CHAPTER 2

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.

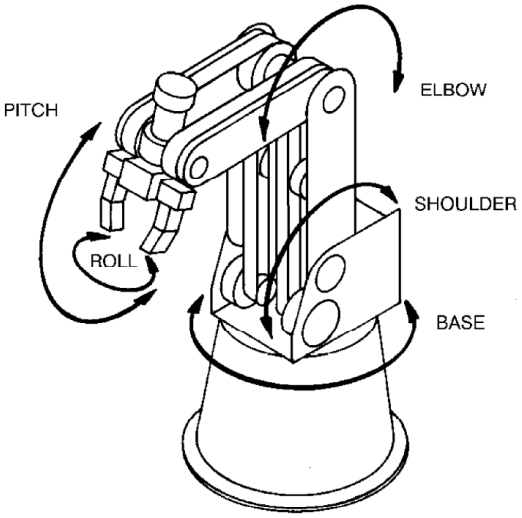

Figure 2-1: Robot Joints

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 ∅ 4 mm (0.16") holes in the gripper fingers (see Figure 2-3).

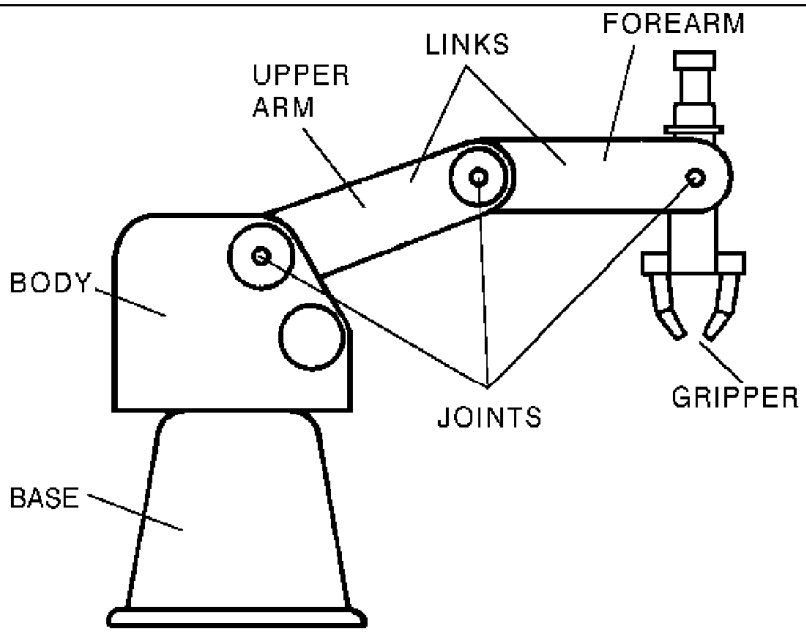

Figure 2-2: Robot Arm Segments

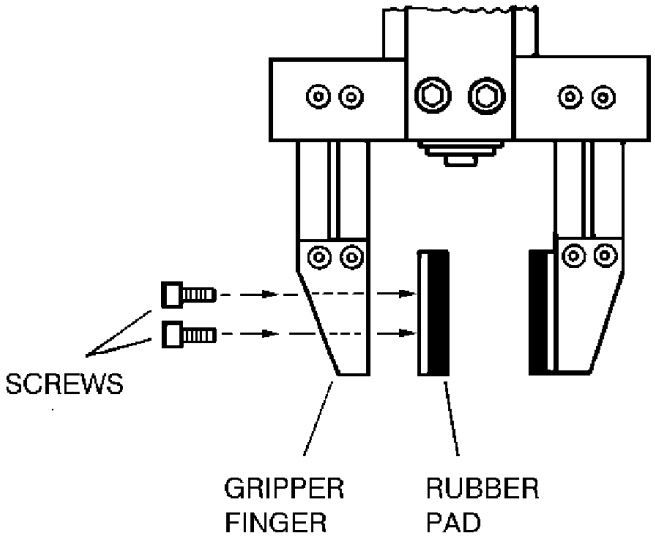

Figure 2-3: Gripper (Removal of Rubber Pads)

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.

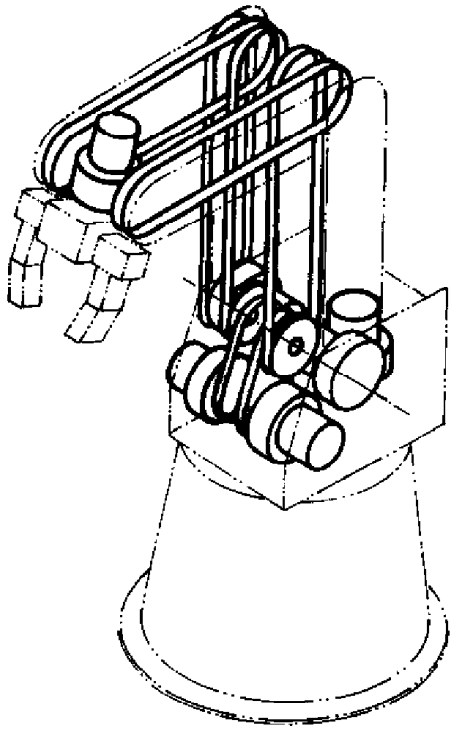

Figure 2-4: Robot Arm Transmissions

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

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.

