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CHAPTER 9

BASIC OPERATION WITH THE MANUAL CONTROL PENDANT

9.1 INTRODUCTION

The Adept robot system has been designed to allow control of the manipulator from either the optional programmer's terminal or the optional Manual Control Pendant (MCP). This chapter provides the instructions for basic system operation using the MCP. If you are using the optional programmer's terminal, skip to Chapter 10 for system operation using the terminal.

It is suggested that you work with the control pendant as you proceed through this tutorial. The MCP cable should be connected to the pendant connector on the controller chassis front panel, and the Key Switch must be placed in the "PENDANT" position.

9.2 MCP OVERVIEW

Figure 9-1 illustrates the various button groupings of the Adept Manual Control Pendant. The MCP be held by putting your left hand through the opening on the left-hand side of the pendant, and using your left thumb to operate the pendant speed bars. Use your right hand for all the other function buttons. The various button groupings of the pendant will be reviewed in this section, with detailed instructions presented throughout this chapter.

Outlined in red are the "mode control" buttons. These are used to enable arm power, place the system in manual mode, and turn off arm power (Panic). They are located in the center of the pendant for easy access.

The row of buttons on the far right-hand side are the "manual control" buttons. When in manual mode, these select the joints or axes of robot motion. The "manual mode" LEDs indicate the type of manual motion which has been selected. The "speed bars" are used to select the speed and direction of manual motion. Robot motion is initiated by placing your left thumb on the speed bars. The SLOW button selects between two different speed ranges of the speed bars.

The "data entry" buttons are used to respond to prompts which appear on the pendant liquid-crystal display (the "LCD").

Using the "function" buttons, you may select and prime application programs for execution. After a program has been primed, it can be

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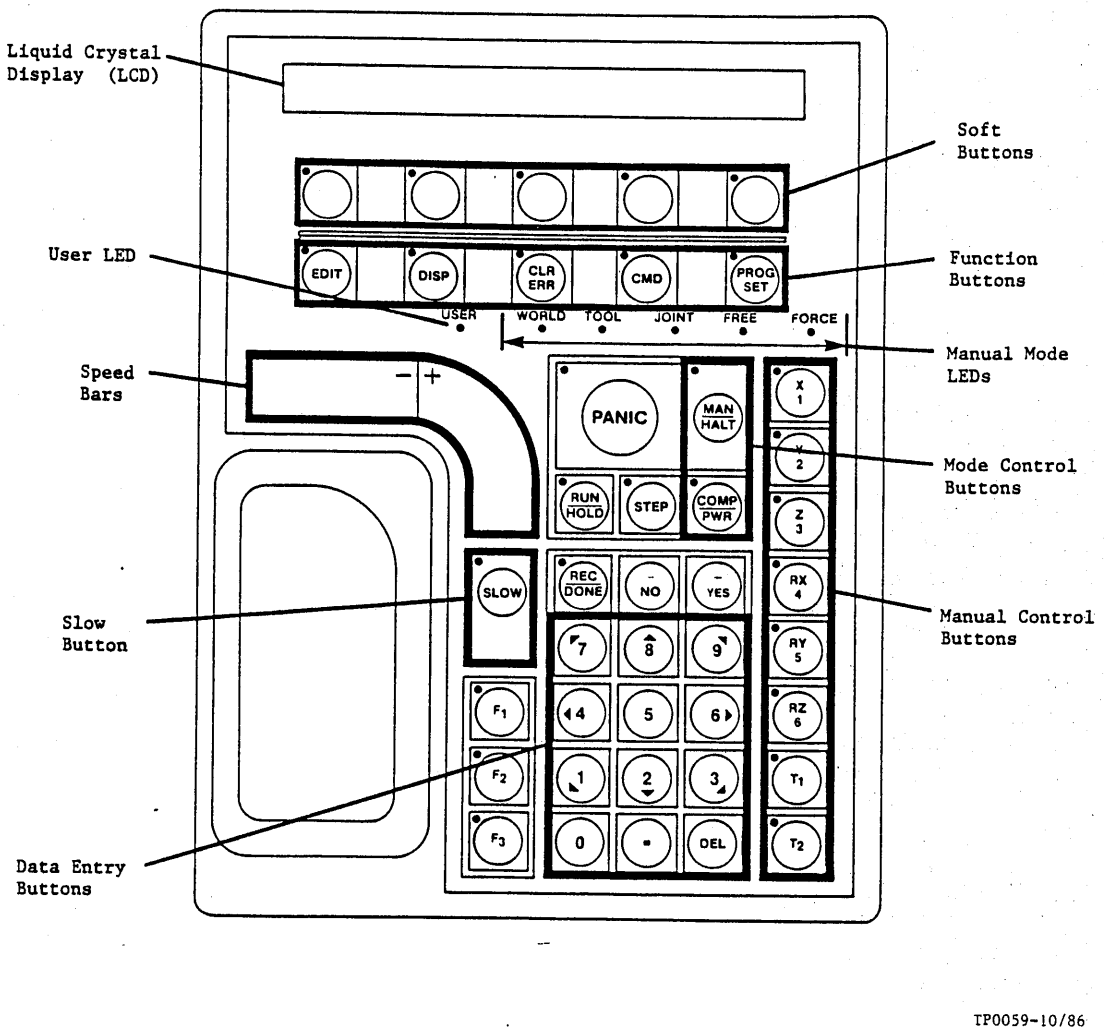


Figure 9-1. Manual Control Pendant (MCP)

executed by pressing and holding down the pendant "RUN/HOLD" button. In addition, three undedicated function buttons (F1, F2, and F3) have been provided for the use of application programs.

The "soft" buttons under the LCD are used during the execution of various application programs. Normally, they correspond to specific menu selections which are displayed on the LCD.

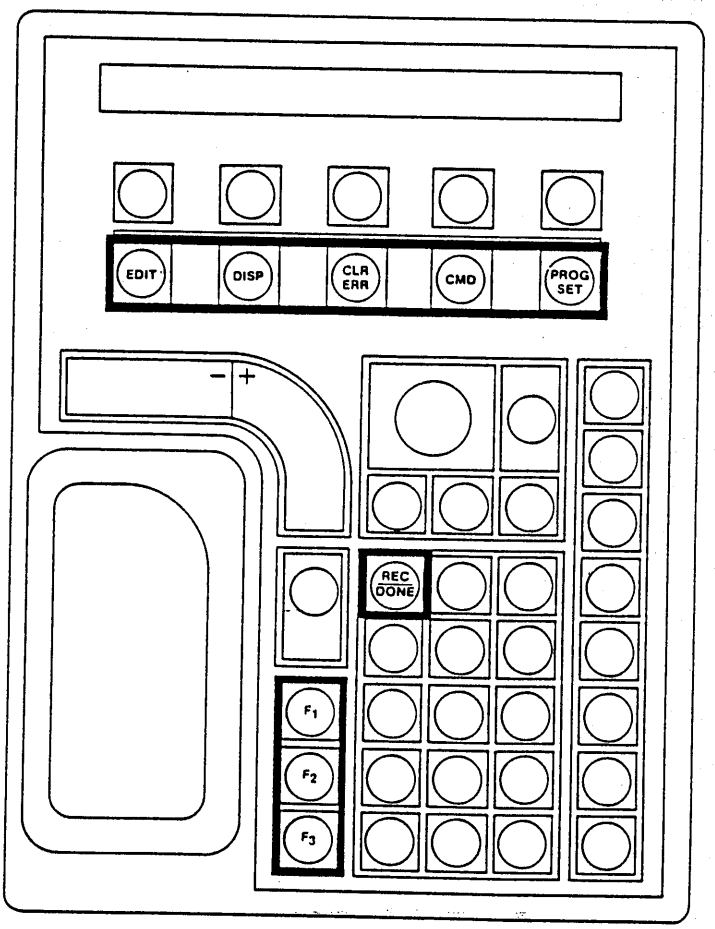
The "USER" LED is lit when an application program is accessing the pendant.

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9.3 MODE CONTROL BUTTONS

The mode control buttons are the only buttons on the MCP that can alter the mode. These buttons are labeled in red for easy identification.

The function buttons are used to initiate specific functions. Figure 9-2 shows the function buttons.



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Figure 9-2. MCP Function Buttons

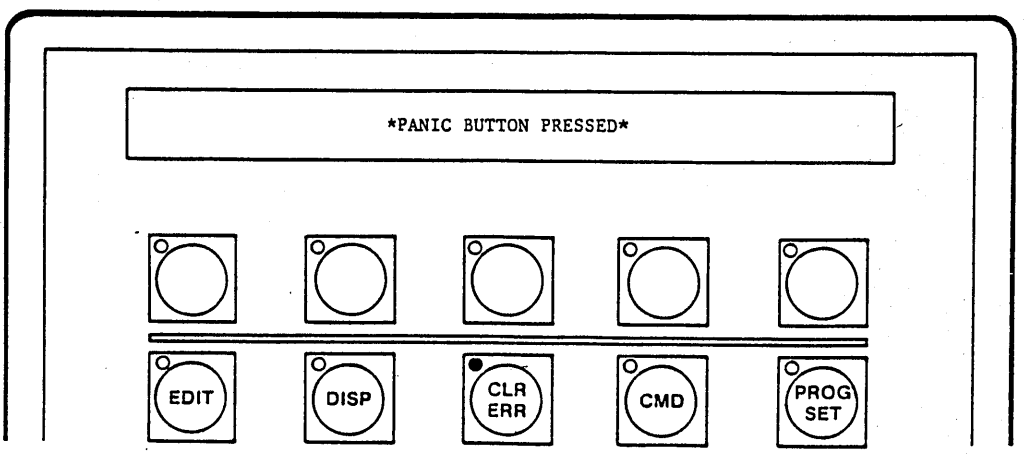
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9.4 GETTING STARTED WITH THE MCP

Two capabilities that relate to the pendant keyboard operation will be discussed below. Other functions will be discussed later in this chapter. The Clear Error function is presented so that you will know how to respond if an error occurs. Setting the viewing angle of the pendant LCD display is also presented to allow you to adjust the display for comfortable viewing.

9.4.1 Clear Error Function

Whenever an error occurs while the controller Key Switch is in the "PENDANT" position the MCP beeps, displays and blinks the error, and lights the LED on the "CLR ERR" button. This is shown in Figure 9-3.



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Figure 9-3. Clear Error Function

The "CLR ERR" button must be pressed for operation to continue. Pressing the "CLR ERR" button will clear the display and return the MCP to its state previous to the error.

9.4.2 MCP Display Viewing Angle Adjustment

The viewing angle of the MCP display can be varied to suit the user, but this can only be performed when no other functions are being exercised. It is suggested that you try the different viewing angle selections now.

There are three viewing angles that can be selected by pressing the "2", "5", or "8" buttons. These buttons select the low, middle and high viewing angles, respectively.

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NOTE

The display viewing angle can be performed only when the MCP display is in the background mode -- see the following paragraph.

9.4.3 Background Mode

The MCP display should now be in background mode. That is, none of the function LEDs should be lit. Check that the LEDs on the "EDIT", "DISP", "CLR ERR", "CMD", and "PROG SET" buttons are off, indicating background mode. If any of the indicated LEDs are on, press the "REC/DONE" button to return the display to background mode.

9.5 SYSTEM CALIBRATION

CAUTION

From this point on, commands will be entered that may cause the manipulator to move. Be sure that the working envelope of the arm is clear of all obstructions. Any obstructions within the work area could result in a collision with the manipulator.

During the following command sequence, the controller will automatically turn Arm Power on and calibrate the manipulator. The program will cause all the joints of the manipulator to move to some extent.

If a problem occurs, Arm Power can be turned off by:

- Pressing the "PANIC" button on the MCP, or
- Pressing the "EMERGENCY STOP" button on the controller front panel, or
- Activating any remote safety device that is installed.

NOTE

During execution of the calibration command, the "RUN/HOLD" button will not start or stop motion of the robot.

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Now press the "CMD" button on the MCP. This will not result in any manipulator motion, but will cause the display shown in Figure 9-4 to appear on the MCP.

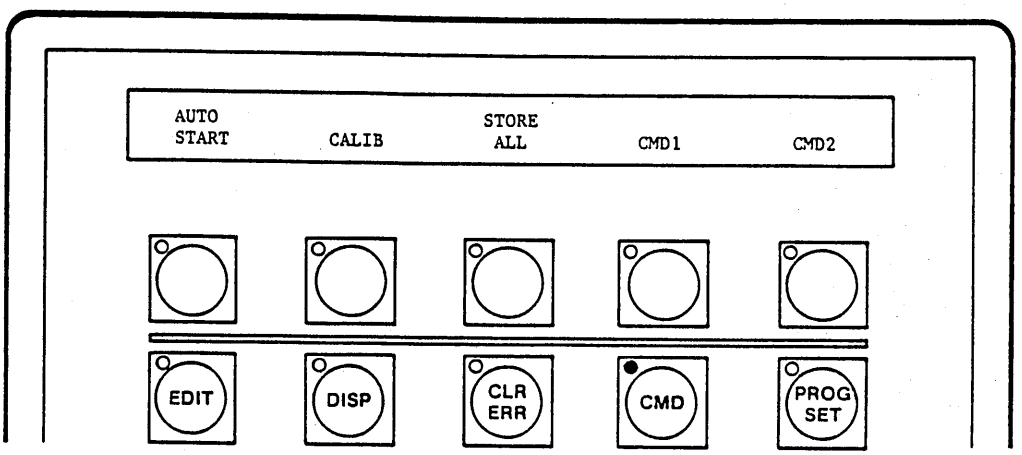


Figure 9-4. Command (CMD) Function

The pendant is displaying the command function options, and the "CMD" button LED is on. The display that is now visible on the MCP denotes labels for the top row of five buttons. Because these buttons do not have fixed labels, but rather can be defined during operation, they are referred to as soft buttons.

WARNING

In the following sequence the manipulator will be calibrated, causing movement of the robot arm. Be sure the manipulator working area is clear and all manipulator joints are clear of their limit stops.

Pressing the "CALIB" button (second from the left in the top row) initiates the calibration sequence, and causes the "PROGRAM START" lamp on the controller front panel to begin flashing. You must then rotate the Key Switch on the controller front panel to the "TERMINAL" position and press the flashing "PROGRAM START" button to start the calibration process. When pressed, the "PROGRAM START" button will stop flashing and the "PROGRAM RUNNING" lamp should light. Return the Key Switch to the "PENDANT" position.

