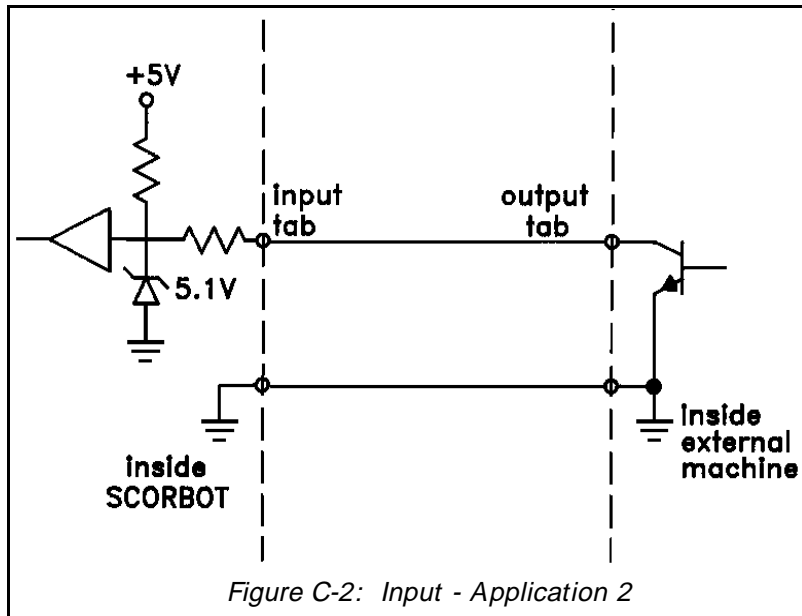


Figure C-2 and Figure C-3 show the connection of a **SCORBOT-ER III** input to an external output.

In Figure C-2, the external machine is an open collector, NPN type, with a grounded emitter.

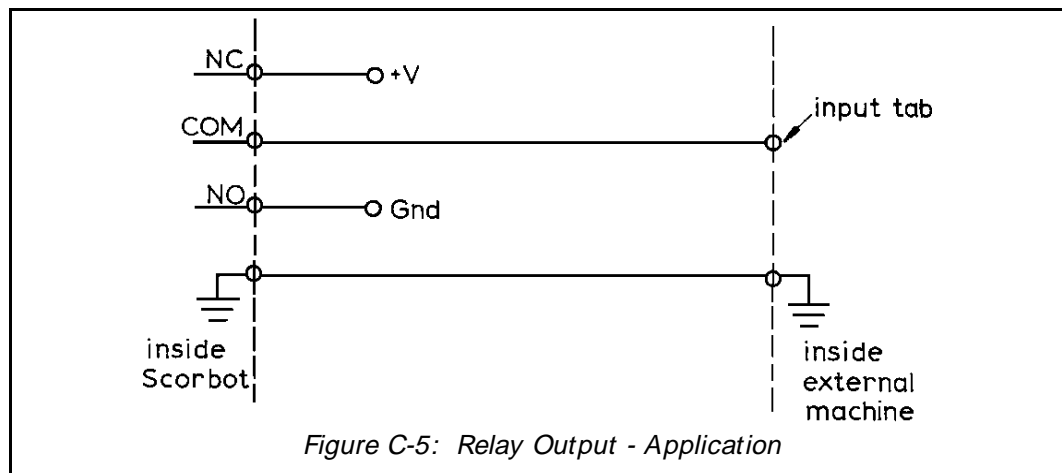
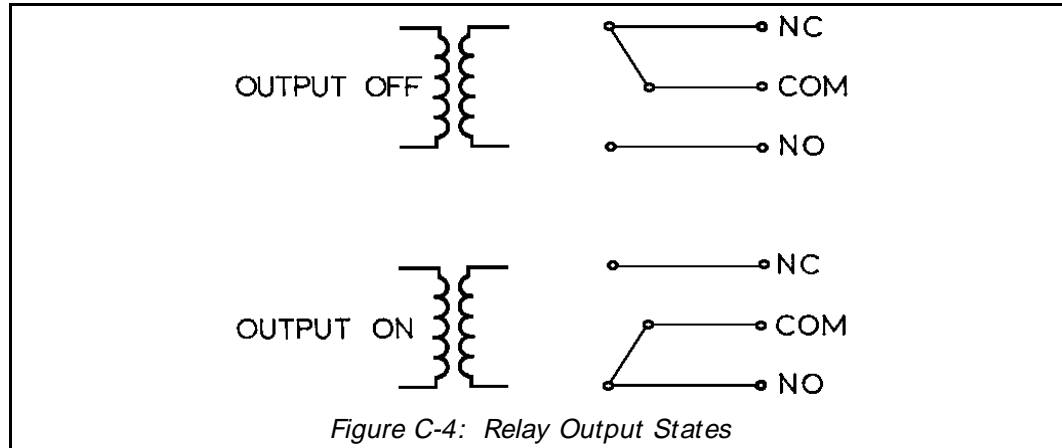
In Figure C-3, the external machine is an open collector, PNP type, with emitter connected to + V.