APPENDIX D

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.

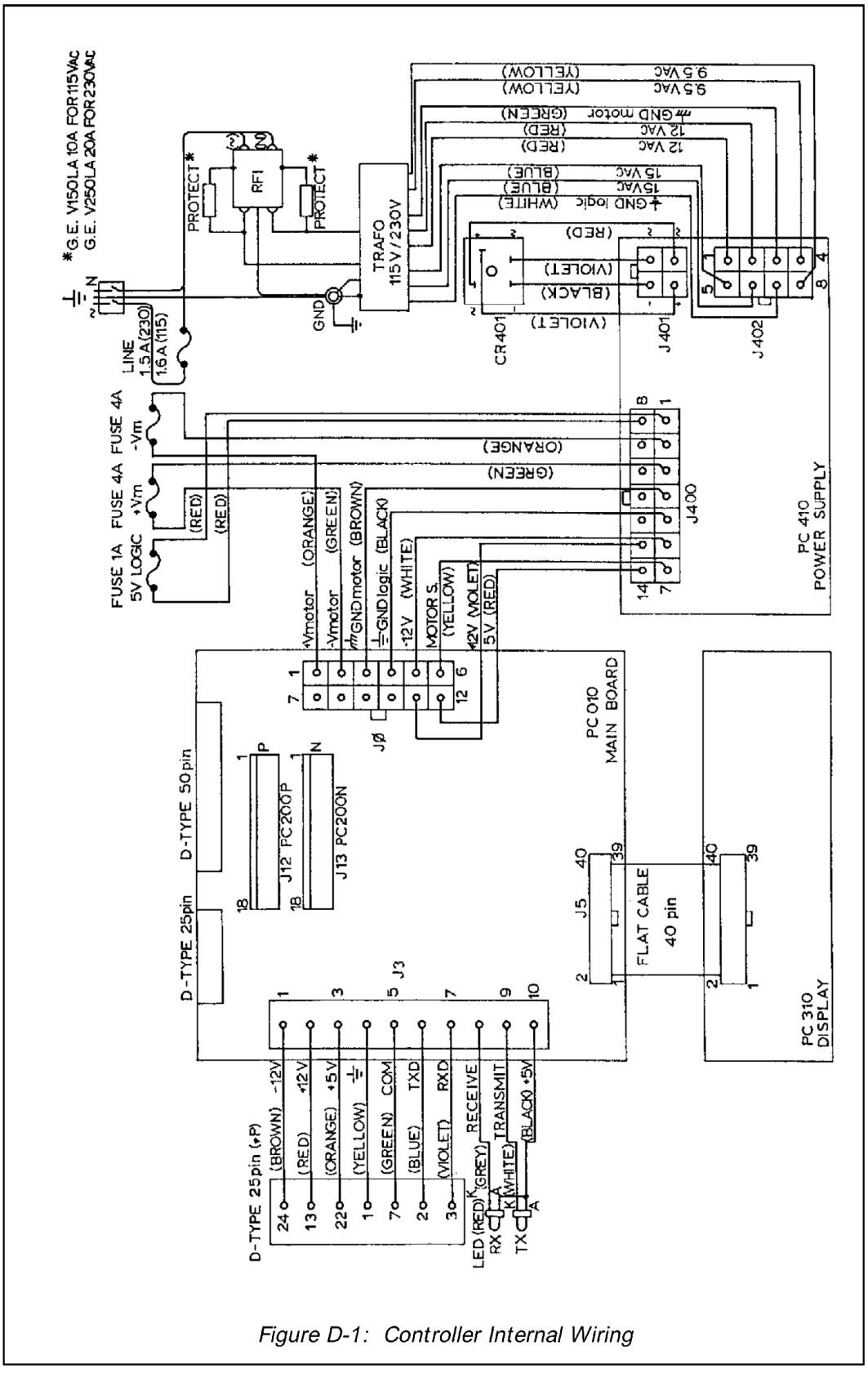

Figure D-1: Controller Internal Wiring

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		white	29			1
	P_1		green/blue	3			3
	5 V_{LED}		yellow	9			2
	P_0		blue	18			4
	Grp GND		white	28	black	12	1
	P_1		grey/blue	19	green	11	3
	Grp V_{LED}		white	25	yellow	10	2
	P_0		white/blue	34	brown	9	4
		1 GND	white	33			
		MS	brown	23			
		2 GND	white	32			
		MS	grey	7			
		3 GND	white	31	white	1	
		MS	orange	24	white	2	
		4 GND	white	30	blue	3	
		MS	green	8	blue	4	
		5 GND	white	29	orange	5	
		MS	bluc	6	orange	6	
not connected	grp GND		white	28			
		MS	brown/grey	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."