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The system will first turn on Arm Power, and display the message:

ENABLE POWER

followed by the message:

CALIBRATE

When calibration is completed, the MCP display returns to the command function display. The manipulator is calibrated and ready for operation. Arm Power is on (the RED LED next to the "PANIC" button is lit), and the system is in computer mode (the LED on the "COMP/PWR" button is lit).

Press the "REC/DONE" button to turn off the LED on the "CMD" button and return the display to background mode.

If Arm Power is ever turned off (by pressing "PANIC" on the MCP, by activating an emergency stop switch, or by a system error condition), the way to turn it back on is to press the "COMP/PWR" button. This causes the system to be in computer mode with Arm Power on. If the manipulator has not been calibrated and Arm Power is turned on, the system will be in uncalibrated mode. This is indicated by the PANIC LED being on, and both the COMP/PWR and MAN/HALT LEDs being off.

9.6 MANUAL MODE

Manual mode is frequently used to move the manipulator to locations. The system must be in manual mode to select the various coordinate systems available for manually-controlled motions.

This mode of operation can be entered only from computer mode. That is, if Arm Power is off (PANIC button LED not lit), the "COMP/PWR" button must be pressed to turn on Arm Power. Then, pressing the "MAN/HALT" button will put the system into manual mode. Manual mode can be verified by checking that:

- The LED on the "MAN/HALT" button is lit, and
- One of the manual mode LEDs is also lit.

The system will remain in manual mode until either Arm Power is turned off, or the "COMP/PWR" button is pressed.

The system will be in WORLD state (world LED is lit) when manual mode is entered for the first time after application of system power. If manual mode is terminated and re-entered (without turning off system power) the previous state is automatically selected. For example, if the system was in JOINT state when manual mode was exited, the system will be in JOINT state when manual mode is reselected.

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In manual mode, pressing the "MAN/HALT" button changes the state; each time the button is pressed the next state to the right is selected. If the system is in FREE state, pressing the "MAN/HALT" button will result in the system going to WORLD state. FORCE state is skipped because it is not currently implemented.

The buttons which are active in the manual mode are outlined in blue and labelled as follows: the -/+ speed bars, the SLOW button, and the X/1, Y/2, Z/3, RX/4, RY/5, and RZ/6 buttons on the right-hand side of the MCP. These buttons are used to move the manipulator. The numbered buttons on the right side are for selection of type of movement, the SLOW button and -/+ speed bars are used to select the direction and speed of motion and to actually start movement of the arm.

NOTE

Do not confuse the -/+ speed bars with the -/NO and +/YES buttons (outlined in black) in the center of the MCP. Only the -/+ speed bars will be used now, the -/NO and +/YES buttons will be described later in this chapter.

The SLOW button performs a toggle function. When you press the SLOW button the associated LED should turn on and remain on. Pressing the SLOW button again will cause the LED to go off. While the LED is on, the entire range of the speed bars and the corresponding motion speed of the arm is scaled down.

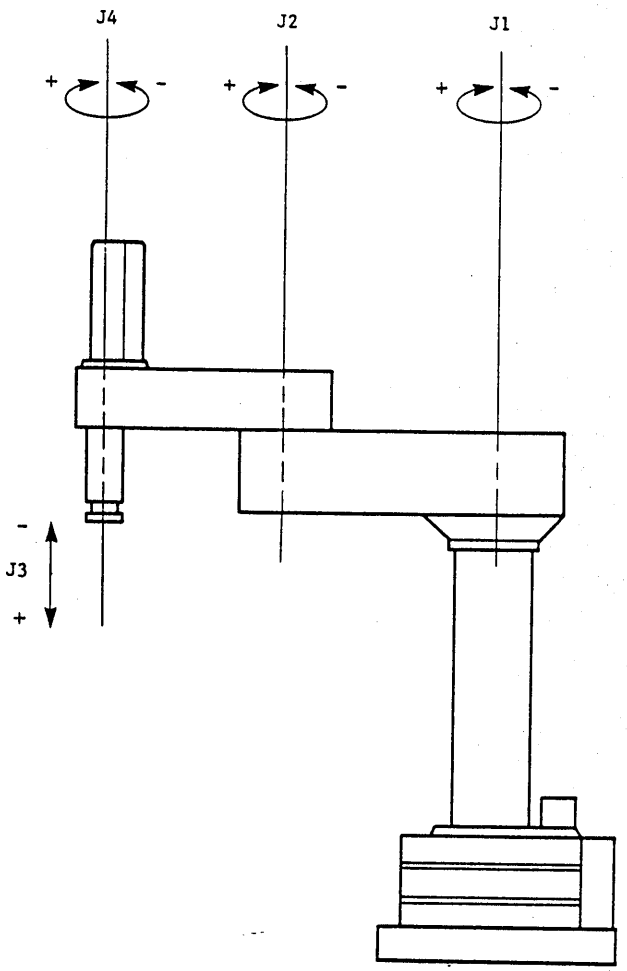
The -/+ speed bars are used to actually move the manipulator. Rather than just an on/off type function, both bars input a range of values to the controller. Pressing the "+" speed bar close to its left edge will move the manipulator slowly in a positive direction. As you press the bar further to the right the manipulator's speed will increase. The "-" speed bar causes movement in the opposite direction.

9.6.1 JOINT State

Enter JOINT state by repeatedly pressing the "MAN/HALT" button until the joint LED is lit. In JOINT state, selected joints are moved individually by the MCP. To select a joint, press the appropriate button on the right-hand side of the pendant. The top button is for joint 1, the next below is for joint 2, and so on. The labels X, Y, Z, RX, RY, and RZ do not apply in JOINT state. Also, with the standard manipulator there are no joints 5 or 6.

Once a joint has been selected, movement of the joint is accomplished by pressing either the +, or the - speed bar (with the SLOW button in the desired state). Figure 9-5 illustrates typical manipulator joint motions.

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Figure 9-5. Typical Manipulator Joint Motions

While moving the manipulator manually you may receive a warning message such as:

JOINT 3 OUT OF RANGE

or

TOO FAR

These messages are not errors (they cannot be cleared by pressing the "CLR ERR" button), rather they warn that an attempt has been made to move the arm beyond a limit stop. To resume normal operation, manually move the arm in the opposite direction using the speed bars. Try moving joint 1 back and forth at various speeds.

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When a particular joint has been selected, and another joint button is pressed, the new joint will automatically take precedence over the previous selection.

NOTE

A joint may only be de-selected by selecting another joint or by changing states (for example, from JOINT state to FREE state). This same concept applies to all states accept FREE state. In FREE state a joint is de-selected by pressing its button.

Now try moving each of the joints, one by one. The T1 button selects operation of the end-effector (T2 is reserved for future use). Select T1 to open or close the hand. If you have a pneumatic hand, pressing anywhere on the - speed bar will close the hand. To open the hand, press anywhere on the + speed bar.

9.6.2 WORLD State

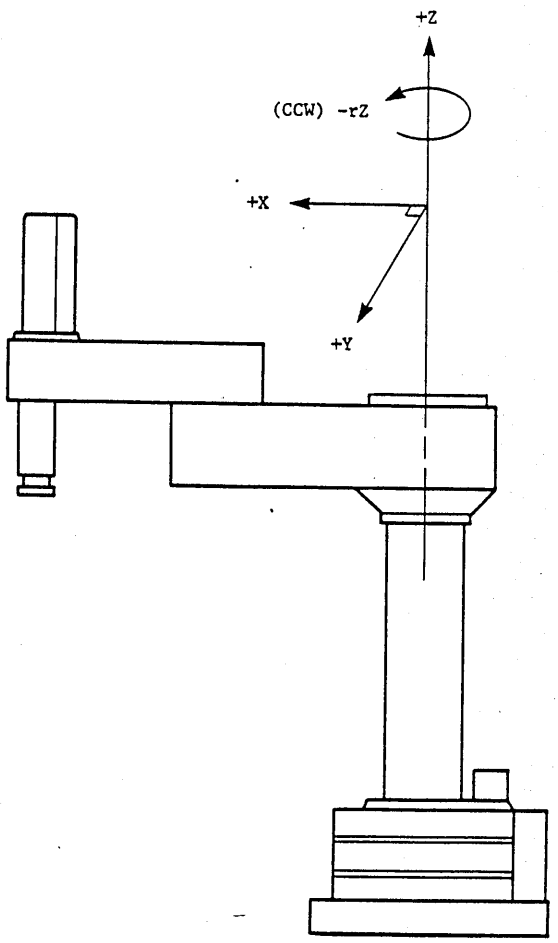
In WORLD state, the buttons (X, Y, Z, RX, RY, RZ, T1 and T2) on the right side of the pendant are used to select the type of motion. The buttons are selected and de-selected the same as in JOINT state. Figure 9-6 illustrates the world coordinate system.

In order to understand the use of the X, Y, Z, RX, RY, and RZ buttons, it is necessary to understand coordinate systems. When X is selected on the MCP, the manipulator will move along the X-axis in either a + or - direction depending on which speed bar is pressed. Similarly, the manipulator can move along the Y and Z axes. RX, RY, and RZ stand for rotation about the X, Y, and Z axes, respectively. For the Adept manipulators, it is physically impossible to rotate about the X or Y axes. Selecting RZ will allow a rotation about the Z-axis, which will be a simple rotation of joint 4.

If all this seems rather complicated, it will become clearer by commanding the manipulator to make some simple movements. Try each of the different motions with the manipulator located in several areas within the working envelope. This is the best way to understand the world coordinate system.

Once mastered, it is often much easier to move the manipulator to a desired location in WORLD state using straight-line motions at the tool tip than it is to move it in JOINT state using the individual joints.

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Figure 9-6. World Coordinate System

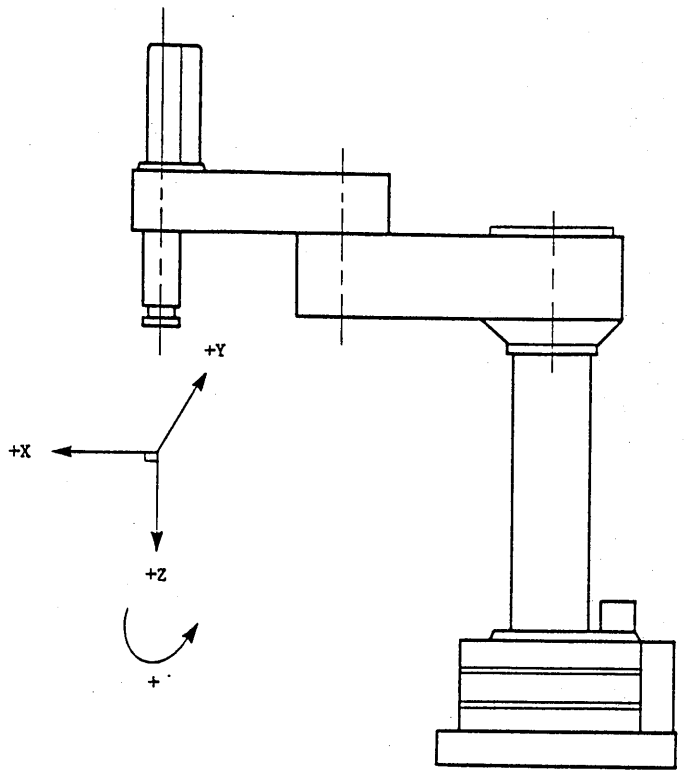
9.6.3 TOOL State

Once WORLD state is mastered, TOOL state is very straightforward. TOOL state also uses the buttons on the right side of the pendant to select motions, and Figure 9-7 illustrates the tool coordinate system.

As shown in Figure 9-7, the tool coordinate system looks almost the same as the world coordinate system. The difference between them is that the world coordinate system is fixed at the base of the manipulator, while the tool coordinate system is fixed to the tool no matter what position the manipulator is in. That is, for example, the X-axis is always placed between the tool fingers.

Try some simple movements in TOOL state to get used to this coordinate system. This type of motion is often used when programming applications

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Figure 9-7. Tool Coordinate System

with an offset tool. Being able to command straight-line motions referenced to the tool can be very useful.

Rotations about the X and Y axes cannot normally be performed, and RZ usually results in a simple rotation of joint 4 (although with some tools, this is not the case).

9.6.4 FREE State

FREE state allows the operator to select one or more joints, and move them around by hand. In the other states (JOINT, WORLD, and TOOL), if a particular button was selected and a new button was pressed, the new button was selected and the old was de-selected. In FREE state, this is not the case as it is often desirable to free up multiple joints.

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CAUTION

When a particular joint is selected in FREE state, the joint becomes limp. On V or V+ system versions 7.2 or later, joint 3 has a special gravity compensation feature that prevents it from dropping to it's fully extended position when selected in FREE mode. This is implemented by supplying a constant compensatory torque to the Joint 3 motor, so if any weight is removed from the end-effector after entering FREE mode, joint 3 will slowly move to the fully retracted position.

On V or V+ system versions 7.1 or earlier, when joint 3 is is selected in FREE mode, it will drop to its full extension. Thus, if joint 3 is selected, be certain to support it to prevent equipment damage. Also, if joint 3 is allowed to drop all the way, on return to World or Joint state you may get a J3 range error.

WARNING

Prior to entry into the work cell to manually move the robot into desired positions, it is recommended that the user lock the Key Switch on the controller front panel in the "PENDANT" position and remove the key. This will prevent operation of the robot from any source other than the pendant.

Now, press "MAN/HALT" repeatedly until the LED indicating FREE is on. Select joint 1 and try moving it around by hand. When you want to deselect joint 1 and freeze it, press the joint 1 button. The LED on button 1 will go off. Note that when joint 1 is selected, joint 2 is automatically selected (and vice versa). When either one is deselected, the other is automatically deselected as well.

FREE state is useful when recording locations. It is often easier to move the manipulator manually to desired locations in FREE state than it is in WORLD, TOOL, or JOINT states.

A pneumatic hand may be "relaxed" by selecting T1 while in FREE state. This removes air pressure from all incoming air lines.

9.6.5 FORCE State

At present this state is not enabled on the MCP. It is reserved for future use.