Relay Outputs (Outputs 1–4)

Figure C-4 shows the OFF and ON states of a **SCORBOT-ER III** relay output.

Figure C-5 shows the connection of a **SCORBOT** relay output to an external input. **Note:** The connection of + V or GND depends on the machine logic of operation, and can be reversed.



Open Collector Outputs (Outputs 5–8)

Figure C-6 shows an open collector output with a suggested application. The open collector output transistor is ULN2003 (NPN).

Figure C-7 shows the connection of a **SCORBOT** open collector output to an external input. The external machine expects a **low voltage** level or ground (0 – 1.5V) for ON activation.

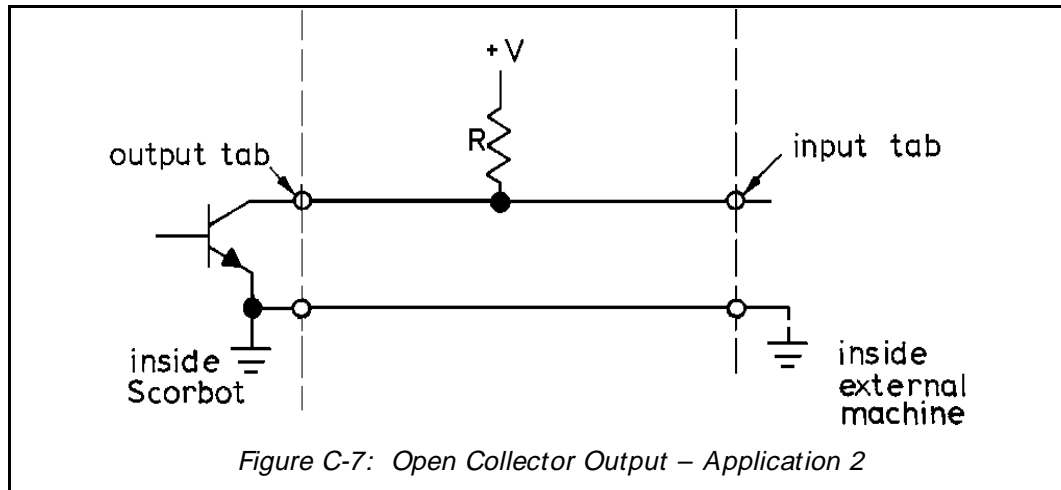
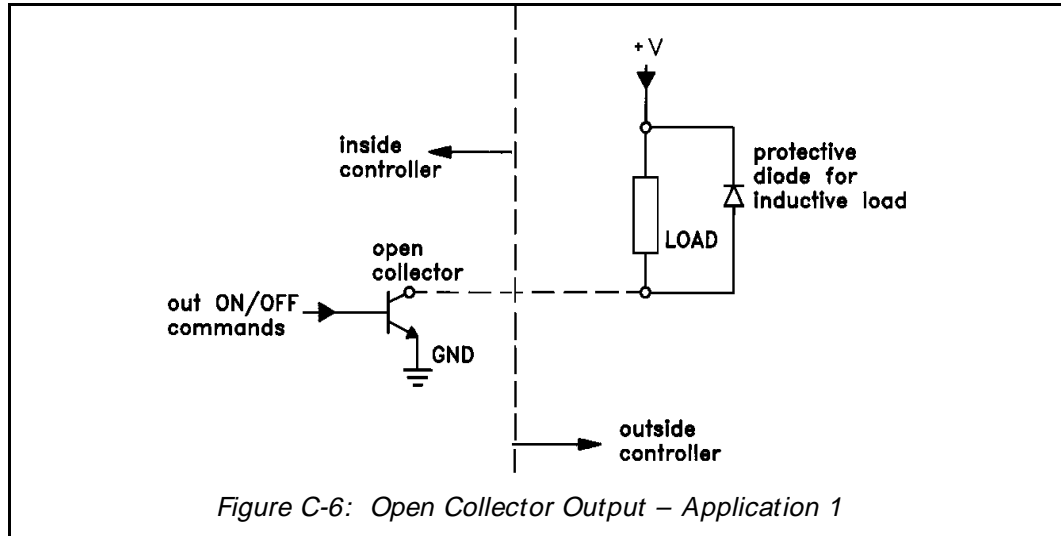
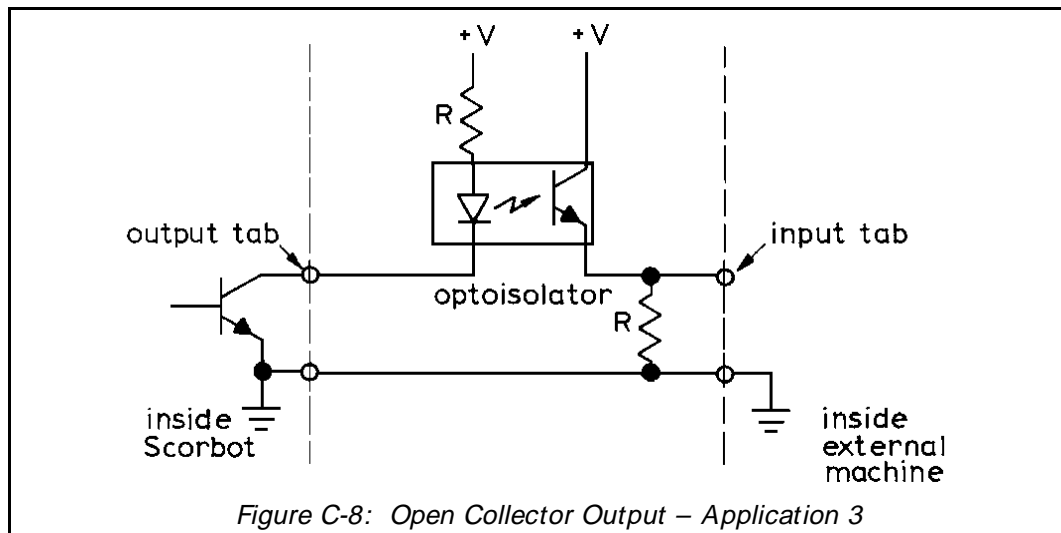