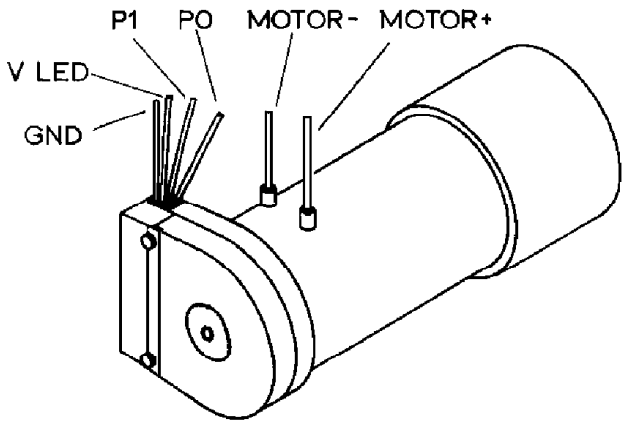

Figure D-2: Motor Wiring

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, P_0 and P_1, are always connected to pads 4 and 3, respectively.

This page intentionally left blank.

APPENDIX **E**

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.

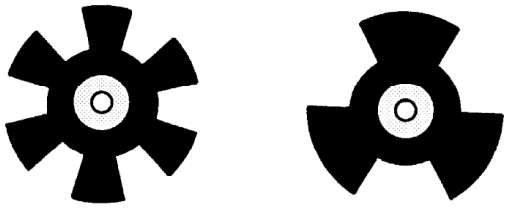

Figure E-1: Encoder Disks

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 mm ± 0.1 mm above the board.
   - In the encoder with a three-slot disk the height is 6.7 mm ± 0.1 mm.

   It is extremely important to maintain the exact height of the components. Figure E-3 shows how to measure

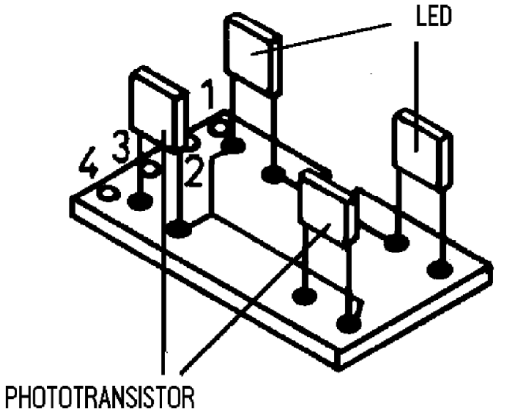

Figure E-2: Encoder Circuitry

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.

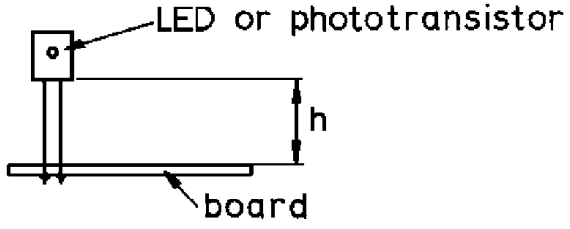

Figure E-3: Height of Electronic Components

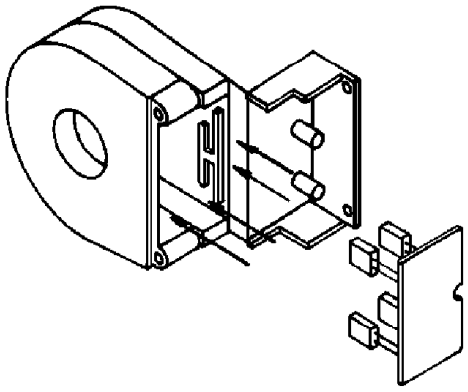

Figure E-4: Encoder Assembly

APPENDIX F

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.

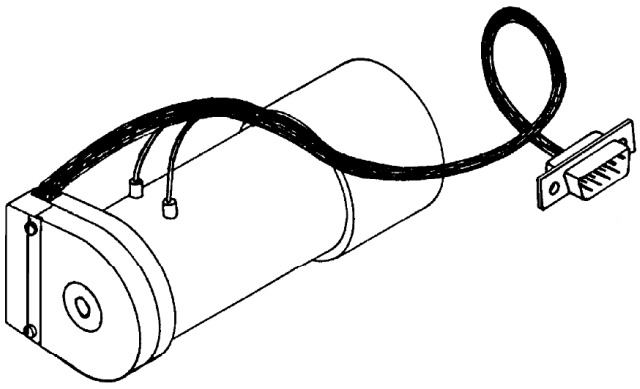

Figure F-1: The Motor Kit

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)

Pin	Function
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.