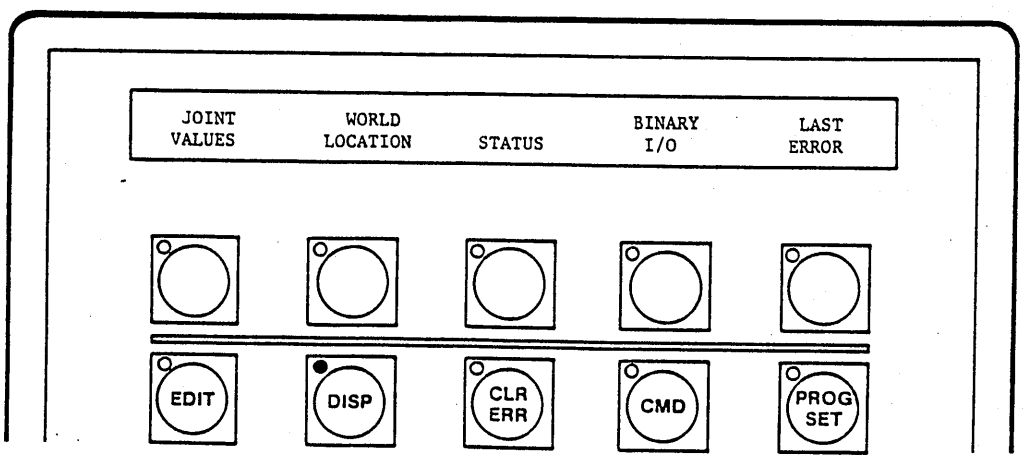
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9.7 COMPUTER MODE

The pendant should be in computer mode in order to select and prime programs that control the robot. Earlier in this chapter we used computer mode in order to calibrate the manipulator. From manual mode, you go into computer mode by pressing the "COMP/PWR" button. You can exit computer mode either by pressing the "MAN/HALT" button, or by turning Arm Power to off.

9.8 DISPLAY FUNCTION

The display function is used to display various system information. When selected, the display function redefines the soft buttons. Press the "DISP" button and observe on the pendant the display shown in Figure 9-8.



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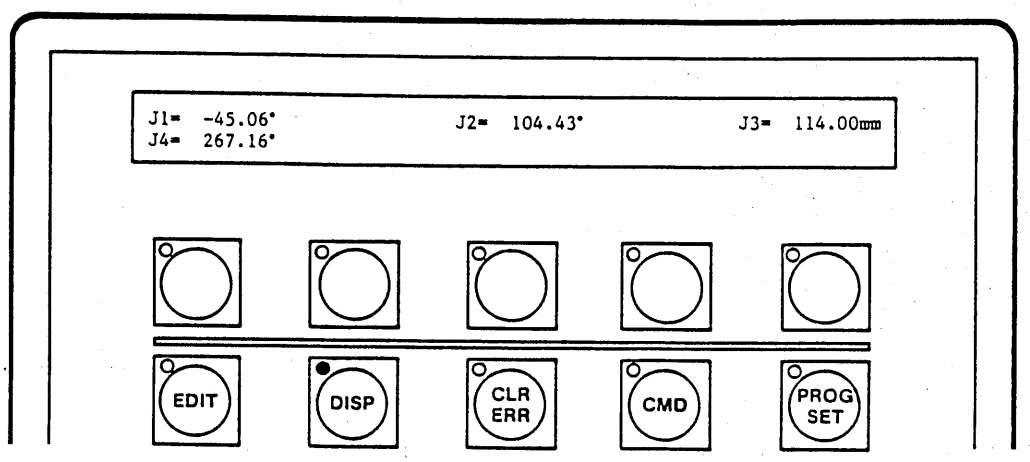
Figure 9-8. Display Function

This display indicates how the five soft buttons have been defined. Each of these buttons, if pressed, will display the indicated information. In the case of Joint Values, World Location, and Binary I/O the display is continuously updated after the corresponding soft button has been pressed.

9.8.1 Joint Values

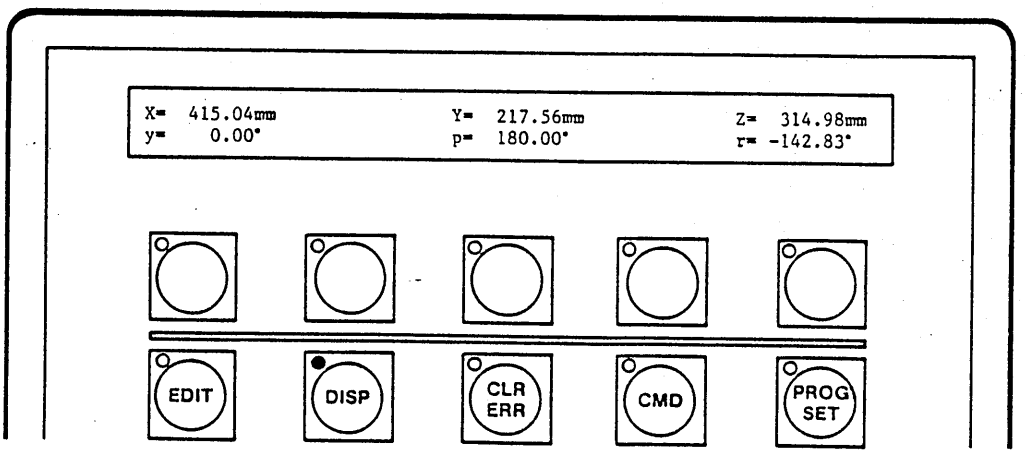
Pressing the joint values button will display the current joint angles of the arm in degrees for joints 1, 2, and 4, and in millimeters for joint 3. Figure 9-9 shows a typical display of joint values. Press

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Figure 9-9. Joint Values Display



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Figure 9-10. World Location Display

joint values now to display the current joint positions. Press the "REC/DONE" button to return to the display function menu.

9.8.2 World Location

Pressing the world location soft button displays the current location of the manipulator in world Cartesian coordinates. The display will show X, Y, Z (Cartesian coordinates in millimeters); y, p, and r (for yaw, pitch, and roll in degrees). Figure 9-10 illustrates a typical world

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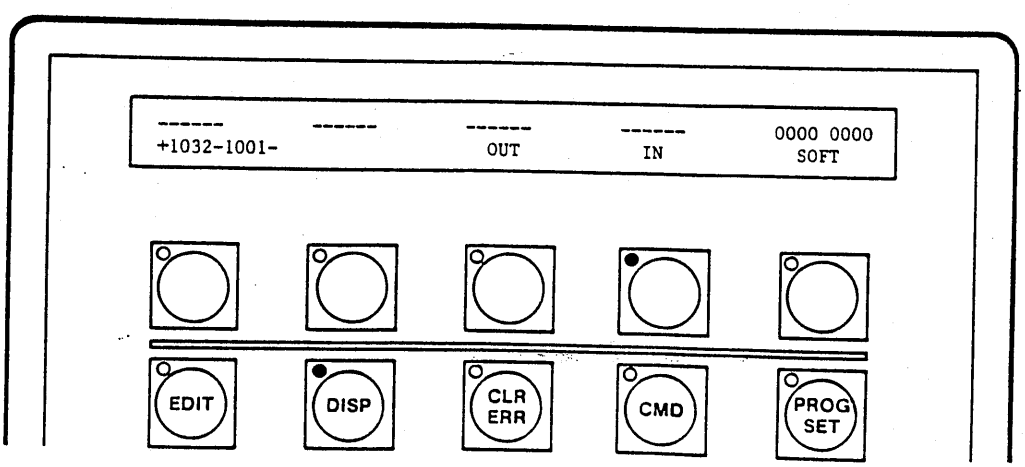
location display. When you are done viewing this display, press the "REC/DONE" button to return to the display function menu.

9.8.3 Status

Pressing the status soft button will display the current status of the program that is executing. As there is presently no program running, the status information will have little meaning for you. However, later in this chapter under the heading "Initializing a Program", we will discuss the meaning of the individual status indications. Pressing the "REC/DONE" button returns the MCP to the display function menu.

9.8.4 Binary I/O

The controller has several binary I/O lines used as inputs (signals from external devices) or outputs (signals to external devices); and soft signals used to communicate internally. Pressing the binary I/O soft button will display the current condition of those signals. Pressing one of the soft buttons labeled out, in, or soft will display the requested binary signals. When interpreting a display, a "1" represents the on condition and "0" the off condition. Figure 9-11 shows a typical display for input signal lines. Note that the LED associated with the "IN" button is on.

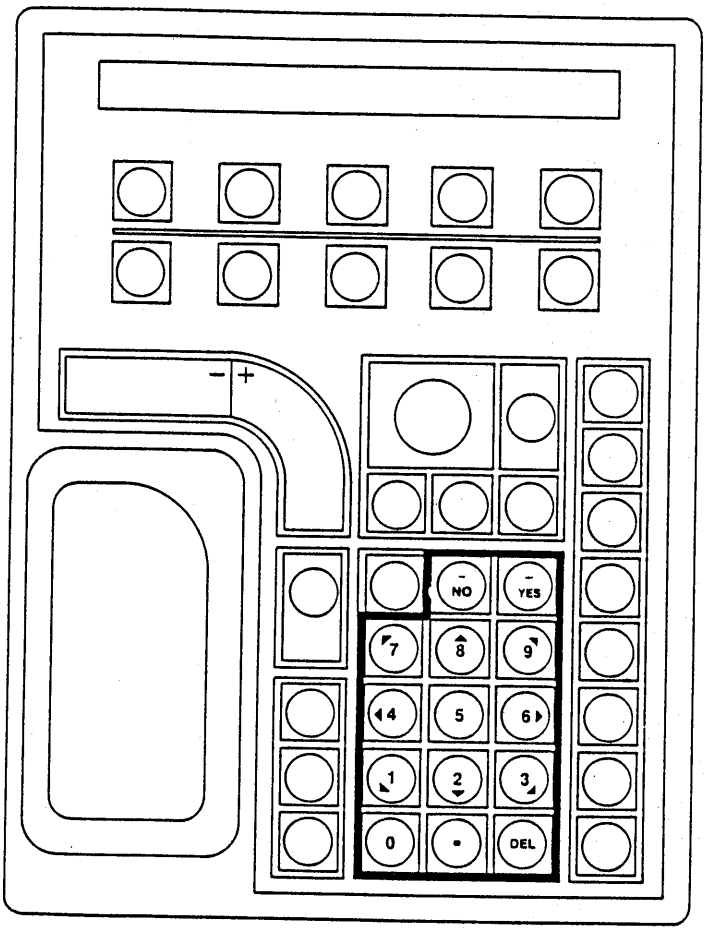


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Figure 9-11. Binary I/O Display

The data entry buttons are shown in Figure 9-12. Pressing the +/YES button displays the next 32 signals. Pressing the -/NO button will display the previous 32 signals. Press "REC/DONE" to return to the display function menu.

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Figure 9-12. Data Entry Buttons

9.8.5 Last Error

Pressing the last error soft button allows you to review up to 30 system errors. Each time you press the last error button, the error that occurred just before the error displayed, is shown. As you review the errors that have occurred, you may see the message

NO OLDER MESSAGES

which indicates that all the errors have been displayed. Pressing the "REC/DONE" button returns you to the display function menu.

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9.9 THE COMMAND FUNCTION

Earlier the command function was used to calibrate the manipulator. Press the "CMD" button now to reenter the command function.

NOTE

A jump from one function to another can be made without using the "REC/DONE" button. Pressing a new function button is a quick way of selecting a different function.

9.9.1 Auto Start

Pressing the "AUTO START" button while in the command function will automatically load all the programs stored in an auto-load file into active memory. Remove the "system diskette" from drive "A" (if necessary), and insert the "utility disk #1" (diskette with blue label). Press the "AUTO START" button to select the file to load. The display should then appear as shown in Figure 9-13.

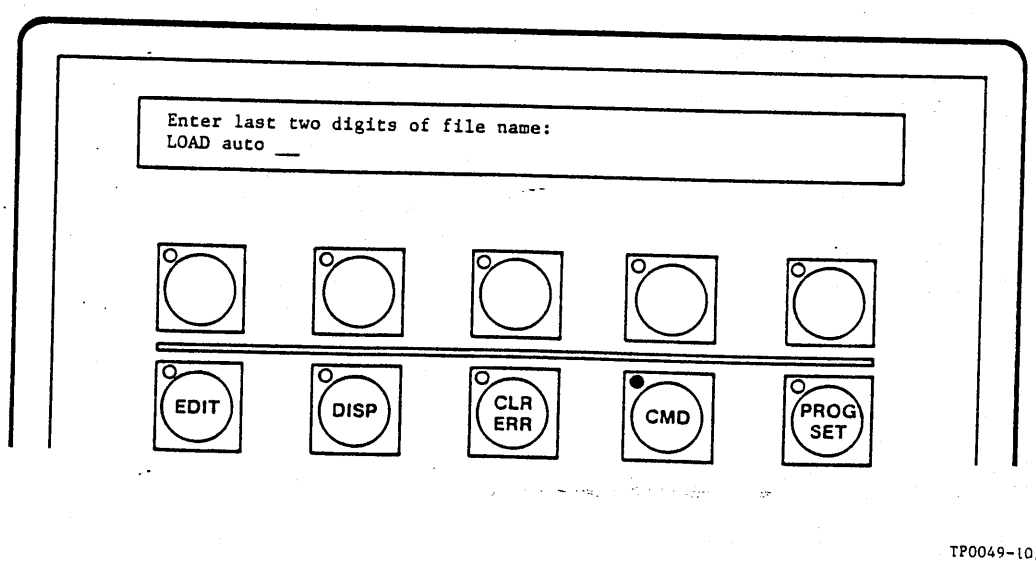


Figure 9-13. Auto Start Display

The pendant cursor (_) is on the bottom line of the display after the word "auto". Input the digits "21" using the data entry buttons. The digits will appear on the display. Press "REC/DONE" to make the entry and load the file. The disk file that is loaded is named, "AUTO21.V2". The V2 file extension indicates that it is a V/V+ program.

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NOTE

Normally, pressing the "REC/DONE" button returns the system to the next higher level function. In this case, it signifies the completion of data entry. As a result, if you hit "AUTO START" by mistake and wish to abort, pressing the "REC/DONE" button will not have the desired affect. If you want to abort "AUTO START", press the "CMD" button and it will return you to the command function menu.

The file AUTO21.V2 has now been loaded into active memory, and the "PROGRAM START" button on the controller front panel begins flashing. The flashing of the light is because of a "WAIT.START" monitor command that is automatically added to all pendant "AUTO" and "CMD" programs. Refer to the V+ Reference Guide or V Reference Guide for more information.

To begin execution, the operator must turn the Key Switch (on the Controller) to "TERMINAL" position and press the Program Start Switch. If it is desirable to see any error messages on the pendant display, the user can switch the Key Switch to the "PENDANT" position.

In order for the "AUTO START" function to work, the specified file must contain a command program. For more details on command programs, refer to the V+ Reference Guide or V Reference Guide.