Figure C-8 shows the connection of a **SCORBOT** open collector output to an external input. The external machine expects a **high voltage** level (2.5 – 24V) for ON activation.



Wiring

Controller Wiring

Figure D-1 shows the wiring which connects the circuits within the controller.

Robot – Controller Connections

The cable which connects the controller to the robot motors, encoders and microswitches contains 50 leads in 25 pairs. In each pair one lead is either white or yellow.

The five motors on the robot body and their encoders are connected directly to the D50 connector, whereas the gripper motor and the microswitches on the arm are not.

A square 12-pin connector (Molex CC7F12I3) on the base of the robot is used for connecting special flexible leads to the gripper and the forearm. These leads are resistant to breakage, even after extensive movement of the robot arm.

Each encoder contains a small printed circuit (PC500).

Table D-1 details the wiring between the various electrical components and the 50-pin connector. The table lists the robot arm signals, the colors of the leads, and the pin number in the D50 connector. The table also includes the Molex 12-pin and PC500 wiring.

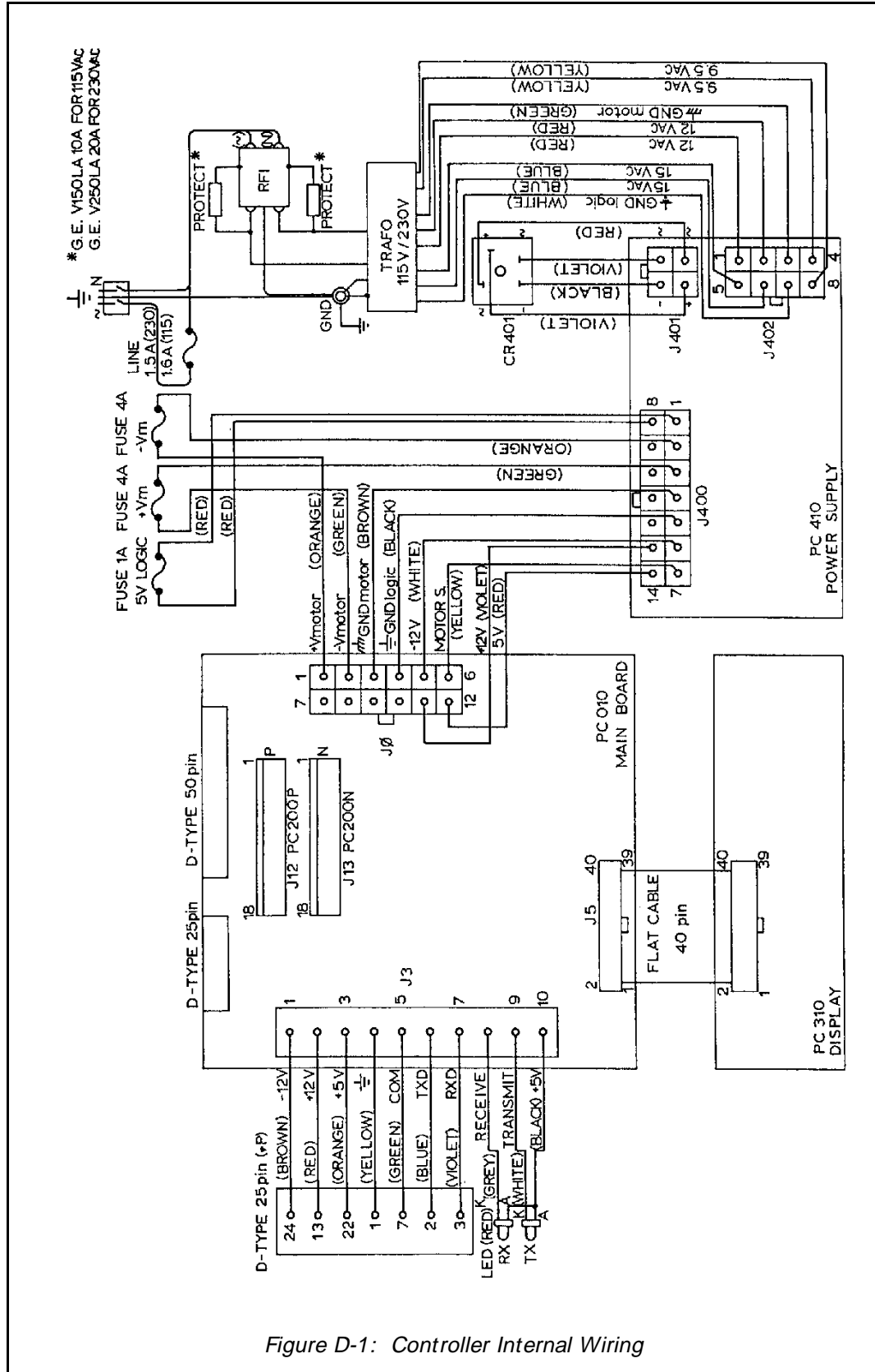


Figure D-1: Controller Internal Wiring

Table D-1: Wiring to Motors, Encoders and Microswitches

Robot Arm Signals			D50 Connector		Molex 12 Pin Connector		Encoder Printed Circuit (PC500)
Motor #	Encoder	Microswitch #	Colors	Pin #	Colors	Pin #	Pad #
1	-		white	50			
	+		grey/green	17			
2	-		white	49			
	+		white/green	16			
