ROBOT PROGRAMMING

COMMANDS

The robot's microprocessor recognizes various *ASCII command codes* that are transmitted to the robot by an external computer. These commands are translated by the microprocessor into control instructions for operating the robot. The robot is connected to the computer in the same manner as you would connect a parallel printer.

A *robot program* is written in the same format as any other program that instructs the computer to send data, in the form of **literal** *characters and numbers, to a printer. The exception is that the robot will recognize and accept only certain characters and strings, which must be in a specific order. A robot command* consists of an **upper-case letter** that is *usually* (but not always) followed by a **parameter list** consisting of numbers. For example, the axes and gripper are manipulated and moved to the chosen coordinates by a **M(ove** command, consisting of the character "M" followed by a string of **parameters** that represent the number of steps each motor must move.

All robot commands must be preceeded by a **PRINT (or LPRINT)** statement (or equivalent statement if using a language other than BASIC). For example, if you wish to send the robot a **C** command (instructs the gripper to **close**), this could be written as: **210 PRINT "C".**

In this case, the "C" command would be interpreted by the robot's microprocessor as an instruction to operate the gripper motor.

The robot commands are explained below, with Apple-DOS BASIC language statements provided as examples. Several additional commands, which are not shown, are used to program external devices. (For detail, refer to *Interfacing External Devices* section of this manual.)

If the robot receives an improper or unknown command, the ERROR lamp will turn on.

Note: Throughout this manual, when reference is made to the "axes", unless otherwise specified, this includes the gripper as well, even though technically the gripper is not an axis.

C(lose

Instructs the gripper to close to the maximum limit.
Input parameter: C
Input example: 150 PRINT "C"
Example results: Gripper closes to maximum position

D(elay

Provides a timed stop or time delay in the running program. The command "D" is followed by the selected delay (in seconds) to a maximum of 99 seconds (± 1%).
Input parameter: Dn
Input example: 170 PRINT "D15"
Example results: After executing the previous command, the program stops for 15 seconds before continuing with the next instruction or command.

G(o-to

Recalls the axes movement parameters that were stored in memory with the *P(osition* and *H(ere* commands. The Command "G" is followed by the previously designated *memory location* number.
Input parameter: Gn
Input example: 190 PRINT "G2"
Example results: Axes parameters stored in memory location 2 are recalled and the axes move according to the stored instructions.

H(ere

Stores the current position of axes in memory. A maximum of 100 positions (270 with expanded RAM memory) can be memorized. The command "H" is followed by a designated *memory location* number.

Input parameter: Hn

Input example: 215 PRINT "H2"

Example results: Current axes positions are stored in Memory location 2.

L(imit

Limits movement of axes to their maximum travel positions. When command "L1" is given, movement of the axes will be restricted to the maximum steps (from zero-position) shown in *Specifications*, irregardless of the input parameters. If an axis limit is exceeded, the robot will stop, the *ERROR* lamp will turn on, and thereafter only the *N(est* command will be recognized. A command "L0" will release the travel limitation.

Input parameter: L0 or L1

Input example: 230 PRINT "L1"

Example results: Movement of axes will be restricted to the maximum steps shown in *Specifications*.

M(ove

Instructs each axis to move a specified amount. The command "M" is followed by a parameter list comprised of the number of steps each motor must move. (Refer to *Axes Parameter List* for axes parameter designations.) Be sure to designate a value for each motor, even if it is "0".

Input parameter: $M_{m1, m2, m3, m4, m5, m6}$

Input example: 245 PRINT "M200, 0, 150, 0, 0, 0"

Example results: Base will move clockwise *200* steps, shoulder *0* steps, elbow upwards *150* steps, wrist-roll, wrist-pitch, and gripper *0* steps.

N(est

Returns axes to the "home" or *zero-position*, which was designated by the previously used *Z(ero* command. Also closes the gripper.

Input parameter: N

Input example: 260 PRINT "N"

Example results: Axes return to zero-position.

O(pen

Instructs the gripper to open to the maximum limit.