9.9.2 Calibrate

Earlier the "CALIB" button was used to calibrate the manipulator. The arm must be calibrated whenever the controller system power is switched to on.

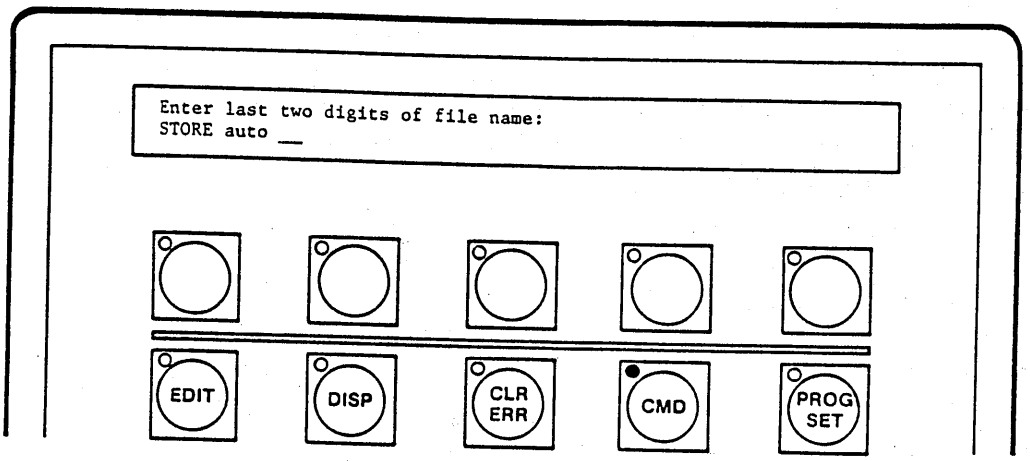
9.9.3 Store All

This function is used to transfer programs and data from active memory to a disk file and to save the changes on the disk. The "STORE ALL" function is not required unless you have made changes to programs, locations, or variables and you wish to save the changed versions.

If the "STORE ALL" button is pressed (it is not necessary to perform this step unless you actually have information to store on disk), the display shown in Figure 9-14 will result.

The system requests two digits which will become part of the file name for the stored information. For instance, if the digits "45" were input, the information would be stored on disk under the file name "A1145.V2", and this file could later be retrieved. Pressing "REC/DONE" completes entry of the digits and initiates the store operation.

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Figure 9-14. Store All Function

If "STORE ALL" is pressed by mistake, abort the function by pressing the "CMD" button.

9.9.4 CMD1 and CMD2

Command programs are special programs consisting of monitor commands rather than program instructions. This special type of program is useful to assist with system start-up and command sequences frequently executed.

Refer to the appendix of the V+ Reference Guide or V Reference Guide titled "Command Programs" for more information concerning the creation and storing of two such special programs that can be loaded and primed for execution by pressing the "CMD1" or "CMD2" soft buttons.

9.10 PROGRAM SETUP FUNCTION

A program is a series of instructions grouped under a program name. Programs are primarily used for repetitious execution of a set of instructions that cause the manipulator to perform a task. An example of such a program is a pick-and-place program which picks up parts from a conveyor and places them into a box. Rather than manually controlling the robot to perform each segment of the task, you could write a program containing the sequence of instructions that would be executed each time a part came down the conveyor.

Programs that are in active memory (that is, loaded in from disk files) can be in one (or more) of three conditions: selected, primed, or

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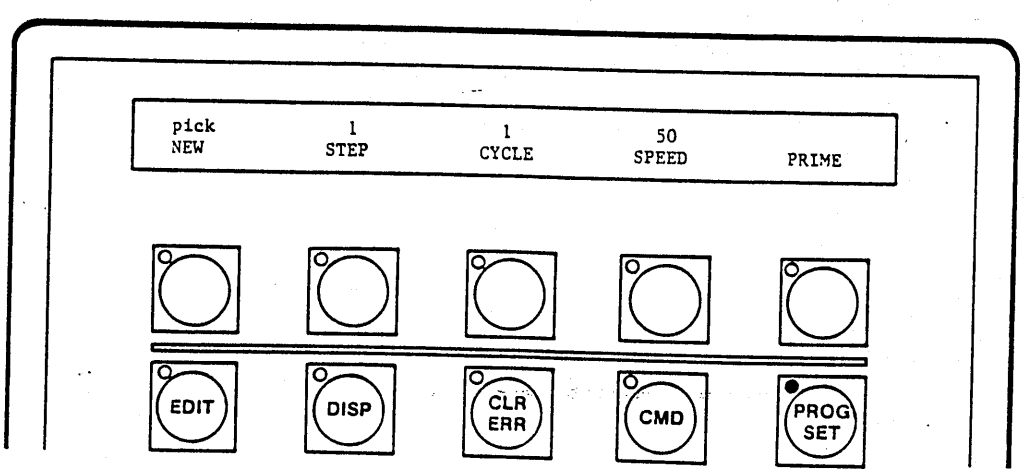
dormant. Only one robot control program can be selected or primed at a time. A program that is neither selected nor primed is in the dormant condition.

In the following paragraphs you will be using the program setup function to perform a sequence of selection and execution of pre-written application programs. You will not be asked to write or edit the programs, only to load them into active memory, select, prime, and execute the desired program.

NOTE

The Key Switch on the controller front panel must be in the "PENDANT" position in order to select and prime a program. With the program primed and Arm Power on, the only way to initiate execution of the program from the pendant is by pressing and holding down the "RUN/HOLD" button. If the "RUN/HOLD" button is released, the program will stop. Execution of application programs from the pendant is intended for checking the operation of new programs.

Press the "PROG SET" button to enter the program setup function. The display should be as shown in Figure 9-15.



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Figure 9-15. Program Setup Function

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9.10.1 Selecting a Program

When the program setup function is first entered, the program selected will always be the first program in alphabetical order. The program "pick' was selected as shown on the display. Press the "NEW" soft button to look at the names of other programs currently loaded into memory.

NOTE

When there are more than four programs loaded into active memory, only the first four (alphabetically) will be shown when you press "NEW". The soft button on the far right is labeled MORE, and pressing it will display the next four programs. The +/YES button performs the same function as MORE, displaying the next four programs. Pressing the -/NO button will display the previous four programs.

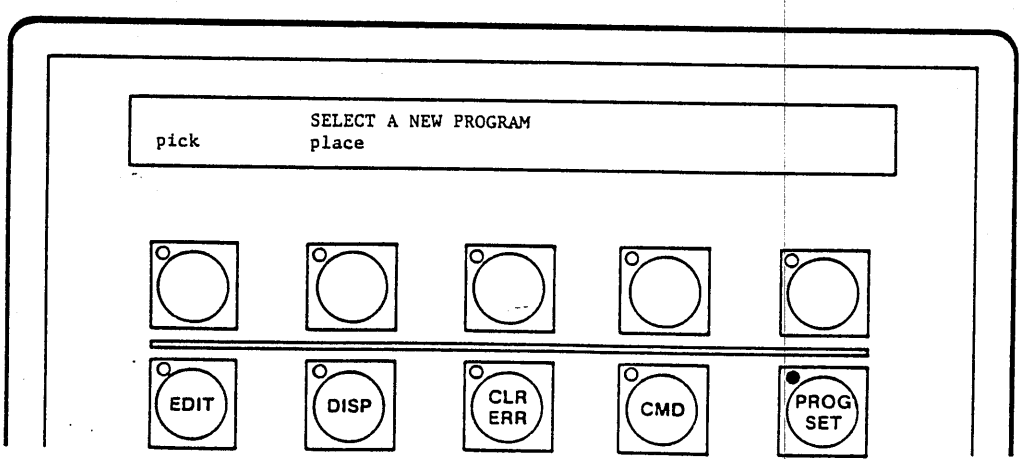


Figure 9-16. New Selection Function

As shown in Figure 9-16, only two programs ("pick" and "place") are loaded, and "place" is in the dormant state. Press the soft button under the program name "place" to select it and return to the program setup display.

NOTE

Pressing "REC/DONE" would return to the program setup function leaving the selected program unchanged.

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The program "place" is now selected, and "pick" has been put into the dormant condition. The program name in the upper left corner of the display indicates the selected program.

9.10.1.1 Initializing a program

The three values STEP, CYCLE, and SPEED govern the execution of the selected program. Program execution will begin with the step that is indicated on the display above the label STEP.

CYCLE is the number of times the program will execute. A value of 0 or 1 will cause the program to execute once. Any positive value entered will cause the program to execute that number of times (for example, a value of 5 will cause the program to execute five times). Any negative value will cause the program to execute indefinitely. In this case, only an error or a manual override will stop the program.

SPEED is the relative speed at which the manipulator will move. Speed 100 is the normal speed.

To change any of the above values, press the soft button under the value you wish to change. The current value will blink, indicating that a new value may be entered. There are two ways to enter a new value. One, is to type in the new value using the data entry buttons. The other way is to use the +/YES and -/NO buttons. Pressing the +/YES button will increment the value, and pressing the -/NO button decrements the value. If a value of -1 for CYCLE is desired, you must use the -/NO button to decrement the existing value. There is no other way to enter a negative number. Pressing the "REC/DONE" button enters the new value and stops the blinking on the display.

NOTE

When entering numeric values using the data entry buttons on the MCP, the "DEL" (delete) button performs a backspace function. Pressing "DEL" will erase the previous entry thus allowing you to correct it.

Now, press the soft button under SPEED and use both methods to change the value. When you are sure that you know how both methods for changing the values work, set the STEP to the value 1, the CYCLE to 1, and the SPEED to 40.

9.10.2 Priming a Program

Now that the values have been set as indicated above, you are ready to prime the program. Pressing the soft button under the PRIME label will prime the currently selected program (PLACE) and take the pendant out of the program setup function.

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9.10.3 Executing the Program

To recap, you have selected the "place" program. You have initialized the program by setting the STEP, CYCLE, and SPEED values, and have primed the program. It is now ready for execution.

If necessary, place the MCP in manual mode by pressing the "MAN/HALT" button, and move the robot to roughly the middle of its workspace. Now press the "COMP/PWR" button to put the system in computer mode with Arm Power on.

CAUTION

> In the following paragraph you will be executing a program that will cause the manipulator to move. The arm should move up, over, down, up, over, down, and stop.

To execute the "place" program once (because CYCLE was set to 1), press and hold down the "RUN/HOLD" button.

NOTE

> When program execution is completed, the program returns to the selected, but not primed, condition. In order to execute it again, the program must be primed again.

Releasing the "RUN/HOLD" button will stop program execution immediately. Pressing and holding down the "RUN/HOLD" button again will cause the program to resume execution from the point at which it stopped.

Pressing the "MAN/HALT" button will also halt the program and leave the system in manual mode with the error message

PANIC BUTTON PRESSED

appearing on the display. To resume program execution you must clear the error (press "CLR ERR"); re-enter computer mode (press "COMP/PWR"); and then press and hold down the "RUN/HOLD" button.

Another way to manually stop execution of a program is to activate an Arm Power Off or Emergency Stop switch. This is a drastic measure to be used in a "panic" situation. Such an action will bring the program to an immediate halt; Arm Power will go off, and the robot brakes will engage.

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9.11 MCP EDIT FUNCTION

The Edit function on the MCP is used to modify the values of real and location variables that are currently in the active memory of the controller.

You can enter the Edit function directly by pressing the EDIT button on the pendant. The display shown in Figure 9-17 will appear.

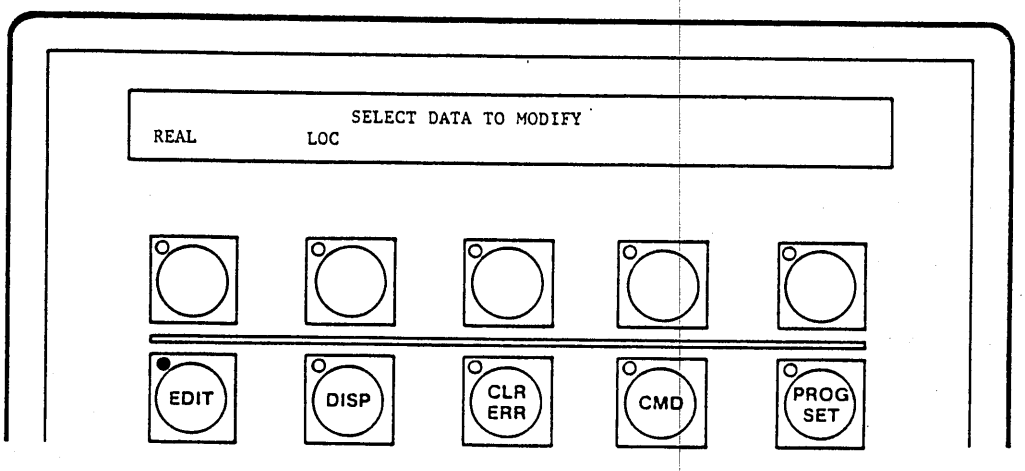


Figure 9-17. Edit Function

The two soft buttons on the left have been defined as edit REAL variables and edit LOCation variables. These are the two sub-functions you can perform in the edit function.

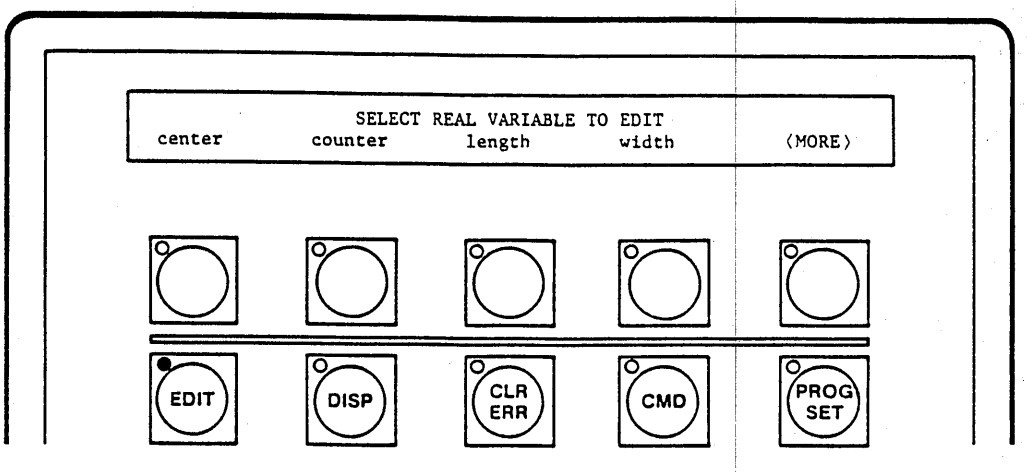
9.11.1 Editing Real Variables

Press the "REAL" soft button to start the process of editing real variables. If you need an explanation of real variables, refer to the V+ Reference Guide or V Reference Guide. Pressing this button will put you in the Real Select function as shown in Figure 9-18.