3	-		white	48			
	+		orange/brown	15			
4	-		white	47			
	+		orange/green	14			
5	-		white	46			
	+		orange/grey	13			
Grp	-		white	45	grey	8	
	+		orange/blue	12	yellow	7	
	1	GND	white	33			1
		P ₁	white/grey	5			3
	1	V _{LED}	yellow	11			2
		P ₀	brown	2			4
	2	GND	white	32			1
		P ₁	white/orange	21			3
	2	V _{LED}	yellow	27			2
		P ₀	grey	1			4
	3	GND	white	31			1
		P ₁	brown/blue	4			3
	3	V _{LED}	yellow	10			2
		P ₀	green	36			4
	4	GND	white	30			1
		P ₁	green/brown	20			3
	4	V _{LED}	yellow	26			2
		P ₀	orange	35			4

Robot Arm Signals			D50 Connector		Molex 12 Pin Connector		Encoder Printed Circuit (PC500)
Motor #	Encoder	Microswitch #	Colors	Pin #	Colors	Pin #	Pad #
	5 GND P ₁		white green/blue	29 3			1 3
	5 V _{LED} P ₀		yellow blue	9 18			2 4
	Grp GND P ₁		white grey/blue	28 19	black green	12 11	1 3
	Grp V _{LED} P ₀		white white/blue	25 34	yellow brown	10 9	2 4
		1 GND MS	white brown	33 23			
		2 GND MS	white grey	32 7			
		3 GND MS	white orange	31 24	white white	1 2	
		4 GND MS	white green	30 8	blue blue	3 4	
		5 GND MS	white blue	29 6	orange orange	5 6	
	not connected grp GND MS		white brown/grey	28 22			

Single Axis Wiring

In addition to the six motors on the robot arm, the controller can control two other motors, which can be used for operating mechanical equipment and accessories such as conveyors and rotary tables.

The additional motors are connected to the D9 female connectors, marked MOTOR 6 and MOTOR 7 on the controller's front panel.

For additional information about **SCORBOT-ER III** motors, see Appendix F, "The Motor Kit."