Input parameter: O

Input example: 265 PRINT "O"

Example results: Gripper opens to maximum

P(osition

Stores axes-position instructions in memory. The axes will not move at this time. The parameters are similar to those of the *M(ove* command, except with this command the axes instructions are sent to memory rather than to the motors. Also, the parameters are based on movement from *zero-position*, rather than movement from the *current position*. A maximum of 100 positions (270 with expanded RAM memory) can be memorized. Command "P" is followed by a user-designated *memory location* number of 0 thru 99, and a parameter list.

Input parameter: $P_{n, m1, m2, m3, m4, m5, m6}$

Input example: 280 PRINT "P8, -800, 500, 150, 0, 0, 0"

Example results: Axes parameters will be stored in memory location #8. When this memory location is later recalled, the base will move counter-clockwise *800* steps, shoulder upward *500* steps, elbow upward *150* steps, wrist-roll, wrist-pitch and gripper *0* steps.

S(peed

Designates speed of all axes motors, with a choice of 5 speeds. (See *Specifications* for speed detail.) All motors run at the same speed. If the *S(peed* command is not used, the motors default to *speed 3*. The command "S" is followed by the selected speed number (1-5).

Input parameter: Sn
Input example: 295 PRINT "S5"
Example results: Axes move at speed 5 until a new speed command is given.

W(ait

Checks the status of an optional external interlock switch. If the switch is *open* (or if no switch is connected), the robot stops all movement until the switch is *closed*. (Refer to *Interfacing External Devices.*) Once the switch is placed in the closed position, this command is deactivated.

Note: If this command is used without a switch connected, depress the RESET button to reactivate the robot.

Input parameter: W
Input example: 360 PRINT "W"
Example results: Checks the status of the interlock switch.

Z(ero

Sets the home or zero-position of axes. Each program should begin with this command, otherwise the zero-position will be the axes positions when power is first applied, and your program will run incorrectly.

Input parameter: Z
Input example: 110 PRINT "Z"
Example results: Current position of axes set as home or zero-position.

AXES PARAMETER LIST

Parameter	Axis
m1	Base
m2	Shoulder
m3	Elbow
m4	Wrist
m5	Wrist
m6	Gripper

SPEED SELECTION

The following axes movement speeds are selectable:

SPEED NO	DESCRIPTION	MOVEMENT SPEED - BASE (Approx.)
1	Very slow	2.5 in./sec. (64 mm/sec.)
2	Slow	4 in./sec. (102 mm/sec.)
3	Medium	5 in./sec. (127 mm/sec.)
4	Fast	7 in./sec. (178 mm/sec.)
5	Very fast	8 in./sec. (203 mm/sec.)

AXES MOVEMENT SPECIFICATIONS

AXIS	DEG/STEP	DIRECTION	MOTOR	+/-	MAX STEPS	EXAMPLE
Base	0.12	cw	M1	+	1000	M1000,0,0,0,0,0
		ccw		-	1000	M -1000,0,0,0,0,0
Shoulder	0.12	up	M2	+	600	M0,600,0,0,0,0
		down		-	600	M0, -600,0,0,0,0
Elbow	0.10	up	M3	+	500	M0,0,500,0,0,0
		down		-	500	M0,0 — 500,0,0,0
Wrist Roll	0.10	cw	M4	+	7200	M0,0,0,7200,7200,0
			M5	+		
		ccw	M4	-	7200	M0,0,0, -7200, -7200,0
			M5	-		
Wrist Pitch	0.10	down	M4	+	900	M0,0,0,900, -900,0
			M5	-		
		up	M4	-	900	M0,0,0, -900,900,0
			M5	+		
Gripper	0.10	close	M6	+	2000	M0,0,0,0,0,2000
		open		-	2000	M0,0,0,0,0, —2000

***Maximum steps from each axis zero-position.**

Note: For wrist-roll and wrist-pitch, motors M4 and M5 must both be programmed so that they move simultaneously.

Please note that since this is a joint-coordinated type robot, when the shoulder axis is instructed to move, the elbow and wrist-pitch axes also move. The ratio of this movement is 10:6:5; that is,

If shoulder is instructed to move +10 steps then:
Elbow moves -6 steps
Wrist-pitch moves -5 steps

If the elbow is instructed to move, the wrist-pitch axis will move as follows:

If elbow is instructed to move +10 steps, then:
Wrist-pitch moves +10 steps