As with the program selection process (in the section on Program Setup), the real variables are displayed in groups of four in alphabetical order. Pressing MORE, the soft button on the far right, will display the next four variables. The +/YES button performs the same function as MORE. The -/NO button allows you to look at the previous four values.

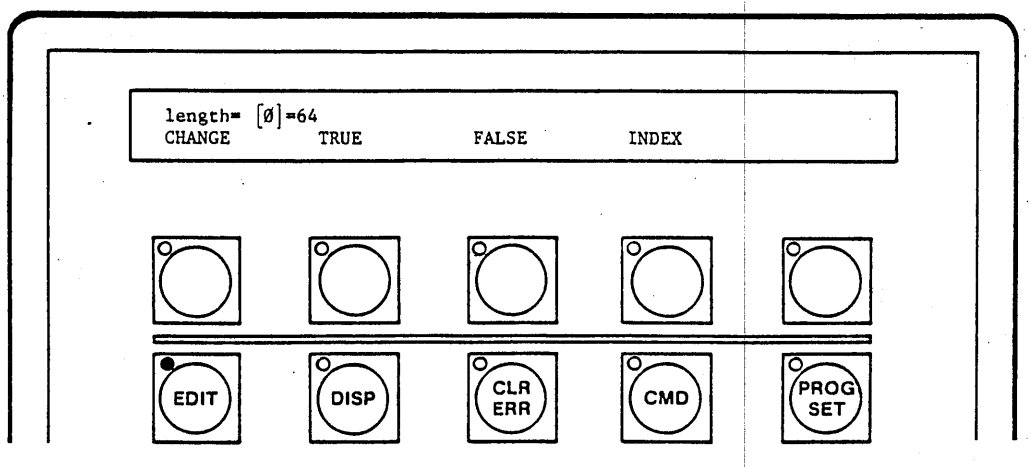
Select the real variable "length" by pressing the soft button under that label. The display will be as shown in Figure 9-19.

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Figure 9-18. Real Select (EDIT) Function



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Figure 9-19. Real Modify (EDIT) Function

Since the variable "length" is an array (with elements 0 to 9), the display shows the first value in the array. The CHANGE button allows you to change the value of "length[0]". Press CHANGE and the cursor will appear. You can now change the value by entering a new value with data entry buttons 0-9 and the DEL button, or with the +/YES and -/NO buttons. When the value you desire is displayed, press the REC/DONE button to enter it and stop the display from blinking. If REC/DONE is pressed and no new value has been entered, the old value returns.

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The TRUE and FALSE buttons are also used to modify the values of real variables. Since real variables can be interpreted as logical values (-1.0=TRUE and 0.0=FALSE), pressing the TRUE or FALSE soft buttons will set the real variable to the appropriate value.

The INDEX soft button is used to display and/or modify other real variables in the array (if the variable is an array--if not, the INDEX label is not displayed). Press the INDEX button to start the current INDEX value to blinking. It can now be modified by entering a new value with the data entry buttons, or by using the +/YES and -/NO buttons to increment or decrement the index. When the desired index value is displayed, press the REC/DONE button to enter the value, stop the INDEX from blinking, and display the value of the corresponding real variable.

You may display and edit as many values as you like to get comfortable with this function. Once you have completed modifying the real values and are in the Real Select function, press REC/DONE again to return you to the top-level Edit function. As you can see, pressing the REC/DONE button moves you back to the previous function level.

9.11.2 Editing Location Variables

Editing location variables is done in much the same manner as editing real variables. Press the LOC soft button to enter the Location Select (Edit) function. The display should look like Figure 9-20.

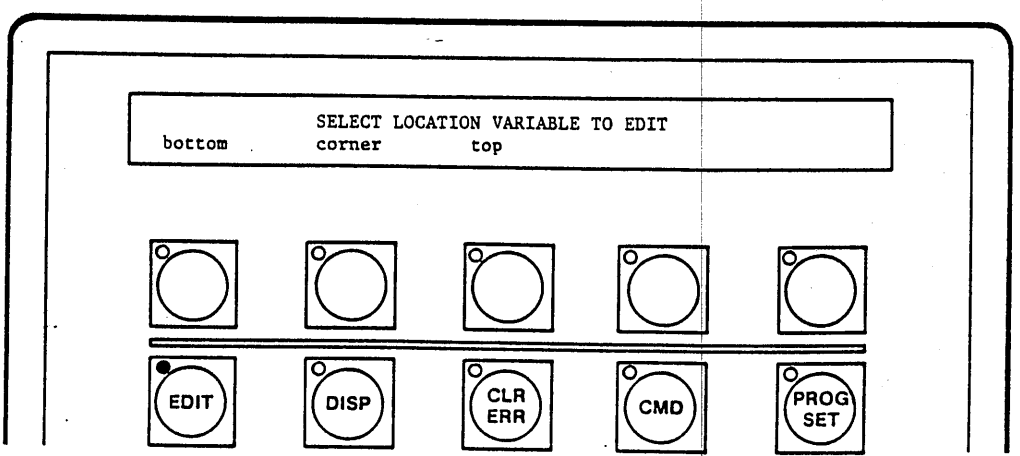


Figure 9-20. Location Select (EDIT) Function

In this case, there are only three location variables currently defined. If there were more than four, the MORE, and +/YES, -/NO buttons would work in the same fashion as with the selection of real variables for

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modification.

Select the location "corner" by pressing the soft button under that label. The display should be as shown in Figure 9-21.

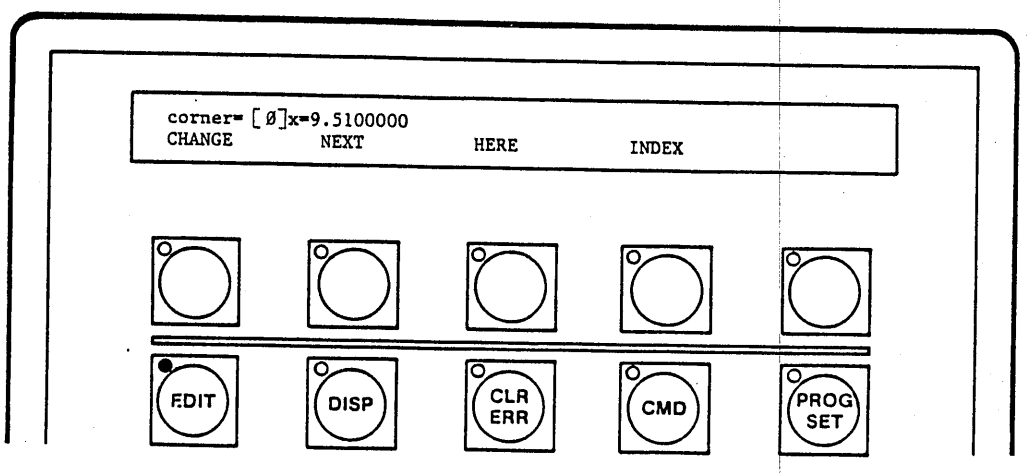


Figure 9-21. Location Modify (EDIT) Function

Each location of the manipulator is defined with six component values (X, Y, Z, y, p, and r). These are different from arrays, as each location has these six components. In the case of a location array (for example, corner[0], corner[2],...corner[8]), each of the location elements has six component values.

When you enter Location Modify function, if the location is an array, the first location in the array (in this case, corner[0]) will be displayed. Also, whether the display is an array or not, when you first display a location, X is the first component value displayed.

Figure 9-21 shows that the location "corner" was selected. At this point you can:

1. Define it where the robot is currently located (HERE)
2. Select a different element within the array (INDEX)
3. Change the value currently being displayed (CHANGE)
4. Select the next component (NEXT)

Press CHANGE to change the value currently displayed. When you press CHANGE you can enter a new value which blinks as it is entered. Pressing the REC/DONE button enters the new value and stops the

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blinking. As when editing real variables, pressing REC/DONE without changing the value causes the old value to be restored.

Pressing the NEXT soft button will display the next component (for example, if "X" is displayed, pressing NEXT will display "Y"). The HERE button is used to redefine all six components to the present location of the manipulator. This is a very quick way of modifying locations using the MCP. The INDEX button is used in the same manner as in the case of modifying real variables discussed earlier.

You should try modifying the different location variables using the mechanisms described here. When you feel comfortable with editing location variables, press REC/DONE twice to return you to the top-level Edit display. Pressing the EDIT button has the same affect, as it returns the system to the top-level EDIT display immediately.

9.12 OTHER MCP FEATURES

Other features of the MCP include the recording of locations for later use, and the function of the "USER" LED located on the MCP.

9.12.1 Recording Locations

The recording of locations is performed using the "REC/DONE" button on the MCP. Pressing this button stores the current arm position for later use such as, playback in a program. Record location is not enabled unless the LED on the "REC/DONE" button is blinking. This function is used in conjunction with the programmer's terminal and will be explained in the following chapter as part of the "Teach-Playback" discussion.

9.12.2 The "USER" LED

To the left of the manual mode LEDs is another LED labeled "USER". This LED is normally off. However, it will come on when an application program writes to the pendant display or reads a pendant button.

If the operator is using one of the pendant functions (EDIT, DISPLAY, CLR ERR, CMD, or PROGRAM SETUP) and a program tries to access the pendant, the "USER" LED will blink. The program will wait until the operator has completed execution of the function by pressing the "REC/DONE" button the appropriate number of times. At that time, the "USER" LED will come on steady and the program will be allowed to write to the display.

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9.13 SUMMARY

This completes the tutorial on system operation using the MCP, except for recording locations which will be covered in a later chapter.

Now press the "REC/DONE" button to return the system to the background mode. Then press the "PANIC" button to remove arm power, and finally turn off system power with the power switch located on the controller front panel. This will allow you to start each chapter of the tutorial from a known power-off condition.

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CHAPTER 10

BASIC OPERATION WITH THE PROGRAMMER'S TERMINAL

10.1 INTRODUCTION

This chapter addresses the use of the optional programmer's terminal to control the manipulator movements. In the previous chapter when you were using the MCP, you were issuing commands to the operating system which in turn was controlling the manipulator. The application program executed with the MCP was written in your V or V+ programming language.

The commands entered with the MCP can also be input directly to the system from the optional programmer's terminal. The terminal can be used to enter all of the commands available with the MCP plus many more. This chapter describes some of these capabilities including information on how to load, execute, and store pre-written application programs.

For persons not familiar with the use of computer terminals the following paragraphs contain information of a general nature to assist you in getting started. If you have used other computer terminals, you can skip ahead to those portions of the chapter dealing with programming.

The procedures in this manual assume use of the programmer's terminal supplied by Adept as an option. If you are using another terminal it is important that you read the next paragraph and follow the instructions for configuring the system for your terminal.

10.2 CONFIGURING OTHER TERMINALS

The serial data I/O port labeled "ASCII TERMINAL" for connection of the optional programmer's terminal is factory configured as follows:

Baud Rate:	9600
Stop Bits:	1
Bits per Byte:	8
Parity:	none
Terminal Type:	4

The EPROM used at system power-on initialization also communicates with the terminal at a baud rate of 9600. The user may select the initial baud rate for communication with his terminal by setting switches 6 and 7 in DIP-Switch SW3 on the 68000 Processor board, Adept Part Number 10300-16600, (slot 5 of Controller card cage) as shown below:

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CONSOLE BAUD RATE	SWITCH 6	POSITION 7
1200	C	O
2400	O	C
9600	C	C
19200	O	O

"C" Closed
"O" Open

After system boot, the user will be required to load the "CONFIG_C.V2" Utility Program in order to change the parameters to suit his terminal. After making the necessary changes with the "CONFIG_C.V2" program the user can save them to the system boot disk, making further changes unnecessary. Refer to the Instructions for Adept Utility Programs manual for more information.

10.3 KEYBOARD FAMILIARIZATION

Locate on your keyboard the spacebar, shift and shift-lock keys, and the delete and backspace keys.

The spacebar is used to key in a space on a line, such as the space between words in this sentence.

The shift keys, one on each side of the keyboard, are used to type capital letters. That is, holding down the shift key and pressing any letter key will result in a capital or uppercase letter being printed. Also when used with non-letter keys (numbers or symbols that have two characters per key) the shift key is used to enter the top symbols.

The shift-lock (or Cap-lock) key is used to type in all capitals. FOR EXAMPLE, THIS IS TYPED USING THE SHIFT-LOCK. Note that the shift-lock has no effect on the number or symbol keys.

The backspace and delete keys can be used to erase the last character typed.

10.3.1 Special Characters

Table 10-1 provides a list of special characters involving the use of the control (Ctrl) key located on the left side of the keyboard. The ^ symbol is used to indicate the control key. For example, if you wish to use the ^C, hold down the control key while pressing the letter "C" key. Note also that ^O is the letter "O" not the numeral "0".

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Table 10-1. Special Control Characters.

CHARACTER	DEFINITION
^C	Abort the program (procedure) in progress.
^O	Stops output to the terminal. Pressing ^O again resumes terminal output. No affect on execution.
^Q	Restarts scrolling of the display after halted by a ^S.
^R	Redraw an input line.
^S	Stop scrolling of the display.
^U	Delete an entire line entry.
^W	Slows down scrolling but does not stop it. Resume normal speed by pressing ^W again.
^Z	Abort a program when it is prompting for an input.

When entering commands via the terminal you may use UPPERCASE, lowercase, or both. Throughout this chapter, command entries will be in uppercase.

The word "enter" will be used in conjunction with issuing a command to the system. The use of enter implies pressing the "Return" key when the command has been completely typed in. As you type in the command it is echoed on the screen, but nothing will happen until you "enter" the command by pressing the return key. In this chapter we will indicate the need for pressing the return key with (Rtn).

10.3.2 Commands and Instructions

Basically, the difference between monitor commands and program instructions is:

- A monitor command is a system command used at the programmer's terminal for manipulation of programs and data, control of program execution, and general control of system status. An example of a monitor command is, "DO" which causes the robot to execute a single program instruction.

- A program instruction is a step in a program used to control the motion, hand, trajectory, and/or configuration of the robot. An example of a program instruction is, "MOVE A" which when

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executed tells the robot to move to a location previously defined as A.

For more information refer to your V Reference Guide or your V+ Reference Guide.

