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APPENDIX L

ANSWERS

APPENDIX L

ANSWERS

UNIT II: RB5X FAMILIARIZATION

CHAPTER 1: CHIPS USED ON THE RB5X CPU BOARD

1. High state
2. Pins 27 through 34
3. To selectively enable the I/O port
4. U1

Experiment 1.1: Chip Location and Identification

1. U2, U3, U10, U21, and U22
2. CD4503 U13
3. ICL7660 U9
4. HM6116 U16, U17, U18, U19
5. Chip is located on the interface panel via a cable.

Experiment 1.2: Initializing RB5X with the Utility Software Module

1. The module in use has 2K of memory.
2a. The sonar program.

2b. Returns RB5X to command mode.
2c. Selects charger-finder routine.
3. Motor relays are identified from rear to front as A, B, C, and D.

CHAPTER 2: THE INS8073 MICROPROCESSOR

1. 7
2. 6
3. Extension (E) register and accumlator (AC) register.
4. Implied, PC relative, pointer relative, direct, indirect, indexed, and absolute.

CHAPTER 3: THE RB5X BUS SYSTEM

1. To allow access to RAMs, ROMs, ports, and the real world.
2. Input and output data.
3. Bumpers and motor drives.

Experiment 3.1: Tracing the Bus

1. To save the batteries from power drain.
2. G, I, O, and Q are not used because they resemble numerals.
3. Jacks 1 and 2, jacks 3 and 4.
4. Jack 11.
5. Distributive capacity at each chip.

CHAPTER 4: GETTING STARTED WITH ASCII PRO

1. Boot ASCII Pro diskette
   Press CONTROL/Q
   Press the number 4 key

   Set switches on robot to read 0110.
2. Press CONTROL/Q R
   Type LIST
   Press CONTROL/Q R
   Press CONTROL/Q W
   Type TEST
   Press Return
3. Out of memory.
4. Improper transfer of data from computer to robot.

Experiment 4.1: Initializing with ASCII Pro

1. The robot would initialize twice.
2. #85A1.
3. Clears all variables from old programs.

Experiment 4.2: Saving and Loading Programs

1. Varies depending on number of programs saved on diskette.
2. Off.
3. Press CONTROL/Q R
   Type LIST
   Press CONTROL/Q R
   Press CONTROL/Q W
   Type TEST
   Press Return
4. Type NEW
   Press CONTROL/Q I
   Press C
   Press Return
   Press CONTROL/Q C
   Press CONTROL/Q R
   Press CONTROL/Q S
   Type NEW TEST
   Press Return three times
   Press | symbol
5. Press CONTROL/Q I
   Press C
   Press Return
   Press CONTROL/Q I
   Press D
   Type ANOTHER TEST
   Press Return

CHAPTER 5: A COMMAND OF TINY BASIC

1. 11 seconds.
2. 1, 2, 3, 0, 0, 0
3. Power on
   Reset
   Start on #8069
   Stop on #80EF
4. Nothing would start and stop (return) on the same line.
5. Five times.

Experiment 5.1: Writing Programs in Tiny BASIC

1. C3
2. Battery is low.
3. G or D6
4. 10 @#7802=1
   20 DELAY 1000
   30 @#7802=2
   40 DELAY 1000
   50 @#7802=4
   60 DELAY 1000
   70 @#7802=8
   80 DELAY 1000
   90 GOTO 10
5. Charger is disconnected.

Experiment 5.2: Writing More Programs in Tiny BASIC

1. Boot ASCII Pro diskette
   Set computer baud rate to 300
   Switch robot on and allow to initialize
   Press bumpers 2 and 4 simultaneously
   Type NEW#1000[RET]
   Type NEW[RET]
2. #7800
   #7802
   #7801
3. 253
4. All except bumper 1.
5. 10 DO
   20 B=@#7800
   30 UNTIL (B=127)
   40 @#7802=255

CHAPTER 6: GETTING THE BUS TO THE OUTSIDE WORLD

1. 10 B=@#7809
   20 PRINT B
2. 27
3. U23 (port B)
4. Jack 1, pin 18

Experiment 6.1: Building the Bus Extender

1. G, I, O, and Q resemble the numerals 6, 1, and 0.
2. For easy connection to bread board.
3. Contact corrosion.
4. To fit the robot's card cage.

Experiment 6.2: Controlling the Extended Bus Lines

1. 235
2. A, first brown, 1, groun
   B, first orange, 2, +5 volts
   C, fourth green, 18, 2C7
   D, fourth blue, V, 2C6
   E, fourth orange, 17, 2C5
   F, fourth yellow, U, 2C4
   G, fourth brown, 16, 2C3
   H, fourth red, T, 2C2
   I, third white, 15, 2C1
   J, third black, S, 2C0
3. Port B of U20.
4. 104.