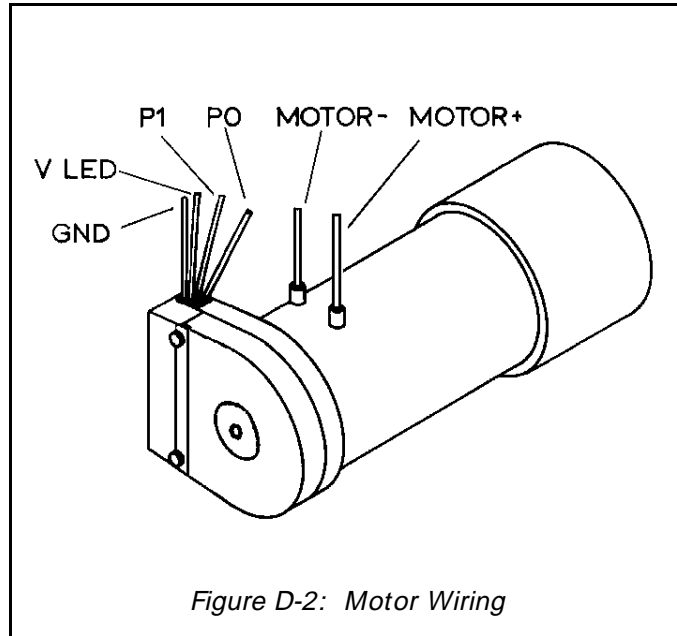


Figure D-2: Motor Wiring

Figure D-2 shows the leads to the motor and encoder. Table D-2 details the wiring in the D9 connector which connects a motor and the controller.

Table D-2: Single Axis Wiring with D9 Connector

Function	Lead Color in External Cable	D9 Connector Pin #	Encoder Circuit (PC500) Pad #
Power Motor (+)	red	1	
Power Motor (-)	green	9	
Phototransistor 0	brown	8	4
Phototransistor 1	white	6	3
V _{LED}	yellow	3	2
Ground Logic (GND)	black	5	1
Microswitch	orange	4	

Note: GND and V_{LED} are always connected to pads 1 and 2, respectively, on the encoder printed circuit (PC500). GND is also connected to the shield on the D9 connector. The phototransistors, P₀ and P₁, are always connected to pads 4 and 3, respectively.

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The Optical Encoders

The **SCORBOT-ER III** uses two kinds of optical encoders. The encoders on motors 1 through 5 differ from those on motors 6 through 8.

Figure E-1 shows the two kinds of encoder disks.

- The encoder disk with six slots (at left) is used on the robot arm motors.
- The encoder disk with three slots (at right) is used on the gripper and accessories such as the conveyor, rotary table or linear slide base.

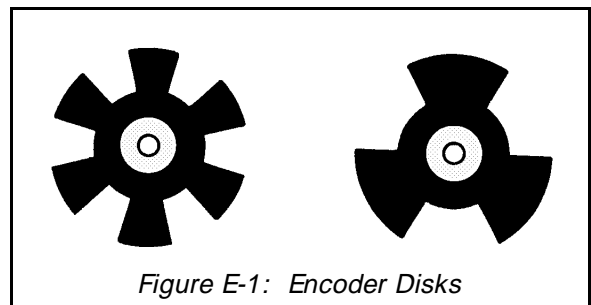


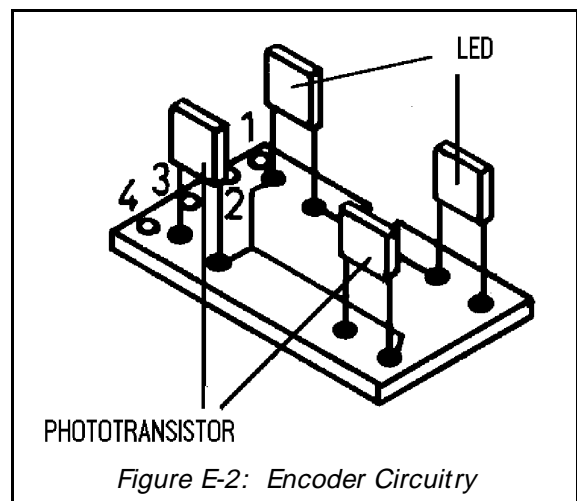
Figure E-2 shows the encoder circuitry. It comprises a printed circuit board (PC500), two LEDs, and two phototransistors (P_0 and P_1).

The circuitry of the two kinds of encoders differs in two ways:

1. Difference in the height of the electronic components above the printed circuit board surface.
 - In the encoder with a six-slot disk the components are $8.2 \text{ mm} \pm 0.1 \text{ mm}$ above the board.
 - In the encoder with a three-slot disk the height is $6.7 \text{ mm} \pm 0.1 \text{ mm}$.

It is extremely important to maintain the exact height of the components.