10.4 SYSTEM OPERATION

Before you can use the terminal to control the system, you must connect the data I/O cable to the ASCII TERMINAL connector located on the rear panel of the controller chassis. Enable the terminal by turning the Key Switch on the front panel to the "TERMINAL" position ,; only difference is:

NOTE

System power was turned off at the end of the last chapter so that operation with the programmer's terminal could be started from the beginning. Refer to chapter 8 "System Startup" to turn on system power and instructions for loading the operating system.

When the system is ready to accept commands it will display the prompt signal on the screen. The normal prompt is a dot ".", and signals the operator that the system is ready.

In the previous chapter we used the MCP to calibrate the manipulator. This operation will now be performed using the programmer's terminal. Be sure the manipulator working area is clear and all manipulator joints are clear of their limit stops.
Turn on Arm Power by entering the "ENABLE POWER" command:

```
.ENABLE POWER (Rtn)
```

Then issue the command:

```
.CALIBRATE (Rtn)
```

Respond with "Y (Rtn)" to the question:

```
Are You Sure (Y/N)?
```

The manipulator will then calibrate itself as it did when you entered the "CALIB" command from the MCP. The manipulator will need to be calibrated only when System Power has been turned off. If Arm Power was turned off, but System Power remained on, the manipulator does not have to be recalibrated. However, issuing the command again does not harm the system.

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10.4.1 Program Storage

The system is equipped with two or more mass storage devices used for storing programs, locations, or other data. Note that when System Power is turned off, any programs or other data not specifically stored in a mass storage device will be lost.

There are five primary commands used for operating the mass storage devices. They are:

- STORE -Stores information on a disk.
- LOAD -Retrieves information from a disk.
- FDIRECTORY -Lists the directory of all files on a disk.
- FDELETE -Deletes information from a disk.
- FORMAT -Formats a new diskette (or optional Winchester).

When operating the mass storage devices, you must specify which device you want to communicate with; unless you are using the default which is normally drive A. For example, if you wished to see what is currently saved on a diskette in drive A, entering

```
.FDIRECTORY (Rtn)
```

would display the names of the files stored, and the amount of free (unused) space on the diskette. The command

```
.FDIRECTORY C:  (Rtn)
```

would be used to list all the files stored on the optional Winchester drive.

Insert the Utility Disk (blue label) into drive A, and load in the file "pick" by entering

```
.LOAD PICK (Rtn)
```

When the dot prompt (.) is displayed, loading is complete. If the file were stored on the optional Winchester, you would use the command

```
.LOAD C:PICK (Rtn)
```

If you were to enter

```
.STORE DUMP (Rtn)
```

all current programs and data in active memory would be stored on the diskette in drive A with the file name "DUMP.V2" (.V2 is always added to end of the file name when a store command is used and no file extension

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is specified).

Another command that communicates with the disk drives is FDELETE. This commands deletes a specific file from the drive media. You could enter

.FDELETE DUMP.V2 (Rtn)

to delete the file DUMP.V2 from the diskette in drive A. In this case, you must add the .V2 at the end of the file name to clearly identify the file to be deleted. The V/V+ system will prompt you to make sure you want to delete the file.

CAUTION

Once you delete a file from a disk, it can not be recovered.

The last of the commands used to communicate with the disk drives is "format". This command is used to format a new diskette, or the optional Winchester drive. This must be done with all new diskettes, such as the blank ones supplied with the system.

CAUTION

If your system has a Winchester drive it is factory configured with the system boot on the disk. If you format a diskette (or Winchester) that has information stored on it, that stored information will be lost.

To format one of the blank diskettes, insert it into drive A and issue the command

.FORMAT A:/Q (Rtn)

which will result in both sides of the diskette being formatted for double-density recording.

10.4.2 Program Execution

When any program is executed, the manipulator moves at a preset speed. With the MCP you controlled the speed with the +/- speed bars, and SLOW button. Using the programmer's terminal you must use the command

.SPEED X (Rtn)

where "X" represents the desired speed as a percentage of the normal speed of 100. When the V/V+ system is initialized, the speed is set to 50. It is recommended that whenever you execute a program for the first

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time that you execute it at a low speed to verify operation. You can check the current speed setting by entering the command

```
.STATUS 0 (Rtn)
```

which will cause a display on the screen of the current status of the manipulator, including the current speed. The display should look like the following

```
.STATUS 0 (Rtn)

Robot State:     COMP Mode
Monitor Speed:   50.00
Program Cycles
    Completed:   0
    Remaining:   0
Program          Next Step
 None                 1
```

The first line of the status output indicates that the controller is in computer mode. The second line of the display indicates the current speed setting. As you proceed with the rest of this chapter, the other lines of the display will be explained. If the speed is not currently set to 50, enter the command

```
.SPEED 50 (Rtn)
```

Now check the status again to verify the speed has been set to 50. In order to execute programs, they must first be loaded from the storage device into active memory. In the preceding paragraph you loaded the "pick" program from drive A. You can verify that it is in active memory by issuing the command

```
.DIRECTORY (Rtn)
```

which will list all programs in active memory. (Remember that the FDIRECTORY command listed all the files on a disk).

Programs are executed from the terminal with the EXECUTE command.

CAUTION

You will be executing a program that will cause the manipulator to move. Be sure that the work envelope is clear of all obstructions.

Enter the command

```
.EXECUTE PICK (Rtn)
```

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which causes the system to execute the "pick" program one time. When a program is running the system prompt changes from the dot (.), to an asterisk (*). However, unless you enter commands while the program is executing, you will not see the (*) prompt. That is, the line with the cursor will be blank until you type the first character, then the asterisk will appear in front of the character just typed.
When the program completes, the display is as follows:

```
Program Completed
Stopped at pick, step 13
```

You can automatically execute the program five times by entering

```
.EXECUTE PICK,5 (Rtn)
```

The number 5 controls the number of loops which the program executes. If you have commanded several loops, you can abort them early by entering

```
*ABORT (Rtn)
```

which will result in the following display:

```
Aborted
Stopped at pick, step 10
```

Your display will not necessarily show step 10, but will show the last step completed when you entered the abort command. Now, enter

```
.PROCEED (Rtn)
```

which will continue execution from where it left off.
Execute the "pick" program continuously by entering

```
.EXECUTE PICK,-1 (Rtn)
```

where the parameter "-1" commands continuous execution. Now, the rest of the status command can be explained. Enter

```
*STATUS 0 (RTN)
```

The display should look similar to this:

```
Robot State:        Program running
Monitor Speed:      50.00
Program Cycles
    Completed:      3
    Remaining:      Infinite
Program             Next step
pick                    6
```

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The first line tells you that the program is running. The second line displays the current speed setting. The next three lines show how many loops or cycles of the program have completed and how many are left (in this case, infinite because you commanded "-1" loops). The last two lines tell you the name of the program and the step to be executed next. You can now stop the program by entering "ABORT".

10.4.3 Input, Output, and Robot Location

The "IO" command is used to display the status of all the binary input and output ports. This display is updated continuously and is useful when verifying the operation of external devices connected to the ports. To display IO status, enter

```
.IO (Rtn)
```

When you wish to stop the display, enter ^C (hold down the Ctrl key while striking the "C" key). This will abort the "IO" command.

NOTE

IO will not display correctly if the TERMINAL parameters are not set properly for the terminal in use.

Another useful command is WHERE, which causes display of the current robot location. Enter the command:

```
.WHERE (Rtn)
```

to display the current location. As can be seen, the command displays the world location (X, Y, Z, yaw, pitch, and roll) as well as the joint locations (1, 2, 3, and 4).

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10.5 BASIC OPERATION SUMMARY

In this section of the manual you have learned the following V/V+ commands:

STORE	-stores information on disk
LOAD	-retrieves information from the disk
FDIRECTORY	-lists a directory of files on disk
FDELETE	-deletes information from the disk
FORMAT	-formats a new diskette (or Winchester)
CALIBRATE	-calibrates the manipulator
SPEED	-sets the manipulator motion speed
STATUS	-lists the current system status
DIRECTORY	-lists directory of programs in memory
EXECUTE	-executes a program
ABORT	-stops the current program
PROCEED	-continues execution of previous program
IO	-displays status of all input, output ports
WHERE	-displays the current robot location

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CHAPTER 11

BASIC SYSTEM PROGRAMMING

11.1 INTRODUCTION

This chapter covers basic programming with the V or V+ language. Several instructions will be presented, followed by a tutorial on using the editor. Using the editor, a simple program will be constructed. In addition, instructions for reading from and writing to the binary input and output ports will be presented.

11.2 BASIC V AND V+ INSTRUCTIONS

Often, when commanding movement of the manipulator, it is desirable to refer to "locations". The most straightforward way to define a location is to manually move the manipulator (with the MCP) to the desired location and then record the points. The following procedure will identify two locations, A and B.

Using the MCP (in WORLD state) move the end-effector from its current location to a position about halfway in towards the base. Then, move the end-effector about six inches down from the top of its travel. Now identify this location to the system by entering at the terminal:

```
.HERE A (Rtn)
```

The system will respond with

```
   x       y       z       y       p       r
xxxxx   yyyyy   zzzzz   yyyyy   ppppp   rrrrr

   Change?
```

The coordinates displayed are the internal representation of the location "A". You may modify the coordinates at this time. Press the return key to indicate that you do not want to change the location. The HERE A command has saved the current location under the name "A".

Again, using the MCP in WORLD state, move the end-effector in the "+Y" direction about twelve inches. Identify this location as "B" by entering:

```
.HERE B (Rtn)
```

and press the return key in answer to the "Change?" prompt.

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Anytime you wish to identify locations to the system you may follow this procedure of moving the manipulator manually and using the HERE command.

CAUTION

You will now be commanding the manipulator to move. Be sure the entire working envelope is clear of all obstructions.

Now, to verify that the locations have been taught to the system, enter:

.DO MOVE A (Rtn)

This commands the manipulator to perform a "joint-interpolated motion" to location "A". A joint-interpolated motion is a coordinated manipulator motion in which each joint is controlled individually. This results in the tool-tip scribing arcs, rather than straight lines. Now use the MOVE instruction to return the manipulator to location "B". That is, enter

.DO MOVE B (Rtn)

If you wished to command a "straight-line motion" rather than a "joint-interpolated motion" you would use the "MOVES" instruction.

Another pair of useful instructions are APPROS and DEPARTS. Often when moving material into and out of boxes, it is necessary to move the manipulator to a position above the box, followed by a motion straight down into the box. If a MOVES instruction were used to move directly to the final location, the manipulator would collide with the side of the box.

Both APPROS and DEPARTS can be commanded "relative" to the locations which have already been taught. Command the manipulator to "approach" location "A" by entering

.DO APPROS A, 100 (Rtn)

This commanded the manipulator to perform a straight-line motion to a location 100 millimeters above location "A". Now, command the manipulator to move down to location "A":

.DO MOVES A (Rtn)

This sequence demonstrated how the robot arm can be made to move above a box of parts, and then down into the box. A similar instruction to APPROS is DEPARTS. This performs the opposite function -- it instructs the manipulator to "depart" from a location. Use the DEPARTS instruction to move the manipulator away from location "A":

.DO DEPARTS 100 (Rtn)

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This commanded the manipulator to perform a straight-line motion back to the location 100 millimeters above "A".

As with MOVE, you can "approach" and "depart" in NON straight-line motions with the instructions APPRO and DEPART, respectively.

To perform basic applications, the instructions OPENI and CLOSEI will be very useful if an optional hand is installed. These open and close the hand. Try these instructions by entering

```
.DO OPENI (Rtn)
```

which should open the hand, followed by

```
.DO CLOSEI (Rtn)
```

which should close the hand.

11.3 BINARY INPUT AND OUTPUT

There are program instructions for turning on and off binary I/O lines, reading the state of these lines, and controlling program execution based on the status of the I/O lines.

There are three types of I/O signals available. Input lines are designated by numbers between 1001 and 1512. Output lines are numbered from 0001 to 0512, and the internal or "soft" signals are numbered from 2001 to 2128.

Binary output lines are turned on and off with the SIGNAL instruction. As with MOVE, APPRO, etc., this instruction can be given directly from the terminal by preceding it with DO. For instance, the instruction

```
.DO SIGNAL 8 (Rtn)
```

will turn on binary output line number 8. The instruction

```
.DO SIGNAL -8 (Rtn)
```

will turn off output line number 8. These instruction can be used to turn on or off any of the output lines.

A similar capability is that of reading the state of particular input line. Recall the use of the "IO" command which read and displayed all of the input and output lines. The SIG instruction can be used to read one or more input lines. We will use this instruction in the next example.

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The WAIT instruction is often used in conjunction with SIG. Within a program, WAIT can be used as follows:

```
WAIT SIG(1010)
```

That will suspend the execution of the program until input signal number 1010 is on. A sample program might look like this:

```
.PROGRAM input
;Wait for input line 1012 to come on, then set
;output line 6
;
      APPROS a,100          ;Approach position a
      WAIT SIG(1012)        ;Wait for pallet to be put in place
      SIGNAL 6              ;Signal machine to continue
      MOVES a               ;Move down to a
      OPENI                 ;Release the part

etc.
```

Thus, with the keywords WAIT, SIG, and SIGNAL, the system can communicate with an external environment and react to changing conditions.

11.4 WRITING A SAMPLE PROGRAM

NOTE

The remainder of this chapter is written for the user with systems using the V robot control and programming language.

For the user with systems using V+, Adept's advanced robot control and programming language, there are two editors furnished with the system. If you choose to use the SEE editor, refer to Chapter 8 of the V+ Reference Guide for more information.

In the preceding paragraphs you issued commands (using the programmer's terminal) that caused an immediate response by the manipulator. Often that is referred to as command mode, since you are directly commanding the manipulator to perform an instruction. Another way of controlling the manipulator is by executing pre-written programs. A program is a series of instructions that is given a name. Thus, when you tell the V system to execute the program (identified by name) that series of instructions is executed in sequence by the manipulator.

In this portion of the chapter you will be writing a small program using the instructions just learned. If you turned off system power, you must

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go through the power up and calibration sequence. In addition, the program you write will make use of the locations "A" and "B" which were taught previously. If system power has been turned off, you need to reteach locations "A" and "B" in the same manner as before.

NOTE

This paragraph and the next on "Using the Editor" go hand-in-hand. Therefore, you may find it useful to read this tutorial (without performing the instructions) and the next paragraph on using the editor, before returning to this point to perform the exercises.

In order to create a program named "TEST", enter

```
.EDIT TEST (Rtn)
```

which tells the system you want to create the program named, and it puts the system in a mode whereby you can create the program.