Experiment 6.3: Know Your Addresses

1. A, 1, first brown
   I, S, third black
   H, 15, third white
   G, T, fourth red
   F, 16, fourth brown
   E, U, fourth yellow
   D, 17, fourth orange
   C, V, fourth blue
   B, 18, fourth green
2. Jack 1 and jack 2.
3. 10 @#7809=196
4. 10 B=@#7804
   20 @#7808=B
5. 192

Experiment 6.4: Activating RB5X

1. Bumper 3 would need to be pressed.
2. Motor relays A and B would energize.
3. 10 @#7802=9
   20 FOR I=1 TO 10:DELAY 1000:NEXT I
   30 @#7802=0
   40 @#7801=128
   50 DELAY 1000
   60 @#7802=5
   70 FOR I=1 TO 6:DELAY 1000:NEXT I
   80 @#7802=0
4. 240 @#7802=1
   260 @#7802=2
   280 @#7802=4
   300 @#7802=8
5. Nothing, no visual action.

UNIT III: ANALOG-TO-DIGITAL (A-TO-D) CONVERSION

CHAPTER 7: CHIPS USED ON THE ENVIRONMENTAL SENSE KIT BOARD

1. U2
2. U8
3. 2, 1, 16 (2=MSB)
4. U4, U5, U6, U7, U8
5. U1, U3

Experiment 7.1: ESK Component Identification

1. Microphone.
2. R1.
3. 9708.
4. Buffer.
5. U4, U5, U6, U7

Experiment 7.2: Varying a DC Input Voltage

1. 55.
2. Approximately 2.4 volts.
3. Approximately 3.8 volts.
4. 10 A=6
   20 LINK#2500

```
30 IF B=10 PRINT "0.5 VOLTS"
40 IF B=20 PRINT "1.0 VOLTS"
50 IF B=30 PRINT "1.5 VOLTS"
60 IF B=40 PRINT "2.0 VOLTS"
70 REM AS MANY LINES AS STUDENT WISHES
200 B=@#7800:IF B[|251 GOTO 20
210 STOP
```

5. B and 2.

CHAPTER 8: ENVIRONMENTAL SENSE KIT BOARD OPERATION

1. Increased sensitivity.
2. Temperature
3. Changing DC.
4. Greater sensitivity.
5. Voltage divider.

Experiment 8.1: Converting Light to Computer Display

1. 45 to 135 degrees.
2. Approximately 6 inches.
3. B.
4. 10 A=1
5. 10 FOR I=1 TO 10:A=1
   20 LINK #2500
   30 PRINT A,B
   40 NEXT I
   50 B=@#7800: IF B[|251 GOTO 10
   60 STOP

Experiment 8.2: Converting Temperature to Computer Display

1. Approximately 1.
2. Approximately 2.
3. 0 no change
4. Approximately 77.
5. Nothing.

Experiment 8.3: Converting Sound to Computer Display

1. 77.

2. 1.
3. Stop program with the horn on.
4. 50 IF C=191 @#7801=128
   60 IF C=127 @#7801=0
   70 IF C[|223 GOTO 10
5. Shout in mic and press bumpers 2 and 4.

Experiment 8.4: RB5X's Response to ESK Board Signals

1. You would need a blow torch to stop the program.
2. The computer is not connected to the robot.
3. 10 and 20.
4. Remove upper shell/dome assembly.
   Remove screws connecting LED display board.
   Seat ESK board in jack 1.
   Gently replace LED display board.
   Replace upper shell/dome assembly.
5. It is all but impossible to do afterwards.

UNIT IV: SONAR CIRCUITRY

CHAPTER 9: SONAR APPLICATIONS

1. 0, infinity
2. BASIC is too slow.
3. LINK #2500.
4. DO
5. By timing from transmitting the sonar pulse until it is returned as an echo.

Experiment 9.1: Displaying Sonar Measurements with the Computer

1. 196.
2. Approximately 130.
3. Depends on the size of the room.
4. High voltage shock from sonar circuitry.
5. The sonar receiver and the charger use the same sense bit (#7802, bit D5).

Experiment 9.2: Responding to Sonar Measurements

1. Approximately 168.

2. 10 CLEAR
   20 LINK #1800
   30 PRINT D
   40 IF D=210 @#7801=64
   50 DELAY 1000
   60 GOTO 10
3. 10 CLEAR
   20 LINK #1800
   30 PRINT D
   40 IF D|185 GOTO 10
   50 IF D[175 GOTO 10
   60 @#7801=128:DELAY 250:@#7801=0
   70 @#7801=128:DELAY 250:@#7801=0
   80 DELAY 250
   90 @#7801=64:DELAY 1000:@#7801=0
   100 B=@#7800: IF B[|251 GOTO 10
   110 STOP
4. Turns robot in a clockwise direction.
5. 10 CLEAR
   20 B=@#7800
   30 IF B[|251 GOTO 20
   40 LINK #1800
   50 IF D=120 @#7801=128:DELAY 250:@#7801=0
   60 B=@#7800:IF B[|254 GOTO 40
   70 STOP