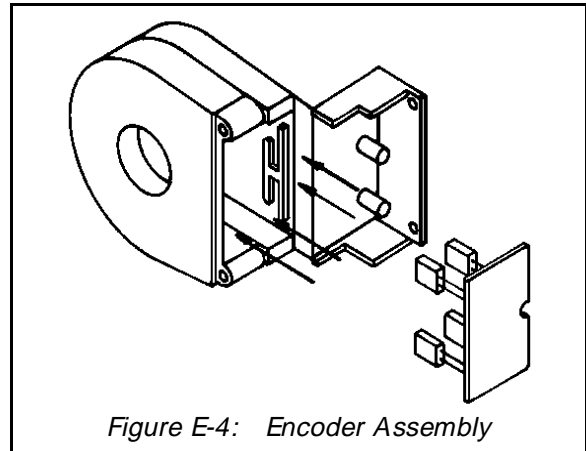
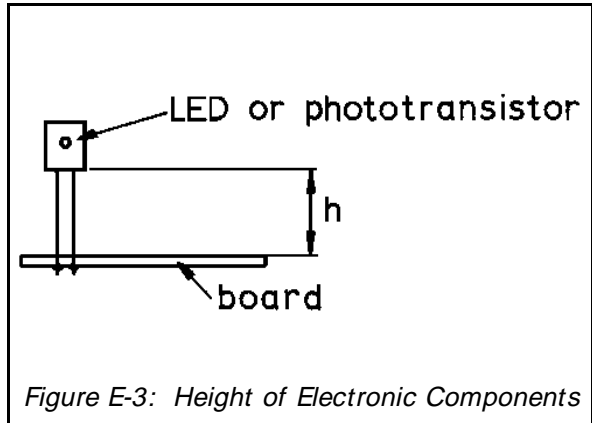
Figure E-3 shows how to measure



the distance between the board and the LED or phototransistor.

2. Difference in the colors of the printed circuit boards.
 - In the encoder with a six-slot disk, there is no solder mask covering the board. The board is a beige color.
 - In the encoder with a three-slot disk, the mask is green and the number 3 is printed on the board.

Figure E-4 shows how the circuitry fits into the encoder housing.



The Motor Kit

The motor kit unit is a complete unit ready to connect axes 6 and 7 to the controller. The motor is identical to the **SCORBOT-ER III** motors. It comprises a DC servo motor, an optical encoder with a three-slot rotating disk, and a connecting cable with a D9 connector (see Figure F-1). It has a gear ratio of 127.7 : 1.

The motor kit allows the quick and easy integration of external devices into the robot system. The output shaft of the motor must be mechanically connected to the device you wish to drive. Electronically, you need only to connect the motor to either of the terminals on the controller front panel, marked **MOTOR 6** and **MOTOR 7**. Activate the motor using **SCORBASE** software; no additional programming is needed.

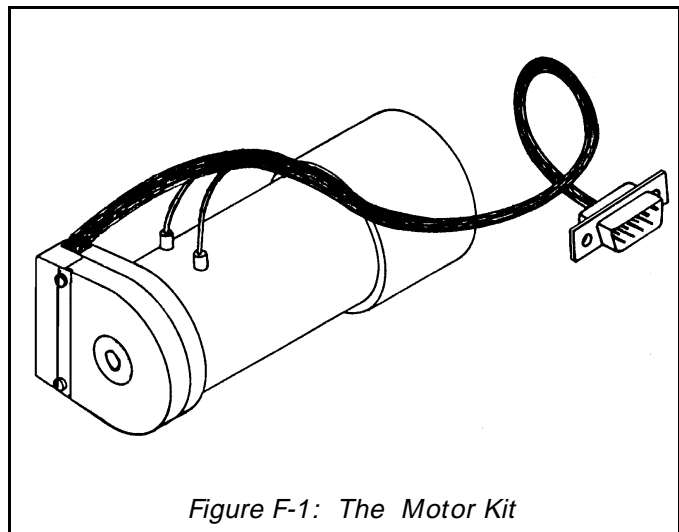


Figure F-1: The Motor Kit

A number of applications are made possible through the use of a motor kit. For example, it can be used to:

- Drive a slidebase, rotating table or conveyor.
- Operate an elevator.
- Control the flow rate of a tap or valve.
- Operate wheels on which robot is mounted.
- Operate a small tracked vehicle (which brings and removes materials to and from a work station).

To drive a two-axis device, use two motor kits connected to the system as motors 6 and 7.

When your application does not require precise movement, you can use the motor kit in an open-loop system. Connect the pair of leads from the motor to an external 12VDC, 1-2 amp power supply, and do not connect the cable to the controller. However, you will probably need a proximity or optical sensors to synchronize the robot and the external device. It is recommended that you switch the current to the motors through one of the relay output terminals on the controller.

When your application requires a DC motor more powerful than the one in the motor kit, you can fit the encoder onto a different motor (provided the motor shaft matches the encoder hole) and connect the encoder leads to the motor.

If you use a motor kit from another source, or if you connect the motor kit to another kind of controller, you must assume full responsibility for the connections. Make sure they are in accordance with the motor kit specifications:

Motor

- 12 VDC nominal voltage.
- 2 amp maximum..

Optical Encoder

- Two channel quadrature output.
- Open collector outputs.
- Emitting diodes fed by 5V supply with a 39 ohm resistor in series.
The resistor is not included in the encoder. Connecting 5V directly to the encoder will damage it.

Cable Wiring (D9 Connector)

<u>Pin</u>	<u>Function</u>
1	Motor (+)
9	Motor (-)
8	Photo Detector
6	Photo Detector
3	V _{LED}
5	Ground Logic (GND)
4	Microswitch *

* If you want to use a microswitch in order to determine a Home position for the motor, connect the microswitch to pins 4 and 5.