After commanding EDIT TEST, the system is prepared to accept instructions that will be sequentially stored (for later execution) in a program named TEST. The V system will respond with:

```
1 .PROGRAM test()
2?
```

The first line of any program must be ".PROGRAM" followed by the name of the program. Since you do not want to modify that line, the editor has automatically prompted you to input the second line. Now you are ready to enter program instructions. Enter

```
SPEED 50 ALWAYS (Rtn)
```

This does not have any immediate affect on the manipulator. Instead, the instruction is stored for later execution. The system will respond with

```
3?
```

asking for the third line of your program.

You will now enter the rest of the program lines that will comprise the TEST program. If you make a mistake while entering the program lines, use the editing commands (explained in the next section) to make a correction. If you are in the middle of a line and realize that you have made a incorrect entry, you can erase by using the backspace key on the terminal keyboard. This allows you to correct mistakes before they are entered into your program.

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Sometimes, after entering a line, the V system will respond with:

Can't interpret line

or

Unknown instruction

and will prompt you for the same line again. This indicates that you have made a mistake and the V system is asking you to re-enter the line correctly.

Now, enter the following lines exactly as shown:

```
;Perform Pick and Place
;
APPROS A,100     ;Approach location "A" by 100 mm
MOVES A          ;Move down to location "A"
CLOSEI           ;Close the hand
DEPARTS 100      ;Depart by 100 mm
APPROS B,100     ;Approach location "B" by 100 mm
MOVES B          ;Move down to location "B"
OPENI            ;Open the hand
DEPARTS 100      ;Depart by 100 mm
E
```

As you can see, the instructions are the same ones you learned earlier. Any line that begins with a semicolon (;) is a comment line and is used solely as a note to yourself (or anyone else reading your program). Also when a semicolon is encountered during execution of the program (for example, "OPENI ;Open hand") everything to the right of the semicolon is interpreted as a comment, and is ignored.

NOTE

Although comment lines are entered and edited as any other line, they are ignored during program execution.

There is no requirement for the number of comment lines in a program, any number from zero on up is acceptable. However, it is very useful to use them as you write a program, and you are encouraged to make liberal use of them.

The last line of the program (E) was used to stop the entering of program lines and to exit the editor.

Earlier you were taught the "speed" command. There is a difference between the SPEED command that you entered at that time, and the SPEED instruction that is in your program. Using the SPEED command to set the speed (referred to as the monitor speed) sets the speed of every motion

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until the speed is changed. Setting the speed within a program with a speed instruction only controls the motion speed within the program. To compute the actual speed, you must multiply the monitor speed (50%) by the program speed of (50%), resulting in a manipulator speed of approximately 25%. Remember, the speed settings are interpreted as rough percentages.

In the program TEST, line 2 is:

```
SPEED 50 ALWAYS
```

If you wanted to modify the speed, but only for the next motion, you would omit the ALWAYS. That is useful for increasing or decreasing certain motion speeds within a program, without changing the speed of the entire program.

You can review the instructions in your program by entering

```
.LISTP TEST (Rtn)
```

which results in the following output:

```
 1  .PROGRAM test()
 2        SPEED 50 ALWAYS
 3  ;Perform Pick and Place
 4  ;
 5        APPROS a,100          ;Approach location "A" by 100 mm
 6        MOVES a               ;Move down to location "A"
 7        CLOSEI                ;Close the hand
 8        DEPARTS 100           ;Depart by 100 mm
 9        APPROS b,100          ;Approach location "B" by 100 mm
10        MOVES b               ;Move down to location "B"
11        OPENI                 ;Open the hand
12        DEPARTS 100           ;Depart by 100 mm
13  .END
```

You will notice that when you command LISTP, the V system reformats your program. Comment lines will be unchanged, but all locations (for example "a") will be in lower-case, and all instructions (for example, "MOVES") will be in upper-case. In addition, the spacing of the lines may be different from what you typed in, but that has no affect upon execution of your program. Also, the V system included the line ".END" in the program to indicate the end of the program.

CAUTION

At this point you must review your program and insure that it perfectly matches the program lines listed above. If there are discrepancies, refer to the following paragraph on using the editor to correct any errors in your program. Any errors

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not corrected could result in unexpected manipulator motions when you execute the program.

For the purposes of this tutorial, and if you are a beginner, it is suggested that you start your program at a slow speed. You may do this by using a speed instruction of "SPEED 10 ALWAYS" to verify proper operation of the program prior to running it at the desired speed.

Now, execute and verify your program using the "EXECUTE" command you learned earlier.

11.5 USING THE EDITOR

You have just learned how to write a simple V program and use it to control the manipulator. It is often desirable to make changes to a program after it has been written. Reasons for this include: Changes in the application or, the program is not working properly. Also, when you are using pre-written application modules, you may wish to change them to incorporate additional capabilities. The process of changing or modifying programs is referred to as editing. The portion of the V system that performs the editing process is called the V Program Editor.

To edit a program, (that is, to enter the editor) enter

```
EDIT program (Rtn)
```

where "program" represents the name of the specific program you wish to edit. Once you are in the editor, there are several operations which you may perform on the program. They include:

- Replace an existing step in a program with a new step
- Delete an existing step (D)
- Insert a new step in between two existing steps (I)
- Skip to a new step (S)
- List a group of steps (P)
- List the previous step (L)
- Exit the editor (E)
- Change to a new program (C)

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Now, invoke the editor on the program you created earlier with the command

```
.EDIT TEST (Rtn)
```

which causes the V system to put your program into the editor and display the first step. The display should look like this:

```
1  .PROGRAM test
1?
```

The prompt "1?" is the editor's way of asking you if you want to change step number 1.

In order to look at step number 2 (without changing step number 1) press the return key. Pressing return will always display the next step in the program. When you want to look at previous steps, enter "L". Enter "L" now to look at step number 1 in your program. The display should look like this:

```
1  .PROGRAM test
1?
2        SPEED 50 ALWAYS
2?L
1  .PROGRAM test
1?
```

Often a step in a program does not do what you expected it to do. When this happens, you will want to "replace" the existing step with a new step. To do this, all you do is enter the new step. Press return to display step 2, and enter

```
SPEED 40 ALWAYS (Rtn)
```

which will replace step number 2 with "SPEED 40 ALWAYS". Whenever you "replace" a step, as you just did, the editor automatically displays the next step in your program. You can verify that step number 2 was replaced by typing "L". The display should look like this:

```
1  .PROGRAM test
1?
2        SPEED 50 ALWAYS
2?L
1  .PROGRAM test
1?
2        SPEED 50 ALWAYS
2?SPEED 40 ALWAYS
3  ;Perform Pick and Place
3?L
2        SPEED 40 ALWAYS
2?
```

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Now press return to display step number 3.

If you determine that there is an unnecessary step in your program, you will want to delete it. This is done by typing "D". Whenever a step is deleted, all of the remaining steps are renumbered and the next step is displayed. Enter "D" and your display should look like this:

```
1  .PROGRAM test
1?
2         SPEED 50 ALWAYS
2?L
1  .PROGRAM test
1?
2         SPEED 50 ALWAYS
2?SPEED 40 ALWAYS
3  ;Perform Pick and Place
3?L
2         SPEED 40 ALWAYS
2?
3  ;Perform Pick and Place
3?D
3  ;
3?
```

The "D" command can also be used to delete more than one line. If you were to enter

D n (Rtn)

"n" number of lines would be deleted. For example, "D 5" will delete 5 lines.

NOTE

When lines are deleted from a program they cannot be recovered. Do not delete any lines that you do not want to lose.

The command for inserting a line between two existing lines is "I". Enter "I" now to insert a new step between steps 2 and 3. The new step will be:

;Perform Operation

When you insert a new step, all the following steps will be renumbered. After you insert a new step, the editor waits to see if you want to insert more new steps. They may be inserted in the same manner you inserted ";Perform Operation". To stop insert, just press the return key in response to the line change prompt (in this case, "4?"). The

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display will look like this:

```
1  .PROGRAM test
1?
2        SPEED 50 ALWAYS
2?L
1  .PROGRAM test
1?
2        SPEED 50 ALWAYS
2?SPEED 40 ALWAYS
3  ;Perform Pick and Place
3?L
2        SPEED 40 ALWAYS
2?
3  ;Perform Pick and Place
3?D
3  ;
3?I
3?;Perform Operation
4?
4  ;
4?
```

You have now used most of the common editor commands. To "exit" the editor all you have to do is enter "E". This saves the edited version of your program in active memory, but not on disk. You must still use the STORE command to do that.

The other editor commands are:

```
S n          -skip to line number n
C program    -exit the current program and edit a new program
R            -Replace part of a line
```

If you wish to replace part of a line, first have the editor display the line you wish to change. For example, suppose you want to change line 3 of your program to read "Perform Application". You are now at step 4, so enter an "L" to display step 3 and then position the cursor, using the spacebar or Tab key, under the first character you wish to replace. The display will look like this:

```
3  ;Perform Operation
3?
```

You are now ready to replace "Operation" with "Application". Do this by entering "R," followed by the word "Application", followed by pressing the return key:

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```
3  ;Perform Operation
3:          R,Application (Rtn)
3  ;Perform Application
3?
```

Remember when using the "R" command, it will replace the characters in the original line with the exact characters you type in after the "R," command.

Often is is a good idea to check the final edited version of your program after you leave the editor. This is done with the LISTP command you learned earlier.

11.6 TEACH-PLAYBACK

The Teach-Playback capability is used to create a program which consists of several MOVE or MOVES instructions. The easiest way to teach the locations for MOVE instructions is to "lead" the manipulator to the various locations with the MCP, rather than entering the locations from the programmer's terminal. However, using the HERE command for each location can be cumbersome. Teach-Playback provides a simple way to create a program and teach several locations.

To use this capability, enter

```
.EDIT test(1) (Rtn)
```

which, creates a program named "test(1)" and puts you in the editor.

Now, enter the command "TS" to the "2?" prompt

```
2?TS A (Rtn)
```

where "A" is the name under which all locations taught will be stored. The V system will then wait for you to record locations.

Move the manipulator with the MCP to the first desired location. When this is accomplished press the REC/DONE button on the pendant.

NOTE

The path you follow between locations during "Teaching" has no effect on the robot path during program-controlled "Playback" of the taught locations.

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The terminal will display

```
1  .PROGRAM test(1)
2?TS A
2         MOVEST a[0]
```

where MOVEST is like the MOVES instruction you learned earlier, the "T" at the end indicates that is was entered through Teach mode. "A" is the location, and [0] is the representation for the hand being closed in this case. The representation for the hand being open is [1].

If you wished to record a series of MOVE rather than MOVEST instructions, you would have entered "T" instead of "TS".

When you want to open or close the hand without movement of the manipulator, use the MCP to change the hand state and press the REC/DONE button on the pendant. This will result in an opening or closing of the hand without any manipulator motion.

NOTE

Actually the system issues a move command to the present location followed by the state of the hand ([1] for open and [0] for closed). In affect this is consistent with the statement made above.

Each time you press the REC/DONE button, a new line will be entered in your program. For the second line, the A will become A1. The next line will be A2, and so on.

When you are finished recording locations, press the Return key on your terminal keyboard. The V system will prompt you for the next line in your program (for example, "6?"). You may now enter more program lines or you can exit by entering "E".

If you wish to teach a series of MOVET or MOVEST instructions in the middle of an existing program, you can use T or TS to insert the instructions in front of the line that is currently displayed by the editor.

Also, if you stop teaching and wish to pickup later where you left off, you would enter:

```
6?TS A6
```

Thus, the next location would be A6, then A7, and so on.

Once the program is complete, it can be executed in the same manner you learned previously.

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A similar capability is the TEACH command, which allows you to teach a series of locations without the MOVET or MOVEST instructions. This is performed by entering