Experiment 9.3: RB5X's Response to Sonar

1. At line numbers 1085, 2035, 2135, 2235, add @#7801=128:DELAY 250:@#7801=0:DELAY 250:@#7801=128:DELAY 250:@#7801=0
2. 10 B=@#7800:IF B[|253 GOTO 10
   20 CLEAR
   30 B=@#7800:IF B=251 @#7802=6
   40 B=@#7800:IF B=247 @#7802=5
   50 B=@#7800:IF B=239 @#7802=9
   60 B=@#7800:IF B=223 @#7802=10
   70 GOTO 20
3. B=@#7800:IF B=254 GOTO 150
   GOTO 30
   150 @#7802=0:STOP

ROBOTICS INSTRUCTIONAL MATERIALS

RB Robot Corporation Golden, Colorado

1985

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PREFACE

THE PROGRAM

Robotics is a subject that has captured the imagination of the general public and the technical world alike. Schools are now beginning to teach robotics in a variety of ways. Central to any program in robotics, however, is an understanding of microprocessors. While many schools have courses that focus on microprocessors, most of the programs do not get into **using the microprocessor as part of a complex system.** The RB5X Robotics Instructional Materials has the student explore the details of controlling a complete system -- in this case, a mobile, interactive robot -- using a microprocessor.

Both high school and college students can dig into the insides of this robot and can develop a thorough knowledge of the system's operation. These Instructional Materials have specific objectives, detailed technical explanations, and hands-on lab activities. The sequencing of the labs takes the students step-by-step from identifying the various components of this robot system to integrating new sensors into RB5X's design.

With only minimum microprocessor background, the student can operate, program, and fully understand how the RB5X system communicates with the external world. This communication includes responding to external signals and producing signals based on the inputs. By studying this system, the student sees how complex robotic systems

function and at what level the technician must know the operation of the equipment to be able to repair and maintain it.

The technical skills taught through the use of this system are the critical elements in the success of every technician. These skills include:

- o Identifying components;
- o Reading electronics schematics;
- o Tracing circuits and busses;
- o Programming, both in Tiny BASIC and in machine language;
- o Soldering;
- o Operating and modifying electronic circuits that convert analog signals, temperature, light, sound, and sonar measurements to digital signals;
- o Understanding communication circuits; and
- o Knowing interface requirements.

With the experience and knowledge gained from completing the RB5X Robotics Instructional Materials, the student has background to learn the details and operation of such industrial robot systems as programmable controllers, robot controllers, smart conveyors, robot safety systems, and the auxiliary equipment that make up the typical robot work-cell.

While some technical programs concentrate all of their training on the details of industrial robots, many schools are educating for the broader fields of robotics and industrial automation. This type of program emphasizes the technician's ability to work on a variety of equipment -- from copy machines to electronic typewriters to personal computers to commercial robots. The RB5X Robotics Instructional Materials are aimed at the education of this broad-based electromechanical technician.

RB5X IN THE CURRICULUM

Where does the RB5X course fit into the technical curriculum? This program is designed to be flexible so that it can be used at

several different levels. The following ideas should help you identify how you might use the course.

As Part of a Course

- This is a nine-week program that can complement a six- to nine-week unit on Introduction to the Microcomputer. The first unit introduces the topic and the second unit shows how microprocessors function in a robot system.

- This robotics curriculum might also be used as part of a course on sensors. The first part of the program might discuss the different types of sensors; the second part would then use RB5X to illustrate how sensors are used as part of a complete system. This approach has the RB5X materials integrated into the total class, lecture, and lab.

As a Class by Itself

- This program is perfect as an introductory course on robotics. By presenting some information on the microprocessor first and then using RB5X in the lab activities that illustrate the detailed use of the microcomputer, students gain an in-depth perspective on how microcomputers are used today.

- After an introductory course on the microcomputer, it makes sense to teach the operation of a complete system as a sequential course. The features used in the RB5X robot can then be used as examples in later courses on interfacing, sensors, and industrial automation systems.

These are merely suggestions. As you examine the materials closely, you will see that they lead the student through the operation and development of an environmentally "smart" robot system. This is the direction in which the industrial robot systems are evolving and the RB5X system is a technically sophisticated, low-cost way for students to get hands-on experience.

THE AUTHORS AND THE EDITORS

Authors Jim Hall and Larry Fryda, Ph.D., are experienced teachers who have taught at both the secondary and community-college level, as well as in industry. Larry is also an associate professor at Illinois State University. Their students have consistently won national honors in technical contests. Jim and Larry have incorporated into this course

the technical expertise and teaching methods that have worked so well for their students for over twenty years. They are currently using these materials in their classes.

Larry Heath, Ph.D., and Sharon D. Smith edited these materials. Larry Heath, a professor at Indiana State University, is the author of Fundamentals of Robotics: Theory and Applications, and these materials are fully compatible with this text.

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