The Rotary Table

A rotary table lets you simulate an automatic industrial work station. The rotary table adds a degree of freedom to the robotic system and enables the positioning of work pieces so the robot can reach them (see Figure G-1).

The rotary table can be used for assembly operations or materials handling. It can also be shared, as in a two-robot system where one robot loads and unloads the workpieces onto the rotary table, and the other robot performs the machining operation.

A motor kit within the table's stationary base activates the rotating plate in both clockwise and counterclockwise directions. The motor has a gear ratio of 426 : 1.

The diameter of the rotating plate is a 305 mm (12"). The plate has four metal frames, or jigs, to prevent the slippage or sliding of work pieces during table movement. The internal dimensions of the jigs are 50 mm², 40 mm² and 30 mm².

Connect the D9 connector on the motor cable to either one of the MOTOR terminals on the controller's front panel. **SCORBASE** will then recognize the rotary table as either axis 6 or axis 7.

The rotary table finds its home position by means of a microswitch under the rotating plate. Unlike the microswitches on the robot arm, however, the microswitch on the rotary table is normally depressed, and is released at the home position. Take note of this reversal when making electrical connections.

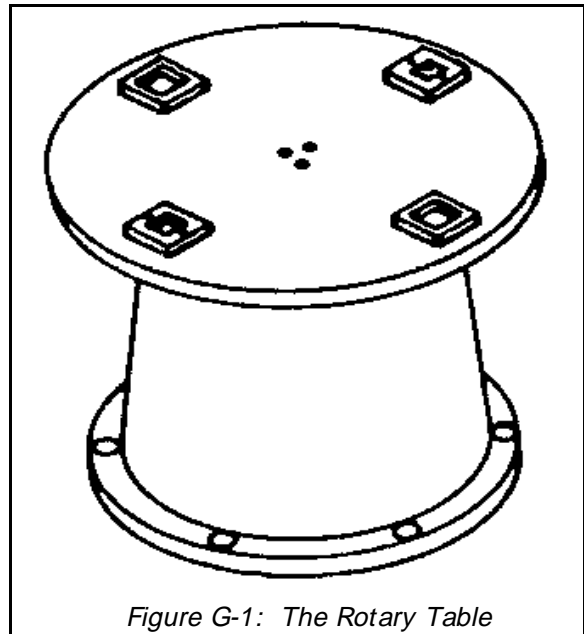


Figure G-1: The Rotary Table

In most robotic applications involving a rotary table, the table must rotate at fixed intervals. To enable periodic movement, use the **SCORBASE** command (available in Level 3): **SET AXIS #. TO ZERO** (where # is the axis number).

Use the Home menu in **SCORBASE** to define and home the rotary table.

The Conveyor

The conveyor accessory expands the robotic system to simulate an industrial work cell. Its main applications are delivering and removing workpieces to and from the robot, and identifying the arrival of a part to the work station (see Figure H-1).

The conveyor is 810 mm long and 100 mm wide. Its metal base has a PVC belt driven by a motor kit with a gear ratio of 65.5 : 1. Supports on each side enable assembly of the conveyor at various heights and angles (maximum of 5 degrees). A number of holes along the length of conveyor enable the attachment of proximity and optical sensors.

The conveyor can be connected as an additional servo axis. Connect the D9 connector on the motor cable to either one of the MOTOR terminals on the controller's front panel. **SCORBASE** will then recognize the conveyor as either axis 6 or axis 7.

The conveyor can also be installed as an open loop device, using an external 12V source on the motor terminals.

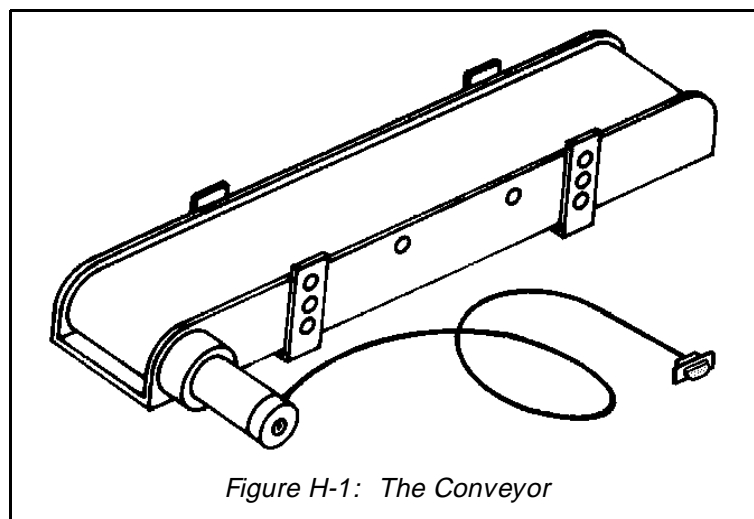


Figure H-1: The Conveyor

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The Experiment (Microswitch) Table

The experiment table is an accessory for demonstrating the concepts of inputs and outputs. You can practice the operation of four controller inputs and two controller outputs.