```
.TEACH start (rtn)
```

which would result in the locations "start", "start1", "start2", etc. being taught each time the REC/DONE button was pressed. Again, pressing the Return key on the keyboard terminates the session.

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CHAPTER 12

CELL CONTROL OPERATIONS

12.1 INTRODUCTION

An important feature of the V and V+ systems is the ability to run "process control" programs asynchronously with "robot control" programs. While a robot control program is controlling the sequence of robot motions, the process control program is capable of simultaneously monitoring and controlling internal and external processes. The processes typically consist of communication with other machinery or safety interlocks. During execution of the robot control program, the process control program can alter the sequence of operations through shared variables, software signal flags, and I/O signal line transitions.

The power of the process control program is made possible by the flexibility of the programming language, and the large quantity of possible I/O lines. Your V/V+ system is capable of handling 512 I/O signal lines, and 128 software channels. Refer to your V+ Reference Guide or V Reference Guide for more information.

The controller, in the standard configuration, comes equipped with one 32 I/O board (BIO) mounted internally in the chassis. This configuration can be expanded to the full 512 I/O capability through the use of optional 64-channel expansion modules.

The process control capability can be thought of as a separate controller within the same chassis as the robot controller. This "separate" controller has the following features:

- Access to all communication channels including binary I/O, serial I/ O, and the optional IEEE-488 bus.
- Easy communication with the robot controller either by using binary I/O, or by common variable names.
- Control of AdeptVision systems.
- Access to all mass storage devices.
- Programmed in the same language as the robot controller.

The value of executing simultaneous robot control and process (or cell) control programs is that the cell control program operates as if it were on a separate controller; its execution is not dependent upon robot motion. Thus, cell control is not synchronous with robot motion. This

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is not only an advantage, it is mandatory for effective cell control.

In order to better understand this unique capability, the following paragraphs detail a typical example.

12.2 TYPICAL APPLICATION EXAMPLE

An Adept robot system is working on a mechanical assembly. One of five possible bases can be presented to the robot on a power-and-free conveyor. The robot uses area AdeptVision mounted on the arm to pick the correct mating part out of a tray, dependent upon which base is presented to it. The process control program must control the conveyor, and incoming bases must be accumulated in front of the robot. When the robot has completed the assembly, the conveyor must index the completed assembly out of the workspace, and index the new base into the workspace. When a new base arrives at the accumulator station, cell control must sense the part type by using a serial communication bar-code reader which will interrupt the cell control program.

12.2.1 Requirement for Cell Control

The movement of the conveyor is not necessarily synchronous with the robot motion. In addition, incoming bases arrive at random intervals, but the bar-code information must be received immediately and not lost. This requires a cell control program that operates asynchronous to robot motions.

12.2.2 Implementation

1) The robot program controls the manipulator and has it pick parts out of a tray and assemble them onto the base. It treats the conveyor as controlled from a separate program. When an assembly is complete, it signals the cell controller to index the conveyor. It waits for a signal from cell control to begin assembly of the next part. In addition, information from the vision system relative to parts in the tray is also received from cell control.

2) The cell control program monitors the conveyor sensors and controls the indexing and accumulating on the conveyor. The assembled base is indexed out when the robot signals completion. The cell control signals the robot after a new base has been indexed into the work area. When a new base enters the accumulation area, the cell control receives an interrupt and the part identification (read from the bar-code) is transmitted via a serial port. Cell control also instructs AdeptVision to take pictures and communicates the part information to the robot program. When a tray of parts has been emptied, cell control indexes the old tray out, and the new tray in.

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Figure 12-1 is a flow chart representation of both programs running concurrently. The following paragraphs contain a detailed explanation of each program and the interaction between them.

12.3 ROBOT CONTROL PROGRAM

The execution of this program will be limited by the speed of the robot. Each program operation is sequential, and synchronous with the robot. At several times in the program, information is retrieved which was created or communicated by the cell control program.

1. "Part Ready?"--This is a simple loop (utilizing a WAIT SIG [2001]) which waits for the cell control program to set signal 2001 indicating that a new base has been indexed into the workspace. After the signal has been set, the robot control program resets signal 2001 and goes to the next step.

2. "Get Part ID From Memory"--The cell control program puts the part identifier into a global string variable. The robot control program will use this information to select the correct mating part for the assembly operation.

3. "Pick Mating Part From Tray"--Using the vision information, which the cell control program has sorted by part type and put into memory, the robot will pick up a mating part.

4. "Assemble"--Perform the physical mating of the part to the base. The completed assembly is left on the incoming pallet.

5. "Signal Assembly Complete"--After the assembly has been successfully performed, the robot program will set signal 2002 to indicate to cell control that the conveyor should be indexed. This conveyor indexing operation could have been included in the robot control program since it is synchronous with assembly, however, it was included with cell control so that all conveyor control would reside in one place.

6. "New Picture Required?"--When cell control has indexed in a new tray of parts, it will set signal 2003 indicating to robot control that a new picture must be taken at the next convenient time. If this signal is not set, the robot goes back to the beginning, waiting for a new assembly.

7. "Move To Camera Location"--If signal 2003 was set, robot control resets it and moves to the location where it will take a picture of the tray.

8. "Take Picture"--This is a one-line instruction (VPICTURE) which causes the camera to take a picture of the tray. The robot control

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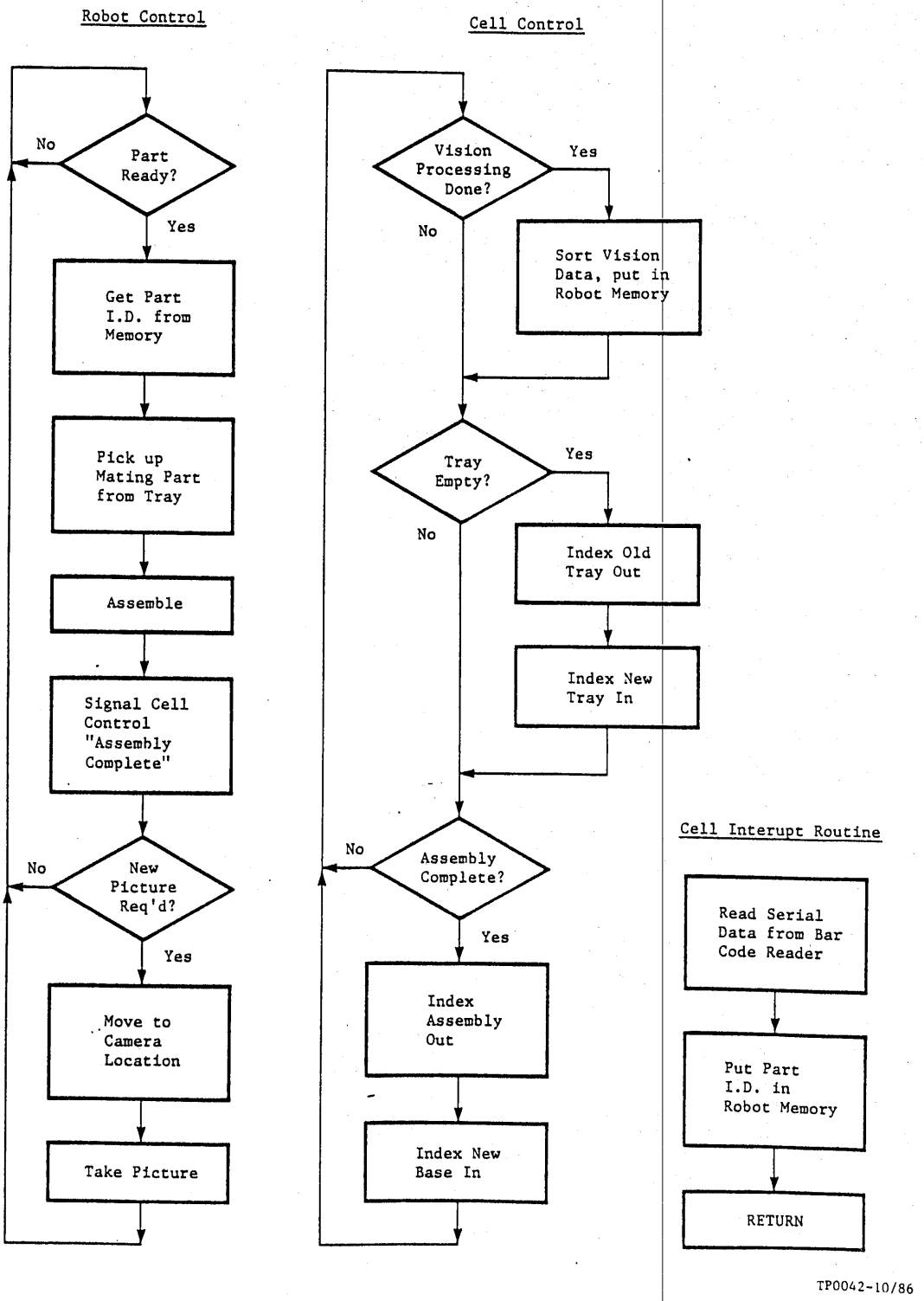


Figure 12-1. Concurrent Robot and Cell Control Programs

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program will immediately continue, allowing the vision information to be processed in parallel. The cell control program is responsible for retrieving the vision information.

12.4 CELL CONTROL PROGRAM

Unlike the robot control program, this program will operate at a speed that is unconstrained by the robot. While each step is still sequential, nothing physical limits its speed. The "cell interrupt routine" contains the program steps which receive the communications from the bar-code reader. This routine will be executed on an interrupt basis whenever a new base comes into the station. When the communication has been received, processing within the main program will continue from where it left off.

1. "Vision Processing Done?"--This queries the vision system as to whether or not the last picture has completed processing (using the VSTATUS instruction).

2. "Sort Information And Put Into Memory"--If the vision system completed processing, the part information is taken from the vision queue (using the VLOCATE instruction), sorted by part type, and put into robot program memory.

3. "Tray Empty?"--Here, the cell control program utilizes the feature of shared memory with the robot control program. The cell program queries the robot memory and finds out whether or not the tray of parts has been emptied.

4. "Index Old Tray Out"--If the current tray of parts is empty (from the previous step), the cell control program signals the conveyor (using binary I/O) to index the old tray out.

5. "Index New Tray In"--The cell control program waits for a signal from the conveyor indicating that the old tray has been indexed out. It then signals the conveyor to index a new tray of parts into the workspace. Signal 2003 is then set by cell control to indicate to the robot control program that a new picture must be taken.

6. "Assembly Complete?"--Cell control merely checks the state of signal 2002. If set (by robot control), this program will execute the process to index the completed assembly out and the new base in.

7. "Index Assembly Out"--If the assembly was completed, cell control signals the conveyor to index the completed assembly out of the workplace.

8. "Index New Base In"--After receiving a signal from the conveyor that the completed assembly has been indexed out, cell control signals the conveyor to index a new base into the workplace. When that is

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completed, signal 2002 is reset, and signal 2001 is set to indicate to the robot control program that a new base is ready for assembly.

9. "Read Bar-Code"--When interrupted by the signal from the incoming base, the cell control program switches to a routine that reads in serial data from the bar-code reader (using the GETC instruction).

10. Put Part ID Into Memory"--After the data has been read the program puts it into a robot memory location where it can be accessed later.

11. "Return"--This instruction returns from the interrupt routine to the main cell control program.

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CHAPTER 13

HANDLING COMMON ERRORS

13.1 INTRODUCTION

Contained in this chapter is a numerical listing of some common errors that are reported by the system. Each listing includes the text of the error message, an explanation of the probable cause for the error, and a suggested action to be taken by the user.

NOTE

This chapter does not replace the detailed information to be found in a messages Appendix to the V+ Reference Guide or the V Reference Guide. The information presented here is extracted from those publications, and is only a sample of the errors encountered by new users of the system.

13.2 COMMON ERROR LISTING

ARM POWER off (-604)

Explanation: Arm power is not turned on.

User Action: Turn on Arm Power and re-enter the last command.

Attempt to redefine variable type (-469)

Explanation: If issued while editing a program, the line just entered contains a reference to a variable that is inconsistent with its use elsewhere in the program. The most likely problem is confusing a location variable with a real variable. If issued when exiting the editor, the named variable conflicts with a global variable that already exists.

User Action: If the new use of the variable is correct, you must delete all references to the incorrect variable and then re-enter the line that caused the error. If the new use is incorrect, use a different name. If there is a conflict with a global variable, either delete that variable with a DELETEx command, or make the conflicting variable LOCAL to the current program.

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CALL argument mismatch (-408)

Explanation: The arguments in a CALL instruction do not match the arguments in the program being called. Either they are of different types, or there are different numbers of arguments.

User Action: Modify the CALL instruction or the .PROGRAM statement of the called program so that the arguments match.

Can't mix MC and program instructions (-414)

Explanation: A program instruction has been encountered during processing of a command program, or an MC instruction had been encountered in a normal program.

User Action: Edit the command program to use the DO command with the program instruction, or remove the MC instruction from the normal program.

COMP mode disabled (-603)

Explanation: The command attempted requires computer control of the robot, but COMPUTER mode was not selected on the pendant.

User Action: Select COMP mode on the pendant, or enable DRY.RUN mode from the terminal, then reissue the command.

Control structure error at step _ (-472)

Explanation: Upon exiting the editor, the program has detected an incomplete or inconsistent control structure at the specified step.

User Action: Edit the program to correct the control structure. The actual error may not be at the step indicated.

Device not ready (-508)

Explanation: The requested disk device (or remote network task) is not prepared to communicate with the V/V+ system, or a limited-access device like the terminal or serial line is attached to a different program task.

User Action: If the intended device is a system microfloppy disk drive, make sure the diskette is inserted properly. If a limited-access device is specified, abort and

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KILL the program task which has it attached, or wait for the program task to release the device.

DO not primed (-302)

Explanation: A DO command was attempted without specifying a program instruction to be executed and no previous DO had been issued.

User Action: Provide the desired instruction with the DO command.

Envelope error Jt n (-1006)

Explanation: The indicated joint was not tracking the commanded position with sufficient accuracy, indicating a failure in the hardware servo system, or something impeding the path of the robot.

User Action: Turn on Arm Power and try to perform the motion at a slower speed. Make sure nothing is obstructing the robot motion. If the error recurs, call Adept Customer Service.

File already exists (-500)

Explanation: There is already a file on the storage device with the name supplied with the last storage request.

User Action: Reissue the storage request with a different file name, or delete the old file.

Illegal monitor command (-300)

Explanation: The name of the command just attempted was not recognized by the system, possibly because it was mistyped, or because it was a program instruction and not a command.

User Action: Check the spelling of the command name and enter the command again. Use the DO command to invoke a program instruction from the terminal.

Illegal PC instruction (-415)

Explanation: An attempt has been made to execute a program instruction in a PC program, which is not permitted.

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In general, the PC program cannot execute a robot motion control instruction.

User Action: Delete the instruction from the program.

Invalid solution Jt n (-1002)

Explanation: The requested motion was beyond the software-limited range of motion for the indicated joint.

User Action: Redefine the destination location.

Keyswitch not set to TERMINAL (-303)

Explanation: An attempt has been made to PRIME or otherwise initiate program execution from the terminal, when the keyswitch in not in the "TERMINAL" position.

User Action: Move the keyswitch to "TERMINAL" position.

Location out of range (-610)

Explanation: The V/V+ system has encountered a location that is too far away to represent, possibly within an intermediate computation. This probably indicates an error in a location function argument value or a compound transformation.

User Action: Check to make sure you are using location functions and operations correctly and edit the program as required.

Location too close (-618)

Explanation: An attempt has been made to move the robot to a location that is too close to the robot column. This probably indicates an error in the value of a location function argument, or an incorrect compound transformation.

User Action: Check to make sure you are using location functions and operations correctly and edit the program as required.

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No program Specified (-301)

Explanation: No program was specified for an EXECUTE or XSTEP command, and no previous program is available as a default.

User Action: Enter the command again, providing a program name.

Nonexistent file (-501)

Explanation: The requested file is not stored on the diskette currently in the disk drive. Either the name was mistyped, or the wrong diskette is being read.

User Action: Check the file name--use the FDIRECTORY command to display the directory of the diskette.

PC program active (-306)

Explanation: An attempt has been made to perform a command that is not allowed when a process control program is executing. (The PCSTATUS command can be used to see the status of the current program.)

User Action: The current program must be aborted with a PCABORT command before the desired command can be processed.

Protection error (-530)

Explanation: An I/O operation cannot be performed because (1) it attempted to write to a disk that is write protected, or (2) the user does not have the proper access status.

User Action: Check the diskette to make sure the write protect tab is in the correct position. Use an FDIRECTORY command to display the disk directory. If the file has protected ("P") or read-only ("R") protection, it cannot be accessed in the way attempted.

Undefined program or variable name (-406)

Explanation: The program or variable referenced in a command or program step does not exist, possibly because the name was mistyped.

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User Action: Create the program or variable with the editor or monitor commands, or by reading it from disk. Then re-enter the line.

Undefined value (-401)

Explanation: A variable has been referenced that has not been assigned a value.

User Action: Assign the variable a value or correct its name.

This completes the listing of common errors. Remember, a complete listing of all error messages can be found in an Appendix to the V Reference Guide and the V+ Reference Guide.

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