The table contains microswitches, and a buzzer and a lamp which are powered by two 1.5V AA batteries mounted within the table (see Figure I-1).

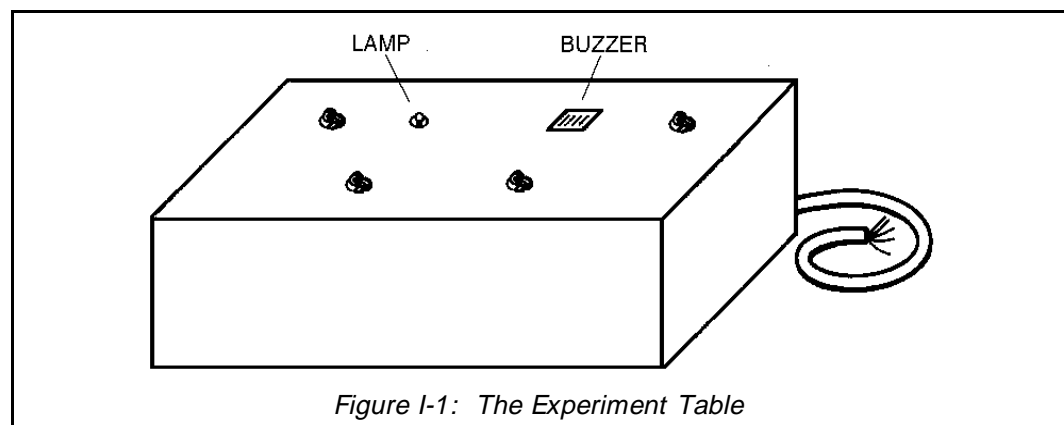


Figure I-1: The Experiment Table

The experiment table's operating cable contains 12 wires, as follows:

Inputs (Black sleeve wiring):

- Input 1: purple, gray
- Input 2: green, blue
- Input 3: yellow, orange
- Input 4: brown, red

To connect a table microswitch to a controller input, select the appropriate pair of wires and connect one wire to ground and one wire to the input tab.

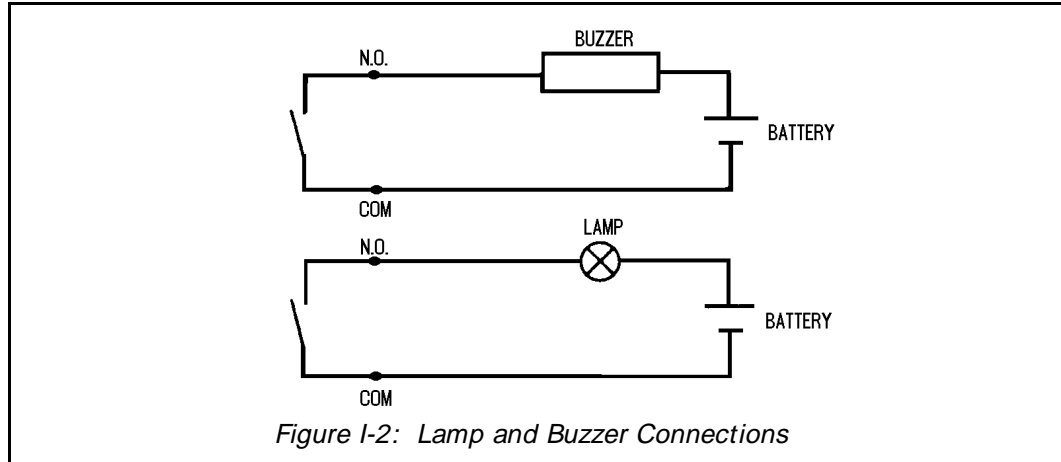
Outputs (Red sleeve wiring):

- Lamp: brown, red
- Buzzer: black, white

The ends of all output wires are insulated to prevent accidental activation of buzzer and/or lamp.

To connect the buzzer or lamp to a relay output, select the appropriate pair of wires and connect one wire to COM and the other to NO.

Figure I-2 shows the connections of the lamp and buzzer to the outputs.



The Linear Slidebase

The linear slidebase (LSB) serves to mobilize the robot and significantly extend its working range. This allows the use of the robot in applications which require it to serve more than one machine or station (see Figure J-1).

Two models of the linear slidebase are available: 48" (1240 mm); 72" (1860 mm). The slidebase can be fastened to the work surface by means of predrilled mounting holes.

The linear slidebase is driven by a DC servo motor with a gear ratio of 5.9 : 1. Connect the D9 connector on the motor cable to either one of the MOTOR terminals on the controller's front panel. **SCORBASE** will then recognize the slidebase as either axis 6 or axis 7.

Use the Home menu in **SCORBASE** to define and home the connected linear slidebase.

